MANAGING SILVERLEAF WHITEFLY IN AUSTRALIAN COTTON

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Silverleaf whitefly (SLW) is a major pest of mid to late-stage cotton. SLW honeydew is a serious contaminant of cotton lint, with the potential to harm our export reputation. Overseas, SLW are also a key vector for exotic viral diseases such as cotton leaf curl. SLW have a large host range, rapid reproduction and are able to quickly develop resistance to insecticides.

SLW populations can increase rapidly during hot conditions, particularly when natural enemies have been disrupted by insecticides. An integrated pest management (IPM) approach that includes farm hygiene, agronomic management, conservation of natural enemies, crop sampling and strategic use of selective insecticides is necessary to optimise SLW control and maintain Australia's reputation for producing uncontaminated, high quality cotton.

HONEYDEW PRODUCTION

Honeydew excretions are a by-product of SLW feeding on phloem vessels that transport sugar-rich photosynthetic products around the plant. Honeydew production varies with the SLW life stage and host plant status. In general, late instar nymphs and adult females will produce the most honeydew. Higher honeydew levels will be produced in low-nutrient or stressed crops as SLW need to consume more sap to maintain their nutrition levels.

PHOTOS CSIRO

Light honeydew contamination.

Heavy honeydew contamination.

Figure 1: Examples of light and heavy SLW honeydew contamination.

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BEST PRACTICE

Unlike aphid honeydew, visible as a thick, wet, sticky coating on areas adjacent to the aphid colony, SLW nymphs flick the honeydew away, resulting in a wider spread throughout the plant, with higher concentrations in the lower canopy. Initial 'reflective speckling' on the lower canopy leaves can develop into a matte sheen over affected leaves and bolls (see Figure 1), that is dry to the touch, but contains a sugar component (trehalulose) that has a lower melting point than the honeydew produced by other sucking pests.

SLW honeydew causes significant issues during textile manufacturing, and can reduce yarn quality. Shutting down machinery for cleaning is costly and reduces productivity, so this issue is regarded seriously by cotton processors, and regions that develop a reputation for honeydew contamination risk severe discounts and loss of market access. Rain before harvest may wash the honeydew off the open lint. Sooty moulds (Figure 2) are favoured by dew or high humidity. While they can aid in the breakdown of honeydew, they are often associated with lint colour downgrade penalties.

WHITEFLY SPECIES FOUND IN AUSTRALIAN COTTON

Referred to as a cryptic species complex, *Bemisia tabaci* is actually a collection of species, that look identical but have slightly different genetics and ecology (such as host range).

While endemic Australian *Bemisia tabaci* and greenhouse (*Trialeurodes vaporariorum*) whiteflies can be present in cotton, SLW (*Bemisia tabaci* Middle East Asia-Minor1 (MEAM1)) has become the dominant whitefly found in eastern Australian cotton crops.

Contaminated cotton may pass through ginning undetected, however the honeydew causes significant issues during textile manufacturing, and can reduce yarn quality

PHOTOS CSIRO

Figure 2: Examples of moderate and heavy SLW honeydew contamination on lint, with sooty mould.

Exotic members of the *Bemisia tabaci* species complex not currently in Australia may have different insecticide resistance profiles (and could carry cotton leaf curl virus). As they cannot be distinguished without molecular testing, an unexpected control failure could indicate an exotic incursion. If control failure without an obvious explanation occurs, please contact your local REO (or call the Exotic Plant Pest Hotline on 1800 084 881) to arrange sampling for genetic analysis to rule out an incursion.

SLW CHARACTERISTICS, LIFECYCLE AND ECOLOGY

SLW adults are small (1.2 mm long), with white wings and creamy yellow bodies. When resting, the wings are folded back at a 'tent' like angle with a clear gap between them. The semi-translucent scale-like juvenile life stages (nymphs) develop on the underside of leaves (see Figure 3). The other whitefly that is sometimes present (but rarely a significant problem) in Australian cotton is greenhouse whitefly. Adults are slightly larger than SLW (about 1.5 mm long) and hold their wings flat and slightly overlapping, (a key visual difference from the *Bemisia tabaci* species complex). Greenhouse nymphs are similar in size to SLW but have fine hairs around the margin of their body.

During summer, SLW development from egg to adult on cotton typically takes around 3 weeks (~21 days). SLW does not have an overwintering diapause stage, relying on alternative host plants to survive. Winter development times are temperature dependent: 40-45 days in central Queensland, 65-70 days in the Macintyre, Gwydir and Namoi valleys, and just over 100 days in Griffith.

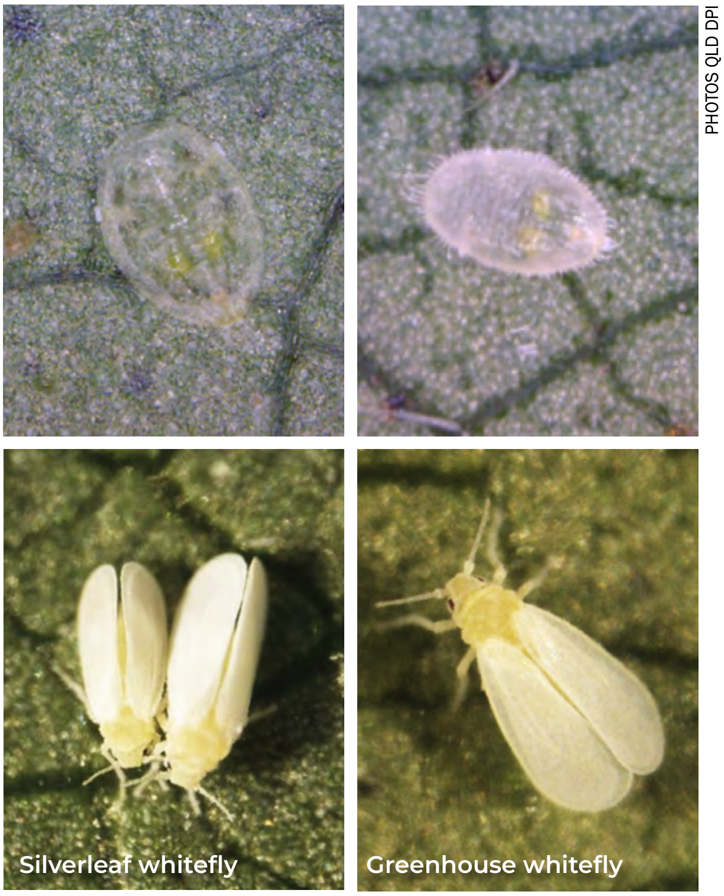
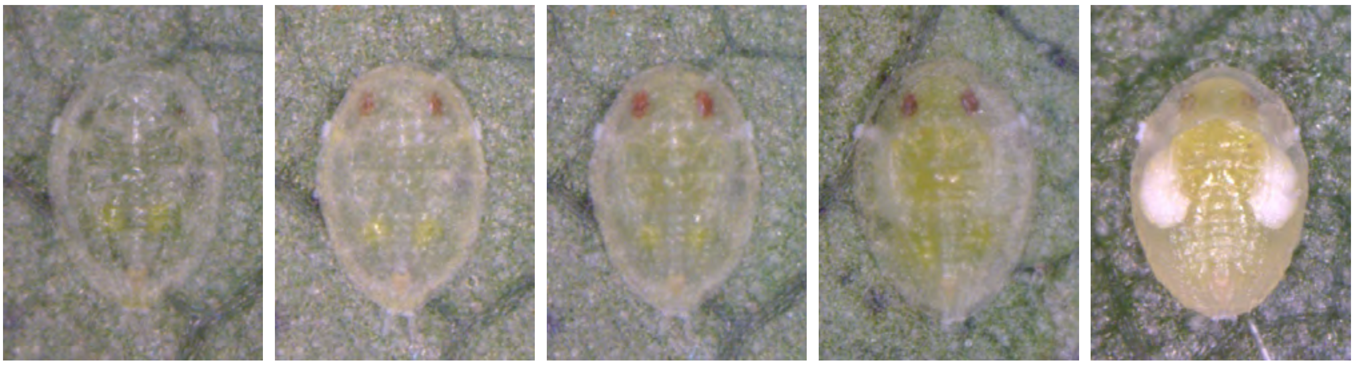


Figure 3: Silverleaf (left) and greenhouse (right) whitefly nymphs and adults. SLW nymphs lack visible hairs, and the adult wings are tent-like with a clear gap.



3rd to 4th instars are relatively transparent

4th instars develop red eyes as they pupate

Wing buds develop just before emergence

Figure 4: Development of SLW nymphs through 3rd and 4th instars.

LIFE STAGES

Eggs

Spindle-shaped eggs about 0.2 mm long are laid on the underside of leaves. Eggs are yellowish white when first laid and gradually turn brown, usually hatching within 6 days.

Nymphs

Newly hatched nymphs (crawlers) can move short distances to locate a suitable feeding site; subsequent instars remain stationary. Late 4th instar nymphs develop distinctive red eyes before feeding ceases. White wing buds develop on the pupal stage before the adult emerges (see Figure 4).

Adults

Adult mating can occur within hours of emergence, with females laying 80–120 eggs over approximately 2 weeks. Adults fly between plants and adjoining fields, and under windy conditions can move significant distances within regions.

Host range

SLW does not have an overwintering diapause stage and relies on alternative host plants to survive between seasons. Even a small patch of favoured hosts can maintain a significant pest population.

SLW is found on a wide range of broadleaf weeds. Within the eastern Australian farming system between winter and spring, sowthistle (*Sonchus* spp.) is a key 'green bridge' host.

In cotton growing areas, important alternative crop hosts include soybeans, sunflowers and all cucurbits. If possible, avoid planting cotton near preferred SLW host crops and destroy crop residue from all susceptible crops immediately after harvest. Monitor your cotton closely for migrations of displaced adult SLW if alternative hosts in the local area have been recently removed (this includes recently defoliated cotton).

Use magnification to assess nymph parasitism. Tell-tale signs include the distortion of small yellow internal organs called mycetomes

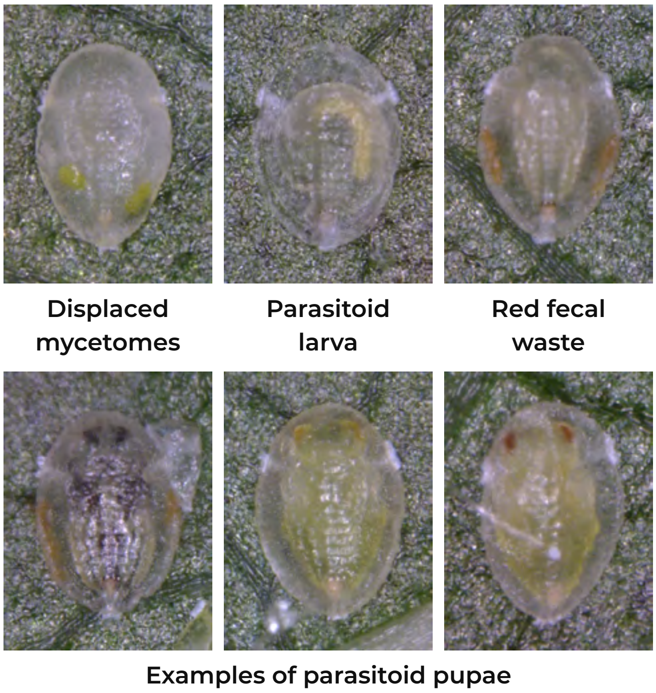


Figure 5: Examples of visual signs of parasitism.

NATURAL ENEMIES

Sustainable SLW management ultimately depends on conserving natural enemies throughout the season. High levels of biological control (>70%) reliably occur in commercial cotton fields that are managed using an IPM-based approach.

Parasitoids

Several whitefly parasitoid wasps (particularly *Eretmocerus* and *Encarsia* species) attack the nymph stage of SLW and contribute significantly to biological control. Magnification is recommended to assess nymph parasitism. Tell-tale signs include the distortion of small yellow internal organs called mycetomes (see Figure 5). In healthy, large nymphs these organs are symmetrical kidney-shaped yellow structures (see Figure 4). A lack of symmetry in their alignment along the mid-line indicates parasitism, as the developing wasp larvae displaces these internal organs.

Immediately prior to wasp emergence, nymphs parasitised by *Encarsia* sp. turn dark brown or

black, while those parasitised by *Eretmocerus* sp. turn yellow/brown with red to green eyes visible (see pupal images in Figure 5).

Circular chewed holes on empty nymph cases indicates parasite emergence, as healthy SLW adults will emerge by pushing their way through the case, leaving a 'T' shaped emergence hole (see Figure 6).

SLW parasitoids are commercially available from suppliers of biological control organisms and can be released manually at the field scale (by licensed drone operators or from aircraft) to boost levels of parasitism.

See the CottonInfo video Identifying parasitism in SLW

youtu.be/SO0cedrGlQI

Predators

Predatory insects and spiders are also very important in helping to suppress SLW populations. These predators include big-eyed bugs, minute pirate bugs, lacewing larvae, ladybeetles, brown smudge bugs, apple dimpling bugs, red and blue beetles and lynx and yellow night stalker spiders

Pest thrips species will also feed on SLW eggs and nymphs just as they do on pest mite species.

(some examples are pictured in Figure 7). Chewing predators may not leave much evidence behind but bugs suck SLW nymphs through their stylet mouthparts, leaving the dried, collapsed nymph 'shell' still attached to the leaf. Pest thrips species will also feed on SLW eggs and nymphs just as they do on pest mite species.

MANAGING SLW

The primary goal of SLW management is to avoid honeydew contamination of lint in the open boll stage. An effective IPM strategy for SLW is underpinned by:

- minimising the disruption of natural enemies by avoiding unnecessary or broad-spectrum sprays, especially early in the season.
- suppression of SLW throughout the year, including control of alternative weed hosts and coordinated crop sowing.

Chewed emergence hole created by parasitoid wasp

Encarsia and Eretmocerus adults

'T' shaped emergence hole created by healthy SLW adults

Figure 6: Empty pupal cases and common parasitoids.

- reliable information on pest abundance and distribution through good sampling.

A nymph-based sampling and spray decision support system (see p7) is recommended for SLW management. The nymph-based sampling method has been tested from southern Queensland through to the southern-most cotton growing regions in Australia (Coleambally, Forbes and Hillston) and is expected to be relevant to most cotton growing regions in Australia.

Sampling strategy

Sampling guidelines use mainstem leaves taken from the mid canopy (nodes 11-14 down from the terminal) and classify a leaf with 2 or more nymphs as 'infested'.

When to sample:

- SLW populations naturally fluctuate. Start sampling during early flowering (750 DD 15_32) to identify a SLW population baseline for comparison as the season progresses.
- Nymphs are not mobile within the plant canopy so time of day does not matter for sampling (unlike adults).
- Assessments can be made post-collection in the comfort of a vehicle or office, but counts must occur before the leaves wilt.

Where to sample:

- Avoid sampling field edges by walking in 20-30 metres before commencing sampling.
- Sample plants at least several metres apart and try to include within-field variability.
- The lower canopy sampling zone is 11–14 nodes down from the mainstem terminal. Figure 8 provides a handy tip on how to find it, based on leaf node 1 as the first unfurling terminal leaf (20 cent coin size).

What to sample:

- Randomly collect at least 30 main stem leaves (one per plant) from the lower canopy for each management unit. A larger number of leaves

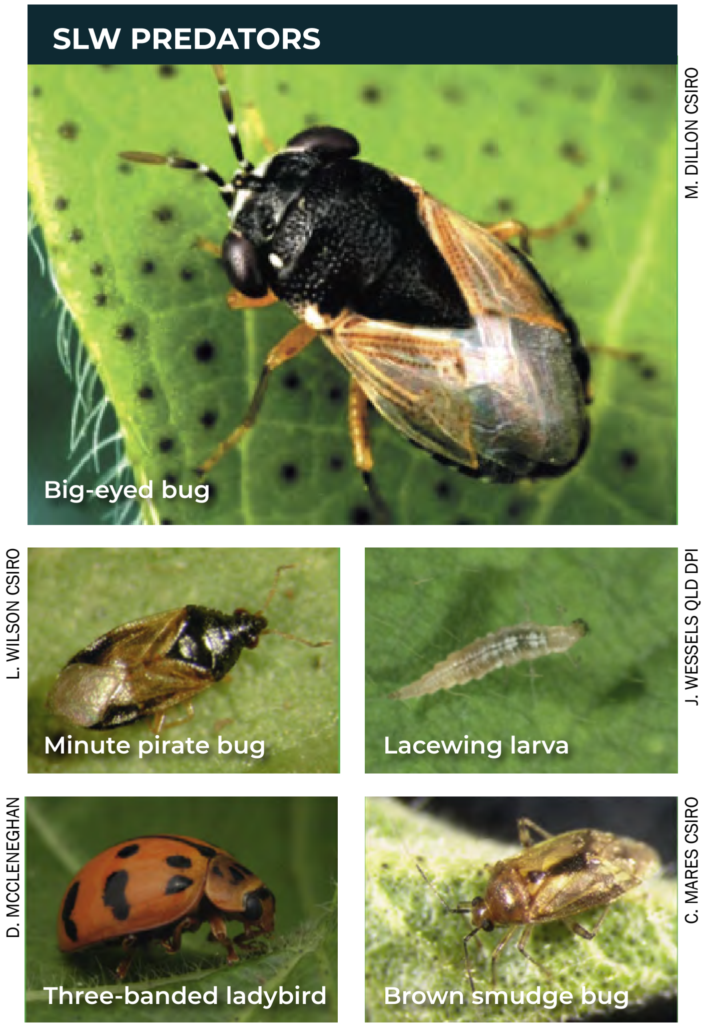


Figure 7: Examples of SLW predators.

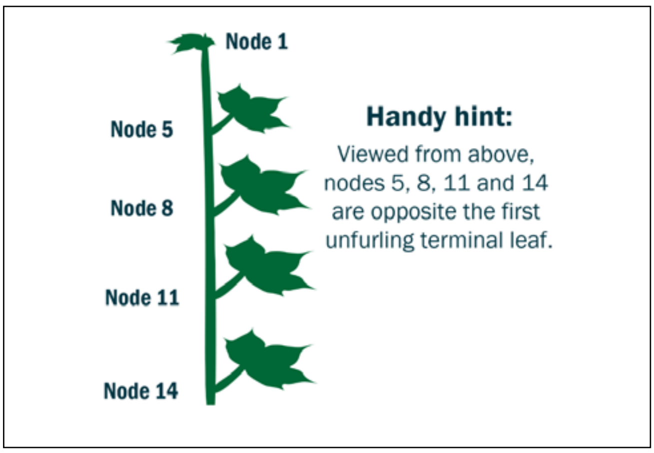


Figure 8: How to quickly find the lower canopy sampling zone (nodes 11-14 down from the terminal).

provides more accurate data, particularly early in an infestation when SLW densities are low.

- Look for large nymphs (3rd or 4th instar – see Figure 4) on the underside of the leaf. If two or more are present, the leaf is considered infested. If there is one or none, then the leaf is uninfested.
- Calculate the proportion of infested leaves and consult the threshold matrix to see your risk area for the crop development stage.
- Also keep an eye out for influxes of displaced adults from nearby crops.

> ***Cool conditions slow population increase. Heavy rainfall may temporarily reduce adults has no lasting impact on population growth***

Other considerations

Cool conditions slow population increase. Heavy rainfall may temporarily reduce adult SLW numbers but has no lasting impact on population growth, as nymphs are unlikely to be affected. Continue sampling after rainfall even if the overall abundance of SLW in the field appears to have fallen.

USING THE MANAGEMENT MATRIX

The SLW management matrix (Figure 9) aims to provide guidance for control decisions and has been split into zones according to crop stage

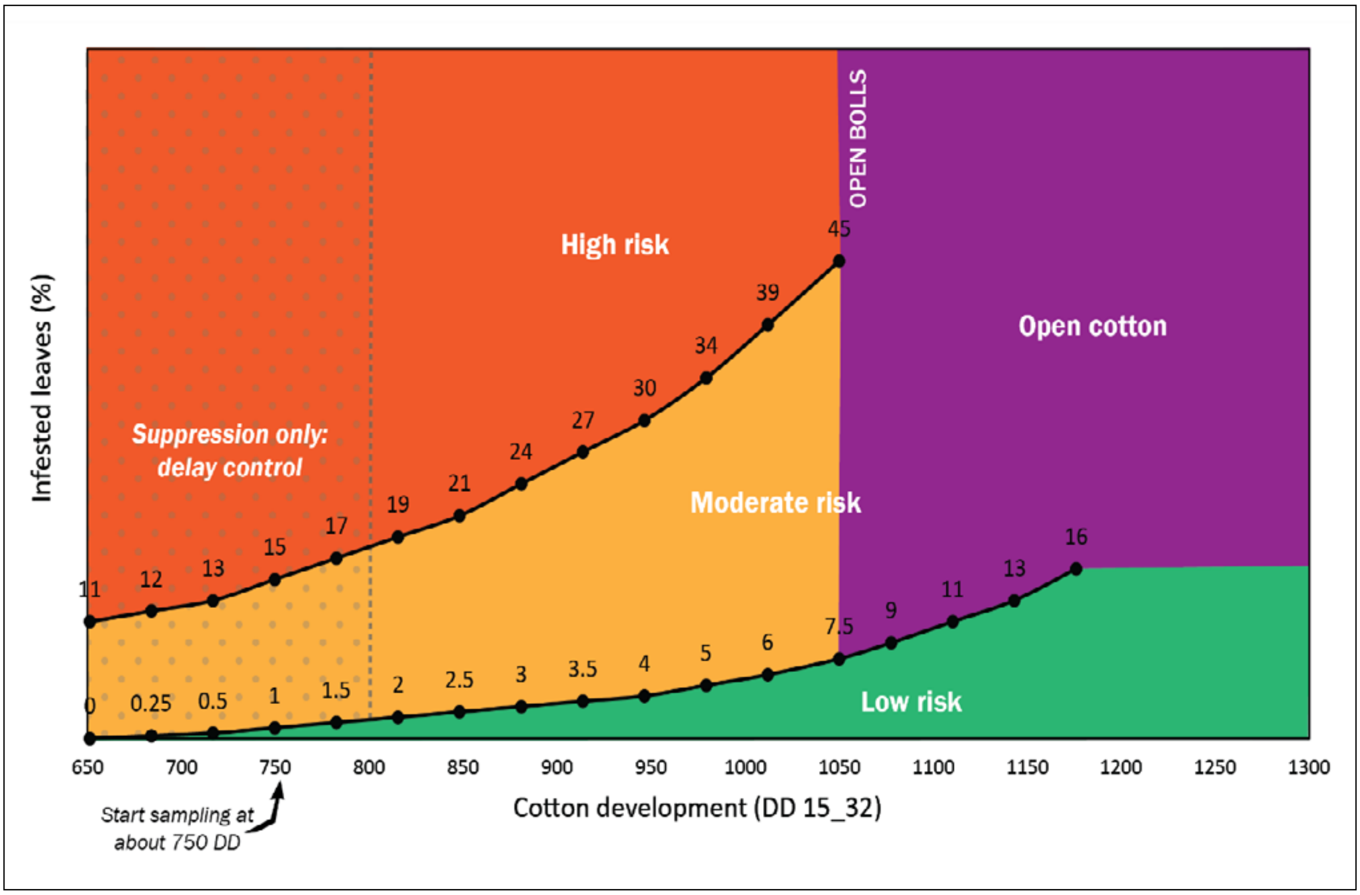


Figure 9: The SLW management matrix.

(defined by DD 15_32) and the percentage of infested leaves. *Note that this nymph-based matrix is not applicable for crops facing a mass immigration situation.*

Management matrix zones

Prior to mid flowering (~800 DD), monitor populations but do not spray for SLW. Conserve beneficials to keep pest populations low. Consider opportunities to supress SLW if there's a need to manage other pests (particularly before row closure) but prioritise selective/soft products.

After 800 DD:

- If in the **'Low risk' (green) zone**, no immediate action is needed. Continue to monitor the situation.
- If in the **'Moderate risk' (orange) zone**, assess the counts over 2-3 consecutive checks. If the population is increasing a control decision is likely. Consider a slower-acting insect growth regulator product between 800-1000 DD. If the crop is nearing open bolls, a faster-acting insecticide may be more appropriate.
- If in the **'High risk' (red) zone**, management action is required. Use slower-acting products such as IGRs prior to 1000 DD. For crops nearing open boll, or that have closed canopies, consider a faster-acting systemic product.
- **Once bolls are open** (~1050+ DD), continue to monitor SLW, but also assess nymph parasitism and honeydew levels. In the 'Low risk' zone, contamination risk should remain low. In the purple zone, base management decisions on viable SLW nymphs, honeydew severity in the lower canopy, and climatic conditions. Focus on knockdown products if control is required.

Chemical use strategy if action is warranted

If control with insecticides is needed, always use them according to their label specifications and optimal performance recommendations from the manufacturer.

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Management decisions are often a balance between minimising the impact on benefical and the risk of re-infestation (and thus need for retreatment), and targeting populations that are low enough for products to provide effective control before there is risk to open cotton.

Use knowledge of the mode of action and natural enemy impacts to guide product selection. A range of products registered for SLW control, that vary from non-residual quick knockdown of adults through to slower acting IGRs (insect growth regulators) that disrupt specific life-stages, breaking the lifecycle and consequently taking up to 2-3 weeks to provide control. IGR use will leave a reduced SLW population with natural enemies largely intact. See Table 1 for insecticide options.

Pest control can be compromised by insecticide resistance. Annual insecticide resistance monitoring is conducted for all major pests of cotton including SLW, and some products are subject to industry usage recommendations by the Transgenic & Insecticide Management Strategy (TIMS) committee for resistance management purposes based on the testing results. For example, spirotetramat and the IGRs pyriproxyfen and buprofezin are limited to one application per season to minimise the risk of resistance.

In Australia, SLW have developed resistance to several insecticide groups including organophosphates, carbamates, pyrethroids, some neonicotinoids, pymetrozine, pyriproxyfen and spirotetramat. The risk of resistance selection to additional insecticides is very high. The IRMS has been developed to manage the risk of resistance development, providing guidance as to when and

how often certain insecticides should be used. The latest IRMS can be found in the current Cotton Pest Management Guide (see further information).

Managing SLW in late planted or developmentally delayed crops

During defoliation, adult SLW will leave the crop while falling leaves take the nymphs with them to the ground. Displaced adult SLW will relocate to nearby host crops and weeds. The management matrix only covers in-crop population build-up, and is not applicable if crops with open bolls experience mass immigration of adults from nearby defoliated areas. SLW management in these situations should be based on (a) expected time to defoliated leaf drop, (b) lint contamination level, and (c) prior chemical use (from a resistance management perspective).

Prior to the first pass of defoliant, make product choices based on potential efficacy (and any control delay), residual impact and withholding periods (WHPs). If the risk of honeydew contamination is high, consider starting defoliation early. The presence of honeydew on leaves is a good indicator of potential lint contamination.

- If defoliation is not due for 10-14 days and honeydew is collecting on the leaves, managing SLW numbers with a knockdown product may be prudent.

INTEGRATED PEST MANAGEMENT FOR SLW

Take a year-round approach to pest management. Major outbreaks of SLW occur when a combination of climatic conditions (especially mild winters) and suitable hosts (winter weeds or alternative crops) enable prolonged population buildup. Reducing available weed hosts and avoiding early season management decisions that disrupt natural enemies (e.g. the use of broad-spectrum insecticides against other pests) can help reduce the severity of SLW outbreaks.

Consider all potential hosts in cropping and non-cropping areas as SLW numbers can build rapidly and adults can move between fields and farms to find suitable hosts. Area wide management, where neighbours share information and coordinate tactics (such as sowing windows, weed management, consensus about delaying disruptive insecticide use to conserve natural enemies, shared adherence to the Insecticide Resistance Management Strategy (IRMS) and coordinated release of natural enemies) can help SLW management.

Conserve natural enemies (predators and parasitoids) that play a vital role in suppressing SLW population growth. Avoiding unnecessary sprays can help to prevent the rapid build-up of SLW numbers. Native vegetation, both on farms and in the region, can also be an important source of natural enemies.

Grow a healthy crop to optimise yield potential and minimise moisture stress as SLW tend to produce more honeydew on stressed crops. Optimising nutrition and water inputs also avoids maturity delays and the risk of SLW resurgence or immigration from surrounding crops.

Consider field selection, planting times and variety selection. Cotton sown in close proximity to other host crops is at greater risk of mass immigration mid-season, and late-maturing cotton could be prone to influxes of SLW adults displaced from crops defoliated earlier. Also consider host plant resistance (e.g. okra-leaf is less attractive to SLW) when selecting varieties.

Good farm hygiene practices such as removing hosts within fields and adjacent farm areas will reduce the 'green bridge' not only for SLW but other pests such as aphids and mealybugs between seasons. Destroy crop residues immediately after harvest to prevent these areas acting as reservoirs for SLW and other pests.

MANAGING SILVERLEAF WHITEFLY IN AUSTRALIAN COTTON

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- If defoliation is 15-21 days away, consider a knockdown spray in the first 7 days and continue monitoring. Commencing defoliation early (at 50% open bolls) may be warranted if significant population resurgence is evident 7 days following treatment.
- If defoliation is ≥21 days away, consider using a systemic product with residual activity to target both nymphs and adults within the canopy.

Options when cotton lint becomes contaminated

When open cotton has been severely contaminated with honeydew, intentionally delaying harvest may increase the odds of crop exposure to rainfall that may remove most of the honeydew. Rainfall of 15-20 mm (in either single or multiple falls) is sufficient to wash off the majority (>80%) of honeydew. Dew or high humidity can promote the growth of sooty moulds, however the breakdown of honeydew sugars by moulds is relatively slow, and mould activity presents significant risks for lint colour downgrade penalties.

However, if conditions remain dry, the high risk for honeydew contaminated lint will remain. If you are concerned cotton is contaminated, it is important to talk to your ginning company/marketer to discuss processing options that may alleviate downstream market discount risks.

If the risk of honeydew contamination is high, consider starting defoliation early. The presence of honeydew on leaves (see Figure 1) is a good indicator of potential lint contamination.

FURTHER INFORMATION

Visit www.cottoninfo.net.au

Cotton Pest Management Guide (contains IRMS)
www.cottoninfo.com.au/publications/cotton-pest-management-guide

Silverleaf whitefly sampling and thresholds
(2024 CottonInfo factsheet) cottoninfo.com.au/publications/2024-silverleaf-whitefly-sampling-and-thresholds

Supporting resources:

The SLW management matrix is aligned to the 15_32 day degree method of tracking crop development. To check where your crop is at, visit the CSD members' portal (www.csd.net.au) to access the 15_32 DD calculator for any location in Australia.

For further information:

Visit www.cottoninfo.com.au

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BEST PRACTICE

TABLE 1. REGISTERED INSECTICIDES FOR THE CONTROL OF SILVERLEAF WHITEFLY.

Pesticide order arranged by impact on beneficials. Information on insecticides is provided as a guide only. All pesticide applications must accord with the currently registered label for that particular pesticide, crop, pest and region. Always follow label and manufacturer's advice.

Insecticide (MoA group)	Formulation and rate	SLW resistance	Impact on natural enemies[1]	Control interval[2] (days)	Comments
Paraffinic oil (UNM)	778 g/L EC or 792 g/L SC @ 2% V/V (min 2 L per ha)	Unknown	Very low		Target low, early season populations. Min 100 L/ha for ground applications. Multiple applications are more effective.
Pyriproxyfen (7C)	100 g/L SC & EC @ 0.5 L/ha	Widespread but low	Very low	14-30	Ensure good coverage. Max 1 application. IGR with translaminar[3] movement. Disrupts egg hatch and 4^{th} instar moult. Reduces adult female fertility.
Clitoria ternatea extract	400 g/L EC @ 2 L/ha	Unknown	Low		Ensure good coverage. Max 5x per season. Treatment effects may not be seen for 3+ days. May require repeat application at 14-20 days if conditions favour pest development.
Buprofezin (16)	440 g/L SC @ 1 L/ha	Not detected	Low	14-30	Max 1 application targeting SLW. IGR that disrupts nymph moulting. Contact and vapour activity. Reduces adult female fertility.
Diafenthiuron (12A)	500 g/L SC @ 0.6 or 0.8 L/ha	Not detected	Low	7-14	Suppression only. Target early developing populations (may not give satisfactory control of established populations). Max 2x per season. Translaminar, contact and vapour activity. Avoid using if moderate or high resistance has been detected in two-spotted mites.
Afidopyropen (9D)	100 g/L DC @ 0.35 L/ha + 0.2% v/v Hasten Spray Adjuvant	Not detected	Low	14-21	Suppression only. Disrupts insect behaviour & feeding best targeted at nymph stage. Max 2x per season targeting SLW. Translaminar and systemic.
Dimpropyridaz (36)	120g/L SL @ 1 L/ha	Unknown	Moderate	Up to 21	Do not apply by aircraft. Disrupts insect behaviour, coordination and feeding and will provide slow knockdown. Max 2 consecutive applications; max 4 applications per season.
Cyantraniliprole (28)	100 g/L SE @ 0.6 L/ha + oil	Not detected	Moderate	14-30	Target early developing populations. Two consecutive applications 10-15 days apart may be required. Max 2x per season.
Spirotetramat (23)	240 g/L SC @ 0.3-0.4 L/ha + Hasten Spray Adjuvant 1.0 L/ha	Widespread – low (very high –extreme in Lockyer Valley)	Moderate	14-30	Use higher rate when targeting high pest populations and when crop is well advanced. Do not reapply within 14 days. Translaminar and systemic. Controls nymphs and reduces adult female fertility. Max 1 application targeting SLW.
Acetamiprid (4A)	200 g/L SL @ 0.225-0.38 L/ha 225 g/L @ 0.34-0.5 mL/ha	Rare – very low	Moderate	7-14	Target nymphs. Evidence of activity will be slower than typical contact insecticides. Contact and systemic. See label for adjuvant information.
Emamectin benzoate + acetamiprid (6/4A)	32.5g/L + 218g /L DC @ 0.3-0.35 L/ha	Not detected/ Rare – very low	Moderate	7-14	Target developing populations. Max 2x per season (use another MOA between applications). Emamectin is translaminar.

Insecticide (MoA group)	Formulation and rate	SLW resistance	Impact on natural enemies[1]	Control interval[2] (days)	Comments
Dinotefuran (4A)	200 g/kg WG @ 250-375 g/ha	Not detected	Moderate	7-14	Target developing populations; use higher rate for high populations. Max 2x per season (use another MoA between applications). Translaminar and systemic.
Bifenthrin (3A)	100 g/L EC @ 0.8 L/ha 250 g/L EC @ 0.32 L/ha 240 g/L SC @ 0.33 L/ha	Widespread – low cross-resistance with other SPs	Very high	7-14	Target adults. Do not spray crops with a high population of nymphs. Thorough coverage essential. Max 1 application per season.

[1] also see label for instructions to minimise impact on bees
[2] control interval is dependent on rate, timing, immigration and pressure, activity of natural enemies
[3] translaminar = movement through leaf from upper to lower surface