



Managing Silverleaf Whitefly in Australian cotton

Introduction

Silverleaf Whitefly (*Bemisia tabaci* MEAM1 (B-Biotype)) is a major pest in cotton. It has the ability to contaminate cotton lint with honeydew, has a large host range, can rapidly reproduce and can develop resistance to many insecticides.

Silverleaf Whitefly (SLW) feed on the phloem vessels that transport the sugar rich products of photosynthesis around the plant. During digestion, a proportion of plant sugars (sucrose, glucose, fructose) are altered into new sugars e.g. trehalulose and melezitose, resulting in a combination of sugars passed out of the SLW in the form of honeydew.

Compared with aphid honeydew, which is evident as thick, wet, sticky honeydew coating leaves and bolls, SLW honeydew often dries to an almost lacquer-like consistency and though visible on the leaves and bolls, may be dry to touch. This is deceptive – the main sugar, trehalulose, has a low melting point and is hygroscopic (attracts moisture).

In the spinning mills, visually “clean” cotton can cause problems as heat generated through friction causes the trehalulose to melt. It then attracts moisture and sticks to machinery, eventually necessitating shut-down for cleaning. Consequently, cotton producing regions that develop a reputation for supplying honeydew contaminated lint risk incurring significant discounts. It is important that the Australian



Control decisions should focus on avoiding lint contamination.

cotton industry upholds best management of SLW to maintain its reputation for producing uncontaminated, high quality cotton.

Greenhouse whitefly (*Trialeurodes vaporariorum*) and Australian Native Whitefly (*Bemisia tabaci*) are present in cotton but not considered pests as they rarely build to significant populations and are easily controlled, often by insecticides targeted against other pests. As a consequence, SLW tends to dominate in sprayed cotton crops.

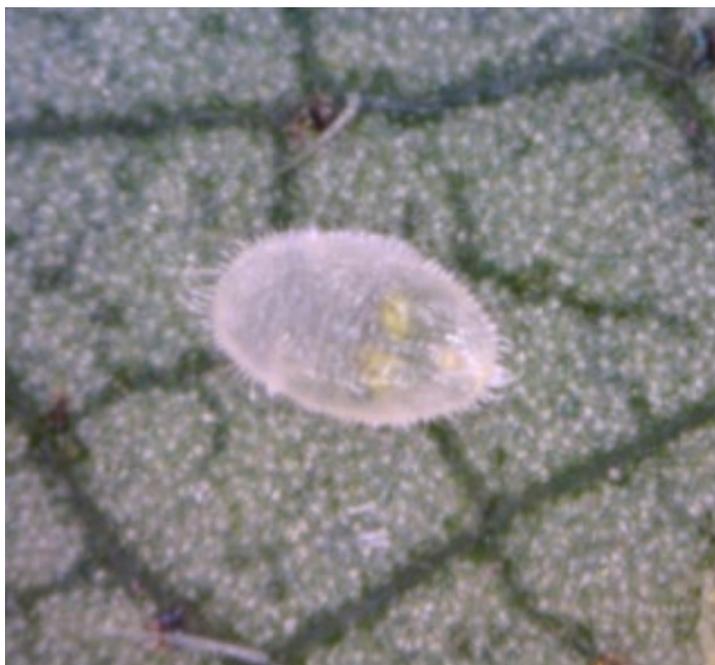
Management of SLW requires a year round Integrated Pest Management (IPM) approach as SLW numbers can rapidly increase, especially if natural enemies are reduced by insecticides and hot seasonal conditions favour fast SLW development.

Identification

Whitefly are tiny sap sucking insects related to aphids, mealybugs, leafhoppers and scales. They belong to the family of insects called Aleyrodidae. The adults have two pairs of wings which are coated in white powdery wax and fly readily when disturbed – hence the name whitefly. They use a fine stylet to puncture the leaf surface and locate and penetrate phloem vessels which carry sugar rich sap. SLW must

consume a lot of phloem sap to obtain enough amino acids and other nutrients for their growth. This means they also consume a lot of sugar which is secreted as honeydew and can contaminate leaves and bolls.

Correctly identifying which whitefly species are present is very important before implementing any management strategies.



(ZARA HALL, QLD DAF)

Note absence of hairs on *Bemisia tabaci* nymph (left) compared to presence on *Trialeurodes vaporariorum* (right).



(RICHARD LLOYD, QLD DAF)

Note the gap between the wings for *Bemisia tabaci* (left) compared with overlapping wings for *Trialeurodes vaporariorum* (right).

Two species of whitefly are found in Australian cotton fields:

- *Bemisia tabaci* – this species has two biotypes
 - (i) the Silverleaf Whitefly (SLW) or Middle East-Asia Minor 1 (MEAM1, also referred to as B-biotype). This biotype is a significant pest of cotton.
 - (ii) the Eastern Australian Native Whitefly (known as EAN or AUS1). This biotype is not a problem.
- *Trialeurodes vaporariorum* – commonly known as Greenhouse whitefly. This species is only very occasionally a problem.

Characteristics

Bemisia tabaci

The MEAM1 (B-biotype) and EAN are identical and cannot be distinguished using morphological features. Biochemical tests such as an esterase or PCR are needed to identify the biotype. Adults are small 0.8 to 1.2 mm long, have white wings and yellow bodies. Adults hold their white powdery wings at an angle more like the pitched roof of a house. However, the wings do not meet at the peak, so when viewed from above the body can be seen between the wings. Nymphs are pale yellow-green and flat scale-like insects that attach to the underside of the leaves of their host plant (see photographs on pg 2).

Greenhouse whitefly

Greenhouse whitefly is about twice the size of *Bemisia tabaci*. Greenhouse whitefly hold their wings flat and slightly overlapping, so they have a slight heart shape when viewed from above. This is a key visual difference between greenhouse whitefly and the two *Bemisia tabaci* biotypes (SLW and EAN). Nymphs are similar to *B. tabaci* but are covered in fine hairs (see photographs on pg 2).

What species have I got?

Whiteflies in commercial cotton fields will typically be SLW. However, other species and/or biotypes can occur; the composition within a field can change rapidly during the season due to factors such as insecticide applications, proximity of other host plants and climate. As described above SLW will usually

SLW will usually dominate sprayed fields as the other species are controlled by insecticides used against other pests.

dominate sprayed fields as the other species are controlled by insecticides used against other pests. It is straightforward to distinguish between greenhouse whitefly and the two *Bemisia tabaci* biotypes (EAN and MEAM1 (B-biotype)) using morphological features. If Greenhouse whitefly are identified early in the season, continue to monitor for the arrival of SLW.

Unfortunately it is not possible to distinguish between the two *Bemisia tabaci* biotypes without a biochemical test. However, in sprayed fields SLW will usually dominate as both greenhouse and EAN are usually controlled by insecticides used against other pests. Further, if whitefly numbers build quickly it is most likely to be MEAM1 (B-biotype) as the AUS1 (EAN) has a much slower growth rate.

Formal verification of the species

If identification of species is proving difficult, sampled leaves can be placed in a paper bag and then inside a plastic bag. Pack this in an esky with an ice brick that has been wrapped in newspaper. Ensure samples are clearly labelled including: collector's name and contact details, farm & field, region, date of collection as well as any other relevant information (such as insecticide usage) as the sample will also be used for resistance monitoring.

Send by overnight courier to;
Jamie Hopkinson, Qld DAF, 203 Tor Street,
Toowoomba QLD 4350. Phone (07) 4529 4152

SLW Lifecycle and Ecology

In warm weather the SLW life cycle takes 18 to 28 days, but is much longer in winter. From Biloela north, the winter generation time is about 80 days, while in the Macintyre, Gwydir and Namoi valleys, generation time

increases to about 120 days and in areas further south this time will be even longer. The diagram represents a lifecycle at an average temperature of 28 °C.

Eggs

Very small spindle shaped eggs are laid on the underside of leaves. These are very hard to see by eye. SLW eggs sit on a stalk that fits into a small slit in the leaf made by the female. Eggs hatch in 7-10 days (in warmer weather).

Nymphs

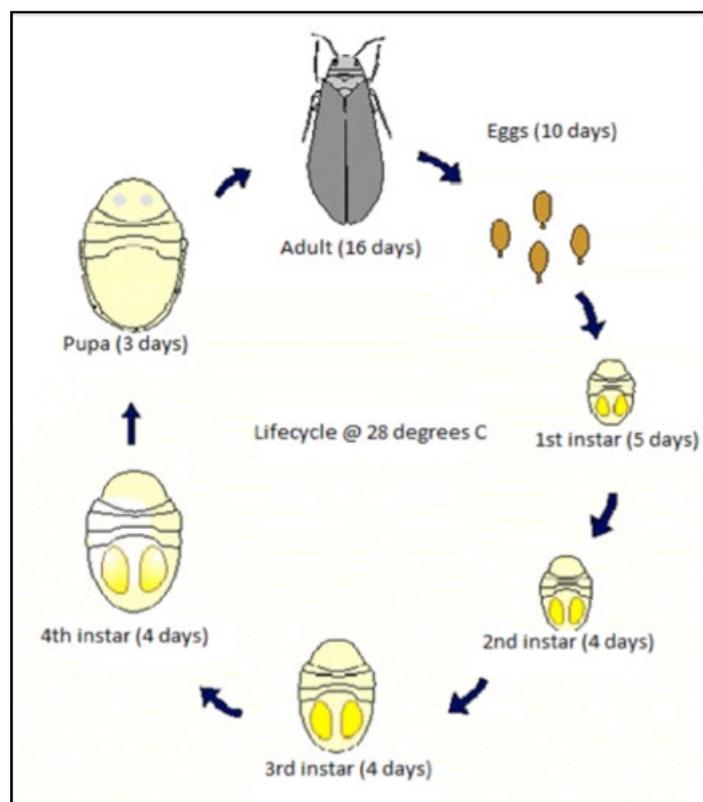
The 1st instar ('crawler stage') is the only mobile nymphal stage. They will move a small distance over several hours to find a suitable feeding site. Once the crawlers settle they don't move again. Instars 2 to 4, have non-functional legs, so they continue to feed in the same spot without moving. The late 4th instar stops feeding and becomes a pupa (or 'red eye') out of which emerges an adult. A pupa from which an adult SLW emerges successfully will have a 'T' shaped split in the back, while a pupa from which a parasitoid emerges will have a small circular hole.

Adults

Adult females are produced from fertilised eggs and males from unfertilised eggs. In warm conditions, mating can take place within a few hours of emergence from the 'red eye' pupal stage. Consequently, most SLW females are mated, resulting in a sex ratio biased toward females. Each female whitefly can lay up to 300 eggs over about a two week life span. Like the nymphs, adults feed on sap from the phloem tissue. Adults are capable of flying for 2 or more hours and may be carried long distances by wind, but they usually only make short flights from plant to plant and to adjoining fields.

Honeydew production

Honeydew production varies with the different life stages. In general, the adult female will produce the most honeydew and nymphs will produce more honeydew as they grow and when feeding on a poor quality host as they need to consume more phloem sap to maintain their nutrition levels.



Host range

SLW does not have an overwintering diapause stage. It relies on alternative host plants to survive. Therefore the availability of a continuous source of hosts is the major contributing factor to a severe SLW problem. Even a small area of a favored host can maintain a significant pest population.

Preferred **weed hosts** include; sow thistle, melons, bladder ketmia, turnip weed, native rosella, burr medic, anoda, rhynchosia, vines (cow, bell and potato), rattlepod, native jute, burr gerkin, blackberry nightshade, other Cucurbitaceae weeds, Josephine burr, young volunteer sunflowers, Euphorbia weeds, poinsettia and volunteer cotton. In winter and spring sowthistle is a key host.

In cotton growing areas the important alternative **crop hosts** are soybeans, sunflowers and all cucurbit crops. Spring plantings of these crops may provide a haven for SLW populations to build up in and then move into cotton. Conversely, autumn plantings of these crops may be affected by large populations moving out of cotton.

Natural enemies

Several species of whitefly parasitoids have been observed in Australia including several species of *Encarsia* and *Eretmocerus*. These beneficials are sometimes overlooked because they are very small and secretive. Whitefly nymphs parasitised by *Encarsia* turn dark brown or black, whereas whitefly parasitised by *Eretmocerus* turn yellow/brown with red to green eyes visible within the whitefly shell just prior to emergence. Whitefly nymphs have two yellowish structures inside them that are visible. These are called mycetomes.

Non-parasitised whitefly nymphs have mycetomes which are symmetrically aligned whereas mycetomes in a parasitised whitefly nymph are displaced and often appear as a yellow squiggle. See table below and CottonInfo video <https://www.youtube.com/watch?v=S00cedrGIQI>.

A wide range of predatory insects and spiders are also very important in helping to prevent SLW populations from increasing quickly. These predators include; big-eyed bugs, minute pirate bugs,

Healthy SLW <small>Photos Qld DAFF</small>						
	Healthy mycetosomes	Red eye nymph	Wing bud development	Adult silverleaf whitefly	Empty nymph case (white)	
	Parasitised SLW <small>Photos Qld DAFF</small>					
		Displaced mycetosomes (asymmetrical)	Red faecal waste (top) & parasitoid larva (bottom)	Parasitoid pupae and adults: <i>Eretmocerus</i> sp (top) & <i>Encarsia</i> sp (bottom)		
		SLW Predators				
Big-eyed bug Photo M.Dillon			Minute pirate bug Photo L.Wilson, CSIRO	Lacewing larva Photo: J Wessels	3 Banded ladybird Photo: D McClenaghan	Brown smudge bug Photo: C Mares

lacewing larvae, ladybeetles, brown smudge bugs, apple dimpling bugs, red and blue beetles and lynx and yellow night stalker spiders. The predatory bugs will often insert their stylet on the underside of the SLW nymph, suck out the contents leaving the dried collapsed body of the nymph still attached to the leaf. Pest thrips species have also been found to attack SLW eggs and nymphs.

Managing SLW

Sampling SLW

Good sampling is the key to successful management of any pest. SLW populations will naturally fluctuate so it is essential to conduct frequent population monitoring. Sampling should commence at flowering and occur twice weekly from peak flowering (1300 Day Degrees). Changes in whitefly density (adults and nymphs) and the level of honeydew contamination evident on the leaves and bolls should be used to determine whether or not control action is warranted. Once lower leaves appear to have a 'honeydew sheen' then generally corrective action needs to be implemented. **Corrective action taken after bolls have started to open has a higher probability of being ineffective.**

Below are some important sampling considerations.

1. Time of sampling

During the heat of the day, whitefly tend to shelter lower in the crop canopy. Aim to sample fields at a similar time each morning before it gets too hot.

2. Define your management unit

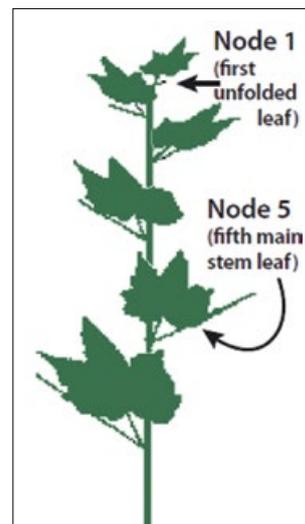
A management unit can be a whole field or part of a field – no larger than 25 ha. Each management unit should have a minimum of 2 sampling sites.

3. Choose a plant to sample

Move at least 10 m into the field before choosing a plant to sample. Choose healthy plants at random, avoiding plants that have already been disturbed by other types of sampling. Sample along a diagonal or zigzag line. Move over several rows, taking 5–10 steps before selecting a new plant.

4. Choose an upper canopy leaf to sample

- From each plant choose one mainstem leaf from either the 3rd, 4th or the 5th node below the terminal of the plant, as shown in the diagram.
- Using the leaf from the 4th node allows these same leaves to be collected and scored for aphids and mites as well.
- Turn the leaf over gently to avoid disturbing the whitefly adults by holding it at the tip of the leaf or by gently rotating the petiole.
- Score leaves with 2 or more whitefly adults as 'infested' and leaves with 0 or 1 whitefly adults as 'uninfested'.
- Using the above protocol, sample 10 leaves/site (20 leaves/management unit). For example a 50ha field should have 40 leaves sampled from 4 sampling sites (2 management units). Calculate the percentage of infested leaves for each management unit (20 leaves) and refer to the threshold matrix for interpretation of the % infested estimate in the context of control action.



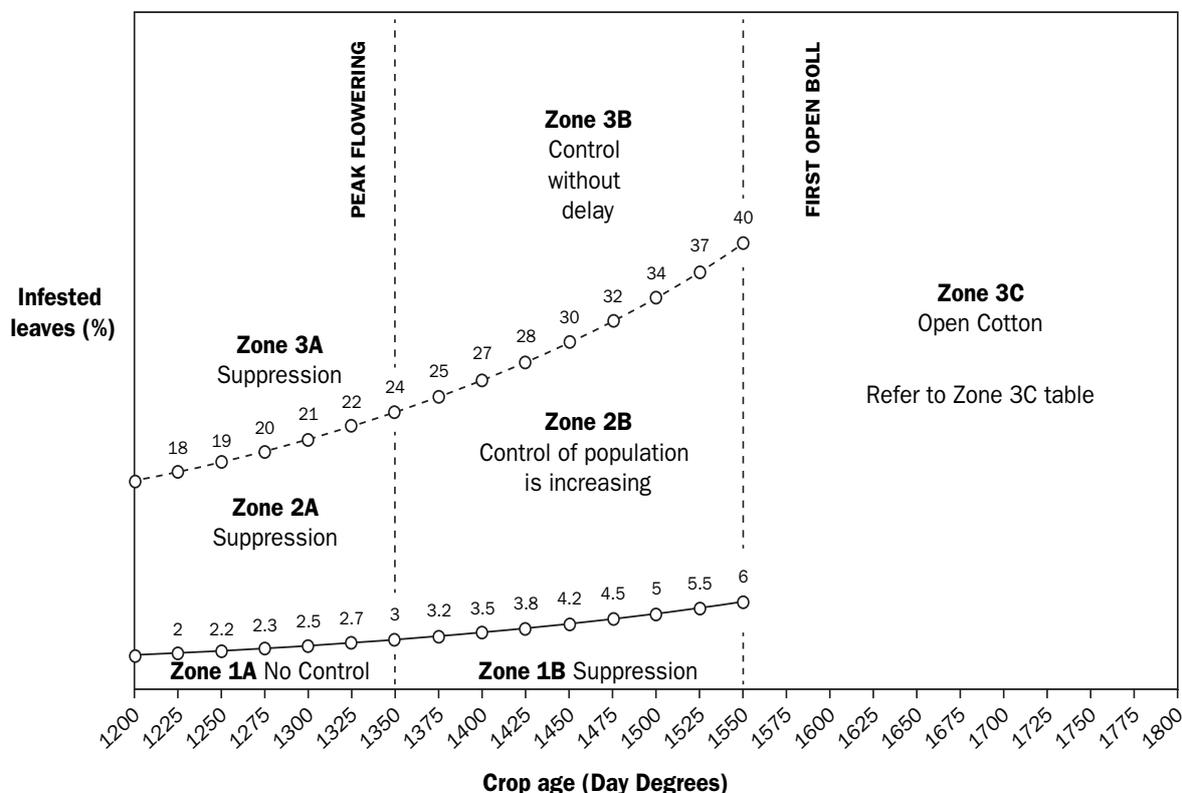
5. Sample the middle canopy for nymphs

- Check the whitefly population growth potential over the next 7-10 days by estimating the abundance of large, red-eye nymphs (RENs) in the middle canopy. These are the 4th instar and pupal stages with conspicuous red eye spots that are clearly visible under a hand lens. RENs will emerge as adults within 4-7 days.



SLW Red Eye Nymphs (RENs) – 4th instar (left) & pupa (right); note red eye spots

SLW Threshold Matrix



NOTES

Sampling protocol	Sample 20 leaves 3rd, 4th or 5th node below the terminal/25 ha weekly from first flower (777 DD) and twice weekly from peak flowering (1300 DD). Convert to % Infested leaves. Infested leaves are those with 2 or more adults. Uninfested leaves are those with 0 or 1 adult.	
Day Degrees	Daily Day Degrees (DD) are calculated using the formula; $DD = [(Max\ ^\circ C - 12) + (Min\ ^\circ C - 12)] \div 2$	
Zone 1A No control	Zone Aim: Preserve beneficials to keep SLW population low. <ul style="list-style-type: none"> Do consider opportunities to suppress SLW when controlling other pests particularly between 1350 and 1550 day degrees (prior to row closure). 	Chemistry: Insecticide use is not warranted for fields with low SLW densities.
Zone 2A, 3A & 1B Suppression	Zone aim: Preserve beneficials to keep SLW population low. <ul style="list-style-type: none"> Consider opportunities to suppress SLW when controlling other pests. If a low density population is present throughout flowering and boll filling stages leading into the open boll stage, refer to Zone 3C table (page 11) for management guidelines 	Chemistry: Aim for selective/soft. <ul style="list-style-type: none"> Oils. Sero-X. Cyantraniliprole (single application). Spirotetramat (lower label rate).
Zone 3C Open cotton	Zone aim: Avoid honeydew contamination/salvage <ul style="list-style-type: none"> Once there is open cotton, the ideal period for control has passed and the risk of honeydew contamination is heightened. Management decisions should be based on: <ul style="list-style-type: none"> time-to-defoliation; lint contamination level; and, population growth rate and size. Refer to Zone 3C table (page 11). 	Chemistry: Partial selectivity to broad spectrum. <ul style="list-style-type: none"> Diafenthiuron (knockdown). Cyantraniliprole (knockdown/control). Spirotetramat (control). Dinotefuran (high rate) (knockdown). Acetamiprid/emamectin (knockdown). Bifenthrin (pyrethroid) (knockdown).

- Sample for RENs at the 8th node leaf from the terminal down. The 8th node leaf is easy to locate using the **1-5-8 rule**: Locate the petiole of the 1st fully unfurled terminal leaf (size of a 50 C piece or larger); the petiole of the 5th node leaf is directly across and down the main stem; the petiole of the 8th node leaf is directly below (and in line with) that of the 5th node leaf (watch a CottonInfo video on whitefly sampling online at <https://youtu.be/vveOLmMEpg8>). The 9th/10th node leaves can also be used to sample RENs but they are deeper within the canopy and more difficult to locate/sample.
- Estimate the average number of RENs on 20-30 whole leaves within a management unit.
- Repeat at least twice a week for each management unit and determine if the average density of RENs/leaf is increasing between checks.
- Consistent (and significant) increases in REN density between checks provide a clear indication that the whitefly population in the crop will increase over the next 7-10 days.

Other sampling considerations

- Temperature is a major driver of SLW populations. Cool conditions slow population increase. Heavy rainfall may temporarily reduce adult SLW numbers but does not have a lasting impact on population growth, as nymph populations are unlikely to be affected. Make sure sampling continues after rainfall even if the first sample after rain shows low adult numbers.
- During the season, SLW adults change preference for location within the canopy in response to phenological/physiological changes in the crop and this needs to be considered when interpreting sampling results.
- Typically, the bulk of the SLW population is mostly in the lower canopy in pre-flowering and flowering stages and gradually moves upwards until cutout. As a consequence, it is not unusual to experience a rapid increase in the sampling density of adults at the 4th node over a short period at or nearing cutout.
- Recent research findings and supporting industry

feedback also indicate that the density of SLW at the 4th node may sometimes be underestimated due to the effects of extreme weather (temperature and possibly humidity) conditions on the behavior of adults. For this reason, monitoring nymph density at or below the 8th node throughout the season, in addition to adult sampling at the 4th node, can provide useful information on expected population growth in the next 7-10 days.

- SLW population dynamics can be quite cyclic – with peaks and troughs in adult numbers. While nymphs are not currently used in the threshold matrix, the presence of nymphs indicates that the population is reproducing. A sudden increase in adult numbers in the absence of a nymph population indicates that the adults have recently migrated into the field from another source.

Deciding if intervention for SLW control is required

The ultimate aim of all management options should be to minimise the risk of honeydew contamination on lint. Each management option will reflect the compromise between wanting to delay treatment, reducing the risk of reinfestation and need for re-treatment whilst targeting populations that are small enough for products to provide effective control.

Thresholds

The threshold matrix is based on rates of population increase relative to the accumulation of day degrees and crop development. Recent research has found that in some seasons the matrix may underestimate early SLW populations and the exponential population growth may occur closer to open cotton. Disruption of beneficials will result in a sharper rise in adult numbers. As a result the matrix has been modified to:

1. Highlight the need to preserve beneficials to keep SLW low;
2. Bring forward ‘control’ decisions to before 1550 day degrees to ensure management has taken affect before open cotton; and,
3. Highlight likely need to respond if low populations are increasing between multiple checks.

The management of SLW in situations involving adult immigration into crops with open bolls and/or developmentally delayed crops with open bolls should be based on (a) expected time to defoliated leaf drop, (b) lint contamination level, and (c) SLW population growth rate (refer to the Zone 3C). Once defoliant starts to take effect, adult SLW will generally leave the crop and falling leaves will take the nymphs with them. The likely efficacy and residual impact of insecticides also needs to be considered. Consider time for product to be fully effective. Due to emerging resistance, pyriproxyfen is no longer recommended for crops with open cotton. Where the risk from honeydew contamination is high, early defoliation can be considered. Finally, honeydew on leaves is a good indicator of potential lint contamination. In the worst case scenario, where cotton lint has been contaminated with honeydew, delaying harvest may assist in breaking down honeydew or expose the crop to rainfall that will remove most of the honeydew. However, if conditions remain dry any reduction in the amount of honeydew on bolls will be slow, and there is a risk that contaminated cotton may still have sufficient honeydew to result in substantial penalties if harvested.

The current recommendation for pyriproxyfen application between 1350 and 1550 Day Degrees

is designed to ensure that this cornerstone product is used when performance is least likely to be limited by crop parameters (eg., canopy closure and dense canopies in high yielding crops), control of the target population is achieved prior to boll opening and multiple generations are not exposed to this product, contributing further to resistance. This is the ultimate objective of whitefly control in cotton. It is important to note that a significant reduction in whitefly numbers will not be evident for up to 3 weeks following application of pyriproxyfen.

Zone 3C – Open Cotton

Once there is open cotton, the ideal period for control has passed and the risk of honeydew contamination is heightened. Management decisions should be based on:

SLW numbers can rapidly increase if natural enemies are reduced by insecticides.

- time-to-defoliation
- lint contamination level, and
- population growth rate and size

This three-pronged approach, presented in the Zone 3C Table (see page 11), is designed to support greater confidence in decision making in a range of situations including late maturing crops and those with an extended period of maturity.

It is important to note that in addition to factors affecting the behavior of adults discussed above, SLW abundance in the open cotton stage can change significantly between checks as a result of adult emigration due to rapidly declining host quality and/or mass immigration from other fields.

All weather-related and population processes that can influence SLW abundance in Zone 3C (e.g. mass immigration and/or emigration of adults, etc.) fit into the categories presented in the Zone 3C Table. For a given time-to-defoliation and level of lint contamination (see below for visual guide to determining level of foliage and lint contamination), the table presents clear guidelines for action depending upon the **growth rate of the adult population** (the change in % infested leaves between checks) regardless of whether it is due to immigration or from within the crop, and, where appropriate, supporting information on **overall abundance** (mean % infested leaves over one or more checks).

Time to defoliation of up to 14 days is best managed by use of a knockdown product in the first 7 days if SLW abundance warrants intervention (see Zone 3C Table). Situations in which defoliation is 15-21 days away may be managed by a knockdown spray in the first 7 days and continued monitoring; defoliation as early as 50% open bolls may be

TABLE 9: Control of silverleaf whitefly

Active ingredient	Concentration and formulation	Application rate of product	Comments
Silverleaf whitefly Bemisia tabaci B-biotype			
Afidopyropen	100 g/L	0.35 L/ha + Hasten Spray Adjuvant 0.2% V/V	When thresholds are reached, apply a single spray before rotating to an alternative insecticide for whitefly control. DO NOT apply more than 2 applications for whitefly control in any one crop. If using for whitefly control, do not apply more than 2 additional applications at the 100ml/ha rate for aphids. Afidopyropen will provide suppression of both adult and nymph stages of whitefly, however it is recommended to target the nymph stage. A general decline in population will occur over time as nymph numbers are suppressed.
Bifenthrin	100 g/L EC 250 g/L EC 240 g/L SC	0.8 L/ha 0.32 L/h 0.33 L/ha a	The adult stage should be targeted. Do not spray crops with a high population of the juvenile stages. Thorough coverage of the crop canopy is essential. IRMS recommends no more than 1 application per season.#
Clitoria ternatea extract	400 g/L EC	2 L/ha	Apply as indicated by field checks and pest presence. Ensure good coverage. Maximum 5 applications per season. Treatment effects may not be seen for 3 or more days. A repeat application may be required at 14– 20 days if conditions favour pest development.
Cyantraniliprole	100 g/L SE	0.6 L/ha + oil	Target early developing populations. 2 consecutive applications of cyantraniliprole 10–15 days apart may be required.#
Dinotefuran	200 g/kg WG	250–375 g/ha	When mirids and SLW are present always use SLW rate. Performance can be reduced in stressed crops or when senescing late season.#
Diafenthiuron	500 g/L SC	0.6 or 0.8 L/ha	Apply when population densities are 10–20% leaves infested. Suppression may not be satisfactory once population densities exceed 25% infestation, or when high numbers of adults are invading from nearby fields. Note: The label indicates that the product may not give satisfactory control of populations >25% infested leaves. This is based on an overseas sampling model. For Australian conditions this equates to ~45% infested leaves#
Emmamectin benzoate/ Acetamiprid	32.5 g/L/218 g/L	0.3–0.35 L/ha	Apply at or just prior to hatching. Use non-ionic surfactant as per label.#
Paraffinic oil	778 g/L EC and 792 g/L SC	2% V/V (min 2 L per sprayed ha)	Most effective when targeting low, early season populations. Apply in a minimum of 100 litres per hectare for ground applications. Multiple applications are more effective.
Pyriproxyfen	100 g/L EC	0.5 L/ha	Ensure thorough coverage. DO NOT apply more than once in a season. Refer to SLW Matrix for use window.
Spirotetramat	240 g/L SC	0.3–0.4 L/ha + Hasten Spray Adjuvant 1.0 L/ha	Use the higher rate when periods of high pest pressure or rapid crop growth are evident, and when crops are well advanced. Do not re-apply within 14 days. Do not apply more than 2 applications per crop. Spirotetramat may not control silverleaf whitefly adults and eggs, however a decline in the total silverleaf whitefly population will occur over time as the juvenile stages are controlled.
#See label for instructions to minimise impact on bees.			

warranted if significant population resurgence is evident within 7 days of treatment.

Time to defoliation of 21 days or over (under February-March weather conditions in most QLD and NSW cotton growing areas) would allow most juvenile SLW developing within the crop to complete their development, but from a control perspective, would also allow an IGR sufficient time to work,

thereby making the use of an IGR cost effective and the product of choice for such situations.

When it is too late – cotton lint is contaminated

In the worst case scenario, where cotton lint has been severely contaminated with honeydew, delaying harvest may assist in providing an opportunity for the amount of contamination to reduce. Rainfall in excess of 15-20 mm either in a single fall or spread over 2 or

Zone 3C table (supporting SLW management options for Zone 3C of the Threshold Matrix).

Refer to the visual diagnostics panel and text for details.

Time to defoliation (days)	Contamination level (visual diagnostic)	Adult population growth rate**	Action recommended
14 or less	No or light contamination	≤3% per 50 dd (every 3-4 days)	No action; continue monitoring
		>3% per 50 dd (every 3-4 days)	Knockdown in first 7 days if % infested leaves ≥10% and/or large nymphs present on most lower canopy leaves and/or consider early defoliation; otherwise, no action and continue monitoring
	Moderate contamination	≤3% per 50 dd (every 3-4 days)	Knockdown in first 7 days if % infested leaves ≥10% and/or large nymphs present on lower canopy leaves; otherwise, no action and consider early defoliation if contamination level increasing
		>3% per 50 dd (every 3-4 days)	Knockdown in first 7 days; consider early defoliation.
15-21	No or light contamination	≤3% per 50 dd (every 3-4 days)	No action; continue monitoring
		>3% per 50 dd (every 3-4 days)	Knockdown in first 7-14 days if % infested leaves ≥10% and/or large nymphs present on most lower canopy leaves; otherwise, no action and continue monitoring
	Moderate contamination	≤3% per 50 dd (every 3-4 days)	Knockdown in first 7-14 days if % infested leaves ≥10% and/or large nymphs present on lower canopy leaves; otherwise, no action and consider early defoliation if contamination level increasing
		>3% per 50 dd (every 3-4 days)	Knockdown in first 7 days & defoliate early if resurgence is evident
>21	No or light contamination	≤3% per 50 dd (every 3-4 days)	No action; continue monitoring
		>3% per 50 dd (every 3-4 days)	Use IGR in first 7 days if % infested leaves ≥10% and/or large nymphs present on most lower canopy leaves; otherwise, no action and continue monitoring
	Moderate contamination	≤3% per 50 dd (every 3-4 days)	Use IGR in first 7 days if % infested leaves ≥10% and/or large nymphs present on lower canopy leaves; otherwise, no action and consider early defoliation if contamination level increasing
		>3% per 50 dd (every 3-4 days)	Use IGR in first 7 days; consider early defoliation if honeydew level appears to be increasing beyond 14 days after IGR application
Severe contamination			Salvage: Knockdown &/or defoliate asap; delay picking – rain will help remove honeydew from bolls.

**Population growth rate measured as the change in % infested leaves between checks (every 3-4 days) at node 3, 4 or 5 (first fully unfurled terminal leaf = node 1); dd = day degrees.

3 falls will wash-off most honeydew (>80%). Honeydew breakdown can also occur through the action of sooty moulds that grow in the presence of dew or high humidity though the rate of breakdown is slow and there is a risk of penalties from the resultant black sooty mould spores that occur. If

conditions remain dry, reductions in the amount of honeydew on bolls will be slow, and there is a risk that contaminated cotton may still have sufficient honeydew to result in substantial penalties if harvested. It is also suggested that after harvest, leave the module/s in the field for as long as possible

Visual diagnostics for SLW management in Zone 3C of the threshold matrix

Light contamination



Honeydew on Middle Leaves



Middle Main Stem Bolls



Bottom 25% Main Stem Bolls

Moderate contamination



Honeydew on Middle Leaves



Middle Main Stem Bolls



Bottom 25% Main Stem Bolls

Severe contamination



Honeydew on Middle Leaves



Middle Main Stem Bolls



Bottom 25% Main Stem Bolls

to potentially reduce the level of honeydew contamination through breakdown.

Product selection

Knowledge of the registered products can help to improve management decisions. Slower acting products with longer residuals (such as an IGR) require up to 14 days to be fully effective, whereas knockdown products provide quick but limited control.

The following is a summary of products registered for use in cotton for SLW. For more information on details for use and rates [please refer to the individual product labels.](#)

- Bifenthrin (pyrethroid) (**Knockdown**) – provides some knockdown of adults, however is highly disruptive to beneficials.
- Diafenthiuron (**Knockdown & Suppression**) – is most effective at targeting low populations and has contact, translaminar and vapour activity. It is activated by light as well as insect enzymes so will be less effective in cloudy weather. If applied during the later half of Zone 2A (refer to matrix), it may collapse the population sufficiently that no further sprays will be required. However if conditions are suitable for SLW, another suppression product may be required to see the crop through to defoliation. Has activity against other late season pests such as mites and aphids.
- Dinotefuran (**Knockdown**) – is suitable to be applied in each of the threshold zones, providing fast knockdown and depending on application timing and crop growth, residual control of SLW adults and nymphs. It is highly systemic and works both by contact and ingestion. It has a low effect on lacewings and spiders, but will impact on wasps and predatory beetles and bugs. This product is restricted to two applications per season, and can also be used to control mirids.
- Pyriproxyfen (**IGR, Control**) – It does not kill adult SLW, but provides population control by preventing eggs from hatching and the progression to adult stage, as well as sterilising adult female insects. This means it will take 10-14 days before the population declines. The threshold matrix accounts for this delay. Pyriproxyfen provides up to 2 weeks residual and has been shown to be effective even on high populations of SLW. It would be expected to give 4-6 weeks of control. However, as pyriproxyfen is strictly one use per season, using this option early will preclude its use again later in the season. Recent studies have detected wide spread resistance to pyriproxyfen and use is now restricted to a one month window in most regions (see https://www.cottoninfo.com.au/sites/default/files/img/Notice_PyriproxyfenWindow.pdf) for further information). Pyriproxyfen is highly selective and has low impact on natural enemies.
- Spirotetramat (**IGR, Control (higher rate) & Suppression (lower rate)**) – is a highly systemic, slow acting compound that targets the nymphal development stage, and has little direct activity against adults or eggs, but does reduce the fertility of adults. Nymphs and pupae stop feeding shortly after application. Control of these life cycle stages is expected 5- 7 days after application, with control extending 3-5 weeks, depending on rate. Spirotetramat is moderately disruptive of natural enemies. Control in stressed cotton (drought, waterlogged) will be adversely affected due to poor translocation of the product.
- Cyantraniliprole (**Knockdown, Control (if used twice in succession within 10-15 days) and Suppression (single application)**) – is a new mode of action for SLW control which rapidly stops the pest feeding on the cotton plant. This product has activity on multiple life stages, although the most impact occurs when targeted at the early nymph stages. This product is restricted to two applications per season.

- Acetamiprid/emamectin benzoate co-formulation (**Knockdown, Control (if higher rate used and Suppression if lower rate used)**) is a recently registered insecticide for SLW control, primarily active on nymphs and evidence of activity will be slower than typical contact insecticides. Will be moderately disruptive on most natural enemies.
- Afidopyropen (**Suppression**) is the newest registered insecticide for SLW control. It is registered to provide suppression of both adult and nymph stages of whitefly, however it is recommended to target the nymph stage.

Insecticide Resistance Management

When SLW was first identified in Australia in 1994 it already possessed resistance to many older insecticide groups. The risk of further building resistant SLW populations is high. Consequently, it is important to follow the Insecticide Resistance Management Strategy (IRMS) described in the Cotton Pest Management Guide which details when and how many times each control option can be used. This needs to be complemented with an effective Integrated Pest Management (IPM) approach to reduce the need to control SLW while ensuring that contamination of lint is prevented. Compliance with the IRMS will ensure that the limited products available for SLW control will remain effective into the future.

- Avoid repeated applications of products from the same mode of action group.
- Do not apply more than the maximum number of applications.
- Do not apply pyriproxyfen more than once within a season.
- Refer to SLW Threshold matrix and IRMS.

Integrated Pest Management

Take a year round approach

Seasonal conditions and farming practices during winter and early spring can have a big influence on summer SLW population. For a SLW outbreak

to occur, SLW require a suitable climate (especially mild winters), a sequence of hosts (winter weeds or alternative crops) and management that disrupts natural SLW enemies (use of broad spectrum insecticides against other pests). A year round approach can allow development of a strategy to reduce the potential for SLW outbreaks to occur.

Area Wide Management (AWM)

Think of the farm and surrounding vegetation as a whole system. SLW numbers can build rapidly, and adults can move around the farm and between farms to find suitable hosts. Consider all potential hosts in cropping and non cropping areas. Area wide management (AWM) involves sharing and coordinating tactics with neighbours, and has been found to be effective in management of SLW. Strategies may include coordinated planting windows, weed management, consensus about delaying the use of disruptive insecticides to conserve beneficials, shared adherence to IRMS, and enhancement of native vegetation areas, such as coordinated weed and pest animal control or tree planting.

Coordinated planting

Late maturing cotton crops face a higher risk for sticky cotton as they will 'inherit' SLW populations displaced from defoliated earlier maturing crops. Timing planting and adjusting crop management to limit the availability of attractive crops late in the season will reduce this risk. It will also help to minimise the number of whitefly generations in the season and consequently the scale to which the population can build.

Maintaining beneficial numbers

Natural enemies or beneficials can play a vital role in the successful management of SLW. If beneficial populations are disrupted, SLW populations will build much faster.

Build beneficials across the farm, by using an IPM approach to manage all crops, not just cotton. This includes using thresholds to avoid

unnecessary sprays, avoiding the early season use of broad spectrum insecticides, particularly synthetic pyrethroids and organophosphates and managing weed hosts across the whole farm. Native vegetation both on farms and in the region can also be an important source of beneficials.

Healthy cotton

Growing a healthy cotton crop optimises both its yield potential and capacity to compensate for pest damage.

If possible, schedule irrigations to avoid moisture stress. Moisture stress increases whitefly severity and honeydew production, as they need to consume more poorer quality host to maintain their nutrition levels. Optimise nutrition and water inputs to avoid delaying maturity, or extended unproductive growth at the end of the season.

Field selection

If cotton is planted in close proximity to other good SLW hosts, such as melons or soybeans, the risk of mass movement of adult SLW to the later maturing crop may be similar to late planted cotton. The greater the isolation from susceptible crops, the less likely there will be mass movement of SLW between crops.

Host free period

As SLW have a wide host range and spend their

winter on plants, removing hosts and maintaining a host free period during this time will reduce the starting population for next season. Non-host crops include sorghum, maize, winter cereals and chickpeas. Consider co-ordinating host free periods with neighbours to enhance their effectiveness.

Farm hygiene

Control farm weeds all year round. Maintain a zero tolerance of volunteer/ratoon cotton throughout the year. Destroy crop residue from all susceptible crops immediately after harvest. This is critical for cucurbit crops that may regrow and act as whitefly reservoirs.

Biosecurity

Although biotype B whitefly is present in Australia there is a risk of other biotype B strains and other biotypes e.g. biotype Q, with different insecticide resistance profiles, entering the country. Whitefly can also be vectors of damaging exotic viruses such as cotton leaf curl disease. Monitor for any unusual plant symptoms, pests or abnormal responses to pesticide. If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

Further information

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