

Setting thresholds for aphids in cotton

By Lewis Wilson^{1,3}, Simone Heimoana^{1,3}, Tracey Farrell^{2,3} and Tanya Smith^{1,3}

Historically cotton aphids (*Aphis gossypii*) are a late season pest. They excrete sugary honeydew onto the cotton lint, reducing its value. But sometimes high numbers occur earlier in the season, creating concern that their feeding may reduce yield.

We found that aphid populations can reduce yield, depending on numbers and timing. Cotton aphids are also the primary vectors of the disease 'Cotton Bunchy Top' (CBT) which can significantly reduce cotton yield. To help growers and consultants decide if control of aphids is required we evaluated the effect of aphids on cotton yield in experiments over four years.

Sampling

Aphids are challenging to sample, as they are patchy in distribution, small and too numerous to count quickly. The current recommendation for aphid sampling uses a presence/absence sampling system. Unfortunately we found that this technique provides poor precision. To overcome this problem we developed a simple scoring system which involves scoring the density of aphids on the 3rd or 4th main-stem node below the terminal as:

- 0 = no aphids
- 1 = 1-10 aphids
- 2 = 11-20 aphids
- 3 = 21-50 aphids

- 4 = 51-100 aphids
- 5 = >100 aphids

An illustration showing these aphid densities is given in Figure 1. After counting aphids the first few times we quickly became confident at estimating abundance (see Figure 2 — What do you think the score for this leaf is?). About 20 leaves are required for accurate estimates of aphid density within a region of a field. In most fields at least four samples should be taken.

Effect of aphids on yield

To investigate the effect of aphids on yield we infested cotton with aphids in December, January and February. The aphids were reared on CBT resistant cotton lines and were free of this disease. We scored the development of the aphid populations each week. Each infestation date also included extra plots where aphids were allowed to build to a predetermined level then controlled. We used Bollgard II or Ingard varieties and other pests were controlled as required. The experiments were machine harvested to determine the effect of aphids on yield.

Relating sample scores to yield loss

We calculated the average aphid score (AAS) for each sample date (total score/number of leaves sampled). To account for

the build up of aphids over time we used the following formula to calculate the sample aphid score (SAS):

$$\text{SAS} = (\text{Previous score} \times \text{days since last score}) + ((\text{current score} - \text{previous score}) \times \text{days since last score}/2)$$

For example, for an AAS of 1.2 last week, and 2.3 this week...

$$\text{SAS} = (1.2 \times 7 \text{ days}) + ((2.3 - 1.2) \times 7/2) = 12.25$$

We accumulated this score across dates to give a 'cumulative season aphid score' (CSAS). An example of this can be seen in Figure 3. A statistical equation was developed that predicted the percentage yield loss from the CSAS and the time remaining from the date the aphid population was first found until 60 per cent bolls open. The equation predicts yield loss with an accuracy of about 85 per cent.

Using this in the field

Fields should be sampled in several locations as aphids tend to be patchy. At each location collect 20 leaves from the 3rd or 4th mainstem node below the terminal, taking one leaf per plant. Score each leaf using Figure 2 as a guide.

The same leaves could also be used to score for mites and whitefly. When counting, do not include the pale brown bloated aphids as these are parasitized.

FIGURE 1: Representation of the aphid scoring system

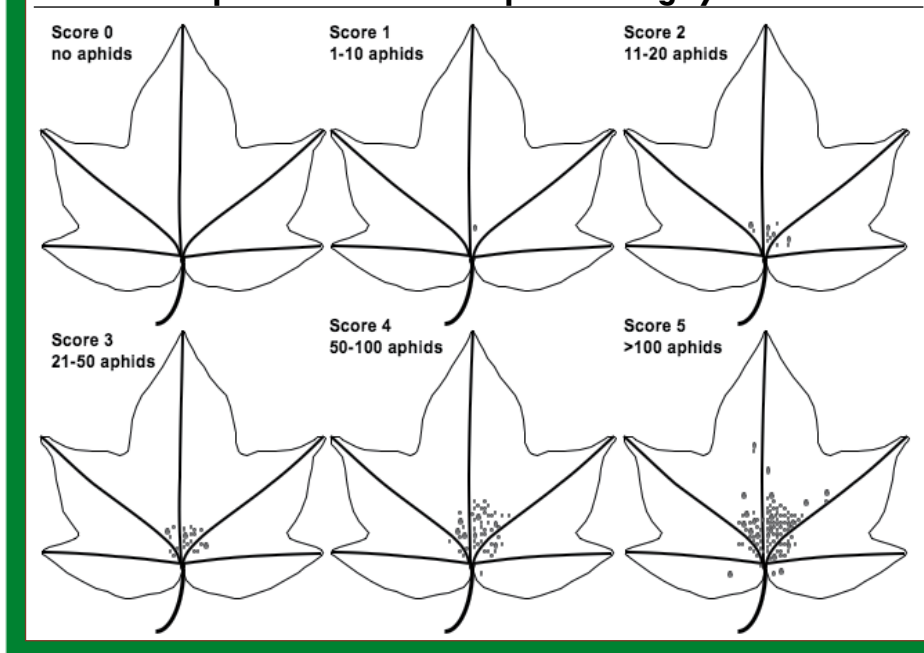


FIGURE 2: Cotton leaf infested with aphids — this is a score of four (51-100 aphids per leaf)



Sum the scores and divide by the number of leaves sampled to calculate the average aphid score (AAS). A hand tally counter helps with tallying the score (enter 'hand tally counter' into Google, check 'Australian sites').

Use Table 1 to convert the AAS into a SAS. For the first assessment of the season assume the 'score last check' was '0'. Find the value in the table where 'this check' and 'last check' intersect. Multiply this value by the number of days that have lapsed between checks. If this is the first assessment of the season, this value is the first CSAS. The CSAS is a cumulative score, so as the season progresses add the checks value to the previous value to give the updated CSAS (see Figure 3).

Table 2 shows the potential yield loss from aphid populations beginning at different stages of the season for a range of CSAS. Use the date that you first found aphids, expressed as days from 60 per cent of bolls open, as your 'Time remaining'. For that 'Time remaining' look down until you reach the line that approximates your current CSAS — this is the yield loss that the aphid population has caused (a worked example is given in Table 3).

The value of the crop and the cost of control should be used to determine how much yield loss can be tolerated before intervention is required. Not controlling non-economic aphid populations saves money and also allows beneficials the chance to build and control aphids and other pests. Crop sensitivity to yield loss from aphids declines as the crop gets older — for example, a higher CSAS is required before yield is affected.

If aphids are controlled, either by a spray applied for aphids or against another pest, or if there are two aphid checks in a row with no aphids found, reset the CSAS to zero. Begin accumulating again when sampling recommences and you first get a non-zero aphid score, using this date as the new 'Time remaining'. If you find these calculations complicated you will be pleased to know that a new aphid threshold tool will be available shortly as part of the CottASSIST tools on the Cotton CRC website. This tool will allow growers or consultants to enter aphid scores and will provide an estimate of yield loss and a guide as to further action.

What about honeydew?

These thresholds are designed to help pest managers to make decisions about the need to control aphids to prevent yield loss in the period from early December

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TABLE 1: Look-up chart to help convert the average aphid score (AAS) to a sample aphid score (SAS)

Average aphid score <i>last check</i>	Average aphid score <i>this check</i>								
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0
0	0.0	0.3	0.5	0.8	1.0	1.3	1.5	2.0	2.5
0.5	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.3	2.8
1.0	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.5	3.0
1.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.8	3.3
2.0	1.0	1.3	1.5	1.8	2.0	2.3	2.5	3.0	3.5
2.5	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.3	3.8
3.0	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.5	4.0
4.0	2.0	2.3	2.5	2.8	3.0	3.3	3.5	4.0	4.5
5.0	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.5	5.0

Look up the appropriate value for the current and previous score. Multiply this number by the number of days between the checks to give the SAS (for example, a score of 1 last week and a score of 2 this week would be $1.5 \times 7 \text{ days} = 10.5$).



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to first open bolls. Thereafter, the risk of aphids reducing yield is low, but the risk of contamination of lint with honeydew increases and pest managers should revert to the existing recommendation:

First open bolls onwards: 50 per cent of plants infested with aphids, or if honeydew is present, 10 per cent of plants infested.

What about CBT disease?

Our research has shown that the spread of this disease in cotton fields is influenced by the source of aphids and the presence of CBT affected stub cotton plants. Aphid

and CBT management begins well before planting. We found that the risk of CBT developing in a cotton field depends on:

- The timing of infection. Yield loss due to CBT is greater the earlier that the infection occurs. When there are isolated infected plants there will be strong compensation — plants with CBT infection grow slower, allowing non-infected neighbours to grow bigger and yield more. But when dense patches of plants are affected, yield in these patches may be significantly reduced. Plants infected late in the season may show no symptoms at all but if they are allowed to

survive through winter they will re-grow with very strong disease symptoms next year.

- The number of aphids entering the field and the number of aphids per plant. If more aphids enter the field then more plants will be infested with more aphids. We found that if plants were colonised by just one CBT affected aphid the transmission rate of CBT was five per cent, whereas if there were three or more aphids this increased to 40 per cent or more.
- The proportion of aphids carrying the disease. This will be influenced by the presence of hosts for both aphids and CBT. A key issue is the presence of volunteer and stub (or ratoon) cotton plants on the farm. These plants are often infested with aphids and CBT and are an on-farm source of a potential disease problem.
- The latent period. This is the time between an aphid carrying CBT feeding on a plant and that plant being capable of infecting new aphids — our data suggest this lag is 10–14 days or longer. This means that the next generation of aphids may not be infected when they feed, and will not transmit the disease if they move to new plants — slowing the transmission of the disease. When young aphids eventually do pick up CBT from the original plant and then move to the next plant there will again be a latent period and so on. This is compounded by the low transmission rate when a single aphid colonises a plant. This scenario is often seen in commercial fields where a single CBT infected plant is often found at the centre of an aphid hotspot, while the nearby plants are disease free.

Under most circumstances pest managers can therefore manage aphids accord-

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TABLE 2: Predicted % yield loss based on time remaining in the season from the time aphids were first found in regular checks and the cumulative seasonal aphid score

Cumulative Season Aphid Score*	Time remaining (days) (Time from when aphids were first recorded until 60% of bolls open)*									
	100	90	80	70	60	50	40	30	20	10
0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
10	2.3	1.8	1.4	0.9	0.5	0	0	0	0	0
15	4.5	3.8	3.1	2.5	1.8	1.2	0.5	0	0	0
20	6.6	5.8	4.9	4.0	3.1	2.3	1.4	0.5	0	0
25	8.8	7.7	6.6	5.5	4.5	3.4	2.3	1.2	0	0
30	10.9	9.6	8.4	7.1	5.8	4.5	3.1	1.8	0.5	0
35	13.0	11.5	10.1	8.6	7.1	5.5	4.0	2.5	0.9	0
40	15.1	13.4	11.7	10.1	8.4	6.6	4.9	3.1	1.4	0
50	19.1	17.1	15.1	13.0	10.9	8.8	6.6	4.5	2.3	0
60	23.1	20.7	18.3	15.9	13.4	10.9	8.4	5.8	3.1	0.5
80	30.8	27.8	24.7	21.5	18.3	15.1	11.7	8.4	4.9	1.4
100	38.0	34.4	30.8	27.0	23.1	19.1	15.1	10.9	6.6	2.3
120	44.8	40.8	36.6	32.2	27.8	23.1	18.3	13.4	8.4	3.1

This table is for a central region with a season length of 165 days from sowing to 60% of bolls open. The decision to control should take into account potential yield loss as well as control costs, impact on beneficials and selection for resistance. In the table a yield loss threshold of about 4% is used so aphids would be controlled once the red zone is reached.

*If aphids are controlled, either by a spray applied for aphids or against another pest, or if there are two aphid checks in a row with no aphids found, reset the CSAS to zero. Begin accumulating again when sampling recommences and you first get a non-zero aphid score, using this date as the new 'Time remaining'.

TABLE 3: An example using the scoring technique to estimate yield loss using data from Figure 3

Time remaining (from when aphids first found until 60% open bolls (days))	Current date (days from 60% bolls open)	Total score (a)	No. of leaves sampled (b)	Average Score (total score/leaves sampled) or a÷b	Season aphid score (check Table 1)	Season Aphid Score (SAS) multiplied by days lapsed since last check (c)	Cumulative SAS (add this score to previous total)	% reduction in yield from this aphid population (check Table 2)
90	90	0	20	0 ÷ 20 = 0	0	0 x 7 = 0	0	0%
90	83	10	20	10 ÷ 20 = 0.5	0.3	0.3 x 7 = 2.1	2.1 + 0 = 2.1	0%
90	76	20	20	20 ÷ 20 = 1	0.8	0.8 x 7 = 5.6	2.1 + 5.6 = 7.7	< 2.3%
90	69	80	20	78 ÷ 20 = 4	2.5	2.5 x 7 = 18.5	7.7 + 18.5 = 26.2	> 6.6%
Spray								
62	62	0	20	0 ÷ 20 = 0	0	0 x 7 = 0	0	0%
62	55	0	20	0 ÷ 20 = 0	0	0 x 7 = 0	0	0%
48	48	30	20	30 ÷ 20 = 1.5	0.8	0.8 x 7 = 5.6	5.6	0%
48	41	60	20	60 ÷ 20 = 3	2.3	1.8 x 7 = 16.1	21.7	<3.4%
Etc								

ing to their potential to reduce yield from feeding rather than via disease transmission. Regular checking in areas where aphids were initially found will confirm if CBT was brought in and if it has spread. An exception would be in a field where there is a high incidence of volunteer or ratoon plants in or around the field.

Bringing it all together

An overall strategy to manage aphids is described in the article ‘Strategies to manage aphids in cotton’ available on the Cotton CRC website and information is also available in the Cotton Pest Management Guide. The essential elements are:

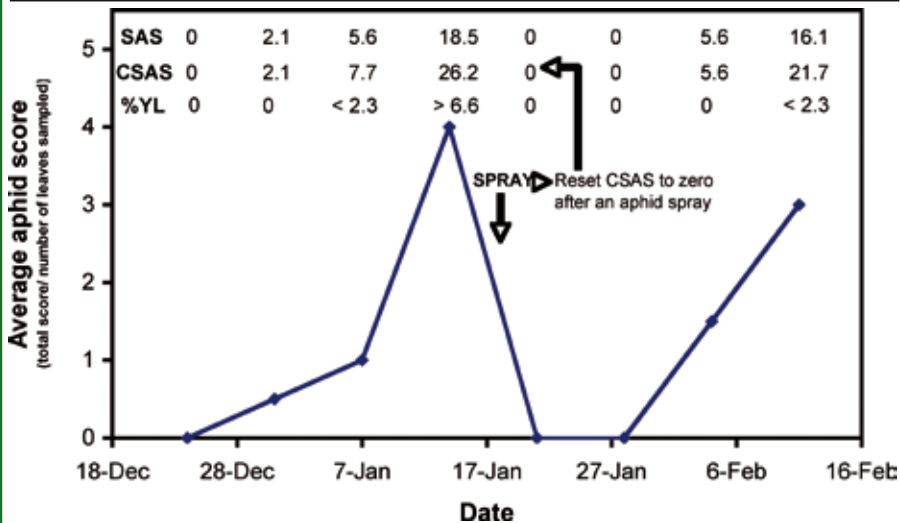
- Control overwinter hosts of aphids and CBT, especially volunteer and ratoon cotton.

- If a field has a higher risk from CBT, because the disease was present the season before or because the field is weedy, especially with volunteer/ratoon cotton, consider using a seed treatment that controls aphids as this may help reduce early infection.
- Begin sampling for aphids early in the season using the scoring system described above. Also score the abundance and type of beneficials.
- Use the thresholds described above to decide if aphids require control to prevent economic yield loss or honeydew contamination. Assess the risk from CBT.
- If aphid control is justified, control them as selectively as possible to help maintain beneficial populations. Knowledge of the main predator/parasite species present can help in this decision.
- Selection of control options for any pest should consider implications for other pests. For instance, use of dimethoate/omethoate against mirids will select for OP and carbamate resistance in aphids present in the field. This will render these products ineffective against aphids later (see the Insecticide Resistance Management Strategy (IRMS) in the Cotton Pest Management Guide available via the Cotton CRC website). Insecticide resistance can quickly become fixed in aphid populations because they reproduce asexually (female aphids produce young that are clones — see ‘Aphid ecology in cotton’ available on the Cotton CRC website). For this reason the IRMS recommends that the first aphid spray used is not from the same mode of action group as the at planting insecticide or seed treatment, and that no aphicides are applied consecutively.

We are indebted to Ammie Kidd, Dee Hamilton, Deon Cameron, Mark Strahle, Nemrod Mor, Kellie Gordon and Lex Cameron for dedicated technical help, Greg Constable, Grant Herron and Loretta Clancy for valuable comments and the Cotton Research and Development Corporation and Cotton Catchment Communities CRC for funding.

¹CSIRO Plant industry.
²NSW DPI.
³Cotton Catchment Communities Cooperative Research Centre.

FIGURE 3: Illustration of the progression of the average aphid score over time, the sample aphid score (SAS), the cumulative total aphid score (CSAS) and the predicted % yield loss (%YL)



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