

## **Recent advances in managing mites on cotton.**

Lewis Wilson  
CSIRO Cotton Research Unit Narrabri

### **Introduction**

The cornerstone of most pest management programs world-wide is the "Economic Threshold" concept which is based on the principle of controlling a pest only if it is economically prudent to do so i.e. the cost of control is less than the value of yield loss caused by the pest. To implement this concept effectively three key criteria must be met. Firstly it must be possible to estimate the abundance of the pest accurately, secondly a rapid curative control must exist, such as an insecticide or miticide, and finally the relationship between the abundance of the pest and reductions in the economic value of the crop must be known.

All of these criteria are now met for mites on cotton in Australia. Over the past cotton season a series of articles was published in the Australian Cottongrower which dealt with all of the key aspects of managing mites on cotton. In particular a new sampling protocol, new thresholds and miticide recommendations were presented for mites. In this paper I would like to elaborate on the background and rationale behind the sampling protocol and thresholds and relay some of the comments I have received regarding their application in the field. I will also briefly re-state an overall approach to managing mites and discuss some aspects of future research on mites.

### **New Sampling Protocol**

The sampling protocol was described in the Australian Cottongrower 12(5): 51-55 and is reproduced below in Box 1. It is based on binomial or presence/absence sampling, where leaves are scored simply as infested with mites (of any stage, eggs, immatures or adults) or un-infested. The percentage of plants infested with mites is directly correlated with the actual number of mites per leaf. This system is much faster than counting the number of mites per leaf, which is difficult and time consuming because of the size and abundance of

mites. With presence/absence sampling there is less information recorded for each leaf sampled than with numerical counts. However, this slight loss in accuracy is more than compensated for by the much greater number of plants that can be sampled which increases the chance of finding mites, an important consideration with a patchily distributed pest.

### **Box 1**

#### **Sampling protocol for mites on cotton.**

- i. Walk into the field about 40m. (Early in the season it is also advisable to sample near the field edges to see if significant influxes of mites have occurred).
- ii. Take a leaf from the first plant on the right or left. The leaf should be from the third, fourth or fifth mainstem node below the terminal. If the plant has less than 3 leaves sample the oldest. Note that early in the season, up to the point that the plant has about 5 true leaves, it is simplest to pull out whole plants.
- iii. Walk 5 steps and take a leaf from the next plant, on the opposite side to the previous one, and so on until you have 50 leaves. (Wait until you have collected all the leaves before scoring them).
- iv. Once all the leaves have been collected score each leaf by turning it over, looking at the underside, firstly near the stalk, then scanning the rest of the leaf. If mites of any stage (eggs or motiles) are present score the leaf as infested. A hand lens will be needed to see mite eggs because they cannot be seen with the naked eye.
- v. Repeat this simple procedure at several widely separated places in the field to allow for differences in mite abundance within the field. Depending on the size of the field, between 4 to 6 sites are needed to obtain a good estimate of mite abundance.
- vi. When finished sampling, calculate the percentage of plants infested in the field.

The choice of the 3rd, 4th or 5th mainstem node leaf below the terminal as the sampling unit is based on extensive study of the within-plant distribution of mites. The modal node (the node with the most mites) is usually between the 3rd to 5th node below the terminal. As the plant grows the position of the modal node in relation to the height of the plant changes. For instance, when plants have only 5 leaves the modal node is at the bottom of the plant, when the plant has 8 true leaves it is near the middle, and when the plant is fully grown, it is near the top.

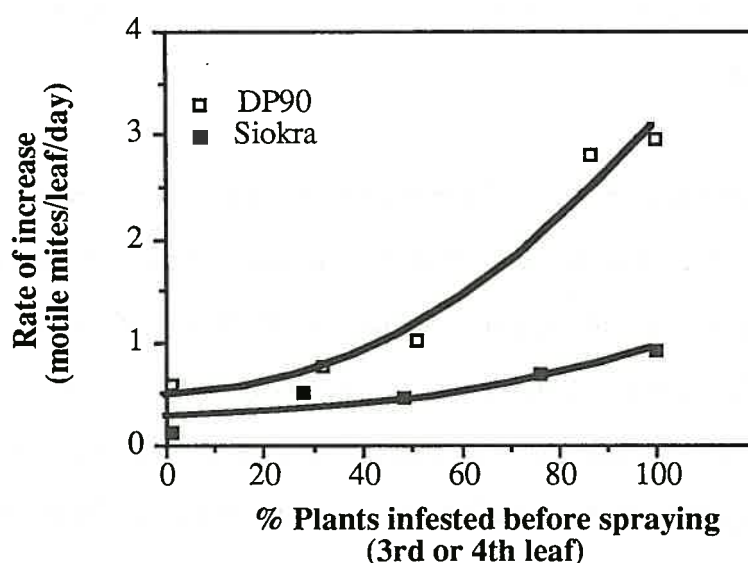
I have received considerable positive feedback regarding the new sampling protocol. If everyone uses the same sampling protocol this facilitates comparison between fields and farms and, more importantly for me, means it is more easy to interpret and respond to telephone queries from growers/consultants regarding mite control. Two concerns have been raised though. The first is that because mite populations are distributed unevenly across fields there is considerable variation or 'noise' between sampling dates. One way to reduce this problem is to 'buffer' sampling. For instance if you normally sample at 4 locations in a field, then on each sample date re-sample from two of the areas sampled at the last check and add 2 new areas. This has the effect of reducing the variability or noise between sample dates.

The second concern was in ways of combining the new mite sampling protocol with existing sampling for other pests, such as the Siratac sampling system. The Siratac sampling protocol uses a card system where each card consists of six groups of 5 plants (30 plants in total). Each group of plants is separated by walking along the row 5m and across 15 rows (15m). A minimum of 2 sampling cards is recommended per management unit (field or group of fields managed as one) up to an area of 100ha with an additional card for each additional 100ha. Unfortunately, sampling groups of five plants means that sampling is concentrated in relatively few 'spots' in the field, whereas in order to find mites it is best to sample as widely as possible. The new mite sampling protocol could be combined with the Siratac sampling protocol if the checker collected 50 leaves on the way into the field, scored them for the presence or absence of mites, did a normal Siratac sample for other pests, then walked out of the field in a different direction again collecting 50 leaves on the way out of the field and scoring them for mites. In this way a sample of two cards per field would result in the recommended 200 leaf sample for mites.

### **New Thresholds**

Yield loss caused by mites depends on when mite populations begin to increase and how quickly they increase - earlier populations which increase quickly are most damaging.

This introduces a particular difficulty in applying the Economic Threshold concept as yield losses caused by mites cannot be associated with particular densities of mites, but instead have to be related to the rate of increase and the time of infestation. The efficacy of control measures is also important in setting thresholds as the level and durability of control is reduced at high mite population densities (Figure 1). Hence the need to control mites at low densities must be reconciled with the need to ensure that a given mite population would have caused economic loss.



**Figure 1.** Relationship between % plants infested before spraying and rate of increase of mite populations between 13 and 20 days after application of Comite 600 EC for DP90 and Siokra. NARS 1990.

To reconcile these needs a simple statistical model, based on 4 years of field experiments, was developed for predicting if a given mite population is likely to produce economically preventable yield loss. From this a maximum rate of increase of mite populations that could be tolerated through the season was derived to form the basis of the new threshold recommendations, given in Box 2. The rate of increase is calculated as the change in the percentage of plants infested per day eg. if a field had 10% of plants infested a week ago and 24% infested now this gives a rate of increase of 2% of plants infested per day. A general threshold of 30% of plants infested is advocated through the bulk of the season

(from squaring to first open bolls), which allows good control to be achieved with miticides, yet gives sufficient time to adequately assess the mite population. Spraying at lower infestation levels does not improve control and increases the chances of spraying mite infestations that were not going to cause yield loss in any case.

As a further aid in managing mites the mite/yield loss model was expressed in Table 1 which allows the user to estimate the potential yield reduction that a given mite population is likely to cause. The values in Table 1 should be used as a guide only - the specific situation must be allowed for, including the vigour of the crop, other pests (ie, are you about to spray with a pyrethroid which may flare mites) and the conditions (ie mites are generally favoured by hot dry conditions). Because Table 1 uses rates of increase of mites, it takes into account differences between the more mite resistant 'okra' leaf varieties and the normal leaf varieties. Rates of increase of mites are slower on the okra leaf varieties, resulting in lower predicted yield reductions, and therefore less likelihood of a miticide application being warranted.

## **Box 2**

### **Thresholds for mites on cotton.**

i. *Seedling emergence to squaring* - Mites are normally suppressed by predators, especially thrips during this period. Mite populations only need to be controlled if they begin to increase, which indicates that natural controls are not keeping them in check.

ii. *Squaring to first open bolls* - control if mite populations increase at greater than 1% of plants infested/day in two consecutive checks or if more than 30% of plants are infested.

Note that pyrethroids in stage 2 may flare mites so either:-

- use softer controls for *Heliothis*
- control mites as well if they are close to threshold
- use a 'non-flaring' pyrethroid or pyrethroid/OP mixture

iii. *First open bolls to 20% open bolls* - control is only warranted if mites are well established (greater than 60% plants infested) and are increasing rapidly (faster than 3% of plants infested/day).

iv. *Crop exceeds 20% open bolls* - control is no longer warranted.

**Table 1.** 'Look-up' chart, to estimate % yield reductions caused by mites. To use the table firstly refer to the section with the current infestation level closest to that of the field. Under that section refer to the column with the rate of increase closest to that found in the field. Look down this column to the value that lines up with the current developmental stage of the crop. This value is the % yield loss the mite population is predicted to cause if not controlled.(Australian Cottongrower 12(5): 51-55).

Time of Season		Current % of plants infested																				
		10%							30%							60%						
Approx. devel stage	Days from sow	Observed rate of increase (%/day)							Observed rate of increase (%/day)							Observed rate of increase (%/day)						
		0.3	0.6	1	1.5	2	3	5	0.3	0.6	1	1.5	2	3	5	0.3	0.6	1	1.5	2	3	5
Emergence	10	0.5	3.4	8.8	19.0	33.1	72.9	100.0	1.9	4.9	11.1	22.3	37.4	79.3	100.0	3.7	7.7	15.1	27.8	44.5	89.4	100.0
	20	0.5	3.0	7.8	16.7	29.0	63.8	100.0	1.8	4.5	9.9	19.8	33.1	69.8	100.0	3.5	7.1	13.7	25.0	39.7	79.3	100.0
	30	0.4	2.7	6.8	14.5	25.2	55.4	100.0	1.6	4.0	8.8	17.5	29.0	60.9	100.0	3.3	6.5	12.4	22.3	35.2	69.8	100.0
	40	0.3	2.3	5.9	12.5	21.7	47.5	100.0	1.5	3.6	7.8	15.2	25.2	52.7	100.0	3.1	6.0	11.1	19.8	31.0	60.9	100.0
1st squares	50	0.3	2.0	5.0	10.6	18.4	40.2	100.0	1.4	3.2	6.8	13.2	21.7	45.0	100.0	2.9	5.4	9.9	17.5	27.1	52.7	100.0
	60	0.2	1.7	4.2	8.9	15.4	33.6	90.9	1.2	2.8	5.9	11.3	18.4	37.9	98.0	2.8	4.9	8.8	15.2	23.4	45.0	100.0
1st flowers	70	0.2	1.4	3.5	7.4	12.7	27.5	74.3	1.1	2.4	5.0	9.5	15.4	31.5	80.7	2.6	4.5	7.8	13.2	20.0	37.9	90.9
	80	0.1	1.2	2.8	6.0	10.2	22.0	59.4	1.0	2.1	4.2	7.9	12.7	25.6	65.1	2.4	4.0	6.8	11.3	16.9	31.5	74.3
	90	0.1	1.0	2.3	4.7	8.0	17.2	46.1	0.9	1.8	3.5	6.4	10.2	20.4	51.2	2.2	3.6	5.9	9.5	14.0	25.6	59.4
	100	0.1	0.7	1.7	3.6	6.0	12.9	34.5	0.8	1.5	2.8	5.1	8.0	15.7	38.9	2.1	3.2	5.0	7.9	11.4	20.4	46.1
1st open bolls	110	0.0	0.6	1.3	2.6	4.4	9.3	24.6	0.7	1.3	2.3	3.9	6.0	11.7	28.4	1.9	2.8	4.2	6.4	9.1	15.7	34.5
	120	0.0	0.4	0.9	1.8	3.0	6.2	16.4	0.6	1.0	1.7	2.9	4.4	8.2	19.4	1.8	2.4	3.5	5.1	7.0	11.7	24.6
	130	0.0	0.3	0.6	1.1	1.9	3.8	9.8	0.5	0.8	1.3	2.1	3.0	5.4	12.2	1.6	2.1	2.8	3.9	5.2	8.2	16.4
20% open	140	0.0	0.2	0.3	0.6	1.0	2.0	4.9	0.5	0.6	0.9	1.3	1.9	3.1	6.7	1.5	1.8	2.3	2.9	3.6	5.4	9.8
	150	0.0	0.1	0.2	0.3	0.4	0.7	1.7	0.4	0.5	0.6	0.8	1.0	1.5	2.8	1.4	1.5	1.7	2.1	2.4	3.1	4.9
	160	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.4	0.4	0.4	0.6	1.2	1.3	1.3	1.3	1.4	1.5	1.7
	170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

As the 1991/92 season was relatively light for mites I have not had much feedback on the new thresholds. A number of consultants did say that they found Table 1 particularly useful for determining when they could cease mite control. The only complaint I received was that the 'days from planting' did not always match up with the stage of development of the crop (Table 1). Part of this discrepancy arises from the fact that the table, for convenience, uses days rather than heat units (day degrees  $> 12^{\circ}\text{C}$ ) which results in a slight reduction in accuracy. An additional consideration is that Table 1 is designed for an 'average' crop which takes about 180 days from planting to 60% open bolls. In the future I will publish tables for early crops and late crops as well, which will help overcome this problem. I would welcome any further feedback regarding either the new sampling protocols or the thresholds.

### **Overall strategy for managing mites on cotton.**

#### *1. Reduce carry over of mites between seasons.*

Mites survive winter as actively reproducing colonies on whatever vegetation is available, including weeds and regrowth (see Australian Cottongrower 12(4): 14-15). In reducing the carry over of mites from one year to the next growers/consultants should:

- i) ensure that cotton is slashed or stalk-pulled as soon as possible after harvest to minimise survival of mites on regrowth.
- ii) ensure that fields, field borders and fence lines are kept as weed free as possible through winter and spring.

#### *2. Try to preserve beneficial insects early in the season.*

Mites are induced pests because they are normally maintained at sub-economic levels by natural controls unless some external factor, usually an insecticide, disrupts this control. Guidelines for early season chemical selection are given in the Australian Cottongrower 12(4): 16-18.

*3. Check the crop soon after emergence to assess the initial level of mite infestation.*

In doing this look at the edges of the crop and the middle of the crop separately. If no mites are found then the potential to create a mite problem with early season spraying is low. If however a significant proportion of seedlings are infested (>10%), both along the edges and in the middle of the field then early season spraying, particularly of organophosphates, has a higher potential to lead to a mite outbreak. In this case the development of the mite population should be monitored closely and every attempt should be made to take a 'soft' approach which will allow natural predation to act. This means reducing the use of organophosphates as far as practical, consistent with ensuring satisfactory plant growth, and using softer insecticides where possible (see Australian Cottongrower 12(4): 16-18). If the mite population begins to increase early in the season (Oct - Dec) then a ground spray of the selective miticide Kelthane, which does not kill predators, may be warranted.

*4. Sample regularly from seedling emergence onwards.*

A weekly sample for mites will be adequate in most instances but less frequent samples may be satisfactory if the early season samples indicate very low initial colonisation of the crop. More frequent samples may be needed if mites are more abundant or once mite populations begin to increase. The percentage of plants infested can be graphed so that the status of the mite population can be readily assessed. This will show if predators are having an impact on the build-up and spread of mites.

*5. Use the level of infestation or the rate of increase of mites (see Box 2 or Table 1) to decide when control is warranted.*

*6. Select the most mite resistant cultivar in mite prone areas.*

Okra leaf varieties are more resistant to mites than normal leaf varieties. I have also found that the rate of increase of mites following control is far lower on Siokra than DP90

(Figure 1). In other words you get better and longer lasting control with Siokra (see Australian Cottongrower 11(3): 14-17).

### **The Future**

- 1) The effect of a range of insecticides on mites and their predators is being studied in order to provide more accurate information on the 'mite flaring' potential of insecticides used early season.
  
- 2) The economic impact of thrips on cotton is being investigated along with studies of new methods of controlling thrips, plant resistance to thrips and general aspect of thrips ecology. Experiments were done on 5 commercial farms this season but results have yet to be analysed. This new direction follows the finding that thrips are key predators of mites.
  
- 3) The efficacy of new miticides is being assessed. The cotton industry currently relies on one key selective miticide, propargite (Comite), and there is a need for another miticide to relieve the selection pressure for resistance on this product. Several new miticides have been developed and have proven to be extremely efficacious (Table 2). Development work is progressing on several of these products but registration is probably still at least 2 or 3 seasons away.
  
- 4) Table 1 can be used to estimate the potential yield loss a mite population is likely to cause from their rate and date of increase. However mite populations increasing at low rates may exceed the threshold (30%) level of plants infested even though they are not predicted to cause yield loss. To give growers confidence not to treat such infestations a new experimental program has been initiated to determine more precisely the exact damage level at which yield loss begins to occur.

**Table 2.** Efficacy of miticides for control of two-spotted spider mites, *Tetranychus urticae*, on cotton, Narrabri Agricultural Research Station, 1992. Confidentiality requirements prevent some products from being identified.

Treat.	Company	Days after treatment						
		Pre-spray	7	14	21	28	35	42
Control	-	2.1	7.4 <sub>d*</sub>	8.0 <sub>f</sub>	11.5 <sub>d</sub>	33.1 <sub>e</sub>	32.8 <sub>e</sub>	145.8 <sub>ef</sub>
Lovis oil	Caltex	1.0	2.7 <sub>e</sub>	4.6 <sub>ef</sub>	7.5 <sub>d</sub>	22.4 <sub>de</sub>	26.2 <sub>de</sub>	163.0 <sub>f</sub>
Prod 1	-	0.6	2.6 <sub>e</sub>	2.6 <sub>de</sub>	3.5 <sub>c</sub>	15.3 <sub>cd</sub>	24.0 <sub>de</sub>	100.1 <sub>def</sub>
Prod 2	-	0.9	2.6 <sub>e</sub>	2.4 <sub>cde</sub>	2.0 <sub>bc</sub>	11.3 <sub>c</sub>	12.6 <sub>cd</sub>	84.9 <sub>de</sub>
Prod 3	-	0.5	1.7 <sub>abc</sub>	1.8 <sub>bcd</sub>	2.4 <sub>bc</sub>	6.7 <sub>bc</sub>	12.4 <sub>bc</sub>	54.6 <sub>cd</sub>
Prod 4	-	1.2	3.4 <sub>e</sub>	1.1 <sub>abcd</sub>	0.8 <sub>ab</sub>	3.5 <sub>ab</sub>	5.8 <sub>abc</sub>	52.5 <sub>cd</sub>
Comite + Lovis oil	ICI Caltex	1.5	1.8 <sub>abc</sub>	0.7 <sub>abc</sub>	1.2 <sub>ab</sub>	5.7 <sub>ab</sub>	5.7 <sub>abc</sub>	48.9 <sub>bc</sub>
AC303,630	American Cyanamid	0.4	0.5 <sub>ab</sub>	0.5 <sub>ab</sub>	0.4 <sub>ab</sub>	1.3 <sub>a</sub>	2.8 <sub>ab</sub>	13.0 <sub>ab</sub>
Comite	ICI	1.0	2.2 <sub>bc</sub>	0.4 <sub>ab</sub>	0.5 <sub>ab</sub>	1.3 <sub>a</sub>	0.8 <sub>a</sub>	7.6 <sub>a</sub>
Prod 6	-	0.9	0.3 <sub>a</sub>	0.3 <sub>a</sub>	0.2 <sub>a</sub>	0.9 <sub>a</sub>	1.1 <sub>a</sub>	10.6 <sub>ab</sub>
p value		0.419	0.0006	0.0001	0.0001	0.0001	0.0001	0.0001

\*Means in columns with different letters are significantly different at  $p=0.05$  using Anova LSD.

5) The potential effectiveness of artificial introductions of the predacious mite *Phytoseiulus persimilis* is being investigated. To date results have been disappointing as the predators have been slow to establish and spread. It may be that conditions in the crop are too hot for this predator, and that a different species may be more appropriate.

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