

Ecology and Management of Spider Mites on Cotton.

Project Number: CSP21C

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Aims:

- Develop a simple mite management package using data collected relating mite infestations to cotton yield loss.
- Complete development and validation of functional sampling procedures.
- Continue studies to determine the effects of temperature, humidity and host plant quality and variety on mite population development.
- Identify and evaluate the role of predators in spider mite management and the potential for inoculative release of predacious mites.

Summary of Results

A brief outline of the major results and outcomes from this project is given below. Where the research has been formally published or published in extension articles the appropriate numbers, corresponding to the number of the reference in the list of publications arising from this project, is given.

1. The effect of mites on yield and fibre quality of cotton was quantified. The physiological bases for these effects were identified and shown to be related to the time and rate of mite population development. It was postulated that mites affect yield by reducing the photosynthetic capacity of leaves, resulting in a decrease in the amount of assimilate a plant has available for developing bolls. Severe mite damage early in the fruiting period will enhance competition for assimilate between sinks (i.e. fruit and leaves) causing shedding of fruit (reducing the number of bolls) and limiting boll development (reducing the size of bolls) and hence reducing yield. Infestations occurring later in the season, after the majority of fruit are set, can affect yield by reducing the plants capacity to meet the demands of maturing bolls, again resulting in a decrease in boll size. (2, 11, 18)
2. This data was summarised in a statistical model which was used to produce 'look-up' tables, along with detailed recommendations regarding selection and application of acaricides, which allow consultants or growers to determine if a particular mite population will affect yield, by how much, and whether control is warranted or not, thus providing an economically rational basis for management of spider mites. (1, 11)
3. Developed a statistically valid binomial sampling protocol, for use in commercial pest management programs, which incorporates the within-plant and within-field distribution patterns of spider mites. The sampling protocol was formally published and extended to industry via conferences, field days and extension publications and is now increasingly used by industry. (4, 11, 15, 18)
4. In collaboration with Stuart McFarlane and Lance McKewen these new sampling techniques, thresholds and yield loss predictions were incorporated into the decision support package 'entomoLOGIC'. The program now calculates the rate of increase of mite populations, predicts the potential yield reduction and generates appropriate recommendations for further action. This represents a considerable improvement in the

sophistication with which mites can be managed. (Detailed in the Entomologic user manual.)

5. A major finding was that the timing and severity of mite outbreaks on cotton was highly correlated with the initial level of colonisation and with the survival of mites in the critical November/December period. Mite infestations were shown to originate from sources outside cotton crops and a number of weeds were identified as major sources of colonising mites. Control weeds in and around fields is recommended in order to reduce initial mite infestation in cotton. (4, 6, 7, 9, 20)
6. Predator exclusion experiments indicate that the major factor influencing the survival of mites through the critical period is natural predation. Excessive early season use of broad spectrum insecticides destroys these predators leading to earlier and more severe mite outbreaks. (18, 7, 8)
7. 'Phytophagous thrips' (*Thrips tabaci*, *T. imaginis* and *Frankliniella schultzei*) and apple dimpling bugs (*Campylomma livida*), regarded as an important early season pests in cotton, were shown to be predacious on mites. Thrips in particular appear to be key early season predators of mites, by virtue of their generally high abundance in cotton, as they migrate from senescent winter crops and weeds. Improvement in management of mites is therefore dependent on establishment of economic thresholds for thrips and sucking bugs, which are not currently available, and development of means of controlling *Heliothis* spp. and sucking bugs without disrupting thrips populations. (7, 18)
8. Repeated early season use of some pesticides (dimethoate, pyrethroids or thiodicarb) was found to lead to severe early season outbreaks of mites, while others did not. These results have important implications for integrated pest management as thiodicarb in particular has long been regarded as a 'soft' insecticide, compatible with IPM. Results of these experiments and their implication for cotton pest management have been extended to industry.
9. Phenological changes in the suitability of cotton for mite reproduction and development did not explain the early season decline of mite populations. Cotton cotyledons were found to be less suitable for mite reproduction than young true leaves. This may slow the development of mite populations, but only until true leaves appear. Mites had higher fecundity and lived longer on young leaves than on old leaves. Furthermore preference tests showed that mites strongly prefer young leaf tissue to old leaf tissue. In the field, mites released near the tops of plants stayed there while those released onto leaves in the middle and bottom of plants tended to move upwards toward younger leaves. It is proposed that the within plant distribution of mites arises as a combination of the ability of mites to assess leaf quality (discriminating in favour of young leaves) and a possible positive photo-taxis that results in mites moving toward younger leaves. (21)
10. The plant resistance of 17 cotton genotypes to thrips and mites was investigated. Detailed counts of thrips were made along with assessments of their effect on plant vigour and this was compared with that of cotton protected from thrips using aldicarb. This data has yet to be analysed. The morphological traits, okra-leaf and glabrous and super-okra, conferred the greatest resistance to mites, though some other lines such as HT-smooth and Pima were also resistant. Laboratory rearing experiments showed that a high gossypol genotype, HG660, and high condensed tannin genotype, Ht-35-14-3 had no effect on mite life history parameters compared with DP90, suggesting that gossypol and tannins confer little resistance to mites. A Pima genotype however showed considerable antibiosis to mites, both in the field and laboratory. (5, 14)
11. The mechanism underlying the resistance of okra leaf cotton genotypes to mites was investigated. Field and laboratory experiments indicated that this resistance was due to leaf shape rather than leaf chemistry. Circumstantial evidence suggests that the micro-

environmental conditions in the boundary layer of the leaf are fundamental in determining which parts of the surface of a leaf are most suitable for the development and reproduction of mites. Mites appear to favour protected locations near leaf veins or in leaf folds. It appears that okra leaves, with long thin lobes, have less of their total surface area suitable for mite reproduction and development than normal shaped leaves. This may lead to more rapid exploitation of the acceptable area of okra leaves, resulting in density dependent competition and hence a slower rate of population growth. (16, 19)

12. The resistance of spider mites to acaricides used in cotton was monitored in collaboration with Dr V. Edge and Mr G. Herron (BCRI). This is an important issue as mites have the potential for rapid resistance development and the cotton industry relies heavily on one key acaricide, propargite. The results have indicated steadily increasing resistance in spider mites to organophosphates, but no resistance has yet been found to the selective acaricides, propargite and dicofol, which were recently registered for use in cotton.
13. The potential use of inoculative releases of the commercially available predacious mite *Phytoseiulus persimilis* for control of *T. urticae* was investigated in two seasons. In general the predators were slow to establish and although released in early January did not become abundant until early March. The distribution of the predators within plants through January and February was biased toward the lower canopy, while that of the prey was biased toward the top. Discussions with other entomologists (Dr G. Thwaite, NSW Agriculture, Orange and Mr. F. Page, QDPI, Stanthorpe) regarding the poor establishment of the predators indicated that they prefer humid conditions and are inhibited by high temperature, perhaps explaining their preference toward the lower canopy.
14. 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 in small scale plot experiments. Development work is progressing on several of these products but registration is probably still at least 2 or 3 seasons away. The efficacy of three rates of the three most promising new acaricides, AC303630, MK239 and Avermectin, was compared with that of the current standard, propargite. AC303630 and MK239 at the two higher rates showed efficacy equivalent or greater than propargite. Avermectin gave poor results at the lower rates, but the highest rate was equivalent to propargite. The efficacy of two new seed treatments, imidocloprid and promet, for control of thrips was also evaluated. Both provided some control of thrips but neither was as effective as aldicarb (Temik), phorate (Thimet) or thiodicarb (Semevin). (15)
15. Cotton is treated with a range of pesticides to control thrips on seedling plants yet there is almost no information on the species identity of thrips on cotton nor their economic impact. Flowing from the observations of the role of thrips as predators of mites a series of on-going experiments and observations was initiated. Initially the seasonal abundance and species composition of thrips on cotton were determined. The results showed that *Thrips imaginis* was not the key pest on cotton, as was previously thought. Instead *Thrips tabaci* and *Frankliniella schultzei* were most abundant. Early results from experiments to determine the economic impacts of thrips on cotton have demonstrated that effects on plant height, plant dry weight and time to first square production are correlated with intensity and the duration of thrips damage. This information provides the basis for assessing if thrips populations are likely to cause economic damage (3, 17).

Recommendations for Future Research

1. The economic impact of thrips on cotton should be determined to refine thresholds for their control. Novel means of control, including new seed treatments, should be evaluated in conjunction with this research.
2. Studies on the range and possible mechanisms of plant resistance to thrips and mites should be continued.
3. The host preferences thrips, their general ecology and the possibility of manipulating of hosts to increase thrips predation or of attracting thrips to cotton to act as predators after the crop is no longer sensitive to thrips damage, possibly using 'food sprays' being developed by Dr Robert Mensah should also be considered.
4. The impact of thrips on mites through predation, induced resistance and effects on plant quality should be investigated further in order to better predict the predator/prey ratios required for effective control of mite populations.
5. Action thresholds for the control of two-spotted spider mites on cotton should be further refined. These experiments would have different timings of mite infestation of cotton crops. Infestations would also be controlled at a range of densities using acaricides to determine the precise mite population density at which yield loss begins to occur. Detailed measurements of plant growth parameters and light interception would allow these findings to be coupled to the Ozcot crop model.
6. Evaluation the efficacy of new acaricides and investigate novel technologies for controlling mites should continue.
7. Resistance levels in mites to acaricides should continue to be monitored as needed. Factors influencing the development of resistance, especially to the organophosphates should be investigated
8. Investigation of the effect of a range of early season insecticides on mites and their predators should continue. In particular the mechanism by which thiodicarb induces outbreaks of mites should be given priority.

Application of Results to Industry

The results of the research reported provides the basic information that should lead to substantial improvements in the management of mites on cotton in Australia. In particular, sources of mites were identified and means for managing these sources proposed, predation by thrips was found to be the most important factor influencing the early season population dynamics of mites and the effectiveness of predation can be strongly influenced by insecticide management. A sampling protocol for mites was developed for use in conjunction with an equation for estimating the yield reductions a given mite population is likely to cause. This provides a rational basis for determining if mites warrant control. Finally, in areas prone to mites, selection of okra leaf varieties can substantially reduce the potential yield reductions resulting from mite infestations, and thus the need for control.

Publications Arising from this Project

Formal Papers

1. Wilson, L.J. (1993) Dynamic thresholds for a dynamic pest: Spider mites in cotton, pp. 407-410. *Proc. 5th Australian Applied Entomological Research Conference*, (S. Corey, D. Dall and W. Milne Eds), April 27 - May 1, Canberra, 1992.
2. Wilson, L.J. (1993). Spider mites (Acari: Tetranychidae) affect yield and fibre quality of cotton. *J. Econ. Entomol.* 86(2): 566-585
3. Wilson, L.J. and Bauer, L.R. (1993). Species composition and seasonal abundance of thrips on cotton in the Namoi Valley, Australia. *J. Aust. Ent. Soc.* 32: 187-192.
4. Wilson, L.J. and Morton, R.M. (1993). Seasonal abundance and distribution of spider mites (Acari: Tetranychidae) on cotton in Australia and implications for management. *Bull. Ent. Res.* 83: 291-303.

Industry Conference Papers and Extension Articles.

5. Fitt, G.P., Mares, C.L., Wilson, L.J. and Thomson, N.J. (1992). Development of resistance of insects in Australian cotton varieties. *Proc. 6th Australian Cotton Conference*, Broadbeach, August 1992, pp. 307-322.
6. Wilson, L.J. (1991). Mite ecology: Where do they come from. *Australian Cottongrower* 12(4): 14-15.
7. Wilson, L.J. (1991). Mite ecology: Factors affecting early season survival. *Australian Cottongrower* 12(4): 16-18.
8. Wilson, L.J. (1991). Early season control and mites - caution required. *Cotton Irrigator* No 8.
9. Wilson, L.J. (1991). Mites on cotton - linking ecology with management. *Proc. Rhone-Poulenc Cotton Physiology Conference*, Coolumb, 4-5th Sept.
10. Wilson, L.J. (1991) Mites in the 1990/91 cotton season. *CSD Variety Trial Results Booklet*, 1990/91, pp 42-43.
11. Wilson, L.J. (1992). Sampling protocol and thresholds for mites. *Australian Cottongrower* 13(1): 51-55.
12. Wilson, L.J. (1992) Identifying mites on cotton. *Australian Cottongrower* 13(5): 68-69.
13. Wilson, L.J. (1992). Don't forget about mites! *Cotton Irrigator* No 13.
14. Wilson, L.J. (1992) Mites in the 1991/92 cotton season. *CSD Variety Trial Results Booklet*, 1991/99, pp 39-40.
15. Wilson, L.J. (1992). Recent advances in managing mites on cotton. *Proc. 6th Australian Cotton Conference*, Broadbeach, August 1992, pp. 217-226.
16. Wilson, L.J. and Bauer, L.R. (1992). Mechanisms of resistance to mites in okra leaf cottons. *Proc. 6th Australian Cotton Conference*, Broadbeach, August 1992, pp. 227-236.
17. Wilson, L.J. and Bauer, L.R. (1992). Thrips - Friend or foe. *Australian Cottongrower* 13(5): 12-18.

Thesis

18. Wilson, L. J. (1992) Pest status and ecology of the two-spotted spider mite on cotton in Australia and implications for management. Ph.D. thesis, University of Queensland, Brisbane, 261pp.

Manuscripts Submitted to Journals

19. Wilson, L.J. (submitted) Resistance of okra-leaf cotton (*Gossypium hirsutum* L.) genotypes to twospotted spider mites (*Tetranychus urticae* Koch)(Acari: Tetranychidae). Submitted to *Journal of Economic Entomology*.
20. Wilson, L.J. (submitted) Habitats of twospotted spider mites (Acari: Tetranychidae) during winter and spring in a cotton producing region of Australia. Submitted to *Environmental Entomology*.
21. Wilson, L.J. (Submitted) Effect of plant quality on life history parameters of the twospotted spider mite (Acari: Tetranychidae) on cotton. Submitted to *Journal of Economic Entomology*.

Detailed Project Report

Most of the findings of this project have been written up either as formal scientific manuscripts or as extension articles for industry and a selection of these articles are included as the detailed project report.