Aphids - where to from here?

Grant A Herron* and Lewis J Wilson[1]

Industry and Investment New South Wales, Elizabeth Macarthur Agricultural Institute, PMB 4008, Narellan, 2567, Australia

[1] CSIRO, Plant Industry and Cotton Catchment Communities Cooperative Research Centre, Australian Cotton Research Institute, Locked Bag 59, Narrabri, 2390, Australia

*grant.herron@industry.nsw.gov.au

Abstract. *Aphis gossypii* Glover (cotton or melon aphid) is an important pest of cotton due to its ability to reduce yield through feeding damage. Until the introduction of *Bt*-cotton to Australia in the mid 1990s cotton aphids were considered late season secondary pest because they were suppressed by insecticides used against other pests. However, from 1998-1999 season aphids have been more troublesome initially with control failures against pirimicarb (Pirimor®) and omethoate (Folimat®) making sticky cotton a real possibility and subsequently nearly a decade later more failures with neonicotinoids. Chemical control failures necessitated a complete re think and modification of the aphid IRMS that is still developing and evolving to this day. The strategy is underpinned by resistance monitoring and mitigation methods based on chemical alternation and no sequential use. This is augmented by a series of adjunct methods of aphid control that help put the resistance gene(s) at a selective disadvantage. Although the newly emerged neonicotinoid resistance in cotton aphid is a serous concern the Australian cotton industry is now much better placed to cope with resistance than back in 1998-1999. With the help of good resistance management Pirimicarb (Pirimor®) and omethoate (Folimat®) now work and from the 2010-2011 season new chemistry called spirotetramat (Movento®) will be available.

Key Words: cotton aphid *Aphis gossypii* Glover, resistance management, Australian cotton

INTRODUCTION

Aphis gossypii Glover (cotton or melon aphid) is an important pest of cotton due to its ability to reduce yield through feeding damage (Godfrey *et al.* 1997) and spread plant diseases such as blue disease in South America, South-East Asia and Africa (Correa *et al.* 2005) and cotton bunchy top disease in Australia (Reddall *et al.* 2004). Additionally, uncontrolled aphids on cotton late in the season cause contamination of the cotton lint with aphid honeydew. This downgrades the lint value due to post harvest problems in processing and spinning.

Until the introduction of *Bt*-cotton (Cry1Ac) to Australia in the mid 1990s and the twin gene *Bt*-cotton (Cry1Ac and Cry2Ab) in 2002, cotton aphids were considered late season pests. This was because for most of the early part of the season they were suppressed by insecticides used against other pests, predominantly *Helicoverpa* spp. As spraying for other pests declined late in the season and with only low numbers of beneficial insects (as a result of spraying) aphid populations were able to establish and increase quickly, often requiring control. With the introduction of transgenic cotton there were dramatic reductions in insecticide applications against *Helicoverpa* spp. (Naranjo *et al.* 2008), allowing aphids to build much earlier in some situations.

CONTROL FAILURES

In the Emerald region in the late 1990's the presence of cotton, citrus and cucurbit crops, all hosts for cotton aphid, meant that aphid populations were subject to considerable insecticide selection pressure, particularly from organophostaphtes (OP) and the carbamate pirimicarb (Pirimor®). It was not long before aphids strains were detected that showed considerable resistance and cross resistance to OP's and pirimicarb (Pirimor®). This situation also occurred in other regions fairly soon after. This was possibly due to the emergence of the aphid vectored disease 'cotton bunchy top' in the 1998-99 growing season, which led to a reduction in aphid tolerance levels by producers, resulting in more targeted insecticide applications for aphid control, and greater

selection pressure for resistance. During subsequent growing seasons resistance levels in cotton aphid increased to organophosphate (Rogor® and Folimat®) and some carbamate (Pirimor®) insecticides with high level resistance causing control failures in many Australian cotton growing regions (Herron *et al*. 2001). Sticky cotton was a real industry wide possibility during the early 1990s.

NEW CONTROL OPTIONS REQUIRED

There were no silver bullets for managing aphids but rather a combination of integrated tactics in combination with established management practices including sequential chemical and total use restrictions. As cotton aphids reproduce parthenogenetically females give birth to live young that are clones of themselves presenting a specific challenge for resistance management. This being the dilution of resistance due to mating of resistant individuals with susceptible individuals will not occur. For this reason greater emphasis must be placed on reducing the abundance of resistant clones. The tactics we used to achieve this comprised:

- *Reduce on-farm overwinter hosts for aphids i.e have a host free period*. Aphids survive through winter feeding on suitable hosts.
- *Consider using an at-planting treatment BUT be aware of potential resistance implications*. Some of the 'at-planting' insecticides or seed treatments will control aphids, potentially reducing early season aphids numbers but do not follow a seed treatment or at-planting insecticides with a foliar spray from the same group.
- *Sample effectively for aphids.* If a high proportion of plants do have winged forms then it is a warning to resample within a few days to check if they have settled and begun producing young. If aphids are found it is important to check the species as this may affect the choice of control options eg resistance to Pirimor in green peach aphid has always been much lower than for cotton aphid.
- *Rotate aphicides*. The means selecting from the full range of aphicides available at the time. If imidacloprid (Gaucho®) has been used the first aphicide could be endosulfan, pirimicarb (Pirimor®), dimethoate (Rogor®) or omethoate (Folimat®), but ideally not imidacloprid (Confidor®). Use of endosulfan should follow the recommended guidelines.
- *Don't follow a failure with another product from the same group*. Ideally if there is a spray failure the follow-up spray should be from a different mode of action group is not prone to the same resistance mechanism.
- *Maintain beneficial insects by using the most selective option if aphids or other pests need to be controlled.* A range of parasitoids and predators will help to reduce aphid survival. However, sprays applied for aphids or other pests can be detrimental to these beneficials.
- *Thresholds and varieties.* The conventional thresholds for aphids (90% of plants infested) are still appropriate in terms of cotton's capacity to tolerate aphid damage. If Cotton Bunchy Top is a risk select more resistant varieties.

PROBLEMS IN YOUR OWN BACKYARD!

Resistance testing was broadened to include aphids from farm backyards, weeds and cotton regrowth. In every instance resistant aphids were detected that may form the nucleus of future on farm control problems. These rogue overwintering aphids are potentially a problem to cotton farmers because:

- Cotton aphid can develop a winged form that can disperse if food quality drops or aphids become too crowded so they can go from the farm gardens, weeds or backyards to the field.
- Australian cotton aphids reproduce pathogenically – that is female aphids give birth to live young that are all females and clones of themselves. Resistance is not diluted by out crossing with susceptible aphids.
- Aphids have a fast life cycle and will develop from 1st instar through to adult in 5-6 days. A small population of resistant aphids can quickly become a field of resistant aphids, especially if beneficials have been suppressed by insecticide sprays.

- Cotton aphid has a wide host range including malvaceous, cucurbitaceous, solanaceous, and asteraceae and legume hosts. These hosts are easily found in farm gardens on plants such as hibiscus where they survive winter.
- In the 2003-2004 cotton season many cotton growers needed to control green mirid (*Creontiades dilutus* Stål). Early season application of broad-spectrum insecticides such as fipronil or dimethoate to control pests not controlled by Bt-cotton, such as the green mirid, often reduced beneficial populations and allowed aphid populations to increase earlier in the season in a transgenic crop. It seems reasonable to suspect that mirid control is now or has the potential to adversely affecting the management of cotton aphid.

NEONICOTINOID RESISTANCE

Despite the overall reduction in sprays associated with the twin gene *Bt*-cotton (Bollgard II®), resistance causing control failure against *A. gossypii* remains an issue. During the 2007-2008 season, we detected for the first time, *A. gossypii* surviving a discriminating dose of the neonicotinoid group insecticides, acetamiprid (Intruder®) and thiamethoxam (Cruiser®) giving a *prima facie* detection of resistance. During the following 2008-2009 season resistant aphids were associated with a control failure of another neonicotinoid clothianidin (Shield®) and the proportion of resistant strains increased significantly. Some strains were resistant to all neonicotinoid products tested so we consider it prudent to assume cross resistance for the purpose of resistance management. Cross-resistance has been established between members of the neonicotinoid group 4A mode of action insecticides in the study of Wang *et al*. (2007) who demonstrated a relationship between imidacloprid and acetamiprid resistance in cotton aphid and that of Alyokhin *et al*. 2007 that linked imidacloprid resistance to thiamethoxam in Colorado potato beetle. Consequently Australian populations of cotton aphid should also be considered a single cross-resistance group within the 4A Group for the purpose of resistance management as suggested by Nauen and Denholm (2005).

The development and apparent increase in neonicotinoid resistance in recent years indicates the need to reduce overall neonicotinoid selection pressure and to use alternative insecticide groups to slow further resistance increase. Options to decrease selection would be (i) use of non-neonicotinoid seed treatments (ii) use of alternative mode of action groups against aphids when foliar sprays are used (iii) managing the use of neonicotinoid insecticides on cotton crops where a neonicotinoid seed treatment is used. The effectiveness of the neonicotinoids as seed treatments, providing control of thrips and suppression of the wireworm complex, and lack of obvious alternatives makes removal for this use impractical as well. Given the value of the neonicotinoids for management of other pests, such as green mirids, excluding foliar use entirely is also not a practical option. Further, another insecticide, spirotetramat, (Movento®) from s different mode of action group (23) was registered in 2010 for control of cotton aphid which provides another alternative. We recommend a compromise;

- Limit in-season use of foliar neonicotinoid treatments if they have been used as a pre-germination seed treatment on the same crop. This will have implications for control of other pests such as *B. tabaci* B-biotype and mirids.
- If foliar sprays are required for aphid control and neonicotinoid seed treatments have been used it is most important that the first foliar spray, targeting aphids, is from a different chemical group.

THE FUTURE

Although resistance is a serious concern the Australian cotton industry is not in the situation seen in the early Emerald failures where no effective chemicals were available for aphid control (Herron *et al*. 2001). A modification to the resistance management strategy for pirimicarb (Pirimor®) and OPs (Farrell 2008) has allowed the efficacy of these chemical groups against aphids to be restored, presumably because resistant clones have been replaced with susceptible ones. If Pirimor® continues to be used in Australian cotton in conjunction with IPM then efficacy may be maintained, but if use should increase again then the long term efficacy would be doubtful. Fortunately other

options exist including spirotetramat (see below) and diafenthiuron (Pegasus®). However, it should be noted that diafenthiuron is now used significantly for control of silverleaf whitefly – and this creates strong selection pressure for resistance in co-incident cotton aphid populations, even if they are at sub-economic levels. This is a risk that will have to be managed carefully in future.

New chemistries continue to be developed by the chemical industry and made available to cotton. For instance the new tetramic acid derivative spirotetramat (Movento®) will be available to Australian cotton growers from season 2010-2011. The product acts as an inhibitor of lipid biosynthesis and affects juvenile insect stages with additional effects on adult insect fecundity (Bruck *et al*. 2009). The product is rather unusual in that after it penetrates through the leaf cuticle and is translocated as the plant transformed active ingredient spirotetramat-enol via xylem and phloem, up to growing shoots and down to roots (Bruck *et al*. 2009). Bayer CropScience AG has been developing spirotetramat (Movento®) for many uses including whiteflies, aphids, mealy bugs and selected thrips species (Bruck *et al*. 2009). New chemistries are out there but are likely to be more expensive that the existing options - a good reason to preserve the neonicotinoids, pirimicarb (Pirimor®) and diafenthiuron (Pegusus®) as long as possible.

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