Helicoverpa armigera insecticide resistance management – key considerations for 2006/07.

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The last 23 years has involved both major change and subtle fine tuning of strategies taken by the Australian Cotton Industry in managing insecticide resistance in the cotton bollworm, *Helicoverpa armigera*. Early strategies linked chemical use across multiple crops and involved window restrictions focussing on pyrethroids and endosulfan. After 10 years the strategy retained a focus on cotton only, and the LepTon test kit allowed for specifically targeting *H. punctigera* populations which remained susceptible to pyrethroids. More recently integrated pest management (IPM) practises and the registration of numerous 'soft' chemistries with greater specificity have provided for less restrictive guidelines on chemical use, with beneficial preservation as a tool for minimising spray events and predating resistant survivors considered as part of the strategy.

The introduction of transgenic Bollgard II® cotton and its widespread adoption is the most recent factor to influence the insecticide resistance management strategy (IRMS), with industry wide plantings of >80 % Bollgard II® in 2005/06 looking to be equalled or increased in 2006/07. Large areas of unsprayed Bollgard II® cotton do not act as a refuge for insecticide resistance as there is very little to no moth emergence from Bollgard II®. Less than 20 % of total cotton planted to conventionally sprayed cotton however increases the relative area of non-sprayed refuge to sprayed cotton, acting as a source of non-selected susceptible moths for diluting resistance. These non-sprayed areas include other crops and pastures, roadsides and non-cropped tracts of land.

With this reduction in sprayed conventional cotton comes the opportunity to further relax restrictions on chemical use within the IRMS to accommodate control requirements within what is often a complex pest system. The widespread uptake of Bollgard II®, which has certainly had a major reductive effect on insecticide use within the Cotton Industry is, however, not the sole consideration when developing the IRMS. In addition to the numerous factors accounted for and underlying the current IRMS, including IPM, chemical control of secondary pests and regional requirements, there are a number of key factors particularly relevant in developing the 2006/07 IRMS within a Bollgard II® dominated cotton system.

Current resistance status

Assessment of the success of resistance management strategies has relied on monitoring data of resistance frequencies across all cotton growing areas of eastern Australia. In the past four seasons there has been a downward trend evident for resistance frequencies to a number of key insecticides. Notably spinosad (Tracer™) resistance has decreased to almost non detectable levels since peaking in 2001/02. Consistent with results from 2002/03, 2003/04 and 2004/05, during the 2005/06 season

there was negligible resistance detected to the other IPM compatible chemistries of indoxacarb (Steward®) and emamectin benzoate (Affirm®), with random survivors detected each season without any indication of increasing frequency during or between seasons. There has been no methoxyfenozide (Prodigy™) resistance detected after three years of registration in cotton. Chlorfenapyr (Intrepid) resistance monitoring was continued as part of long term monitoring despite its unavailability in 2005/06, with very low frequencies of resistance detected.

Results from the past four seasons also suggest a reduction in resistance frequencies to some of the older chemistries. Monitoring for endosulfan and pyrethroid (bifenthrin -Talstar®) resistance has detected only low level resistance frequencies, however monitoring has been relatively limited. While there are varying degrees of cross resistance between the pyrethroids, bifenthrin is one chemistry with which this relationship is weak, and while resistance to this certainly appears to have decreased, it cannot be assumed to extend across all the pyrethroids. Widespread profenofos resistance has been detected at varying frequencies, in contrast to only low frequency detection of chlorpyrifos resistance (note: while both are organophosphates, there is no cross resistance between the two insecticides). Widespread carbamate resistance has also been detected at frequencies similar to previous seasons.

A summary of the 2005/06 insecticide resistance monitoring results across all areas for *H. armigera* is given in Table 1. In addition, over 5000 *H. punctigera* larvae were assessed for resistance to either endosulfan, pyrethroids (fenvalerate) and abamectin (Agrimec®). There was less than 0.2 % resistance found to the three insecticides.

Table 1*: H. armigera* insecticide resistance frequencies, summary all areas, 2005/06

Insecticide	Resistance frequency % (no. tested)
Indoxacarb (Steward®)	1 (2680)
Spinosad (Tracer™)	0.4 (2607)
Emamectin benzoate (Affirm®)	0.6 (2445)
Methoxyfenozide (Prodigy™)	0 (440)
Endosulfan	9 (767)
Bifenthrin (Talstar®) – pyrethroid	4.9 (633)
Methomyl – Carbamate	51 (836)
Chlorpyrifos – OP	1.1 (1169)
Profenofos – OP	4.3 (1450)
Chlorfenapyr (Intrepid)	1.2 (587)

Chemical use in other crops

Selection for resistance is not limited to chemical use in cotton, with registrations of key insecticides in other crops a major consideration in developing the IRMS. Currently both spinosad (Tracer™) and indoxacarb (Steward®) have registration in chickpeas, allowing for resistance selection prior to the cotton season. Both chemistries also have increasing registration in other summer crops, including several pulse crops grown in many of the cotton regions.

As two of the main IPM compatible chemistries used in cotton against *Helicoverpa* species it is particularly important that their use in other crops be incorporated into the IRMS. The IRMS has provided guidelines on their use in chickpeas for the previous four seasons, restricting their use to end dates in September/October (area dependent) to allow for a break of at least one generation before their use in cotton. Such guidelines have previously not been provided for summer pulses. With the increasing importance of these crops in some areas, the resistance risk chemical use on them poses requires consideration, as does the likely use periods of Tracer™ and Steward® in these crops. There is little resistance management logic in restricting their use in cotton if they are available for use in other crops in close vicinity to cotton. The placement of both Tracer™ and Steward® within the cotton IRMS has to account for such use, which may occur past the peak period of insect control in cotton when these chemicals have greatest use.

The future

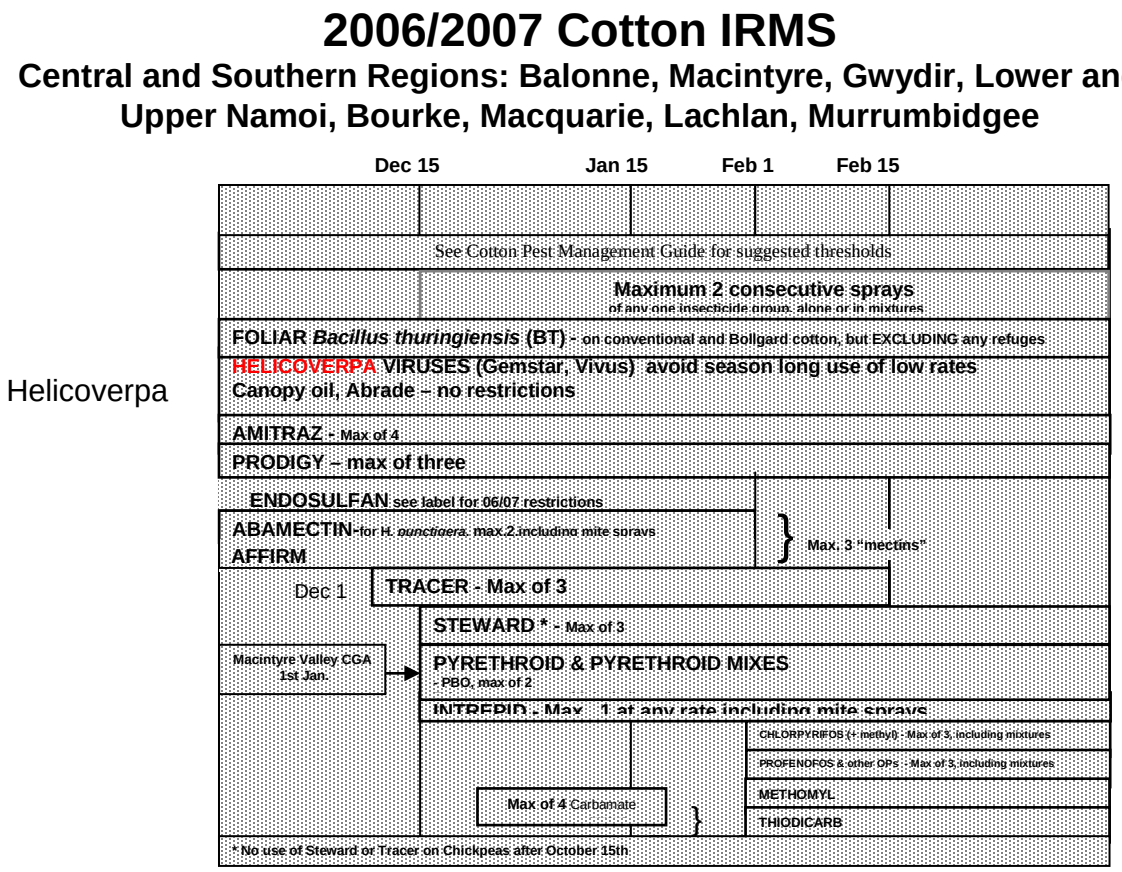
Uncertainties regarding the future in terms of cotton complex (transgenic vs conventional), pest complex and pressure, and resistance (both insecticide and the possible development of Bt resistance) must also be considered in developing the 2006/07 IRMS**.** The rapid and widespread uptake of Bollgard II® technology has changed, and generally simplified, pest control decisions, however it also represents a strong selection pressure for resistance development. This potential threat, combined with agronomic and economic issues which may arise with Bollgard II® cotton, means insecticides must be protected from resistance development for use both now and in the future. As long as insecticides are applied against *Helicoverpa* species in cotton, either conventional or Bollgard II®, a strategy must exist to protect them from resistance development.

2006/07 IRMS

The Helicoverpa IRMS for 2006/07 was recently ratified by the TIMS committee, the key ACGRA supported body involved in resistance management decisions for the Australian Cotton Industry. The previously highlighted issues were initially considered resulting in a draft IRMS that was circulated for industry feedback. This feedback was then used to formulate the final IRMS. The IRMS presented in Figure 1 is the IRMS for the central and southern regions, with slight variations for the Northern and Darling Downs strategies. The key features, however, are essentially the same.

The major change from the previous strategy is a lengthening of the windows of availability for most key insecticides. As previously discussed this is in response to the reduced resistance risk posed by smaller areas of conventional cotton. Non-use periods however remain for the chemical larvicides to allow for a generational break where use of alternative chemistries can manage any developing resistance. In addition to an increase in the availability of both Steward® and Tracer™, their use in chickpeas as well as summer pulses has been accounted for by their placement mid to late season. The pyrethroids have also been moved forward in the season to start earlier in response to their use on *H. punctigera* populations early season.

Figure 1. Central and Southern areas, IRMS 2006/07



Conclusion

The 2006/07 IRMS is not a strictly ideal strategy, with a general 'stretching' of most of the basic underlying principles regarding restricting chemical use for effective resistance management, particularly in selection across only one generation. It is, however; a strategy that has considered the risks associated with resistance development within a cotton complex highly dominated by Bollgard II®, supported by most recent resistance monitoring data which suggests resistance is being effectively managed. The greatest risk to any strategy is complacency and non-compliance in regard to chemical use. This strategy gives greater flexibility in chemical choice, thereby encouraging chemical use within the strategy. Future strategies shall likewise assess the risks associated with resistance development, and shall hinge on monitoring data of resistance frequencies as well as consideration of some of the uncertainties that currently exist but may change in the future.

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