



STEWARDSHIP case study

In it for the long haul: the value of refuge crops

The use of insecticidal biotechnologies in Australian cotton is an integral part of the industry.

In 2014, over 95 per cent of the cotton grown in Australia contained Bt technology. Protecting the use of this technology through good stewardship is critical to the cotton sector's future success.

Recognising the importance of Bt technology, Sinclair Steele, Farm Manager at Auscott - Warren (pictured), takes the view that while the management of refuge crops can create challenges, allowing the development of Bt resistance would create far greater complications for Auscott's farming system.

"We see establishing and managing a healthy refuge as an important part of our operation," said Sinclair.



and residual herbicides are used to help ensure the refuge crops are healthy and weed free.

"The location of our refuges is also really important. Where possible, we plant the refuges upwind of the prevailing wind direction to minimise potential Roundup Ready herbicide drift onto the pigeon pea, and also to make sure the refuges aren't impeding Roundup sprays on our cotton fields.

"Having healthy, attractive refuges means we are doing our bit for resistance management."

Refuge preparation

On Auscott's Warren operation, seed bed preparation for the pigeon pea refuge is exactly the same as the preparation for the cotton crop.

"There are no shortcuts and we work to achieve the same fine tilth we want to see for cotton establishment," said Sinclair.

"We select our refuge areas early and keep a clean long fallow for weed control and moisture retention.

"We water inject the pigeon peas at planting at 500 litres per hectare, with seedling numbers at 15-20 per metre depending on seed germination to ensure a solid stand, and we put the inoculant on with this.

"We aim to plant into moisture with the water inject to make sure establishment is good, but if moisture levels are not adequate we will pre-irrigate, as we find the peas prefer this to watering up after planting."

No peas are planted until the soil temperature is over 17 degrees and rising.



Weed control also consists of a post plant pre emergence herbicide mix of flumetsulan at 50 grams per hectare, and pendimethalin at 2.2 litres per hectare.

“The use of residual herbicides has been critical in controlling weeds in the refuges, although as a result of this chemistry, we have seen some damage to cotton planted in these areas following the peas,” said Sinclair.

“In some cases we will inter row cultivate or put chippers through refuge areas if weed escapes do occur.

“As our refuges have a low weed burden we keep our own seed for the following year by desiccating with diquat, then harvesting with a standard harvester. After harvest we mulch the stalks with a flail mulcher, then root cut as we do in our cotton areas to provide a good bed for the following crop.”

Despite the significant expense, seed is graded and bagged to ensure seed quality and prevent weed seeds from being added to the farming system.

The crop is closely monitored after establishment and is watered at least two to three times during the season.

“This encourages flowering and enhances pod fill, which we need to get decent yield for the next year’s crop,” said Sinclair.

“This ticks two boxes, creating an attractive refuge and secondly providing maximum yield for us to harvest. Typical yields are from 1.2 to 2 tonnes per hectare, depending on insect pressure for that particular season.”

Resistance on the rise: Resistance is present, is higher than expected, and is probably increasing

CSIRO’s resistance monitoring research has shown that in both of the target species, *H. armigera* and *H. punctigera*, resistance to Cry2Ab is present, is higher than expected, and is probably increasing, according to CSIRO entomologist, Dr Sharon Downes.

CSIRO screens against the new protein in Bollgard 3 (Vip3A) have found that in *H. Armigera* the frequency of

genes conferring resistance is around 1 in 20 moths. Not only is this higher than expected, it is much higher than the starting frequencies for Cry2Ab.

Vip3A resistant genes have also been detected in *H. punctigera* at a frequency higher than expected and higher than the starting frequencies for Cry2Ab.

This situation highlights that as the industry moves towards Bollgard 3, effective resistance management will continue to be critical to ensure the efficacy of the Bollgard technology is maintained.

“Refuge crops are a mandatory component of the Bollgard II Resistance Management Plan (RMP) and integral to the protection of the technology for future use,” said Dr Downes.

“The aim of a refuge crop is to generate significant numbers of susceptible moths that have not been exposed to the Bt proteins. Moths produced in the refuge crops will disperse to form part of the local mating population, where they can mate with potentially resistant moths emerging from Bollgard II crops, delaying the development of resistance.

“This strategy works because resistance to the Bt proteins has so far been found to be recessive, so if a resistant individual (rr) from the Bollgard II crop mates with a susceptible (ss) from the refuge, the resulting offspring (rs) will also be susceptible to the Bt toxins.”



Refuge options

There are a number of options for mandatory refuges under the RMP: sprayed cotton, unsprayed cotton, or pigeon pea.

Growers should refer to the current RMP for the refuge ratio required relative to the area of the Bt cotton crop. In irrigated crops only half the area of pigeon pea is required compared to unsprayed cotton, so it's not surprise that almost 70 per cent of refuge crops planted are pigeon pea.

Research conducted by CSIRO has found that pigeon pea refuges are on average twice as effective as unsprayed cotton in producing susceptible moths. Only half the area of pigeon pea crop (compared to unsprayed cotton) is required to produce the same amount of moths.

No matter which refuge is grown, refuge crops must be well managed to optimise attractiveness to *Helicoverpa* moths throughout the cotton growing season.

Improving refuge performance

- As part of the industry's RMP it is a grower's responsibility to ensure refuge crops receive adequate nutrition, and irrigation water (in irrigated refuges), and are managed for weed and pest control (excluding *Helicoverpa* sprays) so that they remain attractive and perform as a viable refuge throughout the growing season.
- The timing of refuge planting needs to synchronise with the timing of Bt cotton planting so that the refuge is flowering (both pigeon pea and cotton refuges) at the same time as the Bt cotton.
- Ideally, refuges should be at least as attractive to *Helicoverpa* or more so than the corresponding Bt crop to ensure females lay eggs in the refuge crop.
- Other crops and natural vegetation play an important role in resistance.
- *Helicoverpa* feed on a wide range of host crops and vegetation, including cotton. Unstructured refuges such as other crops and natural vegetation are important contributors of non Bt exposed moths within the landscape and play an important role in resistance management.
- However natural vegetation and other crops cannot be relied on as the only source of non Bt moths, as their effectiveness as a refuge, their synchronicity with the cotton crop, and their total area, is highly

variable.

- For a refuge to be effective it must be planted in close proximity (within two kilometres) of the primary crop, to increase the likelihood that moths emerging from the refuge will mate with potentially resistant moths bred in the Bt cotton. *Helicoverpa* are capable of migrating long distances. However during the cropping season a significant portion of the population will remain localised on preferred hosts, and are unlikely to move more than a few kilometres.

A valuable resource

Mandatory refuges are a critical component of the current RMP for the cotton industry, providing a reliable source of susceptible moths to dilute the population of resistant individuals.

While there are economic costs involved in establishing and maintaining a healthy and viable refuge, these costs are an investment in protecting the future of Bt cotton in Australia, ensuring the industry has continued access to this critical technology.

For more:

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