To be or not to be (a weed): Potential weediness of Bt cotton

By Rowena Eastick*

As southern Australia contemplates one of the most severe droughts in history, the wet season in northern Australia announces its progression with spectacular thunderstorms, lightning displays and increasing cyclone watch warnings.

Although the 2002–03 wet season is below average in a number of regions, localised persistent lows have contributed to abundant refill of major river systems — such as 500 mm in one week at some stations in the Roper River catchment.

This area is an example of the attractive land and water resources that has renewed interest in cotton production in northern Australia. But this region also has existing stakeholders with an active interest in the allocation of natural resources. It is a mecca for fishermen, contains productive pastoral lands and provides for traditional Aboriginal landholders.

Environmental concerns over the allocation of land and water resources for irrigated agriculture, of which cotton is a major contender, are continually being raised by stakeholder groups. Researchers within the Australian Cotton CRC at Katherine, Kununurra and Broome are committed to addressing these concerns through evaluating viable and environmentally responsible cotton production systems.

Weediness as a concern

Northern Australia commercial cotton production systems would be based on genetically modified Bt cotton. This technology would be the foundation of IPM systems, which would effectively minimise pesticide use — but it also

raises environmental concerns about the ecological effects of the transgene.

One such concern was potential weediness, and whether the addition of the Bt gene would give an ecological advantage over conventional cotton in tropical areas. Cotton (G.hirsutum) evolved in tropical and sub-tropical areas and isolated naturalised populations exist in northern Australia.

So, the question was: “Could the Bt gene enhance the ability for improved cultivars to become naturalised, or alter the ability of existing naturalised populations to persist?” The Office of the Gene Technology Regulator (OGTR) and Environment Australia (EA) requested that these weediness risks be evaluated prior to commercial release of Bt cotton in northern Australia.

Answering the question

A project commenced in 1999 to evaluate the potential for increased weediness of Bt cotton. This was done by comparing the growth and development of conventional and Bt cotton (containing combinations of Cry1Ac, Cry2Aa and Cry2Ab genes) in a range of habitats at Katherine, Kununurra and Broome.

These were habitats into which cotton could potentially disperse, and were categorised as waterway, cattle habitat, native bush and roadside. Three seed types — black seed, fuzzy seed and seed cotton — were hand-planted within each of these habitats in the 1999–00 wet season (summer) to simulate cottonseed dispersal.

Additional sites were established in the initial dry season, plus a second series of sites in the second year. Plant numbers and fruit production were recorded over a two-year period to quantify germination, survivorship, fecundity (boll production) and seedling recruitment as contributors to weediness.

Regular counts of plants at each site were used to calculate population growth, which was equated to invasiveness — considered a major

determinant of weediness. A value greater than one indicates the population is increasing and may become invasive of that habitat, while a value less than one indicates the population is decreasing.

Invasiveness was calculated for each of the two initial years of the project to allow populations to reach a more stable threshold in the second year after the initial establishment year, where seedling mortality was high.

The main body of the project was concluded at the end of 2001 with preliminary results included in a submission by Monsanto to OGTR in mid-2002 for commercial release of Bollgard II in northern Australia. The response from OGTR (see http://www.ogtr.gov.au/rtf/ir/dir012finalrarmp.rtf) was that specific regulation continued to be required for releases north of latitude 20 degrees south until further information on weediness could be provided.

Final Report

The final report for the initial two years of the weediness project was published in November 2002. For the full report, see http://www.cotton.crc.org.au/Assets/PDFFiles/TB3051.pdf.

Main findings

Within each site, seed type was the main factor influencing germination. Seedcotton had the lowest germination rate, attributed to higher moisture requirement for imbibition and also emergence difficulties from the lint.

This has important implications for invasiveness. Seedling recruitment from established volunteer plants would be from seedcotton only, so the number of plants establishing for subsequent generations would be relatively small.

There were highly significant differences between sites for all attributes measured.

Poor establishment, growth and development occurred at all the native bush and roadside habitats. It is unlikely that cotton will be invasive of undisturbed natural habitats.

Five sites had no plants remaining, and the remaining six sites had less than three per cent of plants surviving from the original number of seeds sown.

Only two sites (both disturbed by human actions) — an irrigation drain at Kununurra and a cattle yard at Broome — had greater than 50 per cent of plots with surviving plants, corresponding to less than 15 per cent of plants surviving from the original number of seeds sown. These were the only sites from which plants produced viable open bolls and subsequently recruited some seedlings.

Mean values for invasiveness were not greater than one for any genotype at any site, although some individual plots in some habitats produced values greater than one. This indicates that cotton populations, independent of genotype, will not be invasive weeds of non-agricultural habitats.

Monitoring of naturalised cotton populations

There are approximately 60 recorded populations of naturalised cotton in the NT. A number of these were monitored to provide supplementary information on whether the Bt gene may modify the ability of these populations to persist.

The majority of populations occur as isolated patches in littoral, coastal or floodplain fringe habitats. Figure 1 illustrates the known locations of naturalised cotton in the NT, in association with potential suitable cotton growing areas.

Although the effect of insect damage was not experimentally quantified, it was concluded that the addition of the Bt gene was unlikely to enhance the weediness of these naturalised populations.This was supported by a number of factors including:

• The possibility for gene flow from Bt cotton to these populations is effectively zero due to their geographic isolation from suitable production areas. Any populations which may overlap with production areas could be easily eradicated.

• Indications that Bt susceptible insects are not a

significant constraint to the growth of existing cotton populations and that fire, water availability and soil fertility are greater determinants of establishment of cotton populations.

• No evidence that existing naturalised populations are invasive of their current habitats, to which they have adapted.

• Experimental evidence from the multi-site study, which indicated that the Bt gene did not enhance the ability of improved cultivars to become a weed.

The answer

None of our results indicated that the addition of the Bt gene would enhance the rate of population growth, or invasiveness of cotton in northern environments. We concluded that the commercial release of Bt cotton in northern Australia posed no greater hazard than conventional cotton.

Discussion

While we believe our two-year study clearly indicates that cotton is unlikely to survive and establish in most habitats, we will continue to monitor our experimental populations at two sites for an extended period. Measurements are continuing at the Broome cattle yard and Kununurra drain sites, with data indicating that the populations are continuing to decline.

Monitoring at these habitats, which have the greatest risk of cotton volunteer establishment, will help us better understand the population dynamics of the plant and provide more precise estimates of invasiveness over time. This updated information will be included in subsequent submissions to OGTR for commercial release of Bt cotton in northern Australia.

Cotton development in northern Australia continues to be an emotive issue, with considerable interest from local communities, pastoralists and fishing bodies on the possible environmental impacts of such an industry. Establishment of a commercial cotton industry

based on Bt varieties may lead to instances of volunteer cotton plants in specific niches.

But there is no indication that the chance of this occuring would be increased with Bt genes compared to conventional cotton. So it is a volunteer management issue rather than a gene regulatory issue. Bt cotton would form an integral component in the development of an environmentally sustainable industry based on responsible utilisation of the land and water resources of northern Australia.

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