

## Two gene technology in the Australian scene

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*Summary. Targets for improved efficacy and resistance management of Ingard would be achieved by having a second gene in the plant with a different mode of action: a 10 to 20 fold delay in time to resistance would be achieved. Trials at eight sites in 1997/98 showed that two-Bt gene cotton could yield at least the same as Ingard, particularly under heavy *Helicoverpa* pressure, indicating better efficacy than Ingard. These small scale trials will continue in 1998/99.*

### Introduction

Transgenic Bt (Ingard) cotton has been the biggest step achieved so far in reducing insecticide applications to cotton in Australia. In the past two years there has been a 50% reduction in applications of insecticide to *Helicoverpa* on Ingard compared with conventional cotton (Long *et al* 1997). The reduction in sprays has been especially so with endosulfan in the early part of the cropping season when Bt production and efficacy of Ingard plants has been best.

The technology has disappointed many growers because of marginal and variable efficacy. Although the full reasons for variability are not well understood, better efficacy is required to continue advances in non-chemical pest control over a greater area.

Due to fears of resistance occurring by *Helicoverpa* to Bt, the area of Ingard has and will be limited by regulatory authorities to between 10 and 30%. A resistance management plan involving refuges, planting windows and pupae destruction is necessary to limit the possibility of resistance (Fitt; this conference).

One other method of minimising the likelihood of resistance developing is to have two genes in the plant with different modes of activity against *Helicoverpa*. Any larvae with resistance to one gene product will be killed by the other gene product. Such a mechanism is available as Monsanto has a second Bt (Cry IIA) in addition to the existing Cry IA(c) in Ingard. This approach is calculated to give a 10 to 20 fold increase in time before resistance occurs (eg 50 years instead of 4; Roush 1997).

Monsanto has ceased development with the Cry IIA gene in the USA because of agronomic problems and low yields. Given the greater need for a second gene in Australia, further testing of Cry IIA is continuing here. CSIRO will have multi site trials of a number of two-Bt breeding lines during the 1997/98 and 1998/99 seasons. This paper reports on results from the first season.

### Efficacy

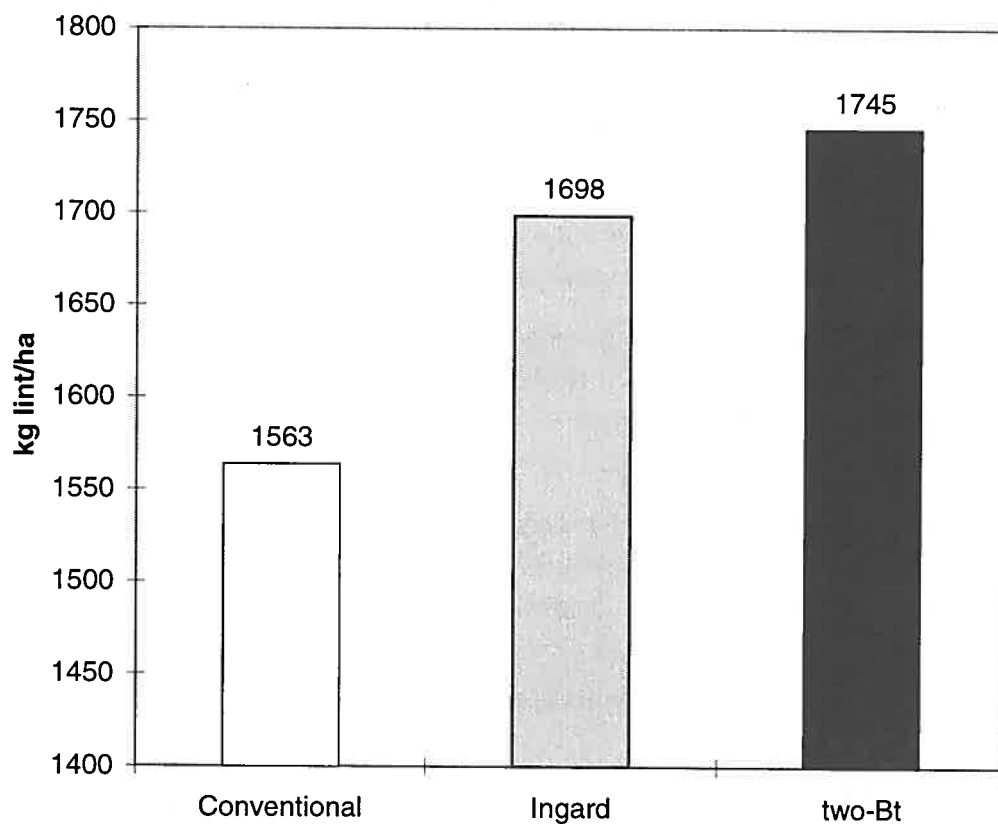
In field bioassays done by Gary Fitt in 1997/98, it was found that two-Bt breeding lines had much greater efficacy than single gene Ingard. Such a result is a bonus for the two-Bt technology as a resistance mechanism: greater efficacy complies with the high-dose strategy required.

## Yield

There were eight sites comparing four varietal backgrounds of conventional, single gene Ingard and two-Bt breeding lines. These experiments were located in commercial Ingard fields and were managed according to insecticide requirements for Ingard. As expected from general experience in 1997/98, the fields on average were sprayed about half the number of times as conventional cotton.

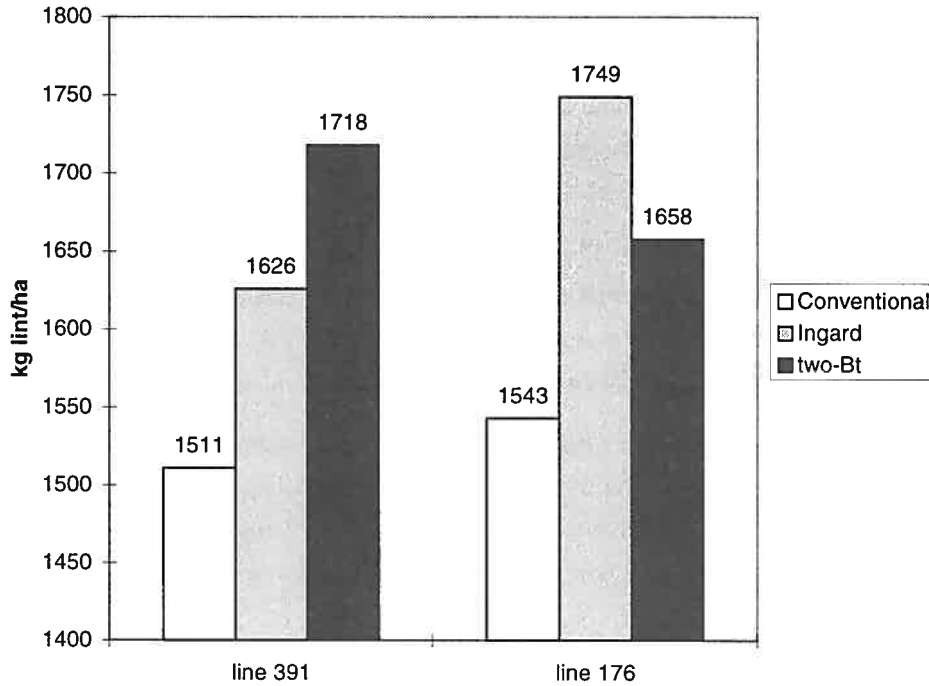
A summary of lint yield from those sites is shown in Figure 1. Ingard yielded about 20% more than conventional - confirming that conventional required more sprays. It was pleasing to see that two-Bt breeding lines averaged about 3% greater yield than the Ingard equivalents. That yield result confirms the greater efficacy found from bioassays.

Figure 1. Lint yield of conventional, Ingard and two-Bt lines in the 1997/98 season. Average for four breeding lines at Emerald, Brookstead, St George, Boggabilla, Moree, Narrabri, Breeza and Warren. Each field was sprayed for insects according to the requirements for Ingard.



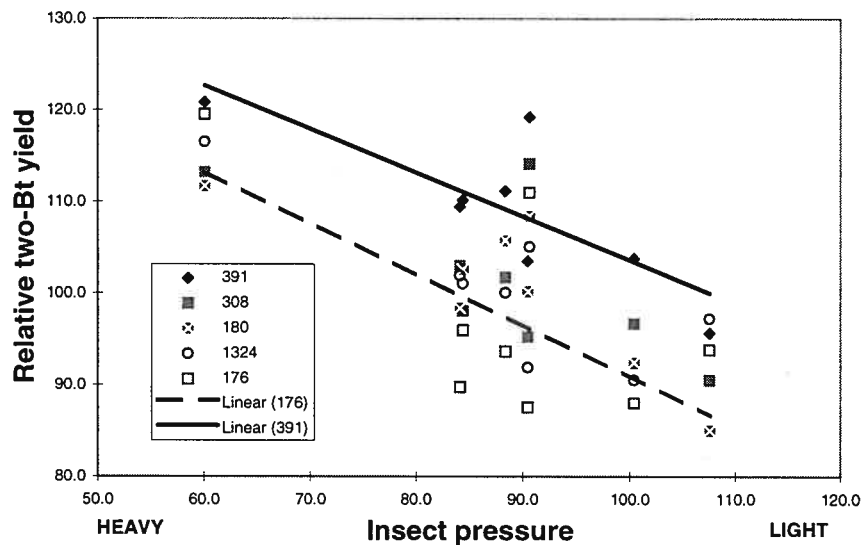
The yield of two-Bt breeding lines varied with genetic background: one line was about 12% lower yielding, while others were up to 10% better than Ingard. Figure 2 summarises the difference between the best and worst two-Bt lines. This result is important in breeding as the variability can be exploited in selecting better types for yield and efficacy. There was no question that some two-Bt lines had an agronomic problem: early drop of bottom leaves and early cutout were particularly evident in one genetic background.

Figure 2. Lint yield of conventional, Ingard and two-Bt lines in the 1997/98 season in two breeding lines at Emerald, Brookstead, St George, Boggabilla, Moree, Narrabri, Breeza and Warren. Each field was sprayed for insects according to the requirements for Ingard.



The benefit of two-Bt lines was most evident at sites where *Helicoverpa* pressure was greatest. That result is summarised in Figure 3, where the site with greatest insect pressure had up to 20% greater yield of two-Bt compared with Ingard. As expected, sites with little insect pressure had the same or lower yield from two-Bt types when compared with single gene Ingard.

Figure 3. Relationship between insect pressure and yield of two-Bt breeding lines compared with their Ingard equivalent. Pooled data for eight sites and four variety backgrounds. Insect pressure was estimated as the relative yield of conventional cotton in the field (it was sprayed for Ingard).



## Discussion

Despite the obvious agronomic problems in some breeding lines, there was sufficient promise in the result from some breeding lines at all sites. CSIRO will continue multi site testing a large number of two-Bt breeding lines in 1998/99. Monsanto will decide in 1999 whether to proceed with this product commercially in Australia.

Given the variability and marginal efficacy of single gene Ingard, it could be argued that product is not viable enough to be grown widely in Australia. If so, then evaluation of Bt gene technology should compare two-Bt types with conventional cotton, sprayed conventionally with old chemicals (and their resistance and environmental problems), and/or with new expensive chemicals.

It is stating the obvious to say that a lower yield can be tolerated if that variety-system is cheaper than conventional cotton. For example, if two-Bt gene Ingard saved \$500 in insecticides and license fees, then about 1 bale/ha *lower* yield could be tolerated with that variety type.

Two-Bt gene types with greater efficacy and resistance insurance would be able to be grown much more widely, achieving a greater overall reduction in pesticide use in the cotton industry. A 50% reduction on 15% of the area is small compared with a 70% reduction on 70% of the area. Because of the lower chance of resistance in two-Bt cotton, a smaller refuge would be required (Roush 1997).

If the current Cry IIA second gene is not suitable, then some other gene will be required. A number of research laboratories are working on such an objective. Monsanto are currently evaluating a new gene (Cry X) in the field this (northern) summer. That gene would not be available commercially in Australia before 2003.

## References

Long, A, Pyke, B and Slack-Smith, P (1997). The performance of Ingard cotton in Australia, 1996/97 season. Occasional paper, Cotton R&D Corporation, 23 pp.

Roush, RT (1997). Bt-transgenic crops: Just another pretty insecticide or a chance for a new start in resistance management ? *Pesticide Science* **51**, 328-334.