Larval survival in Bollgard II

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INTRODUCTION

Bollgard II was planted to about 85 per cent of the Australian cotton industry in 2004–05. From the start of the season I expected it to be perfect at heliothis control, regardless of variety, nitrogen status, time of season or climate.

After all, it had two genes to counter resistant larvae, while in previous years even one good gene in Ingard had been effective until late in the season. But by mid season it appeared that my expectation may not have been realised. Two separate circumstances regarding larvae in Bollgard had been identified.

Firstly, some Bollgard crops in NSW were sprayed with larvicides several times in November and December — that is, early in the season. Apparently some sprays even targeted large egg lays because it was thought that a sufficient number of neonates could cause economic damage.

The egg lays were heavy and continuous, often in excess of 100 eggs per metre, and occurred in all districts in both NSW and Queensland. Collections showed that the eggs were almost all *Heliothis punctigera*.

In the second and far more important circumstance, larvae of at least third to fourth instar size (almost 20 mm long) were observed in crops in January and February — that is, mid season. At St George, 45 such larvae were collected and sent via the local industry development officer to the ACRI for further investigation.

Written and verbal reports from consultants indicated that proportionately similar numbers were found in all other districts. This article reviews information relating to both circumstances where larvae were found and suggests a likely scenario.

EARLY SEASON LARVAE

At St George the small amount of conventional cotton was heavily tip damaged by the early season *Heliothis punctigera*. The onslaught began before squaring and as usual I ignored it. The Bollgard was unaffected.

As squaring proceeded on Bollgard cotton, I counted first position fruit retention on the top five nodes at 50 sites. Retention need only be 60 per cent to maximise yield, although with fewer fruiting points early in the season this was difficult to judge because each is valued at a higher percentage.

But it did not matter. I continued retention counts until mid January. It was always above 90 per cent, often 95 per cent to 100 per cent, on 20 plants per site. There was never a concern that neonates were sufficiently numerous to cause damage.

After all, 50 armyworm neonates can be found on a single leaf without causing permanent damage. Five or 10 neonate heliothis per plant which did not grow past first instar certainly would not be harmful.

Square and boll retention counts are easy to make in Bollgard. If retention is poor in the early season it is due to sucking pests or poor agronomy, not grubs. But since only 60 per cent early retention is needed, counts are hardly meaningful until late November when at least six fruiting nodes are present. Therefore any early sucking pest damage which occurs in Bollgard can be ignored, and it follows that seed dressings to control sucking pests in Bollgard are also unnecessary.

There is another reason why Bollgard should not be sprayed for heliothis. There can never be a more heliothis unfriendly environment. There has never been a better opportunity for parasites and predators of heliothis to demonstrate their worth.

In the past I would inspect conventional cotton looking for two very small or small larvae in a minimum 30 plant sample. I would continue sampling until I was confident that there was or was not a problem. The lower the pest pressure, the more extensively I sampled.

With Bollgard it is the opposite. I do not sample for heliothis because I know that two genes plus beneficial insects are more than enough. When I found a 20 mm grub on a Bollgard crop on January 12, it was parasitised by the wasp Microplitus. I never considered spraying.

MID SEASON LARVAE

The second time that grubs were found in Bollgard was during January. Until then consultants had noted the effectiveness of Bollgard on larvae and were more concerned with mid season sucking pests. Grubs were found by chance or in beat sheets. A total of 78 grubs, including the 45 from St George, was sent to the ACRI for testing (Dr Sharon Downes, personal communication) and I suspect that at least the same number was observed without collection. At first this was alarming and unexpected. How did they reach the third or fourth instar stage? A number of suggestions have been offered. These are:

- Survival on non-Bollgard volunteers from the previous year;
- Survival on alternate weed hosts;
- Survival on pigeon pea refuges followed by movement up to 40 metres into the cotton crop;
- Survival on pollen which is non toxic;
- Impure seed lots;
- Resistance; and,
- Reduced efficacy of plant parts.

Perhaps each of these options is possible but at St George only the last three might have been significant. I observed whole plants which were barren, and since seed purity was a minimum 99 per cent, I would expect one plant in 10 metres to be conventional and therefore susceptible to grubs. They were no more frequent than that. Seed lot impurity could therefore explain the presence of grubs, but since nil or very little seed was produced by the impure plants, it will not be a continuing problem.

Resistance to Bollgard II could arise through any of three circumstances. These are:

- One mutation, making the insect resistant to both proteins;
- Two mutations, causing separate resistance to both proteins; or,
- A resistance that is already present in the population.

Since mutations are random, the probability of that occurring is extremely small. The probability of it occurring or resistance already existing in over 100 situations across the industry in January 2005 is approximately nil. Even without further breeding and testing of the 72 grubs in the lab, we know that the frequency of their occurrence in the field cannot be explained by resistance.

Finally, reduced efficacy is a possibility because the toxin is a protein and therefore subject to any influence which causes variation in the level of nitrogen in the plant. Such influences include soil nitrogen content, soil aeration and plant age. In addition, even under optimum conditions, the genetic material or “construct” might not provide sufficient toxicity against *Heliothis armigera*. This happened with Ingard 189 so in theory could happen again.

But in practice Bollgard II proved very effective under the highest pre-Christmas pressure experienced in years. If it had not been effective, all plants would have been attacked by heliothis, rather than one plant in 100. Efficacy was excellent.

In fact it was so good that there was almost certainly no carryover of uncontrolled heliothis from Bollgard in January and February. There was very little heliothis activity in cotton crops in the new year throughout the industry, except where there were alternate host crops, such as sorghum.

CONCLUSIONS

The success of Bollgard at controlling heliothis means that consultants and researchers should now concentrate on understanding the effects of sucking pests and various aspects of agronomy on Bollgard production. Except for pupae busting, integrated pest management as it relates to heliothis control is not relevant to Bollgard. But IPM in relation to sucking pest management is very relevant.

There is also an environmental benefit of not spraying larvicides on Bollgard II, and an economic benefit to growers which will be difficult to quantify. The very low heliothis activity in the second half of the season was no accident.

It occurred because Bollgard gave such good control in November and December and there were no escapes to pupate and reinfest later. This pattern will continue until resistance to the two genes occurs and that is not likely for some years.

January and February are normally the highest cost months with full conventional cotton, but with Bollgard dominant yet not in full planting, the average cost of insect control per hectare was reduced. In 2005–06 Bollgard will cost $300 per hectare for the licence plus up to $50 per hectare more for sucking pest control.

The average cost of conventional cotton will depend on the area planted and the area of alternate host crops planted in spring. It could well be less than $350 per hectare as it has been in many cases this season. So in future, growers should consider a mix of Bollgard and conventional cotton. The optimum percentage of each will be difficult to estimate, particularly as yields between the two types seem variable.

In this scenario Bollgard itself is the trap crop. But since it is also the commercial objective all our eggs are in the Bollgard basket. To maximise and maintain its effectiveness therefore, all other sources of heliothis infestation, such as other host crops and overwintering pupae, must be controlled or eliminated. This will need full cooperation between neighbours — a great advertisement for area wide pest management.