Bollgard ... Ingard ... conventional ... whatever

By John Barber, Consultant, St George

The 2003–04 season was the first with large scale commercial Bollgard II production in the Australian cotton industry. Everyone saw how it changed pest management practices, but what about agronomy?

It was under development for a few years before release and there were seven years of Ingard before it, so there has been plenty of time to note the effects, if any, of pest control genes on agronomic traits. In 2002–03 trials, Bollgard was apparently higher yielding and earlier than conventional cotton in some areas.

In the spring of 2003–04, the best advice said that it did not need Pix because its heavy boll load prevented excess vegetative growth. The main problem was early cut out, but no one knew how to avoid it.

In fact most of the advice was speculation. There was no data to support it. I questioned why Bollgard management would be so different to that for Ingard or a high yielding conventional crop.

The heliothis pressure in 2003–04 was well above average — in all areas apparently. This should have favoured Bollgard, but at St George the Bollgard crops I observed just before picking did not appear to have greater boll loads than some Ingard and conventional crops.

If that observation would later be confirmed by yields, it would almost certainly not have been due to poor weed control, fertiliser or soil preparation differences between fields. Without doubt these variables had been optimised across the farms by very good managers.

Nor was there a problem with Bollgard efficacy. The product is perfect at heliothis control, since the probability of two mutations occurring at the appropriate gene sites at a single mating event is effectively nil.

The new Bollgard varieties should also be well adapted to the district. They are indeterminate and mid to long season types, just like CS189 and Delta Pearl, which have been very reliable performers at St George for many years.

The greatest management difficulty with Bollgard arose from not finding expected differences in fruit retention and Pix requirement.

Indeterminate varieties are also less likely to “cut out”, that is, to stop growing when the nutrient and photosynthetic demands of a high boll load exceed the ability of the plant and soil reserves to supply those needs.

As the season progressed I would say that the greatest management difficulty with Bollgard arose from not finding differences in fruit retention and Pix requirement, which, from all advice received, were expected to occur. I also considered that advice on plant population, secondary pests and maturity was questionable.

Apart from the absence of heliothis, there were no obvious differences between Bollgard, Ingard and conventional cotton. By the end of the season I had decided that none of the early advice was applicable to St George. Instead I felt that the priority was to test the effects of Pix and foliar nutrition on boll retention and yield. The following article outlines the reasons for this opinion.

TABLE 1: Crop requirements for a 10 bale yield

Plant population	10 plants/m
Total nodes/plant	22
Vegetative nodes/plant	7
Fruiting nodes/plant	15
Maximum potential first and second position fruit/plant	30
Required bolls/plant for 10 bales/ha	16
Required retention for 10 bales/ha	53%

Management of Ingard and conventional cotton

The best methods of soil preparation, including pupae busting, basic fertiliser usage and weed control options are independent of cotton type and well established. After many years of success, my clients are also convinced that the interaction of low sowing rate, early tip damage and Pix applications to indeterminate varieties maximises yield and profit.

They know that a plant population of six to nine seedlings per metre with minimal spraying before first flower, promotes early tip damage which causes several stems per seedling to develop. Pix is applied in mid December at up to 500 ml per hectare and in late January or early February at one litre per hectare.

Pix accelerates maturity which is delayed when pest damage occurs, both early and mid season. Late Pix helps us mature all bolls on the plant, particularly those on the last four or five nodes. Without Pix, these will be immature or lost altogether. It is a predictable result.

Early pest damage is a necessary component of this management system. It causes additional stems to be initiated near ground level, which in turn results in a more spreading growth habit.

This is the quickest way to fill gaps. We can then continue with low or variable plant stands when others might replant. Yields exceeding 10 bales per hectare have been achieved repeatedly and fewer insecticide sprays applied.

On the other hand, at high plant densities the reverse case applies. Early tip damage to a population of 15 seedlings per metre must be minimised by spraying because it increases the height of the first fruiting branch and increases competition between seedlings.

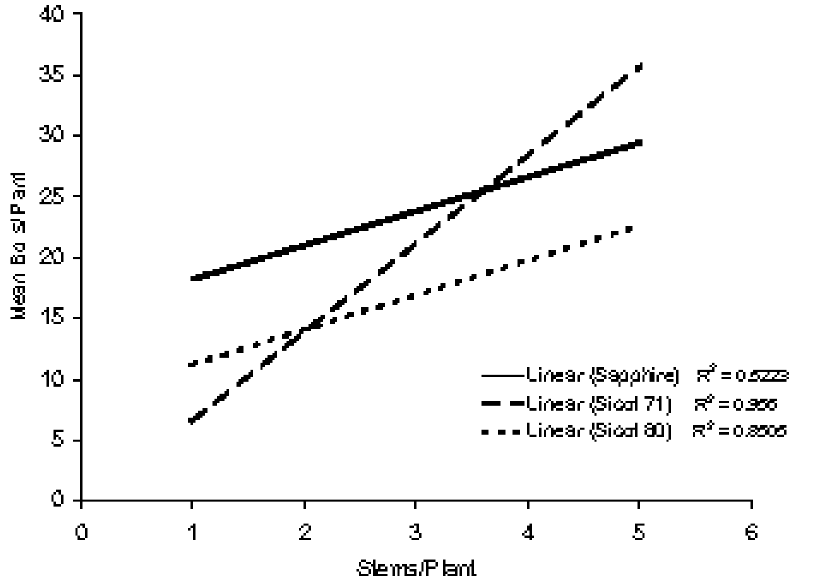
The Bollgard hypothesis

The desirable plant population for Bollgard was recommended as 12 to 15 plants per metre. But I was concerned that tipping out in high plant populations combined with exclusion of Pix from the management program would allow excess vegetative growth, regardless of fruit retention, and leave us without a top crop at the end of the season.

I also suspected that the three way interaction between plant population, early tip damage and Pix would work with Bollgard, which would be free of larvae but often subject to early attack from sucking pests, such as mirids.

In 2003–04 I had only a few fields of Bollgard to supervise across all clients before the anticipated 50 to 60 per cent adoption in 2004–05. I decided to omit Pix and test the hypothesis that in the absence of spraying for the major pest, secondary pests like mirids, aphids and mites would be checked by a greater number of beneficial insects and therefore also not require spraying. Pix would be used as always on conventional and Ingard cotton, so the effect on the farm average of not using Pix on Bollgard, if any, would be minimal.

FIGURE 1: The relationship between stems per plant and bolls per plant in conventional varieties



Higher fruit retention in Bollgard should counter the need for Pix and also prompt the no spray decision for mirids. It was only necessary to keep an eye on the numbers of fruit retained to be sure that we were always on track for at least 10 bales per hectare and if not, to consider why not. This was the essence of integrated pest management applied to Bollgard.

58 ▷

◁57...BOLLGARD MANAGEMENT

Fruit retention

The cotton plant initiates many more squares than are finally matured as bolls. In fact only 50 per cent need be retained for a very satisfactory yield (Table 1).

At the end of the 2003–04 season I decided to estimate actual numbers for some of these variables across the three cotton types. This would assist the decision on whether it was necessary to control early mirids, and if so, the potential yield increase.

Materials and methods

Individual cotton plants were assessed in 17 one metre samples in six different crops in the week before picking. The crops comprised two Bollgards, one Ingard and three conventional varieties, each chosen at random. All except the Bollgard on field F7 were from my clients' farms and I did not consider that there were management differences between the six that might have limited yields.

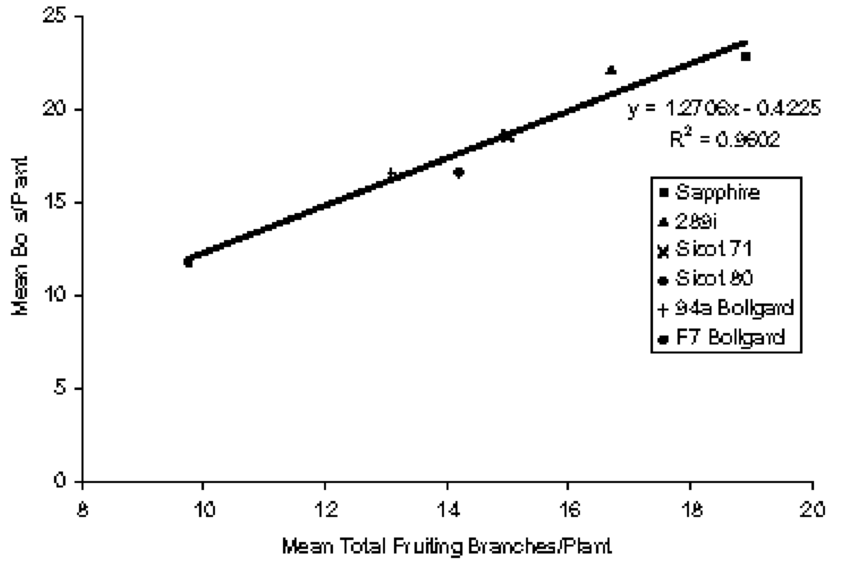
Variables measured were plants per metre, plant height, stems per plant, bolls per plant and number of fruiting branches carrying more than one boll per branch. From this data, the number of fruiting branches (FB) with one boll per branch, total fruiting branches, number of fruiting branches per stem, per cent retention (%R) of first plus second position fruit and bolls per metre were derived. Finally field average yields were determined by machine picking.

Mean data for each site are presented in Table 2.

Pests

The response of the conventional varieties to early tip damage is shown in Figure 1. At populations of six to nine plants per metre there is a positive correlation between the number of stems per plant and the number of bolls per plant. The conventional varieties averaged 3.0 stems per plant, which reflects early larval feeding, while the Ingard and Bollgard lines averaged 1.4 stems per plant.

FIGURE 2: The relationship between fruiting branches per plant and bolls per plant



Damage in the Ingard and Bollgards was caused by sucking pests, probably green mirids. Mirids were regarded by most people as a significant pest in 2003–04. The F7 Bollgard field received four mirid sprays while the other varieties had one mirid spray each.

At a third Bollgard site (not tabled), all insecticide sprays were omitted and the yield was 10 bales per hectare. Therefore I would be confident that the small amount of tip damage caused by sucking pests in Bollgard could be tolerated.

It is worth noting that some Bollgard crops were sprayed for aphids and mites, even after just 60 ml per hectare of Regent had been applied early to control mirids. On the other hand, Ingards generally did not seem to be bothered by these other pests, even after Regent or dimethoate was applied early and a larvacide late. Nor were there mites in conventional cotton. I suspect that petroleum spray oil, which was added to all insecticide sprays on Ingard and conventional cotton, suppressed aphids and mites.

Pix

Pest management of the conventional varieties included one or two Pix sprays, depending on the plants' growth habit. Sapphire and Sicot 71 are more determinant than Sicot 289i and received less Pix.

Both Bollgards in this study would have benefited from Pix. They averaged 11.5 fruiting branches in 116.5 cm with the top 30 cm totally unproductive. In contrast, the 289 Ingard had 17 fruiting branches in 109 cm. It was finished with one litre per hectare of Pix in late January and picked right to the top of the plant. The more indeterminate Sapphire had 19 fruiting branches in 90 cm while Sicot 71 had 15 in 100 cm with low Pix rates.

Pix was applied to the Bollgard block which was not sprayed with insecticides. It was applied later than I wished, but it reduced rank growth and top bolls were filled, so I suspect rate and timing were close to optimum.

My clients have used all the Pix in St George on Sicot 189, 289i and Pearl types over the years, but we will cut rates back with the increasing popularity of the

60 ▷

TABLE 2: Plant structure and yield characteristics

Field	Variety	Plants /metre	Plant Ht (cm)	Stems /plant	Bolls /plant	Bolls /metre	% Retention	Yield (b/ha)	Fruiting Branches			
									1 Boll/br	>1Boll/br	Total FB	FB/stem
F7	Bollgard	12	114.9	1.4	11.75	141	59.9	9.25	8.0	1.8	9.8	7.0
94b	Bollgard	9	118.5	1.1	16.6	150	63.4	9.25	9.75	3.3	13.1	11.9
SK4	289i	7.25	108.7	1.7	22.6	164	66.5	11.75	12.1	4.9	17.0	10.0
K4	Sicot 71	6.25	99.5	2.7	19.0	119	62.1	11.25	11.9	3.4	15.3	5.7
K1	Sapphire	6.7	90.1	3.2	23.0	154	60.5	10.0	15.7	3.3	19.0	5.9
133-1	Sicot 80	9	96.6	3.2	17.1	154	59.0	9.75	12.2	2.3	14.5	4.5
	Mean	8.4	104.7	2.2	18.3	154	61.8	10.21	11.6	3.2	14.8	6.7

◁58...BOLLGARD MANAGEMENT

more determinate Sapphire, Sicot 71 and their Bollgard derivatives.

Fruit retention

The F7 Bollgard field had the least bolls per plant (36 per cent below the mean) and also the least fruiting branches per plant — whether with one boll per branch or more than one boll per branch. Across all varieties, mean bolls per plant was strongly related to mean total fruiting branches per plant (Figure 2).

There was a similar relationship between bolls per metre and fruiting branches per metre. All varieties averaged only 1.2 bolls per fruiting branch, or 60 per cent retention, given a potential two fruiting sites per branch. This was unexpected, particularly in the Bollgards, where we had been advised to expect high fruit retention.

Perhaps 60 per cent retention is high. It is enough to give a yield in excess of 10 bales per hectare with 15 fruiting branches, but not with 10, as in the F7 Bollgard. The plant population of the F7 Bollgard was almost twice that of Sicot 71 and Sapphire, but was still not enough to compensate for the low number of fruiting branches.

Nutrition

Individually, Sapphire, Sicot 71 and 289i had more bolls per plant and more fruiting branches per plant than each of the other varieties. Comparing means, the two characteristics were 37 per cent and 41 per cent greater in Sapphire, Sicot 71 and 289i.

All three were from the same farm where foliar fertiliser was applied regularly before row closure and also a few times after. Therefore foliar nutrient sprays may have improved boll retention and yield. In fact, mixes of foliar nutrient, Pix and petroleum spray oil will probably be the only sprays that Bollgard will need.

Conclusions

This work suggests that it may be unnecessary to control early sucking pests in Bollgard. It also supports the use of Pix in Bollgard to reduce excess vegetative growth and to hasten maturity. Each of these factors has a positive influence on yield. Contrary to expectations, fruit retention was not higher in Bollgard than Ingard and conventional cotton.

The relatively modest yields of the Bollgards should not be a concern. They will be improved with better agronomic inputs.

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The lack of knowledge on agronomy and plant physiology of Bollgard is a concern. There is always far more information accompanying the release of a new herbicide or insecticide than has been offered with the Bollgard technology.

For example, the question of optimum plant population is still outstanding. A high population may reduce the risk of early seedling loss from disease or harsh environment in both Bollgard and conventional cotton, but there is no evidence that it directly increases yield in either.

I thank Brian Hearn who first proposed that early pest damage would increase yield, my clients whose trust was essential to the development of our pest management system over many years and Jane Rigg for critique and proof reading.