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FRUIT RETENTION AND COMPENSATION IN AUSTRALIAN COTTON

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Abstract

Integrated pest management (IPM) has been a major focus of the cotton extension program for the Australian cotton industry. The Australian cotton industry extension model involves Cotton Industry Development Officers (Cotton IDO's) located within each major cotton growing region. A key component of the Cotton IDO role is the adaptation of research at a local level primarily through on-farm trials and demonstrations. The work presented in this paper is the results of a series of on-farm trials carried out across the Australian cotton growing areas in a collaborative effort by researchers and the Australian Cotton Industry Extension Network.

The introduction of Bollgard II® technology has raised some issues regarding high retention crops.

- Does Bollgard II compensate for early season damage to the same extent as conventional cotton?
- What is the impact of the high early retention seen in Bollgard II?
- Will fruiting factor ratios also apply to Bollgard II crops?

Imposing some damage to Bollgard II crops to simulate early season insect damage eg mirids has been demonstrated to impact on yield to varying extents compared with undamaged treatments. Obviously where damage treatments were severe there was a negative impact on yield. However, in most cases simulating insect damage either through fruit removal or terminal damage improved yield. The impact of different Bollgard II retention levels on fibre quality was also included in this work.

The adoption of dynamic insect pest thresholds has meant a more flexible approach to insect pest management. Consequently, monitoring of crop growth rates and fruit development to avoid excessive crop damage is even more critical. An alternative technique for monitoring crop fruit load is the Fruiting Factor. This technique considers fruit in all fruiting positions. The optimum fruiting factor varies depending on crop development stage. The range of fruiting factor values associated with optimum yield has been identified for each crop development stage. Assessment of fruiting factor during the 7-10 day period after first flower can provide a useful indication of the yield potential of the crop and whether there is a significant risk to crop yield and maturity. Monitoring of fruiting factors gives some safety guidelines when using dynamic insect pest thresholds.

Introduction

Integrated pest management (IPM) has been a major focus of the cotton extension program for the Australian cotton industry. The Australian cotton industry extension model involves Cotton Industry Development Officers (Cotton IDO's) located within each major cotton growing region. A key component of the Cotton IDO role is the adaptation of research at a local level primarily through on-farm trials and demonstrations. The work presented in this paper is the results of a series of on-farm trials carried out across the Australian cotton growing areas in a collaborative effort by researchers and the Australian Cotton Industry Extension Network.

Early season compensation in Bollgard II®

Fruit load is obviously a key aspect in determining crop yield and maturity. The loss of fruit during squaring and early flowering is less critical to yield than fruit loss later in the season. It is well documented that excessive early fruit loss can delay final maturity, however it is also known that holding too much fruit can reduce crop growth, cause premature cutout, and thereby reduce yield. The introduction of Bollgard II® technology has raised some issues regarding high retention crops.

- Does Bollgard II compensate for early season damage to the same extent as conventional cotton?
- What is the impact of the high early retention seen in Bollgard II?

Fruit removal treatments

Treatments included:

- Control
- 25% fruit at first flower removed
- 50% fruit at first flower removed
- All fruit at first flower removed

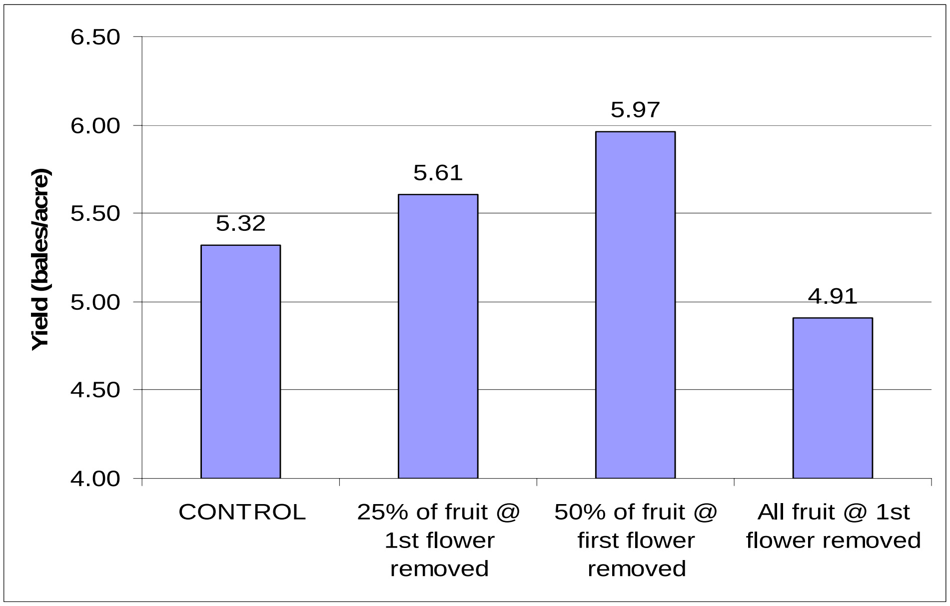

Figure 1. Effect of different fruit removal treatments on yield (bales/acre)

Both the 25% and 50% fruit removal treatments increased yield relative to the control. The 25% fruit removal treatment resulted in an increased yield by 0.3 bales per acre and the 50% fruit removal treatment an increased yield by 0.65 bales per acre. However, only the yield increase following the removal of 50% of fruit was statistically significant. The treatment with all fruit removed at first flower yielded significantly lower than the other fruit removal treatments. Maturity (days after sowing to 60% open) was delayed in all the fruit removal treatments. The 25% fruit removal treatment was delayed by approximately 3 days, the 50% fruit removal treatment by approximately 7 days and the treatment with all fruit removed at first flower approximately 10 days.

All fruit removal treatments had fewer total bolls per metre. The 25% and 50% fruit removal treatments had significantly higher amounts of lint per boll. This indicates that these treatments compensated for fewer boll numbers through increased lint per boll. The treatment with all fruit removed at first flower put on more bolls to reach total boll numbers similar to those for the control, however, the amount of lint per boll was reduced compared with the other treatments.

Table 1. Total harvested bolls per metre and lint per boll (g) for each treatment.

Treatment	Total harvested bolls per metre	Lint/boll (g)
Control	132.5 a	2.23 a
1/3 fruit removed	121.5 a	2.57 b
2/3 fruit removed	122.8 a	2.70 b
All fruit removed @ first flower	133 a	2.07 a

Bollgard II is able to compensate for some fruit damage up until flowering. In this case this damage even resulted in some yield increase. Where there was moderate damage (25% and 50% fruit removal) compensation appeared to be in the form of greater lint per boll. Where fruit removal was more extreme (all fruit removed) the plant had to compensate by re fruiting the plant and putting on more bolls of less lint per boll. The lateness and extremeness of this treatment was such that the plant was unable to compensate within the remainder of the growing season.

Fruiting Factors – How to measure it

The following information on fruiting factors has been modified from Gibb et al (2002) based on coordinated trials carried out by the Australian National Extension Team.

The adoption of dynamic insect pest thresholds has meant a more flexible approach to insect pest management. Consequently, monitoring of crop growth rates and fruit development to avoid excessive crop damage is even more critical. An alternative technique for monitoring crop fruit load is the Fruiting Factor. The concept of fruiting factors was developed in 2000 in response to comments from growers and consultants that monitoring first position fruit retention by itself was not providing an effective guide to crop performance, particularly in situations where high early fruit loss and excessive vegetative damage, tipping out, has occurred. It was felt that because first position retention didn't consider secondary fruit, it underestimated the ability of a crop to compensate for fruit loss and this could in turn cause unnecessary reduction in pest thresholds. Figure 2 demonstrates some of the variability in first position fruit retention from fields of the same yield.

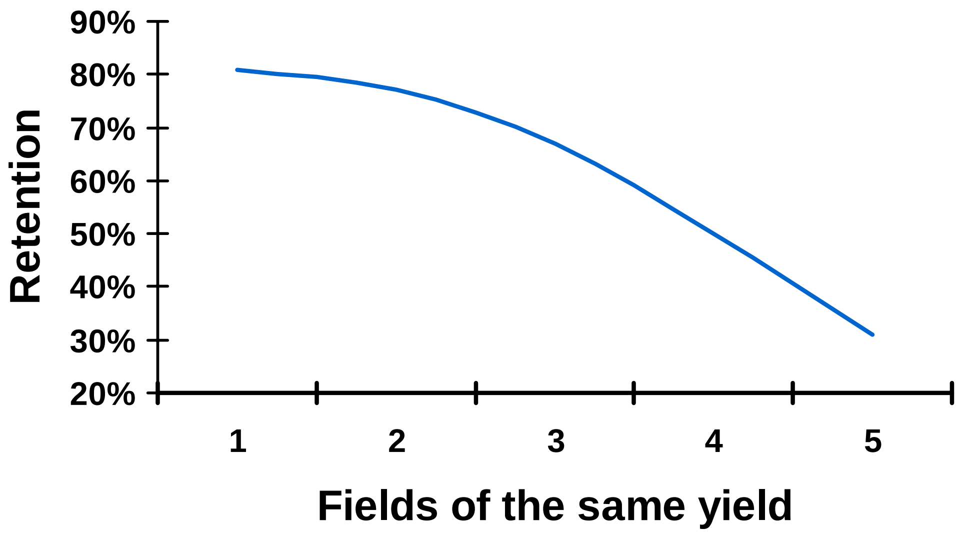

Figure 2. First position fruit retention for fields of the same yield.

Plant monitoring has always been an important component in the management of insect pests. Growers and consultants have recognised that cotton has a high capacity to compensate for early vegetative and fruit damage. With the aim to reduce insecticide costs without affecting yield or crop maturity it is important to have guidelines for the levels of damage that can be tolerated.

Through monitoring fruiting factors, insect thresholds can be managed in accordance with yield expectations. Fruiting factors provide a measure of fruit load that can be related to crop yield potential and maturity. Fruiting factor has been developed to consider both fruit counts and the number of fruiting branches.

To determine a crops fruiting factor, simply divide the fruit count by the number of fruiting branches.

$$\text{Fruiting Factor} = \frac{\text{total fruit count per metre}}{\text{Total number of fruiting branches per meter}}$$

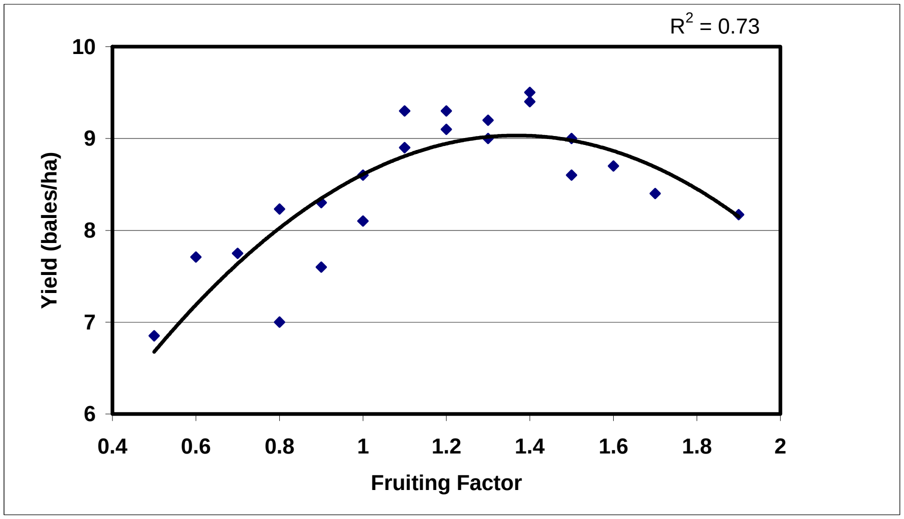

Figure 3. Fields of various yields versus fruiting factor at flowering.

A key period for measuring fruiting factors is at flowering. In assessing the average fruiting factor across all the trials, maximum yield was generally produced with a fruiting factor of 1.1 to 1.3 at flowering. Assessment of fruiting factor during the 7-10 day period after first flower can provide a useful indication of the yield potential of the crop and whether there is a significant risk to crop yield and maturity. Table 2 provides a general guide to fruiting factors at flowering. The objective is to use this information in conjunction with information on pest abundance to make better decisions regarding the need to control pests.

Table 2 General guide to using fruiting factors at flowering

Fruiting Factor at Flowering	Impact on yield and maturity
Less than 0.8	High risk if yield decline and maturity delay. Particularly in cooler regions
1.1 to 1.3	Optimum for yield
More than 1.5	High risk of premature cutout and yield decline.

Across all trials there was a decline in yield for crops that held excessive fruit loads at flowering, that is fruiting factors greater than 1.5. This clearly shows that high fruit loads can be detrimental to crop performance. The higher the fruiting factor the greater the number of fruit per fruiting branch. Once a crop has flowered the plant begins to prioritise boll development over vegetative growth. When fruit load exceeds the plants ability to support effective boll development and additional vegetative growth, the crop begins to shut down or progress to cutout. This can be an advantage if we want an early maturing crop, however premature cutout can result in reduce yield, as clearly indicated by crops with fruiting factors greater than 1.5 at flowering.

The optimum fruiting factor varies depending on crop development stage. The range of fruiting factor values associated with optimum yield has been identified for each crop development stage. Table 3 details how fruiting factors can be used as a tool throughout the season to assess crop fruit loads. The values shown in Table 3 provide a guide to interpreting fruiting factors throughout the season and indicate values that will prevent any significant risk to crop yield or maturity.

Table 3 General guide to using fruiting factors throughout the season.

Stage of Growth	**Fruiting Factor**
Pre flowering	0.8 to 1.0
Flowering	1.1 to 1.3
Peak Flowering	1.3 to 1.4
Boll maturity	1.0

Monitoring of fruiting factors gives some safety guidelines when using dynamic insect pest thresholds. Fruiting factors can best be used when making a decision of whether or not to control insects just under or over threshold limits, or in situations where consistent low insect pressure has been present. For example, there is no value in controlling a pest infestation that is just over threshold if the crop is fruiting well and some damage can be tolerated without effecting yield. Another example is where the combination of below threshold populations of heliothis and mirids can reduce fruit retention if present in a crop for an expended period. By monitoring fruit load a decision can be made if such populations are worth controlling.

Simulating mirid damage

The introduction of Bollgard II® has resulted in reduced insecticide applications for Helicoverpa control and consequently sucking pest pressure has increased. Trials were conducted to address the problem of green mirid damage to squares & bolls in Bollgard II cotton. Currently we do not have a good understanding of how much boll damage from mirids feeding on cotton bolls can be tolerated without losing yield. Boll damage comparable to low, medium and high mirid infestations at three time periods during boll filling was simulated by injection of a pectinase enzyme solution. This will allow assessment of the relative degree of yield recovery from different levels of damage at different times during the season as part of a series of trials to better determine mirid thresholds in cotton

Each boll to be damaged received pectinase enzyme solution injected into 2 opposing locks at 1.0 µl per lock. The bolls selected for damage were 8-12 days old. This age corresponds to a boll diameter of 2.5cm. The solution was prepared by mixing one part pectinase (Sigma-Aldrich P4716 Pectinase from *Aspergillus niger*, solution in 40% glycerol) and 10 parts water. Since this enzyme may degrade in high temperature, the mixture was freshly prepared on the day of the application and kept on ice while in the field. Early damage took place 2 weeks after first flower (to ensure sufficient number of bolls of the appropriate age), mid and late damage treatments occured at five and eight weeks after first flower respectively.

Treatments
- Control
- 5 bolls/m, two weeks after first flower injected with pectinase (Early Low)
- 5 bolls/m, five weeks after first flower injected with pectinase (Mid Low)
- 5 bolls/m, eight weeks after first flower injected with pectinase (Late Low)
- 20 bolls/m, two weeks after first flower injected with pectinase (Early Medium)
- 20 bolls/m, five weeks after first flower injected with pectinase (Mid Medium)
- 20 bolls/m, eight weeks after first flower injected with pectinase (Late Medium)
- 50 bolls/m, five weeks after first flower injected with pectinase (Mid High)
- 50 bolls/m, eight weeks after first flower injected with pectinase (Late High)

Although trends existed, yields did not differ statistically between treatments (Fig 1). When damage imposed was high (i.e. 50 bolls per m) and either mid or late season, plants tended to be less able to compensate for boll damage. These treatments relied on damaged bolls for a considerable proportion of their lint yield and as a result they had a tendency to produce a lower yield. At other sites where this trial was conducted there was a yield penalty when treatments involving high levels of damage (i.e. when 50 bolls/m were injected) either mid or late season. It may be that the higher yield potential of this site (control averaged almost 14 bales/ha compared to around 10 bales/ha at other sites) may have meant that the crops were more able to compensate for the boll damage.

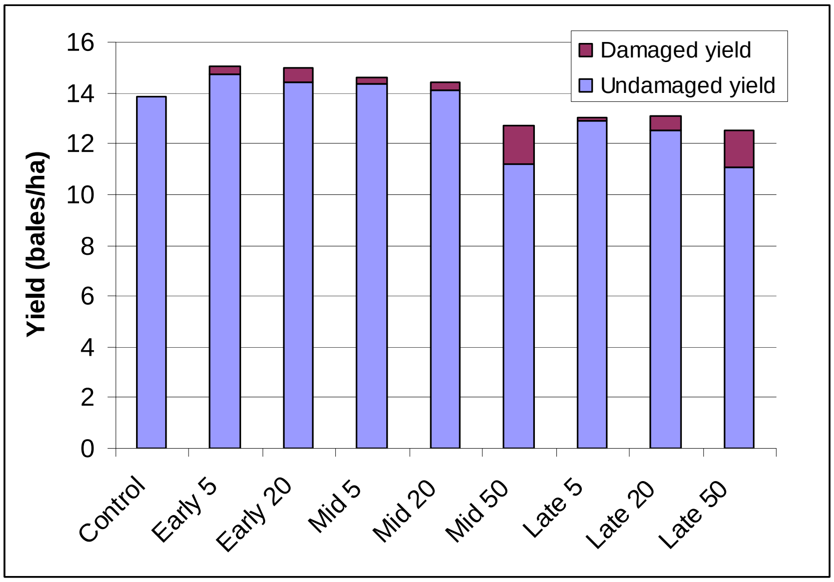

Figure 4. Yield (bales/ha) for each of the simulated mirid damage treatments.

None of the treatments imposed reduced lint yield at this site, although there was a trend for a reduced yield when high levels of damage were imposed mid or late season. This may have been the result of the high yield potential at this site as other sites with lower yield levels did record differences for these treatments. It appeared that there was some degree of compensation for early season damage through increased boll numbers as well as increased lint per boll in undamaged bolls. It would also appear that cotton can tolerate some degree of mid season mirid damage to bolls without significant loss of yield.

References

Gibb, D., Hickman, M. and MacPherson, I. (2002). Monitoring fruiting factors as a tool in insect management. *Proc. 11th Aust. Cotton. Conf.*, August 13-15th, Brisbane, Queensland, pp. 425- 431.

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