An Insight to Heliothis Thresholds for Ingard®

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Introduction

In managing insect pests growers are today faced with increasing insecticide resistance, a lack of new chemistry and increasing production costs. The introduction of transgenic *Bacillus thuringiensis* ,(BT- Cry1Ac), technology will allow a general reduction in insecticide use. However it is important to delay resistance to conventional chemistry for as long as possible, as their use will play a critical role in managing/delaying resistance to transgenic (Ingard®), plants. Therefore using appropriate *heliothis* thresholds for Ingard® crops is important.

Ingard® was first released for commercial use in the 1996/97 season. Prior to its release extensive trials were conducted to assess its performance against non Ingard® cotton. Most of these trials compared either conventionally sprayed or totally unsprayed Ingard® with conventionally sprayed non Ingard® cotton. No specific threshold trials were conducted. The results from this work indicated that the survival of *heliothis,* (in Ingard®crops), increased as the crops reached cutout or vegetative maturity. Survival was also found to increase during periods of waterlogging and cloudy weather. At that time research from other countries did not detect this trend in survival.

The level of *heliothis* survival, although less than that in non Ingard® cotton, was difficult to predict and highly variable. The survival rate of larvae though to the third instar (small) was less than that of larger larvae.

In considering all these factors the initial threshold recommendations for the control of *heliothis* in Ingard® was 3 small larvae and or 1 medium larvae per metre based over 2 consecutive checks. The threshold did not include eggs or first instar larvae (very small larvae <3mm). Consecutive checking was introduced to allow time for the surviving small larvae to feed and die. This was thought to be particularly important in times of waterlogging and cloudy weather.

Grower and consultant experience during the first year of release suggested that the threshold recommendations were to high and further investigations were required. In response, a series of large scale field trials, supported by Monsanto, were conducted across different growing regions during 1996/97 and 1997/98. This paper will discuss the broad conclusions made from the first year of trials as well as preliminary results collected last season.

Treatments and Yield Results

1996/97

Treatments

A 2 small larvae/m or 1 medium found on the first check

B 2 small larvae/m or 1 medium found over 2 consecutive checks

C 3 small larvae/m or 1 medium found over 2 consecutive checks

D Unsprayed #

Yield bales per hectare

Location	Treatments			
	A 2 L/m once	B 2 L/m twice	C 3 L/m twice	D Un-sprayed
Dalby		8.44	8.37	5.66*
Goondi	10.05	9.89	9.74*	
Moree		8.66	7.69*	
Upper Namoi		6.8	6.7	5.4*
Warren		9.92	10	9.4
Average		**8.74**	**8.50 ns**	

Dalby unsprayed treatment was sprayed twice and the Upper Namoi unsprayed treatment was sprayed once late in the season due to excessive damage.

* denotes significant result. ns denotes non-significant

1997/98

Treatments

A 2 small larvae/m or 1 medium found on the first check

B 2 small larvae/m or 1 medium found over 2 consecutive checks

C Pre-cutout - 2 small larvae/m or 1 medium found over 2 consecutive checks
Post-cutout - 2 small larvae/m or 1 medium found on the first check

D Unsprayed

Yield bales per hectare

Location	Treatments			
	A 2 L/m once	B 2 L/m twice	C 2 L/m twice + 2 L/m once	D Un-sprayed
Mungindi	8.63	8.48	8.55	8.38
Dalby	6.29	5.61	6.26	2.45#

Different variety from other treatments

Trials were conducted in other regions however results were not available in time for this paper.

General Conclusions

1996/97

Significant levels of *heliothis* larval survival were first detected in mid to late January. However this varied depending on insect pressure and crop growth stage. Three of the five trials were sprayed prior to the crops reaching cutout, (NAWF = 4).

Average yield results indicate that there was no significant difference between the consecutive check treatments of 2 small larvae/m and 3 small larvae/m or 1 medium larvae/m. However in respect to chemical use there was no difference in the average number of sprays applied between these two treatments.

To gain any advantage for resistance management one of the aims of developing a suitable threshold is to minimise the total number of sprays applied. Therefore, with no spray difference achieved by using the higher threshold of 3 small larvae/m there would appear to be no advantage in recommending this threshold for Ingard®. This simple conclusion does not consider the fact crop yields can be maintained despite a higher number of surviving larvae. The average number of medium plus large larvae present in the higher threshold, from mid to late January was almost double that found in the 2 small larvae/m treatment, (1.17/m and 0.64/m respectively).

In the one trial where spray decisions were based on a threshold being reached on the first check, no yield advantage was achieved despite two (2), additional sprays being applied. Thus lowering the threshold in this case was less profitable and increased selection pressure for resistance. On this basis such a threshold could not be recommended.

1997/98 - Preliminary results

Completely different results were produced in the two trials reported. In Mungindi the first treatment of 2 small larvae/m found on the first check was sprayed four (4) times and yet produced only a marginal yield increase over unsprayed Ingard®. While unsprayed Ingard® at Dalby resulted in a significant yield reduction.

The first sign of significant levels of *heliothis* survival occurred in early to mid December across both trials. Thus the difference in yield results may be explained by differences in insect pressure between the two regions rather than the performance of Ingard®. That is , the percentage of survival of *heliothis* may have been similar across both sites, however the overall insect pressure was higher at Dalby than at Mungindi. The average number of eggs found per check were 14/m and 4/m at Dalby and at Mungindi respectively.

The assessment of *heliothis* survival throughout the season and across different regions tends to support this conclusion. However, variation in the performance of Ingard® has also been observed across individual fields on the same farm. This emphasises the problem of making a single blanket threshold recommendation for Ingard®. Clearly more research is required to determine what factors effect the performance of Ingard®.

Accepting the Dalby trial endured consistent high *heliothis* pressure, it was encouraging to see the consecutive checks pre-cutout followed by first check post-cutout treatment producing a similar yield to spray decisions based only on a first check assessment. The total number of sprays were reduced by two (2), when using consecutive checks. It would appear that when under consistent high pressure, after cutout, consecutive checks may provide no advantage and increase the risk of yield loss. This is consistent with the increase in *heliothis* survival occurring post-cutout. Full conclusions, however can not be made until the results from other trials have been assessed.

Thresholds Need to be Dynamic

What ever recommendations are made for Heliothis thresholds they are not absolute. They are only a guide to what level of insect pressure can be tolerated without causing significant yield reductions. In terms of monitoring the impact of a pest population on crop yield, the duration for which a particular population is present in the crop may be more important than any one single infestation. The following diagrams demonstrate the impact of both the average number and duration of infestation, of medium and large larvae/m late in the season (from late January), on the yield of Ingard® cotton. These results have been extrapolated from the 1996/97 threshold trials. (*Heliothis* found two weeks prior to defoliation were not included in the data)

During the latter part of the season, how many large larvae can I carry?

The question is always raised on what number of *heliothis* can be tolerated without causing large yield reductions?

The answer to this question will depend on the stage of crop growth at which the infestation occurs. Figure1 shows the relationship between the average number of medium and large larvae that can be found at any time and crop yield. This would indicate that between 1 and 1.5 medium and large larvae/m can be tolerated in Ingard® during the latter part of the season without causing significant yield reductions

What is the impact of continual low pressure?

The next question often asked, is what would be the impact of a continual low infestation of medium and large larvae on the crop?

Figure 2 illustrates that an average infestation of between 0.5 to 1.0 medium and large larvae/m will not impact on yield. Again supporting the recommendation that 1 to 1.5 larvae/m can be tolerated without impacting on yield during the latter part of the season

Figure 1 Average number of medium plus large larvae/m present at each check and yield of Ingard®

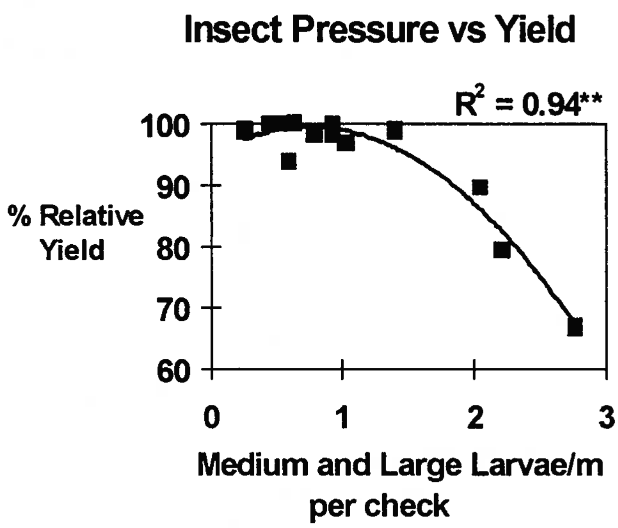
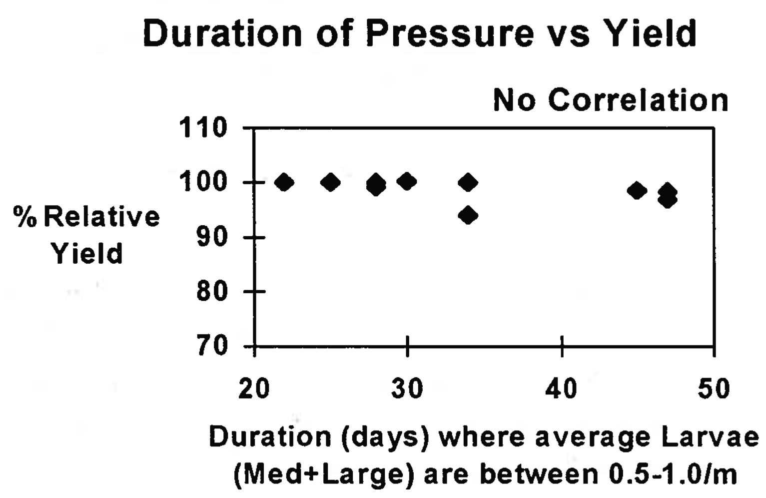


Figure 2 Duration of 0.5 to 1.0 medium plus large larvae/m present at each check and yield of Ingard®



Relative yield refers to the % of the highest yield achieved within each trial.

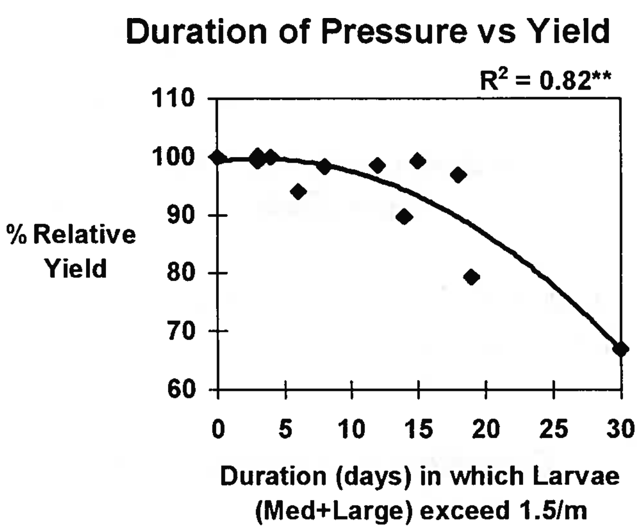
What happens with large infestations?

The answer to this question is difficult because it involves both the degree of the initial infestation as well as the duration of the infestation.

Figure 2 illustrated that between 0.5 - 1.0 larvae/m can be tolerated indefinitely late in the season. However figure 3 indicates that once larvae exceed 1.5/m such a infestation may be tolerated for 10 to 15 days before impacting on yield.

Clearly this result would depend on size of the infestation. This data represents a maximum continual average infestation of 2.8 larvae/m, with a range in the maximum initial infestation of 1 to 9 larvae/m.

Figure 3 Duration of more than 1.5 medium plus large larvae/m present at each check and yield of Ingard®



Conclusion

Variation in the performance of Ingard®, in its control of *heliothis*, has made it difficult to develop specific threshold recommendations. The current threshold recommendation is 2 small larvae/m (greater than 3mm), present over 2 consecutive checks or one medium larvae/m on the first check. Results from threshold trials conducted over the last two seasons indicate that this threshold can be used in most situations without causing any significant yield reductions. At this stage any variations from this recommendation would need to be related to the stage of crop growth and insect pressure.

In situations of low *heliothis* pressure the need to spray Ingard® crops may be questioned. Converse to this, is the situations of continual high pressure, where if left unsprayed significant yield reductions can occur. The question often asked, is if crops are under continual high pressure should an egg threshold be used to prevent any large escapes of larvae which prove difficult to control due to the high levels of insecticide resistance.

None of the treatments used within the trials included an egg threshold. Therefore it is difficult to comment on the value of an egg threshold for Ingard®. However in those trials where a treatment allowed a spray decision to be based on 2 small larvae/m found on the first check, only one trial, to date, has shown any significant yield advantage from using such a treatment compared to the recommendation of 2 small larvae/m (greater than 3mm), present over 2 consecutive checks. In this trial the use of consecutive checks pre-cutout followed by first check post-cutout prevented any yield reduction but at the same time reduced the number of sprays applied by two (2) compared to the sprays based on the first check. This reduction in total sprays may have significant effects in delaying insecticide resistance.

Assessment of the impact of larger larvae present in the crop indicates that from mid to late January 1 to 1.5 medium plus large larvae/m may be sustained without significant yield reductions. This knowledge can be used to determine the value of re-spraying any spray failures which may occur during the latter part of the season. The ability of the crop to tolerate these levels of larger larvae may also be used to develop future IPM strategies which reduce conventional insecticide use. The impact of sustaining these levels of larger larvae prior to mid January is unclear.

The title of this paper is "An Insight to Heliothis Thresholds for Ingard®". The trials outlined in this paper only examine how Ingard® can be used as a tool within current pest management systems. Clearly there is more work to be conducted to better understand the management of *heliothis* in transgenic plants. The technology will provide the industry with the opportunity to adopt IPM strategies which are less reliant on the use of conventional insecticides. Future programs need to focus on incorporating transgenic plants into novel approaches to pest management. Once this is achieved the true value of the technology will become obvious.

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