Insect Management and Plant Growth Interactions

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Introduction

Determining the level of insect infestation which causes economic damage (yield loss or significant crop maturity delays), is no simple task. The more we learn about plant responses to damage and those factors which effect plant and insect growth or survival, the more it is apparent that insect thresholds need to be dynamic rather than set on any one predetermined value.

In the past when insecticide resistance was limited and the cost of insect control relatively low, the economic benefits of using dynamic thresholds within IPM systems were not obvious, at least not in the short term. However, in the current environment of high insecticide resistance, any refinement of insect thresholds which allow a reduction in insecticide use has both short and long term economic benefits.

The introduction of transgenic (Ingard®), plants provides the opportunity to more towards more flexible and acceptable IPM strategies. Field experience with Ingard® indicates that the survival of *Heliothis* may vary across fields and during different times of the year. This fact forces a dynamic approach to insect thresholds to be taken.

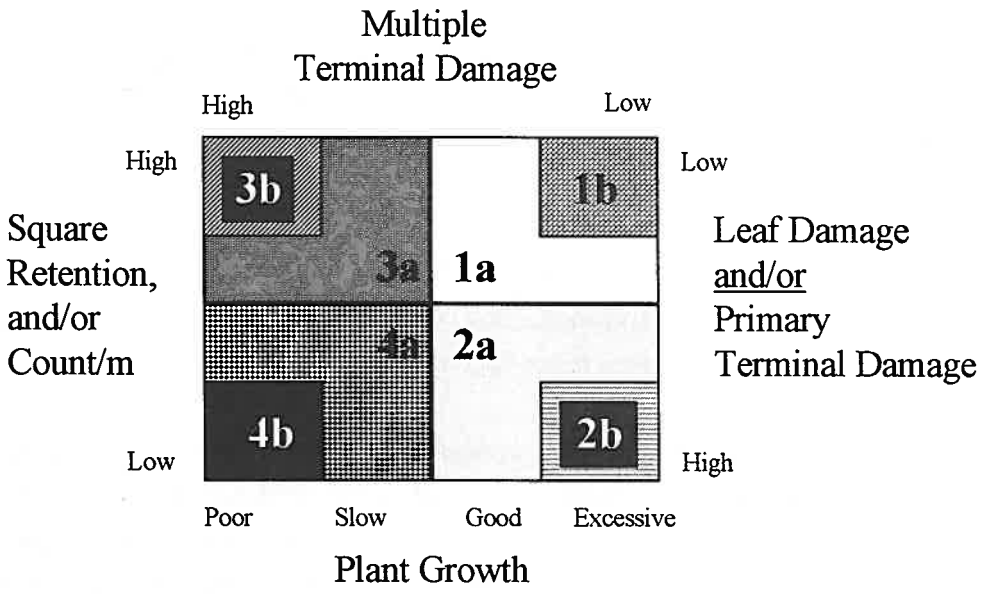
Using dynamic thresholds within an IPM strategy relies on balancing plant damage with the level of insect infestation. Many growers and consultants argue that dynamic thresholds can only be used in situations of light to moderate insect pressure. In part this is true, however in times of heavy insect infestation the management of those insects which escape the previous spray, common in times of high insecticide resistance, need to be based on predicting what level of plant damage may occur and can be tolerated.

In making a spray decision many factors other than insect control need to be considered. These may include areas of spray drift hazard and the location of sensitive crops. Through a greater understanding plant responses to damage and plant growth interactions different insect management strategies can be used throughout the farm.

The purpose of this paper is, in part to introduce a method for considering plant growth interactions, however its main aim is to promote the use dynamic insect thresholds. In saying this, if we accept that the industry already uses dynamic thresholds then the challenge is to broaden our comfort zones

for plant damage to levels where acceptable, not maximum, yields are achieved with minimum insecticide use. This will in turn reduce or delay insecticide resistance.

Plant Growth Interactions and Insect Damage



Why Consider Plant Growth Interactions in Insect Management

A range of insect pests attack cotton and cause different types of damage. It is important to try to understand what interactions occur when a crop endures a single or multiple types of damage. Apart from insect attack, many factors effect a crops growth and final yield potential. Individual plants and crops may respond in different ways to a given level of insect damage depending on the stage of growth when the damage occurred and the overall rate of plant growth. The study of host plant resistance (HPR), has shown that individual varieties may have different tolerance levels to damage. Environmental conditions under which a crop is grown also play an important part in the ability of the crop to tolerate damage. If we can better understand such interactions crop and insect management can be refined.

The "Plant Growth Interaction" diagram, above, is an attempt to provide a basis for interpreting plant growth interactions in respect to the different types of damage which may occur from insects.

Four broad categories of plant growth and damage are identified. These are in order of their impact on yield and/or crop maturity, (table 1). The sub-categories, **a** verses **b**, distinguish caution from action phases of management, that is sub-category **a** indicates low to moderate, acceptable, levels of insect damage and **b** indicates high or excessive damage.

At this stage no values have been placed on the categories. These will vary depending on the a individual growers tolerance level of crop damage. Suggested values, determined from research will

be added and promoted at a later date. At this stage the general principles of the diagram may be used to help growers with their consultants develop guidelines for acceptable crop damage and therefore strategies for insect management.

Table 1 Categories of plant growth and insect damage.

Category	Major Characteristics	Concerning Damage	Management Strategy
1a	Optimum growth with little damage	Low to moderate damage levels	Able to tolerate increased levels of damage
2a	Optimum growth with moderate levels of terminal and/or fruit damage	Fruit loss, only if it becomes excessive	Caution phase aim to minimise further fruit damage
3a	Reduced growth with moderate levels of multiple terminal damage	Multiple terminal damage, greater impact on maturity than yield	Caution phase aim to minimise further terminal damage and encourage growth
4a	Reduced growth with moderate levels of terminal, leaf and fruit damage	All levels of damage	High level of caution. Prevent any further damage and encourage growth

Plant Growth Factors to be Considered

Plant Growth

Crop growth rate forms the basis for all other interactions. A crop with reduced or poor early growth may respond differently to damage compared to a crop showing good growth. Plant growth may be measured in a number of ways. These include;

- Length of internodes;
- Rate of node development
- Rate of square development

Leaf Loss

Excessive leaf loss (due to thrips), may effect early plant growth which can be a concern particularly in cooler regions. Monitoring the number of nodes effected by leaf loss is important.

Terminal Damage - (damage to growing point)

Terminal damage has been divided into single (primary), and multiple levels of damage. Plants with single terminal damage may have little impact on yield and maturity, particularly is the damage occurs during the pre-squaring phase of growth. Multiple terminal damage (tipping), however, may cause delays in crop maturity and in cooler regions this could have a impact on yield. Terminal damage under conditions of poor growth may also be a concern.

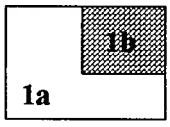
Fruit Loss

Excessive fruit loss is an obvious concern, however a high fruit load in conjunction with poor growth may also limit final yield potential. Fruit loss may be measured by the level of first position retention and total fruit counts. Retention and fruit counts may be used together to ensure that adequate fruit numbers are maintained.

Interpretation of Plant Growth Interactions

The following interpretation of plant growth/damage interactions, for each of the categories outlined above, should be used in conjunction with recommended insect thresholds. The objective is make an assessment of plant damage and its impact on crop performance prior to making a spray decision. However, in situations where high insect pressure exists, control may be necessary irrespective of the crop growth, (i.e. don't wait for excessive damage to occur if insect pressure is high).

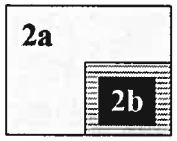
At this stage no specific values have been placed on the levels of damage that may be tolerated only a broad interpretation has been made. Growers/consultants can place their own values on what plant damage is acceptable. Interpretation has been broken into pre and post squaring phases of growth.



Category 1

1a - Good growth with moderate to low levels of plant damage.
1b - Excessive plant growth despite high fruit load.

Response - If excessive growth is evident, careful management is required to restrict crop growth. Monitor/check irrigation deficits to optimise irrigation timing. Avoid premature irrigation as this may compound high crop growth rates. Monitor crop nitrogen as a possible cause of excessive growth. Growth regulant use may be required however if fruit retention is high, avoid using high rates.



Category 2

Pre-squaring

2a - Crop has good growth but has suffered a moderate level of early leaf damage and/or primary terminal damage, no action required.
2b - Crop has good to excessive crop growth despite a high level of early leaf loss and/or primary terminal damage

Response - Due to good crop growth no immediate action is required however, continue to monitor crop closely and if terminal damage increases particularly multiple tipping, and/or the rate of plant growth is reduced further damage should be avoided (particularly in cooler regions).

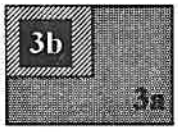
Post-squaring

2a - Crop growth is good however, fruit retention is reduced and/or a moderate level of terminal damage is present. No immediate action is required however continue to monitor crop closely in conjunction with insect checks.

2b - Crop growth is good or excessive however, fruit retention is low and/or a high level of post-squaring terminal damage is present. A high level of leaf loss may also still be present.

Response - The major area of concern would be to prevent excessive fruit loss. If this is a concern monitor for insect pests and if near or above threshold control may be required. With good crop growth plants should recover from any primary terminal damage. Caution should be taken to prevent increases in multiple terminal damage.

If crop has excessive growth careful management is required. Monitor/check irrigation deficits to prevent early irrigation. Monitor crop nitrogen. Growth regulant use may be required particularly if fruit retention is low.



Category 3

Pre-squaring

3a - Plant growth is reduced and the levels of multiple terminal damage may be increasing. The plants however, should be able to recover. Continue to monitor crop growth. If crop growth doesn't improve avoid any further increase in terminal damage.

3b - Reduced or poor plant growth is evident and some plants have received a high level of multiple terminal damage (both primary and/or secondary terminal damage.)

Response - Monitor for insect pests and control if near or above threshold. Aim to prevent any further increase in terminal damage.

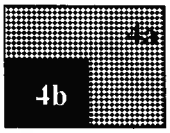
Post-squaring

3a - Plant growth is reduced and the crop may have received a moderate level of multiple terminal damage. Fruit retention is good. If terminal damage is limited to the pre-squaring stage of growth no

immediate action is required. If post-squaring terminal damage has occurred continue to monitor crop growth and if crop growth doesn't improve avoid any further increase in terminal damage. Only low to moderate levels of square damage has occurred, therefore given an increase in crop growth there should be little impact on yield.

3b - Reduced or poor plant growth is evident. Fruit retention is still good. If post-squaring terminal damage is high, monitor for insect pests and control if near or above threshold. If terminal damage is low, reduced growth may be a physiological characteristic rather than due to current insect pressure. High early retention in conjunction with poor plant growth may lead to early cutout.

Response - Careful management is required to increase plant growth. Monitor/check irrigation deficits and crop nitrogen requirements. Correct timing of the first irrigation will be important. Avoid any extra environmental / physiological stress, (i.e. water stress, herbicide stress, growth regulants). If fruit retention is high some fruit loss can occur without concern to help prevent premature cutout. Avoid any extra terminal damage.



Category 4

Pre-squaring

4a - Plant growth is reduced and the crop may have received a moderate to high level of early terminal and/or leaf damage . Multiple terminal damage may also be increasing. Due to poor growth continue to monitor crop growth and avoid any further increase in terminal and leaf damage. Monitor for insect pests and control if near or above threshold.

4b - Reduced or poor plant growth is evident and the crops have received a high level of early terminal and leaf damage (both primary and/or secondary terminal damage.) Leaf damage continues to occur beyond nodes 4 and 5.

Response - Monitor for insect pests and control if near or above threshold. Insect thresholds may need to be reduced until plant growth recovers. Check for any extra environmental / physiological stress that is contributing to the poor crop growth (moisture stress, disease, herbicide damage).

Post-squaring

4a - Plant growth is reduced and the crop may have received a moderate level of early terminal and leaf damage. Multiple terminal and post-squaring terminal damage may be present. Fruit retention may also be reduced. Continue to monitor crop growth and avoid any further increase in damage and other plant stress (i.e. water stress). Monitor for insect pests and control if near or above threshold.

4b - Reduced or poor plant growth is evident and the crops have received a high level of terminal damage (both primary and/or secondary terminal damage.) Fruit retention is low.

Response - Monitor for insect pests and control if near or above threshold. Insect thresholds may need to be reduced until plant growth recovers. Careful management is required to increase plant growth. Monitor/check irrigation deficits and crop nitrogen requirements. Correct timing of the first irrigation will be important. Check for any extra environmental / physiological stress that is contributing to the poor crop growth (moisture stress, disease, herbicide damage).

Summary

A sustainable future for the industry requires effective management of insecticide resistance. Any reduction in insecticide use will help reduce or delay resistance. Developing appropriate insect thresholds is an important step in managing resistance. Dynamic thresholds aim to balance plant damage with the level of insect infestation. If we can better understand interactions between different types of plant damage overall crop and insect management can be refined.

Plant growth interactions have been presented in the form of a plant damage matrix. This is the first type of "Plant Growth Interaction" diagram to be developed for cotton to help understand the interactions between factors which effect plant growth and crop yield potential. It provides a format for discussion and if found useful for crop / farm management the concept can be further developed. . Research continues to develop guidelines as to what levels of plant damage can be tolerated. The outcomes of this research can be incorporated into the plant growth matrix discussed in this paper.

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