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Diamondback moth pheromone trapping and pest scouting

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1 Executive summary

Diamondback moth (DBM), *Plutella xylostella,* is found throughout the world and is considered the most destructive insect pest of brassica crops. Control relies upon regular applications of insecticides from planting to harvest. This has led to the development of insecticide resistance in DBM in New Zealand. Recently, Crop & Food Research has developed an integrated pest management (IPM) programme for vegetable brassicas based on crop scouting and the use of economic spray thresholds. Crop scouting ensures that insecticides are only used when absolutely necessary, and that the choice and timing of any insecticide application are correct.

We investigated the use of pheromone traps to allow crop managers to assess periods when DBM larval numbers in the crop are likely to increase to damaging levels. Pheromone traps may help reduce the time required to scout crops and guide decisions concerning when to initiate crop scouting in spring and how often to scout.

In the 1999/2000 season, we field-tested and identified a suitable pheromone blend for use in the traps. During the 2000/01 season we monitored the male DBM population using pheromone traps at five sites, including four large commercial properties. We scouted these fields, following the IPM programme recommendations, to measure the DBM larvae present. This allowed us to determine whether there was a relationship between the numbers of DBM moths caught in traps and the number of DBM larvae in the field a set number of days later.

The pheromone trap catch data predicted subsequent larval infestations in most plantings during the period of the first two crops (spring to mid summer). However, large moth catches in late summer were not useful indicators of larval infestations in late crops. Most larval infestations were adequately assessed by normal scouting routines and weekly scouting is required during the high risk periods for other insect pests. However, pheromone traps may be useful indicators of high DBM larval infestations in early spring when insect pest infestations are erratic.

In conclusion:

- analysis of trapping field trials identified a suitable DBM pheromone blend for use in pheromone traps in New Zealand,
- increases in moth trap catches predicted two to four weeks ahead increases in larval infestations in four of five crops in spring and early summer,
- in mid summer, trap catches predicted larval infestations in all crops. Insecticide applications were required to prevent economic losses,

- moth trap catch data in late summer were of limited use in crop management,
- pheromone traps were of limited value in reducing scouting time in the main risk periods for DBM (from spring until autumn) because crops need to be scouted regularly for other pests,
- in early spring, pheromone trap data may usefully predict occasional DBM pest problems and signal the need for crop scouting,
- to utilise this technology, two traps should be placed out in early season crops (in early September) and monitored weekly,
- reductions in insecticide use in the commercial crops were attributed to the use of the Crop & Food Research IPM scouting programme and action thresholds.

2 Introduction

Diamondback moth (DBM), *Plutella xylostella,* is found throughout the world and is considered the most destructive insect pest of brassica crops. Previously, regular applications of insecticides were required, from planting until harvest. This has led to major problems with insecticide resistance in DBM in New Zealand. Recently, Crop & Food Research has developed an integrated pest management (IPM) programme for vegetable brassicas based on crop scouting and the use of economic spray thresholds. Crop scouting is essential to ensure that insecticides are only used when absolutely necessary and that the choice and timing of any insecticide application are correct.

Crop scouting for larval infestations is an effective method for deciding whether or not an insecticide application is required. However, it is time consuming. During parts of the crop cycle and various times of the year very few DBM will be present while at other times larval numbers will very quickly increase above an action threshold.

We are investigating the use of pheromone traps as a tool to forewarn growers or crop managers of periods when DBM larval numbers in their crops are likely to increase to economically damaging levels. This may reduce the time required to scout the crop. Pheromone trap catches may also guide decisions about when to initiate crop scouting in spring and how often to scout.

Female moths attract males using chemicals called pheromones. They release pheromones in very small amounts (often at dusk). When the males detect the pheromone they are stimulated and fly towards the female moth. Consequently, pheromones are a very powerful tool that can be used to monitor insect pest populations.

The first priority of this project was to find the best pheromone lure for catching the male moths in sticky traps. DBM pheromone blends can vary between countries so it was necessary to confirm the components and ratio of the pheromone blend released by DBM females in New Zealand. Correct pheromone identification also ensures that the lures are as cost-effective as possible.

Eight different blends of pheromone were field-tested at five sites in Pukekohe in the 1999/2000 season. Although virgin female traps outperformed the synthetic pheromone blends, the best of these blends was good enough to represent changes in DBM moth populations (see Rogers et al 2000, 2001).

This report covers the research undertaken in the second year of the project. During the 2000/01 season we monitored male DBM populations using pheromone traps containing the best pheromone blend at five sites, and scouted these fields to measure the DBM larvae found feeding in the crops. This allowed us to identify any link between the numbers of DBM moths caught in traps and numbers of DBM larvae in the crop a set number of days later.

3 *Methods for field-testing*

3.1 *Pheromone trap placement*

Pheromone traps were set in five brassica growing areas in South Auckland in early spring at Pukekohe, Bombay, Puni, Tuakau and Drury. Moth trap catches were monitored weekly throughout three crop cycles until late autumn at all sites, except Drury where monitoring took place for two crop cycles because brassica plantings ceased in mid summer.

At four of the sites commercial crops were growing with plantings varying in size from about 1 to 3 ha. At the four commercial sites, five traps were placed in new brassica plantings. One trap was positioned in the centre of the crop and four traps were positioned 10 m in from the edge of the centre of each side of the planting. The traps were labelled as north, east, south, west and centre traps. Lures (a rubber septa impregnated with a standard amount of pheromone) containing the best pheromone blend (as determined in the previous year's field study), were placed in the centre of the sticky base in standard delta traps. Traps were positioned about 30 cm above the ground when plants were small and were adjusted upwards as required to ensure they remained just above canopy height.

The fifth site was at Pukekohe Research Centre, Pukekohe, where the planting was small (about 600 plants, in 4 rows of 60 m length). Only two traps were deployed, 10 m in from the east and west ends of each rectangular planting.

3.2 *Trap monitoring and crop scouting*

All sites were monitored weekly until harvest when traps were moved to adjacent, new plantings. Lures were replaced every three weeks and sticky bases replaced as required (when the sticky surface was clogged up with moths or if the surface had lost its adhesiveness). Moths were not removed from the sticky trap base. The total number of moths present was recorded each week. The number of moths caught per trap per week was calculated as the number of moths caught from a trap position minus the total number caught the previous week from that particular trap. The number of moths caught per trap per week for each site was calculated as the mean of the five trap catches for the commercial crops, and as the mean of the two traps at the Pukekohe Research Centre.

At all sites, the number of DBM larvae per plant was counted from 50 or 100 randomly selected plants. These plants were sampled following the techniques recommended in the Crop & Food Research's scouting system to ensure a representative sample for that site (Berry 2000). Fifty plants were sampled at each site until larval infestations increased to more than 2-3 per 50 plants, at which stage the number of plants sampled was increased to 100. However, at Pukekohe Research Centre only 50 plants were sampled throughout the season because of the small area involved.

4 Results

4.1 Pheromone trap placement and performance

The pheromone lure appeared to work well and traps did not normally interfere with routine crop management practices (fertiliser and pesticide applications), although occasionally a trap was "knocked over" by machinery. If a trap was displaced, the mean catch for that week was calculated from the remaining four traps. The traps were easily moved from old crops into new plantings and sticky bases replaced at these times. There was minimal disruption to moth catches from changing lures or sticky bases (G Walker, personal observation). However, the white traps attracted bees, and in some traps large numbers were caught and died. At the Drury site, white delta traps were replaced by green traps, and bee numbers were greatly reduced.

4.2 Trap positioning in the crops

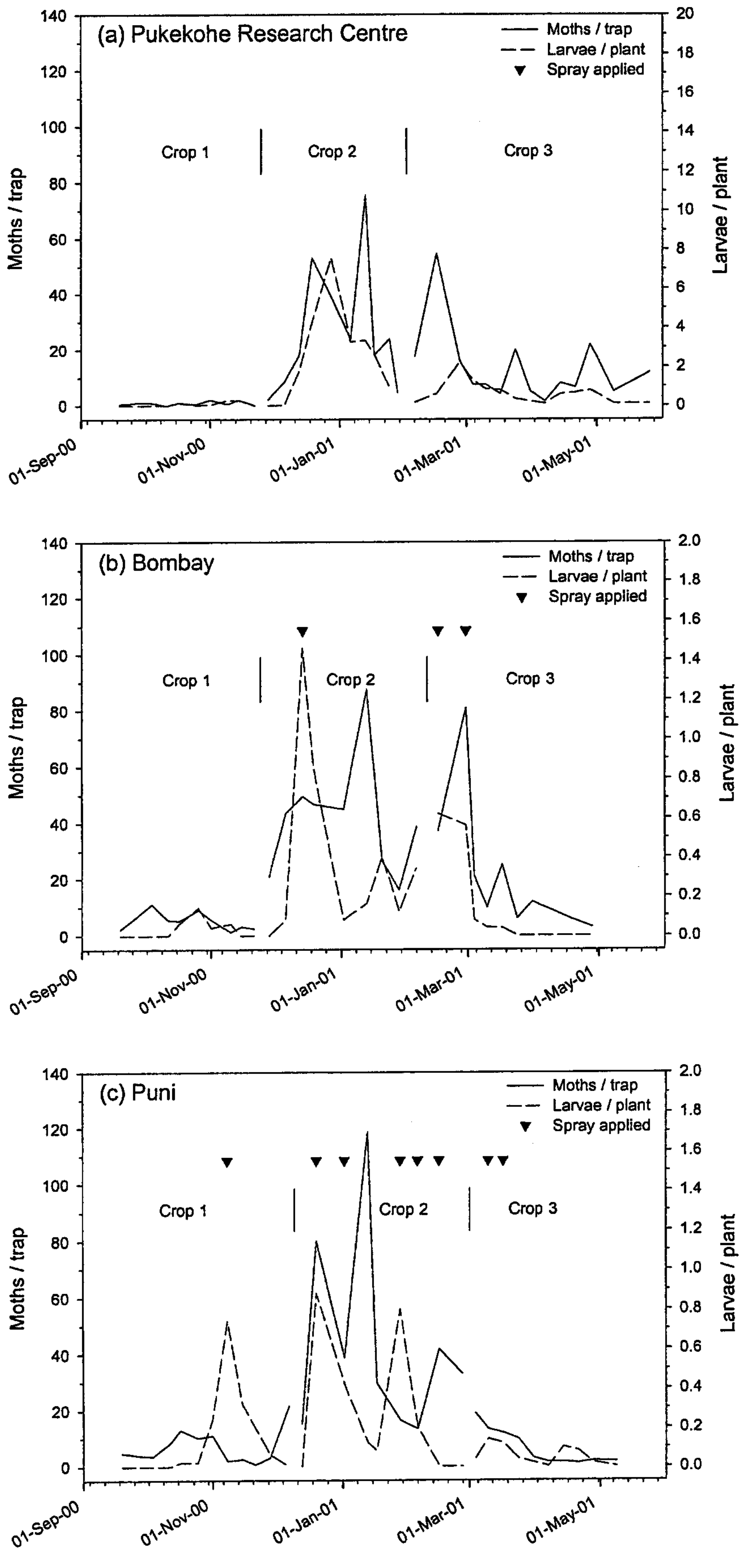
Differences in moth trap catches did not seem to be related to position of the traps in the crops, except at Drury where fewer moths were caught in the centre trap. This was probably due to the fact that it was the first season of brassicas in that area so initial infestations originated from small numbers of moths outside the crop whose progeny slowly spread into the crop (in other words there was very little outside recruitment, G Walker, personal observation). However, at the other sites, when traps were placed in newly planted crops immediately adjacent to older crops, moth catches were invariably higher in the trap (or traps) nearest the older plantings. Early season there also seemed to be a relationship between prevailing wind direction and initial moth catches, but this was not considered important (G Walker, personal observation).

4.3 *Trap monitoring and crop scouting – moth numbers versus larval counts*

At all sites, crop scouting began one week after placing the traps in the crops and continued weekly until all traps were removed and scouting ceased in early May when crops were considered to be safe from DBM larval infestations (G Walker, personal observation). This meant that three plantings were continuously monitored at all sites, except at Drury where brassica plantings were discontinued after the summer crop (mid January).

Growers normally initiate scouting to protect their spring plantings and start to look out for insect pests when temperatures increase in mid to late September, or early October, depending on weather conditions. At this time, scouting would be at weekly intervals and include checks for weed problems, disease symptoms and any irrigation or fertiliser requirements. Monitoring started early enough to detect any early insect pest infestations in these crops. Green peach aphid (GPA) (*Myzus persicae*) adults migrated into the young crops in early and mid September. However, colonies were rarely found and no control was necessary for this minor pest. Three crops had bad slug infestations that required treatment. Insect pest infestations were not a concern until about mid October when DBM and white butterfly larval populations increased rapidly.

Results from moth trap catches and crop scouting for DBM larval infestations are presented in Figure 1 (a-e). Breaks in the lines in Figure 1 indicate the removal of traps from crops that were about to be harvested to newly planted crops. Scouting of the new crops began as soon as the traps were placed in them, to ensure that no early larval infestations were missed. Insecticide applications for control of any insect pests are highlighted on each graph. No insecticides were applied to the plantings at the Pukekohe Research Centre.



(a) Pukekohe Research Centre
Moths / trap
Larvae / plant
Spray applied
Crop 1
Crop 2
Crop 3
Moths / trap
Larvae / plant
01-Sep-00
01-Nov-00
01-Jan-01
01-Mar-01
01-May-01
(b) Bombay
Moths / trap
Larvae / plant
Spray applied
Crop 1
Crop 2
Crop 3
Moths / trap
Larvae / plant
01-Sep-00
01-Nov-00
01-Jan-01
01-Mar-01
01-May-01
(c) Puni
Moths / trap
Larvae / plant
Spray applied
Crop 1
Crop 2
Crop 3
Moths / trap
Larvae / plant
01-Sep-00
01-Nov-00
01-Jan-01
01-Mar-01
01-May-01

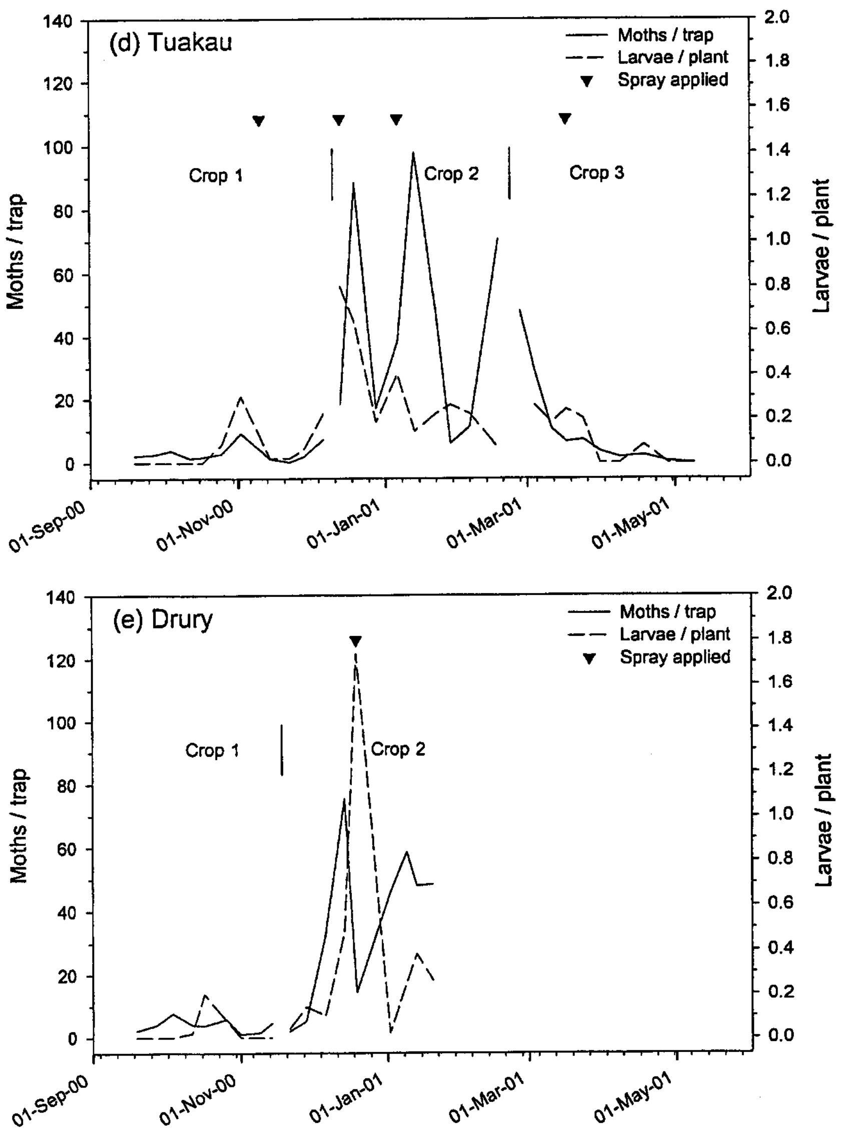


Figure 1: Mean number of diamondback moths caught per pheromone trap per week at five brassica-growing sites and average number of larvae per plant from 50/100 plants sampled weekly, and insecticide applications in the 2000/01 season.

At the Pukekohe Research Centre there were very few DBM, either moths or larvae, until early December when an increase in moth numbers was followed two weeks later by a large larval infestation. Many DBM parasitoids and predators were observed in spring at this site (G Walker, personal observation) and their activity most likely explains the lack of DBM. This site has had continuous plantings of brassicas for the past decade and some part of each crop has been left unsprayed, allowing considerable build-up of natural enemies. For most of the season, natural enemies exerted considerable control of the other key pests, particularly the new parasitoid, *Cotesia rubecula,* controlling white butterfly (*Pieris rapae*) larval populations (a range of 67 to 95% parasitism was recorded throughout the season) and aphid control by parasitoids and generalist predators (G Walker, personal observations).

At the other four sites, DBM larval populations (and other key insect pests and beneficials) were monitored following the Crop & Food Research scouting programme. When action thresholds were exceeded for any particular crop or growth stage, insecticide applications were recommended (see Berry (2000) for action threshold details). Recommendations were to use Bt sprays if the infestations were small and/or if the plants were small. If the infestations were large, and/or the larvae were generally of a large size, the new selective insecticides, Success (spinosad) or Steward (indoxacarb), were recommended. The recommendation to separate the different insecticides (Success and Steward) in different seasonal windows follows the insecticide resistance management rotation strategy (outlined in the IPM Manual) to prevent continuous selection for resistance in DBM to any particular insecticide class.

From time of trap placement, in early spring (early September) moths were caught every week in nearly every trap at every site. Initially the numbers caught were low, six or less per week at all sites, except at Puni where moth catches were a little higher. The first larval infestations corresponded with trap catches reaching about 10 or more moths in about half the traps at a site (data not shown). This increase in moth numbers happened 0 to 4 weeks before increases in larval infestations.

At the beginning of October small increases in moth trap catches at two sites (Drury and Bombay) preceded minor larval infestations later in the month. These were broccoli crops for where the action threshold is higher than in cabbage at the leafy stage (see IPM Manual). If these crops had been cabbage, the infestations may have reached the action threshold. In this case, these minor larval infestations did not require control.

In all four spring/early summer commercial crops (crop 1 for each site, see Figure 1), small outbreaks of DBM required spray applications at two sites (the action threshold was exceeded). Increases in moth trap catches (by about 2-3 times) preceded the buildup of DBM larvae in these crops at 3 of the 4 commercial sites. In the other crop, at Tuakau, increased moth trap catches did not precede the small but damaging larval infestation in this crop (which required spraying). In this crop, increases in moth catches occurred on the same day that damaging populations of larvae were detected.

In the summer crops (the second major planting), moth trap catches gave two weeks warning (a 2-10 times increase in number of moths was recorded) of damaging larval infestations in all crops. Larval infestations reached action thresholds in all crops, and growers applied selective insecticides (Btk products or Success) as recommended by Crop & Food Research scouts. An additional very early spray was required at Tuakau when traps were first moved to the second crop. This was not preceded by high moth catches in the first crop (all catches less than 10 per trap). One grower (at Puni) applied two applications of a broad spectrum, systemic insecticide for aphid control in February.

In mid to late January an epizootic (an outbreak of a fungal disease that attacks caterpillars, including DBM) associated with warm moist conditions led to a collapse in DBM larval numbers, particularly at the Pukekohe and Bombay sites. The fungal pathogen was identified as *Zoophthora radicans*, a naturally occurring fungal disease that will decimate DBM populations in mid summer if conducive weather conditions are associated with large larval populations (G Walker, personal observations). This epizootic was evident at all sites but much more noticeable at the Pukekohe Research Centre where larval infestations were much higher than at other sites (up to 7 DBM larvae per plant).

During the early growth period of the third crop, from late February to mid March, weekly moth trap catches were high and were not useful for predicting larval infestations, which occasionally required insecticide applications (see Figure 1 (b-d)). In autumn, high infestations of large looper caterpillars and large, white butterfly caterpillars required applications of the selective insecticide Steward, and a synthetic pyrethroid spray was applied at one site (Tuakau). The application of the broad spectrum insecticides at two sites during the season led to markedly reduced control from natural enemies (data not presented here) which led to further insecticide applications being required to keep the key caterpillar and aphid pests under control at these sites.

Other data from the trials, including results from scouting the crops for percent larval infestations of other pests, percent aphid infestations and information on levels of parasitism of the major pests, will be further analysed and reported in the proceedings of the New Zealand Plant Protection conference and, where appropriate, to growers in the Grower magazine.

Discussion

This intensive study highlights one of the key benefits of the Crop & Food Research's IPM programme, that is minimising insecticide use. In the four commercial areas, where growers followed the Crop & Food Research IPM programme, two growers applied no insecticides to their spring/early summer crop, while the other two growers applied only one insecticide spray. On the second, summer crop, two growers applied only one insecticide while a third grower applied two insecticides. Overall, one grower (at Drury) applied only one insecticide on two consecutive crops, while for the whole season (three consecutive crops) two growers (at Bombay and Tuakau) applied a total of three and four insecticides respectively. The fourth grower needed to apply a greater number of insecticides, particularly on the second, summer crop. This situation was partly due to outbreaks of cabbage gray aphid (*Brevicoryne brassicae*) and the use of broad-spectrum insecticides for aphid control, which subsequently led to further pest outbreaks because of reduced protection from natural enemies and the need for insecticide applications.

Overall, because of the predominant use of selective insecticides, there was little disruption to moth populations. However, the selective insecticides were applied to control DBM or other caterpillar infestations and disrupted the links between moth catches and larval populations in crops.

Overall, the pheromone traps were useful tools for predicting larval infestations in most crops in spring and early summer. However, the large moth catches in late summer were not useful indicators of larval infestations in later crops. Although trap catches in spring and summer usually predicted subsequent larval infestations, most larval infestations would have been adequately assessed by normal scouting routines because weekly scouting was required to monitor for emerging aphid and white butterfly infestations.

During these studies, trap catches in early spring (early September) did predict small, but potentially damaging larval infestations in late September. Under other circumstances (perhaps in other seasons or cabbage crops instead of broccoli), insecticide applications may have been necessary. Therefore, trap catch data may be useful indicators of emerging DBM larval infestations in spring.

6 Conclusions

- Data from traps set in field trials were analysed to identify a suitable DBM pheromone blend for use in pheromone traps in New Zealand.
- Green delta traps should be used instead of white traps to minimise bee captures.
- Increases in moth trap catches predicted by 2-4 weeks subsequent increases in larval infestations in four of five crops in spring and early summer. Some of these increases in larval populations did not require insecticide applications.
- In mid summer, trap catches predicted larval infestations in all five crops that subsequently required insecticide applications to prevent economic losses.
- Moth trap catch data in mid to late summer were too high to guide crop management.
- Although they predict larval infestations, pheromone traps are of limited value in reducing scouting time in the main risk periods for DBM (spring to autumn) because crops need to be scouted regularly for other pests.
- In early spring, pheromone traps may be useful for predicting occasional DBM pest problems and initiating crop scouting.
- Two traps should be placed out in early season crops (in early September) and monitored weekly. One trap should be placed in the centre of the planting. The other should be positioned at the centre of the side nearest any older planting or other host plants, and 10 m in from the edge.
- Reductions in insecticide use in the commercial crops were attributed to the use of Crop & Food Research's IPM scouting programme and action thresholds.

7 References

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8 Acknowledgements

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