# Final Report

## Improving the management of insect contaminants in processed leafy vegetables

Dr Gordon Rogers
Applied Horticultural Research Pty Ltd

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Level 8, 1 Chifley Square
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Tel: (02) 8295 2300
Fax: (02) 8295 2399

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Summary

Insects are potential contaminants of processed leafy vegetables. Pest and beneficial species, in both the juvenile and adult stages of their life cycles can easily become unwanted contaminants if they make their way from the field into the final product, and to the end consumer.

Insect contamination can result in rejections and lost sales for growers, added cost for processors and bad publicity for retailers. Ensuring year round supply of insect free produce is a difficult challenge. The main products affected are baby leaf spinach and coral leaf lettuce. The major insects causing problems are: moths, soldier files, Rutherglen bugs and ladybeetles.

The approach was to first review current published research on controlling insect contaminants in leafy vegetables crops. Then a range of measures were evaluated in field trials with the aim of reducing insect contaminant levels. Trials included insect deterrents and attractants, floating row covers, and harvester modifications intended to remove insects at harvest. In addition, trials were conducted in the factory to assess the best methods of removing insect contaminants along the processing line.

The most effective methods for reducing the level of insect contaminants were the use a moth attractant plus a knockdown insecticide, light traps to reduce moth populations in a radius of 100m, harvester modifications to remove insects at harvest and floating row covers to exclude insects from baby leaf spinach crops. In the factory, rotating drums removed most of the insect contaminants and dead moths were much easier to remove than live moths.

The key results were put into a 4-page grower factsheet which was distributed to all vegetable growers. Four regional workshops were conducted (Qld, Vic and WA) where 70 growers and agronomists were trained on the techniques. The workshops were run in conjunction with the national Integrated Crop Protection extension project (VG13078).

# Keywords

Baby leaf, lettuce, spinach, rocket, arugula, soldier beetle, Rutherglen bug, Helicoverpa, pest, vegetable, extension, light trap, insect contamination

# Introduction

Insects are potential contaminants of processed leafy vegetables. Pest and beneficial species, in both the juvenile and adult stages of their life cycles can easily become unwanted contaminants if they make their way from the field into the final product, and to the end consumer.

Insect contamination can result in rejections and lost sales for growers, added cost for processors and bad publicity for retailers. Ensuring year round supply of insect free produce is a difficult challenge. The main products affected are baby leaf spinach and coral leaf lettuce. The major insects causing problems are:

- Caterpillars in both larval and adult form, e.g. *Helicoverpa* sp.
- Aphids, bugs and leafhoppers
- Beetles, both beneficial and pest, e.g. Lady beetles
- Flies
- Ants and wasps
- Earwigs

The aim of this project was to investigate where further improvements could be made along the supply chain to reduce the potential for insect contamination in the final product. The two main areas of focus would be in the field and at the processing facility.

Field trials were conducted to determine whether current practices could be modified to reduce the number of insects in the crop at the point of harvest. The trials included insect deterrent sprays, the use of insect attractants to lure insects away from the crops, floating row covers, and the use of harvesting technology to dislodge insects from crops at the point of harvest.

At two commercial vegetable processing facilities, insect removal techniques on the processing lines were assessed for efficiency, and key areas and approaches for intervention were identified.

The results were assembled into a best practice guide which was distributed to vegetable growers, and supported by a series of workshops in Queensland, Victoria and Western Australia.

# Methodology

The project included a review of current control practices in Australia and internationally for the control of insect contaminants in leafy vegetable crops.

Then research was focused on field techniques to stop insects getting into the harvested product in the first place, and factory techniques to remove contaminants before they are sent to retail, or packed into fresh cut packages.

The field work investigated insect deterrents, insect traps and harvester modifications. The factory work focused on evaluating insect removal techniques and also some studies of insect levels at retail.

## *Review of alternative control measures for insects contaminating baby leaf lettuce crops: spinach, lettuce and rocket*

### Background

The research on removing insects from baby leaf crops including spinach, lettuce and rocket close to harvest was reviewed. In Australia, the main insect contaminants in harvested baby leaf products are moths and soldier beetles, and to a lesser extent Rutherglen Bug. To the best of our knowledge, there have been no formal studies on how to best remove these insects from baby leaf crops in Australia.

There has been some research on soldier beetle (*Chauliognathus lugubris*), i.e., (Mensah and Madden 1994[1], Shohet and Clarke 1997[2], Beveridge and Elek 1999[3]). These studies are more about the biology of the insect and about control. One paper describes the use of soldier beetle as a biological control agent for coccinellids in eucalypts.

The most promising paper in relation to controlling insects in baby leaf crops close to harvest, and insect contamination in harvested baby leaf product, is by Italian researcher Luigi Sannino (Sannino 2010[4]). He identifies the following categories of insects as being the main problems in baby leaf crops: moths (noctuids, beet armyworm, cabbage moth, silver Y moth and cutworms), flea beetles, sciarid flies and leaf miners and reports on a number of control methods. Two other studies (Isaacs, Mercader et al. 2004[5], Baumler and Potter 2007[6]) also report on the use of low-toxicity sprays for the control of beetles, but not specifically in baby leaf crops. These studies are relevant, however, because they assess the effectiveness of some insect deterrent chemicals on beetles.

The potential control measures and deterrents which were identified in the literature review are listed below, and the findings of the relevant studies indicated in (Table 1).

---

[1] Mensah, R. K. and J. L. Madden (1994). "Conservation of two predator species for biological control of Chrysophtharta bimaculata (Col.: Chrysomelidae) in Tasmanian forests." Entomophaga **39**(1): 71-83.
[2] Shohet, D. and A. R. Clarke (1997). "Life history of Chauliognathus lugubris (F.) (Coleoptera: Cantharidae) in Tasmanian forests." Australian Journal of Entomology **36**(1): 37-44.
[3] Beveridge, N. and J. A. Elek (1999). "Bacillus thuringiensis var. tenebrionis shows no toxicity to the predator Chauliognathus lugubris (F.) (Coleoptera: Cantharidae)." Australian Journal of Entomology **38**(1): 34-39.
[4] Sannino, L. (2010). "Control of insects on fresh-cut vegetables.
[5] Isaacs, R., R. J. Mercader and J. C. Wise (2004). "Activity of conventional and reduced-risk insecticides for protection of grapevines against the rose chafer, Macrodactylus subspinosus (Coleoptera: Scarabaeidae)." Journal of Applied Entomology **128**(5): 371-376.
[6] Baumler, R. E. and D. A. Potter (2007). "Knockdown, residual, and antifeedant activity of pyrethroids and home landscape bioinsecticides against Japanese beetles (Coleoptera: Scarabaeidae) on linden foliage." Journal of Economic Entomology **100**(2): 451-458

Table 1 Summary of control measures for baby leaf crops

| **Potential control** | **Information and comments** | **Suggested actions** |
|---|---|---|
| ***Pheromone traps*** | These were effective in measuring levels of insects. The traps should be monitored once per week, and up to twice per week in periods of high insect activity. Traps should be spaced 35 m apart (Sannino 2010). Consider sticky traps. | Install and monitor sticky traps |
| ***Pyrethroids*** | (Baumler and Potter 2007) evaluated five pyrethroids against Japanese beetles (*Popillia japonica*), a small beetle similar in size to soldier beetles. They found that deltamethrin, cyfluthrin, bifenthrin, and cyhalothrin gave a high level of protection when sprayed foliage was challenged with live beetles. The leaves were protected for at least 19 days after application and these pyrethroids were better than carbaryl and permethrin.<br><br>The Australian registration status is:<br><br>***Deltamethrin* (e.g. Ballistic Elite)**: registered for a wide range of vegetables, but not leafy. Registered on brassicas for Lepidopterous insects. Permit on sunflower against Rutherglen Bug. Seven-day withholding period.<br><br>**Cyfluthrin**: no relevant registrations or permits<br><br>**Bifenthrin (e.g. Talstar 100)**: permitted on a wide range of vegetable crops including lettuce. Seven-day withholding period.<br><br>**Cyhalothrin**: no registrations | Trial Talstar 100 in Victoria |
| ***Emamectin*** (Proclaim) | Permit available for Heliothis on Brassica leafy vegetables, celery and eggplant. Three-day withholding period[7]. | Trial proclaim in Victoria |
| ***Spinosad*** *(e.g. Success)* | Spinosad has high efficacy, broad insect pest spectrum, low mammalian toxicity, and a good environmental profile. Spinosad is highly active, by both contact and ingestion, on numerous pests. Spinosad's overall protective effect varies with pest species and life stage. Spinosad affects certain insect pests only in the adult stage, but can affect other pests at more than one life stage [8]. Spinosad is registered on a range a vegetable crops in Australia including lettuce. Three-day withholding period depending on crop[9]. | Trial spinosad in Victoria |
| ***Barrier Plus + Chilli spray*** | Showed promise when applied together in SE Qld. | Trial in Vic |
| ***Capsaicin formulations***<br><br>(e.g. chilli sprays). | Chilli sprays (hot pepper wax) was tested by (Baumler and Potter 2007) and found to be ineffective against Japanese beetle. Capsaicin was also ineffective against rose chafer (beetle) on grapes (Isaacs, Mercader et al. 2004). | Not effective |

[7] Agricultural And Veterinary Permits Search
[8] Wikipedia http://en.wikipedia.org/wiki/Spinosad
[9] Pubcris

| | | |
|---|---|---|
| ***Neem extracts*** (azadirachtin) | Azadirachtin (Azatin) deterred feeding of Japanese beetles for 14 days after application (Baumler and Potter 2007). Neem Away is a lower concentration azadirachtin product and this gave good short-term protection, (less than 3 days after application). Azadirachtin resulted in knockdown and a low level of mortality to Rose chafer on grapevines for up to 3 days after application (Isaacs, Mercader et al. 2004). Mainly effective on larvae (Sannino 2010).<br><br>**Note**: Neem is registered in Australia as Neemazal, Eco Neem Botanical Insecticide and Azamax. It is also known as Azatin XL. It is not registered in Australia for use on food crops, only ornamentals plus a permit for use on hemp and wildflowers. | Not registered in Australia |
| ***Kaolin*** | Kaolin particle film was tested by (Baumler and Potter 2007) and found to be ineffective against Japanese beetle. Kaolin was also ineffective against Rose chafer on grapevines (Isaacs, Mercader et al. 2004). | Not effective |
| ***Rotenone + Pyrethrins*** | Rotenone + Pyrethrins were tested by (Baumler and Potter 2007) and found to be ineffective against Japanese beetle. | Not effective |
| ***D-Limone*** | D-Limone (Orange guard) was tested by (Baumler and Potter 2007) and found to be ineffective against Japanese beetle. | Not effective |
| ***Garlic sprays*** | Garlic sprays were tested by (Baumler and Potter 2007) and found to be ineffective against Japanese beetle. | Not effective |
| ***Inidacloprid (Confidor)*** | Imidacloprid caused the greatest initial mortality and knockdown of Rose chafer beetles on grapevines (Isaacs, Mercader et al. 2004). This product currently has a 6week withholding period on lettuce, meaning that it could not be applied close to harvest. | Too long a withholding period |
| **Canola Oil + Pyrethrins** | Good short term control (less than 3 day protection) (Baumler and Potter 2007) . | |

Table 2 Summary of products tested by Braumler and Potter

**Table 1. Insecticides and putative antifeedants evaluated for activity against *P. japonica* adults on linden foliage**

| Active ingredient | Trade name (formulation)[a] | (AI) (% in product) | Application rate (ml or g/liter) |
|---|---|---|---|
| Professional products | | | |
| Bifenthrin | TalstarOne (0.67 SC) | 7.9 | 1.69 ml |
| Bifenthrin | Onyx (2 EC) | 23.4 | 1.00 ml |
| Carbaryl | Sevin SL (4 F) | 43.0 | 2.50 ml |
| Cyfluthrin | Tempo SC Ultra (1 SC) | 11.8 | 0.42 ml |
| Deltamethrin | Deltagard T&O (5 SC) | 4.75 | 0.63 ml |
| λ-Cyhalothin | Scimitar GC (0.88 CS) | 9.7 | 0.40 ml |
| Permethrin | Astro (3.2 EC) | 36.8 | 0.63 ml |
| Azadirachtin | Azatin XL (0.265 EC) | 3.0 | 1.25 ml |
| Home landscape bioinsecticides/ antifeedants[b] | | | |
| Azadirachtin | Neem-Away | 0.09 | 23.4 ml |
| Capsaicin/capsaicinoids | Hot Pepper Wax | 0.00018 | 31.3 ml |
| D-Limonene | Orange Guard | 5.8 | 200 ml |
| Garlic juice and oil | Garlic Guard | 40.0 | 50 ml |
| Kaolin clay | Surround WP | 95.0 | 60 g |
| Pyrethrins + canola oil | Pyola | 0.5 + 89.5 | 20 ml |
| Rotenone and pyrethrins | Rotenone-pyrethrins | 1.1 + 0.8 | 2.64 ml |

[a] Product sources: TalstarOne, Onyx, Astro (FMC, Philadelphia, PA); Sevin, Tempo, Bayer Advanced, Deltagard (Bayer, Research Triangle Park, NC), Scimitar (Syngenta, Greensboro, NC).
[b] Neem-Away, Pyola (Gardens Alive, Lawrenceburg, IN); Hot Pepper Wax (Hot Pepper Wax, Greenville, PA); Orange Guard (Carmel Valley, CA); Garlic Guard (Super Natural Gardner, Exeter, NH); Rotenone-Pyrethrins (Bonide, Oriskany, NY).

## *1. Insect attractant and deterrent trials – Queensland*

### Field Trial 1.1: Insecticide sprays and moth attractants –Stanthorpe, Qld

***Aim*** The purpose of this trial was to determine whether commercially available insecticides and moth attractants could be used to kill moths in baby leaf crops which were close to harvest. The premise of the study was based on a separate finding that it is much easier to remove dead moths in the processing line than live moths.

***Materials and Methods*** A range of short withholding period insecticides, either with or without a moth attractant, were evaluated as a control measure for adult *Helicoverpa* moths on baby leaf spinach in Toowoomba, Qld. The products tested are shown in Table 3.

Table 3 Insect deterrent sprays and moth attractant treatments

| | **Product** | **Active** | **Rate** | **Comment** |
|---|---|---|---|---|
| 1 | Methomyl 225 | Methomyl 225 g/L | 200 mL/100L water | |
| 2 | Belt® 480 SC Insecticide | flubendiamide 480 g/L | 100 mL/ha | |
| 3 | Success Neo | 120 g/L spinetoram | 400 mL/ha | |
| 4 | Alpha Cypermethrin | 100g/L alpha-cypermethrin. | 400 mL/ha | |
| 5 | Proclaim | 44 g/kg emamectin present as emamectin benzoate | 250 g/ha | |
| 6 | Success Neo + Magnet | 120 g/L spinetoram + Magnet | Magnet at 500 mL per 100 m. Success at 400 mL/ha | Used a larger nozzle |
| 7 | Methomyl 225 + Magnet | Methomyl 225 g/L + Magnet | Magnet at 500 mL per 100 m. Methomyl at 200 mL/100L water. | Used a larger nozzle |
| 8 | Water + Wetter (control 1) | - | - | |
| 9 | Magnet + Water (Control 2) | Magnet | Magnet at 500 mL (of Magnet Mixture) per 100 m. | Used a larger nozzle |

The trial was established at Westview Gardens seedlings, Wyreema Qld. The sprays were applied on 27 February 2015 and data collected over the next 24 hours. The trial was a completely randomised design with nine treatments and three replicates (n=3). Each plot was one seedling tray and a separate wire cage. Insect proof wire cages were placed over young cos lettuce plants in seedling trays (Figure 1). The spray treatments were applied using a conventional boom spray at the rates indicated in Table 3 and in 500 mL water per ha. Six live adult *Helicoverpa* moths were placed under each cage. The dead moths under each cage were counted at 5 min, 30 min, 1 h, 4h and 24h after the insects were placed in the cages. The cages prevented the insects from escaping, but allowed them easy access to the lettuce plants.

Figure 1 Trial setup showing trays and cages to contain the moths and the spray application setup

***Results and Discussion*** There was a dramatic impact of the moth control sprays on the mortality of the moths (Figure 2). The most effective treatment was methomyl + Magnet. Moth mortality reached 90% after one hour. The next best treatment was methomyl alone, with 60% mortality after 4h. Success neo plus Magnet was also quite effective, achieving a moth mortality rate of 55% after 24h.

There is a clear benefit of using the moth attractant Magnet in combination with insecticides. There could also be a benefit from testing the combination of Magnet with the other sprays used in this experiment.

An observational trial was conducted in the field at Plainview, near Gatton at Gibb Bros Farming. Magnet® alone, Magnet® + Dominex® and a water-only control were applied to inter row areas in an attempt to attract moths away from the crop, and then kill them with the insecticide. Initial observations suggest that this could be an effective treatment, and should be pursued in a more formal follow up trial.

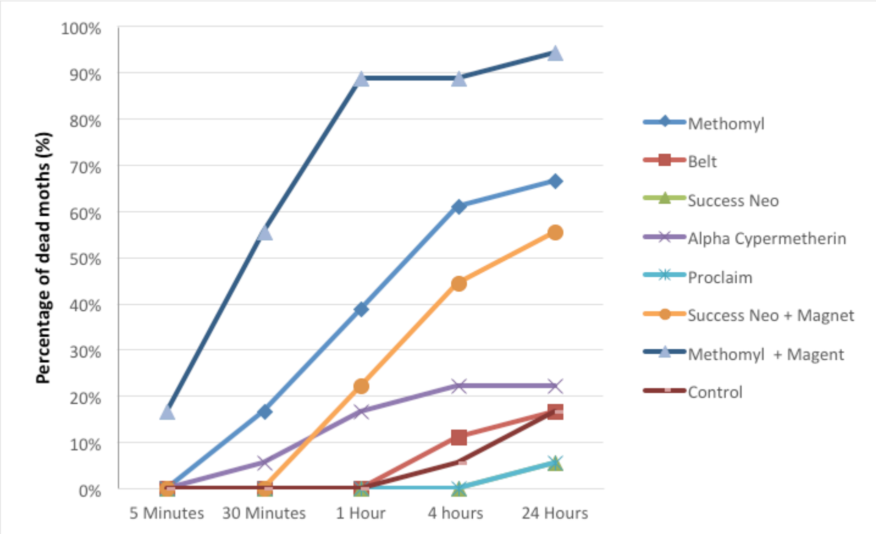



Figure 2 Impact of moth sprays on moth mortality

***Conclusion*** The most effective controls for live moths were methomyl + Magnet, methomyl and Success Neo + Magnet.

## Field Trial 1.2: Insecticide sprays and moth attractants –Stanthorpe, Qld

***Aim*** The purpose of this trial was assess the effectiveness of an insect attractant (Magnet®) mixed with a rapid knockdown, short withholding period insecticide (methomyl) applied to a non-crop area adjacent to a leafy vegetable crop.

Magnet® Insect Attractant Technology is an integrated pest management tool that has been developed to manage *Helicoverpa* spp. (Heliothis) and other lepidopteran pests in a wide range of crops. The product is the result of years of research and development by a group of Australian Cotton CRC scientists based at the University of New England, Armidale, along with field development by Ag Biotech. The research was focused around the understanding that moths are attracted to flowering plants as a source of nectar for energy. Insects perceive by olfaction (smell) volatile compounds that are released by plants. They are attracted to certain volatile compounds that indicate the presence of flowers and nectar[10]. Magnet® has potential to be used as an insect attractant in leafy vegetable crops.

***Materials and Methods*** The trial was established at Westview Gardens seedlings, Wyreema Qld. The sprays were applied on 12 September 2015 and data collected over the next 24 hours. The trial was a completely randomised design with three treatments, three replicates (n=3) and two sampling intervals. The treatments were applied to 50 m long x 1 m wide strips of headland area adjacent to lettuce crops as per Table 4.

The 50 m long plots were then vacuumed with the same equipment used to sample insects in other trials described in this report. Any moths collected were identified and counted.

[10] http://www.agbitech.com/media/4168/magnet-tech-manual.pdf (accessed 25/11/2015)

Table 4 Insect deterrent sprays and moth attractant treatments

| | Product | Active | Rate |
|---|---|---|---|
| 1 | Magnet + Water | Magnet | Magnet at 500 mL (of Magnet Mixture) per 100 m in a 1 m wide strip. |
| 2 | Methomyl 225 + Magnet | Methomyl 225 g/L + Magnet | Magnet at 500 mL per 100 m in a 1 m wide strip. Methomyl at 2L/100L water. |
| 3 | Methomyl 225 | Methomyl 225 g/L | 200 mL/100L water |

***Results and Discussion*** Magnet® plus methomyl attracted and killed 3.3 *Helicoverpa* moths per 50 $m^2$ after three hours and 8.3 Helicoverpa moths per 50 $m^2$ after nine hours. This compares with no Helicoverpa for the methomyl treatments and virtually no moths for the Magnet® only treatment.

This result is promising, and confirms the potential of Magnet® plus methomyl as a means of attracting and killing *Helicoverpa* moths near leafy vegetable crops.

Note: The Magnet® plus methomyl treatment is not registered for use on or near leafy vegetable crops and the necessary regulatory approvals would need to be achieved before this combination could be used in commercial production.

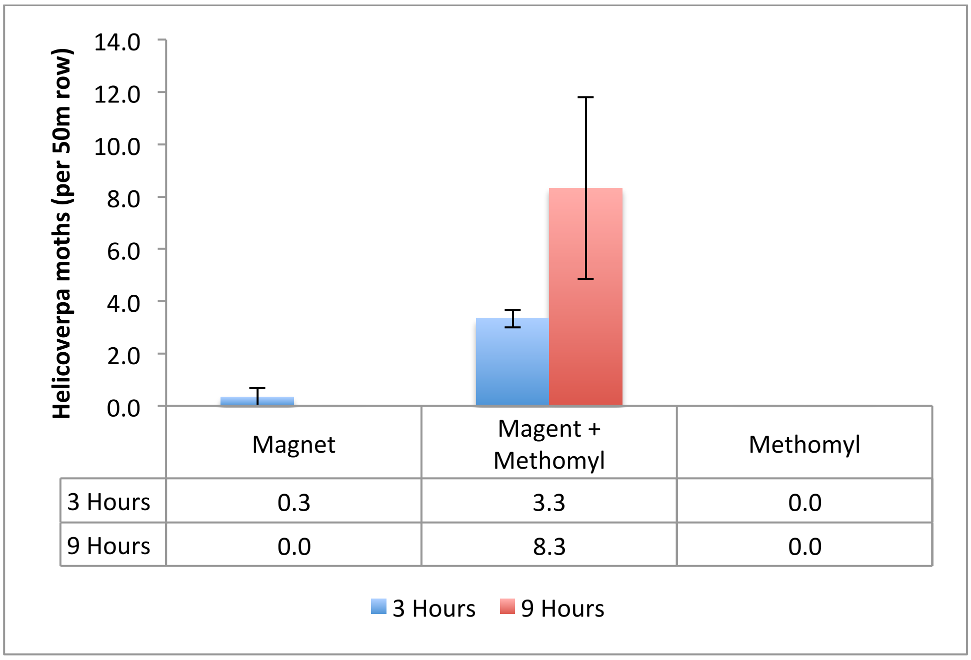



Figure 3 Results of *Helicoverpa* attractant Magnet® with and without methomyl

## Field Trial 1.3: Insect deterrent product assessment, Britton Produce– Gatton (SE Qld)

***Aim*** The purpose of these trials was to determine whether commercially available deterrents could be used to reduce the number of insects in baby leaf crops close to harvest.

***Materials and Methods*** The trials were set up at Gatton, SE Queensland on a commercial baby leaf farm as a randomised complete block design (RCBD) trial with 5 replicates (N=5). The individual plots were 5 m in length and 1.5 m wide (the width of the bed). Treatments were: Barrier Plus® 3 mL/L chilli spray at 10 mL/L, Chilli + Barriers Plus® at recommended rates, Dominex® (400 mL/ha) (positive control) and a water-only control. Treatments were applied three times, commencing 20/10/2013 and the trial was assessed on 15/11/2013. On the day of sample collection, a section 1.33 m long was selected from each plot; this represented a 2 $m^2$ sampling area. A blower vacuum was used for 40 seconds to sample the insects from the sampling area.

Figure 4 Field trials Gatton, and insects collected using insect sampling equipment

**Results and Discussion** The combination of Chilli + Barriers Plus® was effective at controlling all insects present in the trial, as good as the conventional control measure Dominex® (Figure 5).

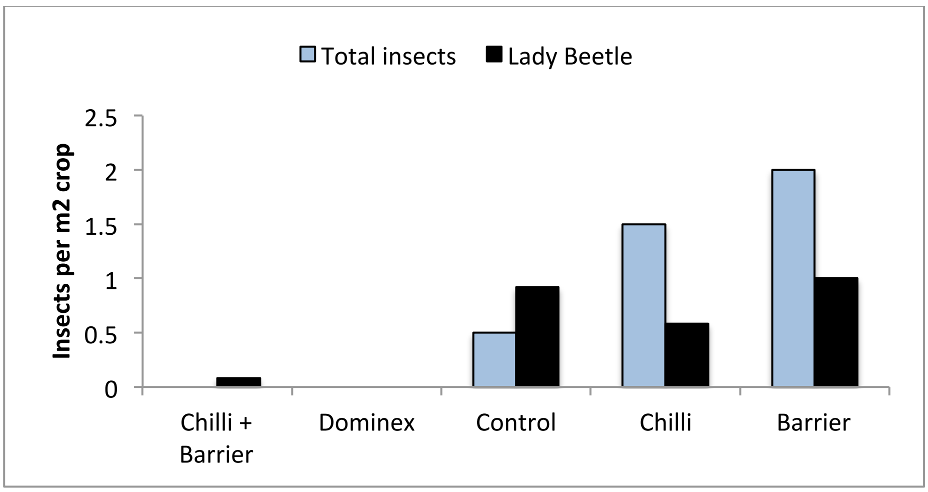



Figure 5 Impact of insect deterrent treatments on insects in baby leaf spinach – Trial 1

## Field Trial 1.4: Insect deterrent product assessment, Britton Produce– Gatton

***Aim*** The purpose of these trials was to determine whether commercially available deterrents could be used to reduce the number of insects in baby leaf crops close to harvest.

***Materials and Methods*** The trials were set up at Gatton, SE Queensland, on a commercial baby leaf farm as a randomised complete block design (RCBD) trial with 5 replicates (N=5). The individual plots were 5 m in length and 1.5 m wide (the width of the bed). Treatments: Barrier Plus® 3 mL/L, chilli spray at 10 mL/L, Chilli + Barriers Plus® and control. Treatments were applied once (on 12/11/2013) and assessed three days later. The other sprays applied were Dominex® and Movento® on 30/10/13, Bugmaster® on 6/10/13, Dominex® on 12/1/13. On the day of sample collection a section 1.33 m long was selected from each plot which represented a 2 $m^2$ sampling area. A blower vacuum was used for 40 seconds to sample the insects from the sampling area. The deterrents were applied in addition to normal pest control products.

**Results and Discussion** Conventional control (Dominex) was effective at controlling insects in this trial. There was no added benefit of the insect deterrent products used two days before harvest (Figure 6).

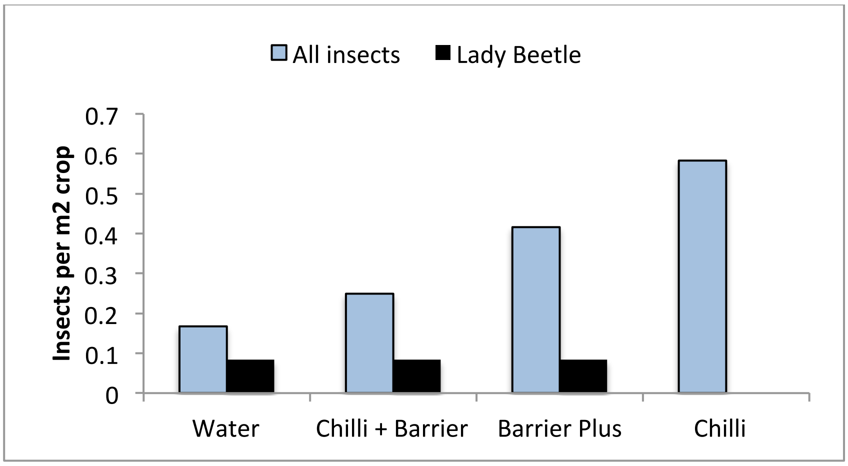



Figure 6 Impact of insect deterrent treatments on insects in baby leaf spinach – Trial 2

## Field Trial 1.5: Insect control and deterrent sprays –Stanthorpe, Qld

***Aim*** The purpose of this trial was to determine whether commercially available low toxicity/short withholding period products could be used to kill insects in baby leaf crops which are close to harvest.

***Materials and Methods*** The trial was set up as a randomised complete block design with five replicates in a commercial spinach block located at Stanthorpe, Qld (Britton Farms). Each plot was 5 m in length and 1.5 m wide. The sprays were applied on 9 January 2015 and the insects counted two days after the spray application. On the day of sample collection, a section of row 1.33 m long was selected from each plot, giving a 2 $m^2$ sampling area. A blower vacuum was used to collect insects. The vacuum was operated for 25 seconds for each plot, and the contents bagged for later inspection and counting. Three low toxicity products evaluated in the trial are specified in Table 5.

Table 5 Treatments for Field Trial 1.5

| | Product | Active | Rate | Comment |
|---|---|---|---|---|
| 1 | Alpha Cypermethrin | 100g/L alpha-cypermethrin | 400 mL/ha | 1 day WHP (Permit No. PER14433) |
| 2 | Belt® 480 SC | flubendiamide 480 g/L | 100 mL/ha | 1 day WHP |
| 3 | Barrier Plus® + chilli spray | | Barrier Plus® at 3 mL/L chilli spray at 10 mL/L | Natural pyrethrum |
| 4 | Control | Water + wetting agent | | |

***Results and Discussion*** Both Alpha Cypermethrin and Barrier Plus® + chilli spray effectively reduced the number of live Rutherglen bugs in baby leaf spinach (Figure 7). There was no significant effect of Alpha Cypermethrin, Belt® or Barrier Plus® + chilli spray on the populations of Heliothis moths or lady beetles (Figure 8).

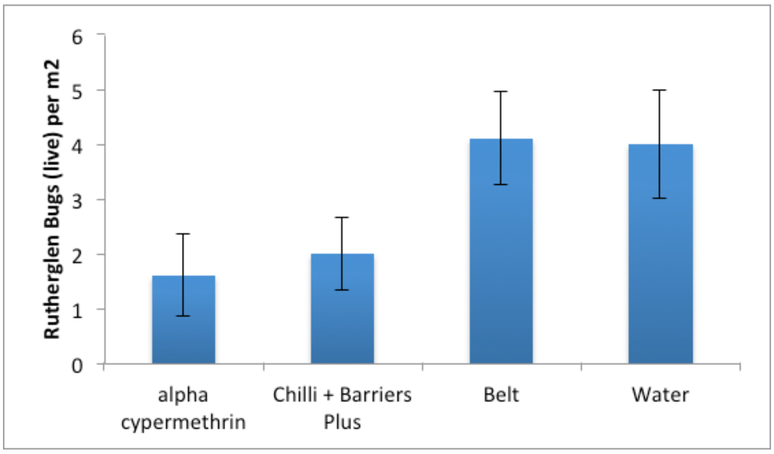



Figure 7 Impact of sprays on the numbers of live Rutherglen bugs in spinach

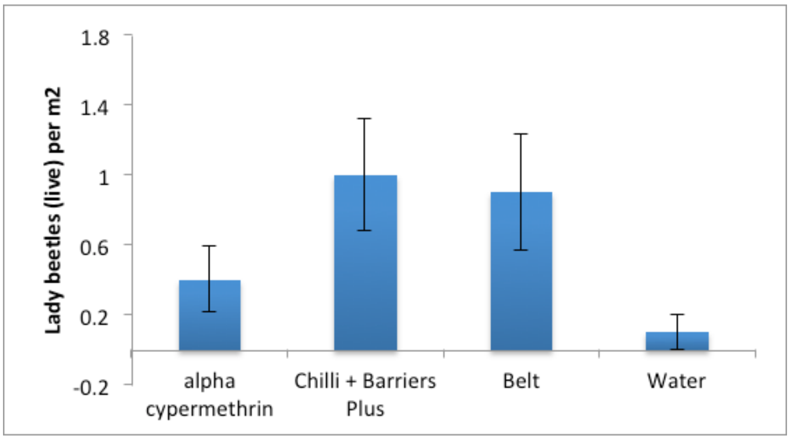



Figure 8 Impact of sprays on the numbers of live lady beetles in spinach

***Conclusion*** Alpha cypermethrin and Barrier Plus® + chilli spray can both be used to control Rutherglen bugs late in the crop. There is a current permit (PER14433) which covers the use of alpha cypermethrin under certain conditions, with a one-day withholding period.

## *2. Insect deterrent trials – Victoria*

### Field Trial 2.1: Insect deterrent product assessment– Bairnsdale, Vic.

***Aim*** The purpose of this trial was to determine whether commercially available low toxicity/short withholding period products could be used to kill insects in baby leaf crops which are close to harvest.

***Materials and Methods*** Two insect deterrent products were evaluated on a commercial baby leaf farming operation (Australia Fresh Salads) in addition to the grower's normal pest control program. The trial was set up on spinach. The treatments were: Barrier Plus® 3 mL/L chilli spray at 10 mL/L, Chilli + Barriers Plus® at recommended rates, Dominex® (400 mL/ha) (positive control) and a water-only control. Treatments were applied three times, commencing 20/10/2013 and the trial was assessed on 15/11/2013. Plots were 5 m in length and 1.5 m wide (the width of the bed). On the day of sample collection a section 1.33 m long was selected from each plot which represented a 2 $m^2$ sampling area. A blower vacuum was used for 40 seconds to sample the insects from the sampling area.

**Results and Discussion** The results of the trial on spinach are shown in Figure 9. In this trial, the insects were mainly Rutherglen Bug, but the counts were relatively high. None of the insect deterrent treatments resulted in effective control of insects, i.e. no better than the control treatment (Dominex).

The insect levels were too low in the rocket trial to make any useful assessment (data not shown).

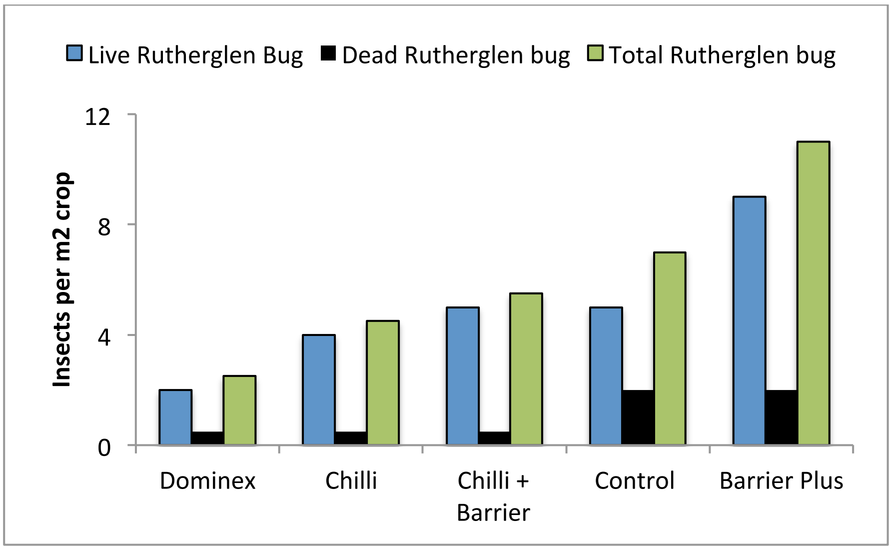



Figure 9 Impact of insect deterrent treatments on insects in baby leaf spinach; Bairnsdale February 2014

The trial was repeated in March 2014 on a block of spinach that was not sprayed with any insecticide for 20 days leading up to the trial sprays being applied. The trial area was regrown from a commercial crop harvested on 3/3/14 and then allowed to regrow. The treatment sprays were applied on the 24/3/14 and the trial assessed the next day on the 25/3/14. The results are shown in Figure 10.

The insect deterrent products were no better than unsprayed controls, or the positive control (Dominex). Insect numbers were again low, despite the block being unsprayed until the treatments were applied.

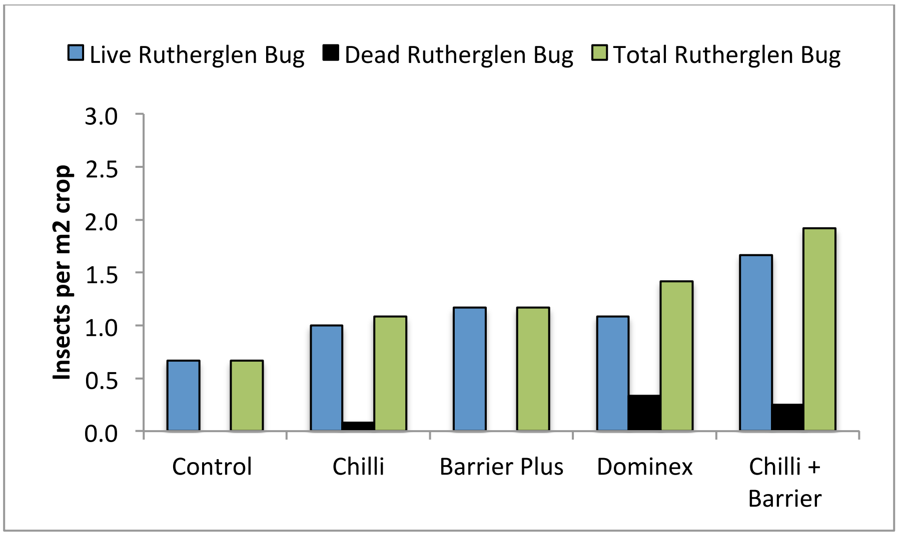



Figure 10 Impact of insect deterrent treatments on insects in baby leaf spinach; Bairnsdale March 2014

**Overall conclusions on insect deterrent products** The insect deterrent products tested so far, i.e. chilli spray and Barrier Plus, are not effective at removing insects from baby leaf crop prior to harvest. While insect levels were low during trials, there is insufficient evidence to continue trialling these products.

## *3. Field trials: Light traps*

**Introduction** A significant and recurring problem for leafy vegetable growers (baby leaf, iceberg and cos lettuce) and processors is insect contamination in fresh produce and the processed product. Insect contamination causes rejections and lost sales for growers, added costs for processors and bad publicity for retailers. Consumers are also affected as product supply is reduced and retail prices can rise as a result. Most customer complaints are about contamination by moths or soldier beetles in spinach, lettuce and rocket. The purpose of this trial was to determine whether light traps could reduce insect numbers in a spinach crop. Light traps have been effective at reducing insect numbers in field crops such as chickpeas.

### Trial 3.1: Light trial assessment – Gatton

***Aim*** The aim of this trial was to determine whether light traps could be used to reduce moth numbers in a lettuce crop. Light traps have been effective at reducing insect numbers in field crops such as chickpeas.

***Materials and Methods*** Light traps (Figure 11) were set up in duplicate on a baby leaf spinach farm at Gatton to test their effectiveness at reducing the number of moths present in the crop. Insect numbers in the crop were sampled 5 m, 30 m, 75 m, 150 m and 250 m from the traps. Insects were sampled on 29/10/2013, 5/11/2013 and 12/11/2013 from 2 $m^2$ plots using the same sampling protocol used for the insect deterrent trials, and mean insect counts reported as insects per $m^2$.

Figure 11 Light trap at Gatton, SE Qld

**Results and Discussion** There were no significant differences in insect counts between any of the sampling locations. The moth numbers were low at the time of sampling and this may have been responsible for this result. The experiment was repeated in trial 3.2.

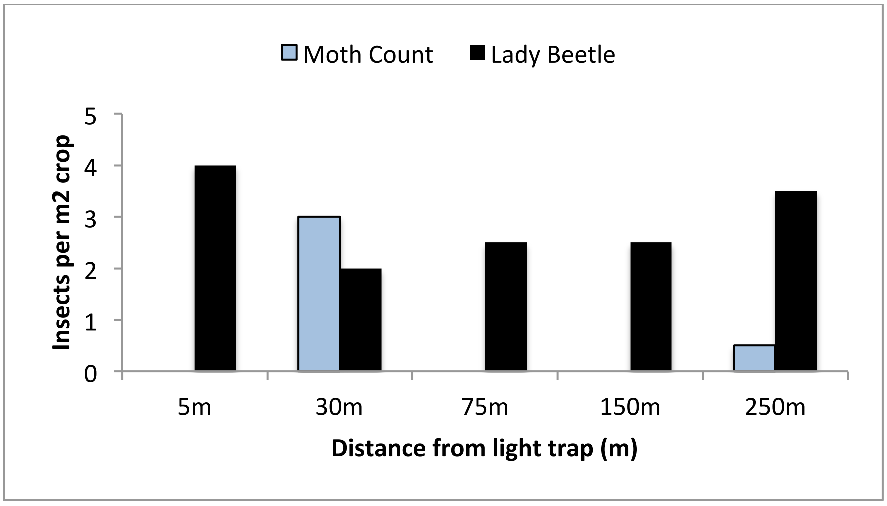



Figure 12 Results of light trap trial 3.1 Gatton

## Trial 3.2: Light trial assessment – Gatton

***Materials and Methods*** The light trap trials were repeated in March 2014, with the expectation of higher insect populations. This time, insect levels in baby leaf spinach were sampled from plots at 10 m, 50 m, 100 m and 200 m from the traps using the same methods as for Trial 3.1. Sampling dates were 16/04/2014, 23/04/2014, 30/04/2014 and 7/05/2014 from 2 $m^2$ plots using the same sampling protocol used for field trials 1 and 2, and mean insect counts reported as insects per $m^2$.

***Results and Discussion*** The result from the second light trap trial is shown in Figure 13. Again, insect numbers were very low at the time of sampling, and as a result there were no significant differences between any of the sampling points.

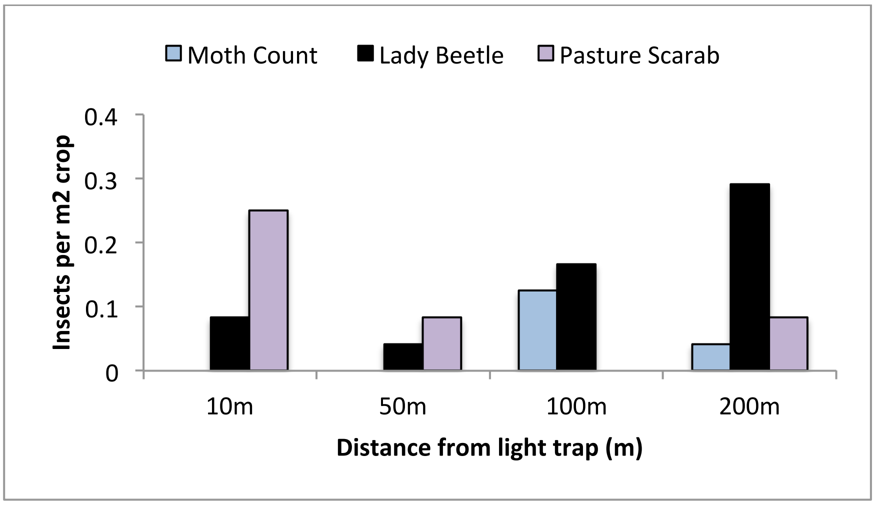



Figure 13 Results of light trap trial 3.2, Gatton

## Trial 3.3: Light trial assessment – Gatton

***Materials and Methods*** Light traps were set up in duplicate at Gatton in a baby leaf spinach crop to test their effectiveness at reducing pressure of moths in a spinach crop. Insect levels in baby leaf spinach were sampled at 5 m, 30 m, 75 m, 150 m and 250 m from the traps. Insects were sampled weekly from each of two replicate traps from 23 July to 20 October 2014 using an inverted blower (suction) to sample insects from 50 m of row. Mean counts were calculated of the sampling period and standard errors calculated.

***Results and Discussion*** There was a significant effect of the light trap on moth numbers. The insect counts from plots located 150 m and 250 m away from the light trap showed that moth numbers were consistently about 1.5 adults per 50 m of row. Closer to the light trap—at 5, 30 and 75 m— the moth counts were significantly lower, suggesting that the light traps are able to reduce moth numbers by more than 50% up to 75 m from the light source (Figure 14).

The effect seems to be specific to moths, as lady beetle numbers were not significantly affected by the light trap (Figure 15).

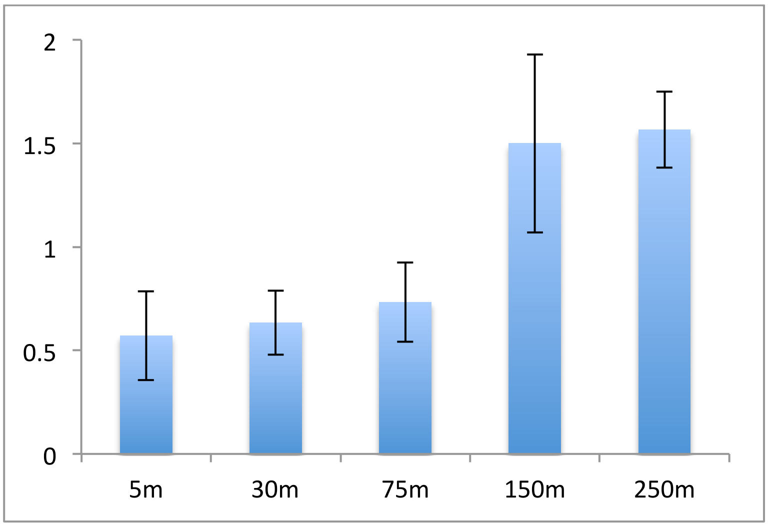



Figure 14 Impact of light trap on moth numbers at Gatton in a baby leaf spinach crop Vertical axis is moths per 50 m or row. Error bars indicate SE of the mean.

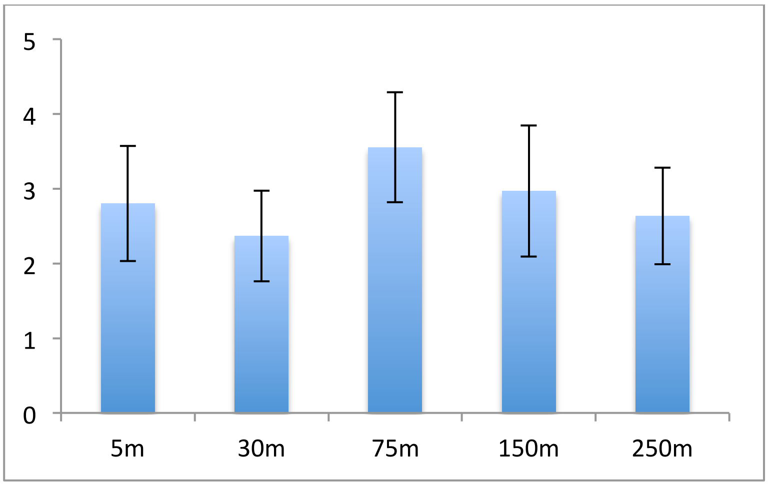



Figure 15 Impact of light traps on lady beetle numbers at Gatton in a baby leaf spinach crop Vertical axis is lady beetles per 50 m or row. Error bars indicate SE of the mean.

The more even distribution of lady beetles and the consistent numbers of moths at 150 and 250 m from the light suggests the distribution of insect numbers across the block in the trial was relatively uniform. In previous trials (3.1 and 3.2) with a smaller sampling area, the results were inconclusive. In this trial, moths and lady beetles were counted from each 50 m of row, whereas in the previous trial only 5 m plots were sampled. In future trials, 50 m of row should be sampled when assessing moth numbers in spinach.

## Trial 3.4: Light trial assessment – Darling Downs

***Aim*** The aim of this trial was to determine whether light traps could be used to reduce moth numbers in a lettuce crop. Light traps have been effective at reducing insect numbers in field crops such as chickpeas. Previous light trap trials from this project have suggested they might be of some benefit in reducing moth numbers.

***Materials and Methods*** A light trap was set up in a baby cos lettuce crop on a vegetable farm in the Darling Downs, , to test the effectiveness of the light trap at reducing the pressure of moths in the crop. Insect levels in the lettuce were measured at 5 m, 30 m, 75 m, 150 m and 250 m from the traps by sampling weekly (ten samplings) from each of two replicate traps from 7 November 2014 to 12 May 2015. Moths were collected using an inverted blower (vacuum) to sample insects from 50 m of row at the above distances from the light trap.

Mean insect counts were recorded fortnightly from two positions at each distance over the sampling period. Standard errors were calculated (N=10) and used to compare the impact of the light trap on moth counts at various distances from the trap. (Note that a significant amount of the variation within "distances" was actually due to variation in the number of moths in the area at the time of sampling.)

***Results and Discussion*** There was a significant effect of the light trap on *Helicoverpa* sp. moth numbers. The insect counts from plots located 100 m, 150 m and 250 m away from the light trap, showed higher moth numbers than the insect count 5 m and 50 m from the light trap, suggesting the traps were able to reduce moth numbers by more than 50% up to 50 m from the light source (Figure 16).

There was a somewhat similar trend with beet webworm moth numbers, however the numbers of these moths were very low (Figure 17).

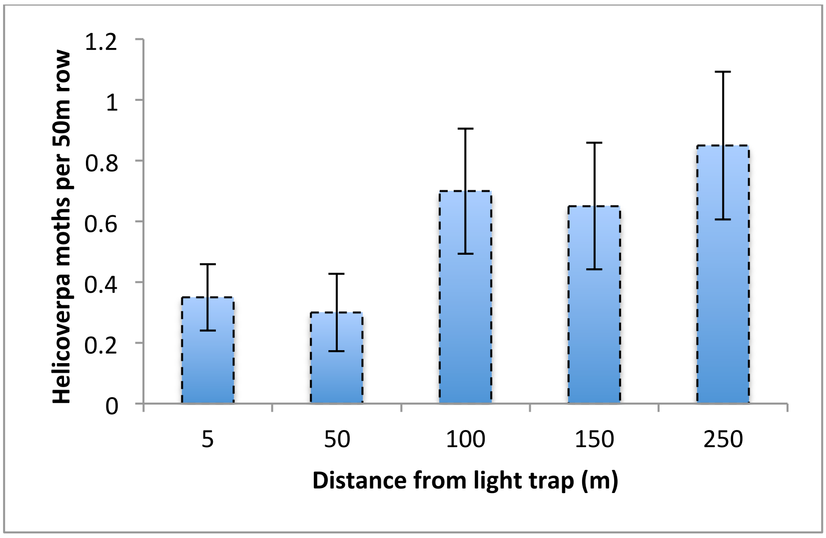


Figure 16 Impact of the light trap on *Helicoverpa* moth numbers on the Darling Downs in a baby leaf spinach crop. Error bars indicate SE of the mean.

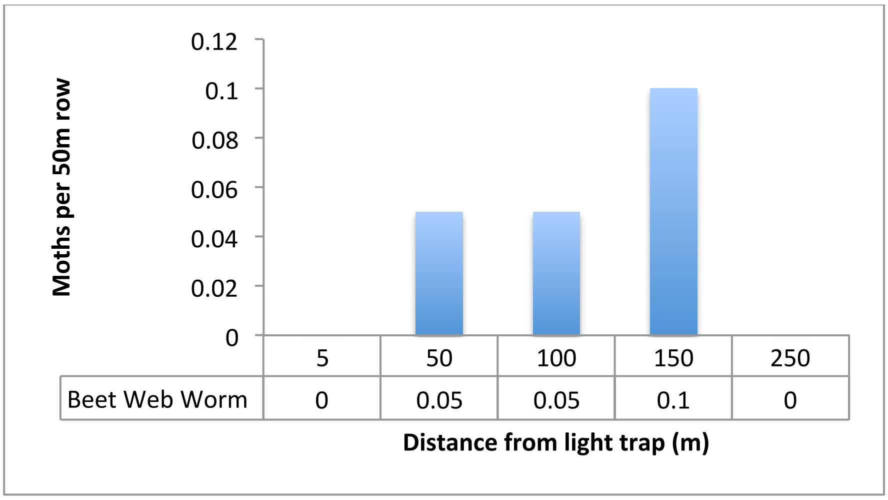



Figure 17 Impact of the light trap on beet webworm moth numbers on the Darling Downs in a baby leaf spinach crop. Error bars indicate SE of the mean.

## Trial 3.5: Light trial assessment – Darling Downs

***Aim*** The light trap trial reported in Trial 3.4 was set up again the following season on the same farm in the Darling Downs, Queensland, except this time egg counts on the baby cos lettuce leaves were used as an indicator of moth activity.

***Materials and Methods*** A light trap was set up on the Darling Downs on 3 June 2015 in a baby cos lettuce crop to confirm the effectiveness of light traps at reducing the numbers of moths in the crop. This time, *Helicoverpa* sp. eggs were used as a measure of moth activity, in an attempt provide a more reliable measure. Egg levels on the baby cos plants were measured at 50, 100, 150 and 300 m from the traps by placing 0.1 $m^2$ grids at these distances from the light traps. Two samples were collected at each distance, at each sampling time. Egg counts were collected at 18 different occasions between 6 June 2015 and 7 October 2015. During this time numerous crops were used for monitoring in the same area, and the traps relocated to a new position after two data collection events. Sampling was carried out around the mid crop development stage. Standard errors were calculated (N=18) and used to compare the impact of the light trap on moth counts at various distances from the trap.

***Results and Discussion*** The light trap resulted in a significant reduction in the number of *Helicoverpa* sp. egg within 100 m of the light trap. The data shows the number of eggs laid could be reduced from about 3.6 eggs per 0.1 $m^2$ to 1.2 eggs per 0.1 $m^2$ within a radius of 100 m from the trap (

Figure 18). Another picture of the effect of the light trap can be seen from where the egg counts are shown for each sampling date. This data clearly shows the fluctuations in egg lays at different times, and the effect of the light trap at 50 m and 100 m from the trap can be clearly seen. The effect is especially noticeable when the levels of egg lays are high, indicating high moth pressure.

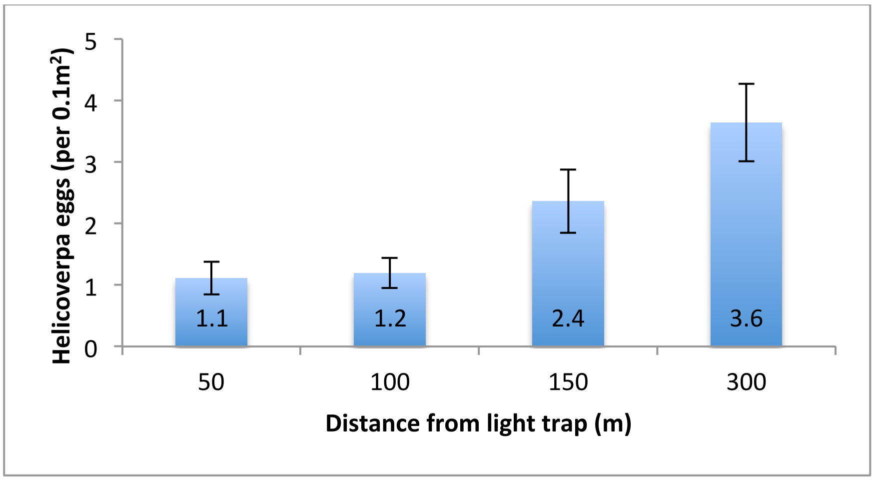



Figure 18 Impact of a light trap on the mean number of *Helicoverpa* sp. eggs in a cos lettuce crop.

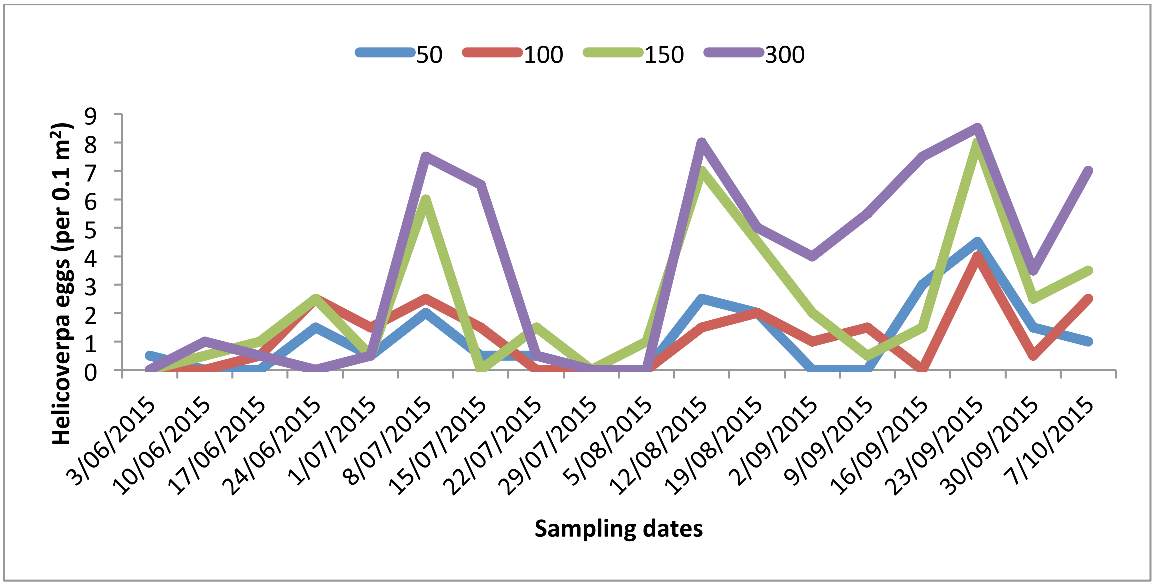



Figure 19 Impact of a light trap on the number of *Helicoverpa* sp. eggs in a cos lettuce crop, by date.

## ***Conclusion***

Light traps are effective at reducing moth numbers in lettuce and baby leaf spinach crops up to 100 m from the light trap. These traps should be considered as a way of reducing the load of moths in harvested product, especially when insect pressure is high.

## *4. Field Trials: Floating row covers*

### Trial 4. 1: Floating row covers – Stanthorpe

***Aim*** The aim of this trial was to test the effect of netting on insect management as well as yield and quality of spinach plants.

***Materials and Method*** Two trials were conducted at Stanthorpe to examine the impact on growth of baby spinach and insect populations in the crop under a large hail net structure, under floating covers (Crop Solutions UK Insect Net, 0.8mm mesh 70g.m2) and in an open field. Temperature and humidity were logged using Hobo U-23 external data loggers. These were protected from the elements, mounted inside a vented piece of PVC pipe, open at the base.

The first trial was conducted from December 2014 to January 2015. Temperature, humidity, insect populations, yield and shelf life were all recorded. The trial was set up on a commercial spinach crop on the farm of Colin Britton, New England Highway, Stanthorpe, Qld. Spinach was sown on 10 December 2014 using a commercial baby leaf seeder. Floating row covers were installed ten days later, which gave the plants time to establish. Insect data, yield and sampling for shelf life was done on 7 January 2015 (Figure 20).

The second trial commenced in February 2015. Although yield and quality information was not recorded due to poor crop quality, temperature and humidity data was still collected.

Figure 20 Floating row cover trial set up at Stanthorpe

*Insect sampling*: At commercial maturity the covers were removed. Twelve samples were taken of insects under the floating covers and compared to twelve samples collected from the adjacent open area. Each sample was collected from an area of 2.6 $m^2$. The sampling plots were vacuumed for 40 seconds using the vacuum blower that was described under experiment 1.3 and the insects collected were counted and identified. The main insects present in this trial were beet webworm, Heliothis moths, Rutherglen bugs, and lady beetles.

*Yield and shelf life assessment*: Yield data was collected from ten randomly selected positions within each treatment block. Each sampling area consisted of a 0.3 m x 0.3 m square (Figure 21). Spinach was harvested using a pair of scissors to trim leaves to within 10 mm of the ground to give an estimate of total yield. From each harvested sample, a 30 leaf subsample within the commercial specification of between 80 and 120 mm in length was selected and weighed. Samples were then stored in low-density polyethylene bags at 5°C and examined each day to determine the number of days until they were no longer of commercially acceptable quality.

Figure 21 Sampling grid used for measuring yield and collecting sample for shelf life assessment, and spinach after sample collected.

***Results and Discussion*** *Growing environment*: In general, temperature and humidity under the floating covers and the hail net structures were not significantly different to those outside. Exceptions were noted during hot weather, when daily maximum temperatures were higher under the floating row covers than in the open area (Figure 22). However, conditions also varied between the three treatment types during a period of relatively even temperatures. During this time daily maximum and minimum temperatures in the open field were respectively higher and lower than those under the hail net or floating covers (Figure 23). Similar results were found for relative humidity; in the first of these periods humidity was slightly lower in the open area, whereas in the second period relative humidity in the open field was higher at night and lower during the day than in the protected areas.

These apparently contradictory results may be due to the impact of wind as well as direct sunshine, soil moisture and irrigation timing. It seems that the effect of netting types on temperature and relative humidity is not straightforward, but can vary with other environmental factors.

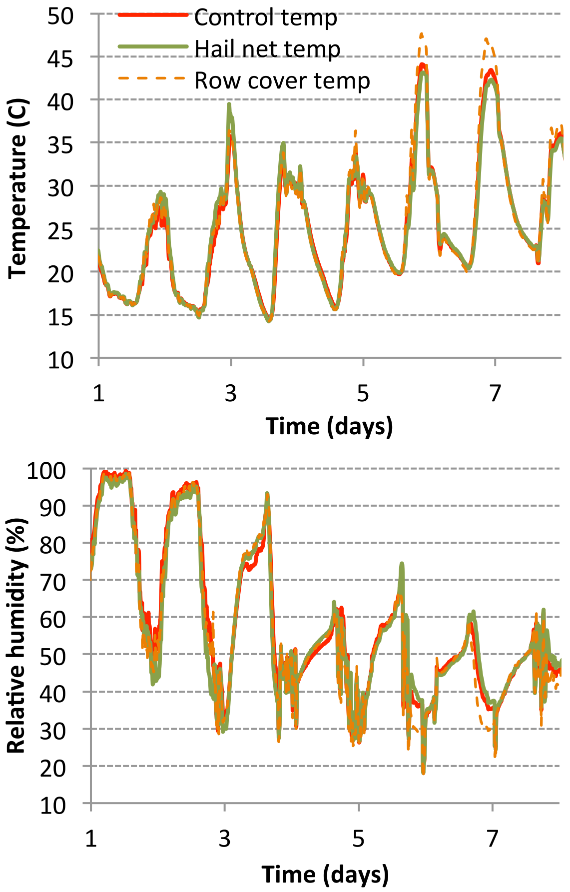
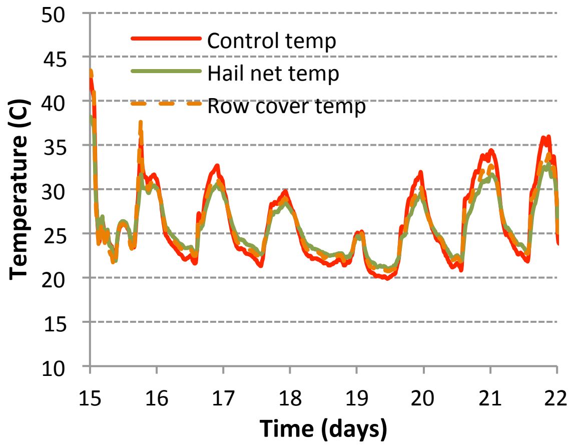



Figure 22 Temperature and relative humidity in an open field, under a floating row cover and under hail net in Stanthorpe, Qld from 5/1/2015 to 12/1/2015



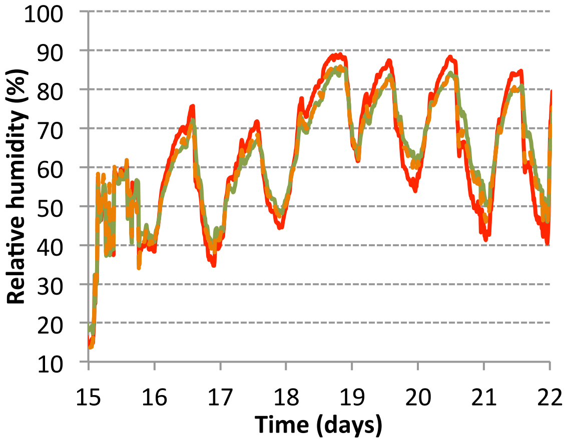



Figure 23 Temperature and relative humidity in an open field, under a floating row cover and under hail net in Stanthorpe, Qld from 20/1/2015 to 27/1/2015

*Insect control*: The floating row covers were very effective in controlling Rutherglen bugs in spinach. In the open field there were approximately ten live bugs per square metre and virtually zero under the row covers (Figure 24). As Rutherglen bugs are a major contamination problem for baby spinach production, this is a very positive result for the use of the netting material. The floating cover also mostly excluded beet webworm (Figure 25), although it was less effective against lady beetles (Figure 26). Although lady beetles are also a contamination issue, they may be more easily detected during packing. The higher than expected number of lady beetles under the row cover was surprising.

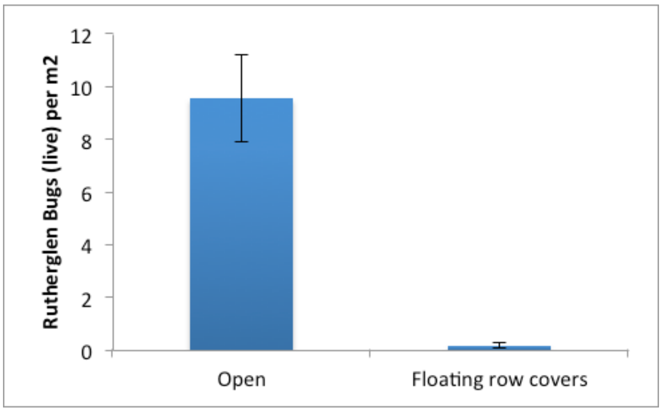



Figure 24 The effect of floating row covers on the numbers of live Rutherglen bugs in spinach, Stanthorpe, Qld. The vertical bars are standard errors of the mean.

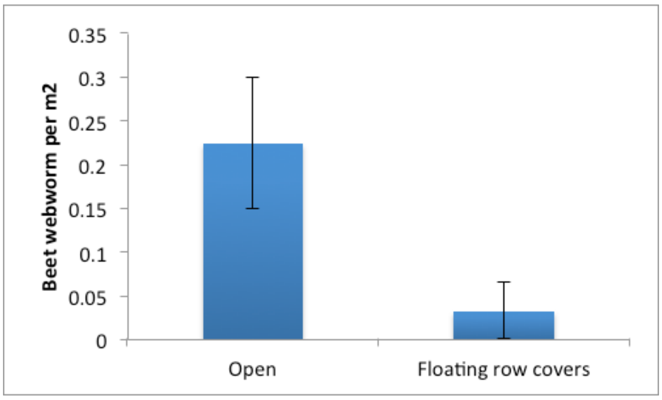


Figure 25 The effect of floating row covers in the numbers of live beet webworm in spinach, Stanthorpe, Qld. The vertical bars are standard errors of the mean.

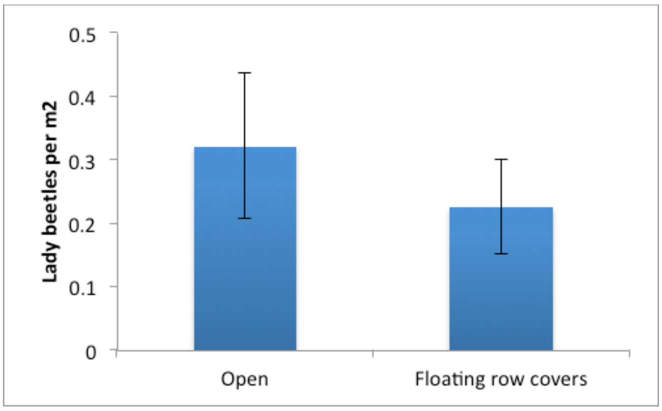



Figure 26 The effect of floating row covers in the numbers of live lady beetles in spinach, Stanthorpe, Qld. The vertical bars are standard errors of the mean.

*Yield, average leaf weight and shelf life*: Yield and shelf life of spinach grown under the floating row cover was not significantly different to that grown in the open field (Figure 27). Samples of 30 leaves were weighed to assess the relative sizes of leaves. This indicated that spinach leaves grown under the netting were approximately 10% smaller on average than those grown outside (Figure 27). Although yield from under the hail netting appeared to be slightly reduced, these results suggest the crop was simply slightly less mature at harvest. This limits any inference with regard to effects of growing method on total yield. Neither the floating covers nor the netting had any significant impact on shelf life (Figure 28).

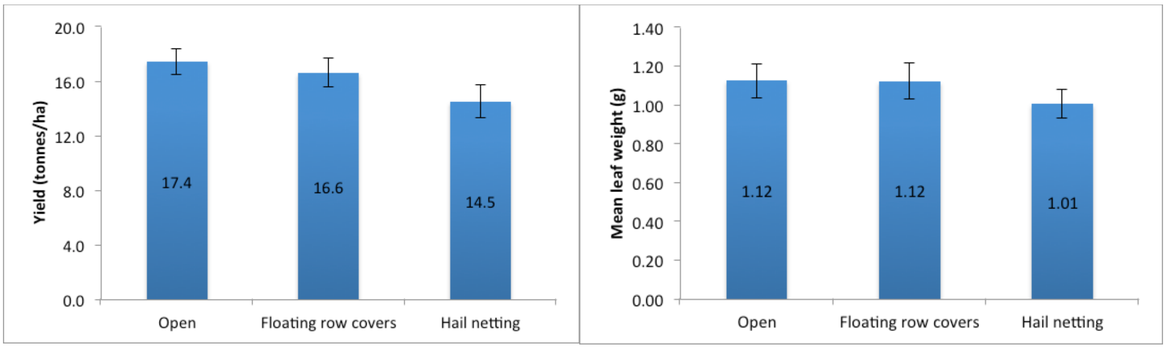



Figure 27 The effect of floating row covers and hail netting on yield and mean leaf weight of Spinach, Stanthorpe, Qld. The vertical bars are Standard Errors of the mean.

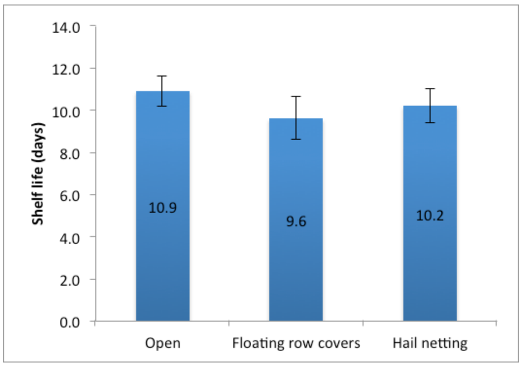



Figure 28 The effect of floating row covers and hail netting on the shelf life of spinach, Stanthorpe,

Qld. The vertical bars are standard errors of the mean.

***Conclusions*** The most promising result is the large reduction in insect contamination of the crop by floating covers, without negatively affecting yield or quality. This result is consistent with those from other sites and using other materials, and represents a promising area for further research.

## Trial 4.2: Floating Row Covers – Camden (three trials)

***Aim*** To test the effects of floating covers on yield, quality and presence of contaminants in baby spinach crops grown at Camden NSW, with particular emphasis on how such protection methods modify the effects of extreme temperature or weather events.

***Materials and Method***

### Trial (4.2.1) – 12 November to 5 December 2014

Two x 50 m long sections of Insulnet (Redpath, Australia) were placed over spinach plants immediately after seeding. Each piece was wide enough to cover two beds. The edges of the material were weighed down with sandbags. Adjacent beds were left uncovered.

Temperature was recorded using Hobo temperature and RH dataloggers. These were placed inside protective shields constructed of pieces of PVC pipe. Environmental conditions were also recorded using a weather station located within 1 km of the cropping area.

Figure 29 Insulnet installed over a double bed of baby spinach (left) and temperature + RH data logger inside a protective piece of PVC pipe

At commercial maturity, randomly selected 1 $m^2$ sections of the crop under the net and in the open field were harvested (n=5). Plants were cut approximately 10 mm above soil level and weighed to determine average yield/$m^2$.

### Trial 4.2.2 – 5 March to 1 April 2015

Two types of cover were trialled for protection from insects:

- VegeNet - a woven material, weight 45 $g.m^{-2}$, mesh size approximately 1 x 3 mm
- InsectNet - also woven, weight 125 $g.m^{-2}$, mesh size 0.5 x 1 mm

Three replicated sections 20 to 30 m long of each type of floating cover material were placed over beds three days after seeding with baby spinach. The edges were secured using sandbags. Each treatment block, including the uncovered control areas, were randomly allocated between the two beds used for the trial, as shown in Figure 30. Buffer areas at least 2 m long were included between treatment blocks. A Hobo U23 external temperature and humidity data logger was mounted under each type of material as well as in the uncovered control area (Figure 31). In this case loggers were not placed in any type of protective shield but left exposed.

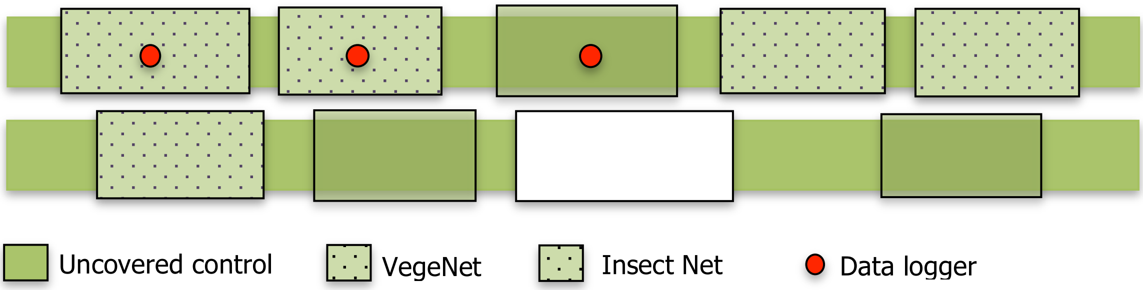



Figure 30 Layout of trial 2, showing treatment blocks of each type of material and locations of data loggers

Figure 31 Hobo data logger installed in the open, uncovered area of the bed and under a floating row cover

At commercial maturity each cover was removed and a blower-vac was used to sample insects from the central area of the crop. Each sample was taken over a timed 20 second period, with the operator slowly walking along the treatment block during the vacuuming procedure. Each sample was bagged for later examination of the type and numbers of insects present.

A 0.3 m x 0.3 m guide was used to harvest three randomly selected sections from each treatment block (total n=9). Spinach was harvested as previously, with plants cut approximately 10 mm from the ground level. Samples were returned to the lab, weighed, sorted, and segregated into units for evaluation of storage quality at 4, 7 and 10$^{o}$C. Quality was assessed subjectively from Excellent (4) to very poor (0) with OK (2) the limit of acceptability.

**Trial 4.2.3 – 16 April to 27 May**

Three types of cover were trialled for protection from insects:

- VegeNet - a woven material, weight 45 $g.m^{-2}$, mesh size approximately 1 x 3 mm
- InsectNet - also woven, weight 125 $g.m^{-2}$, mesh size 0.5 x 1 mm
- Agryl frost protection fleece, weight 22 $g.m^{-2}$, spun bonded material

Methods used were the same as those in Trial 2, with three replicated blocks of each type of material along with sections of uncovered control randomly allocated along two beds of baby spinach. Materials were applied a few days after seeding and secured with sandbags (Figure 32). A Hobo U23 data logger was mounted within each treatment type, as in the previous trial.

Figure 32 Installing three different types of floating cover on newly seeded beds of baby spinach

Insect number and presence, yield and storage quality were assessed as previously.

***Results and Discussion***

**Trial 4.2.1:** Temperatures under the floating row cover were similar to those recorded by the nearby weather station. However, humidity was maintained under the floating cover, with overnight values regularly approaching or reaching 100% RH. No desiccated plants were observed underneath the netting. However a number of dead areas occurred in the uncovered adjacent beds, where irrigation had not been enough to compensate for hot summer temperatures.

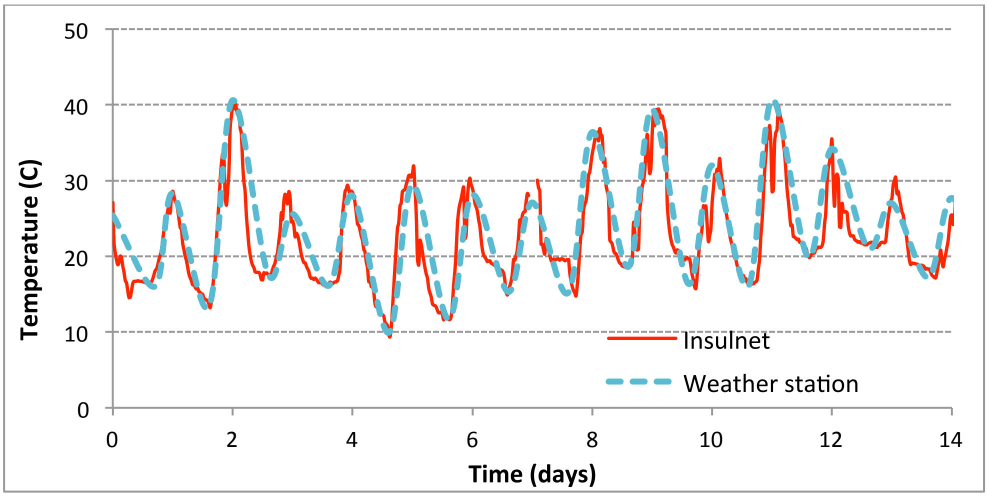



Figure 33 Temperatures recorded under Insulnet and at a nearby weather station during November 2014

Unfortunately patchy establishment of the crop meant that yield was generally low. Yield appeared to be lower under the Insulnet cover than the open areas, although high variability meant that these differences were not significantly different (Figure 34).

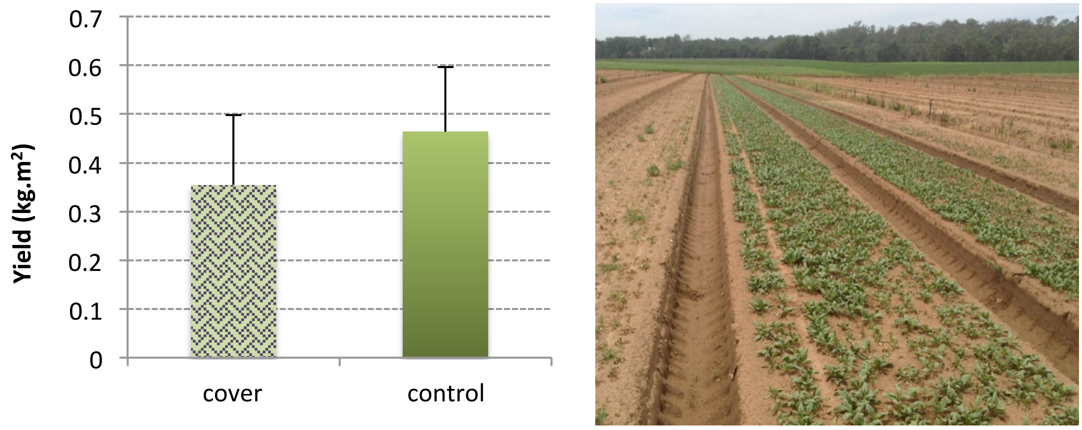



Figure 34 Yield of spinach grown under a floating row cover of insulnet and in the open field (control), bars indicate the standard deviation of each mean value (n=5) (left) and patchy growth in the spinach crop.

**Trial 4.2.2:** Temperatures under the Insect Net and VegeNet were generally very similar to those in the uncovered control. However, the Insect Net did slightly mitigate against cold night temperatures, with both netting types slightly increasing daytime maximums (Figure 35). Relative humidity was slightly higher under the Insect Net but, as with temperature, such effects were marginal.

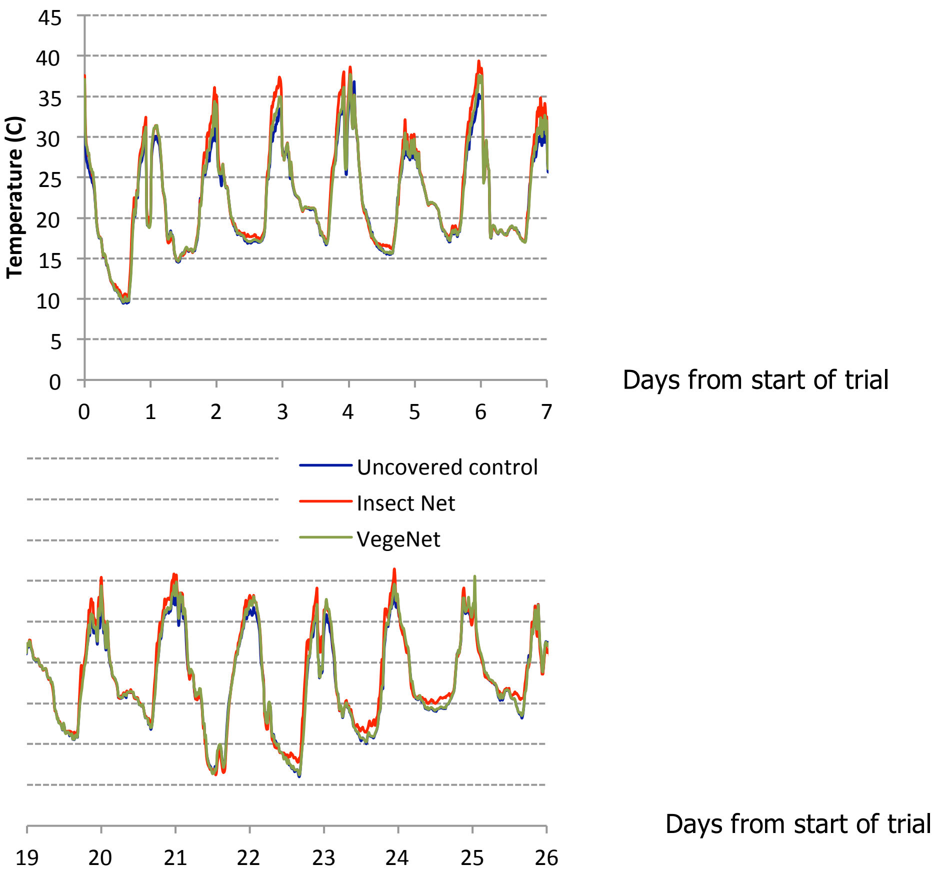



Figure 35 Temperatures during the first and last weeks of Trial 2 in uncovered control plots, under

Insect Net and under VegeNet floating covers

Although insects were found under both of the floating cover types, numbers were significantly reduced compared to the uncovered controls (Table 6). The ends of the nets were not very securely fastened for the trials, partly because the nets were loosened to allow for growth of the crop underneath. Had the nets been more securely fastened results may have been improved.

Table 6 Total insects collected from the uncovered, Insect Net and VegeNet covered crop

| | Weevil | Moth | Caterpillars | Rutherglen bug | Flea beetle | Wasp / parasitoids | Thrips | Flies | Leafhoppers | Aphids | Beetles | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uncovered control | 6 | 1 | 6 | 6 | 1 | 3 | 1 | 140 | 6 | 7 | 5 | 182 |
| VegeNet | 4 | - | 6 | 4 | - | 3 | 1 | 55 | 1 | 1 | - | 75 |
| Insect Net | 1 | 1 | 3 | 2 | 3 | 4 | - | 58 | - | 1 | - | 73 |

One potential issue noted with baby spinach growing underneath the VegeNet was that the cotyledons were narrow enough to poke through the mesh. The Insect Net mesh was too fine to allow this. When this was observed the nets were loosened and the cotyledons detached. However, this may have been unnecessary, as it was later observed that the cotyledons would naturally detach as the larger true leaves expanded under the netting.

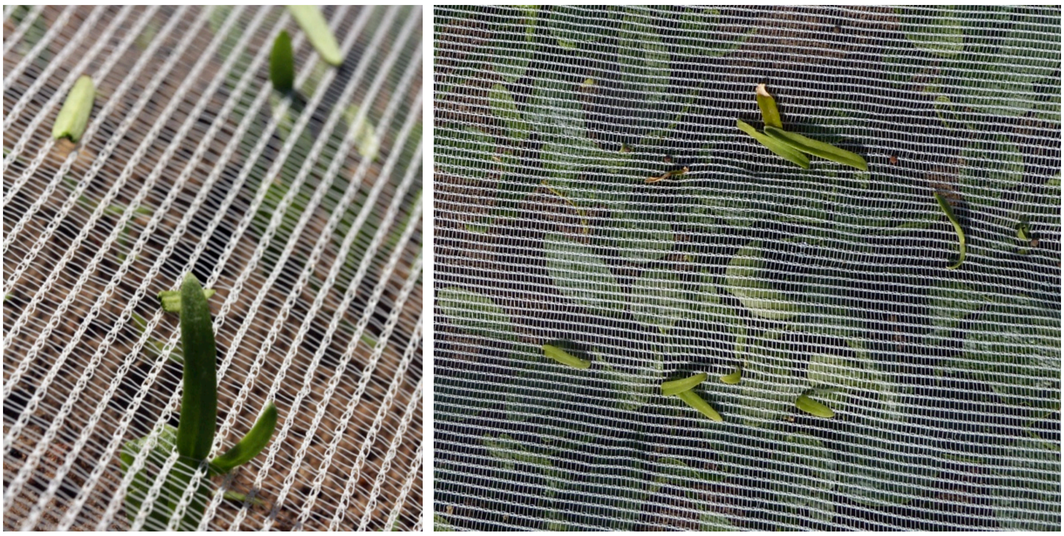


Figure 36 The spinach cotyledons could poke through VegeNet but tended to naturally detach as the plants grew

Yield results for this trial were severely affected by weeds. Although the grower had applied a pre-emergent herbicide before seeding, heavy rain the following day had clearly reduced its effectiveness. Moreover, weeds appeared to be favoured by the netting, especially the Insect Net. Yield of spinach as a percentage of total yield of vegetation was 91% in the uncovered control compared to 62% under VegeNet and only 29% under Insect Net.

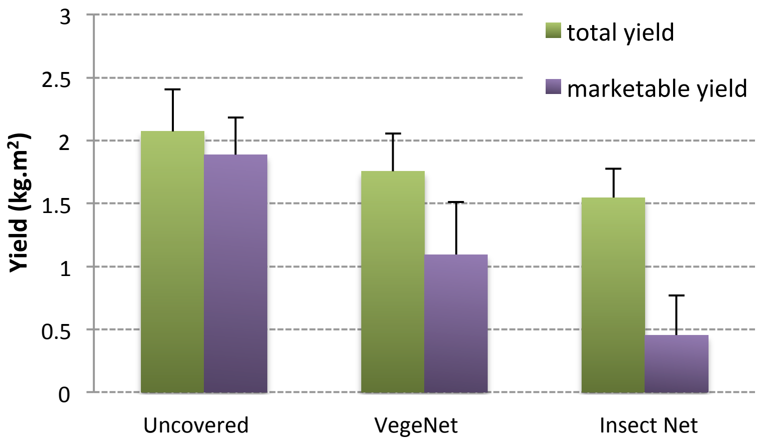



Figure 37 Total average yield of vegetation and actual marketable yield of spinach of crop grown in an uncovered bed (control), under VegeNet and under Insect Net. Bars indicate the standard deviation of each mean value.

Quality was also negatively affected by the netting materials, particularly the Insect Net.

After 12 days of storage at 4, 7 or 10°C, the spinach grown uncovered in the open field remained acceptable at all storage temperatures. However, spinach grown under either type of netting and stored at 7 or 10°C was no longer marketable or consumable.

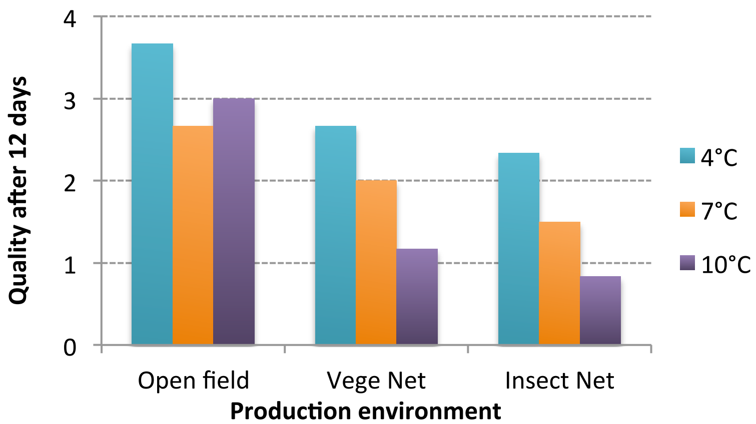



Figure 38 Average quality of spinach grown in the open, under VegeNet or under Insect Net after 12 days storage at 4, 7 or 12°C (n=3). Quality subjectively assessed from Excellent (4) to very poor (0).

**Trial 4.2.3:** During the period of Trial 3, temperatures decreased and growing time increased. As temperatures declined, differences in temperature between the different types of floating cover increased. Night minimum temperatures were up to 5°C higher under the Agryl than under the control or VegeNet. This material also increased daytime maximum temperatures, but as ambient temperatures were generally below 25°C this could have had a positive, rather than a negative effect on growth.

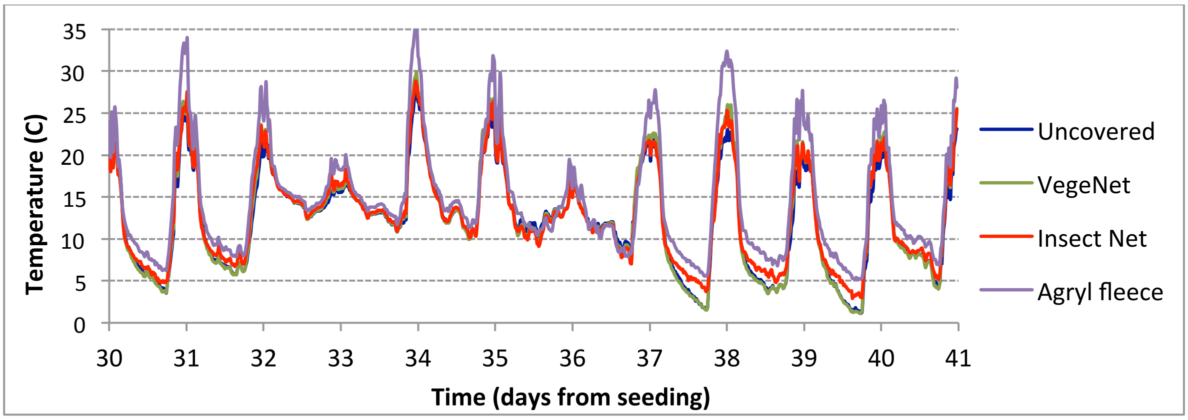



Figure 39 Temperatures during the later stages of crop growth of spinach in an uncovered control compared to under VegeNet, Insect Net and Agryl fleece

In this trial, the netting materials had been secured at the end of each block using a metal pin. There was also less pest pressure at this time compared to that in the previous trial. These factors may have helped to reduce the number of insects getting underneath; with all three floating covers proving effective at reducing the numbers of insects in the crop (Figure 40).

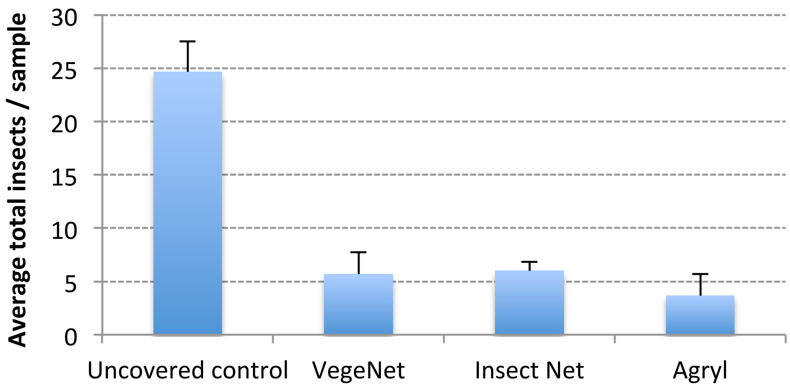



Figure 40 Average number of insects per sample (n=3) from the uncovered control compared to under floating covers of VegeNet, Insect Net and Agryl fleece. Bars indicate the standard deviation of each mean value.

Again, growth during this trial was somewhat patchy. This was due to uneven spreading of fertiliser at planting. Also, heavy rain during the trial period had leached fertiliser from the sandy loam soil, with the result that plants had almost run out of fertiliser near the end of the cropping cycle. Growth was also affected slightly by weeds, particularly under the floating covers, which again had increased weed growth to more than was observed in the uncovered areas (Figure 41).

In this trial, samples from the uncovered areas contained 3.5% weed material compared to 8.8%, 12.6% and 15.3% in the VegeNet, Insect Net and Agryl fleece treatments respectively.

Figure 41 Crop growth in the uncovered control (left) compared to that under Agryl fleece (centre) and Insect Net (right)

The favouring of weed growth under floating covers is an issue that will need to be addressed if this method is to be commercialised. The soil under the covers was observed to be much damper than that of the uncovered control, particularly the soil under the Agryl fleece and Insect Net. Increased soil moisture is likely to favour weeds. Reducing irrigation frequency could possibly address this issue – as well as reduce production costs.

All three floating covers reduced yield. However, as may be observed from the large error bars shown in Figure 42, results were highly variable. Spinach growth adjacent to the logger position under the Agryl was the highest observed anywhere in the crop (2.1 $kg.m^2$) and also almost entirely weed free. At this point the material was held slightly above the crop rather than resting on it.

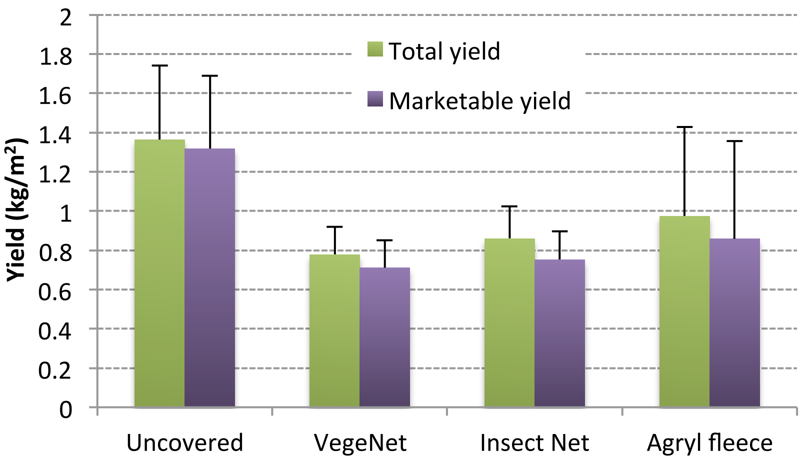



Figure 42 Total yield compared to marketable yield of spinach from the uncovered control compared to that grown underneath floating covers of VegeNet, Insect Net and Agryl fleece. Bars indicate the standard deviation of each mean value.

**Conclusion** Although the results are not positive overall in terms of application of floating covers, they do suggest a number of refinements to the application method. The warming effect of the Agryl fleece certainly deserves further investigation for winter production. However, results may be improved if the material is raised slightly off the crop and, perhaps, irrigation frequency is reduced.

## Trial 4.3 Floating row covers – Bundaberg

***Aim*** The aim of this trial was to test the effects of netting on insect management as well as yield and quality of capsicum plants.

***Materials and Method*** The trial was set up using a commercial capsicum crop. Seedlings were planted at the beginning of February 2015. The nets were installed four weeks later, which allowed time for the plants to establish. At this stage plants were approximately 40 cm high and starting to flower.

Two types of netting were used:

- VegeNet – a woven material, weight 45 $g/m^{-2}$, mesh size approximately 1 x 3 mm
- InsectNet – also woven, weight 125 $g/m^{-2}$, mesh size 0.5 x 1 mm

Two sections of each netting type were located randomly in the crop. Each section was approximately 30 m long. A further three sites were selected to use as untreated controls.

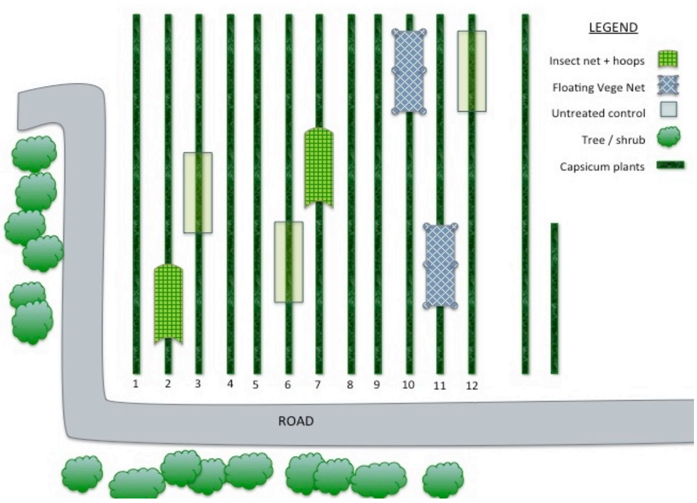



Figure 43 Trial plan for capsicums in Bundaberg

The insect net was secured using 50 cm high cloche hoops at 2 m intervals. These clamped the netting quite tightly and ensured it reached the ground. Initially the ends were not sealed, however this was corrected part way through the trial. As the VegeNet was lighter it could be draped directly over the plants and secured with sandbags.

Yellow sticky traps were placed inside and outside each netting type to monitor insects. Temperature and humidity data loggers were installed within the uncovered crop and under each netting type.

Figure 44 VegeNet (left) was draped directly onto capsicum plants while the Insect Net (right) was secured using low cloche hoops

Five days before the first commercial harvest, the netting was removed and 2 x 5 m long sections in the centre of each unit were vacuumed using an electric blower-vac. Insects were collected and kept for counting and identification (Figure 45).

Figure 45 Temperature logger installed within the crop; and collecting insects using an electric blower-vac

Yield and quality was assessed using eight randomly selected plants for each treatment block (including the untreated controls). These plants were strip-picked of all fruit, including those below marketable size (n=16 per treatment). The harvested fruit were individually weighed as well as assessed in terms of insect damage, colour and quality. Total yield, total potential yield and marketable yield were calculated for each treatment.

***Results and Discussion*** Temperatures under the VegeNet were generally similar to those in the open field. In some cases the night temperature was slightly (~1$^{o}$C) higher under the net, but this was not always the case. Temperatures under the hoops with insect net were also similar to the untreated control at night. However, in this case the netting reduced daytime maximums by up to 5$^{o}$C. This was particularly apparent during hotter weather (>30$^{o}$C) and where there was a large swing between day and night extremes.

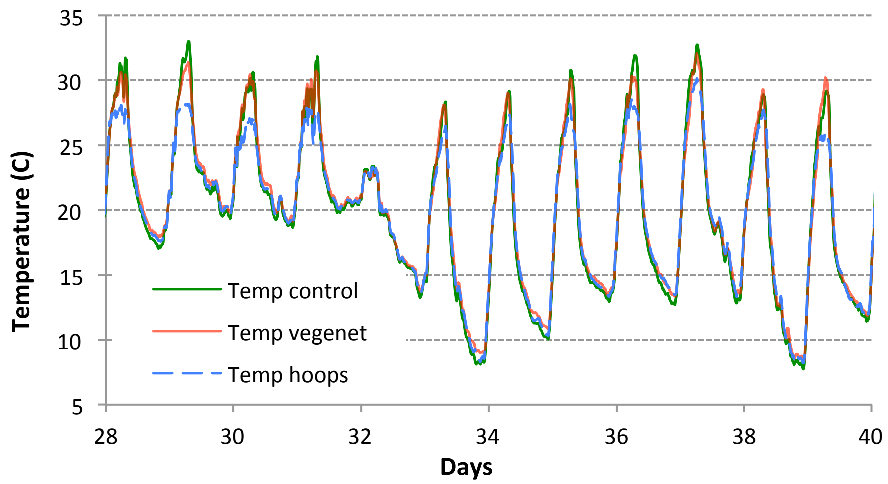



Figure 46 Temperature recorded between April 16 and 30 in an open field, under VegeNet and under hoops with InsectNet

Perhaps surprisingly, relative humidity (RH) was slightly lower under the VegeNet than in the open field, at least during evening periods. Under the VegeNet it rarely exceeded 95%, whereas in the field RH approached 100%. While this is a small difference, this could result in a difference in leaf wetness. It seems possible that the netting reduces overnight settling of dew on the crop, which could provide some benefits in terms of disease control.

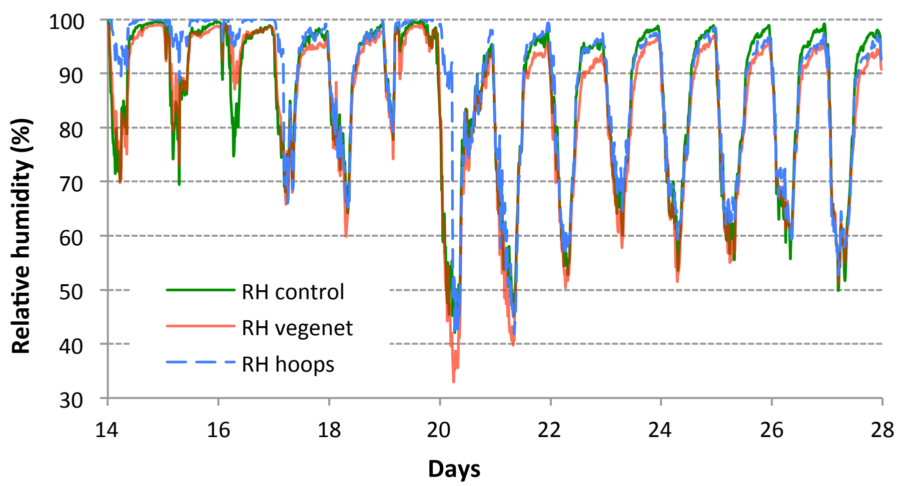



Figure 47 Relative humidity (% RH) recorded between April 2 and 16 in an open field, under VegeNet and under hoops with InsectNet

Results from the sticky traps suggested that there was an increase in the number of thrips under the Insect Net. An average of 52 thrips.trap$^{-1}$ were recovered from under the hoops compared to 15 thrips.trap$^{-1}$ from the open field. However, aphids and jassids were found on the sticky traps in the open field whereas none were found on those under the insect net.

Similar results were found in the samples removed by vacuuming. As shown in Table 7 there was a greater diversity of insects in the open field, whereas the Insect Net with hoops system appeared to favour thrips. This may be because of reduced penetration of insecticides, or because the protected environment inside the hoops was more suitable for these pests.

Table 7 Average numbers and types of insects recovered by vacuuming a 5 m section of capsicum plants

| | Thrips | Whitefly | Aphid | Jassid | Click beetle | Heliothis |
|---|---|---|---|---|---|---|
| Open field | 2 | 7 | 2 | 1 | | |
| Hoops | 5 | 3 | | | | 4 |
| VegeNet | 3 | 3 | | | 1 | |

While no measurements were taken to establish plant health, capsicum plants grown under either type of netting appeared to be healthier and stronger than those grown in the open field (Figure 48). The leaves were dark and undamaged, whereas those in the open tended to have curled edges and showed signs of wind / abrasion damage. Although there were significant numbers of sunburned fruit in the open, none were observed under the netted areas. There were also more signs of healed insect damage in the open field (Figure 49). These benefits may be due to reduction of wind damage (the site was quite exposed and near the coast) as well as filtering of direct sunlight.

Figure 48 Plants grown under netting (left) appeared healthier and more robust than those grown in an open field (right)

Figure 49 Damage observed on plants grown in the open field; sunburned fruit, healed insect damage (weevil) and leaves with dry, curled edges

While total yield was not affected by the netting, there was a significant increase in marketable yield from plants under the VegeNet compared to those from the open field. This was partly due to reduction in sunburn and other types of damage. Thrip damage was also greatest in the untreated control fruit, while the number of fruit with rots was increased under the Insect Net. Total potential yield was also greatest under the VegeNet, with the total number of fruit increasing from 8.5 to 9.3 per plant.

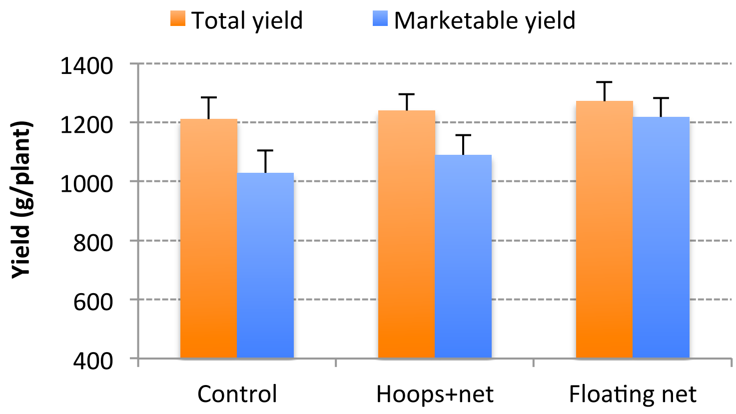



Figure 50 Total yield and marketable yield from capsicum plants grown in the open, under hoops covered with Insect Net, and under a floating cover of VegeNet

While this study was limited by reliance on a single harvest (whereas commercially there may be two to four), it appeared that fruit grown under VegeNet matured faster than that from other treatments, with an approximate doubling in the number of red fruit (Figure 51).

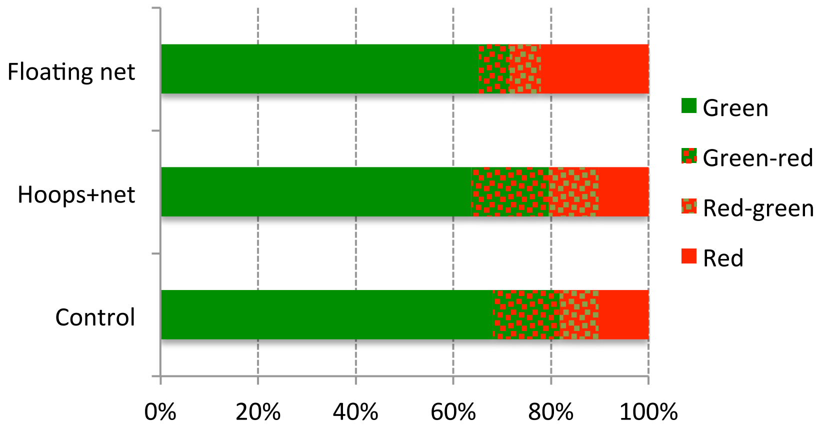



Figure 51 Proportion of harvested capsicums which were green, mostly green, mostly red or red

***Conclusions*** These results are extremely promising; suggesting that a floating row cover can improve quality and yield of capsicums. It also seems likely that insecticide and water use could be reduced under this system, although this remains to be investigated.

### *5. Harvester modification trials*

## Trial 5.1 Assessment of harvester modification for removing insects from harvested spinach in Bairnsdale, Victoria

***Aim*** To evaluate baby leaf harvester modifications for their effectiveness at removing insects from the crop at harvest.

***Materials and methods*** The modifications tested were:

- fans at the front of the tractor
- chains dragged through the crop
- a perforated conveyer belt which carries the harvested product from the cutters

Figure 52 Chains in front of the harvester to dislodge insects

The trials were conducted on spinach crops on 6 February 2014 and then again in March 2014 on a crop that was not sprayed for insects. The harvester modifications were tested alone and in combination, and 10 x 15 kg samples of harvested product were assessed for insects from each combination. Results are expressed as insect per 15 kg crate of spinach. The treatments were:

1. All modifications used together
2. Chain only
3. Perforated belt only
4. Fan only
5. Fan and chains together
6. No modifications

**Results and Discussion** The East Gippsland trials showed the combined use of fans at the front of the tractor, chains dragged through the crop and a perforated conveyer belt were effective at removing Rutherglen bugs and flies from harvested spinach. These trials should be repeated when there is a high pressure from soldier beetle and moths to see if they are still effective under those conditions (Figure 53).

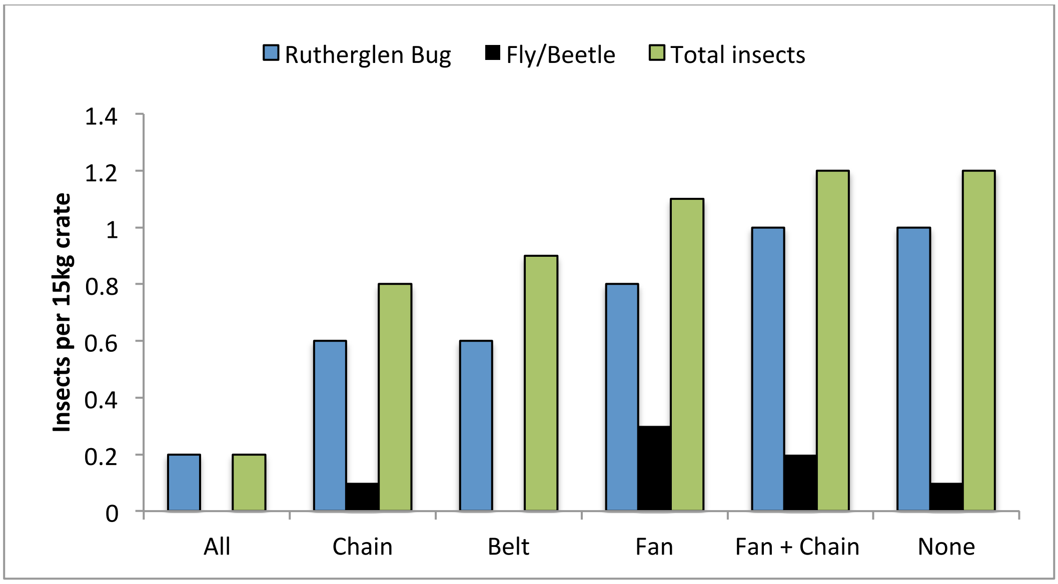



Figure 53 Effect of harvester modification on the level of insect contaminants in spinach, February 2013

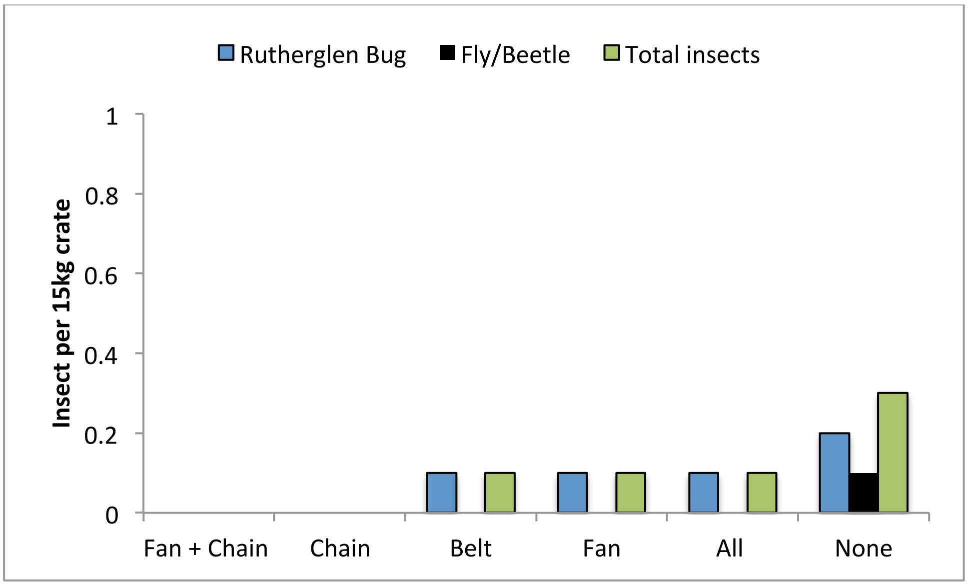



Figure 54 Effect of harvester modification on the level of insect contaminants in spinach, March 2013

**Overall conclusions on harvester modifications** The harvester modifications show promising results and these modifications should be used at times of high insect pressure.

### ***6. Factory assessments and trials***

## Trial 6.1 Insect contamination levels in spinach received from growers in East Gippsland January 2014

***Aim*** Contamination of leafy vegetables by insects is one of the main challenges in delivering high quality baby leaf product to consumers. This report provides information on the levels and composition of insect contaminants during January 2014 from the OneHarvest factory at Bairnsdale, Victoria.

OneHarvest are now sending this type of information to their growers in Victoria in an effort to help growers focus their efforts on reducing the numbers of contaminant insects in harvested product, especially during periods of high insect populations.

***Materials and Methods*** Since December 2013, data has been collected daily on insect contaminants at the OneHarvest plant in Bairnsdale, Vic. The number and identity of insects were recorded over 16 days in January 2014 at various control points in the processing line. These points include: receivals, washing line, skimmer boxes and the optical sorter.

***Results and Discussion*** The composition of all insects found in leafy vegetables in January 2014 is shown in Figure 1. Rutherglen bug was the most abundant insect contaminant ( Figure 55). The relative proportions of other insect contaminants are also shown in  Figure 55.

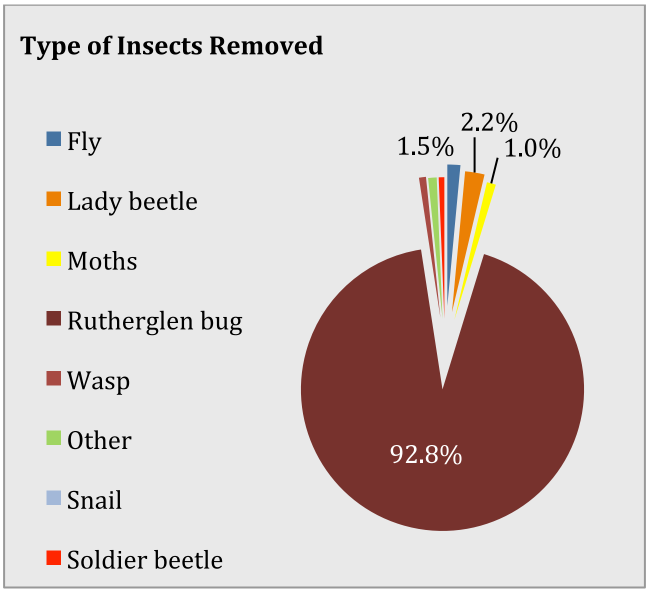



Figure 55 Insect contaminants in baby leaf crops January 2014

### ***Rutherglen bugs***

The number of Rutherglen bugs removed per kg of raw material over 16 days in January 2014 is shown in Figure 56. Fortunately, the removal of Rutherglen bugs in the processing line is relatively effective, and very few insects remain by the time the product reaches the optical sorter, which is the last line of defence before it is packed into bags for sale.

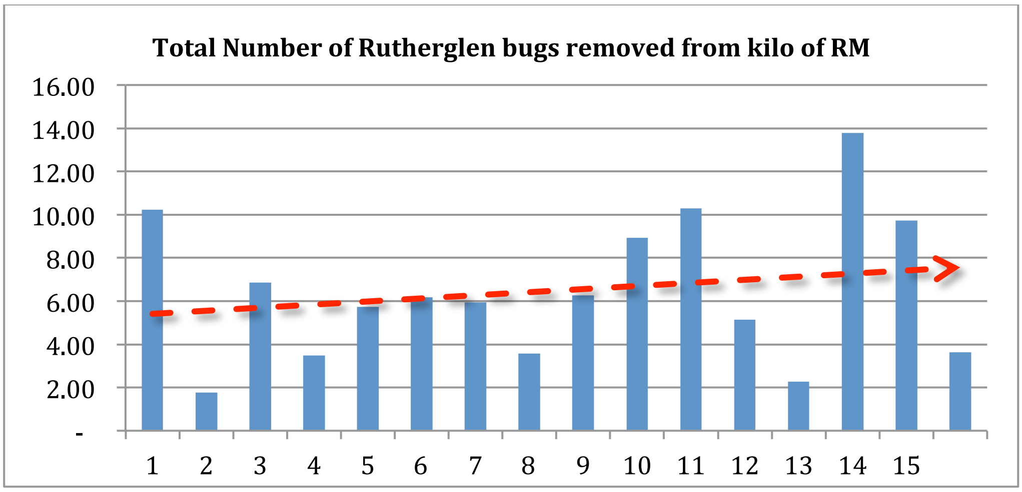



Figure 56 Rutherglen bugs removed from raw material in January 2014

**Flies, Lady beetles, soldier beetles and moths**

Flies, lady beetles, soldier beetles and moths are the second most common group of insects found on the processing line. The levels of contamination from these insects are shown in Figure 57 to Figure 60.

Lady beetles, despite being beneficial insects, remain one of the major insect contamination issues in baby leaf crops. The number of lady beetles that occurred over January was highly variable, with a peak around days 9 to 11 (Figure 57).

Soldier beetle contamination is another significant issue in baby leaf crops. Occurrence of solider beetles is also highly variable, and depends on swarms of these insects coming into a region (Figure 58). They are usually high in January in Victoria, and followed a similar pattern of occurrence to lady beetles. Flies occurred over the whole sampling period, but their occurrence was highly variable (Figure 59).

Moth contamination appears to be different from other insects. There were decreasing numbers of moths over the sampling period (Figure 60). Moths swarm from outlying regions rather than persisting locally near production areas. OneHarvest suggests growers compare the results on moths in these reports to observations on their own farms.

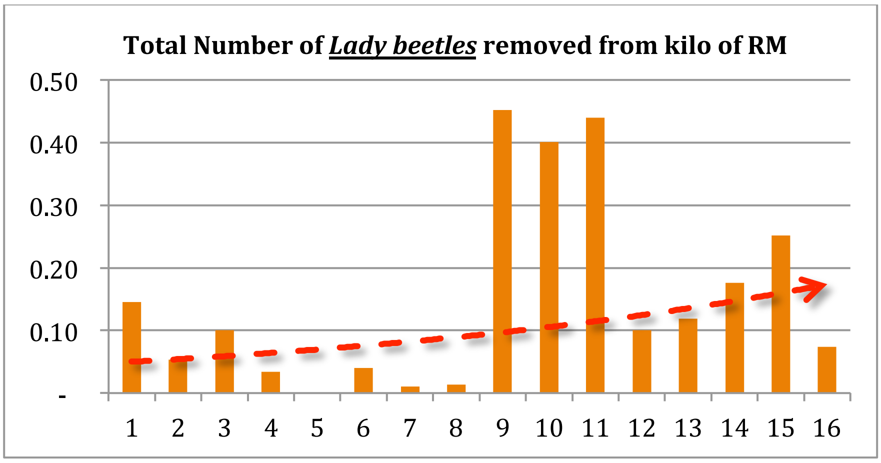



Figure 57 Lady beetles removed from raw material in January 2014

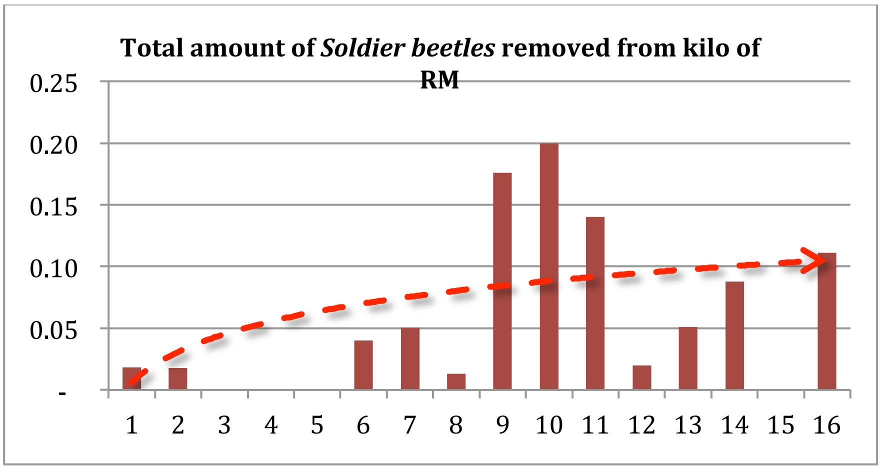



Figure 58 Soldier beetles removed from raw material in January 2014

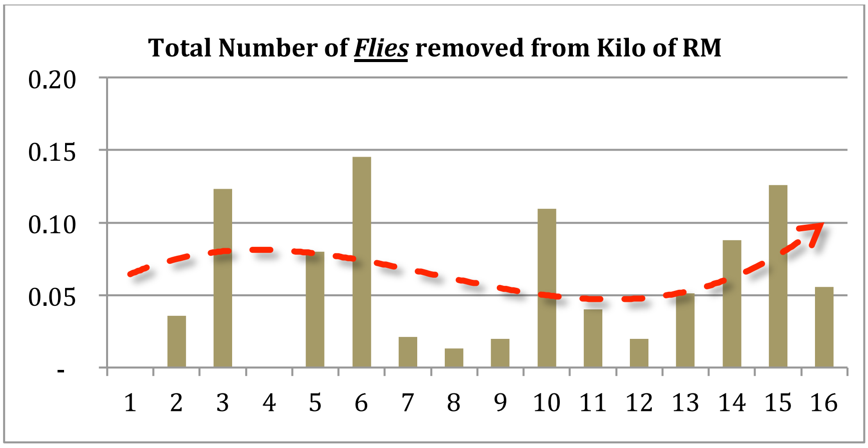



Figure 59 Flies removed from raw material in January 2014

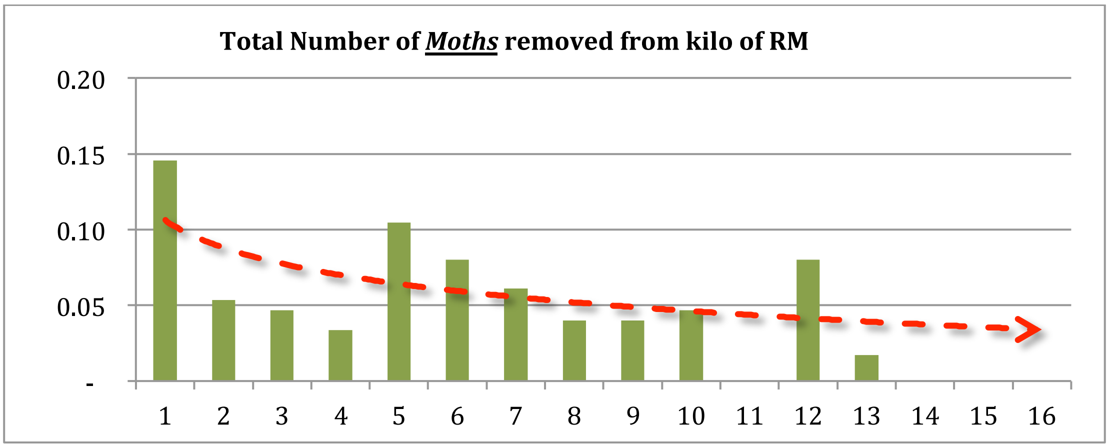



Figure 60 Moths removed from raw material in January 2014

## Trial 6.2 Initial factory assessment at OneHarvest – Brisbane

***Aim*** A preliminary investigation of the OneHarvest factory at Wacol, Brisbane was carried out to determine the areas in which improvements would be likely to provide the greatest benefits.

Insects are removed from harvested leafy vegetables at the factory by skimming drums, and the speed with which these drums rotate is likely to have an impact on the efficiency with which the drums extract insects from the washed product. A trial was carried out where the speed of these drums was varied, and the number of insects removed at each speed assessed.

***Materials and Methods*** The factory trial was conducted in November 2013, and assessed three drum rotation speeds (18, 12 and 6 rpm). Insects were added to harvested product at a rate of 6 moths (3 Heliothis and 3 hawk moths) plus 1 cricket per 30 kg of harvested baby leaf spinach. Insects in the wash water, and insects in the washed product were counted. The number of other insect recovered in the wash water were also counted, i.e., Rutherglen bugs and lady beetles. The trial was replicated twice, and the mean data presented.

***Results and Discussion*** Initial results indicate that the slower drum speeds do a better job of removing insects from the product. The slowest drum speed of 6 rpm, however, was only able to extract 30% of the added moths and the fastest drum speed did not extract any moths at all. The slower drums speeds also extracted more Rutherglen bugs and beetles than the faster speed (Figure 61). There is another opportunity for insects to be removed further down the packing line using an optical sorter. Further factory trials are planned using larger numbers of added moths, slower drum speeds, and including an evaluation of the efficiency of the optical sorter. Trials are also planned for the Bairnsdale factory, which uses skimmer boxes rather than drums for extracting contaminants.

Table 8 Number of insect recovered from 30 kg leaf material

| | Number of insects recovered (per 30kg) | | | |
|---|---|---|---|---|
| Drum speed (rpm) | Heliothis | Rutherglen Bug | Beetles | Total |
| 18 | | 6 | 1 | 7 |
| 12 | 2 | 5 | 2 | 9 |
| 6 | 2 | 0 | 7 | 9 |

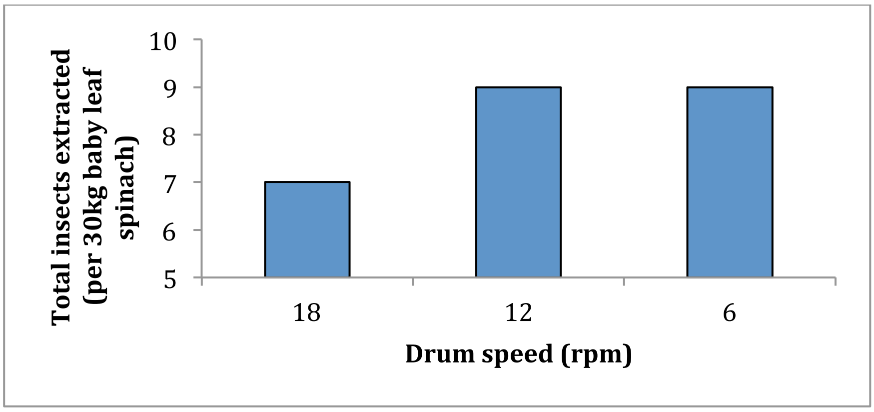



Figure 61 Impact of drum speed on the removal of insect contaminants from baby leaf spinach

## Trial 6.3 Assessment of insect removal techniques at the OneHarvest factory in Bairnsdale, Victoria

***Aim*** An assessment of the efficiency with which the OneHarvest factory at Bairnsdale, Victoria, can remove insect contaminants from harvested baby leaf products was carried out as part of the project. The Bairnsdale factory uses drums which are similar to those used at the Wacol factory. The drums at Bairnsdale replace skimmer boxes, which have been used up to now to remove contaminants. Both factories have an optical sorter which follows the primary contaminant removal mechanism.

***Materials and Methods*** The trial was conducted on 25 March 2014, a time of year when insect pressure on baby leaf crops is high.

The trial was run twice on the commercial processing line at the factory. Normal commercial processing had to be suspended while the trial was conducted. Two crates each containing 40 kg of spinach were used for the assessment. To each crate, 30 dead Heliothis moths were added at the start of the processing line. The moths had been killed by freezing, which is a commonly used technique for euthanizing insects.

The processing line removes insects, and other contaminants in the following way:

1. ***Shaking belt***: Raw product is run over a shaking belt. This perforated belt shakes the product and allows contaminants to fall through the holes.
2. ***Rotating drum 1***: A perforated drum which rotates and, with the aid of wash water, removes insect from the leafy product (Figure 62).
3. ***Rotating drum 2:*** Same as drum 1, removes more material.
4. ***Optical sorter:*** The sorter uses optical detection to identify discoloured leaves, insects and other foreign material from the spinach before packing (Figure 63).

The trial was conducted by feeding each lot of spinach plus added moths to the line, and then collecting insects removed at each point along the line.

Figure 62 Drum processor

Figure 63 Optical sorter, ARDO, Europe

***Results and Discussion*** The shaking table in the trim room removed 7% of the added insects. The first drum removed a further 40% of the insects, the second drum removed another 18% and the optical sorter removed 2%. This left 33% of the added insects remaining in the processed product (Figure 64).

The results show the drums are efficient, removing about 40% of the moths present in the spinach as it passes through. The shaker is not especially good as a primary removal point for moths, removing only 7%. The optical spotter is poor at removing moths; it removed only 2% of the total number of moths added, and allowed 33% of the initial load to pass through into packed product.

More attention needs to be given to improving the efficiency of the optical sorter for removing moths, if it is the last line of defence. The system needs to be tested on other insects such as soldier beetles, lady beetles and Rutherglen bugs.

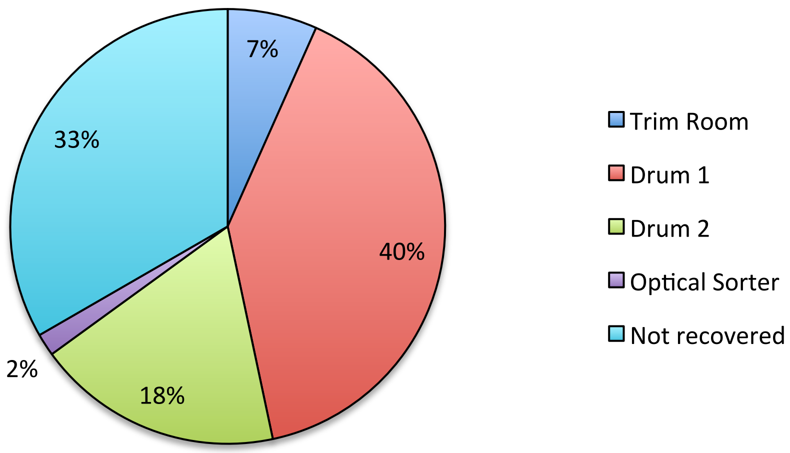



Figure 64 The efficiency of each control point in the processing line of removing Heliothis insects from spinach. Data shows % of insects removed at each point.

## Trial 6.4 Factory alive v's dead moths – Brisbane

***Aim*** It has been observed in the OneHarvest leafy vegetable processing factories' trials that most of the moths passing through the washing and sorting lines (resulting in customer complaints) are still alive. This suggests that if the moths are dead at the time baby leaf products come into the factory, the washing and sorting processes might be able to remove them more easily than living moths. An experiment was devised at the Wacol OneHarvest plant to test the idea that dead moths are easier to remove than live moths.

***Materials and Methods*** A total of three groups, each of 15 live moths; and three groups, each of 15 dead moths, were used in this trial. The wings of the moths were labelled to identify whether they were alive or dead at the time they were added to the harvested crop, prior to processing.

There are three points at which insects can be removed from crops on the processing line: drum 1, drum 2 and the optical sorter (Figure 65).

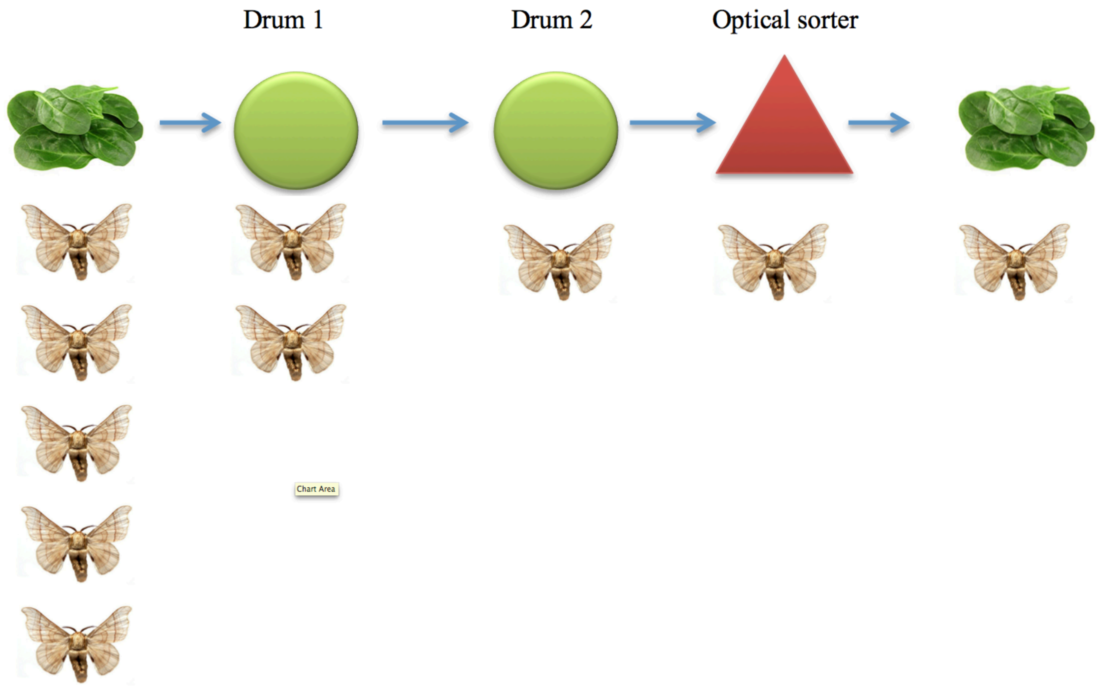



Figure 65 Schematic of the points in the processing line where insects can be removed.

On three separate runs of the processing line, 15 live and 15 dead *Helicoverpa* moths were added to spinach at the start of the line. The line was then run, and moths collected at drum 1, drum 2, the optical sorter, and from spinach at the end of the line. The number of live and dead moths at each point was counted.

***Results and Discussion*** Dead moths were more effectively removed by the two drums on the processing line. Of the 15 moths added in each test run, on average the insect removal equipment was able to remove 11 of the 15 (73%) dead moths present in the spinach but only 5 of the 15 (33%) of the live moths (Figure 66, Figure 67). This clearly shows that dead moths are easier to remove than live moths.

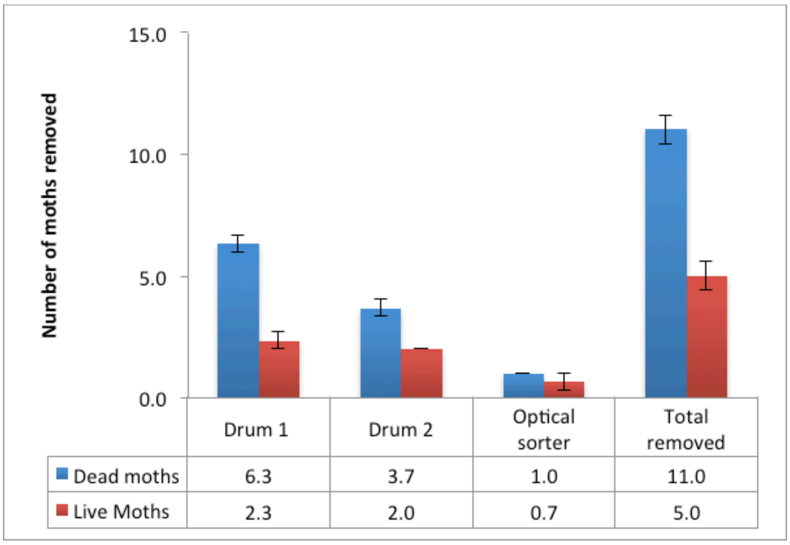



Figure 66 Number of dead or living moths out of a total of 15 removed at each stage of the processing line.

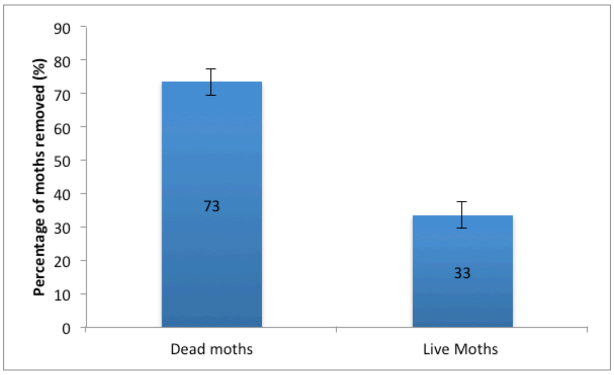



Figure 67 Percentage of dead and alive moths removed by all stages of the processing line

***Conclusions*** If moths can be killed before harvest, it will be easier to remove them in the processing line.

## Trial 6.5 Insect contamination levels in processing factories

***Aim*** The idea of this experiment was to see if there is some correlation between the number of moths found in processed baby leaf product and complaints received from consumers at the retail level. If this were the case, it may be possible to determine a threshold level of insect contaminants found in the product line, then to raise an alarm if contaminant numbers were to exceed that threshold.

***Materials and Methods*** At each of the three HFC processing factories (Brisbane, Perth and Bairnsdale), records were kept of the number of moths that were removed from product on each of the processing lines. At the same time the number of kilos of product that passed through the line on a particular day was recorded, and the level of insect contamination calculated as the numbers of moths per kg of product.

The numbers of complaints received at the retail level were also recorded. These complaints were from Woolworths and Coles supermarkets and related to product identified as being sent from Bairnsdale, Brisbane or Perth. The data was plotted so that the complaints matched the production dates of the product in question.

***Results and Discussion*** Brisbane: There was some correlation between numbers of customer complaints and the levels of moth contamination. In the first half of December 2014 there were low levels of moth contamination, and no complaints during that period. In mid December, the levels of contaminants increased, and there was a corresponding increase in the frequency of consumer complaints. There was a sharp peak in contaminant levels in early January which declined at the start of February. This period of heightened moth contaminant levels also corresponded with a higher frequency of customer complaints (Figure 68).

Bairnsdale: During the period from early December to Christmas there were very low levels of moths and virtually no customer complaints. (Perhaps people were thinking more about Christmas than complaining about the insects in their vegetables during that period?) After Christmas, in January, the level of insect contaminants remained low, however the number of customer complaints increased significantly during the first two weeks of January. Around 19 January, the level of insect contaminants jumped quite markedly, and there was a corresponding increase in the number of complaints. Insect contaminant levels dropped by the end of January but complaints carried on at a similar level until the middle of February (Figure 69).

Perth: The most striking result for Perth was the generally high level of insect contaminants compared to the other two states. This suggests that the growers supplying the Perth factory are not controlling their insect levels in the field as well as growers in Queensland and Victoria. Interestingly, the overall level of complaints from retail consumers in Perth is low compared to the other two states, and fairly evenly distributed over the year, despite the much higher level of moth contamination. A possible explanation for the apparent contradiction could be that moth eradication practices are so good in Perth that very few moths actually get through the removal process, and so do not make it into retail packs (Figure 70).

***Conclusions*** The data is certainly interesting and does show some clear correlations between the level of moth contamination and the number of customer complaints. However, whether the correlation between the numbers of moths removed on the processing line, and retail customer complaints is close enough to warrant the adoption of a threshold contaminant level to trigger increased efforts to remove moths, is difficult to say.

The apparent discrepancy between insect contamination levels and customer complaints in Perth warrants further investigation. Are insect removal techniques better in the Perth factory? And why are growers supplying product with high levels of moth contamination? Growers supplying the Brisbane and Bairnsdale factories appear to be supplying product with much lower levels of moth contamination than Perth. Do Perth growers need to improve their methods? Is there something to be learned about the efficiency of moth contaminant removal in the Perth factory given the apparent discrepancy between insect contaminant levels and customer complaints?

The observations in Brisbane and Bairnsdale about interactions between the impact of Christmas on the level of complaints are interesting, and could be investigated further.

The main period for moth contamination for Brisbane was mid December to early February. For Bairnsdale it was late January, and for Perth, contaminant levels were high all year.

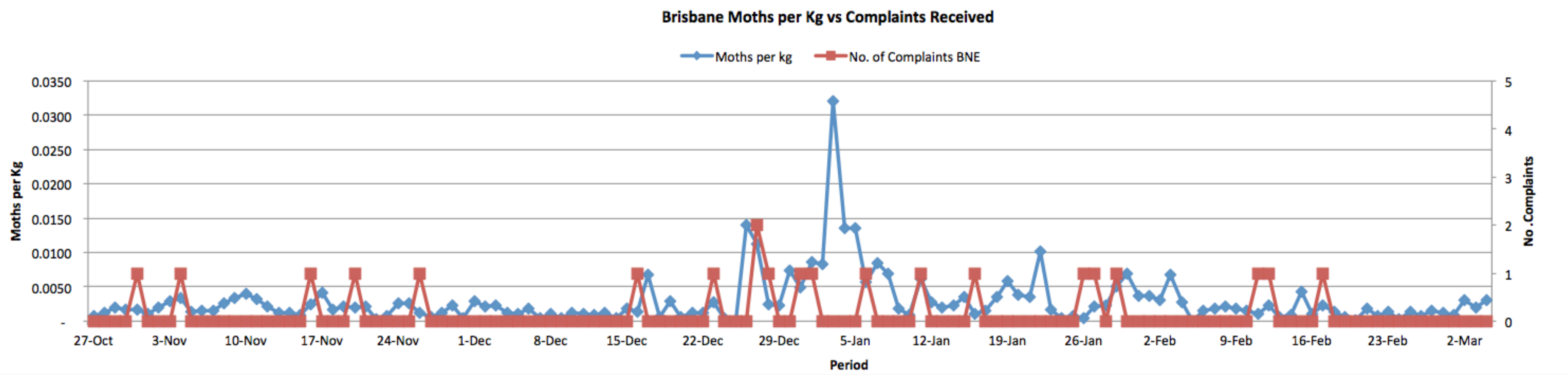



Figure 68 The number of moths removed per kg of baby leaf product processed in the Brisbane HFC plant from October 2014 to March 2015 and the total number of customer complaints received for the same period.

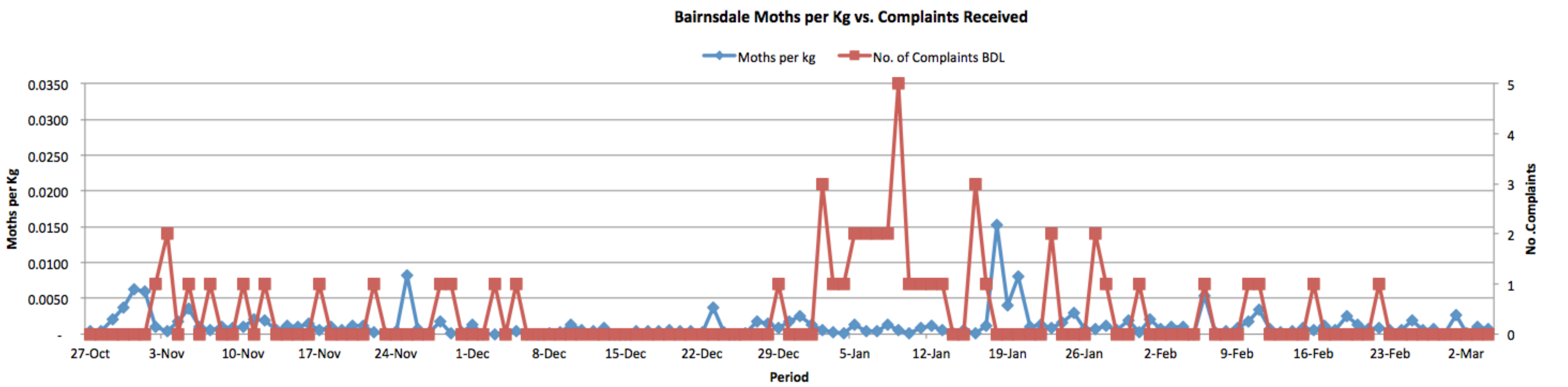



Figure 69 The number of moths removed per kg of baby leaf product processed in the Bairnsdale (Vic) HFC plant from October 2014 to March 2015 and the total number of customer complaints received for the same period.

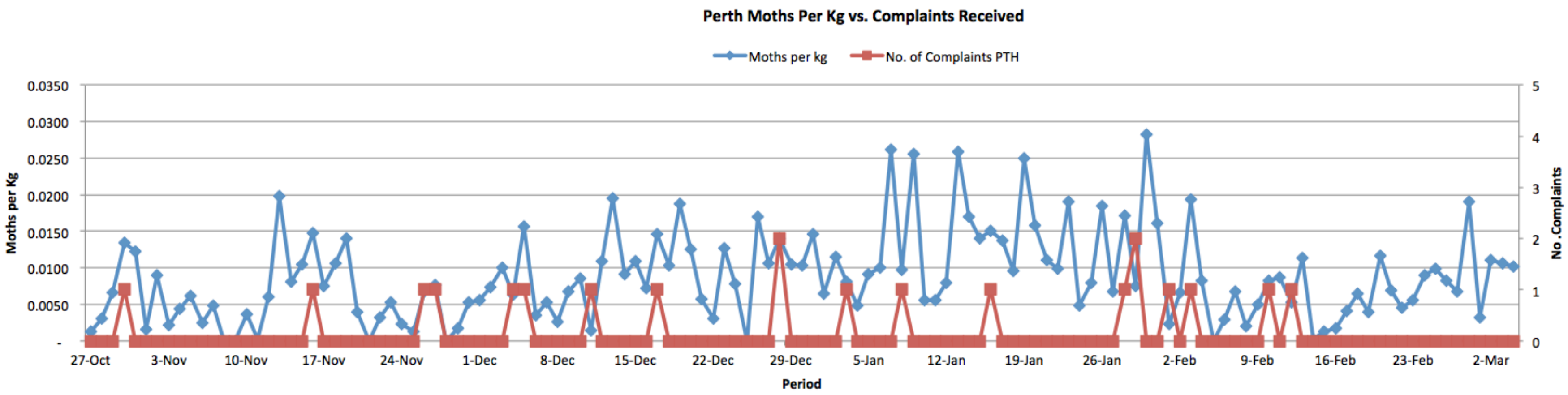



Figure 70 The number of moths removed per kg of baby leaf product processed in the Perth HFC plant from October 2014 to March 2015 and the total number of customer complaints received for the same period.

# Outputs

## *1. Managing insect contaminants in processed leafy vegetables: A best practice guide*

The key results from the project have been assembled and published in a 4-page best practice guide (Figure 71). The full guide is attached as Appendix 2.

The guide is aimed at growers and industry professionals and presents the main findings of the project in a succinct way. Some of the more experimental outcomes from the project such as promising insect deterrents, and the *Helicoverpa* attractant (Mangneta®) could not be included, as these are not yet registered, or covered by permits in Australia for leafy vegetables. The details of these products have been described in full in this report. The guide covers:

- Which insect result in the most complaints.
- Factory removal of insect contaminants.
- Control in the field using deterrents and row covers.
- Light traps.
- Modifications to baby leaf harvesters to dislodge insects at harvest.

The best practice guide has been sent to all Australian vegetable growers via the AUSVEG weekly update. It has also been sent directly by email to 1500 growers and industry professions via the AHR vegetable growers data base. The fact sheet is available via the AHR website (www.ahr.com.au) and the Integrated Crop protection website (www.integratedcropprotection.com.au). It was also provided to all workshop participants in hard copy.


Managing insect contaminants in processed leafy vegetables: A best practice guide

Integrated Crop Protection
PROTECTING CROPS

Introduction

Insects are potential contaminants of processed leafy vegetables. Pest and beneficial species, in both the juvenile and adult stages of their life cycles can become unwanted contaminants if they make their way from the field into the final packaged product and to the end consumer.

This best practice guide summarises the key findings of a project conducted by Applied Horticultural Research and Harvest Fresh Cuts. The focus of this project was to find ways to control contaminants and assess their impact in processed leafy vegetable products.

To determine which insect groups were of most relevance, and how to reduce insect contamination of packaged produce, the project started at the customer level and worked back through the supply chain, examining

Figure 1. Soldier beetle

Figure 71 Managing insect contaminants in processed leafy vegetables: A best practice guide.

## *2. Regional workshops and communications*

Four regional workshops were held to communicate to growers the outcomes of the project, and to explain the current best practice in reducing insect contaminants in leafy vegetable crops. The flyers for each workshop are included as attachment 3. The details of the events were:

1. **Lindenow (Victoria):** 9th September 2015, Time: 2:00 – 4:00pm, Place: Lindenow Hotel (Farmers Home Hotel), 167 Main Rd, Lindenow VIC 3865.
2. **Gatton** (SE Qld): 26th August 2015. 3pm – 5pm, Gatton Research Station Lawes, 4343.
3. **Cranbourne** (Vic): 11th September 2015, 2:00 – 4:00pm, Bear House Restaurant 110 Sladen St Cranbourne VIC 3977.
4. **Wanneroo** (WA) 2nd October 2015, 4:30 – 6:30pm, Wanneroo Villa Tavern 18 Dundebar Rd Wanneroo WA 6065.

The attendance at the workshops was Gatton (29), Lindenow (15), Cranbourne (18), Wanneroo (8) = total attendance = 70 growers and agronomists.

The information sessions were well attended and very well received by the growers and agronomists who attended. The sessions were combined with a presentation on IPM by Dr Paul Horne as part of the Integrated Crop Protection project (VG13076). The activities were combined to increase the attractiveness to the industry.

***Assessment of the effectiveness of regional workshops***

Analysis of the workshop feedback form could be summarised as:

- Knowledge and confidence of participants in controlling insects in leafy crops improved as a result of attending the information sessions (rating shift from 3.1/5 to 3.6/5).
- Almost all participants identified they were able to make more informed decisions about how to manage insect contaminants following the information sessions (93%).

**Issues with workshops**: While the workshops were very well received by attendees, there was considerable difficulty in attracting participants to these events. Issues identified as problems by participants were: clashed with school holidays, other events, time of day. AHR attempted to run the sessions at times that would suit growers and went to considerable lengths to publiscise the events. Flyers were sent to growers via the AUSVEG weekly update, direct emails form the AHR data base, personal phone calls and working through regional organisations, (e.g. Vegetables WA, Victorian vegetable growers' association). It remains difficult attract growers to workshops given their time constraints, and other avenues should be considered to supplement these events such as webinars and articles in regional magazines.

### *3. Vegenotes 41*

A Vegenote was produced by AUSVEG for this project (Figure 72). The Vegenote is attached as Appendix 1.

vegenotes 41

2014

IN THIS ISSUE:

- **Improving the management of insect contaminants in processed leafy vegetables.**

**HAL R&D project number: VG12108**

Project VG12108 is investigating a proposed solution for improvements to the supply chain to reduce the potential for insect contamination in processed leafy vegetables.

Figure 72 Vegenote 41: Improving the management of insect contaminants in processed leafy vegetables.

# Outcomes

The main outcome of the project is the increased understanding of how to manage insect contaminants in leafy vegetables, in the field and in the factory. The result will be less customer complaints about contaminants, and fewer rejections of leafy vegetable consignments by retailers.

The project also contributed to the following outcomes of the Integrated Crop Protection project (VG13076):

Improved awareness, knowledge, capacity and decision-making

- Over 260 individual growers, advisors and industry stakeholders involved in project extension events.
- Approximately 17,000 hectares of vegetable production has been covered by participating growers in training and events.
- The topic and content, delivery, relevance to business, venue location and catering of all 14 training and events has been rated above 4/5 by participants.
- Access to advisors extends the reach of information provision to growers (multiplier effect). Approximately 40% of participants have been advisors to date, in either private firms or public extension.

Application of Integrated Pest Management

- Knowledge and confidence of participants in controlling insect pests generally improved as a result of attending the information sessions (rating shift from 3.1/5 to 3.6/5).
- Almost all participants identified they were able to make more informed decisions about which pesticide to use following the information sessions (93%).
- The majority of participants were aware of IPM with over half (50---70%) applying IPM to their farm business or the advice they were providing. A smaller percentage (10---15%) were interested in starting.

# Evaluation and Discussion

***Insect attractants*** There appears to be a clear benefit of using the moth attractant Magnet® in combination with insecticides. Methomyl + Magnet® applied to *Helicoverpa* moths resulted in 90% mortality after one hour. Methomyl alone resulted in a 60% mortality after 4h. Success Neo™ plus Magnet® was also effective, resulting in a moth mortality rate of 55% after 24h. When applied to the intercrop area, Magnet® plus methomyl attracted and killed 3.3 *Helicoverpa* moths per 50 $m^2$ after three hours and 8.3 Helicoverpa moths per 50 $m^2$ after nine hours. This result is promising, and confirms the potential of Magnet® plus methomyl as a means of attracting and killing *Helicoverpa* moths near leafy vegetable crops.

**Note**: The Magnet® plus methomyl treatment is not registered for use on or near leafy vegetable crops and the necessary regulatory approvals would need to be achieved before this combination could be used in commercial production.

***Insect deterrents*** The use of low toxicity, short withholding period chemicals were evaluated in Queensland and Victoria, and the results were mixed. In Queensland trials, alpha cypermethrin and Barrier Plus® mixed with chilli spray were effective at reducing the numbers of Rutherglen bugs late in baby leaf spinach crops. There is a current permit (PER14433) which covers the use of alpha cypermethrin under certain conditions, with a one-day withholding period. In Victorian trials, alpha cypermethrin was effective at controlling Rutherglen bugs late in the crop, but Barrier Plus® mixed with chilli spray was not.

***Light traps*** Light traps were evaluated over five separate trials in SE Queensland and were found to be effective at reducing *Helicoverpa* sp. (Heliothis) moth numbers in lettuce and baby leaf spinach crops up to 100 m from the light trap. Adult moth numbers were reduced by at least 50% and egg numbers were reduced by 70% compared to controls. Light traps should be considered as a way of reducing the load of moths in harvested product, especially when insect pressure is high.

***Floating row covers*** The floating row covers were very effective in controlling Rutherglen bugs in spinach. In the open field there were approximately 10 live bugs per square metre and virtually zero under the row covers. As Rutherglen bugs are a major contamination problem for baby spinach production, this is a very positive result for the use of the netting material. The floating cover also mostly excluded beet webworm, although they were not effective against lady beetles. Although lady beetles are also a contamination issue, they may be more easily detected during packing. Floating row covers could be used to reduce insect numbers without adversely affecting spinach quality, although crop development can be delayed.

***Harvester modifications*** Trials in Victoria confirmed earlier results from a separate project that the combined use of (1) fans at the front of the tractor, (2) chains dragged through the crop and (3) a perforated conveyer belt were effective at removing Rutherglen bugs and flies from harvested spinach. These modifications should be repeated when there is a high pressure from insects such as Rutherglen bugs, soldier beetle and moths.

***Removal of insect contaminants in the factory*** Rutherglen bugs were the most abundant insect contaminant, followed by flies, lady beetles, soldier beetles and moths. The relative importance of shaking belts, rotating drums and optical sorters for removing live moths from baby leaf spinach on processing lines for fresh cuts were assessed. If the moths were alive at the start of processing, the drums removed 31% of added moths, and the optical sorter another 5%, leaving 73% of the moths in the product. If the moths were already dead when the spinach entered the line, they were much easier to remove. For dead moths, the drums removed 67% of the moths, the optical sorter another 7%, leaving only 27% of the added moths behind.

This is an important result and means that growers should be aiming to control moths close to harvest. Control measures in the field will significant reduce moths in the harvested crop, and even if some dead moths find their way into the harvested product they will be much easier to remove on the processing line than live moths.

***Relationship between the number of moths in processed baby leaf product and consumer complaints*** The data showed some clear correlations between the level of moth contamination and the number of customer complaints. However, the correlation between the numbers of moths removed on the processing line, and retail customer complaints was not close enough to warrant the adoption of a threshold contaminant level to trigger increased efforts to remove moths.

# Recommendations

1. Growers should fit harvester modification to their babyleaf harvesters to remove insects at the point of harvest.
2. The use of the insect attractant Magnet® should be further investigated, with a view to seeking registration or a permit for the control of moths in leafy vegetables.
3. Growers should be considering the use of light traps to reduce the population of moths around crops when moth numbers are high.
4. Floating row covers should be considered for reducing insect contamination levels when insect populations are high. Anecdotal evidence is also suggesting they might be effective at controlling other insects such as thrips.

# Intellectual Property/Commercialisation

There are no intellectual property, commercialisation or confidentiality issues.

The factory assessments were carried out at OneHarvest factories in Bairnsdale and Brisbane (Wacol). The results of these assessments have been communicated to OneHarvest management and they have had the opportunity to implement changes in their processing lines as a result. There is no confidential information in this report – it is all in the public domain.

# Acknowledgements

AHR staff and Brad Giggins wish to thank OneHarvest for their part the project, and for readily making facilities available for research.

AHR also wish to thank Dr Paul Horne and RMCG staff for assisting with the organisation of the regional workshops.

AHR would like to thank the grower co-operators for allowing us to run trials on their properties, in particular, Colin Britton (Stanthorpe and Gatton), Westview Gardens (Toowoomba) and Australian Fresh Salads (Sale).

# Appendices

Appendix 1 - Vegenotes41.pdf

Appendix 2 - Managing Insect Contaminants Best Practice Guide.pdf

Appendix 3 - Workshop Flyers.pdf

# vegenotes 41

2014

**IN THIS ISSUE:**

- **Improving the management of insect contaminants in processed leafy vegetables.**

### HAL R&D project number: VG12108

Project VG12108 is investigating a proposed solution for improvements to the supply chain to reduce the potential for insect contamination in processed leafy vegetables.

- **National Bee Pest Surveillance Program**

### HAL R&D project number: MT12011

Project MT12011 is providing an early warning system to detect new incursions of exotic pests and pest bees, and trade support in order to facilitate their exportation to countries sensitive to a range of such pests.

www.ausveg.com.au

# Improving the management of insect contaminants in processed leafy vegetables.

**Facilitators:**

Milestone 102 of Project VG12108 has recently been completed by Project Leader Dr Gordon Rogers from Applied Horticultural Research NSW and team.

## Introduction

A significant and recurring problem for leafy vegetable growers and processors is insect contamination in fresh produce and the processed product. Insect contamination causes rejections and lost sales for growers, added costs for processors and negative publicity for retailers.

Rejections are expensive for growers, lead to lost sales for processors due to unfulfilled orders, and reduce income throughout the supply chain. Consumers are also affected as product supply is reduced and retail prices can rise as a result.

Leafy vegetable processors have experienced increases in contaminant levels of processed products in recent years with the summer of 2012/13 being particularly bad. Victoria has been the most severely affected with one processor reporting that 70% of the insect complaints originated in the state. However, seasonal spikes are seen throughout Australia's supply regions.

## About the project

Project VG12108 aims to find ways to reduce insect contaminants in processed leafy vegetables through a coordinated approach at the processor and grower levels. New methods to control and remove insects will be assessed, along with the development of a standard set of sampling guidelines for use in the field and factory. A best-practice guide will also be developed and made available to the wider industry.

Project leader Dr Gordon Rogers said trials were well underway and numerous activities had been completed since the project's implementation in mid-2013.

"The project team first looked at the US experience," Dr Rogers said.

"In California, similar insects to those in Australia find their way into harvested baby leaf crops. The main focus on US farms has been to clean up border areas such as weedy fence lines, which can harbour the moths and beetles."

"In Europe, good results have been achieved using Neem extracts for deterring beetles, but in Australia these extracts are not registered for use on food crops. Synthetic pyrethroids are widely used, as well as spinosad, which we will trial in Australia."

"There has also been success in Europe using pheromone traps to disrupt mating of cluster caterpillar in spinach, and to monitor moth activity. This approach could potentially be used in Australia for beet webworm."

## Field trials

In the field, the project team has looked at harvester modifications designed to remove insects, and assessed the effectiveness of low-toxicity insect deterrents applied close to harvest time.

Dr Rogers said trials conducted in Gatton, Queensland and East Gippsland, Victoria would help determine whether current field practices could be improved to reduce insects in the crop near to harvest time, or if further modifications to baby leaf harvesting equipment were required.

"The most encouraging results so far have been on modifications to baby leaf harvesters," he said.

"In East Gippsland trials this summer, the combined use of fans at the front of the tractor, chains dragged through the crop and a perforated conveyer belt was highly effective at removing Rutherglen Bugs and flies from spinach."

Brad Giggins, who has conducted the trials, said: "We need to test these harvester modifications again when there is a high pressure from soldier beetle and moths to see if they are still effective under those conditions."

Trials in Gatton and East Gippsland have also been used to evaluate the effectiveness at controlling insects of chilli sprays and natural pyrethrum applied to baby leaf spinach crops close to harvest time.

"In the Queensland trials, the conventional controls (Dominex™ and Movento™) were effective at controlling insects, and there was no added benefit from applying insect deterrents two days before harvest. The East Gippsland trials showed a similar result with no added benefit from using deterrents,

especially against Rutherglen bug," Dr Rogers said.
A third set of trials evaluated light traps, which were set up in duplicate at Gatton to test their effectiveness at reducing pressure of moths on the crop.

While the traps proved effective at catching moths, there was no difference observed in the number of moths in spinach crops nearby.

## Factory assessments

A preliminary investigation of the OneHarvest factory at Wacol, Brisbane was carried out to determine areas where improvements would be likely to provide the greatest benefits.

Dr Rogers said initial findings highlighted that the best opportunity for insect removal was to focus on optimising the optical sorter.

Further trials are planned for the Wacol factory and OneHarvest's processing facility at Bairnsdale, Victoria.

### THE BOTTOM LINE: VG12108

- Using all harvester modifications at the same time, keeping insects well under control and cleaning up areas that potentially could harbour insects near leafy vegetable crops have the greatest potential to reduce insect contamination.

## Acknowledgements

The project is funded by HAL with voluntary contributions from OneHarvest. For further information contact Gordon Rogers (AHR) 02 9527 0826 or Brad Giggins 0427 014 990.

# National Bee Pest Surveillance Program

**Facilitators:**

Project MT12011 is being conducted by Project Leader Rod Turner, of Plant Health Australia.

## Introduction

Australia's freedom from many of the exotic pests that affect honey bees overseas provides the Australian honey bee industry advantages in terms of honey production and its ability to deliver paid pollination services.

This freedom also provides plant industries that are reliant on, or responsive to, pollination by honey bees, yield advantages through access to managed pollination services, as well as through the presence of wild honey bee populations that contribute a significant amount of incidental "free" pollination.

A system of national surveillance for early detection of a key pest threat of honey bees, such as the varroa mite, is an important tool in preventing its establishment. The earlier a new pest can be detected the greater the chance it will be restricted to a limited area and that eradication will be technically feasible.

## About the project

The National Bee Pest Surveillance Program (NBPSP) is an early warning system to detect new incursions of exotic bee pests and pest bees. The program follows on from the National Sentinel Hive Program established in 2000 to improve post-border monitoring around Australia for exotic pests of honey bees.

Project Leader Rod Turner, of Plant Health Australia, said the NBPSP involved a range of surveillance methods conducted at sentinel hives, i.e. the most likely entry point for bee pests and pest bees throughout Australia.

"The purpose of this project is to provide information on Australia's honey bee industry health status to support the beekeeping and horticultural industries, facilitate trade in honey bee industry commodities and meet Australia's international reporting obligations," he said.

"Early detection of these pests is critical to providing the best possible opportunity to eradicate an incursion, and to limit the size and cost of an eradication program."

"The program also contributes to competitive market access for Australia's queen bees and packaged bees, and provides information on Australia's capabilities and activities regarding surveillance and control of honey bee pests and pest bees."

Surveillance of honey bee health will be undertaken through support for a national program of sentinel hives, remote surveillance hives, sweep netting, and hobby beekeeper involvement at high-risk ports of entry throughout Australia.

"Hives are tested every two months using an acaricide (miticide) for the early detection of varroa mites and tropilaelaps mites, which could possibly enter via exotic bees on a vessel or other transport," Mr Turner said.

"Samples of bees are also taken from these sentinel hives every two months and submitted for dissection and examination for tracheal mite, which could also enter via exotic bees."

## Major findings

In 2013, 128 sentinel hives for bee parasites were maintained at sea ports and airports across Australia that receive significant volumes of imported cargo or regular berthing of vessels from international locations where exotic pests of honey bees are known to occur.

"This is an increase from the 26 sentinel hives which were managed throughout Australia in 2011," Mr Turner said.

During the same period, 54 empty hives were deployed at a number of southern ports as an additional measure for detecting swarms of exotic bees. Trials of remote surveillance hives continued to be conducted in 2013, with deployment in Cairns and Brisbane, Queensland. These will continue to be trialled in 2014 at additional locations for inclusion in the NBPSP.

Mr Turner said formalised surveillance for small hive beetle (SHB) across Australia also began in 2013.

"Surveillance consisting of hive inspection and oil traps began in the Northern Territory and Tasmania where SHB is currently not present, as well as southern Western Australia, where SHB is confined to northern Western Australia (Karratha)," he said.

The Australian-wide registration of Apithor was released in December 2013 and will be incorporated into the NBSP as the formal method of surveillance for SHB from 2014 onwards.

## Conclusion

The NBPSP is an ongoing program and a component of a larger program being developed by the Australian Honey Bee Industry. Surveillance will be a key component of this program, combined with advice to beekeepers on how best to manage their hives and how to prevent endemic and exotic pests affecting their livelihoods. Beekeepers with improved biosecurity skills will benefit pollination-reliant industries by ensuring a greater reliability of pollination services. It is envisaged the new program will commence early next financial year.

### THE BOTTOM LINE: MT12011

- The premise of this project is to try and protect the honey bee industry from exotic bee pests and the varroa mite.
- If varroa establishes in Australia, feral bee numbers will dramatically decline, the cost of managing hives will increase and pollination-reliant industries will be more dependent of pollination providers. The cost of these services will also increase significantly.

## Acknowledgements

The project is jointly funded by HAL, the Australian Honey Bee Industry Council, and the Australian Government through the Department of Agriculture.

**Photo credits:**
VG12108 photos credit: Dr Gordon Rodgers, Applied Horticultural Research NSW.
MT12011 photos credit: Plant Health Australia.

*Please contact Jamie Racicos at AUSVEG on 03 9882 0277 or email jamie.racicos@ausveg.com.auto submit topics for potential inclusion in future editions of* **vege**notes*.*

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AUSVEG HAL Horticulture Australia

# Managing insect contaminants in processed leafy vegetables: A best practice guide

Integrated Crop Protection
PROTECTING CROPS

## Introduction

Insects are potential contaminants of processed leafy vegetables. Pest and beneficial species, in both the juvenile and adult stages of their life cycles can become unwanted contaminants if they make their way from the field into the final packaged product and to the end consumer.

This best practice guide summarises the key findings of a project conducted by Applied Horticultural Research and Harvest Fresh Cuts. The focus of this project was to find ways to control contaminants and assess their impact in processed leafy vegetable products.

To determine which insect groups were of most relevance, and how to reduce insect contamination of packaged produce, the project started at the customer level and worked back through the supply chain, examining where information was lacking, and where commercial improvements could be made.

## Which insects get the most complaints?

Reviews into historical commercial data from customer complaints about manufactured leafy vegetable mixes found that moths and soldier beetles were the most reported insect contaminant. Insects referred to as moths in the data included Diamondback Moth (*Plutella sp*.), Heliothis (*Helicoverpa sp*.), Cabbage White Butterfly (*Pieris rapae*) and Beet Webworm (*Spoladea mimetica*.) Other insect groups were represented in the data at lower levels. Spiders, Rutherglen bugs, red and blue beetles and beneficials such as lady beetles made up only a small proportion of customer complaints.

Different insect species can show up in customer complaints data, and the regularity at which insect pests appear differs widely between species. The moths group (the order Lepidoptera) includes moths and butterflies. Lepidoptera pests—while seasonal—are quite regular. Soldier beetles, (*Chauliognathus sp.)* on the other hand, are a very sporadic contaminant. Rutherglen bugs (*Nysius sp.)* do not create severe contamination issues unless in plague proportions

Figure 1. Soldier beetle

in the field. Large scale commercial washing and processing lines have the capacity to remove the majority of insect contaminants.

## Wanted – Dead or alive

### In the factory

The project investigated whether the moths in customer complaints were reported as being dead or alive. Most moth complaints were from consumers reporting the presence of live moths, even though factory product inspection reports showed that both live and dead moths were making it to the factory.

The live moths were more likely to result in customer complaints.

Factory trials recorded the overall removal rate of live and dead moths from the wash line and it was confirmed that dead moths are easier to remove from leafy vegetables in the processing line than live moths.

Figure 2 shows the where insects are removed in the wash line, and how the first and second cleaning drums are much more effective at removing dead moths than live moths.

This project has been funded by Horticulture Innovation Australia Limited using the vegetable levy and funds from the Australian Government.

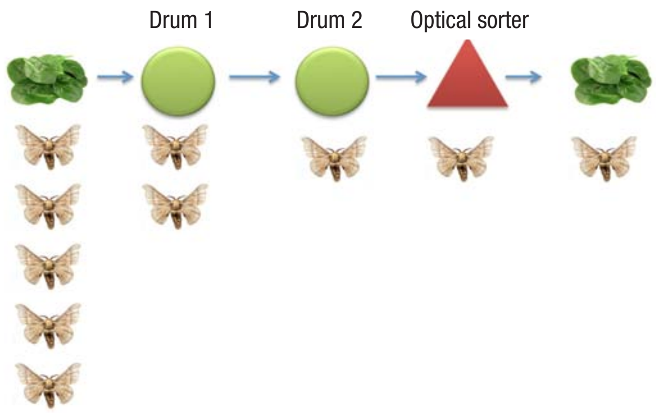



Figure 2: Diagram showing the points in the processing line where insects can be removed.

The first drum removed 42% of the dead moths, but only 15% of the live moths. The second drum removed another 24% of the remaining dead moths but only 13% of the remaining live moths (Figure 3).

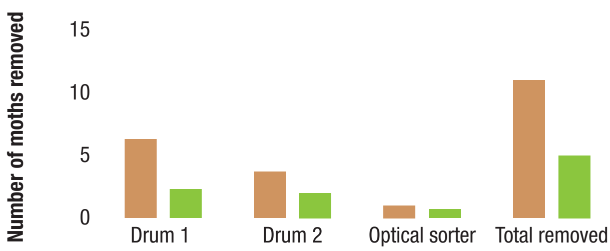
It is clear that a dead insect is much more likely to be removed in the washing process and that live ones are more likely to end up as a customer complaint.

## In the field

In Australia the majority of our leafy vegetables are grown in the open field, and it common for pest and beneficial insects to be present in these crops.

There are several ways to reduce the number of insects in a crop:

- Control insects in the crop
- Control insects outside the cropping area
- Make the cropping environment unattractive to insects
- Lure the insect away from the crop




| | Drum 1 | Drum 2 | Optical sorter | Total removed |
|---|---|---|---|---|
| Dead moths | 6.3 | 3.7 | 1.0 | 11.0 |
| Live Moths | 2.3 | 2.0 | 0.7 | 5.0 |

Figure 3. Live and dead moths extracted from baby leaf spinach at various stages of the washing line.

- Exclude insects from the crop using a barrier
- Remove insects at the point of harvest

**Remember:** Dead insects are easier to remove in the wash line than living insects.

### Control insects in the crop

Our single largest group of insect contaminants, the Lepidoptera group, are significant pests in their larval stages of growth in leafy vegetable production. Leafy vegetable producers aim to control these pests in their larval state. However, little consideration is given to the adult moth that lays the egg that becomes the caterpillar that causes the damage. Spray programs target freshly laid eggs and the early larval instar stages.

With the further adoption of more recently developed 'soft' chemistry, fewer broad spectrum insecticides are being used. Investigations examined how effective different groups of chemistry were in controlling adult heliothis moths. Other studies looked at the timing of 'knockdown' sprays in relation to harvest.

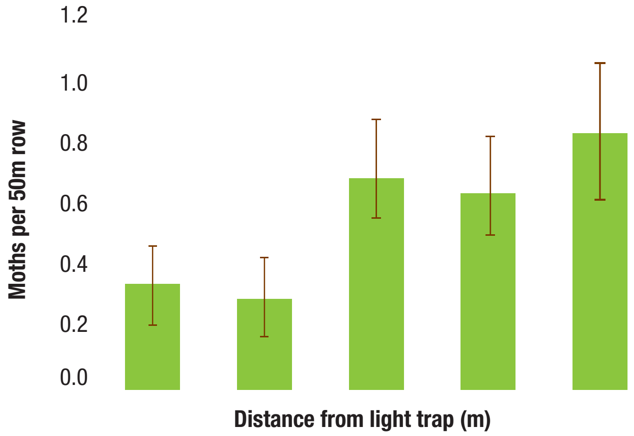
Preliminary trials were conducted on the use of moth attractants mixed with insecticide to lure adult moths to treated parts of the crop or to non-crop areas. The results were encouraging however the appropriate permits or label registrations approvals will need to obtained before these methods can be used.

### Make the cropping environment unattractive to insects

Plant based extracts such as chilli were also tested. These products initially appeared to have some impact on target insect species, however in most cases the use of a deterrent such as chilli had little effect. When mixed with natural pyrethroid, the effectiveness of chilli increased slightly. Once overhead irrigation is reapplied almost all effects appear to be lost on species like Rutherglen bug and lady beetles. Overall chilli sprays appear to have little effect on adult Lepidoptera species.

### Lure the insect away from the crop

The Vortex insect trapping system was trialled over two seasons with very good results. In a small cropping situation this device was able to greatly reduce moth numbers in baby leaf spinach up to 50m from the trap. Figure 4 show the light trap and its effect on the number of Heliothis moths found in spinach crops. For more information visit http://www.vortexics.com.au/insects.htm




| | 5 | 50 | 100 | 150 | 250 |
|---|---|---|---|---|---|
| Heliothis | 0.35 | 0.3 | 0.7 | 0.65 | 0.85 |

Figure 4. Vortex light trap and impact of the light trap on moth numbers in a baby leaf spinach crop in SE Qld.

## Exclude insects from the crop using a barrier

The project investigated the use of floating row covers to exclude insects. There are many different styles of cover and their effectiveness in excluding most insect species was very high. There are agronomic challenges to consider if row covers are to be used as a control option as floating row covers perform other functions, with insect control an additional benefit.

Figure 5 shows that floating row covers can be very effective in keeping both beet webworm and Rutherglen bugs out of baby leaf spinach crops. They were less effective on lady beetles. It was observed that some beneficial eggs were laid on the row cover itself and the very small juvenile lady beetles may have found a way through the row cover after hatching (Figure 6).

Readers are also directed to a separate study which evaluated the use of floating row covers for the production of babyleaf lettuce[1].

Figure 5. Floating row covers.

1 The production of baby-leaf lettuce under floating crop covers. Horticulture Australia project number VG09188 (2013)

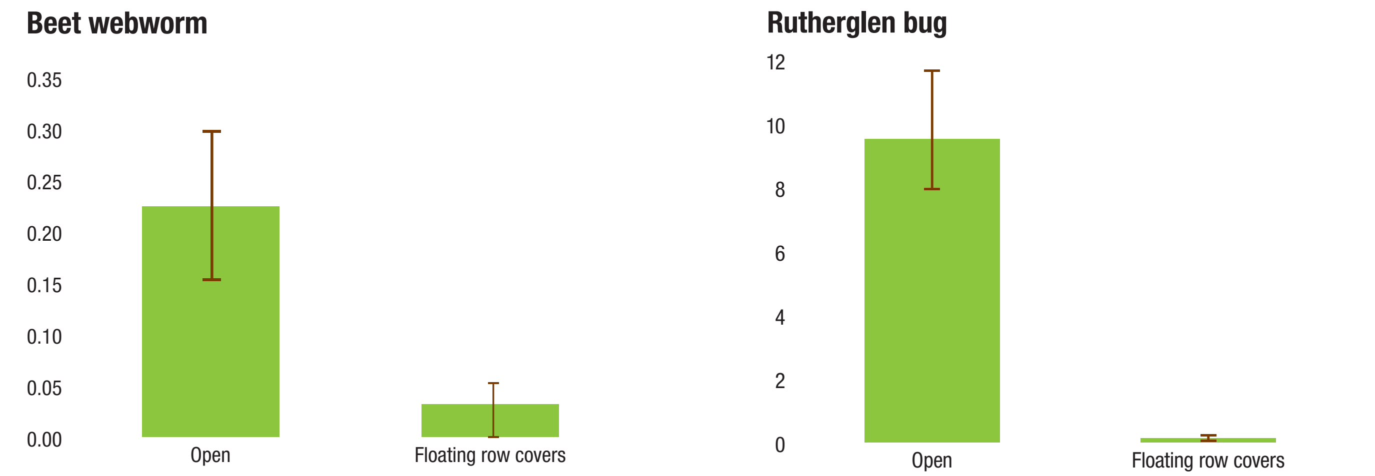



Figure 6. The effect of floating row covers in the numbers of live Rutherglen bug and Beet webworms in Spinach, Stanthorpe, Qld.

## Remove insects at the point of harvest

The harvester modifications have shown promising results in field trials carried out as part of this project. The modification evaluated were:

- Fans at the front of the tractor to blow insects out of the crop just before it is harvested.
- Chains attached to the front of the harvester and dragged through the crop to dislodge insects (Figure 7).
- A perforated conveyer belt, which carries the harvested product from the cutters. The perforations allow foreign material such as insects to fall through the holes.

Figure 7. Chains in front of the harvester to dislodge insects

Trials showed that modifications worked best when they were all used together, i.e. fans + chains + the perforated belt. They were especially effective at reducing Rutherglen bug numbers in harvested baby leaf spinach. Used in combination, the modifications were able to reduce overall insect contaminate levels in spinach (Figure 8).

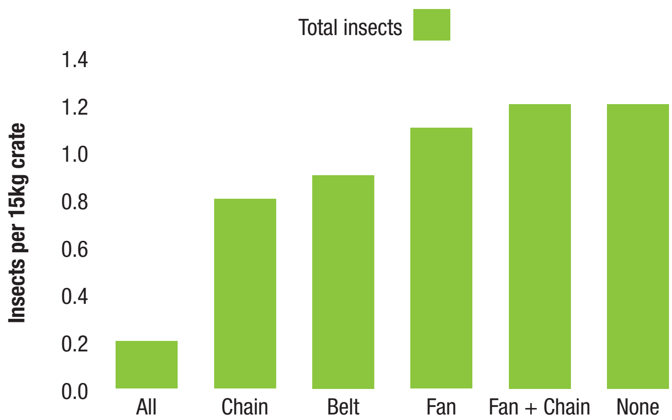



Figure 8. Effect of harvester modification on the level of insect contaminants in spinach, February 2013. The insects reported included Rutherglen Bug, flies and beetles.

**For more information, visit the AHR website at www.ahr.com.au or contact Brad Giggins on 0427 014 990**


This project has been funded by Horticulture Innovation Australia Limited with co-investment from Harvest Freshcuts Pty Ltd and Applied Horticultural Research and funds from the Australian Government.



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# Integrated Crop Protection Information Session

Integrated Crop Protection
PROTECTING CROPS

## Get the latest information and advice on controlling insect pests in vegetable crops

Controlling insect pests in vegetable crops is always an issue for farmers and advisors. The problem pests are similar each season but how to control them is not always the same. Insecticide resistance management is something to be considered carefully and using all the available cultural controls is something that is often overlooked. Preparing well for the coming season can help to avoid problems rather than try to solve them during the life of the crop.

Speakers include:

- **Dr Paul Horne**, Director / Entomologist, IPM Technologies Pty Ltd on preparing for the season ahead
- **Brad Giggins,** Director, Total Horticultural Consulting on improving the management of insect contaminants in processed leafy vegetables.

### Hurry places are limited

Contact Lynn Christie at **lynn@ahr.com.au** or call **02 9527 0826** to attend.

### Further information

Please contact Anne-Maree Boland **03 9882 2670** or Gordon Rogers **0418 517 777**

### Stay informed:

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on Twitter @ProtectingCrops

### Details

**Date:** 2 October 2015

**Time:** 4:30 – 6:30pm

**Place:** Wanneroo Villa Tavern
18 Dundebar Rd
Wanneroo WA 6065

**Free refreshments and parking provided.**

This project has been funded by Horticulture Innovation Australia Limited using the vegetable levy and funds from the Australian Government.

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### Details

**Date:** Wednesday 9 September 2015

**Time:** 2:00 – 4:00pm

**Place:** Lindenow Hotel (Farmers Home Hotel) 167 Main Rd, Lindenow VIC 3865

**Refreshments provided**

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### Details

**Date:** Friday 11 September 2015

**Time:** 2:00 – 4:00pm

**Place:** Bear House Restaurant
110 Sladen St
Cranbourne VIC 3977

**Refreshments provided**

This project has been funded by Horticulture Innovation Australia Limited using the vegetable levy and funds from the Australian Government.

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### Further information

Please contact Anne-Maree Boland **03 9882 2670** or Gordon Rogers **0418 517 777**

### Details

**Date:** **26th August 2015**

**Time:** **3pm – 5pm**

**Place:** **Gatton Research Station, Warrego Highway, Lawes, 4343**

**Free BBQ tea and parking provided**

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