Know-how for Horticulture™

Improving lettuce insect pest management - NSW and QLD

Dr Sandra McDougall
NSW Department of Primary Industries

Project Number: VG01028

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FINAL REPORT

VG01028

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CONVENIENCE FOODS

Media Summary

New options for managing insect pests in lettuce have been developed and lettuce growers have been assisted in adopting an Integrated Pest Management (IPM) approach. Australian lettuce growers have been assisted in preparing for the arrival of the new pest, Currant Lettuce aphid into their growing areas and those affected by the pest's arrival have been assisted in it's management.

The initial 3 year lettuce integrated pest management (IPM) project (VG98048) focused on managing the key pest, heliothis. One species of this pest group, like most key pests, had developed resistance to the insecticides used to control it. Although growers still got some control using the old chemistry, chemical failures had become more common. An IPM approach seeks to utilize both beneficial insects and selective pesticides that have less negative impact on benefical to assist in managing pests. In an IPM system, crops are monitored and attention is paid to cultural control practices such as removing weeds that host diseases or pests.

This project continued working with growers to improve understanding of an integrated pest management approach, to recognize pests, beneficials, diseases and disorders in their lettuce crops, and learn from each other through lettuce industry conferences. The field identification guide was produced as a reference that growers' and industry people can continue to refer to.

Following VG98048 heliothis and other caterpillars could effectively be managed by relying on beneficial insects and using new generation insecticides or some biological products. However, towards the end of VG98048 silverleaf whitefly moved into SE Queensland lettuce producing areas causing considerable damage. The currant-lettuce aphid devastated the NZ lettuce industry just after this project began in 2002 and arrived in Tasmania (Mar 2004) 14 months before this project finished. Western flower thrips also moved more into field grown lettuce crops causing considerable damage by spreading tomato spotted wilt virus. These sapsucking insects were the focus of trials for new insecticides throughout this project. Some work also continued to test insecticides for heliothis management. There are some products, particularly some soil or seedling drenches that showed very good control of aphids and leafhoppers. A smaller group reduced whitefly numbers and data was inconclusive or variable on thrips control.

Western flower thrips appears to be a major impediment to adoption of IPM in lettuce in South and Western Australia. The lack of IPM consultants in most lettuce growing areas is also a major impediment to adoption. Like heliothis, these new pests of lettuce: silverleaf whitefly, western flower thrips and currant-lettuce aphid have developed resistance to most chemicals that has been used against them intensively. Therefore developing an integrated approach that relies on more than just a single chemical to manage each pest is as important as ever.

Technical Summary

A biointensive IPM strategy should be more effective and resilient in the long term in managing pests than reliance on a few regularly applied broad spectrum insecticides. Developing a biointensive IPM strategy for an industry and having an industry adopt a biointensive IPM strategy is a slow and potentially complicated business.

This project screened the efficacy of 23 new products and some novel applications of old chemistry against various sap suckers and/or lepidoptera. A variety of polyhouse pot and field trials were conducted. Some trials were conducted on field stations (Yanco and Gatton) and some were conducted in commercial lettuce growers fields. In trying to tie together the various combinations of new chemistry 'best management option' (BMO) trials were conducted. Some BMOs were incorporated into replicated small plot trials, some were as unreplicated commercial-scale trials paired to 'grower controls'.

For aphid management the neonicotinyl insecticides were effective as as foliar (acetamiprid, clothianidin and thiacloprid), soil or seedling drenches (imidacloprid, thiomethoxam and clothianidin) and/or granular band applications (thiomethoxam). Seedling drenches were quickest to take effect. Soil or seedling drenches and granular band killed aphids for life of crop/trial at recommended rates but for a shorter period at lower rates. Foliar sprays had knockdown and some residue for a week or so.

In trials where leafhoppers were present neonicotinyl insecticides were effective, and also had some reduction on Rutherglen bugs and mirids. Thrips activity was mixed between trials and products. Imidacloprid reduced whitefly numbers, however acetamiprid seemed to promote development of whitefly. Pirimicarb and dimethoate used as soil or seedling drench had good activity although serious phytotoxicity problems were noted at higher rates of dimethoate. Pymetrozine as a foliar spray was slow to show activity, reducing for aphid and leafhopper numbers but not whitefly or western flower thrips. Pyriproxyfen as a foliar showed no western flower thrips activity but reduced whitefly egg production. Of the experimental foliar products DC068 showed aphid and leafhopper activity for 2 weeks, and DC027 showed some thrips but not whitefly activity. MTI446 as a furrow spray not properly tested.

Parrifin oil, SilicaK, Natrasoap, kaolin and azadiractin showed no aphid activity. DC041, S1812, emamectin benzoate and methoxyfenozide were all effective against heliothis, although prodigy is slower to act. Emamectin and S1812 were good at controlling lucerne leafroller (LLR), although the lower rate of S1812 was not as good at getting LLR in lettuce heads. The heliothis virus products Gemstar® and Vivus® did eventually kill virtually all heliothis, however many larvae continued to feed for days and in some cases weeks.
BMO trials were variable in methodology and results but tended to give reasonable control. However BMOs proved to be more costly when compared to the 'grower' control.

Raising awareness of IPM with growers was facilitated via field days, workshops, the bimonthly newsletter, training of an IPM scout in one region, and two national lettuce industry conferences. Identification of pests, beneficials, diseases and disorders was assisted with the production and distribution to all lettuce growers a field identification guide for lettuce.

Introduction

Lettuce Industry

The Australian lettuce industry produces between 100,000-150,000 tonnes of lettuce valued around $100 million annually (ABS, Catalogue 7121.0). Average yields are approximately 22.6 tonnes per hectare (AUSVEG 2005). Lettuce is produced in all states with Queensland producing the most (35%) followed by Victoria (28%), NSW (17%), WA (11%), SA (6%) and Tasmania (3%).

Lettuce production can be classified into ‘head’, ‘fancy’, and ‘baby-leaf’ lettuce. It can be grown in fields or hydroponically. It can be sold on the ‘fresh’ market or processed. Data is not readily available for the breakdown of the different lettuce sectors.

Processing of head lettuce involves washing and shredding for fast food or restaurant sectors. Processing of baby-leaf usually involves washing and bagging for the restaurant or retail sectors. Head lettuce sold on the fresh market usually is sold with some wrapper leaves still attached but if bagged the wrapper leaves are removed. Similarly wrapper leaves are removed from head lettuce sold to the processing sector.

Integrated Pest Management

Integrated Pest Management (IPM) is a strategy which seeks to integrate all available knowledge to best manage pests and diseases. Definitions of IPM vary as do IPM strategies for different crops and for similar crops in different regions. Nevertheless, there are many similar elements to all IPM strategies. The debate tends to rage around which tools or elements are the minimum necessary to be called an IPM practitioner, for in reality there is an IPM spectrum. The beginning of the spectrum is debatable and the end is farm planning that minimises pests, maximises beneficials and rarely requires pesticide applications, and when they are needed biological pesticides are preferred.

Developing an IPM system for a crop requires building up the knowledge base of what pests, diseases and beneficials are in the system. Also understanding their interactions and impacts on the crop. It requires getting access to more specific pesticides that are ‘softer’ on beneficial insects, or getting access to varieties that are resistant to pests or diseases. It requires developing crop monitoring techniques or strategies that are time and cost effective and where possible, developing action thresholds or information on when intervention is required.

Project direction

Prior to the first lettuce IPM project VG98048 growers had no access to ‘soft’ chemistry. All but a few growers were spraying on a calendar basis and few could identify their key pests and even fewer knew what other insects or diseases could help manage those pests. In VG98048 emphasis was put on regular monitoring of a range of lettuce crops to understand what pests, diseases and beneficials were in the system. Generating efficacy data to assist in registration of new 'IPM-friendly' pesticides for the key pest, Heliothis, and to develop greater knowledge in how these pesticides might be best used in lettuce was also a key focus. Workshops and an IPM Information Guide were produced to help growers and consultants learn what pests, beneficials and diseases were found in lettuce crops and what their management options might be. Information was gathered to help better target pesticides to the vulnerable life stages of the pest. Trials were conducted to improve spray application with modified overhead booms, air assist or CDA sprayers. Towards the end of the project other sap-sucking insects were causing problems in the lettuce industry. Silverleaf whitefly had arrived in SE Queensland, growers in the central west of NSW were experiencing trouble with aphid or thrips transmitted viruses and growers in Sydney basin were seeing more problems with thrips. VG01028 was funded to continue the insect pest work and look more broadly than just Heliothis.

Efficacy trials

Currant-Lettuce aphid *Nasonovia ribis-nigri* is currently the most threatening insect pest that attacks lettuce in Australia. Heliothis, *Helicoverpa armigera* and *Helicoverpa punctigera* , western flower thrips *Frankliniella occidentalis* and Silverleaf whitefly *Bemisia tabaci* Biotype B remain as key insect pests in parts of Australia. With the exception of *Helicoverpa punctigera*, all these insect pests have displayed an ability to develop resistance to some of the older carbamate, organophosphate and synthetic pyrethroid insecticide chemistries.

There is considerable political and environmental pressure for the Australian vegetable industry to adopt growing practices with greater sustainability. An increasing number of growers are adopting integrated pest management (IPM) strategies in their crop management. To some extent the availability of suitable insecticide chemistry limits the success of IPM adoption. Much of the older insecticide chemistry has broad spectrum insecticidal activity which is not always a suitable choice in an IPM system.

Since the Australian pesticide market is relatively small in the global scene the trans-national chemical companies are reluctant to invest in the research that is needed to generate the data required by our pesticide regulatory body, APMVA. In Australia data is required on the efficacy of a pesticide to control the target pest/s on each crop for which registration is being sought. Residue data is also required for the pesticide on the crop and an extensive toxicology package is needed. If the pesticide has been registered in another crop in Australia it must already have generated a toxicology package so will only require the efficacy and residue data for the pest-crop combination. Often when chemical companies were first approached about potential new chemical registrations in lettuce they responded negatively but readily changed when suggested that the project could fund some efficacy data.

An IPM strategy uses all available tools to manage the pests within a crop. One important tool in the long-term management of pests are beneficials, which are often other insects but may be insect pathogens (e.g. entomophagus fungi, nematodes, viruses). These beneficials are usually killed by broad-spectrum insecticides and hence are not of any assistance for pest management. However many of the new insecticides have narrower activity and are less toxic to some or all of the key beneficials that can be found in a cropping system. Therefore getting access to these newer insecticides can allow the pest management strategy to utilize beneficial insects. The benefits of protecting beneficials is that fewer insecticides may need to be applied therefore less resistance pressure is put on those insecticides and more consistently marketable product would be expected.

This and the previous project have done considerable numbers of trials to screen potential insecticides that may be of value to growers and particularly to find those that are less toxic to the key predators or parasitoids in the system.

The insecticide trials for this project were at Gatton in Queensland and at both Yanco and Hay in New South Wales. Foliar, soil drench and seedling drench insecticide trials evaluated the efficacy of different chemicals on sap sucking insect pests, (predominantly aphids and whitefly). The insecticides trialled were Actara®, Confidor®, MTI446, Chess®, Admiral® Ti-435, DC-068, DC-027, Intruder®, Calypso®, Dimethoate®, Pirimor®, Biopest®, SilicaK®, Surround® and Natrasoap® (Table 1). Some of the aphid trials were done in a polyhouse, while others were small plot trials in a lettuce crop.

Polyhouse and small plot trials were used to compare the efficacy of new insecticide options for heliothis and lucerne leafroller *Merophyas divulsana* control. Insecticides trialled against Lepidopterera pests included DC-041, Azamax®, Proclaim®, S1812, Gemstar®, Vivus® and Success®. Vivus® was trialled in the field in both foliar and sprinkler insecticide application trials (Table 1).

In both the sap sucking and lepidopterera efficacy trials, data was collected on beneficial insect species to determine the effects of these insecticide chemistries on beneficial insects and spiders. This has helped to determine where a new chemistry may fit into an IPM system. Data generated in these trials are passed onto the chemical companies to assist them if they decide to seek registration or to assist in getting support for a minor use or emergency permit.

The following information on the different insecticides (Table 1) used in the chemical efficacy trial work is largely from the chemical company websites that are distributing these products in Australia.

Table 1. Summary of trial insecticides

Target	Active group	Insecticide	Company	Group	Group
Sucking	thiomethoxam	Actara®	Syngenta	4A	nitroguanidine insecticides
Sucking	imidacloprid	Confidor®	Bayer	4A	nitroguanidine & pyridylmethylamine
Sucking	clothianidin	TI-435	Sumitomo	4A	nitroguanidine insecticides
Sucking	acetamiprid	Intruder®/ DPX3002	Dupont	4A	pyridylmethylamine
Sucking	thiacloprid	Calypso®	Bayer	4A	pyridylmethylamine
Sucking		MTI446	Sumitomo	4A	
Sucking	pymetrozine	Chess®	Syngenta	9A	antifeedants
Sucking	pyriproxyfen	Admiral®	Bayer	7C	juvenile hormone mimics
Sucking		DC-068	Bayer		
Sucking		DC-027	Bayer		
Broad	alpha cypermethrin	Fastac®	NuFarm	3A	pyrethroid ester insecticides
Sucking	dimethoate	Dimethoate®	Nufarm	1B	aliphatic amide organothiophosphate
Aphids	pirimicarb	Pirimor®	Syngenta	1A	dimethylcarbamate insecticides
Broad	parrifinic oil	BioPest Parrifin Oil®	Sacoa		suffocant
Broad	mineral earth	SilicaK®,	Southern Minerals		dessicant
	kaolin	Surround(R)	AgNova Technologies		
Sucking	potassium salts + oils	Natrasoap + agral	Agrobest		suffocant
Broad	azidiractin	Azamax® [Neem]	Organic Crop Protectants		insect growth regulator, antifeedant
Lepidoptera		DC-041	Bayer		
Lepidoptera	emamectin benzoate	Proclaim®	Syngenta	6A	avermectin insecticides
Lepidoptera	methoxyfenozide	Prodigy®	Dow	16A	moulting hormone agonists
Lepidoptera	pyridalyl	S1812	Sumitomo		
Helicoverpa spp.	Heliothis nuclearpolyhedrosis virus	Gemstar®	Bayer		nuclearpolyhedrosis virus
Helicoverpa spp.	Heliothis nuclearpolyhedrosis virus	Vivus®	Ag Biotech Australia		nuclearpolyhedrosis virus
Lepidoptera, thrips,	spinosyns	Success®	Dow	5A	macrocyclic lactone insecticides

Trial products

Actara® (Thiamethoxam) [Syngenta Crop Protection] is a second-generation neonicotinoid insecticide from the nicotinoid nitroguanidine class of insecticides. Actrara® is systemic and can be translocated throughout a plant. Thiamethoxam shows activity against aphids, whitefly, soil beetles and their grubs. Different formulations of thiamethoxam are registered in cotton as a seed drench and a foliar spray for aphids.

Admiral® (pyriproxyfen) [Bayer CropScience] is an insect growth regulator that mimics the action of juvenile hormone. Nymphs or larvae are targeted and the juvenoid compounds disrupt metamorphosis, killing the insect by retarding its growth. The juvenile hormone is also a growth regulator that also affects the sterility of the adult insects. Pyriproxyfen has shown activity against whitefly, aphids, scale insects, leaf miners, leafrollers and codling moth. Pyriproxyfen has a long lasting residual control of pests and there are formulations for cockroach, flea and mosquito control.

Azamax® (Azadirachtin) [Organic Crop Protectants] is classified as a botanical insecticide. Azadirachtin is derived from the seeds of the neem tree, Azadirachta indica, which is widely distributed throughout Asia and Africa. Azadirachtin is structurally similar to 'ecdysone' insect hormone and acts as a blocker of this hormone thereby preventing molting and hence breaking the lifecycle of some insects. Azadirachtin has also been shown to cause repellent, or antifeedent behaviour in some insects. It has shown some activity against a range of insect pests including: whiteflies, aphids, thrips, fungus gnats, caterpillars, beetles, mushroom flies, mealybugs, leafminers, and gypsy moths (EXOTOXNET PIP 2005).

BioPest® (Parrifinic Oil) [Sacoa] is a refined food grade iso-paraffinic oil formulation that is designed for use as an insecticide and a spray adjuvant. Mineral oils have shown efficacy against scale insects, aphids, mites, leafminers, thrips, and whitefly. Mineral oils primary mode of action is suffocation of the insect pest and they can also modify certain key insect behaviours including feeding and egg laying (Sacoa 2005).

Calypso® (thiacloprid) [Bayer CropScience] is a neonicotinoid insecticide that is in nicotinoid pyridylmethylamine insecticide class. Thiacloprid is systemic and has both contact and ingestion insecticide activity. Thiacloprid has activity on aphids, whiteflies, codling moth, oriental fruit moth and some species of beetles. Bees and some predatory mites are not harmed by thiacloprid.

Confidor® (Imidacloprid) [Bayer CropScience] is a neonicotinoid insecticide that is in both the nicotinoid nitroguanidine and nicotinoid pyridylmethylamine insecticide class. Confidor® is systemic and can be translocated throughout a plant. The active ingredient imidacloprid is used in a wide variety of products in different formulations. Imidacloprid shows activity against aphids, thrips, whitefly, wireworms, red legged earth mite, termites, psyllids, scale insects, soil beetles and their grubs. Formulations of imidacloprid are used for flea and worm control in pets.

Chess® (Pymetrozine) [Syngenta Crop Protection] is classified as an antifeedant insecticide. The active ingredient in Chess® binds to neuronal receptors in aphids creating a nervous inhibition of feeding (Syngenta Australia website 2005). The aphids stop feeding with in an hour and starve to death over three days. Pymetrozine has also shown efficacy against whiteflies and is active on both insect nymphs and adults. Pymetrozine is a systemic chemical that has translaminar activity.

DC027 [Bayer CropScience] is a new experimental chemistry for the control of sap sucking insect pests. This insecticide may fit into an integrated pest management system.

DC041 is a new experimental chemistry for the control of caterpillar insect pests. This insecticide may fit into an integrated pest management system.

DC068 [Bayer CropScience] is a new experimental chemistry for the control of sap sucking insect pests. This insecticide may fit into an integrated pest management system.

Dimethoate® (dimethoate) [Nufarm] is an organophosphate insecticide that has a broad spectrum of insecticidal activity, usually targeting sucking insect pests. Dimethoate is a fully systemic chemical.

DPX3002 see Intruder®

Fastac Duo® (alpha-cypermethrin) [Nufarm] is a synthetic pyrethroid insecticide that has broad spectrum of insecticide activity. The synthetic pyrethroid group if insecticides are sodium channel modulators. The active ingredient rapidly enters the insect (contact and ingestion), disrupts the transmission of nerve impulses. Within minutes the insect stops feeding, loses muscular control (paralysis) and eventually dies. Synthetic pyrethroid insecticides generally give considerable efficacy at a low dosage rate and are effective against most growth stages of an insect (egg, larvae, adult).

Gemstar® (nuclear polyhedrosis virus, (NPV)) [Bayer CropScience] is a biological insecticide that is highly specific to heliothis larvae. Gemstar® has similar properties to Vivus®.

Intruder® [DPX3002] (acetamiprid) [Dupont] is a neonicotinoid insecticide that is in the nicotinoid pyridylmethylamine insecticide class. Acetamiprid is a systemic chemical that has translaminar activity through the leaf surface to the underside of the leaf. Intruder® shows activity against aphids. Like most neonicotinoid insecticides, acetamiprid kills insects by blocking nicotinergic acetylcholine receptors in the insect's nervous system (Sparks 2001).

MTI-446 (experimental) [Sumitomo] is a neonicotinoid insecticide that has similarities to imidacloprid (Confidor®).

Natrasoap® (potassium salts + oils) [AgroBest] is an insecticidal soap concentrate made from potassium salts and biodegradable fatty acids. Insecticidal soaps can be effective against aphids, mealy bugs, mites, leafhoppers, thrips and whitefly. Thorough spray coverage is important as Natrasoap® is a contact insecticide. Insecticidal soaps have no residual and are relatively soft on beneficial insects.

Pirimor® (pirimicarb) [Syngenta Crop Protection] is a carbamate insecticide from the dimethylcarbamate insecticide class. Pirimor® is a neurotoxin and kills aphids by inhibiting cholinesterase, an enzyme that regulates nerve impulses (Palumbo JC 2001). Pirimicarb kills by direct contact, fumigant and systemic activity. Pirimicarb is soft on beneficial insects.

Proclaim® (emamectin benzoate) [Syngenta Crop Protection] is grouped in the avermectins insecticide class. It is a neurotoxin that adversely affects the insect nervous system functioning of the chloride ion channels. Emamectin benzoate is a very effective insecticide for lepidopterous (moth and butterfly) larvae. Larvae stop feeding shortly after ingesting emamectin benzoate and become irreversibly paralysed (Palumbo JC 2001). Emamectin shows translaminar movement into plant tissue and degrades rapidly on leaf surfaces reducing the impact on beneficial insects.

Prodigy® (methoxyfenozide) [Dow AgroSciences] is classified as a diacylhydrazine insecticide. Methoxyfenozide is an insect growth regulator that mimics the moulting hormone of lepidopterous (moth and butterfly) larvae. Within a few hours of ingestion the larvae cease feeding and undergo a premature molt. The larvae die within 2 to 5 days from starvation and dehydration. Methoxyfenozide is highly selective and has little effect on beneficial insects.

S1812 (Pyridalyl) (other names pyridanil) [Sumitomo] is currently an unclassified insecticide with a mode of action that is not completely understood. Pyridalyl gives good control of various lepidopterous (moth and butterfly) larvae and shown variable results on thysanopterous (thrips) insect pests. To date pyridalyl has shown little impact on beneficial insects.

SilicaK® (silicic acid) [Southern Minerals] is classified as an inorganic, desiccant insecticide. Silica is an earth mineral supplement that has been shown to have some insecticidal activity against aphids. Silica absorbs the insect's waxy cuticle, causing desiccation and death.

Success® (spinosad) [Dow AgroSciences] is classed in the macrocyclic lactone insecticide group. Spinosad is a mixture of spinosyn A and spinosyn D molecules, a naturally derived group of toxicants from a species of Acti-nomycete bacteria. Spinosad is active through both ingestion and contact exposure and causes excitation of the insect nervous system, leading to involuntary muscle contractions, prostration with tremors, and finally paralysis (Dow Agrosciences 2005). Spinosad gives good control of lepidopterous (moth and butterfly) larvae, thrips and some beetle pests. Formulations of spinosad are used in fruit fly baits and for blowfly and lice control in sheep. Spinosad is toxic to wasps and ants, but generally has a low impact on other beneficial insects.

Surround® WP (Kaolin) [AgNova technologies]
When applied at label rates, Surround® is used to form a white coating on fruits like citrus, apple and tomato crops. The clay coating helps to protect fruits and foliage from sunburn and heat stress. Surround® was trialled in lettuce because the coating may act as an insect pest deterrent, by making the feeding sites of a plant unrecognisable to insects like leafhoppers and aphids. Thorough spray coverage of a plant's foliage is required to have this effect. The white clay coating can be washed off produce.

TI-435 (Clothianidin) [Sumitomo] is a neonicotinoid insecticide from the nicotinoid, nitroguanidine class of insecticides. TI-435 is systemic and can be translocated throughout a plant.

Vivus® (nuclear polyhedrosis virus, (NPV)) [AgBiotech Australia] is a biological insecticide that is highly specific to heliothis (*Helicoverpa spp*.) larvae. Larvae size and temperature influence the time it takes to kill a larvae. The virus is most effective on small larvae (7mm or less) which can die within 3 days of ingesting a lethal dose. Medium larvae (15mm) need to ingest a larger volume of the virus to obtain a lethal dose and may take a week to die (AgBiotech 2004). The virus works best in humid conditions at temperatures of $25^{o}C – 35^{o}C$. NPV is broken down by sunlight; however the virus is persistent in the field for 2 days. Thorough spray coverage is important as ingestion is needed for infection to occur. Due to their selectivity biological insecticides containing NPV are well suited to integrated pest management (IPM) as they have no effect on other pests or beneficial insects in the crop.

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Field Trial Reports

Sap-sucking insects insecticide efficacy trial, Spring 2002 (Leeton RS, NSW)

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Introduction

The primary aim of this investigation was to obtain efficacy data on Actara®, MTI446 and Confidor® when used as pre-planting soil drenches in lettuce for control of aphids and other sap sucking insects. Effects on beneficial insects was also recorded.

Materials and Methods

Two replicated small plot trials were conducted at the Leeton Research Station near Yanco NSW 2703 during October-December 2002. The trial site soil was grey self-mulching clay and furrow irrigated. The four treatments were replicated five times. The treatments were as follows:

1. 9g/100m Actara® [Thiomethoxam 25WG]; Syngenta
2. 25g/100m MTI446 [MTI446 50% WDG]; Sumitomo
3. 25ml/100m Confidor® [Imidacloprid 200SC]; Bayer
4. Control (water 300L/Ha)

The four treatments were arranged randomly into 5 blocks and each treatment plot consisted of a 4.5m section of lettuce bed with two rows of lettuce per bed. The bed centres were 1.5m apart. Plant spacing within the row was 30cm and the lettuce cultivar was the hearting variety Target®. A plot consisted of 30 plants.

Sprays were applied with a 14 litre Silvan battery powered backpack sprayer with a Hardie 10cm wide shielded wand attachment. The shielded wand was fitted with a blue Hardie 110/20 flat fan nozzle delivering 300L/ha.

A 5cm deep trench was made in the Confidor® and MTI446 plots directly where the plant rows were to go. The chemicals were banded at the bottom of the trench. The bed was then levelled, backfilling the trench.

Actara® was applied as a 10cm wide band over each plant row, after the seedlings had been transplanted.

Thirty litres of water was applied per plot with watering cans post transplanting. This watered the seedlings in and also washed Actara® into the rootzone.

Three days after planting (DAP) the plots were monitored for aphids. Immediately after monitoring the natural aphid population was augmented with the placement within the plots of potted lettuce plants heavily infested with brown sowthistle aphids (*Uroleucon sonchi*). The plots were monitored for insects 7, 14, 21 & 32 DAP.

White collared ladybird beetles (*Hippodamia variegata*) was the main predator of aphids present at the trial site. To measure its impact on the aphid population, further augmentation of brown sowthistle aphids was made at the trial site during trial-2 at 10 DAP immediately following monitoring by shaking aphid infested sowthistle over the plots .

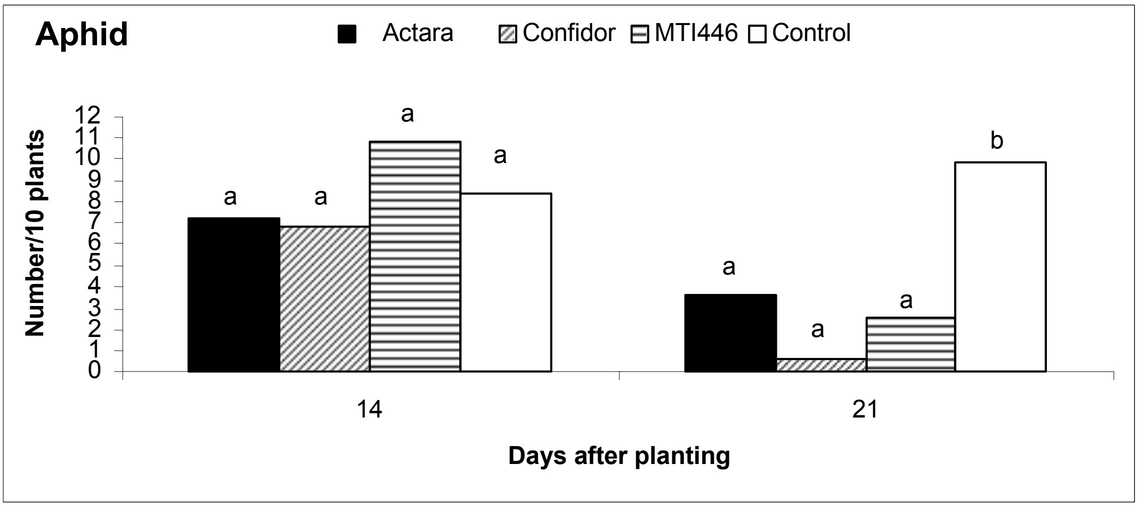
Data Analysis

Differences in the number of aphids among the treatments were analysed with ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's New Multiple Range Test.

Results and Discussion

Trial-1. No significant differences in the numbers of the aphids were detected at 14 DAP ($P > 0.05$). At 21 DAP, however, all three insecticides resulted in significant reductions of aphids as compared to the control ($P < 0.05$)(Figure 3). Apart from aphids, reasonable numbers of thrips, primarily tomato thrips (*Frankliniella schultzei*); leafhoppers, primarily green vegetable leafhoppers (*Austroasca viridigrisea*); and the white collared ladybird beetle (*Hippodamia variegata*) were also found at the trial site. No significant effects of the treatments were detected on the abundance of any of these three species ($P > 0.05$).

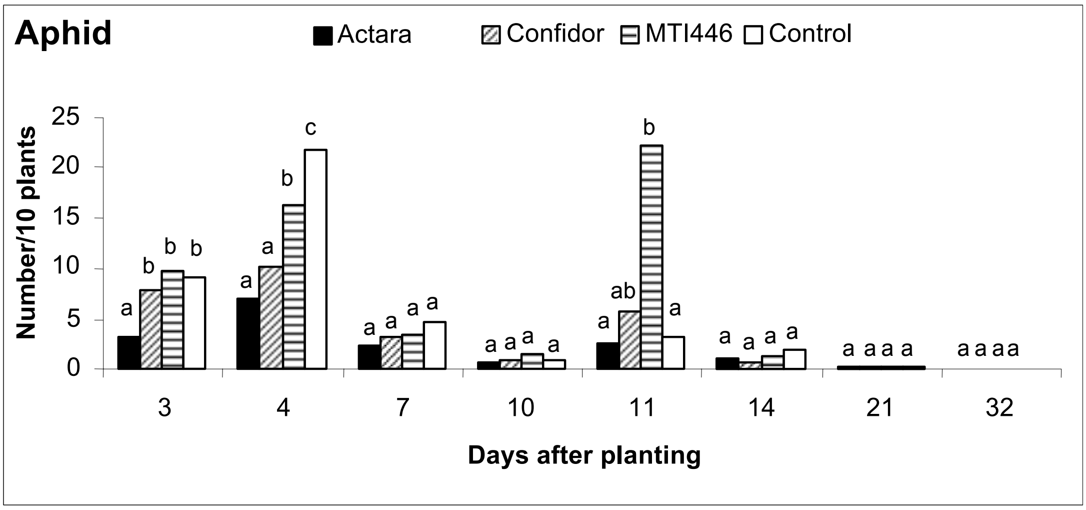
Figure 3. Aphid numbers from trial-1



Means with the same subscript within a period are not significantly different at the 5% level.

Trial-2. Actara® and Confidor® showed some significant effects ($P < 0.05$) in reducing aphid numbers. The effects were detected at 3 and 4 DAP for Actara® and 4 DAP for Confidor®. As shown in Figure 4 no such effects were detected on later days, probably due to low aphid numbers as result of heavy predation of aphids ($P > 0.05$). After artificially introducing large numbers of aphids at 10 DAP a spike in aphid numbers in MTI446 was observed at 11 DAP . Uneven distribution of the introduced aphids may have been responsible for this unexpected outcome. The number of aphids in Actara® or Confidor® treated plots was similar to that in the control plots .

Figure 4. Aphid numbers from trial-2

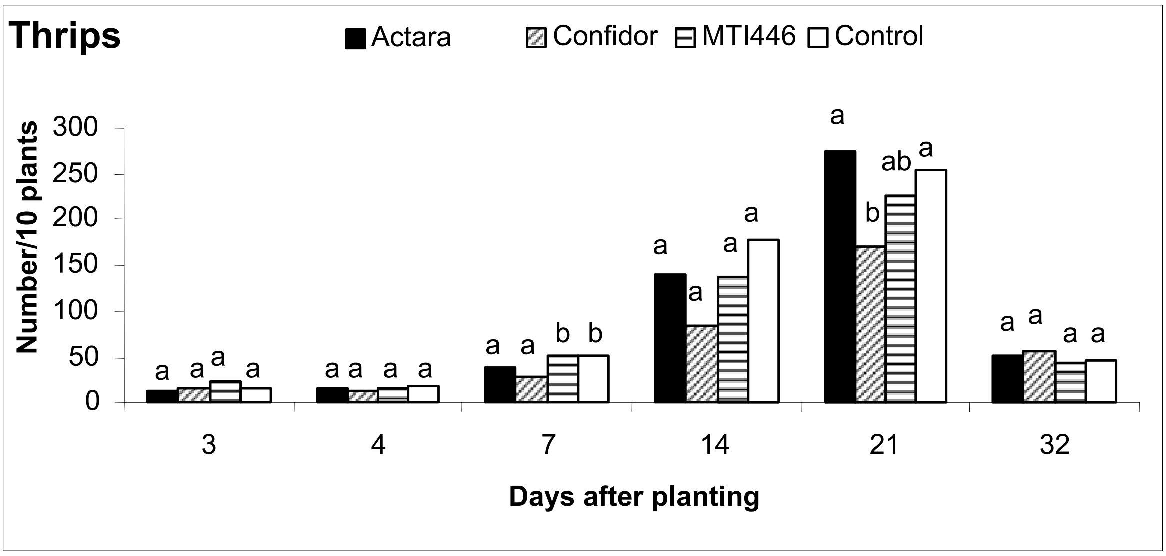


Means with the same subscript within a period are not significantly different at the 5% level.

Other insects observed in reasonable numbers during the experiment were thrips, primarily tomato thrips (*Frankliniella schultzei*); Rutherglen Bug [RGB] (*Nysius vinitor*); leafhoppers, primarily green vegetable leafhoppers (*Austroasca viridigrisea*); and the white collared ladybird beetle (*Hippodamia variegata*). Confidor® showed significant effects in reducing thrips at 21 DAP (Figure 5).

None of the three insecticides significantly reduced RGB and ladybird beetle numbers in comparison to the control ($P > 0.05$). Confidor® treated plots had significantly more ladybird beetles than control plots on two occasions and MTI446 treated plots had significantly more ladybird beetles than control plots on one occasion ($P < 0.05$).

Figure 5. Thrips numbers from trial-2.



Means with the same subscript within a period are not significantly different at the 5% level.

Confidor® treated plots also had significantly more RGB than control plots on one occasion. At 14 DAP, dead ladybird beetles were found in large numbers at the trial site. Similar numbers of dead ladybird beetles were found in Actara® and Confidor® treated plots and in control plots ($P > 0.05$). However, the number of dead ladybird beetles was significantly higher in MTI446 treated plots than in the control plots ($P < 0.05$). Both RGB and the white collared ladybird beetles are highly mobile insects. Frequent inter-treatment movement of these insects makes it difficult to interpret the observed treatment effects.

Conclusion

Results of this preliminary trial were not strong or consistent. Predation by the white collared ladybird beetle and potentially uneven application of aphids on 10 DAP confounded the results. Prior to the white collared ladybird beetle colonizing the plots in a significant way both Actara® and Confidor® appeared to be reasonably effective as soil treatments to control aphids in lettuce. The effective period of the two chemicals could not be determined due to low aphid numbers in the later stage of the trials. Impacts against other insects were not clear from the data collected. More trials are needed to determine the effects of the three insecticides on sap-sucking insects on lettuce.

Sap-sucking insects insecticide efficacy trial, Autumn 2003 (Gatton, QLD)

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Introduction

Lettuce is one of the main autumn/winter/spring crops grown in the Lockyer Valley with planting commencing from mid to late February and continuing until late August early September. Crops are typically planted once or twice a week, water and land permitting. The start of the season generally sees an increase in pest activity, with heliothis being the major pest to growers across the Lockyer Valley and beyond. Over the past 3 years a number of other pests have started to make an impact on a range of crops, including lettuce, making it even more difficult to grow produce free from pests and the insecticides that are needed to try and manage them.

Those other pests that have come to the fore include western flower thrips (WFT) and silver leaf whitefly (SLWF), both of which are very difficult to control due their ability to develop resistance to a wide range of insecticides, including some of those used to manage heliothis. With best management options being developed for the control of heliothis, with a focus on heliothis specific insecticides and softer option insecticides, other insect pests are left to their own devices. This has meant that other insecticides have needed to be used that may not be as soft on beneficial insects or the environment and are generally not much use against heliothis. Insect pests that are resistant to a range of insecticides, compounds the problem even more, reducing the availability of registered products that can be legally used to manage these pests as well as others.

As such, this trial was designed to look at a number of potentially useful insecticides, both new and old, to try and manage both WFT and SLWF as well as other sap-sucking insect pests commonly found to attack lettuce early in the growing season.

Material and Methods

Trial site

The treatment area was approximately 25m wide by 126m long. This allowed for 9 treatments, 4 replications, using a randomised complete block design, with plot size consisting of 3 assessment beds each 14m long. A buffer bed was planted on either side of the treatment plots. Plants were spaced 33cm apart and grown on double row beds and watered using solid set irrigation and fertilised using standard growing practices. A trial layout is below in Figure 1.

Lettuce variety “Raider” was transplanted on the 17th and 19th March 2003 at the Gatton Research Station. The bulk of the planting was carried out on the 17th March while those treatments that were dipped were planted on the 19th March.

Figure 1. Trial layout at Gatton Research Station March 2003.

TI-435 (Dip)	Admiral	DPX-3002 200ml	Chess
Admiral	Unsprayed	DPX-3002 100ml	Confidor (Furrow)
TI-435	Confidor (Furrow)	Unsprayed	TI-435 (Dip)
Confidor (Dip)	DPX-3002 200ml	Admiral	Confidor (Dip)
DPX-3002 200ml	TI-435	Chess	Admiral
Unsprayed	TI-435 (Dip)	Confidor (Furrow)	DPX-3002 100ml
Chess	DPX-3002 100ml	TI-435	DPX-3002 200ml
DPX-3002 100ml	Chess	Confidor (Dip)	TI-435
Confidor (Furrow)	Confidor (Dip)	TI-435 (Dip)	Unsprayed
Rep 1	Rep 2	Rep 3	Rep 4

Treatment insecticides

The insecticides used in this trial included:

1. 25ml/100m (pre plant furrow application) Confidor® [Imidacloprid 200SC]; Bayer
2. 175ml/100L water (pre plant dip of seedlings) Confidor® [Imidacloprid 200SC]; Bayer
3. 100ml/ha DPX-3002 [experimental]; Dupont (foliar application)
4. 200ml/ha DPX-3002 [experimental]; Dupont (foliar application)
5. 200g/ha Chess® [Pymetrozine 250g/Kg]; Syngenta (foliar application)
6. 500ml/ha Admiral® [Pyriproxyfen 100g/L]; Sumitomo (foliar application)
7. 300ml/ha TI-435 [Clothianidin]; Sumitomo (foliar application)
8. 175ml/100L water (pre plant dip of seedlings) TI-435 [Clothianidin]; Sumitomo
9. Unsprayed control

Application methods

The Confidor® furrow application was applied on the 12th March by creating a furrow with a narrow hoe, applying the Confidor® solution with a watering can to the furrow at the required rate and covering the furrow afterwards. Plants were then hand planted on the furrow on the 17th March. The Confidor® and TI-435 dip treatments were carried out by firstly allowing the plants in the seedling trays to miss a watering the afternoon before dipping to allow them to dry out a little. The trays were then dipped in the chemical solutions for 2 minutes to allow the seedling cells to become saturated and then removed and allowed to drain before hand planting into the trial site.

The spray application treatments were applied early in the mornings and were only applied according to insect pest pressure determined by monitoring. Treatments were applied by a motorised SOLO backpack sprayer putting out approximately 450L/ha of water per hectare. A 1.2m wide lance, which had 4 equally spaced Twin-Jet nozzles, was attached to the sprayer. Each treatment also included an appropriate wetting agent.

Table 1. The dates of treatment applications

Treatments	Date of application(s)
Confidor® preplant furrow application	12 March 2003
Confidor® dip application	19 March 2003
DPX-3002 (100ml) foliar applications	27 March; 5 April; 17 April
DPX-3002 (200ml) foliar applications	27 March; 5 April; 17 April
Chess® foliar applications	27 March; 5 April; 17 April
Admiral® foliar applications	27 March; 5 April; 17 April
TI-435 foliar applications	27 March; 5 April; 17 April
TI-435 dip application	19 March 2003
Unsprayed control	

Monitoring methods

The trial site was monitored once a week with a decision being made on whether an application would be required in respect to the foliar applied insecticides. The initial assessment, one week after planting, used direct field counts of whitefly, thrips, jassids (vegetable leaf hopper) and aphids. Subsequent counts were carried out the same with the exception of the whitefly. This pest was assessed using leaf discs taken from a fully expanded leaf (Siva Subramaniam, pers.com.). The leaf discs were 16mm diameter. As the plants grew the leaf number assessed increased from the 3rd newest fully expanded leaf 2 weeks after planting to the 6th newest fully expanded leaf 1 week prior to harvest. The last assessment of whitefly was actually assessed on eggs and nymphs per half a leaf. Data were analysed by analysis of variance using the GenStat 5th edition program. At harvest 10 plants were selected from each plot from the middle 4 rows, selecting every 5th lettuce plant within these rows. The plants were then weighed in the field to give an overall weight per 10 plants. These weights were then assessed and averaged out per treatment and analysed using the GenStat program.

Results

Thrips, aphids, jassids (vegetable leafhopper) and silverleaf whitefly were assessed from soon after planting until harvest 7.5 weeks latter. Counts of the first 3 insects were assessed in the field, with thrips being the most common and the only pest that could be assessed on a regular basis statistically (Figure 2). Silverleaf whitefly consisted of checking 20 leaf discs per plot for either eggs or nymphs (Figure 3), or half a leaf just prior to harvest (Figure 4).

Plant weights were also assessed 7.5 Weeks After Planting (WAP) using GenStat (Figure 5).

For each graph, those treatments and same coloured bars that have the same letter above them are not significantly different at the 5% level.

Figure 2. Thrips populations during trial

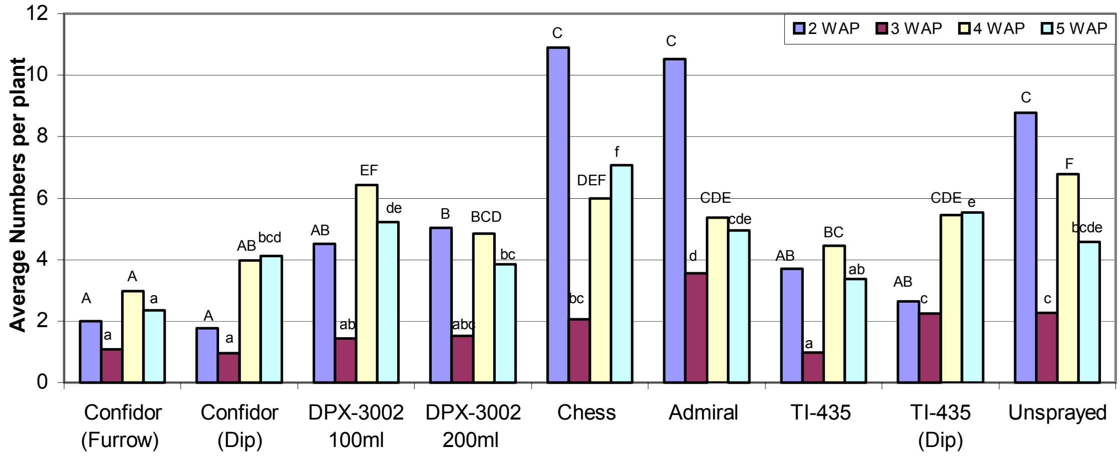


Figure 3. Average number of whitefly eggs taken over a 4 week period using the leaf discs to assess for egg numbers.

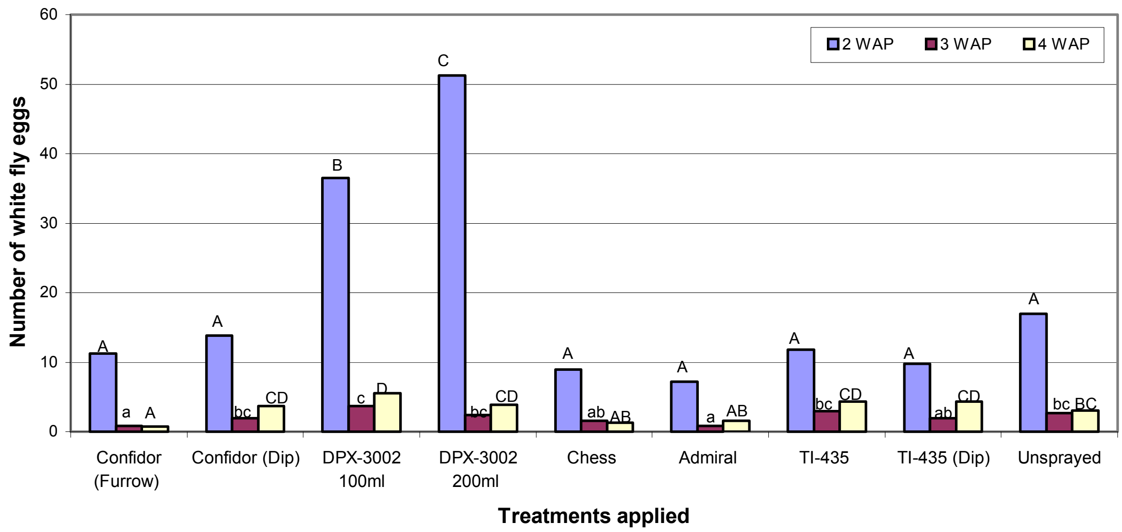


Figure 4. Average number of white fly eggs/nymphs on 10 half leaves taken from the 6th fully expanded leaf, 6 WAP 28/04/03

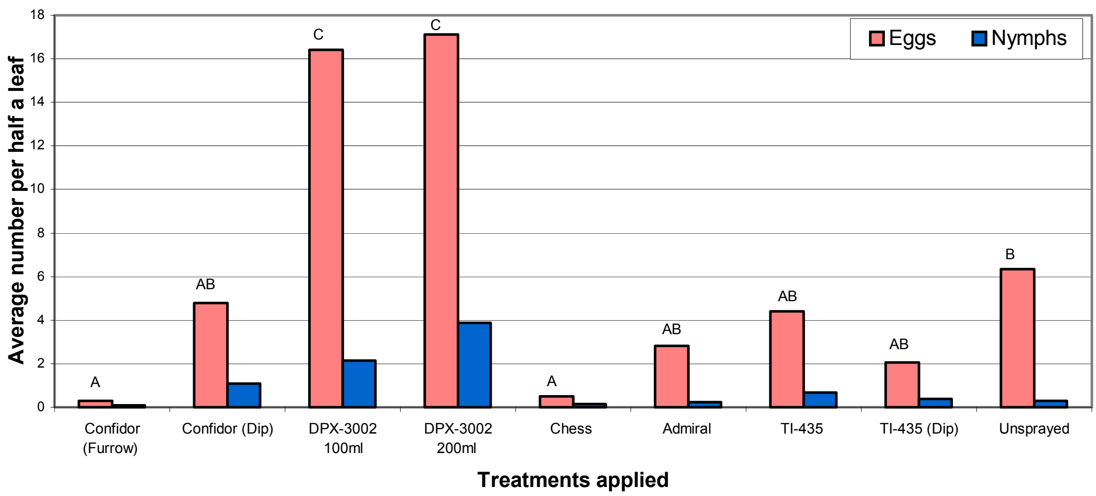
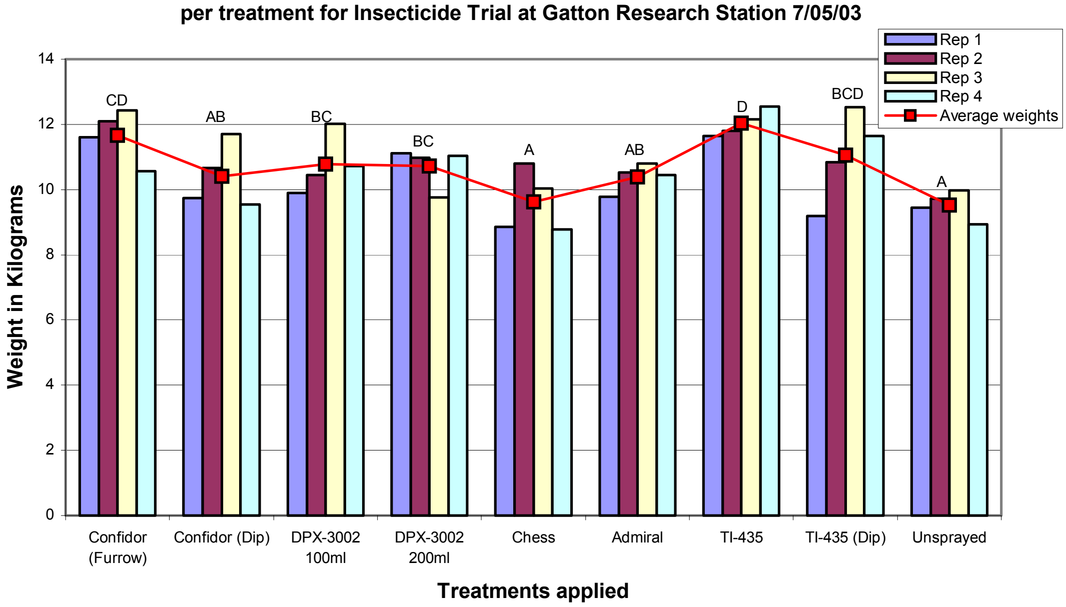


Figure 5. Weights of 10 plants per rep at harvest plus the average weights per treatment for Insecticide Trial at Gatton Research Station 7/05/03



Discussion

There were only 2 obvious sap-sucking pests that were present in any significant numbers in this trial and they were thrips and silverleaf whitefly. The other sap-sucking pests, aphids and jassids were in very low numbers during the length of this trial and were not significantly different between treatments for the majority of the trial.

The thrips was predominantly western flower thrips (*Frankliniella occidentalis*). Although thrips numbers were low they can cause a great deal of damage to seedlings and transmit tomato spotted wilt virus. From the treatments applied, Confidor® furrow application gave by far the best control of thrips numbers in this trial even 5 weeks after planting as seen in Figure 2. The Confidor® dip application started to break down after 3-4 weeks as did the TI-435 dip application. The higher rate of DPX-3002 was better in the long term at controlling thrips, as was the TI-435 foliar treatment compared to the dip application of this product. Chess® and Admiral® both gave poor control of thrips with differences being equal to or greater than the unsprayed control.

The reduced effectiveness of some of these products over time could be as a result of the rapid growth of the plants and the increased surface area that the products need to be effective over. An increase in water volume may have helped by delivering more of the product to where the thrips were most active and protected by the leaves. This is the benefit that the Confidor® furrow application would have had over all other treatments by being readily absorbed from the soil and transported throughout the plant including those difficult to get at places. The performance of the high rate of DPX-3002, TI-435 and the Confidor® dip could have a place early in the crop life when thrips can be an issue, especially for the control or management of tomato spotted wilt virus, which lettuce do suffer from. These were generally not significantly different from one another, even after 2 weeks from planting and in some cases 3 weeks after planting.

Silverleaf whitefly was present on the seedlings from day one, with adult numbers being too numerous to count with any degree of accuracy on the plants by week 2. Instead leaf discs were taken, 2 per plant and checked for both eggs and nymphs. This is the same method used in other crops and recommended by one of the silverleaf whitefly researchers (Siva Subramanium, pers.com.). This was a bit of a hit and miss method for assessing pest numbers, particularly with lettuce leaves, which are fairly large and crinkly with the results potentially giving a false representation of what actually might be there. The last assessment, Figure 4, relied on checking half a leaf instead of using the leaf discs, which would give a truer picture of numbers of eggs and nymphs and should have been used throughout the trial instead of the leaf discs.

Although the adult numbers remained high throughout the trial, in the majority of the treatments, the expected number of nymphs on the leaves were lacking across all treatments including the unsprayed control plots. The greatest number of nymphs was present during the last count, Figure 4, even though there was no significant difference between treatments. Egg counts could only be used with any degree of reliability, but is this a useful method of determining the effectiveness of the individual products in managing this pest? Some products do affect the egg laying potential of the adults but if the eggs do not develop any further due to the unsuitability of the host for the pest to develop on, these egg numbers my be irrelevant. A reliable and accurate method for assessing adult numbers needs to be developed, as there was a visual difference in adult numbers between some of the treatments and it would have been a better indicator as to the overall effectiveness of the individual products.

Egg counts did however show a significant difference between treatments with the Confidor® furrow application performing consistently better throughout the trial period, as did Chess® and Admiral®, which were not significantly different from the Confidor® furrow application. These low numbers could be attributed to the fact that there was visually less adults seen in the Confidor® furrow application and that Chess® is supposed to stop the adults from feeding which in turn would affect the number of eggs laid. Admiral® also affects the sterility of the adult female and therefore the number of eggs.

The DPX-3002 appeared to actually promote whitefly development as seen in Figure 4 as egg numbers were 2-3 time those found in the unsprayed control plots. There was even up to 2-4 times the number of nymphs present in these treatments. I am unsure as to explain this result, but it could be a result of beneficial numbers. DPX-3002 may have an adverse effect on predators that would otherwise be eating eggs.

With a lack of nymphs to complete the life cycle of this pest, the question has to be asked whether this pest is actually an issue for lettuce growers. Certainly there were still a large number of adults visible in all plots except the Confidor® furrow application plots and as seen in Figure 5 the overall yield of the lettuce in the Confidor® furrow application treatment was significantly improved over the untreated control as well as a number of other treatments. It is felt that this reduction in yield was directly attributed to the presence of the whitefly and not the other sap-sucking pests, which were quite low in numbers.

Figure 6. Lettuce trial with Confidor® furrow application treatment.

Figure 6 on the left was taken just prior to harvest of the trial with the treatment in the fore ground showing the Confidor® furrow application. These plants appear larger than the other treatments. The Confidor® furrow application treatment also gave significantly greater yields compared to the Confidor® dip treatment, Chess® and Admiral® treatments.

Further research

A better monitoring technique needs to be developed to assess the impact of adult SLWF numbers on the crop, as the number of nymphs throughout this trial were very low and would have had a minimal impact on the crops development. This will hopefully be in place for the start of the season in 2004.

Due to the apparent effectiveness of Confidor® as a furrow application it would be important to determine the minimum rate that could be used to manage SLWF. This would also have an effect on reducing the cost of this product for growers. A furrow application of any product would fit in with a developing IPM system having minimal impact on any beneficial insects that might be present in the crop for the control of other pests.

Acknowledgements

I would like to thank Carolyn Lee for her technical assistance and Karen Kruger an industrial placement student for their assistance with monitoring. Also the farm staff of the Gatton Research Station for the management of the crop and Sumitomo Chemicals, Bayer CropScience and DuPont Agricultural Products for the supply of product for this trial. This trial was conducted as part of the project VG01028 “Lettuce Insect Pest Management” funded by Horticulture Australia.

Aphid soil drench efficacy trial, Spring 2003 (Yanco, NSW)

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Introduction

The primary aim of this investigation was to obtain efficacy data on Actara®, Ti-435 and Confidor® when used as preplant soil drenches in lettuce for control of aphids and other sap sucking insects. Effects on beneficial insects was also recorded.

Materials and Methods

A replicated small-plot trial was set up at the Yanco Agricultural Institute, Yanco NSW 2703. The trial site was a sandy loam soil type and the lettuces were irrigated with surface drip irrigation. 'Target' variety lettuces were planted as seedlings on the 6th of October 2003 and were assessed for harvest on 3rd of December. The four treatments were replicated five times. The treatments were as follows:

1. 9g/100m Actara® [Thiomethoxam 25WG]; Syngenta
2. 10g/100m Ti-435 [Clothianidin 50% WDG]; Sumitomo
3. 25ml/100m Confidor® [Imidacloprid 200SC]; Bayer
4. Control (water 300L/ha)

The four treatments were arranged randomly into 5 blocks and each treatment plot consisted of 5m of lettuce bed totalling 34 plants (Figure1).

Figure 1 Diagram of trial plots

Block1	buffer	T3	Lettuce buffer	T4	Lettuce buffer	T2	Lettuce buffer	T1	buffer
Block2	buffer	T2		T1		T3		T4	buffer
Block3	buffer	T4		T3		T2		T1	buffer
Block4	buffer	T2		T1		T4		T3	buffer
Block5	buffer	T1		T3		T2		T4	buffer
	5m	5m	1m	5m	1m	5m	1m	5m	5m
dist (m)	**34**	29		23		17		11	5

Sprays were applied prior to planting with a 14 litre Silvan battery powered backpack sprayer with a Hardie 10cm wide shielded wand attachment. The shielded wand was fitted with a blue Hardie 110/20 flat fan nozzle delivering 300L/ha. The spray was applied into a 10cm deep furrow along the plant line. After the chemicals were applied the furrow was filled and the lettuce seedlings were planted in the trial site.

Monitoring commenced 7 days after planting (DAP), after which brown sowthistle aphids, (*Uroleucon sonchi*) were introduced to all plots, approximately 3,500 sprinkled across each plot. This augmented the natural aphid pressure and assisted with determining the activity period of the chemicals. Subsequently two more aphid introductions were made to the trial site at 14 and 21 DAP respectively. Both dead and live insects were recorded in the weekly monitoring up to and including 42 days after planting. Aphids only were monitored on extra monitoring at 10, 17 and 24 DAP.

The number of lettuce plants checked on each monitoring occasion was 28 before 35 DAP and 18 afterwards . A harvest assessment was made 7 weeks after planting. 20 lettuces from each plot were visually assessed for size, caterpillar damage, *Erwinia* infection (slimy lettuce) and speckled wrap leaves.

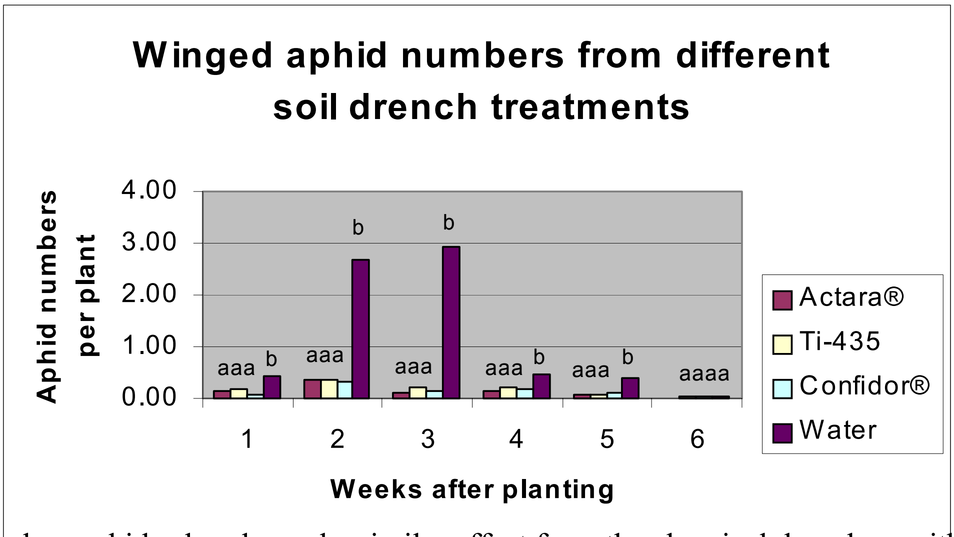
Data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

All 3 insecticides applied were clearly active until 6 weeks after planting. In this trial the greatest efficacy was against aphids and leafhoppers, none of the chemicals showed a significant effect on thrips at a 5% level of significance. The chemical treatments all showed significant numbers of beneficial insects were also indirectly killed.

Winged aphids were significantly controlled in the treated plots for 5 weeks (Figure 2). In week 6 local aphid populations were killed off due to predators and hot weather. Beneficial insects were vigorously predating on aphids during the trial and there were a few days of extreme weather in late November. At 6 weeks after planting, the aphid numbers remaining in the trial were not enough to show any significant effect of the chemicals on aphids. Data from other insects indicated that the chemical was still active at this time.

Figure 2. Weekly winged aphid numbers.



Wingless aphids also showed a similar effect from the chemical drenches, with chemicals displaying efficacy up to 5 weeks (Table 1). Two days after artificial introduction of high numbers of aphids into the trial site at 7, 14 and 21 DAP, aphid numbers dropped to zero nearly zero in all plots except control, indicating that all three chemicals killed the aphids within two days.

Table 1. Treatment means of wingless aphids from 28 plants or 18 plants (35 and 42 days)

Treatment	7 days	10 days	14 days	17 days	21 days
Actara®	0.2a	34.0a	5.2a	4.8a	0.2a
Ti-435	0.2a	47.0 b	4.2a	12.2a	0.4a
Confidor®	0.2a	11.6a	1.8a	3.0a	0.4a
Control	29.0 b	467.8 c	545.0 b	874.0 b	1045.0 b

Treatment	24 days	28 days	35 days	42 days
Actara®	0.0a	0.0a	0.0a	0.0a
Ti-435	0.2a	0.0a	0.0a	0.2a
Confidor®	0.0a	0.0a	1.0a	0.0a
Control	267.6 b	56.8 b	41.0 b	0.8a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Thrips, particularly tomato thrips (*Frankliniella schultzei),* were present throughout the trial and in later stages of the trial up to 6 thrips were recorded on each lettuce. There was no difference in thrips numbers between the treatments at a 5% level of significance.

Live leafhoppers could not be accurately recorded, as they would jump away in all directions when a lettuce was touched. However, sick, sluggish and dead leafhoppers were easy to record. Understandably most of these dead insects were recorded in the chemical treated plots. Most of the leafhoppers observed were vegetable leafhoppers (*Austroasca viridigrisea).* The soil drenches showed significant effects against leafhoppers for up to 6 weeks after planting, (Table 2). Confidor® was the most active chemical against leafhoppers on 4 of the 6 monitoring occasions.

Table 2. Treatment means for dead leafhoppers on 28 plants or 18 plants (35 and 42 days)

treatment	7 days	14 days	21 days	28 days	35 days	42 days
Actara®	33.6 b	34.8 b	35.0 b	40.6 b	114.2 b	36.6 b
Ti-435	41.0 b	31.2 b	39.4 b	45.4 b	115.6 b	39.4 b
Confidor®	46.0 b	82.4 c	74.6 c	69.2 c	131.0 b	61.8 c
Control	1.0a	0.4a	0.6a	1.0a	16.2a	2.2a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Seven days after planting the effects of leafhopper sucking damage & leaf speckling could easily be seen on the untreated plots (Image 1).

Image 1.
Left - lettuce with leaf hopper speckling,   Right – undamaged lettuce, chemical plot

There was no significant difference in the numbers of live mirrids (Miridae spp.) and vegetable weevils (*Listroderes difficilis)* between the treatments. It is unclear why there were significantly greater numbers of Rutherglen bugs (*Nysius vinitor*) in the Confidor® plots 4, 5 and 6 weeks after planting (averaging approximately 8 per plot compared to 4 per plot in other treatments).

Analysis of the data from the dead Rutherglen bugs shows that Confidor® were significantly more effective against the sucking bugs on 4 of the 6 monitoring occasions. Pooled data of dead Rutherglen bugs, mirrids and vegetable weevils showed that the soil drench treatments have some effect on these insects. At a 5% level of significance, the pooled data showed the drenches to have efficacy 3, 4, 5 and 6 weeks after planting (Table 3).

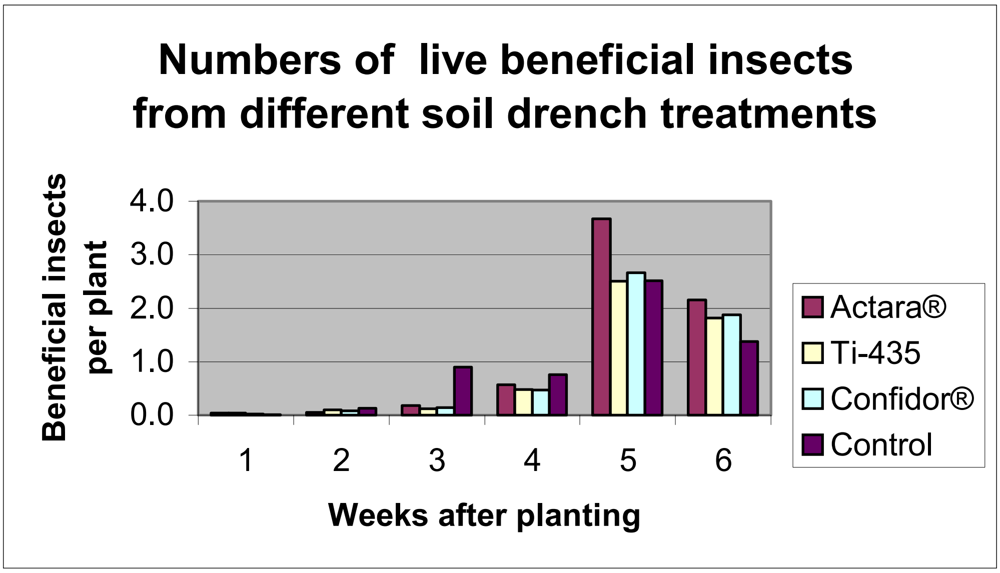
Table 3. Treatment means for 28 plants for sum of dead Rutherglen bugs, mirrids and vegetable weevils.

treatment	7 days	14 days	21 days	28 days	35 days	42 days
Actara®	0.2a	0.2a	0.8a	0.6a	3.0ab	2.4a
Ti-435	0.8a	0.0a	1.0a	2.2a	6.2 b	3.0a
Confidor®	0.4a	0.6a	3.0 b	4.8 b	6.4 b	7.6 b
Control	0.0a	0.0a	0.0a	0.2a	0.4a	0.2a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Red & blue beetles (*Dicranolaius bellulus)*, ladybird beetles (*Hippodamia viriegata* and *Coccinella transversalis)*, carabid beetles (Carabidae spp), wasps, brown lacewings (*Micromus tasmaniane)*, damsel bugs (*Nabis kingbergii)*, big eyed bugs (*Geocoris lubra)* and syrphids (Syphidae sp.) were beneficial insects recorded throughout the trial. Spiders were also recorded. Figure 3 shows the gradual build up of beneficial insects over the 6 weeks of monitoring.

Figure 3. Live beneficial insects per plant monitored each week.



Control plots had significantly greater numbers of beneficial insects, mainly ladybird beetles and brown lacewings, 3 and 4 weeks after planting (Table 4). Syrphids were only recorded in the control plot. These extra beneficial insects were feeding on the aphids.

Table 4. Treatment means for live beneficial insects on 28 plants or 18 plants (35 and 42 days)

treatment	7 days	14 days	21 days	28 days	35 days	42 days
Actara®	1.0a	1.4a	5.0 b	15.8ab	66.0 b	38.8 b
Ti-435	1.2a	2.8a	3.4 b	13.4 b	45.0a	32.6ab
Confidor®	0.6a	2.2a	4.0 b	13.0 b	48.0a	33.8 b
Control	0.4a	3.6a	25.0a	21.2a	45.2a	24.8a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

In weeks 5 and 6 the soil drench treatments had significantly greater numbers of beneficial insects, primarily ladybird beetles (2 ladybird beetles per lettuce compared to 0.5 in the control, see table 5). This is presumably because the aphid numbers in the control plots had declined and the beneficial insects switched to the sick and poisoned insects found in the chemically treated plots as a new food source.

Table 5. Treatment means for live ladybird beetles on 28 plants or 18 plants (35 and 42 days)

treatment	7 days	14 days	21 days	28 days	35 days	42 days
Actara®	0.4a	0.6a	1.6 b	9.4ab	34.2 b	24.4 b
Ti-435	0.0a	0.8a	1.2 b	6.2 b	28.6 b	20.6 b
Confidor®	0.2a	0.8a	1.0 b	5.8 b	29.6 b	20.6 b
Control	0.4a	2.2a	12.8a	10.2a	19.8a	8.0a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Damsel bugs, brown lacewings, carabid beetles and ladybird beetles were the dead beneficial insects recorded in the trial. Table 6 shows that dead ladybird beetles were higher in the soil drench treated plots 4, 5 and 6 weeks after planting at a 5% level of significance.

Table 6. Treatment means for dead ladybird beetles on 28 plants or 18 plants (35 and 42 days)

treatment	7 days	14 days	21 days	28 days	35 days	42 days
Actara®	0.0a	0.0a	0.0a	1.6ab	4.0 bc	2.4 b
Ti-435	0.0a	0.2a	0.8a	6.2 b	6.2 c	2.2 b
Confidor®	0.0a	0.2a	0.8a	1.8ab	1.8ab	1.2ab
Control	0.0a	0.2a	0.0a	0.0a	0.4a	0.2a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

The sum of the dead beneficial insects only showed a significant difference between the treatments in weeks 5 and 6 after planting (Table 7).

Table 7. Treatment means for the sum of all dead beneficial insects on 28 plants or 18 plants (35 and 42 days).

treatment	7 days	14 days	21 days	28 days	35 days	42 days
Actara®	0.0a	0.0a	0.6a	4.8a	12.8 b	7.6 b
Ti-435	0.0a	0.4a	1.0a	3.6a	10.8 b	6.4 b
Confidor®	0.0a	0.2a	0.8a	3.2a	6.6ab	4.8ab
Control	0.0a	0.2a	0.0a	0.0a	0.6a	0.4a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

The soil drench treatments did not impact on looper (*Chrysodexis spp.)* or heliothis (*Helicoverpa spp.)* caterpillar numbers.

The harvest assessment showed that lettuces from the control plots were smaller and had significantly greater leafhopper damage to the wrap leaves, (Table 8). It is unclear why the number of slimy *Erwinia* infected lettuce varied with treatments.

Table 8. Harvest assessment means for different soil drench treatments.

treatment	Small size	Caterpillar damage	*Erwinia* Slimy's	Speckled wrap leaves
Actara®	9.0a	0.0a	14.6 c	1.8a
Ti-435	8.6a	0.0a	12.0 bc	1.0a
Confidor®	8.8a	0.6a	5.4a	1.6a
Control	15.2 b	0.6a	10.0 b	15.8 b

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Conclusion

Soil drench treatments prior to transplanting clearly gave aphid control for 5 weeks. Soil drenches at these rates also gave control of leafhoppers and to some extent other sap sucking insects such as Rutherglen bugs and mirrids. In this trial thrips numbers were not affected by the chemical treatments. Treating the soil with the systemic insecticides used in this trial indirectly killed beneficial insects that were preying on poisoned pest insects. From the beneficial insect population, ladybird beetles were most affected by the treatments. Further trials are needed to investigate efficacy of reduced chemical rates and their impact on both pest and beneficial insects.

Acknowledgements

Thanks to Meryl Snudden for monitoring assistance. Thanks to Syngenta and Sumitomo Chemicals for providing Actara® and Ti-435 respectively. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Aphid insecticide efficacy trial, Spring 2003 (Yanco, NSW)

Andrew Creek, Sandra McDougall and Jianhua Mo
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Introduction

The primary aim of this investigation was to obtain efficacy data on Chess® and two experimental chemicals DC-068 and DPX-3002 for aphid control in field lettuce. A Dimethoate® treatment was included in the trial because growers commonly use this insecticide for aphid control. The main aphid species used in the trial was brown sowthistle aphid (*Uroleucon sonchi*). Data was also collected on other pest and beneficial insect species at the trial site.

Materials and Methods

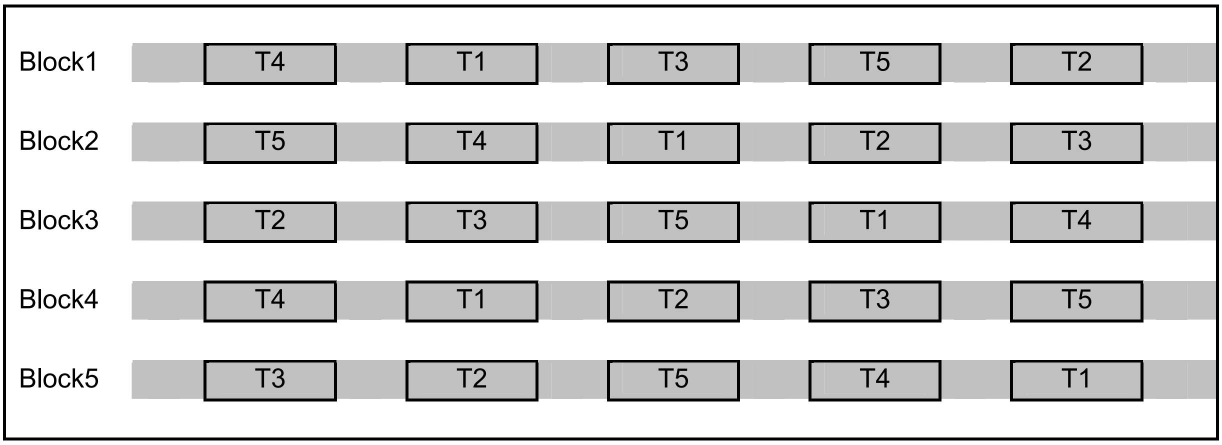
A replicated small plot trial was established at the Yanco Agricultural Institute, Yanco NSW 2703. The trial site had a sandy loam soil type. The lettuces were irrigated with surface drip irrigation. 'Target' variety lettuces were planted as seedlings on the 14th October 2003. Plants were spaced 30cm within the row and there were two rows per bed spaced 50cm apart. The bed centres were at 1.5m spacing.

The following five treatments were replicated five times:

1. 750ml/ha Dimethoate® [400g/L dimethoate]; Nufarm
2. 200g/ha Chess® [250g/Kg pymetrozine]; Syngenta
3. 200ml/ha DC-068 [experimental]; Bayer Crop Science
4. 200ml/ha, DPX-3002 [experimental]; Dupont
5. Control (water 600L/ha)

The five treatments were arranged randomly into 5 blocks and each treatment plot consisted of 4m of lettuce bed totalling 30 plants (Figure 1). There was a 3m buffer, (two beds) between each block of plots.

Figure 1 Diagram of trial plots



Ten days after planting the lettuce were monitored for aphids. The natural wingless aphid population was low. On 23rd October, about ten aphids per lettuce were introduced to the trial site with a fine brush. Twenty four lettuces in each plot were monitored for winged and wingless aphids on 28th October. At this time the lettuce crop was at the pre-hearting stage of development. Wind gusts varying from 10-20 knots prevented the spraying of the trial until morning of the 30th October. The spray treatments were applied at 7.30am in 4-knot winds.

The sprays were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet TXVK-6 hollow cone nozzles delivering 600L/ha of water.

Twenty four lettuces were monitored from each plot and all live insects were recorded on both 1 and 7 days after the spray (DAS). Twelve lettuces were monitored 14 and 21 DAS and only winged and wingless aphids were recorded. The trial site was then destroyed. The lettuces were hearting and about two weeks from harvest.

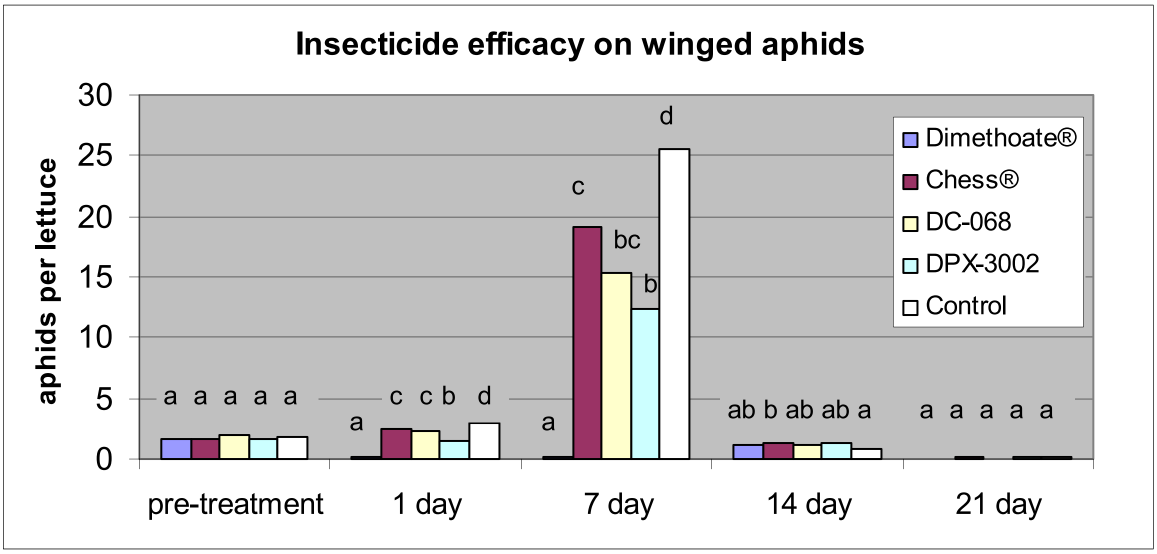
The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

There was no significant difference in aphid pressure between the plots prior to the insecticide treatment (Figure 2 and 3). The lettuce was at a pre-heart stage of development and there was an average of 12 wingless aphids and 2 winged aphids per plant. Dimethoate® was clearly the best performing aphid insecticide at 1 DAS. An average of only 1 wingless aphid and 0.2 winged aphids remained on each lettuce in the Dimethoate® treated plots. The number of winged aphids per lettuce actually increased in the Chess®, DC-068 and DPX-3002 plots, from a mean of 1.5 to 2.0 winged aphids per lettuce. However this increase was significantly lower than that on the control lettuce.

Winged aphid flights continued and their numbers increased greatly in all plots except Dimethoate®. Dimethoate® clearly gave the best winged aphid control til 14 DAS (Figure 2). Seven days after the spray, Chess®, DC-068, DPX-3002 and the control plots had 19, 15, 13 and 26 winged aphids respectively per lettuce. There was still however a significant difference at 7 DAS in the efficacy of Chess®, DC-068 and DPX-3002 against winged aphids when compared to the control. At 14 DAS the winged aphid flights had reduced, and the chemical spray 14 days prior had no real impact on winged aphid numbers.

Figure 2. Mean number of winged aphids per lettuce before and after the insecticide treatments.

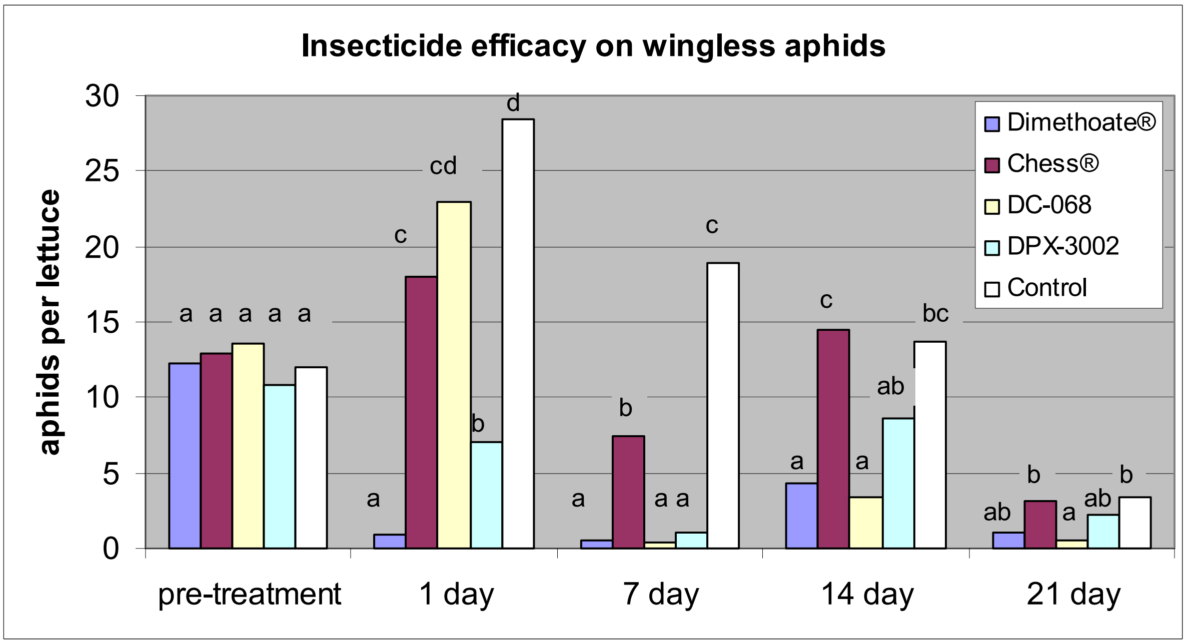


NB. Means with the same subscript within a period are not significantly different at the 5% level

Dimethoate® was the fastest acting insecticide, having killed 93% of the wingless aphids at 1 DAS. DPX-3002 also showed some efficacy on the first day, killing 35% of its wingless aphid population. Wingless aphid numbers actually increased in the Chess®, DC-068 and control plots for the 1 DAS count (Figure 3). The control plot wingless aphid population had increased by 136% to a mean of 28.5 aphids per lettuce.

The pre-treatment count was taken 40 hours prior to the spray event. Most aphids, including the brown sowthistle aphid have wingless reproductive forms. Mature wingless aphids can reproduce without mating and give birth to live young, who can in turn, be reproductive in as little as 3 days under highly favourable conditions (Carver 1991). These mature wingless aphids may produce 20-60 young each so aphid populations can increase dramatically in a short time under favourable conditions (Hill 1994). The wingless aphid population could have increased tenfold over this period, giving a false indication of Chess® and DC-068 efficacy at 1 day after a spray. The active ingredients in Chess® and DC-068 may well also be slow acting as data from 7 DAS shows a greatly improved efficacy (Figure 3).

Figure 3. Mean number of wingless aphids per lettuce before and after the insecticide treatments.



NB. Means with the same subscript within a period are not significantly different at the 5% level

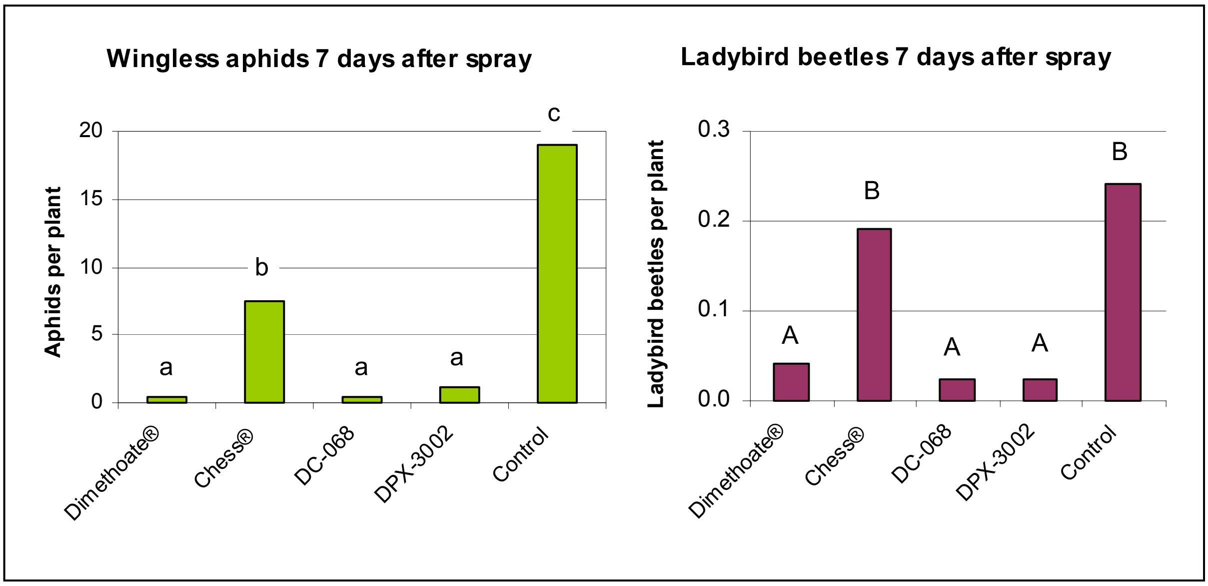
Data collected 7 DAS showed DC-068 and DPX-3002 were as effective as Dimethoate®. Chess® did not perform as well, but it was significantly better than the control. There appeared to be greater numbers of beneficial insects in the control and Chess® plots.

Data collected 14 DAS showed that the wingless aphid population had started to increase in all plots. The DC-068 and Dimethoate® plots had one third the aphids of the Chess® and control plots. The wingless aphid numbers per lettuce were at pre-treatment levels in the Chess® and control plots 14 DAS.

Hot and dry day temperatures, (34 °C – 40°C), prior to the 21 DAS monitoring killed the aphid colonies. The DC-068, DPX-3002 and Dimethoate® plots had slightly fewer aphids than the Chess® and control plots.

Predation by beneficial insects may account for the reduction in aphid numbers in the control plots 14 DAS. Ladybird beetles, brown lacewings (*Micromus tasmaniae*), nabids (*Nabis kinbergii*) and syrphid larvae (*Syrphidae*) were common in the trial plots. These beneficial insects were recorded more in the Chess® and control plots, however their numbers were not great enough to prove any significance, except in the case of ladybird beetles (Figure 4). The beneficial insect numbers were greater in plots with the highest aphid populations. There was a mix of ladybird beetle species in the trial site. These included transverse ladybird (*Coccinella transversalis*), white collared ladybird (*Hippodamia variegata*) and the minute two-spotted ladybird (*Diomus notescens*).

Figure 4. Comparison of wingless aphids and ladybird beetles 7 days after the insecticide application.



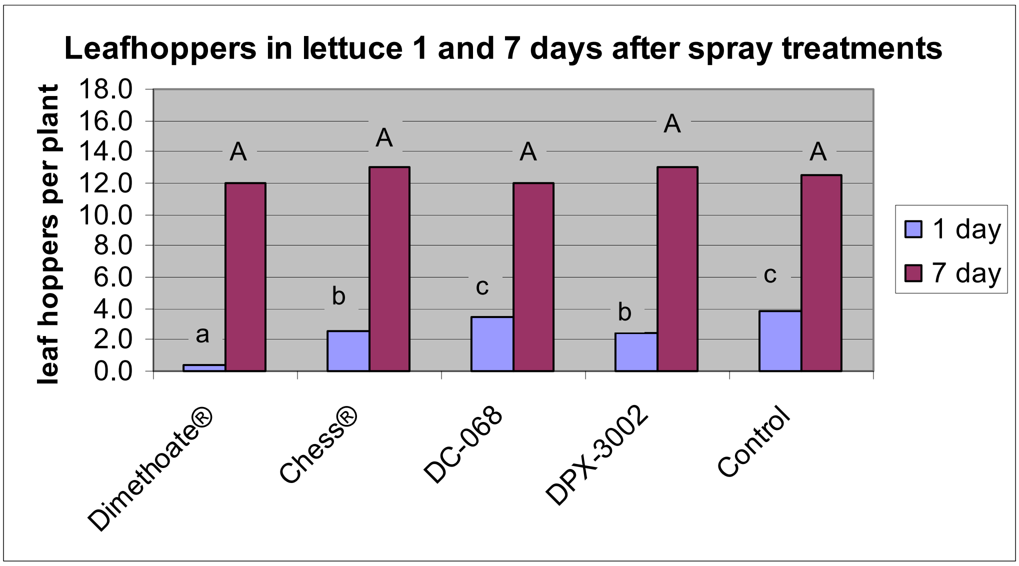
NB. Means with the same subscript are not significantly different at the 5% level

Beneficial insect data collected 1 DAS indicates that the Dimethoate® was the hardest insecticide on beneficial insects. The impact of each insecticide treatment on beneficial insects could not be determined as the beneficial insect numbers were too small to prove any significance.

There were not enough thrips or Rutherglen bugs in the trial to prove any efficacy of the chemicals on these two pest insects. The insecticide treatments did not appear to have an effect on heliothis larvae (*Helicoverpa spp*.).

There were sufficient leafhoppers to significantly show that Dimethoate® was the strongest chemical against leafhoppers (Figure 5). The impact of the Dimethoate® spray on the leafhopper population was not evident 7 DAS. DPX-3002 and Chess® also showed an effect on the leafhoppers 1 DAS. DC-068 did not appear to impact on leafhoppers.

Figure 5. Mean number of leafhoppers per lettuce 1 and 7 days after the insecticide.



NB. Means with the same subscript are not significantly different at the 5% level

Conclusion

Dimethoate® was the fastest acting insecticide, displaying efficacy against both aphids and leafhoppers. At 7 DAS DC-068 and DPX-3002 had comparable efficacy to Dimethoate® on aphids. DPX-3002 also showed efficacy against leafhoppers. In this trial Chess® only showed half the efficacy of DC-068 and DPX-3002 against aphids, however Chess® was significantly better than the control 7 DAS.

The activity of the insecticides had waned within 14 days of application as the wingless aphid population had begun to increase in the treated plots. To the contrary, the aphid population was decreasing in the control plots due to beneficial insect activity. Given time, the aphid population may have been reduced in the control plots to similar numbers as the treated plots.

Currently in lettuce Pirimor® is the only 'soft' chemical option registered in lettuce for aphid control. Further trials are needed to determine the effects of DC-068 and DPX-3002 on thrips, ladybird beetles, brown lacewings and nabids.

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Acknowledgements

Thanks to Meryl Snudden for assisting with planting and data collection. Thanks to Syngenta, Bayer and Dupont for providing Chess®, DC-068 and DPX-3002 respectively. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Sap-sucking insects insecticide efficacy trial, Autumn 2004 (Gatton, QLD)

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Introduction

Silverleaf whitefly (SLWF) is one of the main insect pests that growers face in the Lockyer Valley QLD, early in the planting season from February until around April. This pest attacks the seedlings as soon as they are planted with large numbers of adults severely affecting the growth of the developing seedlings with the potential of delaying the maturation of the crop by up to 2 weeks if left untreated. Observations of this pest in lettuce have shown that it is only the adult that is a problem as this pest seems unable to develop, ie. complete a life cycle, on the crop. The adult will still lay eggs on the underneath side of the leaves but very few of these eggs appear to develop further into nymphs. Whether this is a reaction to the type of plant or specific compounds within the latex type sap produced by lettuce is unknown. Dispite this, the adult will still affect the overall appearance of the developing seedlings and needs to be managed on some way to limit the impact that they have on the newly planted seedlings.

This trial was therefore set up to look at the potential of using a number of newer insecticides in different ways to manage this pest early in the crop life. Once the plant starts to cup or heart up the plant seems capable of with standing some whitefly activity due in part to the rapid growth by the plant and possibly the high water content of the plant.

Materials and Methods

Treatments to be trialled

1. 200ml/ha DC-027 [experimental]; Bayer Crop Science
2. 400ml/ha Intruder® (acetamiprid); Dupont
3. 25ml/100m of row TI-435 (clothianidin); Sumitomo [furrow application]
4. 25ml/100m of row Confidor® 200SC (imidacloprid); Bayer Crop Science [furrow application]
5. SLWF BMO – Confidor® 200SC dip initially (175ml/100L water), then foliar applications of either /Admiral® (pyriproxyfen)/Applaud® (buprofezin)/Chess® (pymetrozine) at recommended rates
6. Unsprayed

The treatment area consisted of a randomised complete block design with 4 replications. Plot size consisting of 3 assessment beds each 10m long. A buffer bed was planted on either side of the treatment plots. Plants were spaced 33cm apart and grown on double row beds and watered using solid set irrigation and fertilised using standard growing practices. Lettuce variety used in this trial was "Raider" and was transplanted on the 24th March 2004.

The Confidor® and TI-435 furrow applications were applied on the 19th March by creating a furrow with a narrow hoe, applying the treatment solution with a backpack sprayer into the furrow at the required rate and covering the furrow afterwards. The plants were then hand planted above the furrow on the 24th March 2004. The Confidor® dip treatment consisted of firstly allowing the plants in the seedling trays to miss a watering the afternoon before dipping to allow them to dry out a little. The trays were then dipped in the chemical solution for 2 minutes to allow the seedling cells to become saturated and then removed and allowed to drain before hand planting into the trial site.

Treatments were applied using a motorised SOLO backpack sprayer putting out approximately 450L/ha of water per hectare. A 1.2m wide lance was used which had 4 equally spaced Twin-Jet nozzles along its length.

Table 1. The dates of treatment applications

Treatments	Date of application(s)
Confidor® 200 SC preplant furrow application	19 March 2004
TI-435 preplant furrow application	19 March 2004
SLWF – BMO Confidor® 200 SC dip Chess® foliar	 24 March 2004 8 April 2004
DC-027 foliar application	1 April 2004; 15 April 2004
Intruder® foliar application	1 April 2004; 8 April 2004; 15 April 2004
Unsprayed control	

Monitoring

The trial site was monitored once a week with a decision being made on whether an application was to be required in respect to the foliar applied insecticides. Adult whitelfy were counted from 10 plants per plot by carefully turning the leaves over and quickly counting their number before they flew off. Whitefly eggs were counted on the underneath side of half a leaf from 10 randomly selected plants per plot. The forth or fith fully expanded leaf was used on each assessment date. Other sucking insect pests were also monitored for, such as aphids, jassids and thrips. Total numbers of these pests were counted on 10 plants per plot. All data were analysed by analysis of variance using the GenStat 6th edition program. At harvest 10 plants were selected from each plot from the middle 4 rows. This was carried out by selecting every 5th lettuce plant within these rows. The plants were then weighed in the field to give an overall weight per 10 plants. These weights were then be assessed and averaged out per treatment and analysed using the GenStat program.

Results

Silverleaf whitefly – Bemisia tabaci

Adult whitefly numbers were present on the lettuce seedlings from the moment they wer planted into the ground. As seen in Figure 1. the adult populations increased from week to week in the untreated control plots while the treatments TI-435, Confidor® and the BMO consistently had fewer and in most cases significantly fewer adults on the plants. One week after planting there was very little difference between numbers of adults in the various treatments. Intruder®, Confidor® and the BMO treatments were significantly better at reducing adult numbers. It wasn't until week two and week four that differences started to become more apparent and consistently so. Intruder® and DC-027 were however not better than the untreated control at reducing adult numbers. TI-435 and Confidor® were the better performers at reducing the adult populations of whitefly.

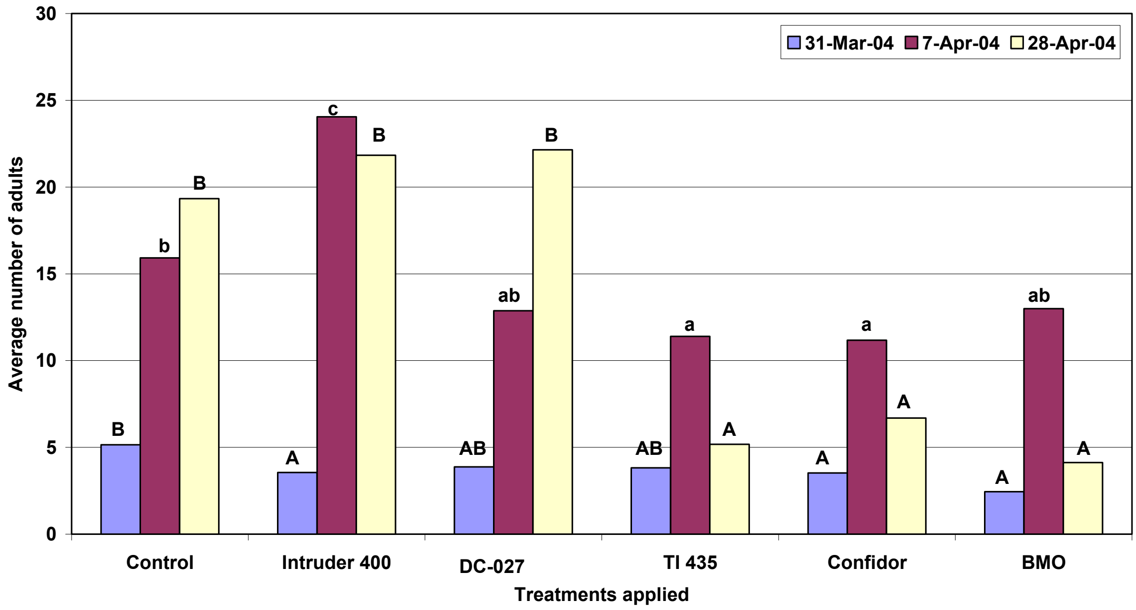

Figure 1. Adult whitefly counts taken from the whole plant.

Whitefly *egg* numbers were significantly reduced after three weeks in the TI-435 and Confidor® treatments as seen in Figure 2. The number of eggs in the BMO treatments was less than what was found in the untreated control but this was not significant. Intruder® and DC-027 appeared to encourage the whitefly to lay more eggs. By week four all chemical treatments helped to significanlty reduce the number of eggs being laid. TI-435 and the Confidor® treatments were however significantly better than the control and the Intruder and DC-027 treatments.

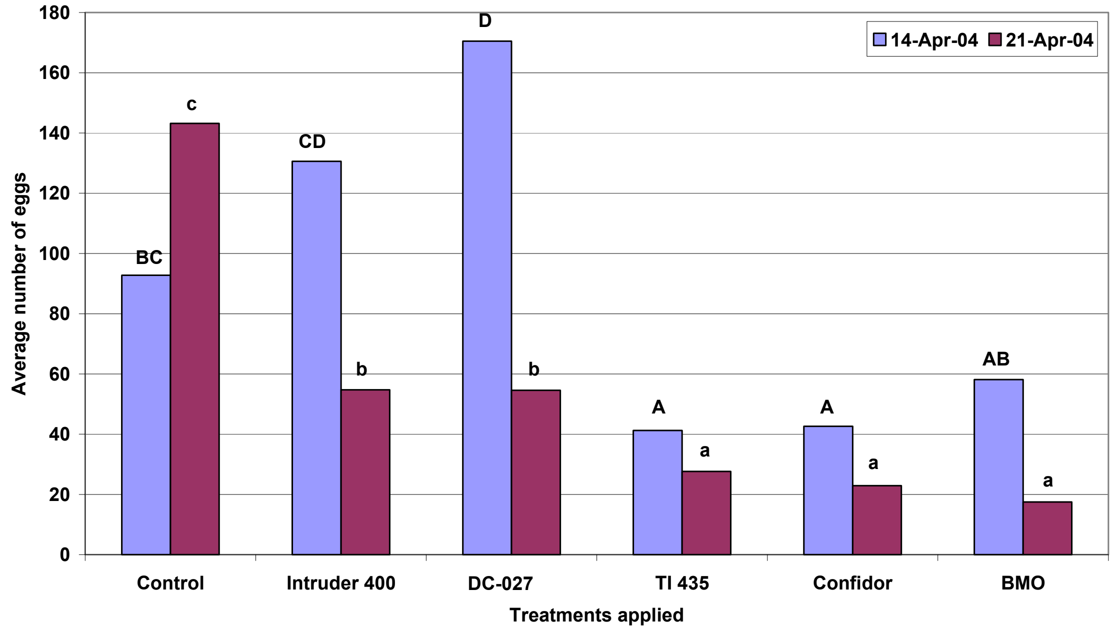

Figure 2. Whitefly egg counts taken from half a lettuce leaf

Other sucking insects

Thrips were the only other sap sucking insect pest that was in high enough numbers to warrant investigation. Aphids and the vegetable leafhopper (Jassids) were present but in very low numbers. Thrips numbers were significantly reduced in all chemical treatments by week two as seen in Figure 3. This reduction in thrips numbers was evident even 5 weeks after planting. The TI-435, Confidor® and BMO treatments performed better than the Intruder® and DC-027 treatments up until 3 weeks after planting. Five weeks after planting all chemical treatments were not significantly different from one another but they were all better than the untreated control. The BMO treatment as seen in Figure 3 appeared to perform better than the other treatments. The BMO treatments was significantly better from the two and three week assessment intervals than the in-ground Confidor® application but was not significantly different from the TI-435 treatment.

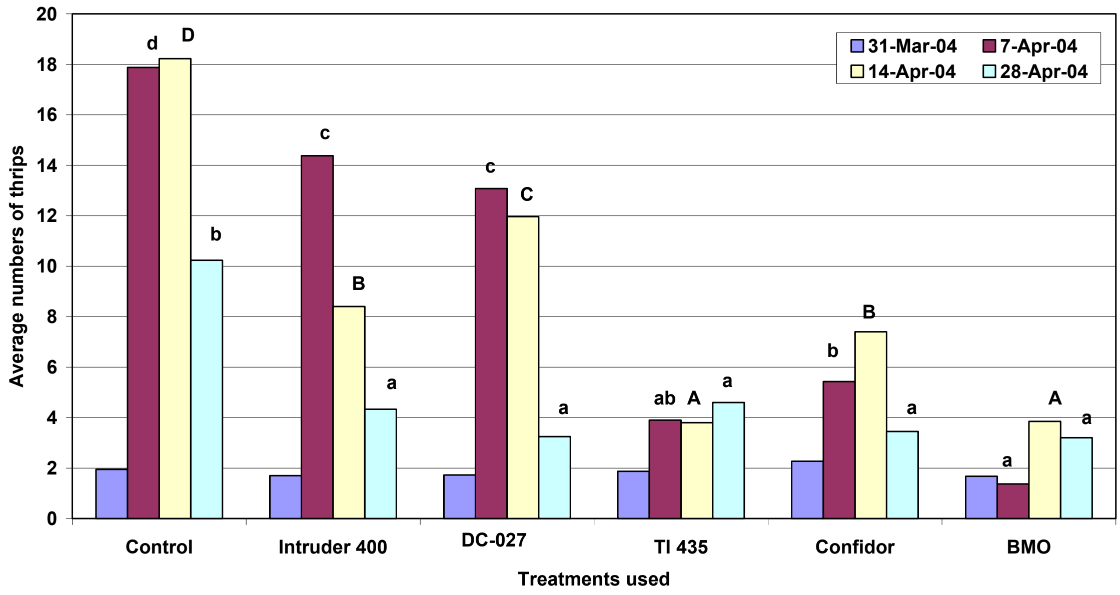

Figure 3. Average Thrips numbers from 10 plants per plot.

Harvest weights were significantly different in half of the treatments (Figure 4). TI-435, Confidor® and BMO treatments yielded significantly more than the untreated control and the DC-027 treatments. There was no significant difference between Intruder® and any of the other treatments.

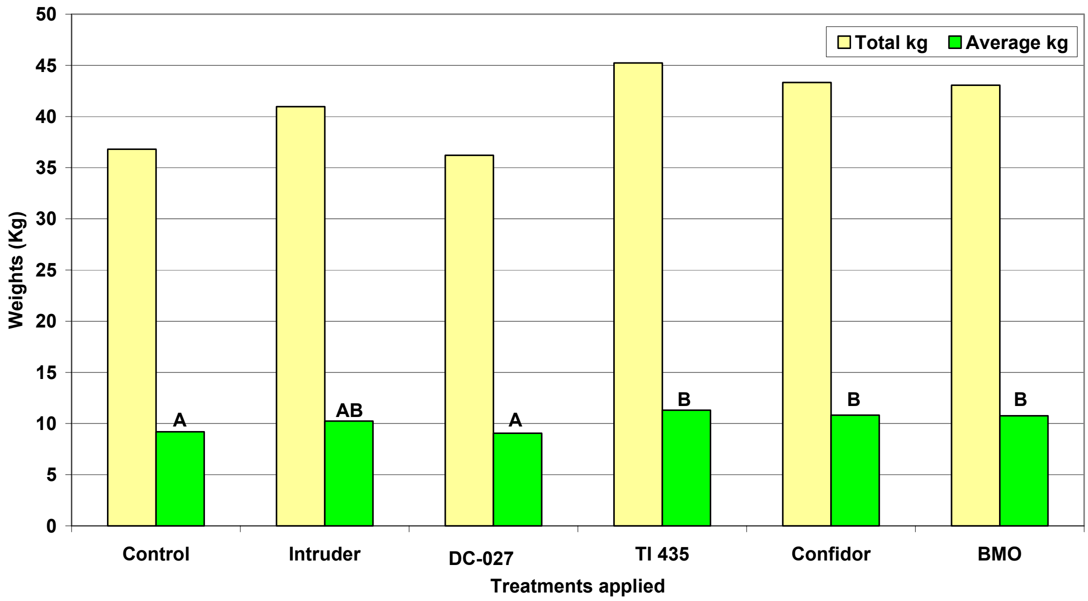

Figure 4. Lettuce harvest results from the 14th May 2004

Discussion

Sap sucking insects are difficult to manage in most Integrated Pest Management systems, as there are very few, if any, soft option insecticides useful as control options for pests like thrips, jassids and whitefly. Silverleaf whitefly has been increasing in importance as a pest of vegetables in the Lockyer Valley, with each year seeing greater numbers attacking a wide range of vegetable crops, including lettuce.

SLWF doesn't appear to fully develop on lettuce and anecdotal evidence indicates that this pest is not capable of breeding on this crop. The large numbers of adults clearly have an impact on the crop as shown in the Figure 4 and the yields measured. SLWF also lay large numbers of eggs on the leaves. However, there were very few nymphs associated with such a population, indicating that the adults in this instance is the most important life stage affecting lettuce. It is not clear what the reason for this is but perhaps it has something to do with the latex produced by lettuce which could interfere with the delicate mouth parts of the 1st and 2nd instar nymphs. Adult mouth parts would be more robust and better able to tolerate the latex produced when they injure the leaf. Whatever the cause, once the plants reach the hearting up stage, they grow so fast that they are able to withstand some SLWF adult activity, whether the various insecticides are still having an effect on adult populations or not.

This trial has demonstrated that SLWF can be effectively managed early in the crops development stage by using either a new product TI-435 or Confidor®. Applying these products as an in-ground application is an efficient and time saving way of using these insecticides. The application of Confidor® as a pre-plant dip was also very useful at managing SLWF numbers as well as thrips numbers. The BMO treatment appeared to work better as a thrips control treatment (Figure 3). Although the thrips numbers were not significantly different from the TI-435 treatment, they were lower and there was a significant reduction when compared to the Confidor® treatment. This significance was also evident up to three weeks after planting when compared to the Confidor® treatment but not the TI-435 treatment. This could be due to the seedlings being able to take up Confidor® in the seedling cells when dipped and being sent around the plant almost over night. While the plants would have to send out their roots into the treated soil before being able to absorb any product into the plant. Chess® was also applied to the BMO treatment 15 days after planting and could have aided in the reduced number of thrips found on the plants. It would be interesting to see if a dip application alone would result in the same numbers of pests as the in-ground application treatments.

Intruder® and DC-027did not appear to have much of an impact on SLWF adult populations (Figure 1) but they did have a significant effect compared to the control on the number of eggs being laid (Figure 2). However, this was only evident four weeks after planting. There could be a cumulative effect necessary in order to have an impact on certain pests like whitefly. Although in this crop a drop in egg numbers would still not be a useful outcome for these insecticides as the adult is the part of the life cycle causing the damage. This cumulative effect could also be the case with thrips, as the reduction in thrips numbers was not as pronounced as in the TI-435 and Confidor® treatments until the week five assessment (Figure 3) when both Intruder® and DC-027 were not significantly different from the TI-435 and Confidor® treatments.

There is clearly some hope for growers when trying to manage SLWF and thrips in their lettuce crops. There is currently a permit application for Confidor® use in lettuce which will help keep this pest in check and coincidently have an effect on thrips which could spread tomato spotted wilt virus in lettuce crops, particularly early in the crop life. Until there are alternatives available to growers for SLWF control, such as biological control agents, then chemical control is the only viable option, an option that clearly works.

Acknowledgements

I would like to thank the farm staff of the Gatton Research Station for the management of the crop and Sumitomo Chemicals, Bayer CropScience and DuPont Agricultural Products for the supply of product for this trial. This trial was conducted as part of the project VG01028 "Lettuce Insect Pest Management" funded by Horticulture Australia.

Aphid soil drench efficacy trial, Spring 2004 (Hay, NSW)

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Introduction

The primary aim of this investigation was to obtain efficacy data on Actara® and Confidor® when applied as a pre-plant, banded soil drench in lettuce for control of aphids and other sap sucking insects. The impact on caterpillars, spiders and beneficial insects was also recorded.

Materials and Methods

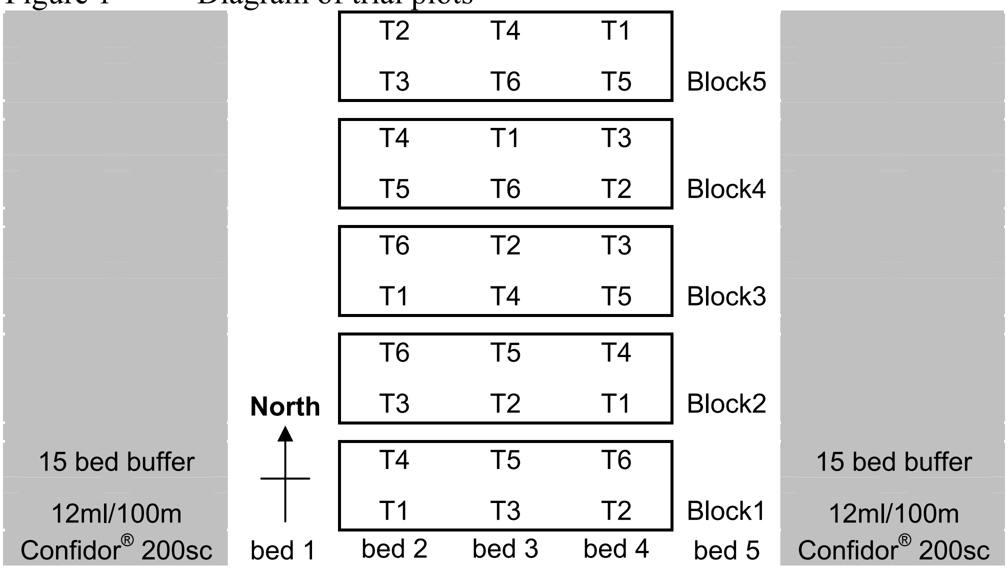
A replicated plot trial was set up on John Langley's property off University Road, Hay NSW 2711. The trial site had a heavy grey clay soil type, typical of the Hay plains. The chemical treatments were applied on 7th July 2004, a few days prior to the direct seedling of 'Magnum' variety lettuce. The lettuce planting was irrigated with furrow irrigation on 14th July 2004. The lettuce crop was ready for harvest around the 20th October 2004.

Six treatments were replicated five times. The treatments were as follows:

1. 8g/100m Actara® [Thiomethoxam 25WG]; Syngenta, (spray band)
2. 8g/100m Actara® [Thiomethoxam 25WG]; Syngenta, (granule band)
3. 4g/100m Actara® [Thiomethoxam 25WG]; Syngenta, (spray band)
4. 25ml/100m Confidor® [Imidacloprid 200SC]; Bayer, (spray band)
5. 12ml/100m Confidor® [Imidacloprid 200SC]; Bayer, (spray band)
6. Control (water 300L/ha spray band)

The treatments were arranged randomly into 5 blocks. The trial plots were arranged over 3 beds that were 130m long. Each treatment plot included 10m of lettuce bed. There was a 2-m, within-row buffer between the plots (Figure 1). The beds ran north to south, with 1.4m bed centres. Each bed had 2 rows of lettuce plants spaced 40cm between rows and 30 cm within rows.

Figure 1 Diagram of trial plots



The liquid spray treatments were applied prior to planting using modified spray equipment mounted on a tool bar. The tool bar was fitted with narrow cultivating tynes with a pressurised spray line mounted behind each tyne. At the end of each spray line a blue Teejet® TJ60 flat fan spray delivered 160L/ha of water in a 5cm wide band. The cultivating tynes and spray nozzles were adjusted to inject a chemical band 10cm below the bed surface, under each lettuce row. Press wheels were fitted to the rear of the toolbar to firm the bed surface back down, ready for planting.

The same tool bar was modified to apply the granular treatment of Actara®. For this treatment, the spray nozzles were removed and a Gandy Box® was used to metre the granule behind the cultivating tynes.

The trial area was monitored weekly for insects . To manage heliothis (*Helicoverpa spp.*), two Dipel® sprays were applied early in the crop and two Avatar® sprays were applied during the critical hearting stage. These chemicals were not known to affect aphids and thrips and so would not affect our analysis of the effect of soil drench chemicals on the two groups of insects.

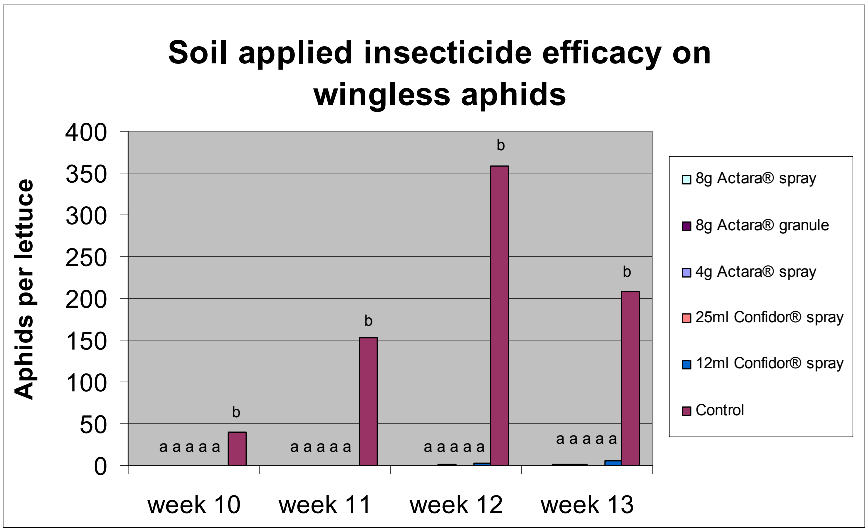
The natural aphid pressure was not high enough to produce significant results 9 weeks after planting so brown sowthistle aphids, (*Uroleucon sonchi*) were artificially introduced to all plots. Approximately 10-15 aphids were introduced to 36 plants in each plot. These lettuces were flagged for future reference. Intensive plot monitoring was done 10, 11, 12 and 13 weeks after planting where all insects and spiders were recorded from a random 15 plants, chosen from flagged lettuce in each plot. Dead insect numbers were also recorded for some insect species.

The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test. Where proportional data was used the data was transformed using an arc-sin transformation.

Results and Discussion

Winged aphids did not establish colonies on any of the treated plots over the duration of the crop (Figure 2). The half rates of both Actara® and Confidor® showed equal efficacy against *Uroleucon sonchi*, when compared to the full rates.

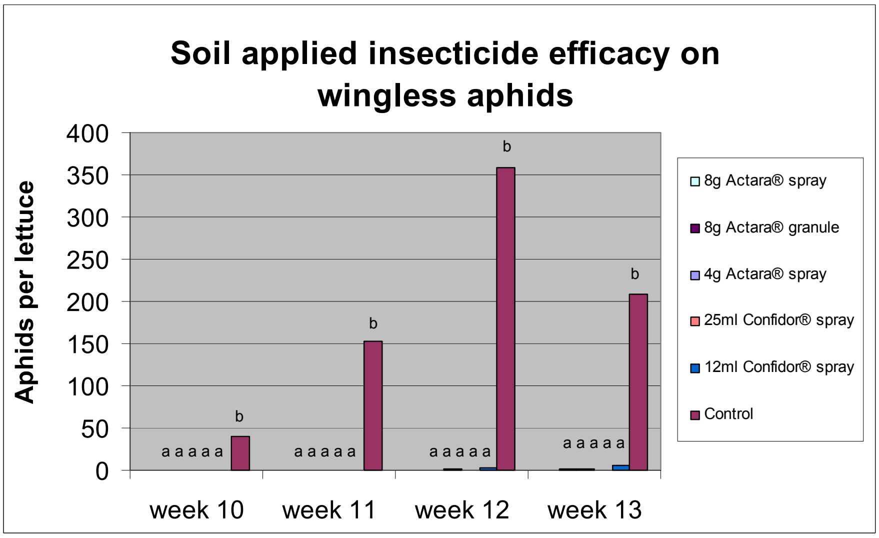
Figure 2. Mean number of winged aphids per lettuce after soil insecticide treatments.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

Twelve weeks after seeding, and more so, thirteen weeks after seeding the wingless aphid data showed slight declining of efficacy in all soil drench treatments. However the trend was not significant at a 95% confidence interval (Figure 3).

Figure 3. Mean number of wingless aphids per lettuce after soil insecticide treatments.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

Tomato thrips (*Frankliniella schultzei)* and Western Flower Thrips (*Frankliniella occidentalis*) were present throughout the trial. The pest thrips numbers were low over the trial period. Less than 1 thrips per lettuce was recorded on average for weeks 10, 11 and 12 after planting. Some treatments had an average of 3 thrips per lettuce by week 13. The pest thrips population was too low to significantly test if either Actara® or Confidor® soil treatments had any effects on the thrips.

Predatory thrips numbers generally averaged less than 1 per lettuce, so the data was too variable to test any significance. The Actara® and Confidor® soil treatments did not appear to affect predatory thrips.
There were significant differences in the numbers of green leafhoppers between the soil drench treatments and the control (Table 1). Most of the leafhoppers observed were

vegetable leafhoppers (*Austroasca viridigrisea).* However, no clear trend regarding the relative efficacy of individual treatments can be discerned from the results, probably due to the behaviour of the leafhoppers. Live leafhoppers are generally active and jump away in all directions when a lettuce is approached or touched. However sluggish leafhoppers, lets say the ones under the influence of the chemical drench did not tend to jump away, allowing them to be recorded. The data in Table 1 gathered on week 13 best indicates this theory as the control clearly recorded less live leafhoppers than the chemical treatments.

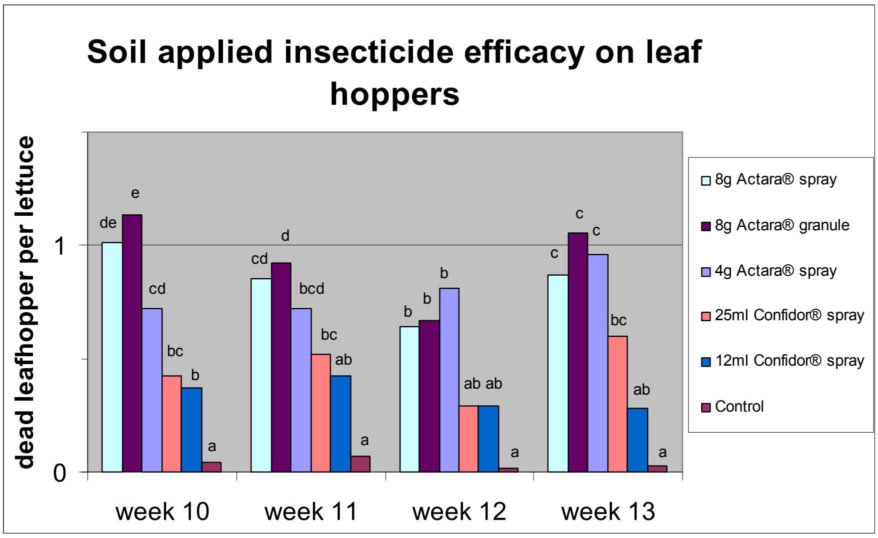
Table 1. Treatment means for live leafhoppers on 15 plants

treatment	Week 10	Week 11	Week 12	Week 13
8g Actara® spray	3.4abc	3.6a	3.8a	27.4 c
8g Actara® granule	2.4ab	2.8a	3.0a	24.0 bc
4g Actara® spray	5.0 c	1.8a	4.4a	21.6 bc
25ml Confidor® spray	2.2a	2.2a	4.4a	15.2 b
12ml Confidor® spray	2.4ab	2.0a	3.0a	16.4 b
Control	4.6 bc	2.2a	4.2a	4.0a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Dead leafhoppers were lying in the leaf axis of the lettuce, and could be accurately recorded. The data collected on dead leafhoppers shows clearly that the chemical drenches killed leafhoppers (Figure 4). Actara® generally displayed greater efficacy against leafhoppers than Confidor®.

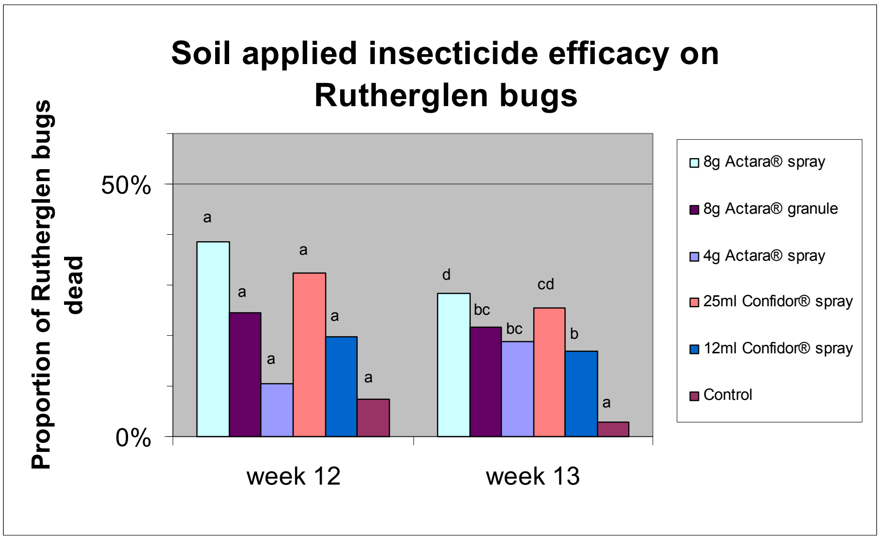
Figure 4. Mean number of dead leaf hoppers per lettuce after soil insecticide treatments.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

Rutherglen bugs (*Nysius vinitor*) were present at the trial site. Their presence was very low for both 10 and 11 weeks after planting, having an average of 0.1 and 0.3 per lettuce respectively. As the temperature warmed up in October, the Rutherglen bugs began to move into the lettuce trial. Their total numbers increased tenfold to an average of 1.6 and 3.6 per lettuce, 12 and 13 weeks respectively after planting. There were enough Rutherglen bugs in the trial site to present a trend for week 12 and a significant difference at week 13 (Figure 5). Since the data was calculated as a proportion of dead Rutherglen bugs the data was arcsine transformed before analysis. The high rates of Actara® and Confidor® were still active enough in the plant 13 weeks after planting to kill 30% of the Rutherglen bug population.

Figure 5. Proportion of dead Rutherglen bugs after soil insecticide treatments.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

There were not enough mirrids (Miridae) in the trial to prove any efficacy of the insecticide drenches against mirrids. There was 1 heliothis (*Helicoverpa spp.)* in every 5 lettuce 10 weeks after planting. The soil drench treatments did not significantly impact heliothis or looper (*Chrysodexis spp.)* caterpillar numbers.

Red & blue beetles (*Dicranolaius bellulus)*, ladybird beetles (*Hippodamia variegata* and *Coccinella transversalis)*, wasps, brown lacewings (*Micromus tasmaniae)*, damsel bugs (*Nabis kingbergii)*, big eyed bugs (*Geocoris lubra)*, assassin bug (*Pristhesancus* spp.) and syrphids (Syphidae sp.) were beneficial insects recorded throughout the trial.There were significantly greater numbers of beneficial insects in the control plots (Table 2). The control plots had an average of 3 beneficial insects in each lettuce a week before harvest. The beneficial insect numbers increased with the increasing availability of food, mostly aphids in the control plots, and most likely sick leafhoppers in the chemical treated plots.

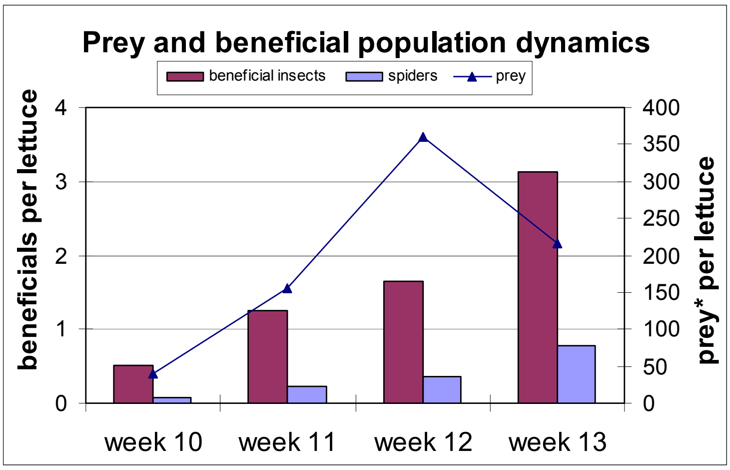
Table 2. Treatment means for live beneficial insects on 15 plants

treatment	Week 10	Week 11	Week 12	Week 13
8g Actara® spray	4.4a	6.4a	10.6a	18.0ab
8g Actara® granule	4.0a	5.0a	11.8a	21.0ab
4g Actara® spray	5.8ab	7.2a	13.4a	17.4a
25ml Confidor® spray	5.4ab	7.6a	14.2a	26.2 b
12ml Confidor® spray	6.4ab	8.8a	11.8a	26.2 b
Control	7.8 b	19.0 b	24.6 b	47.0 c

NB. Means within each column with the same subscript are not significantly different at the 5% level.

There was no significant difference in the numbers of spiders between treatments for all monitoring events. Spider numbers in the trial site increased from an average of 0.1 to almost 1 spider in each lettuce a week before harvest. Spiders did not appear to be affected by the soil drenches. The increase in spider numbers towards crop maturity was similar to the increase in beneficial insect numbers (Figure 6). The beneficial insect and spider numbers increased along with an increase in prey numbers. Of the prey species observed aphids accounted for more than 95%. The dynamics of the pest and beneficial populations in this trial would have been impacted negatively by the fact 80% of the trial area were treated with insecticide soil drenches. Trials in Tasmania clearly demonstrated that beneficial insects can control lettuce aphid. But when 2/3 of two plantings were drenched, the beneficial insects failed to control the aphids (Hill 2005).

Figure 6. Prey and beneficial population dynamics from the control plots.



* Prey is the sum of aphids, thrips, leafhoppers and Rutherglen bugs.

Dead red and blue beetles, ladybird beetles, brown lacewings and nabids were seen in the lettuce leaf axis of all treatments (Table 3). Conclusions cannot be made about the impact of soil drenches on beneficial insects from the data gathered in this trial. Three reasons for this include low beneficial insect numbers, predator mobility and Avatar® sprays. These are outlined below:

1. There were not enough beneficial insect numbers to significantly prove the impact of Actara® or Confidor® soil drench treatments on individual beneficial insect species.
2. Predatory insects are mobile and could move easily between the treatments in this trial design. A beneficial insect may have indirectly ingested insecticide by eating poisoned prey from an Actara® or Confidor® treated plot. This beneficial insect may have then flown to the control plots to feed, where they just happened to die.
3. Avatar®, active ingredient Indocacarb, was used to control heliothis twice. A direct spray of indoxacarb has a very high toxicity to ladybird beetles. This may account for some of the dead ladybird beetles in the control plots (Deutscher S.A. *et al.* 2005).

Table 3. Treatment means for dead beneficial insects* on 15 plants

treatment	Week 10	Week 11	Week 12	Week 13
8g Actara® spray	0.0a	0.8a	2.4a	2.2a
8g Actara® granule	0.0a	0.2a	1.2a	1.0a
4g Actara® spray	0.0ab	0.2a	1.2a	1.2a
25ml Confidor® spray	0.0a	0.2a	1.4a	1.8a
12ml Confidor® spray	0.4a	0.2a	1.8a	0.8a
Control	0.6a	0.2a	2.4a	6.2 b

NB. Means within each column with the same subscript are not significantly different at the 5% level.
* Red and blue beetles, ladybird beetles, brown lacewings and nabids

In lettuce plants, both Actara® and Confidor® seedling drenches at recommended rates were highly toxic to brown lacewings through indirect poisoning for up to 5 weeks (Horne and Cole 2005). Horne and Cole's bioassay trials also showed that even a one tenth rate of

Confidor® caused moderate toxicity to brown lacewings for 3 weeks. Given the indirect toxicity of both Actara® and Confidor® seedling drenches to brown lacewings, it is possible that other predatory insects, like ladybird beetles and nabids may be similarly affected.

Conclusion

Both 8g/100m of Actara® or 25ml/100m Confidor® banded in the soil prior to seeding, controlled aphids for the 14 week duration of a winter sown lettuce crop at Hay. The soil drenches also showed efficacy against leafhoppers and Rutherglen bugs. Applying Actara® as a granule band did not significantly reduce the chemical's efficacy in the furrow irrigated clay soil. Applying half rates of Actara® and Confidor® did not significantly reduce the efficacy against aphids, however halving the application rates reduced the efficacy against leafhoppers and Rutherglen bugs. The effects of soil applied insecticide drenches on pest thrips could not be determined in this trial. Predatory beneficial insects appeared to be indirectly poisoned in this trial. Spiders were unaffected by the soil applied insecticide bands.

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Acknowledgements

A special thanks to John Langley for taking time to assist with the chemical application and allowing us to establish the trial site on his property. Thanks to Tony Napier and Meryl Snudden for assisting with trial establishment and monitoring. Thanks to Syngenta for supplying Actara® for the trial. This project was funded by NSW DPI, the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Heliothis insecticide efficacy trial, Autumn 2002 (Gatton, QLD)

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Introduction

Heliothis, *Helicoverpa armigera* and *Helicoverpa punctigera* have traditionally been the most important pests to attack lettuce crops throughout Australia. Of the two pests *H. armigera* is the most serious due to its ability to develop resistance to a wide range of synthetic insecticides and the limited number of insecticides currently registered for Heliothis control in lettuce. *H. punctigera* has not been shown to be resistant to insecticides and is readily controlled with currently registered insecticides and is generally only of concern to growers during the spring plantings of lettuce.

Those insecticides traditionally used for the control of Heliothis, namely methomyl and alpha-cypermethrin are having increased pressures placed upon them from environmentalists and government agencies to reduce their use due to their supposed environmental impact and also from consumers who are after produce with less synthetic chemicals applied to them. These insecticide trials were conducted to provide efficacy data to help with the registration of new insecticide products for the control of Heliothis. These products are considered to be generally more environmentally friendly, to both the consumer and the naturally occurring beneficial insects known to attack Heliothis and other insect pests.

Methods

A replicated small plot trial was set up on a grower's property just outside of Gatton in the Lockyer Valley to evaluate the effectiveness of a range of insecticides, both new and old, which included three products yet to be registered for the control of *Helicoverpa* species in lettuce.

Each treatment was replicated either 3 or 4 times using a randomised complete block design. The Best Management Option and the unsprayed control were only replicated 3 times due to insufficient area. Plot sizes were approximately 6m (3 beds) x 10m long beds. Total area of lettuce planted was 1320m^2. The treatment design is in Figure 1.

The treatments were as follows:

1. Best Management Option (Methomyl, Bt [Xentari] Bayer, Success®[Spinosyn 120g/L], Dow;
   Avatar®[Indoxacarb 400g/Kg] Dupont
2. 250g/ha Proclaim® [Emamectin benzoate 50SG]; Syngenta
3. 100ml/ha, S1812 [experimental]; Sumitomo-chemicals
4. 200ml/ha, S1812 [experimental]; Sumitomo-chemicals
5. 1.35L/ha Azamax® [Neem]; Organic Crop Protectants, plus foliar fertilisers Aminogrow® and Acadian®
6. Unsprayed control

The BMO approach was to use Bt sprays early in the crop up until pre-hearting and then rotating the use of Success® and Avatar® until harvest. The use of methomyl would only be required if a large egg lay was found to have occurred and would then be added to either Bt, Success® or Avatar®. All spray treatments had Eco-oil® added as a wetting agent at 4ml/L of spray volume.

BMO R.3.	Proclaim R.4.
S1812 200ml R.4.	Control R.3.
Azamax R.4.	S1812 100ml R.4.
S1812 200ml R.3.	Azamax R.3.
S1812 100ml R.3.	Proclaim R.3.
Proclaim R.2.	Control R.2.
Azamax R.2.	BMO R.2.
S1812 200ml R.2.	S1812 100ml R.2.
BMO R.1.	Azamax R.1.
Proclaim R.1.	Control R.1.
S1812 100ml R.1.	S1812 200ml R.1.

Figure 1. Trial layout at Lower Tenthill April/May 2002.

The treatments were applied early in the morning according to insect pest pressure determined by monitoring, see Table 1. Treatments were applied by a motorised SOLO backpack sprayer putting out approximately 450L/ha of water per hectare. A 1.2m wide lance, which had 4 equally spaced Twin-Jet nozzles, was attached to the sprayer.

Table 1. The dates of treatment applications

Treatments	Date of application(s)
All treatments	10 April 2002
All treatments	15 April 2002
S1812 100ml, Azamax, BMO	20 April 2002
S1812 200ml	22 April 2002
S1812 100ml, Azamax, BMO	29 April 2002
All treatments	5 May 2002
Harvest	15 May 2002

Monitoring methods

The trial site was monitored once a week with a decision being made on whether an insecticide application would be required and when. Ten plants were checked from each plot for Heliothis and other pests. At harvest 10 plants were selected from each plot from the middle 4 rows, selecting every 5th lettuce plant within these rows. The plants were then examined for the presence of larvae on the wrapper leaves and within the lettuce head/heart by cutting them open. These results were then analysed using the GenStat statistical program.

Results and Discussion

Heliothis egg and larval pressures were at or above the recommended thresholds for most of the life of the crop (Figures 2 and 3). There appeared to be very little difference in the egg numbers between treatments for most of the trial period. The peak in egg numbers in the control on the 19th April is difficult to explain. All other treatments also had higher egg numbers on this date. Subsequent larval numbers also increased a week later, particularly for the unsprayed control as well as the Azamax® treatment (Figure 3). There was very little difference between the other treatments, although there was a slight increase in larval numbers for the S1812 treatments just prior to harvest. This was not significantly different from the Proclaim and the BMO treatments however.

Figure 2. Heliothis egg numbers found on lettuce plants during the spray trial.

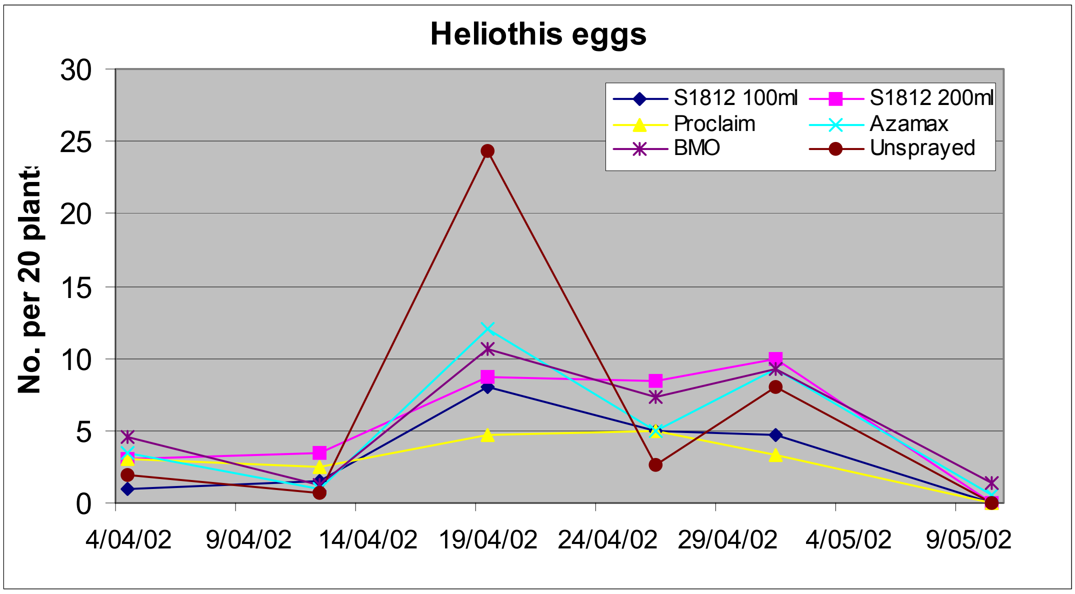
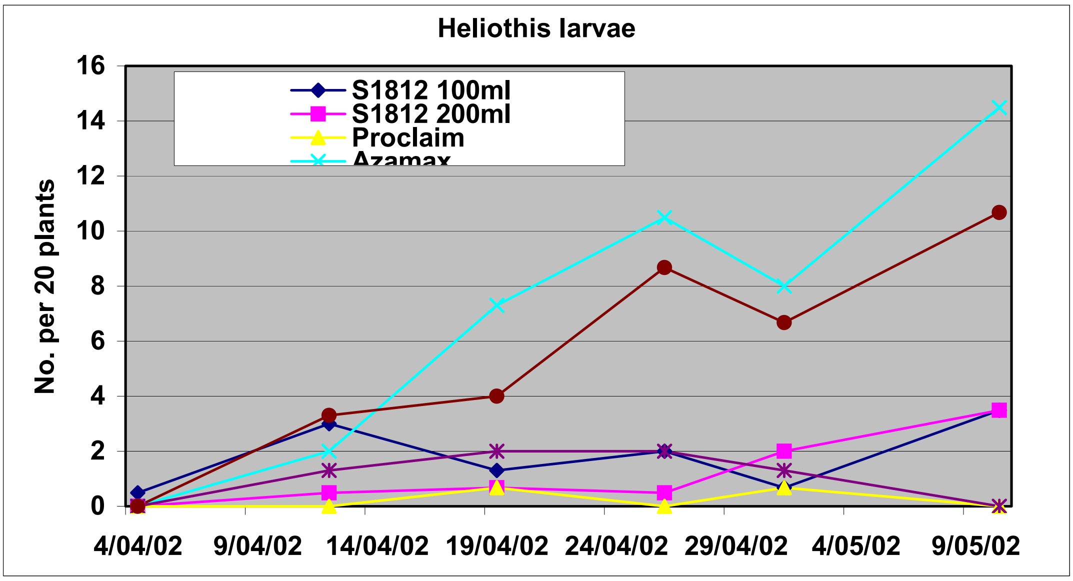


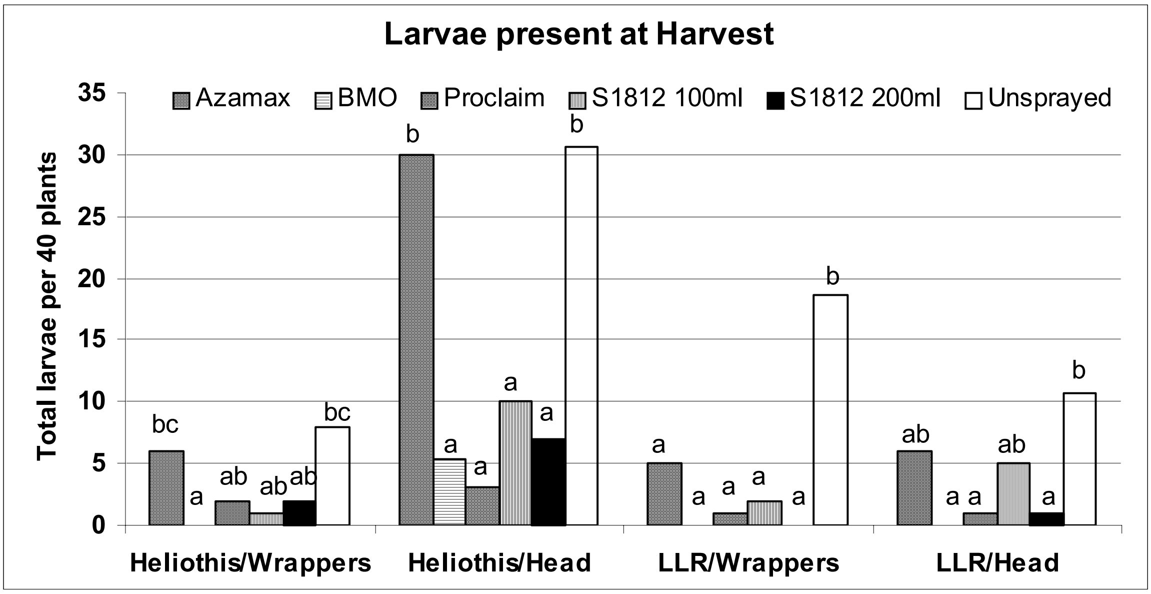
Figure 3. Heliothis larval numbers found on the lettuce crop during the spray trial.



Azamax® and the unsprayed control had the greatest number of heliothis present in the lettuce at harvest. Pest numbers were looked at on the wrapper leaves and the head or heart due to the fact that some growers only harvest the head or heart for processing while the majority harvest a good part of the crop including a number of the wrapper leaves which may or may not be utilised by the consumer. The majority of heliothis were found on or within the head/heart of the plant with Azamax® performing poorly in this trial compared with the other insecticide treatments. Azamax® was no better at controlling heliothis than the unsprayed control. The other spray treatments were significantly better than the unsprayed control at controlling heliothis in the head/heart, but were not significantly different from one another. It is possible the rate of Azamax® used in this trial was not high enough or that the water rate per hectare was not high enough. This will be looked at in future trial work for heliothis control. Although the number of heliothis found on the wrapper leaves was less in the BMO, Proclaim® and S1812 treatments, they were generally not significantly different from either the Azamax® treatment or the unsprayed control. The BMO was the only treatment that was significantly different from the Azamax® treatment and the unsprayed control.

The only other pest that was present in any great numbers was lucerne leaf roller *Merophyas divulsana*. This pest was a particular problem at harvest, where infestations of this pest were of concern (Figure 4). There was very little difference between insecticide treatments at controlling lucerne leafroller. All the sprays were generally better than the unsprayed control, although there was no significant difference between the control, the Azamax® and the S1812 100ml treatment, in the number of larvae found underneath the outermost leaf on the head of the lettuce. Proclaim® and S1812 did however give better control of lucerne leafroller and could therefore have some place in future pest management practices for lettuce. The BMO adopted in this trial also showed promise against this pest.

Figure 4. Heliothis and Lucerne leafroller (LLR) incidence at harvest, 15 May 2002.



Conclusion

There are some promising new insecticides being looked for the control of heliothis and lucerne leafroller, in particular in lettuce. Once other insecticides become available, growers will have a greater range to choose from for the control of larval pests in lettuce. No heavy insecticides were used during this BMO treatment, however the use of methomyl as an ovicide, with either Bt, Success® or Avatar®, may still be necessary if a large egg lay was found to have occurred. The methomyl has a very short residual and so any eggs that are missed and hatch should then be cleaned up with either Bt, Success® or Avatar® due to their longer residual effect. No product is 100% effective at controlling insect pests.

Heliothis insecticide efficacy trial, Autumn 2003 (Hay, NSW)

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Introduction

This insecticide trial compared the efficacy of recommended rates of Proclaim®, Prodigy®, S1812 and Azamax®. Success® was included as a standard for heliothis management and a water treatment was included as the control. In this field trial the lettuce crop was exposed to the natural *Helicoverpa armigera* and *Helicoverpa punctigera* pressure during autumn at Hay. Insect data was also gathered on aphids, thrips, leafhoppers and Rutherglen bugs to assess the efficacy of the chemicals on these pests.

Materials and Methods

'Target' variety lettuces were direct seeded on the 12th of March, 2003 in a furrow irrigated grey clay soil type at Hay, NSW 2711. The bed centres were at 1.5m spacing, with two rows of lettuce per bed spaced 40cm apart. After chipping, the within the row plant spacing was about 30cm.

The following six spray treatments were applied:

1. 250g/ha Proclaim® [Emamectin benzoate 50SG]; Syngenta
2. 1.6L/ha Prodigy® [Methoxyfenozide 240g/L]; Dow
3. 0.2L/ha S1812, [experimental]; Sumitomo-chemicals
4. 3L/ha Azamax® + 1L/ha Eco-oil® [Neem]; Organic Crop Protectants
5. 0.8L/ha Success® [Spinosyn 120g/L]; Dow
6. Control (water 600L/ha)

The six treatments were arranged randomly into 5 blocks and each treatment plot consisted of 10m of lettuce bed totalling 66 plants (Figure 1). The design had 2m of lettuce bed as a buffer between plots and the there were two beds of lettuce as buffer between each block of lettuce plots (Figure 1).

Figure 1. Diagram of trial plots

Two bed lettuce buffer						
Block1	T1	T4	T3	T2	T6	T5
Two bed lettuce buffer						
Block2	T2	T5	T6	T3	T4	T1
Two bed lettuce buffer						
Block3	T4	T6	T2	T1	T5	T3
Two bed lettuce buffer						
Block4	T6	T1	T5	T4	T3	T2
Two bed lettuce buffer						
Block5	T5	T3	T2	T1	T6	T4
Two bed lettuce buffer						

The sprays were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet TXVK-6 hollow cone nozzles delivering 600L/ha of water.

The trial site was monitored weekly to a protocol. Pheromone pot traps were used to monitor *H. armigera* and *H. punctigera* moth flights over the trial period. There were sufficient *Helicoverpa spp*. caterpillars to apply the insecticide treatments on April 11th 2003. At this time the lettuce crop was at a pre-hearting stage of development. There was again sufficient larval pressure to reapply the treatments on 6th May 2003, whilst the plants were hearting.

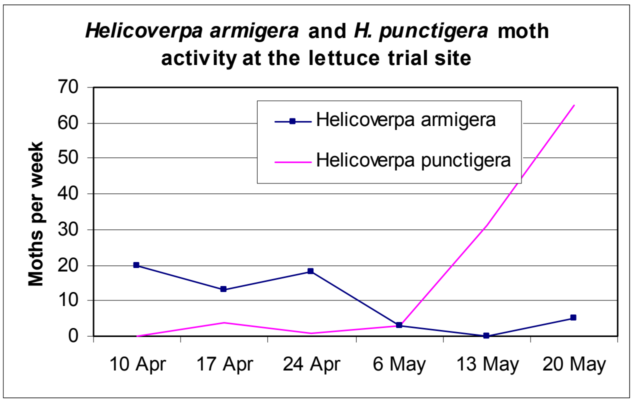
A random sample of 30 plants from each plot were monitored weekly until the plants were at early hearting and 20 plants from each plot whilst the lettuces were hearting. Heliothis eggs, all insects and spiders were recorded from each lettuce monitored. The insects included heliothis larvae, looper larvae, aphids, thrips, leafhoppers and Rutherglen bugs as well as a range of beneficial insects. Half a week before the crop was ready for harvest, 40 plants per plot were destructively sampled for heliothis larvae. The larvae were recorded as instar stages of 1st, 2nd, 3rd or 4th+.

The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

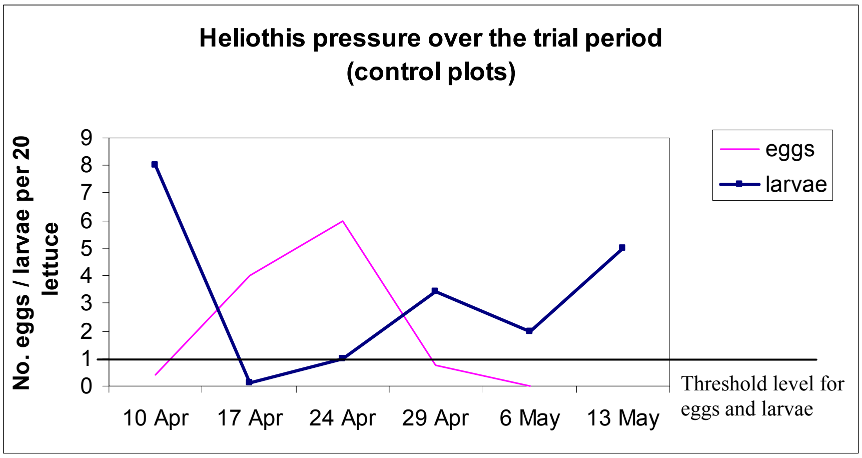
Moth trappings from the pot traps suggest that both *Helicoperva armigera* and *Helicoperva punctigera* larvae were present in the trial (Figure 2). Over 80% of the moths caught over the period prior to the second spray application (6 May), were the *H. armigera* species.

Figure 2. *Helicoverpa spp*. moth trappings over the trial period



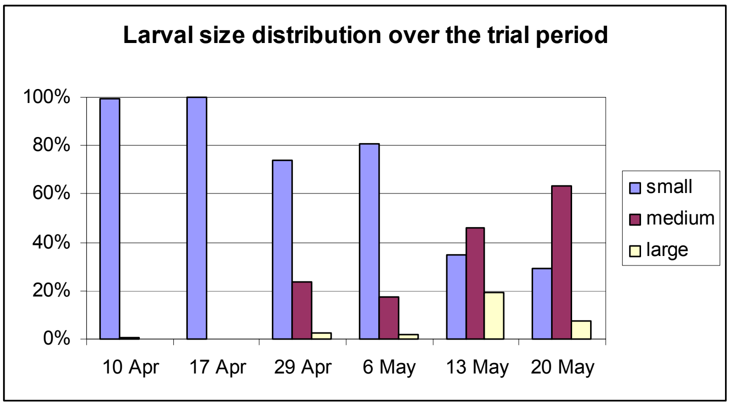
On 11th April, the time of the first spray, the heliothis larval pressure was high, with an average of eight larvae per 20 lettuces (Figure 3). All were 1st to 2nd instar larvae (Figure 4). On the 13th April, 2 days after spray (2 DAS), there was 75mm of heavy rainfall. This storm killed many larvae because the larvae were small and unprotected in the open rosette lettuces. The sharp decline in larval numbers present in the control plot on the 17th April reflects the impact of the storm (Figure 3). Larvae pressure again increased as the trial progressed, with enough larval pressure to apply the spray treatments a second time on the 6th of May.

Figure 3. *Helicoverpa spp.* larvae and egg pressure during the autumn trial period at Hay



At the time of the first spray, (April 11th), the heliothis larvae were all 1st to 2nd instar. At the time of the second spray, (May 6th), 20% of the larvae were a medium size 3rd instar and the rest were small 1st to 2nd instar larvae (Figure 4). At the harvest assessment the majority of the larvae were 3rd instar.

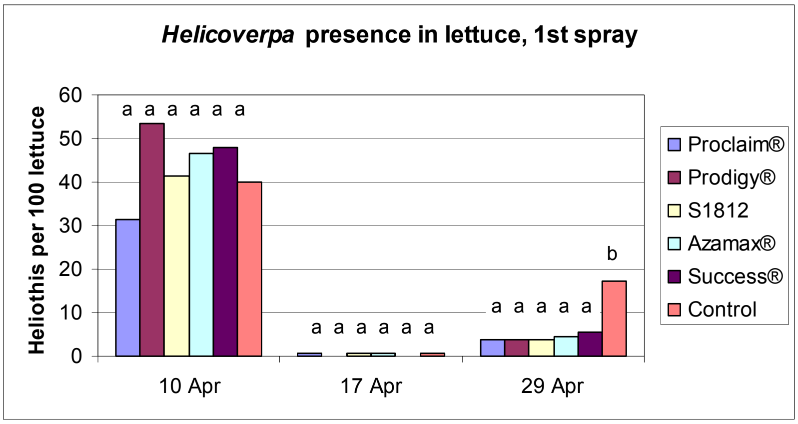
Figure 4. *Helicoverpa spp.* larval size distribution over the trial period



Small = 1st + 2nd instar, Medium = 3rd instar, Large = 4+ instar

Almost half the lettuce plants had heliothis larvae prior to the first spray and there was no significant difference in the mean number of larvae per plot between treatments ($P > 0.05$). As mentioned earlier, at 2 DAS there was 75mm of rain and the results of the first spray were not evident on 17th April (Figure 5). Of the 150 lettuce plants monitored in control plots on that day, only one small heliothis larva was found. On the 29th of April all the insecticide treatments had significantly less larvae than the control.

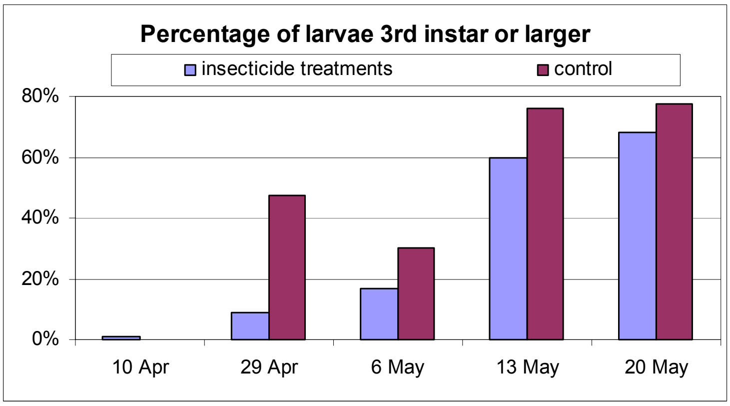
Figure 5. *Helicoverpa spp.* larvae means for sample dates before and after the first spray
N=30 lettuces randomly monitored from each treatment plot.



Means with the same subscript within a period are not significantly different at the 5% level.

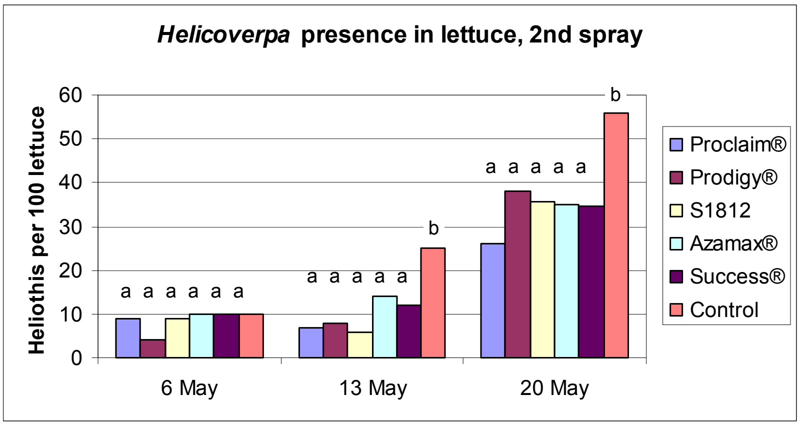
On the 29th April, 50% of the larvae from the control plots were a medium size or larger (3rd + instars), which compared to only 10% from the other treatments (Figure 6). The insecticides must have had some effect prior to the rain event on larval numbers. The larvae must have been overlooked during the monitoring the week prior. The control plots continued to have a greater proportion of medium larvae throughout the duration of the trial.

Figure 6. Comparison of larvae size between the insecticide treatments and the control



There was again no significant difference in the mean number of larvae between the treatments on the 6th May (Figure7). This may be due to the fact that the monitoring was not done destructively and the larger larvae may have been in the lettuce heart. On the 20th of May, 40 lettuce were destructively sampled from each plot for heliothis larvae, over 1/2 of the lettuces in the control plots had a caterpillar. This was significantly more than all the insecticide treatments, which had about 1/3 of the lettuces with heliothis damage ($P > 0.05$). The harvest assessment revealed that there was no significant difference between the insecticide treatments.

Figure 7. *Helicoverpa spp.* larval means for sample dates before and after the second spray.



Means with the same subscript within a period are not significantly different at the 5% level.

Through out the trial Proclaim®, Prodigy®, S1812, Azamax® all showed no significant efficacy against aphids, thrips, leafhoppers and Rutherglen bugs. There was also appeared to be no significant effects on beneficial insect species.

Conclusion

This was not a good trial to compare the efficacy of Proclaim®, Prodigy®, S1812, Azamax® and Success®. All treatments appeared to perform significantly better than the control however there was no separation between the treatments at the 5% level. An earlier series of polyhouse efficacy trials showed continued separation between these treatments. It is likely that the 75mm of rain two days after the first spray influenced the results in this trial. Furthermore, the second spray was applied a week too late allowing larvae to escape the full effects of the chemical treatments.

Acknowledgements

Thanks to Appolo Valley for the trial site, Mick Laracy for monitoring and spraying assistance. Thanks to Dow Agroscience, Sumitomo Chemicals and Organic Crop Protectants for respectively providing Prodigy®, S1812 and Azamax® for our investigation. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Heliothis insecticide efficacy trial, Spring 2003 (Yanco, NSW)

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Introduction

The primary aim of this investigation was to obtain efficacy data on Proclaim®, Success®, Prodigy®, DC-041 and S1812 when used at half the recommended rates. Heliothis larvae, both (*Helicoverpa armigera* and *Helicoverpa punctigera*) were the targeted pest species. Data on loopers (*Chrysodeixis spp*.) was also collected.

Materials and Methods

A replicated small plot trial was set up at the Yanco Agricultural Institute, Yanco NSW 2703. The trial site had a sandy loam soil type. The lettuces were irrigated with surface drip irrigation. 'Target' variety lettuces were planted as seedlings on the 20th of November 2003. Plants were spaced 30cm within the row and there were two rows per bed spaced 50cm apart. The bed centres were at 1.5m spacing.

The following six treatments were replicated five times:

1. 150g/ha Proclaim® [Emamectin benzoate 50SG]; Syngenta
2. 400ml/ha Success® [Spinosyn 120g/L]; Dow
3. 800ml/ha Prodigy® [Methoxyfenozide 240g/L]; Dow
4. 60ml/ha DC-041; Bayer Crop Science
5. 100ml/ha, S1812; [experimental]; Sumitomo-chemicals
6. Control (water 600L/ha)

The six treatments were arranged randomly into 5 blocks and each treatment plot consisted of 7.5m of lettuce bed totalling 50 plants (Figure 1). There was a two bed buffer between each block of lettuce plots.

Figure 1 Diagram of trial plots

Block1	T2	T5	T3	T1	T4	T6
Block2	T3	T6	T2	T4	T5	T1
Block3	T1	T4	T5	T3	T2	T6
Block4	T4	T2	T6	T1	T3	T5
Block5	T6	T1	T5	T4	T2	T3

The trial site as a whole was monitored weekly to a protocol until there were sufficient *Helicoverpa spp*. caterpillars to apply the insecticide treatments on December 13th 2003. At this time the lettuce crop was at an early hearting stage of development. A more intense monitoring protocol was then used prior to the insecticide application. The monitoring protocol included egg and larvae counts taken from a random sample of 30 plants from each plot. The pre-treatment monitoring recorded heliothis and looper larvae at 1st, 2nd, 3rd or 4^{th+} instars. Heliothis and looper eggs were recorded as white, orange, brown or parasitised.

The treatments were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet TXVK-6 hollow cone nozzles delivering 600L/ha of water.

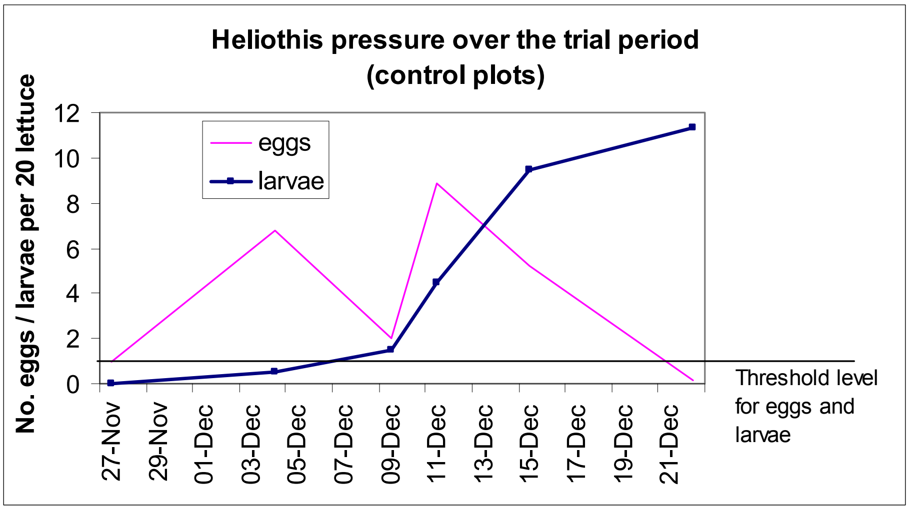
Caterpillar egg and larvae counts were taken 3 days after the insecticide spray following the same protocol used in the pre-treatment counts. Data showed continued larval pressure so a second insecticide treatment was applied. Five days after the second spray the trial plots were monitored again using the pre-treatment monitoring protocol. The trial site was then destroyed. The lettuces were hearting and about two weeks from harvest.

The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

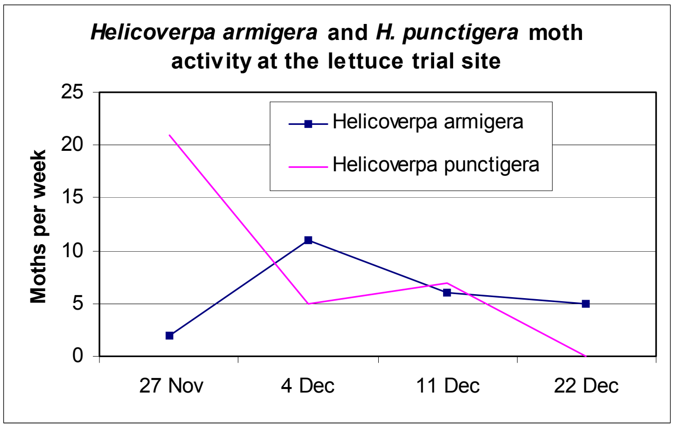
Heliothis pressure during the trial was moderate during the pre-hearting stage of the crop. The pressure built to high levels during the hearting stage (Figure 2). The numbers of eggs during the hearting stage of the crop was above the threshold of 1 viable egg or larvae in 20 plants, however we waited until the level of 5 larvae in 20 plants before spraying. The numbers of heliothis larvae had the potential to be a lot higher. Afternoon storms throughout the first week of December resulted in high mortality rates for heliothis eggs & neonate larvae. Six eggs per 20 lettuce resulted in only one larva per 20 lettuce plants.

Figure 2. Heliothis pressure during the trial period from the 27th November until the 22nd December 2003.



Data from pheromone pot traps indicated that both *Helicoverpa armigera* and *H. punctigera* were active at the trial site (Figure 3). The heliothis larvae were likely a mix of both species.

Figure 3. Weekly moth catch of *Helicoverpa armigera* and *H. punctigera.*

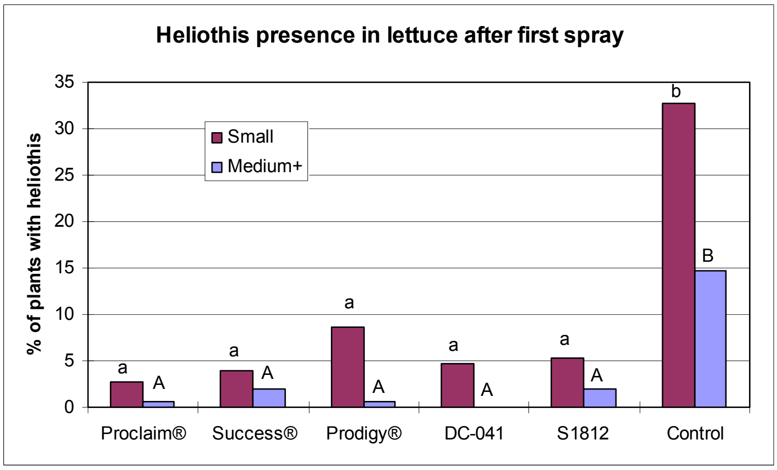


Pre-treatment counts for both small and medium heliothis larvae were statistically equivalent at a confidence level of 0.95 for all treatment plots. First and 2nd instar larvae were scored as small larvae, whilst 3rd and 4th instar larvae were scored as medium.

Similarly there was no significant difference between the numbers of heliothis eggs, numbers of loopers and numbers of looper eggs for all treatment plots at a confidence level of 0.95.

Three days after the first spraying, all insecticide treatments worked significantly better against heliothis larvae than the control (Figure 4). 48% of the lettuce in the control plots had heliothis larvae compared to less than 9% in the insecticide treated plots.

Figure 4. Percentage of lettuce with heliothis larvae 3 days after the first spray.



Percentages with the same subscript are not significantly different at the 5% level.

As in the pre-treatment, there was no significant difference between the numbers of heliothis eggs in each treatment (Table 1). The insecticides did not repel moths nor significantly reduce the numbers of eggs laid.

Table 1. Means from 30 plants for heliothis eggs.

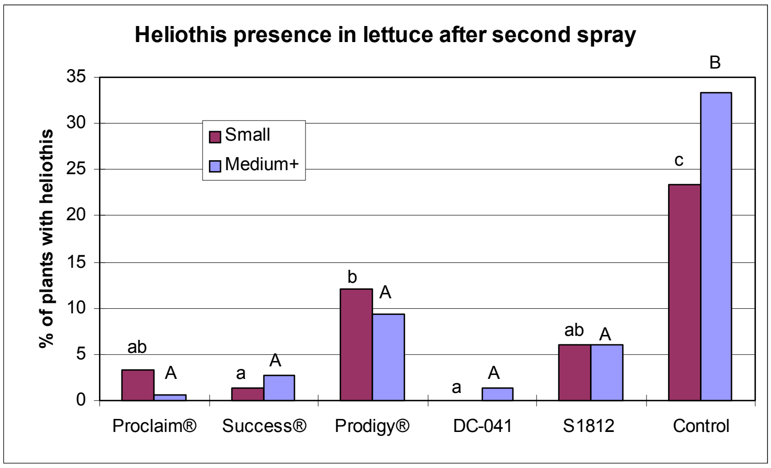
treatment	white eggs		orange eggs	
Proclaim®	3.6	a	4.0	a
Success®	3.6	a	3.8	a
Prodigy®	4.2	a	1.8	a
DC-041	4.4	a	3.0	a
S1812	3.4	a	3.0	a
Control	5.2	a	2.6	a

Means within each column with the same subscript are not significantly different at the 5% level.

Since there was continuing heliothis pressure from eggs and small larvae, a second spray was applied 5 days after the first spray.

Monitoring results 3 days after the second spray indicated that all insecticides worked significantly better than the control (Figure 5). However, not all insecticides performed equally well.

Figure 5. Percentage of lettuce with heliothis larvae 3 days after the second spray.



Percentages with the same subscript are not significantly different at the 5% level

Over the three days between the second spray application and the monitoring a total of 21mm of rain fell associated with storm activity. There was 8mm in a storm 29 hours after the spray was applied. It can only be assumed that the storm activity reduced the efficacy of Prodigy® when compared to Proclaim®, Success®, S1812 and DC-041.

Conclusion

From this trial, it would appear that Prodigy®, DC-041 and S1812 have a place in pest management in lettuce. Chemicals like Prodigy® and S1812 are 'soft' on beneficial insects and would have a place for growers using an integrated pest management strategy.

Acknowledgements

Thanks to Meryl Snudden for monitoring assistance. Thanks to Dow, Bayer and Sumitomo Chemicals for providing Prodigy®, DC-041 and S1812 respectively. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

NPV sprinkler efficacy trial September 2004 (Yanco, NSW)

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Introduction

The primary aim of this investigation was to obtain efficacy data of nuclear polyhedrosis virus (NPV) when applied through overhead sprinklers for controlling *Helicoverpa spp*. This heliothis control method is well suited to integrated pest management and in some cases may be a quick and cheaper heliothis control option. Vivus® was the NPV product used in this trial. Vivus® is a biological insecticide that is highly specific to *Helicoverpa spp*. The virus works best in humid conditions at temperatures of 25°C – 35°C. Thorough coverage is required as ingestion is needed for infection to occur.

Materials and Methods

A replicated plot trial was set up at the Yanco Agricultural Institute, Yanco NSW 2703. The trial site had a sandy loam soil type. The lettuces were irrigated with Nelson R2000WF overhead sprinklers fitted with a red WF16 upper nozzle and a size 15 tan lower nozzle. The irrigation system adjusted to operate at 300kpa. Each sprinkler head delivered 600L/hr on a 9m X 12m grid.

'Target' variety lettuces were planted as seedlings on the 16th of September 2004. Plants were spaced 30cm within the row and there were two rows per bed spaced 50cm apart. The bed centres were at 1.5m spacing. The trial plots were 30m long and only lettuce from the centre three beds were monitored and sampled (Figure 1).

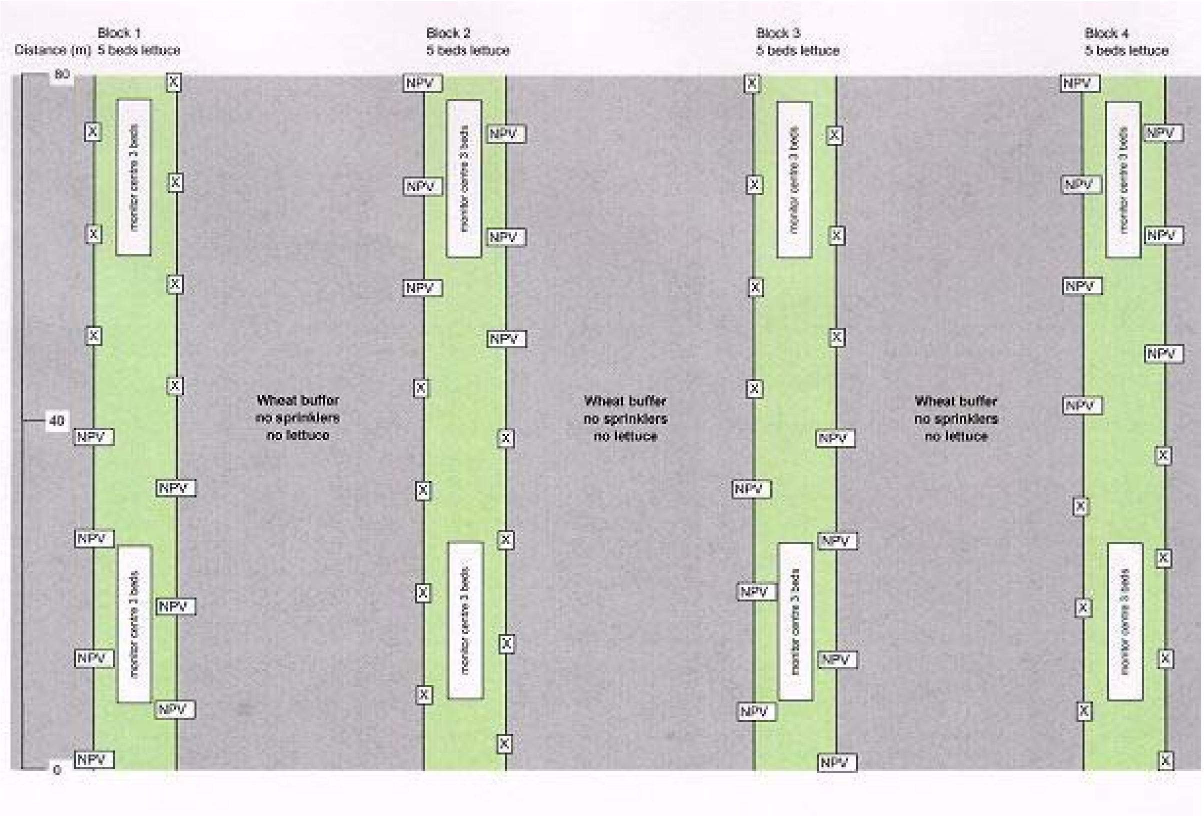
Monitoring

The trial site as a whole was monitored weekly to a protocol until early hearting. Heliothis larvae pressure was low so it was decided to spike a portion of each plot with reared *Helicoperva armigera* larvae each week prior to the NPV application. Thirty lettuce were flagged in each plot, (five in each row) and two 3rd instar larvae were placed on each lettuce. Each week, prior to the NPV application, another thirty plants were marked in each plot and two heliothis larvae were placed on each lettuce.

NPV application

The Vivus® and control treatments were replicated four times (Figure 1). The Vivus® contained 2 X 10^9 polyhedral occlusion bodies of the nuclear polyhedrosis virus of *Helicoverpa zea* per millilitre. The Vivus® was applied three times at a rate of 750ml/ha. The planned NPV application was to apply Vivus® weekly from an early rosette growth stage, 20 days after transplanting. Heliothis larvae availability and windy weather conditions meant we started the applications almost a week later than planned. Applications were made 26 (12th October), 34 (20th October) and 40 (26th October) days after transplanting. An Ecofertic® hydraulic fertiliser injection pump was used to inject 200ml of Vivus® mixed with 20L of water into the mainline over a period of six minutes. The sprinkler heads took two minutes for each 360° rotation.

Figure 1 Diagram of trial plots



Prior to the first Vivus® application the irrigation system's lateral operating pressures were adjusted to 300kpa. Sprinklers were blanked according to the trial plan (Figure 1), and two dye tests were done to calibrate the irrigation system. The time was recorded when the last sprinkler in each lateral was flushed clear of dye. The lateral was then turned off and times were recorded for the remaining irrigation laterals. The dye test is a critical part of this NPV application technique, as it gives an accurate indication of when to turn each lateral off after NPV injection.

After each Vivus® application each irrigation lateral was flushed for two minutes to make absolutely certain all NPV had been flushed out off the irrigation system. Blanked sprinklers were reconnected to the lateral for normal irrigation only after flushing. The lettuce crop was irrigated on the day of NPV injection, prior to the application. Two hour irrigations were then generally applied every two to three days, depending on weather conditions.

A Tinytag® logger recorded temperature and humidity in the trial site throughout the trial period. Pheromone pot traps were used to monitor *Helicoperva armigera* and *Helicoperva punctigera* moth flights over the trial period.

Bioassays

Each week leaf samples were taken 1day, 3days and 6days after the Vivus® was applied. Sixteen leaves were randomly sampled from each plot. The youngest fully expanded leaf was collected for the first two bioassays. A wrapper leaf was used for the third bioassay. To prevent sample contamination leaves were collected from all of the control plots before the Vivus® plots were sampled. The sampled leaves from each plot were sealed in labelled bags and placed in an esky for transport to the laboratory.

Half of the sampled leaves from each plot were bagged and stored in the refrigerator at 4°C to be used in a single bioassay with the same batch of larvae. This was done to prove that differences in larvae mortality were not due to larval batch variation. The eight remaining leaves from each plot were used in a bioassay.

The bioassays were done in C-D International Bio-RT-32 rearing trays. The work area, leaf cutting vials, tools and brushes were treated with cavicide®, hospital grade disinfectant / decontaminant cleaner after each use. Bioassays from all control plots were done before the Vivus® plot bioassays.

In each bioassay two 2.5cm lettuce leaf discs were placed with a 2nd instar *Helicoperva armigera* larvae. Each leaf had four leaf discs cut from them. A tray had eight covers stuck on top when all cells had one larva and two leaf discs. The trays were then stored in a controlled temperature room at 27°C set at 14L:10D photoperiod. The larvae were checked daily. When a larva had eaten all of the lettuce in a cell, it was fed a diet cube (ref?). The heliothis diet used was based on soybean flour, wheat germ and brewers yeast. Daily records kept for each larva / cell included the date diet was fed, the date a larva died or the date a larva pupated.

Pupae from the first week of bioassays were transferred to peat moss and the numbers of emerging moths were recorded.

Harvest assessment

The lettuces were mature and a harvest assessment started on 5th of November, 50 days after transplanting. The 90 flagged lettuce from each plot, that is the lettuce which had heliothis larvae introduced, and also 30 randomly selected lettuce from each plot were assessed. Each lettuce was scored as having wrap damage, heart damage or no damage. Lettuce were cut then visually inspected for the presence of heliothis and looper larvae. The size and number of larvae was recorded. Any dead larvae, oozing from virus death were also recorded.

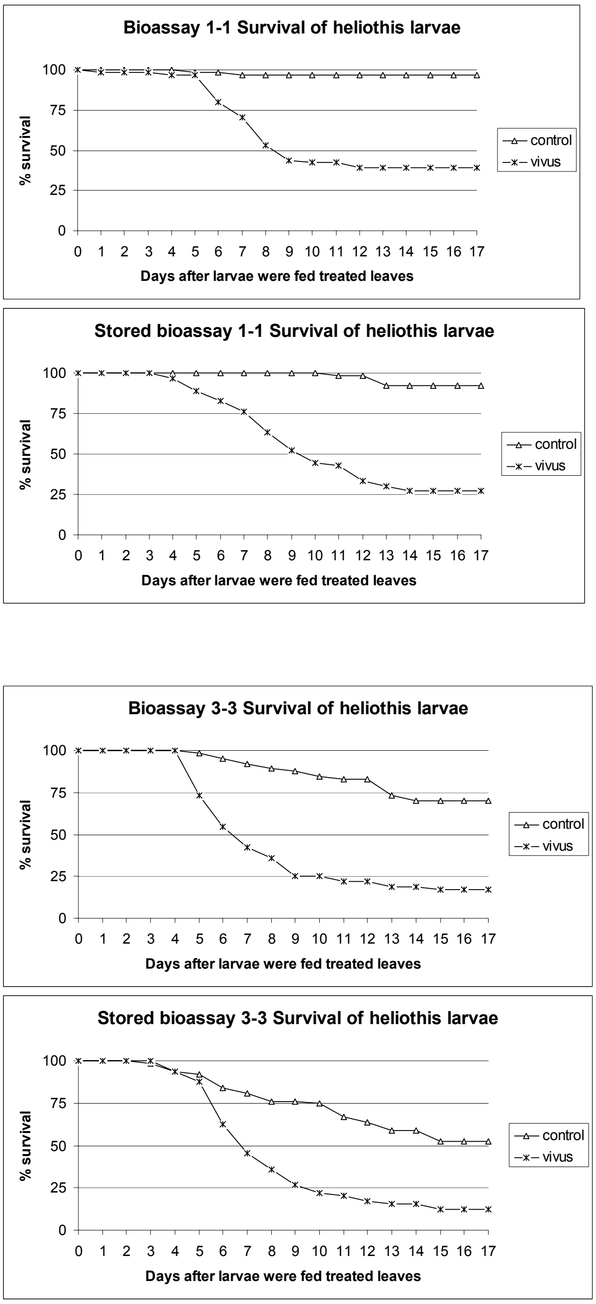
Data analysis

Larvae deaths from the stored and immediate bioassay were summed for each sampling date. This data was analysed with a paired t-test for each bioassay. The harvest data was analysed with a paired t-test.

Results and Discussion

Bioassay data indicated that the sprinkler application of Vivus® worked effectively. A consistently lower percentage of heliothis larvae survived the Vivus® bioassays compared to the control bioassays (Figure 2). Most heliothis larvae died between 4 and 9 days after they were fed treated leaves. Variation in larva survival was not significant between the immediate and stored bioassays (Figure 2). This was the case for bioassays from all nine sample dates over the three week sample period. This indicates that any inherent difference between larva batches did not affect the ability of virus to kill the larvae.

Figure 2. Comparison of immediate and stored bioassays.



As there was no significant variation in percentage survival for either treatment between immediate and stored bioassys, the data for each replicate was summed for analysis. That is, the number of dead larvae from immediate bioassay 1-1 was added to the number of dead larvae from stored bioassay 1-1 for each replicate prior to analysis by paired t-Test.

Heliothis mortality was significantly higher in the Vivus® treatment in 8 of the 9 bioassay sample dates(Table1). NPV is degraded by ultra violet light. This could be a reason why 6 days after only one application of Vivus®, (week1-day6), there was no significant difference in mortality between the Vivus® and control.

Table 1. Percent Mortality (% Dead larvae) for bioassays

harvest criteria	Vivus®		Control	
week1-day1	66.6	a	5.5	b
week1-day3	23.1	a	3.8	b
week1-day6	31.9	a	14.1	a
week2-day1	65.6	a	25.9	b
week2-day3	47.5	a	14.1	b
week2-day6	58.4	a	21.6	b
week3-day1	92.8	a	45.9	b
week3-day3	85.3	a	40.6	b
week3-day6	75.0	a	43.1	b

NB.Means between columns with the same subscript are not significantly different at the 5% level by paired t-test.
Stored and immediate bioassays were combined for analysis (n=32 per replicate)

Heliothis NPV mortality increased over the three week period in both the Vivus® and control bioassays (Table1). This bioassay trend could happen as a result of the following:

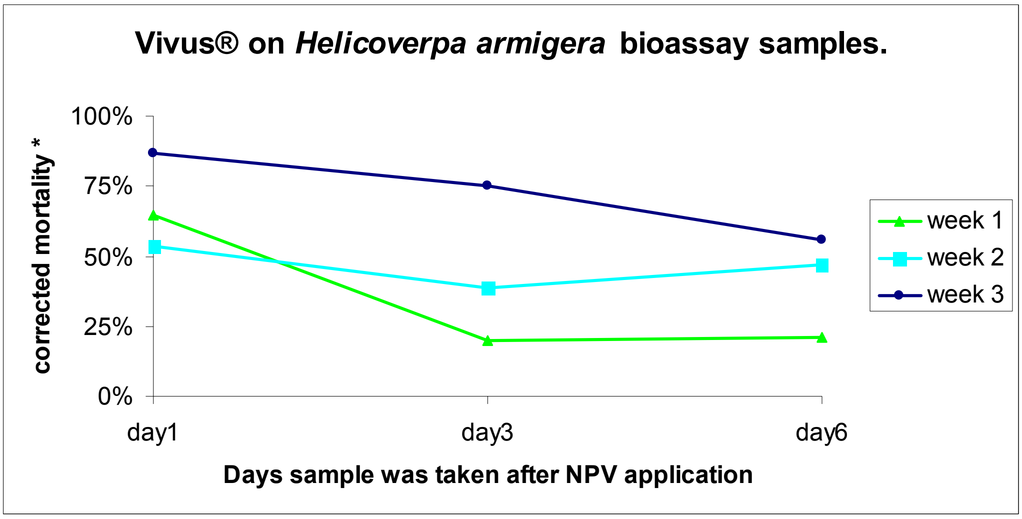
- Increased NPV virus levels in the field and natural dispersal.
- Contamination during the bioassay process.
- NPV virus contamination getting into trays in the CT room.

It cannot be stated for certain why this has occurred but field contamination is the most likely cause. Bioassays stored in separate temperature cabinets from another trial indicated field contamination. Harvest assessment data certainly indicates field contamination with NPV killed heliothis larvae found in all control replicates.

The buffer zone of 30m between plots was an insufficient for a virus trial. Drift during application, insufficient line flushing after application, natural viral spread in the field or water dispersal whilst irrigating under windy conditions could all be contributing factors to the virus's spread. All three Vivus® applications were done in less than 5 Knot winds and the lines were well flushed prior to the next irrigation. NB. The virus also spread in the field in another NPV spray trial, which was actually irrigated by dripper tube.

After applying Abbott's formula to the data, the corrected *Helicoverpa armigera* mortality in the bioassays was 65% one day after the first Vivus® application. This increased to a corrected mortality of 87% one day after the third Vivus® application (Figure 3).

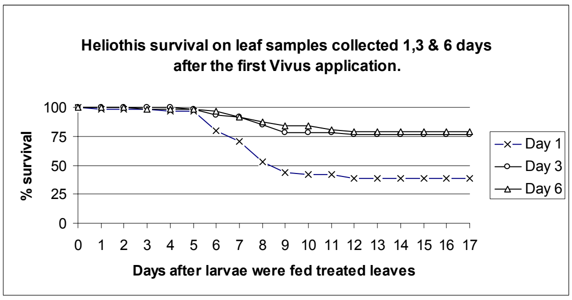
Figure 3. Corrected *Helicoverpa armigera* mortality after three weekly Vivus® applications.

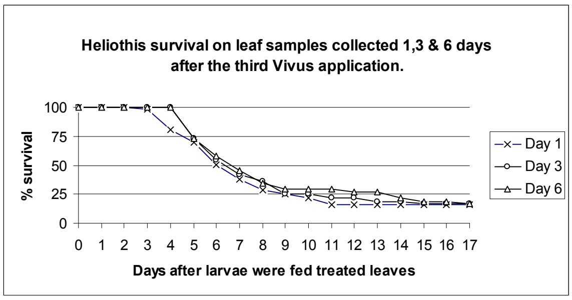


* Data corrected using Abbott's formula

After the first Vivus® application the virus's efficacy decreased over the week. The third weekly Vivus® application did not show this trend (Figure 4).

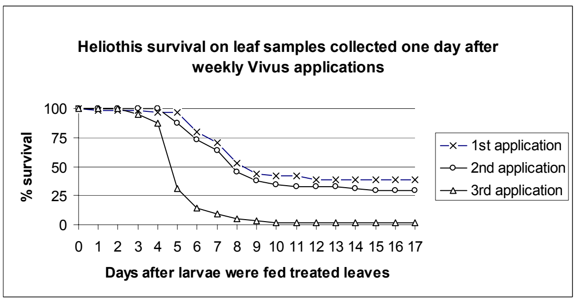
Figure 4. Survival of *Helicoverpa armigera* over a week's leaf sampling for the first and third Vivus® applications.

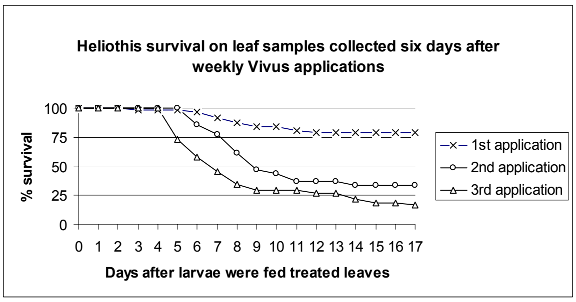




The leaves became more potent with successive weeks of Vivus® application. This effect can be seen in the bioassay results from leaf samples taken one and six days after each weekly Vivus® application (Figure 5).

Figure 5. Survival of *Helicoverpa armigera* on leaf samples taken one and six days after each weekly Vivus® application.





At harvest there were significantly more heliothis larvae found in lettuces from the control plots (Table 2, 3 and 4). Fewer larvae were found in the plots from the first application because the larvae were 5-6th instar at harvest and some may had pupated. Introducing 3rd instar heliothis larvae to the lettuce prior to the Vivus® applications meant there was a lot more wrap and heart chewing damage when compared to the lettuce under natural pressure. Firstly there were two larvae applied to each lettuce, and a proportion of the applied larvae would have sheltered into the lettuce heart and not eaten the virus. The virus also takes longer to kill larger larvae. A 15mm larva may take 6-7days to die, that is a lot of chewing damage before it dies compared to a small neonate that would die in 2-3days. Only 5% of the lettuce under natural pressure were unmarketable (heart damage) (Table 5), compared to 20-60% where larvae were introduced (Table 2, 3 and 4).

Table 2.
Harvest assessment for heliothis introduced to lettuce prior to the first Vivus® application.
Percent damage at harvest and larvae means for lettuce (n=30 per replicate)

Harvest Criteria	No chew damage	wrap damage	heart damage	heliothis larvae	looper larvae
Vivus®	22.7% a	71.0% a	28.3% a	4.8 a	1.0 a
Control	11.0% a	89.3% b	47.7% b	8.3 b	0.8 a

NB.Means with the same subscript are not significantly different at the 5% level by paired t-test.

Table 3.
Harvest assessment for heliothis introduced to lettuce prior to the second Vivus® application.
Percent damage at harvest and larvae means for lettuce (n=30 per replicate)

Harvest Criteria	No chew damage	wrap damage	heart damage	heliothis larvae	looper larvae
Vivus®	16.7% a	45.0% a	64.3% a	15.0 a	0.8 a
Control	7.7% b	76.7% b	84.3% a	23.5 b	0.5 a

NB.Means the same subscript are not significantly different at the 5% level by paired t-test.

Table 4.
Harvest assessment for heliothis introduced to lettuce prior to the third Vivus® application.
Percent damage at harvest and larvae means for lettuce (n=30 per replicate)

Harvest Criteria	No chew damage	wrap damage	heart damage	heliothis larvae	looper larvae
Vivus®	39.3% a	41.0% a	22.7% a	6.8 a	1.5 a
Control	18.3% a	70.0% b	66.7% b	28.5 b	1.3 a

NB.Means with the same subscript are not significantly different at the 5% level by paired t-test.

Table 5. Harvest assessment for lettuce that were under natural heliothis pressure.
Percent damage at harvest and larvae means for lettuce (n=30 per replicate)

Harvest Criteria	No chew damage	wrap damage	heart damage	heliothis larvae	looper larvae
Vivus®	76.7% a	18.3% a	5.0% a	1.0 a	0.0 a
Control	33.3% b	61.7% b	39.3% b	3.0 a	0.8 a

NB.Means with the same subscript are not significantly different at the 5% level by paired t-test.

Data from pheromone pot traps indicated that Helicoverpa punctigera was the main heliothis moth species causing the natural heliothis pressure (Table 6). A very low proportion of the weekly moth sample was H. armigera.

Table 6 Weekly moth catch of Helicoverpa armigera and H. punctigera.

Sample date	*H.armigera*	*H.punctigera*
22-Sep	2	896
29-Sep	2	240
5-Oct	1	115
12-Oct	1	32
19-Oct	5	13

Conclusion

From this trial, it would appear that applying Vivus® through the sprinkler irrigation system is an effective control method for Helicoverpa spp. in lettuce. The calibration (dye test) of the irrigation system is a most important component in the success of this caterpillar control method. Both Vivus® and Gemstar® are biological insectides and environmental factors can affect their efficacy.

Vivus® is highly specific to Helicoverpa spp and does not impact other organisms. This makes it ideally suited to Integrated Pest Management (IPM) as beneficial insects are unharmed by NPV. However this specificity of the virus means caterpillars like Loopers, Chrysodeixis spp. and cutworm, Agrotis spp. may still be a problem. Regular crop monitoring is recommended as a foundation for all IPM systems.

Acknowledgements

Thanks to Alan Boulton, Andrew Watson and Tony Napier for assisting with bed preparation and planting the lettuce. Thanks to Laura Weckett for assisting with the harvest assessment. Thanks to Ag Biotech Australia for the Vivus®. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Heliothis NPV spray efficacy trial, Spring 2004 (Yanco, NSW)

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NSW DPI, National Vegetable Industry Centre, Yanco NSW 2703

Introduction

The aim of this trial was to obtain efficacy data on heliothis nuclear polyhedrosis virus (NPV) when applied with a spray boom for controlling *Helicoverpa spp*. in lettuce. NPV is well suited to integrated pest management because the virus is highly specific to *Helicoverpa spp*. and has no effect on beneficial insects. Vivus® was the NPV product used in this trial. This trial was done in hot and dry conditions, to test the efficacy of Vivus® outside the virus's optimum environmental conditions of humid weather at temperatures of 25°C – 35°C.

Materials and Methods

Design

A replicated small plot trial was set up at the Yanco Agricultural Institute, Yanco NSW 2703. The trial site had a sandy loam soil type. 'Target' variety lettuces were planted as seedlings on the 18th of October 2004. Lettuces were planted 30cm apart within the row. The bed centres were at 1.5m spacing and two rows of lettuce were planted on each bed, 50cm apart. The planted trial area was 0.2ha.

The following three treatments were replicated five times:

1. 750ml/ha Vivus® [2 x 10^9 polyhedral occlusion bodies of the nuclear polyhedrosis virus of *Helicoverpa zea* per millilitre]; Ag Biotech Australia
2. 400ml/ha Success® [Spinosyn 120g/L]; Dow
3. Control [water]

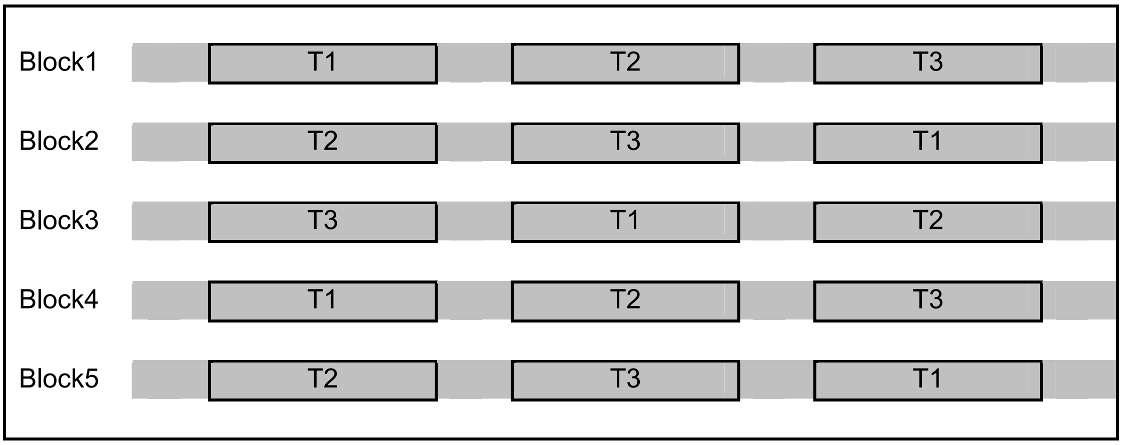
Vivus® is a biological insecticide and thorough leaf coverage is required because a heliothis caterpillar has to ingest the virus to be infected. To improve leaf coverage, all treatments were applied with 4ml of Agral®, (a non ionic surfactant), per 20L of water.

The spray treatments were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet® TXVK-6 hollow cone nozzles delivering 600L/ha of water.

The first spray application was made in the evening on November 15th, when the lettuce were at an early hearting stage. Ideally the spray treatments would have been applied a week earlier, just prior to hearting but adverse weather conditions prevented their application. The treatments were applied weekly, early morning on Tuesday 23rd November and also early morning on Tuesday 30th November. Treatments were applied a total of three times, (weekly for three weeks).

The treatments were arranged randomly into five blocks and each plot consisted of 20m of lettuce bed (Figure 1). There was a 3m buffer, (two beds of lettuce) between each block. A one bed buffer of lettuce was on the trials edge and there was 5m buffer between plots within a block.

Figure 1. Diagram of trial plots



The lettuces were irrigated with overhead sprinklers until they were at an early rosette growth stage. Subsurface drip irrigation was then used to irrigate the lettuce for the remaining duration of the trial. NPV works best in humid conditions at temperatures of 25°C – 35°C. The subsurface drip irrigation was chosen so that humidity in the trial area would be deliberately low, to test the efficacy of the virus outside optimum environmental conditions. A Tinytag® data logger was installed in a plant row, between lettuces, at about crop height. The logger recorded temperature and humidity data every 30 minutes.

Monitoring

The trial site as a whole was monitored weekly to a protocol until early hearting. Heliothis larvae pressure was moderate so a portion of each plot was spiked with reared *Helicoverpa armigera* larvae. Prior to the first spray application, thirty five lettuces were flagged in each plot and two 3rd instar larvae were placed on each lettuce using a fine brush. Prior to the second spray, larvae were also added to a different set of thirty five lettuces in each plot. There were about 65 lettuces in each plot remaining that could be assessed as natural pressure. Pheromone pot traps were used to monitor *Helicoverpa armigera* and *Helicoverpa punctigera* moth flights over the trial period.

Bioassays

Each week leaf samples were taken 1 day and 7 days after the first and second spray treatments. Leaf samples were taken 1, 3 and 7 days after the third spray treatment. All leaf samples were taken from the natural pressure portion of each plot. Eight leaves were randomly sampled from each plot. The youngest fully expanded leaf was collected for the first bioassay, whereas a wrapper leaf was used for the remaining bioassays. To prevent sample contamination leaves were collected from all of the control and Success® plots before the Vivus® plots were sampled. The sampled leaves from each plot were sealed in labelled bags and placed in an esky for transport to the laboratory.

The bioassays were done in C-D International Bio-RT-32 rearing trays. The work area, leaf cutting vials, tools and brushes were treated with cavicide®, hospital grade disinfectant / decontaminant cleaner after each use. Bioassays from all control and Success® plots were done before the Vivus® plot bioassays.

In each bioassay two 2.5cm lettuce leaf discs were placed with a 2nd instar *Helicoverpa armigera* larvae. Each leaf had four leaf discs randomly cut from them. When all cells had one larva and two leaf discs, tray covers were stuck on top to prevent larvae escaping. The trays were then stored in a controlled temperature room at 27°C set at 14L:10D photoperiod. The larvae were checked daily. When a larva had eaten all of the lettuce in a cell, it was fed a diet cube. The heliothis diet used was based on soybean flour, wheat germ and brewers yeast (ref?). Daily records kept for each larva / cell included the date diet was fed, the date a larva died or the date a larva pupated.

Harvest assessment

The lettuces were mature and a harvest assessment started on 9th of December, 52 days after transplanting. For the harvest assessment each lettuce was scored as having wrap damage, heart damage or no-chewing symptom. Lettuce were then cut and visually inspected for the presence of heliothis and looper larvae. The size and number of larvae was recorded. Any dead larvae that were black and oozing were classed as having died from virus infection and were also recorded as such. Thirty lettuces from each plot were assessed from first spiking, second spiking and natural pressure portion of each plot. A total of sixty lettuces were scored from the natural pressure section in each plot for caterpillar chewing damage.

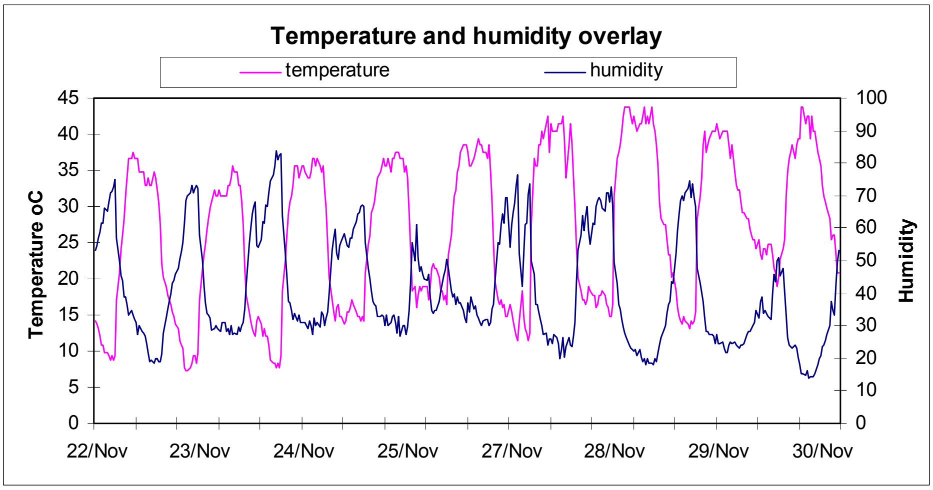
Data analysis

The total larvae deaths from each bioassay and the harvest data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

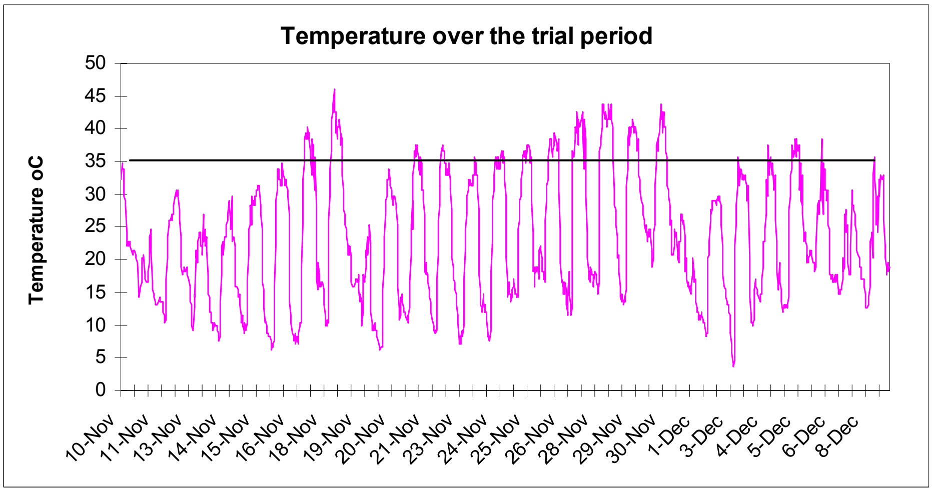
The spray treatments were applied weekly over a period of three weeks starting from when the plants were at an early hearting stage of development. During this time the days were hot and dry. During the day the temperature increased and the humidity would drop to low levels. At night the temperatures would decrease and humidity increased (Figure 2).

Figure 2. Temperature and humidity for the week after the second spray application



These typical summer weather patterns provided environmental conditions that were not the optimum environmental conditions for a biological insecticide like NPV. Ultra violet light levels were high and in 17 of the 24 days that comprised the effective chemical trial period the maximum daily temperature was over 35°C (Figure 3).

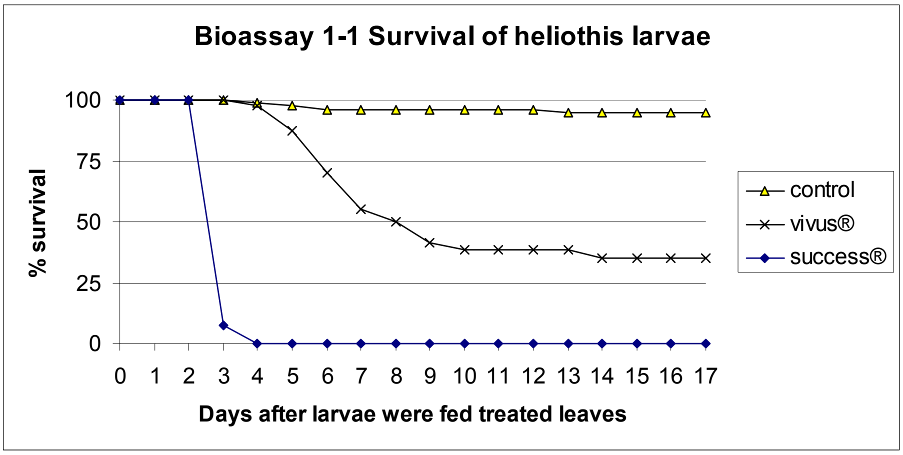
Figure 3. Temperature data during the spray period of the trial



Pot trap catches showed very little moth activity. Traps were emptied weekly between the 26th October and 3rd December. Five moths were the most caught in any one week, with both *Helicoverpa armigera* and *Helicoverpa punctigera* present. Contrary to the low pressure as indicated by the traps, at harvest only 30% of the lettuces from the natural pressure portion of the control plots were marketable.

In most bioassays, the control larvae fed with the artifical diet started feeding a day earlier than the larvae that were fed Vivus® treated leaf discs. On average it took 4 days for larvae to consume the two Vivus® treated leaf discs. NPV infection appears to reduce a larvae's appetite. Larvae that were fed Success® treated leaf discs ceased feeding immediately and died after 3 days (Figure 4). Diet was generally not needed for the Success® bioassays. Peak control from Vivus® was obtained between 4 and 9 days after the larvae were fed leaf discs (Figure 4).

Figure 4. Bioassay data from leaf samples taken 1 day after the 1st spray application



The bioassays showed that the efficacy of a single Vivus® or Success® application reduced over time. The time it took larvae to die also increased. For the 400ml/ha Success® treatment, 100% of larvae died 3 days after being fed leaf discs that were sampled 1 day after the spray application (Figure 5). Samples taken from the Success® treatment 3 days after the application killed 100% of the larvae after 7 days (Figure 6). Leaf discs taken from same Success® treated plots 7 days after the application only killed 50% of the bioassay larvae after 10 days (Figure 7). Degradation by ultra violet light is the most likely cause because there was no rainfall between the sampling dates. A single application of Vivus® also showed a similar reduction of efficacy as the days after application increased (Figure 5, 6 and 7).

Figure 5. Bioassay data from leaf samples taken 1 day after the 3rd spray application

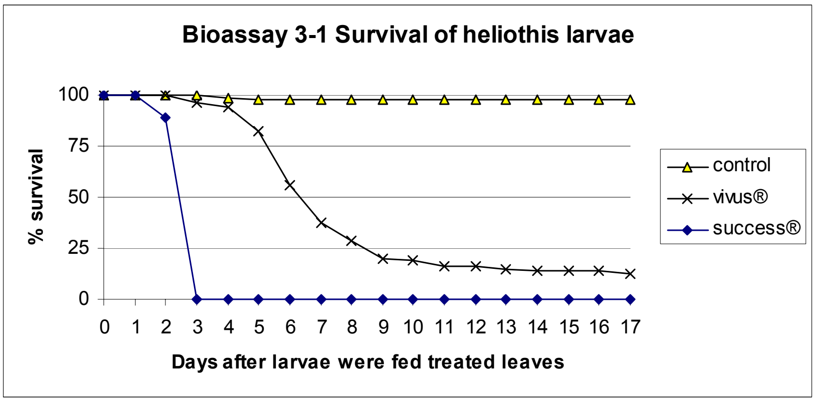


Figure 6. Bioassay data from leaf samples taken 3 days after the 3rd spray application

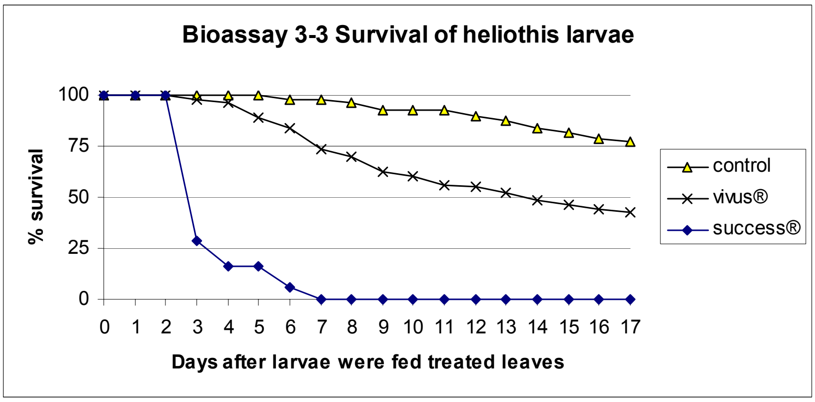
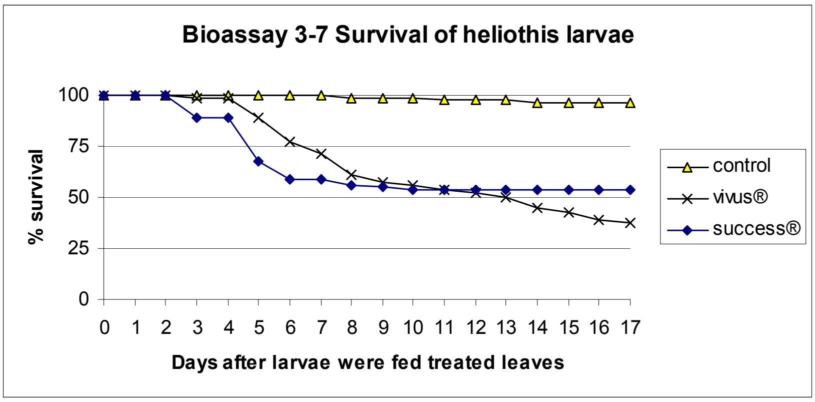
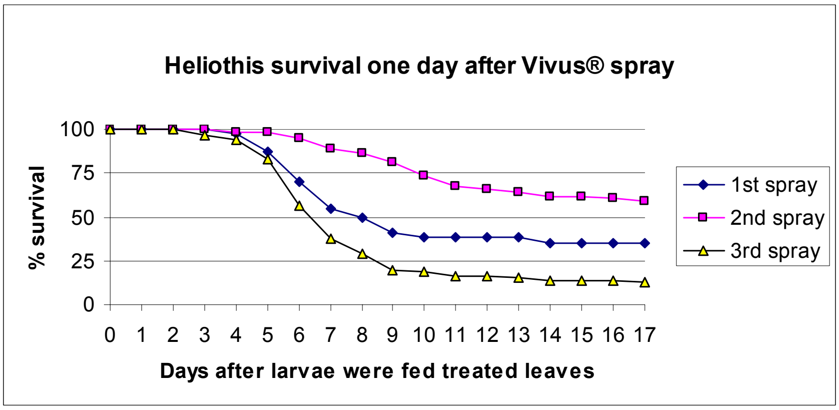


Figure 7. Bioassay data from leaf samples taken 7 days after the 3rd spray application



The spray treatments were applied three times at a weekly interval. The efficacy of Vivus® increased from the first spray to the third spray but not from the first spray to the second spray (Figure 8). The unexpected increase of heliothis survival after the second spray was probably because the Agral® wetting agent was not added to the spray mixes in the second spray. As Vivus® has to be ingested, good spray coverage is important and application with a non ionic wetting agent is recommended. Unfortunatly only leaves from the Vivus® and the control plots were bioassayed in the second week and a similar reduction of efficacy was not tested for in the Success® treatment.

Figure 8. Bioassay data from leaf samples taken 1 day after all spray applications



The bioassay data showed that Success® gave 100% mortality of *Helicoverpa armigera* from leaf samples taken 1 day after a spray application. This mortality reduced to 80% 3 days after the spray and to 47% 7 days after a spray (Table 1).

Leaf samples taken 7 days after the 1st spray (W1-D7) were frozen and the bioassays were contaminated, with most larvae dying with NPV virus symptoms. The bioassay done 1 day after the second spray was also contaminated (W2-D1). Data from these two bioassays should be disregarded.

Table 1. Percentage mortality of *Helicoverpa armigera* larvae from lettuce bioassays
% mortality (n=16 per replicate, W2-D1* n=32)

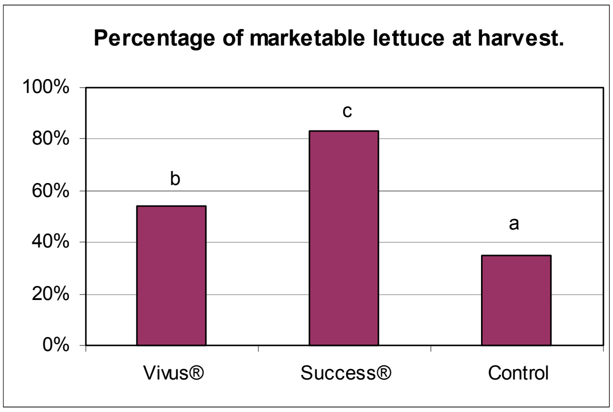
Treatment	W1-D1	W1-D7	W2-D1*	W2-D7	W3-D1	W3-D3	W3-D7
Vivus®	65.0 b	87.5 a	41.3 a	16.3 ab	87.5 b	57.5 ab	62.5 b
Success®	100.0 c	86.3 a		35.0 b	100.0 c	80.0 b	47.5 b
control	5.0 a	97.5 a	71.3 a	7.5 a	0.0 a	23.8 a	3.8 a

NB. Means with the same subscript are not significantly different at the 5% level.
W1-D1= week 1 day1 (1st spray application and leaf samples taken 1 day after spray)

Success® showed significantly greater efficacy than Vivus® in all bioassays done 1 day after the spray. Vivus® gave significant *Helicoverpa* mortality in bioassays done 1 day after the spray. Vivus® was generally not significantly different to the control in samples taken 3 and 7 days after the spray application. However Vivus® did show significant efficacy in the last bioassay for the trial period, 7 days after the 3rd spray. It is disappointing that bioassays from W1D7 and W2-D1 failed as data from these samples would have given a clearer indication of the performance of Vivus®. The fact that wetting agent was left out of the second spray further complicates the comparison of treatments between weeks.

The bioassay data was useful to determine the strength of a treatments efficacy. The harvest data provides a true indication of the efficacy of Vivus® for *Helicoverpa* control in lettuce under hot and dry weather conditions. In the natural pressure section of the plots, 54% of the Vivus® sprayed lettuces were marketable (Figure 9). This compared to 83% in from the Success® plots and 35% in the control plots.

Figure 9. Percentage of marketable lettuce from the natural pressure section of plots (n=60 per replicate)



NB. Means with the same subscript are not significantly different at the 5% level.

Of the lettuces from the natural pressure section, Success® had significantly less heliothis larvae than the control, 1 larva in 30 lettuces compared to 6 in 30 lettuces (Table 2). There was actually no significant difference in larval numbers between Success® and Vivus®. There were significant differences between all treatments in the percentage of lettuce scored to have heart damage and no chewing damage.

Table 2. Harvest assessment of lettuce that was under natural heliothis pressure.
Percent damage at harvest and larvae means for lettuce (n=30 per replicate)

Treatment	No chew damage	wrap damage	heart damage	heliothis larvae
Vivus®	46.7% b	2.7% a	52.0% b	3.0 ab
Success®	81.3% c	0.0% a	18.7% a	1.0 a
Control	29.3% a	3.3% a	68.0% c	6.0 b

NB. Means with the same subscript are not significantly different at the 5% level.

Prior to the first spray application, two 3rd instar *Helicoverpa armigera* larvae each were introduced to 30 lettuces in each plot. The harvest assessment in these lettuces, like the natural pressure, showed significant differences between all treatments in the percentage of lettuce scored to have heart damage and no chewing damage (Table 3). The Success® plots had significantly less larvae in the lettuce than the control, 1.2 to 8.0 respectively. The

Vivus® had 4.8 larvae per plot and was neither significantly different to Success® or the control treatments. None of the lettuce in the Success® plots had wrap damage, whilst 8.7% of the lettuces from the Vivus® plots showed wrapper leaf chewing damage, however this difference was not significant at a 5% level.

Table 3. Harvest assessment of lettuce with heliothis applied prior to the 1st spray.
Percent damage at harvest and larvae means for lettuce (n=30 per replicate)

Treatment	No chew damage	wrap damage	heart damage	heliothis larvae
Vivus®	52.0% b	8.7% ab	38.7% b	4.8 ab
Success®	92.0% c	0.0% a	8.0% a	1.2 a
Control	22.0% a	19.3% b	65.3% c	8.0 b

NB. Means with the same subscript are not significantly different at the 5% level.

Prior to the second spray application two 3rd instar *Helicoverpa armigera* larvae each were introduced to a second subset of 30 lettuces in each plot. Harvest assessment data from these lettuces indicates a significant difference between all treatments in the numbers of heliothis larvae found in the cut lettuces. The Success® plots had the lowest larval numbers with an average of 0.2 larvae in 30 lettuce. Vivus® plots had a mean of 5.4 larvae in 30 lettuces whereas the control plots had 9 larvae in 30 lettuces (Table 4).

Table 4. Harvest assessment of lettuce with heliothis applied prior to the 2nd spray.
Percent damage at harvest and larvae means for lettuce (n=30 per replicate)

Treatment	No chew damage	wrap damage	heart damage	heliothis larvae
Vivus®	51.3% a	13.3% b	33.3% b	5.4 b
Success®	94.0% b	0.0% a	4.7% a	0.2 a
Control	43.3% a	5.3% a	50.0% c	9.0 c

NB. Means with the same subscript are not significantly different at the 5% level.

Each lettuce plot was split into three sections, 1st *Helicoverpa* spiking, 2nd *Helicoverpa* spiking and natural *Helicoverpa* pressure. It is interesting that the lettuces from the natural *Helicoverpa* pressure section had the greatest amount of heart damage in all three treatments (Table 2, 3 and 4). Adding two additional laboratory reared *Helicoverpa armigera* to each lettuce did not increase the heart damage. You would assume a biological insecticide like Vivus® would show the greatest efficacy on small larvae, especially neonates.

Conclusion

When used alone under extreme environmental conditions, like hot dry summers in southern NSW, a nuclear polyhedrosis virus based biological insecticide like Vivus® would struggle to give commercially acceptable efficacy. In this trial the Vivus® treatment yielded 54% marketable lettuce compared to 83% marketable lettuce in the Success® treatment. It appeared that the efficacy of both Success® and Vivus® is reduced by ultraviolet light. From this trial it is recommended that when using Success® for heliothis control in lettuce during summer type weather conditions, that the higher label rate is used.

Acknowledgements

Thanks to Alan Boulton, Andrew Watson and Tony Napier for assisting with bed preparation and planting the lettuce. Laura Weckett assisted with the harvest assessment and some bioassay work. Thanks to Ag Biotech Australia for supplying Vivus®. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Pot Trial Reports

Particle film efficacy trial, Winter 2002 (Yanco, NSW)

Andrew Creek, Sandra McDougall, and Jianhua Mo
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Introduction

The aim of this trial was to assess the efficacy of Surround® to protect lettuce plants against aphid infestation. Surround® is a kaolin clay based product that covers plant surfaces with a white protective film. The particle film is meant to act as an insect pest deterrent. Thorough coverage of the plant's foliage is required to make the feeding site unrecognisable.

Materials and Methods

On the 13th August 2002, a lettuce pot trial was set up in a polyhouse at the Yanco Agricultural Institute, Yanco NSW 2703. The two treatments in the trial were the particle film, (Surround®) and the control. The potted lettuces used in the trial were at a pre-hearting stage of development. There were no aphids present on either the particle film or the control plants. The pots were labelled with their treatment and numbered from 1 to 24. The particle film potted lettuces were sprayed outside the polyhouse with 50g/L of Surround® using a 5L hand operated pressure sprayer. Care was taken to thoroughly cover the foliage. When the film had dried, the pots were then moved back into the poly house and arranged as shown in (Figure 1), with only a 5cm gap between plants.

Pre-hearting lettuce plants with established aphid colonies were numbered and scored for the aphids present. The scoring was as follows:

0 = absent
1 = light < 10 aphids
2 = moderate 10 – 30 aphids
3 = heavy > 30 aphids

Sixty of the plants with scores of 2 and 3 were placed in a formation around the particle film treated lettuce and the control lettuce so as not to bias either treatment with greater aphid pressure (Figure 1).

Figure 1. Diagram of trial plots

x	x	x	x	x	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x
x	p	c	p	c	p	c	p	c	p	c	p	c	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x
x	c	p	c	p	c	p	c	p	c	p	c	p	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x
x	p	c	p	c	p	c	p	c	p	c	p	c	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x
x	c	p	c	p	c	p	c	p	c	p	c	p	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x

Key: x = infested lettuce plant, p = partical film, c = control

The lettuces from both treatments were monitored for both juvenile and adult numbers 7, 14 and 21 days after the trials establishment. Aphid numbers from lettuce wrap leaves and heart leaves was recorded separately. Juvenile aphids in the heart were scored 21 days after the trials establishment because their numbers were so great.

The juvenile aphid scoring was as follows:

0 = 1 – 20 aphids
1 = 20 – 50 aphids
2 = 50 – 75 aphids
3 = 75 - 100 aphids

Data from coded scores were analysed with Wilcoxon rank-sum test. Uncoded count data were analysed with Welch's modified t-test (assuming unequal variances).

Results and Discussion

Under the high aphid pressure in the trial, the mineral-based particle film did not inhibit aphids from infesting the lettuce. There was no significant difference between treatments 7, 14, and 21 days after the trials establishment (Table 1, 2, and 3). At day 7, there was a mean of only 1 adult and 1 juvenile aphid on each lettuce. By day 14 this had increased a mean of 2 adults and 6 juvenile aphids on the wrap leaves. There were greater numbers of juvenile and winged aphids in the heart leaves of both treatments.

Strangely, in this trial, the *Uroleucon sonchi* aphids preferred to establish on the newer outer heart lettuce leaves. Twenty-one days after the trials establishment there were between 75 and 100 aphids in some lettuce, however, there was still no significant difference in the numbers of aphids in both the wrap and heart leaves between the control and the Surround® treated plants.

Table 1. Mean number of aphids per lettuce 7 days after trial establishment

treatment	Juvenile (Wrap)	Juvenile* (Heart)	Adult (Wrap)	Adult (Heart)
Surround®	1.5a		1.0a	
Control	0.9a		1.3a	

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Table 2. Mean number of aphids per lettuce 14 days after trial establishment

treatment	Juvenile (Wrap)	Juvenile (Heart)	Adult (Wrap)	Adult (Heart)
Surround®	6.9a	21.5a	2.3 b	3.7a
Control	5.0a	25.2a	1.4a	3.1a

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Table 3. Mean number of aphids per lettuce 21 days after trial establishment

treatment	Juvenile (Wrap)	Juvenile (Heart)	Adult (Wrap)	Adult (Heart)
Surround®	5.9a	1.54*a	1.5a	8.8a
Control	3.5a	1.50*a	1.5a	9.5a

NB. Means within each column with the same subscript are not significantly different at the 5% level.
* Juvenile aphids in the heart were scored as described in the materials and methods.

Conclusion

Spraying pre-heart lettuce plants with 50g/L of Surround® , a clay particle film, did not delay or prevent *Uroleucon sonchi* aphids from establishing colonies on the lettuce.

Acknowledgements

This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Aphid insecticide efficacy trial, Spring 2002

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Introduction

The aim of this investigation was to evaluate the efficacy of Natrasoap®, Azamax®, BioPest Parrifin Oil ® and Calypso® for aphid control in lettuce. The main aphid species used in the trial was brown sowthistle aphid (*Uroleucon sonchi*). Efficacy data was also collected on green peach aphid (*Myzus persicae*).

Materials and Methods

A replicated pot trial was established in a polyhouse at the Yanco Agricultural Institute on 3rd of September 2002. Lettuce seedlings of the cultivar "Target" were planted in 1-L pots filled with mixed loam. A week after transplanting brown sowthistle aphids (*Uroleucon sonchi*) and green peach aphids (*Myzus persicae*) were introduced to the lettuces. The lettuce grew to an early hearting stage with the developing aphid colonies prior to the trial commencement.

The number of aphids on each plant was recorded at 1 day before the application of the treatments. To test differences in the insecticide mode's of action, brown sowthistle aphids were recorded as follows: juvenile (wrap), adult (wrap), juvenile (heart) and adult (heart). Green peach aphid numbers were lower and were recorded as a total per plot.

The treatments were:

1. 20 ml/L Natrasoap® [285g/L potassium salts of fatty acids]; Agrobest + 1 ml/L Agral® [600g/L non-ionic organic surfactant]; Syngenta
2. 4ml/L Azamax® [Neem] + 5ml/L Eco-oil® [850g/L emulsifiable botanical oils]; Organic Crop Protectants
3. 10ml/L BioPest Parrifin Oil® [815g/L parrifinic oil]; Sacoa
4. 0.30ml/L Calypso® [480g/L thiacloprid]; Bayer
5. 0.75 ml/L Dimethoate® [400g/L dimethoate]; Nufarm
6. Control (water)

Dimethoate was used as the industry standard. Application of the treatments was made with a 14-L Silvan® backpack sprayer (nozzle: XR Teejet 11003 VK). The plants were sprayed till run-off.

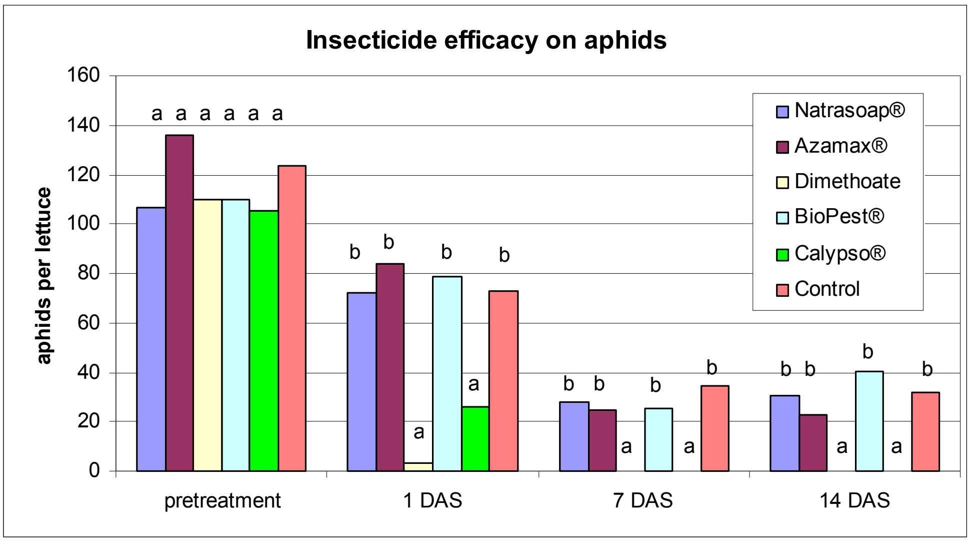
The trial was designed as 5 x 6 randomised complete blocks with four potted lettuce plants in each plot. The plots consisted of a 4-m section of lettuce bed totalling 30 plants. The number of aphids on each plant was recorded at 1, 7, and 14 days after the spray (DAS).

Differences in the number of aphids among the treatments were analysed with ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's New Multiple Range Test.

Results and Discussion

Before the spray there were no significant differences in the number of aphids among the six treatments (P > 0.05). In each of the three post-treatment counts, the number of aphids on dimethoate and Calypso® treated plants were significantly lower than that in the control (P < 0.05). Dimethoate reduced the numbers of aphids per lettuce by 97% at 1 DAS and completely by 7 DAS. Calypso® reduced the aphids by 75.7% at 1 DAS and 99.7% and 99.9% at 7 and 14 DAS respectively (Figure 1). There was however no significant difference between these two treatments (P > 0.05).

Figure 1. Mean number of aphids per lettuce before and after the insecticide treatments.



NB. Means with the same subscript within a period are not significantly different at the 5% level

The other three insecticides did not result in significant reductions of aphid numbers as compared to the control in any of the three post-treatment counts (P > 0.05). This was also the case for the individual data of *Uroleucon sonchi* counts for both the adult and juvenile aphids on the wrap leaves and in the heart. There was no significant difference between all six treatments for *Myzus persicae* due to low green peach aphid numbers.

Conclusion

Calypso® appears to be an effective foliar applied insecticide against aphids in lettuce. Further trials are needed to verify this effectiveness in the field. Natrasoap®, Azamax® and BioPest Parrifin Oil ® did not show any significant efficacy against aphids in lettuce.

Acknowledgements

Thanks to Meryl Snudden for monitoring assistance and to Boomaroo nurseries for donating the lettuce seedlings. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Aphid seedling drench efficacy trial, Winter 2004 (Yanco, NSW)

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Introduction

The primary aim of this investigation was to obtain efficacy data on Actara®, Confidor® and Dimethoate® as seedling drenches for aphid control. The efficacy of Actara® applied as a banded granule was also evaluated. SilicaK® was evaluated as an organic alternative to the chemical insecticides primarily used for aphid control.

Materials and Methods

A replicated crate trial was set up in a polyhouse at the Yanco Agricultural Institute, Yanco NSW 2703. The crates used in the trial were 52-L stack and nest crates measured 645 x 413 x 276mm. The crates were filled with a “mixed loam” soil purchased from a garden centre. The raw ingredients to the “mixed loam” were cow manure, cow paunch, rice pollard, lawn clippings and sand. The ingredients were composted and turned for 12 months to produce the mixed loam product.

The trial was established on the 21st of June 2004. Seedlings of the hearting lettuce variety ‘Target’ were used in the trial. A total of six lettuces were transplanted into each crate in two rows with a spacing of 20cm between the plants. The lettuces were irrigated with T-Tape® TSX 512-20-250 drip tube. The drip tube was placed down the centres of the crates, between the lettuce rows. The trial was finished on the 20th of September 2004, when the Actara® and Confidor® treatments were a week past maturity.

Seven treatments were replicated five times. The treatments were as follows:

i. 27g/1000 plants Actara® [Thiomethoxam 25WG]; Syngenta, (cell drench)
ii. 27g/1000 plants Actara® [Thiomethoxam 25WG]; Syngenta, (granule band)
iii. 55ml/1000 plants Confidor® [Imidacloprid 200SC]; Bayer, (cell drench)
iv. 71ml/1000 plants Dimethoate®, [Dimethoate 400g/L]; Nufarm, (cell drench)
v. 142ml/1000 plants Dimethoate® , [Dimethoate 400g/L]; Nufarm, (cell drench)
vi. 500Kg/ha (10g/crate) SilicaK®, Southern Minerals, (mixed into top 10cm of loam)
vii. Control

The cell drench treatments were applied using a Gilson® pipette, each cell receiving 3-ml of the treatment solution prior to transplanting. This was enough to wet the cells without having drainage through the bottom of the tray. The granule band of Actara® was applied at a depth 5cm below the soil surface in a narrow band under each lettuce row. A modified Gilson® pipette dispensing tip was used as a funnel to evenly distribute the granules. The SilicaK® was sprinkled evenly over each plot and mixed into the top 10cm of loam using a garden hand fork.

Each crate had six plants and was considered a plot. The treatments were arranged randomly into 5 blocks inside the poly house (Figure 1). The blocks ran north to south and were spaced 1m apart, with 0.2m between plots in each block. Tangle foot® trap coating was put on the T-Tape® between the plots to prevent aphids walking along the tape from one plot to another.

Figure 1 Diagram of trial plots

Block1	T3	T6	T2	T4	T1	T5	T7
Block2	T4	T7	T3	T5	T2	T6	T1
Block3	T1	T5	T2	T6	T4	T3	T7
Block4	T3	T2	T7	T4	T1	T5	T6
Block5	T7	T1	T6	T5	T3	T4	T2

Brown sowthistle aphids, (*Uroleucon sonchi*) were first introduced to all plots 4 days after planting. Using a fine brush, 10 to 15 aphids were introduced to each plant. All plots were monitored 7 days after planting for both winged and non-winged aphids. Aphid introductions and subsequent monitoring were repeated weekly for 13 weeks.

Aphids were recorded from all lettuce leaves in each plot up to and including 5 weeks after planting. The lettuce's had twelve leaves 6 weeks after planting and were at an early hearting stage. By then the aphid colonies were too large in the control and SilicaK® plots to be monitored for every leaf. The monitoring protocol was altered to record all the aphids in one outer leaf from the every plant in a plot. This was done until the end of the trial, 13 weeks after planting.

At the sixth week after planting, the aphids were not prolific in the Actara® and Confidor® treatments. A second data set was established for these treatments as we continued to monitor all aphids on every leaf from all plants in a plot for the duration of the trial.

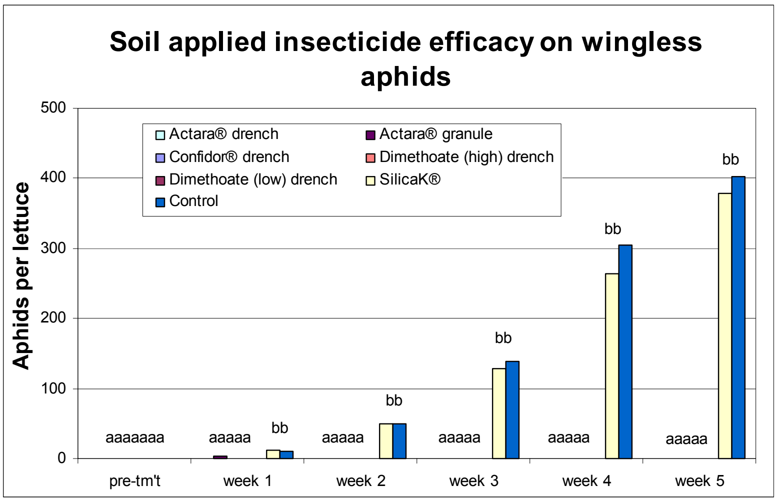
The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

Cell drenching Dimethoate® at both 142ml and 71ml per 1000 plants severely set the plants back. The Dimethoate® treated plants were not ready for harvest until 13 weeks after planting, and their hearts appeared to be smaller than the lettuce from the Actara® and Confidor® plots. Root damage from the concentrated Dimethoate® solutions may have caused the stunting and seedling set back. The higher rate caused some lettuce seedling death. The Actara® and Confidor® treated lettuce had firm hearts after 11-12 weeks. The lettuce in both the SilicaK® and control plots were stunted, disfigured and covered in honeydew, they did not have firm hearts after 13 weeks.

The incorporation of SilicaK® into the top 10cm of the soil gave no aphid control, but the rest of the chemicals worked well (Figure 2 and 3). The increase in wingless aphid numbers in both the SilicaK® and control plots showed a steep linear trend as the aphid colonies built up. Five weeks after planting the lettuces were at an early hearting stage (about 9 leaves) and both the SilicaK® and control plots had an average of close to 400 aphids per lettuce, compared to 0 in the other chemically treated plots(Figure 2).

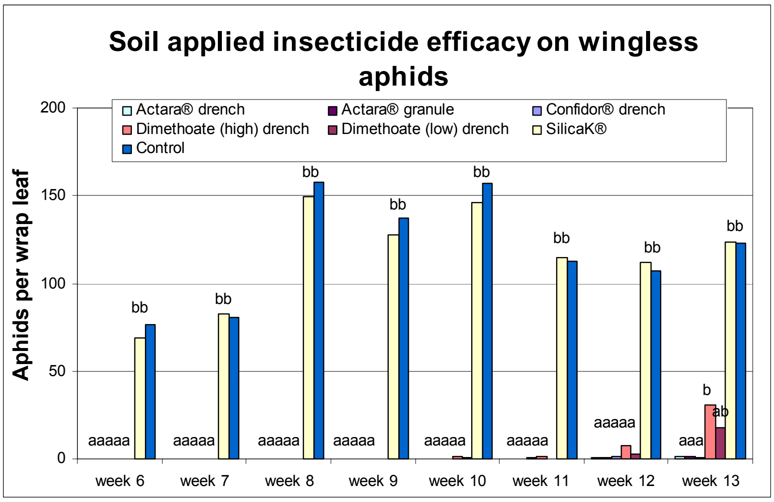
Figure 2. Weekly means for wingless aphids on lettuce plants.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

The Actara®, Confidor® and Dimethoate® treatments equally controlled wingless aphids for 12 weeks after planting. Both Dimethoate® rates showed signs of a drop in efficacy from week 10 onwards, however the decrease in efficacy was only significant for the Actara® and Confidor® treatments 13 weeks after planting (Figure 3).

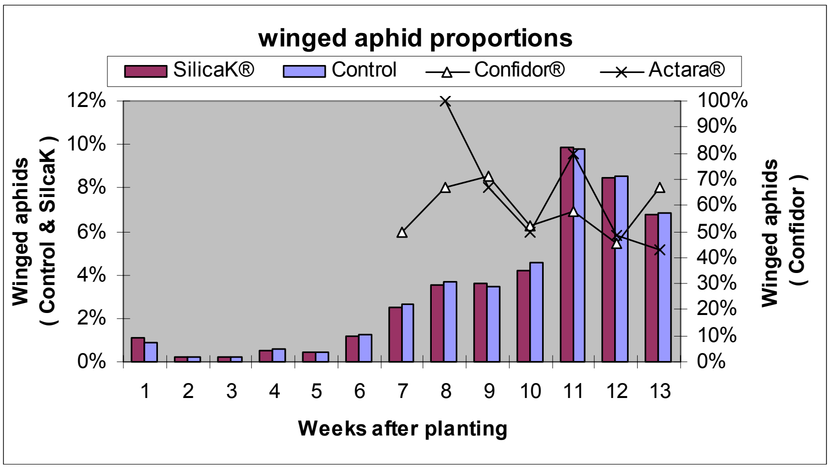
Figure 3. Weekly means for wingless aphids on lettuce outer wrap leaves.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

The aphid colonies continued to grow in the SilicaK® and control plots, reaching a plateau of 150 aphids per wrap leaf in weeks 8, 9 and 10 after planting (Figure 3). The lettuce plants were stunted, covered in honeydew and stressed. The aphid colonies actually decreased in size for the last three weeks of the trial. During this time the increasing proportion of winged aphids being produced indicates the declining food quality of the overcrowded lettuces. The proportion of winged aphids in the SilicaK® and control plots rose from 4% in week 10, to more than doubling in week 11 to 10% (Figure 4). The proportion of winged aphids in the chemically treated plots was a lot higher, varying from 40 to 100%. The higher winged proportions are explained by the fact winged aphids were migrating around the polyhouse, (ex the SilicaK® and control plots) and settling on the other plots. The large variation in the winged aphid proportion from the Confidor® and Actara® drenched plots is a factor of the very low aphid numbers in these treatments.

Figure 4. Comparisons of winged aphid proportions from different treatments.



Data for winged aphids showed the same significant trends as that for the wingless aphids. Winged Brown Sowthistle aphids did not establish colonies on any of the Actara®, Confidor® or Dimethoate® treated plots over the 13 week duration of the trial. Winged aphids established colonies immediately in the SilicaK® and control plots. There were significantly greater numbers of winged aphids for the entire duration of the trial in the SilicaK® and control plots (Table 1a and 1b). Lettuce from the SilicaK® and control plots were covered with aphids. The winged aphid population peaked after 11 weeks in the SilicaK® and control plots with 13 winged aphids per outer wrap leaf (Table 1b). For the corresponding period, the 27g/1000 plants Actara® and 55ml/1000 plants Confidor® drenches only had a mean of 0.27 and 0.90 winged aphids per outer wrap respectively.

Table 1a. Treatment means for winged aphids per lettuce.

treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6*
Actara® drench	0.03a	0.00a	0.00a	0.03a	0.00a	0.00a
Actara® granule	0.03a	0.00a	0.03a	0.00a	0.00a	0.03a
Confidor® drench	0.00a	0.00a	0.00a	0.00a	0.07a	0.00a
Dimethoate (high)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
Dimethoate (low)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
SilicaK®	0.13 b	0.10 b	0.30 b	1.27 b	1.57 b	0.80 b
Control	0.10 b	0.10 b	0.43 b	1.67 b	1.63 b	0.60 b

* Week 6 is treatment means for winged aphids from 1 outer wrapper leaf.
NB. Means within each column with the same subscript are not significantly different at the 5% level.

Table 1b. Treatment means for winged aphids from one wrapper leaf per lettuce.

treatment	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
Actara® drench	0.00a	0.03a	0.13a	0.27a	0.27a	0.60a	0.80a
Actara® granule	0.07a	0.00a	0.13a	0.27a	0.20a	0.50a	1.20ab
Confidor® drench	0.10a	0.40a	0.33a	0.37a	0.90a	1.17a	1.53ab
Dimethoate (high)	0.00a	0.00a	0.00a	0.30a	0.67a	1.47a	2.63 b
Dimethoate (low)	0.00a	0.00a	0.00a	0.13a	0.10a	1.00a	2.63 b
SilicaK®	2.13 b	5.43 b	4.83 b	6.40 b	12.60 b	10.37 b	8.97 c
Control	3.00 c	6.17 b	4.83 b	7.10 b	13.13 b	10.60 b	8.33 c

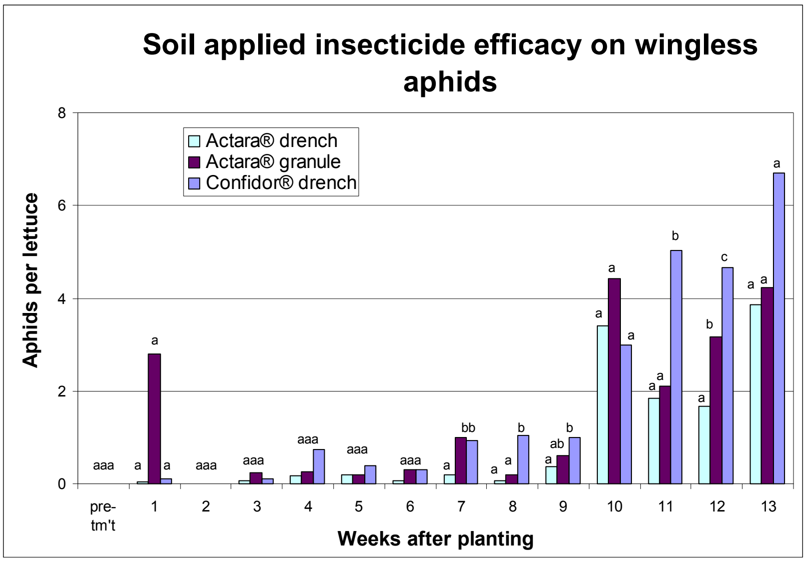
NB. Means within each column with the same subscript are not significantly different at the 5% level.

The monitoring protocol was altered 6 weeks after planting for greater efficiency because of the large sized aphid colonies in the SilicaK® and control treatments. The protocol changed from counting aphids on every leaf per plant to only counting the aphids from only one outer leaf per plant. Naturally this reduced the accuracy of the data collected on the treatments with few aphids. Hence for the second data set for the Actara® and Confidor® treatments every outer lettuce leaf was monitored for the entire duration of the trial.

The data collected one week after planting on wingless aphids indicated aphid control was not immediate in the granule band application (Figure5). It took about a week for the seedling roots to grow out into the chemical band and take up the chemical. At weeks 7 and 12 after planting, the granule band application of Actara® had significantly more aphids than the seedling drench of Actara®. This suggests that a granule band application of Actara® is not as efficient as direct seedling drenches.

Seven weeks after planting, the Confidor® cell drench had significantly more wingless aphids than the Actara® cell drench, this occurred for 5 of the 7 remaining monitoring occasions. This suggests that Confidor® applied at 55ml per 1000 plants was losing efficacy sooner than Actara® applied at 27g per 1000 plants. It has to be noted that Confidor® applied at 55ml per 1000 plants gave ample aphid (*Uroleucon sonchi*) control to cut sufficiently clean lettuce. Actara® applied at 27g per 1000 plants may be an excessive rate.

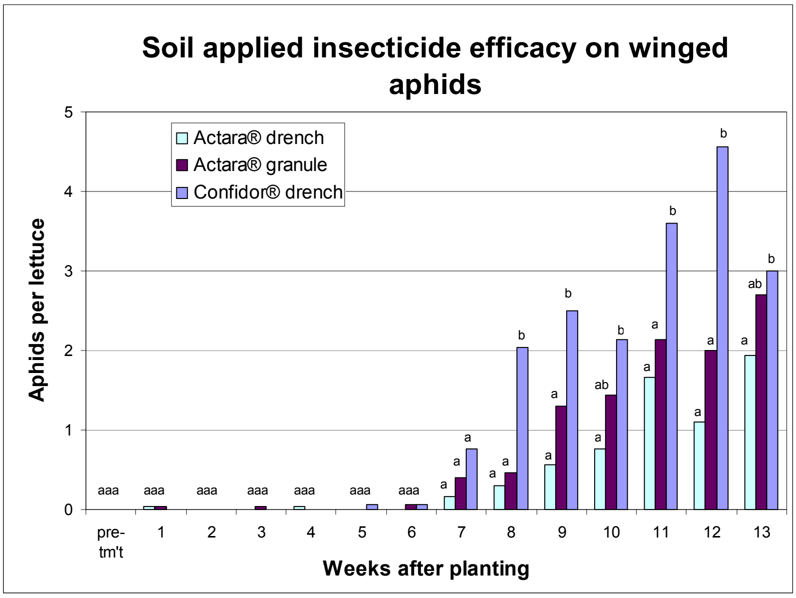
Figure 5. Wingless aphid means on lettuce plants for the Actara® & Confidor® treatments.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

From week 7 onwards, the winged aphid data indicates there was a greater number of winged aphid in the Actara® granule band when compared to the cell drench Actara® treatment, however this trend was not significant at a 5% level (Figure 6). The Confidor® treatment had significantly higher numbers of winged aphids from 8 weeks after planting to the end of the trial 13 weeks after planting.

Figure 6. Winged aphid means on lettuce plants for the Actara® & Confidor® treatments.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

Conclusion

Both the Actara® and Confidor® seedling drench treatments controlled the regularly introduced *Uroleucon sonchi* aphids for thirteen weeks. The granule Actara® treatment also controlled the aphids for thirteen weeks. The aphid control response was not immediate in the granule band application when compared to the cell drenches. Dimethoate® cell drenches of 142ml and 71ml per 1000 plants gave comparable aphid control to Actara® and Confidor®. At these rates, the chemical damage to the lettuce seedlings out weighed the aphid control gains. There is the need to testl the efficacy of lower Dimethoate® application rates to avoid lettuce damage. SilicaK® incorporated into the top 10cm of the soil gave absolutely no aphid control.

Acknowledgements

Thanks to Alan Boulton for assisting with trial establishment and Tony Napier for assisting the cleanup. Thanks to Syngenta for supplying Actara® for the trial. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Aphid soil & cell drench efficacy trial, Spring 2004 (Yanco, NSW)

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Introduction

The primary aim of this investigation was to compare the efficacy of low rates Actara® and Confidor® when applied as a seedling drench or a soil applied spray band. A previous lettuce trial proved the systemic activity of Dimethoate® when applied as a seedling drench prior to planting, however phytotoxicity was an issue. This trial also evaluates low rates of Fastac® and Dimethoate® applied as a seedling drench.

Materials and Methods

A replicated crate trial was set up in a polyhouse at the Yanco Agricultural Institute, Yanco NSW 2703. The crates used in the trial were 52-L stack and nest crates measured 645 x 413 x 276 mm. The crates were filled with a "mixed loam" soil purchased from a garden centre. The raw ingredients to the "mixed loam" were cow manure, cow paunch, rice pollard, lawn clippings and sand. The ingredients were composted and turned for 12 months to produce the mixed loam product.

The trial was established on the 21st of September 2004. Seedlings of the hearting lettuce variety 'Target' were used in the trial. A total of six lettuces were transplanted into each crate in two rows with spacing of 20cm between the plants. The lettuces were irrigated with T-Tape® TSX 512-20-250 drip tube. The drip tube was placed down the centres of the crates, between the lettuce rows. The trial was ended after 6 weeks on the 1st of November 2004 because of difficulty maintaining aphid populations. The plants were at a hearting stage at the conclusion of the trial.

Seven treatments were replicated five times. The treatments were as follows:

1. 12g/1000 plants Actara® [Thiomethoxam 25WG]; Syngenta, (cell drench)
2. 4g/100m of row Actara® [Thiomethoxam 25WG]; Syngenta, (spray band)
3. 35ml/1000 plants Confidor® [Imidacloprid 200SC]; Bayer, (cell drench)
4. 11.6ml/100m of row Confidor® [Imidacloprid 200SC]; Bayer, (spray band)
5. 11.6ml/100m of row Fastac® [Alpha-cypermethrin 100g/L]; Nufarm, (cell drench)
6. 11.6ml/100m of row Dimethoate® , [Dimethoate 400g/L]; Nufarm, (cell drench)
7. Control

The cell drench treatments were applied using a Gilson® pipette, each cell receiving 3ml of the treatment solution prior to transplanting. This was enough to wet the cells without having drainage through the bottom of the tray.

The spray band treatments were applied along the lettuce rows prior to planting, A 14-litre Silvan battery powered backpack sprayer fitted with a Hardie 10cm-wide shielded wand attachment was used to apply the chemical bands. The shielded wand was fitted with a blue Hardie 110/20 flat fan nozzle delivering 300L/ha. A 5-cm layer of cover soil was added to each crate after the chemical band had been applied, effectively burying the band below the soil surface.

After all treatments were applied, the crates were moved into the poly house and arranged randomly into 5 blocks (Figure 1). Six lettuce seedlings were then planted into each crate and were considered a plot. The blocks ran north to south and were spaced 1m apart, with 0.2m between plots in each block. Tangle foot® trap coating was put on the T-Tape® between the plots to prevent aphids walking along the tape from one plot to another.

Figure 1 Diagram of trial plots

Block1	T3	T6	T2	T4	T1	T5	T7
Block2	T4	T7	T3	T5	T2	T6	T1
Block3	T1	T5	T2	T6	T4	T3	T7
Block4	T3	T2	T7	T4	T1	T5	T6
Block5	T7	T1	T6	T5	T3	T4	T2

All plots were monitored 7 days after planting (DAP) for both winged and non-winged aphids. For the first two weeks of the trial, there was sufficient aphid pressure from the Brown sowthistle aphid (*Uroleucon sonchi*) colony in the poly house. The aphid colony was situated 10m away from the trial, in the northern end of the poly house. Winged aphids were moving throughout the polyhouse. For unknown reasons, the aphid colony died 12 days into the trial. Brown sowthistle aphids were then sourced from wild colonies living on sow thistles. Aphids were shaken from sow thistles onto a tray. A fine brush was used to transfer 10 to 15 aphids to each lettuce.

For the remaining duration of the trial, aphids were introduced on every Friday and the weekly monitoring was done three days later on Mondays. The monitoring protocol recorded all the winged and wingless aphids from all 6 lettuces in each plot. Due to time constraints, aphid introduction at 31 DAP was done without a brush and made directly by shaking the infested sow thistles. Later on this proved to be the detriment of the trial.

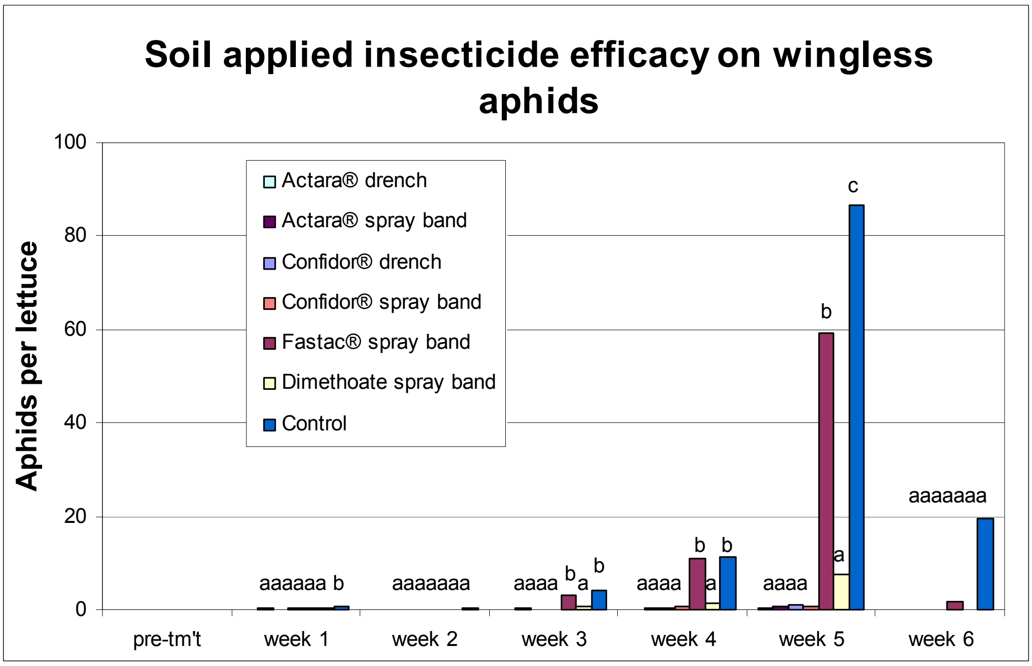
The data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

Aphid colonies were very difficult to establish throughout this trial, and aphid numbers were low when compared to previous trials, however significant differences were established between the treatments. The Tinytag® data loggers showed the temperature in the polyhouse stayed in the range of 10-25°C. Temperature extremes were not the cause of the aphid colony death during the second week of the trial. It is not known what caused this colony decline.

The data collected one week after planting for wingless aphids showed all insecticide treatments had significant efficacy compared to the control (Figure 2). However this result may be questionable because the wingless aphid numbers were low, with less than 1 wingless aphid per plant in the control. As mentioned earlier, for an unknown reason colonies were not establishing and there were not enough wingless aphids to prove any significance in efficacy between the treatments two weeks after planting.

Figure 2. Weekly means for wingless aphids on lettuce plants.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

The data for wingless aphids generally showed that in weeks 3, 4 and 5, all chemical treatments except for Fastac® showed significant efficacy compared to the control. For wingless aphid data, Fastac® was only significantly different from the control in week 5. The Actara®, Confidor® and Dimethoate® treatments equally controlled wingless aphids for the effective 5 week period of the trial. Data was variable in the sixth week and there was no significant difference between treatments, however the data did indicate the same trend as weeks 3, 4 and 5 that Actara®, Confidor® and Dimethoate® treatments were effective.

Except for the first week after planting, in the first 5 weeks there appeared to be no difference in efficacy on winged aphids between the cell drenches and the soil applied insecticide bands. Winged aphid data collected one week after planting indicated that aphid control was not immediate in the spray band applications. One week after planting the Actara® and Confidor® cell drench treatments had a mean of 2.6 and 4.4 winged aphids per plot respectively (Table 1). This compares to the spray band treatments with a mean number of winged aphid per plot ranging from 22 to 31. Aphid control may not be immediate because the seedling roots had to grow into the chemical band to uptake chemical.

In this trial all Actara® and Confidor® and Dimethoate® treatments showed similar efficacy against winged aphids. Fastac® was generally not significantly different to the control, except for weeks 4 and 5 after planting.

Table 1. Treatment means for winged aphids on 6 lettuce plants

treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Actara® drench	2.6a	0.4a	0.0a	0.2a	0.2a	0.4a
Actara® band	28.6 b	2.6 b	0.8a	0.0a	0.6ab	0.0a
Confidor® drench	4.4a	0.0a	0.0a	0.0a	0.4ab	0.0a
Confidor® band	25.4 b	1.6ab	0.2a	0.0a	0.4ab	0.0a
Fastac® drench	22.4 b	3.4 bc	4.2 bc	2.4 b	5.6 c	0.6a
Dimethoate® drench	25.8 b	1.6ab	2.2ab	1.0a	2.0 b	0.2a
Control	31.2 b	5.2 c	6.2 c	4.0 c	7.8 d	3.4 b

NB. Means within each column with the same subscript are not significantly different at the 5% level.

In a previous polyhouse trial, cell drenching Dimethoate® at 71ml per 1000 plants or greater set the plants back, with phytotoxic symptoms. The spray band of 11.6ml per 100m did not show any phytotoxic symptoms like leaf scald or plant stunting. This lower rate of Dimethoate® gave similar aphid control as the low rates of Actara® and Confidor® spray bands. At the lettuce plant spacing used in this trial, the 11.6ml/100m spray band rate equates to 23ml per 1000 plants. Further trials are needed to see whether a direct cell drench of 23ml of Dimethoate® per plant causes phytotoxicity. Further lettuce field trials should also be grown to maturity to test whether Dimethoate® at this rate losses efficacy before Actara® and Confidor® treatments.

Sourcing aphids from wild colonies introduced parasitic wasps *Aphidiidae* to the polyhouse and these added to the difficulty of establishing aphid colonies. The single time aphids were applied without a brush (31 DAP) where aphids were shaken directly from sow thistles onto the lettuce plots introduced brown lacewings (BLW) *Micromus tasmaniae* to the polyhouse. By the sixth week, there were 2 to 7 BLW per plot with a mean of 3.8 per plot. There were dead BLW recorded in all treatments except Fastac®. There was an average of 1 dead BLW per plot, however there was no significant difference between the insecticide treatments.

Predation by brown lacewings, the parsitic wasps and unknown reason for the colony decline from the second week combined to give insignificant results 6 weeks after planting. The trial was abandoned with the lettuce only half hearted.

Conclusion

The Actara®, Confidor® and Dimethoate® treatments controlled the regularly introduced *Uroleucon sonchi* aphids for up to six weeks. The efficacy of these treatments may well be longer and further field trials are needed to prove this. The lower Dimethoate® rates applied as a soil insecticide band did not show any phytotoxic effects to the lettuce plants like higher rate cell drenches in the previous trial. The efficacy of Fastac® when applied at 11.6ml/100m of row to control aphids is questionable.

For the six week duration of this trial, apart from the early stages of seedling establishment, there appears to be no significant difference in efficacy between the Actara® and Confidor® seedling drenches and their comparable soil applied spray bands. This comparison was strongly tested in this trial because the rate of active ingredient available per plant in the soil applied bands was one third less than the comparative cell drench treatments. However lettuce needs to be grown to maturity in field trials to test this comparison for a period greater than the six week duration of this trial.

Acknowledgements

Thanks to Alan Boulton for assisting with the trial establishment. Thanks to Syngenta for supplying Actara® for the trial. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Aphid soil drench efficacy trial, Winter 2005 (Yanco, NSW)

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Introduction

The primary aim of this investigation was to obtain efficacy data on Pirimor® for aphid control when it is applied as either a pre-planting soil treatment or a pre-planting seedling drench. A Confidor® pre-planting soil treatment of 25ml/100m of plant row was used as comparative treatment.

Materials and Methods

A replicated crate trial was set up in a polyhouse at the Yanco Agricultural Institute, Yanco NSW 2703. The crates used in the trial were 52-L stack and nest crates (645 x 413 x 276 mm). The crates were filled with a "mixed loam" soil purchased from a garden centre. The raw ingredients to the "mixed loam" were cow manure, cow paunch, rice pollard, lawn clippings and sand. The ingredients were composted and turned for 12 months to produce the mixed loam product.

The trial was established on the 27th of May 2005. Seedlings of the hearting lettuce variety 'Patagonia RZ' were used in the trial. A total of six lettuces were transplanted into each crate, in two rows with spacing of 20cm between the plants. The lettuces were irrigated with T-Tape® TSX 512-20-250 drip tube. The drip tube was placed down the centres of the crates, between the lettuce rows. The trial was finished on the 25th of July 2005, when the lettuces were at a 50% hearted stage.

Seven treatments were replicated five times. The treatments were as follows:

1. 22g/1000 plants (1kg/ha) Pirmor® [Pirimicarb 500g/kg]; Syngenta, (seedling drench)
2. 25ml/100m (3.3L/ha) Confidor® [Imidacloprid 200SC]; Bayer, (soil spray band)
3. 14.6g/100m (2kg/ha) Pirmor® [Pirimicarb 500g/kg]; Syngenta, (soil spray band)
4. 7.3g/100m (1kg/ha) Pirmor® [Pirimicarb 500g/kg]; Syngenta, (soil spray band)
5. 3.6g/100m (500g/ha) Pirmor® [Pirimicarb 500g/kg]; Syngenta, (soil spray band)
6. 1.8g/100m (250g/ha) Pirmor® [Pirimicarb 500g/kg]; Syngenta, (soil spray band)
7. Control

The Pirimor® seedling drench treatment was applied using a Gilson® pipette, with each cell receiving 3ml of the treatment solution prior to transplanting. This was enough to wet the cells without having drainage through the bottom of the tray.

The spray band treatments were applied along the lettuce rows prior to planting. A 14-litre Silvan battery powered backpack sprayer fitted with a 8cm-wide shielded wand attachment was used to apply the chemical bands. The shielded wand was fitted with a blue Hardie 110/20 flat fan nozzle delivering 300L/ha. A 5cm layer of cover soil was added to each crate after the chemical band had been applied, effectively burying the band below the soil surface.

After all treatments were applied, the crates were moved into the polyhouse and arranged randomly into 5 blocks (Figure 1). Six lettuce seedlings were then planted into each crate and were considered a plot. The blocks ran north to south and were spaced 1m apart, with 0.2m spacing between plots in each block. Tangle foot® trap coating was put on the T-Tape® between the plots to prevent aphids walking along the tape from one plot to another.

Figure 1 Diagram of trial plots

Block1	T3	T6	T2	T4	T1	T5	T7
Block2	T4	T7	T3	T5	T2	T6	T1
Block3	T1	T5	T2	T6	T4	T3	T7
Block4	T3	T2	T7	T4	T1	T5	T6
Block5	T7	T1	T6	T5	T3	T4	T2

Brown sowthistle aphids(*Uroleucon sonchi*) were first introduced to all plots 7 days after planting. Using a fine brush, 10 to 15 aphids were introduced to each plant. All plots were monitored 10 days after planting for both winged and non-winged aphids. The aphid introductions (Fridays) and subsequent monitoring (Mondays) was repeated weekly for the duration of the trial.

Aphids were recorded from all lettuce leaves in each plot up to and including 6 weeks after planting. By then the lettuces had twelve leaves and were at an early hearting stage. The aphid colonies were large in the control and low rate Pirimor® plots. It was not practical to monitor every leaf in these treatments so the monitoring protocol was altered to record all the aphids in one outer leaf from every plant in a plot. This was done for the remainder of the trial.

At the seventh week after planting, the aphids were not prolific in the higher rate Pirimor® and Confidor® treatments. A second data set was established for these treatments as we continued to monitor all aphids on every leaf from all plants in a plot.

The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

Pirimor® is registered in lettuce as a foliar spray for aphid control. In this trial Pirimor® controlled aphids when it was applied as either a banded spray to the soil or directly to the seedling as a drench. There appeared to be no phytotoxicity from Pirimor® when applied to the lettuce plants at these rates. The efficacy of Pirimor® was less than that of the industry standard Confidor® treatment, with aphid colonies clearly starting to establish in the highest rate Pirimor® treatments after 7 weeks.

The Pirimor® seedling drench was effective immediately, having significantly fewer of both winged and wingless aphids one week after planting when compared to all the soil applied spray band treatments (Table 1a and 2a). This is probably because for the spray band treatments the lettuce plants needed to establish roots into the chemical band before they could absorb the chemicals.

The number of winged aphids per lettuce was quite low, with the control plots generally having the most. For the first four weeks there was a significant difference in the mean number of winged aphids per lettuce between the chemical treatments ($P > 0.05$). The difference in the number of winged aphids per lettuce after week 4 was insignificant (Table 2).

Table 1a. Treatment means for winged aphids per lettuce

treatment	week 1	week 2	week 3	week 4
Pirimor® 1Kg (seedling)	0.0 a	0.0 a	0.0 a	0.1 a
Confidor® 3.3L (soil)	0.9 bc	0.1 a	0.2 a	0.1 ab
Pirimor® 2Kg (soil)	0.7 b	0.3 ab	0.5 ab	0.1 ab
Pirimor® 1Kg (soil)	1.2 c	0.9 cd	1.0 c	0.8 c
Pirimor® 500g (soil)	0.8 b	0.6 c	0.8 bc	0.7 bc
Pirimor® 250g (soil)	0.8 bc	0.6 bc	0.9 bc	0.9 c
Control	1.2 c	1.0 d	1.6 d	1.7 d

NB. Means within each column with the same subscript are not significantly different at the 5% level.

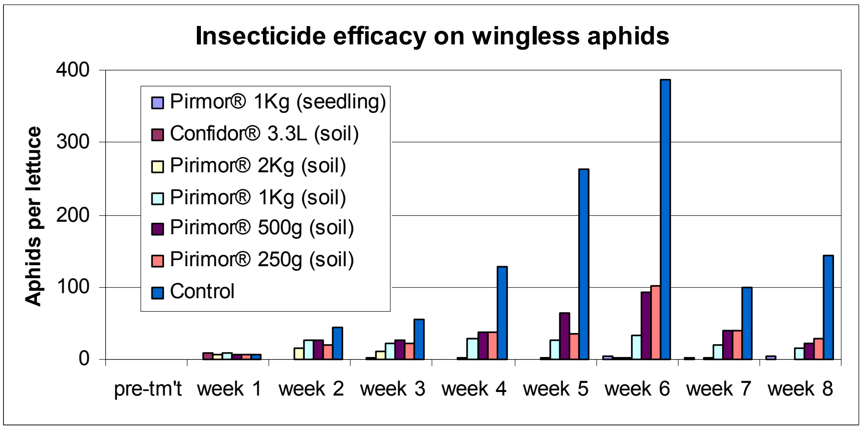
Table 1b. Treatment means for winged aphids per lettuce

treatment	week 5	week 6	week 7*	week 8*
Pirimor® 1Kg (seedling)	0.0 a	0.4 a	0.3 a	0.5 a
Confidor® 3.3L (soil)	0.1 ab	0.3 a	0.2 a	0.2 a
Pirimor® 2Kg (soil)	0.0 a	0.3 a	0.3 a	0.3 a
Pirimor® 1Kg (soil)	0.2 ab	0.7 a	0.6 a	0.5 a
Pirimor® 500g (soil)	0.3 b	1.3 a	0.7 a	0.6 a
Pirimor® 250g (soil)	0.3 ab	1.6 a	0.7 a	0.5 a
Control	0.6 c	7.7 b	3.3 b	3.1 b

* Week 7 and 8 are treatment means for wingless aphids from one outer lettuce leaf per lettuce.
NB. Means within each column with the same subscript are not significantly different at the 5% level.

Even the quarter rate of the recommended foliar Pirimor® rate of 1kg/ha showed considerable efficacy when compared to the control (Figure 2). At week six the control had almost 400 winged aphids per lettuce, this was four times more than the lowest Pirimor® rate. The aphid numbers appear to decline in all treatments for weeks 7 and 8 because only one outer lettuce leaf was monitored rather than entire lettuces. Overall the aphid colonies continued to increase in size during week 7 and 8.

Figure 2. Weekly means for wingless aphids on lettuce plants.



* Week 7 and 8 are treatment means for wingless aphids from one outer lettuce leaf per lettuce.

Pirimor® showed greater efficacy when applied as a seedling drench rather than as a soil applied spray band. A comparison of the 1kg/ha rates of Pirimor® shows that the seedling drench generally had fewer wingless aphids (Table 2a).

From week 5 after planting there was generally no significant difference between the chemical treatments in the mean number of wingless aphids per lettuce or leaf (Table 2b)

Table 2a. Treatment means for wingless aphids per lettuce

treatment	week 1	week 2	week 3	week 4
Pirimor® 1Kg (seedling)	0.0 a	0.0 a	0.0 a	0.2 a
Confidor® 3.3L (soil)	8.0 b	1.0 a	2.3 a	0.9 a
Pirimor® 2Kg (soil)	6.5 b	16.2 b	11.7 ab	3.1 ab
Pirimor® 1Kg (soil)	7.8 b	25.7 b	21.2 b	28.2 abc
Pirimor® 500g (soil)	7.0 b	26.3 b	25.5 b	38.3 c
Pirimor® 250g (soil)	6.8 b	19.2 b	23.0 b	36.7 bc
Control	7.7 b	44.2 c	55.5 c	128.7 d

NB. Means within each column with the same subscript are not significantly different at the 5% level.

Table 2b. Treatment means for wingless aphids per lettuce

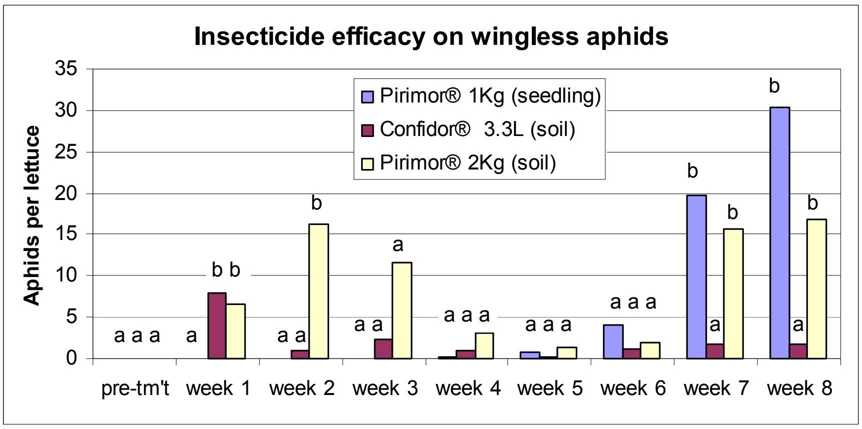
treatment	week 5	week 6	week 7*	week 8*
Pirimor® 1Kg (seedling)	0.9 a	4.1 a	2.0 a	4.1 a
Confidor® 3.3L(soil)	0.1 a	1.2 a	0.3 a	0.1 a
Pirimor® 2Kg (soil)	1.3 a	1.9 a	1.4 a	1.0 a
Pirimor® 1Kg (soil)	26.7 ab	34.0 a	20.2 ab	16.4 a
Pirimor® 500g (soil)	64.8 b	91.8 a	40.0 b	21.3 a
Pirimor® 250g (soil)	34.7 ab	102.5 a	39.5 b	28.3 a
Control	263.2 c	385.7 b	100.0 c	144.7 b

* Week 7 and 8 are treatment means for wingless aphids from one outer lettuce leaf per lettuce.
NB. Means within each column with the same subscript are not significantly different at the 5% level.

A separate data set was created due to the change in the monitoring protocol at week 7. There was no significant difference in the mean number of winged aphids between these treatments. Winged aphid numbers were low, being less than 1 per lettuce for the first six weeks, and reaching a peak of 3 per lettuce in week 8.

One week into the trial, the Pirimor® seedling drench had significantly fewer wingless aphids than the Confidor® and Pirimor® soil spray bands (Figure 3). The lettuces remained relatively aphid free for weeks 3, 4, 5 and 6 after planting, with no significant difference in aphid means between treatments (P > 0.05).

Figure 3. Weekly means for wingless aphids on lettuce plants.



NB. Means within each week with the same subscript are not significantly different at the 5% level.

Monitoring data from week 7 and 8 shows that the efficacy of the 1kg/ha Pirimor® seedling drench and the 2kg/ha Pirimor® spray band was declining significantly when compared to the 3.3L Confidor® spray band treatment. The effect of the Pirimor® was declining with between 20-30 wingless aphids present per lettuce, many of which were juvenile. The Confidor® spray band treatment continued to have a mean of only two winless aphids per lettuce. The trial was concluded at this stage as it was clear that the Pirimor® treatments were not as good as the industry standard. The lettuces were half hearted, about 3 weeks from harvest

Conclusion

Pirimor® showed efficacy against aphids when it was applied as a banded spray to the soil prior to planting and even more so when applied directly to the seedling as a drench prior to planting. The lettuce plants showed no phytotoxic symptoms from the Pirimor® rates used in this trial. In this trial the efficacy of the highest Pirimor® rate treatments declined after seven weeks. This was about three weeks before harvest and the Confidor® soil band was still very effective.

The Pirimor® material safety data sheet from Syngenta Crop Protection suggests “there is evidence of rapid degradation in soil”. This could be why the seedling drench had greater efficacy than the comparative soil spray band. Further trials are needed to investigate the efficacy of higher Pirimor® seedling drench application rates.

Acknowledgements

This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Polyhouse Heliothis insecticide efficacy trial I, Winter 2003 (Yanco, NSW)

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Introduction

This insecticide trial compared the efficacy of Proclaim®, Prodigy®, S1812 and Azamax®. Success® was included as the grower standard for heliothis control and a water treatment was also included as the control. Laboratory reared *Helicoverpa armigera* were used in this potted lettuce trial.

Materials and Methods

This was the first of a series of replicated spray efficacy pot trials that were established at the Yanco Agricultural Institute, Yanco NSW 2703. 'Target' variety lettuces were planted as seedlings on the 26th of May, 2003 in 100mm pots, with a 600ml volume. The pots were filled with a complete potting mix. The potted lettuces were then placed into a polyhouse, watered and allowed to establish.

On the 13th of June 2003, six 2nd instar *Helicoverpa armigera* were placed on each lettuce plant with a fine brush. As the larvae were reared on a bean diet, two days were let pass prior to the pre-treatment larvae counts. The two day wait prior to spraying gave the larvae time to adjust to their new diet of lettuce. The potted lettuce were carefully taken outside the poly house and placed on the ground for the spray application at a plant density similar to Hay field lettuce production. The pots were spaced 30cm within the row and there were two rows spaced 50cm apart. At the time of spraying the *H.armigera* larvae were 3rd instar.

The following seven spray treatments were applied:

1. 250g/ha Proclaim® [Emamectin benzoate 50SG]; Syngenta
2. 0.8L/ha Prodigy® [Methoxyfenozide 240g/L]; Dow
3. 1.6L/ha Prodigy® [Methoxyfenozide 240g/L]; Dow
4. 0.2L/ha S1812, [experimental]; Sumitomo-chemicals
5. 3L/ha Azamax® + 1L/ha Eco-oil® [Neem]; Organic Crop Protectants
6. 0.8L/ha Success® [Spinosyn 120g/L]; Dow
7. Control (water 600L/ha)

The sprays were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet TXVK-6 hollow cone nozzles delivering 600L/ha of water.

After spraying, the pots were placed in groups of seven into plastic trays. Seven pots were regarded as a plot. The trays with potted lettuce were then placed back in the polyhouse in a complete random block design (Figure 1).

Figure 1. Diagram of trial plots

Block1	3	6	2	4	1	5	7
Block2	4	7	3	5	2	6	1
Block3	1	5	2	6	4	3	7
Block4	3	2	7	4	1	5	6
Block5	7	1	6	5	3	4	2

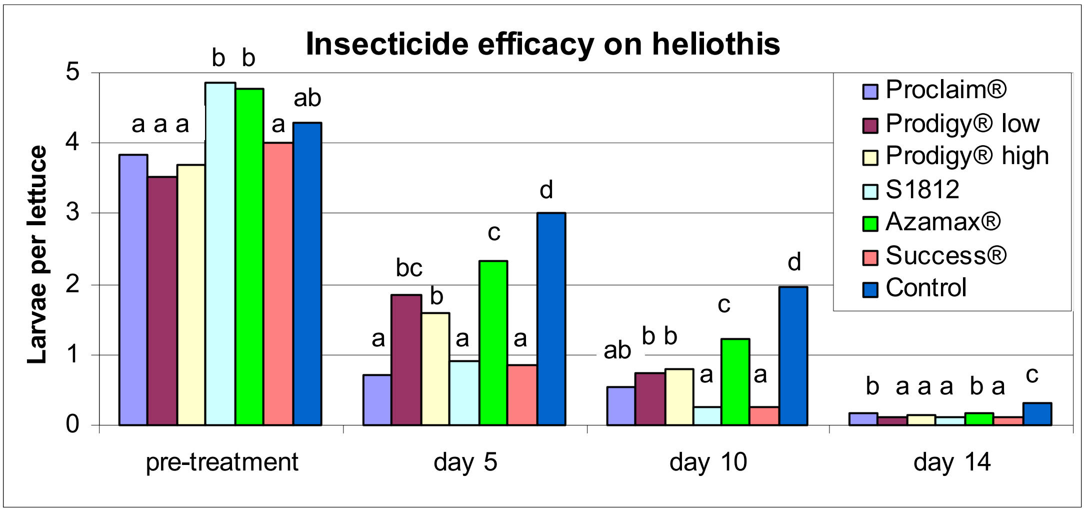
The lettuces were irrigated twice a week with a slow running hand hose that was directed under the leaves into the top of each pot. This was done to avoid washing chemical and caterpillars off the leaves. Each lettuce was visually monitored for larvae 5, 10 and 14 days after the spray treatment (DAS). A leaf damage count was also taken 14 DAS. The trial was then concluded and the potted lettuce discarded.

The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

There was a significant difference between the treatment means prior to the insecticide application in total number of Heliothis larvae in each treatment ($P < 0.05$). The mean number of larvae per lettuce was significantly higher for the S1812 and Azamax® treatments; however no treatment was significantly different to the control (Figure 2). All treatments were significantly better than the control at 5 DAS ($P < 0.05$). Proclaim®, Success® and S1812 were significantly the best performing insecticides with about an 80% reduction in larvae numbers. At 5 DAS the high rate of Prodigy® was significantly better than the Azamax®, however the lower rate of Prodigy® was not. There was a 30% reduction in larvae numbers in the control plots at 5 DAS. The reduction in larvae numbers over time in the control was due to larvae dropping off the lettuce and onto the polyhouse floor.

Figure 2. *Helicoverpa armigera* larvae means for sample days after insecticide treatments. Each treatment was applied to 35 potted lettuces, each having 3-8 larvae per lettuce at the beginning of the trial.



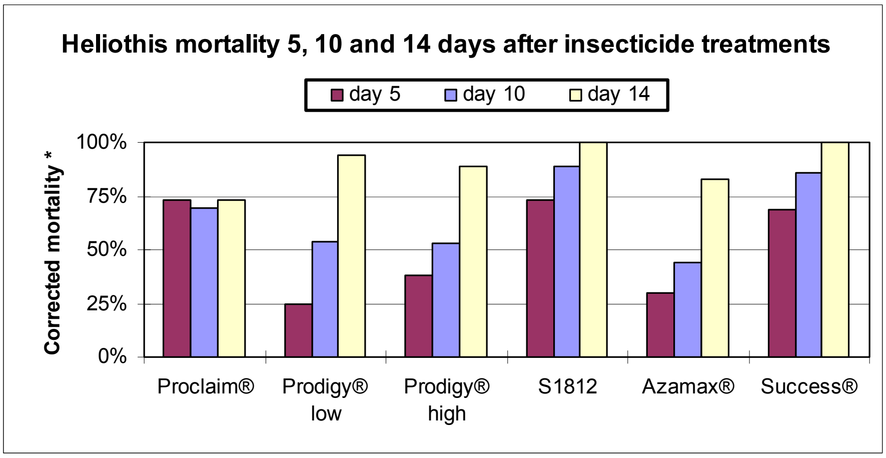
Means with the same subscript within a period are not significantly different at the 5% level.

The mortality increased in all treatments by 10 DAS. Proclaim®, Success® and S1812 were still significantly the best performing insecticides, followed by Prodigy®. The Proclaim®, Prodigy®, S1812 and Success® treatments all had a mean number of larvae per lettuce less than one, compared to the control with two. Azamax® + Eco-oil® was significantly better than the control but was not as effective as the other insecticide treatments.

At 14DAS the number of larvae had reduced to a level where we were unable to effectively separate the treatments. Only 14% of the original larvae remained in the control plots due to larvae dropping off the plants.

Correction of the data using the Henderson-Tilton formula (ref?) makes allowances for the reduction. Proclaim®, S1812 and Success® gave the highest corrected mortality at 5DAS, followed by the high rate of Prodigy® (Figure 3). S1812 and Success® had the greatest mortality for both 10 and 14DAS, having 100% at 14DAS. Of all the insecticide treatments, Azamax® tended to give the lowest mortality.

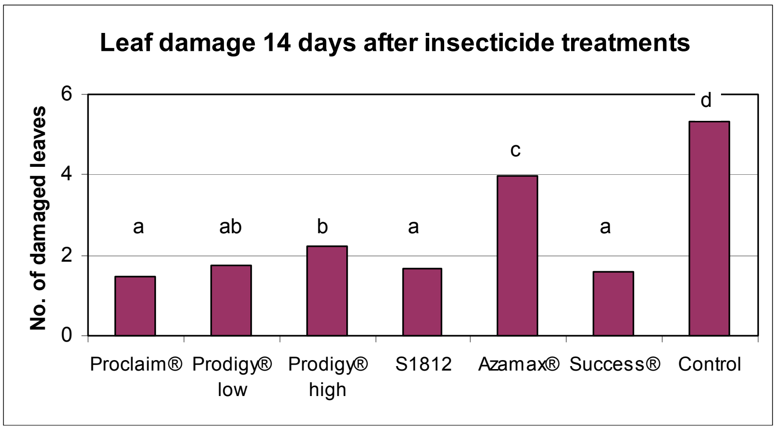
Figure 3. Corrected *Helicoverpa armigera* larvae mortality after various spray treatments.



* Data corrected using Henderson-Tilton formula

Leaf chewing damage showed similar pattern with respect to treatments as larval numbers. Proclaim®, S1812, Success® and the Prodigy® low rate had the least number of damaged leaves per plant, in the range of 1.5 to 1.7 damaged leaves per lettuce (Figure 4). The lower rate of Prodigy® had a lower mean number of damaged leaves per lettuce than the higher rate. The high rate had a mean of 2.2, however this difference was not significant (P > 0.05). Azamax® had mean number of 4 damaged leaves per lettuce, which was significantly different to the control with a mean of 5.3 (P > 0.05).

Figure 4. Mean number of damaged leaves per lettuce plant 14 DAS.



Conclusion

Both 250g/ha of Proclaim® and 200ml/ha of S1812 were not significantly different in efficacy to 800ml/ha of Success® for *Helicoverpa armigera* control. Prodigy® did not show the same level of efficacy of Success® against 3rd instar *H. armigera* larvae. Under the polyhouse environmental conditions the efficacy of 800ml/ha and 1.6L/ha of Prodigy® could not be significantly separated. The spray of 3L/ha Azamax® + 1L/ha Eco-oil® showed efficacy against the *H. armigera* larvae. However it is doubtful that the level of control would be commercially acceptable.

Acknowledgements

Thanks to Scott Munro and Meryl Snudden for monitoring assistance. Thanks to Dow Agroscience, Sumitomo Chemicals and Organic Crop Protectants for respectively providing Prodigy®, S1812 and Azamax® for our investigation. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Polyhouse Heliothis insecticide efficacy trial II, Winter 2003 (Yanco, NSW)

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Introduction

This insecticide trial compared the efficacy of high rates of Proclaim®, Prodigy®, S1812 and Azamax®. Success® was included as the grower standard for heliothis control and a water treatment was also included as the control. Laboratory reared *Helicoverpa armigera* were used in this potted lettuce trial. This second trial was done to further confirm the results in the previous polyhouse efficacy trial in June 2003.

Materials and Methods

This was the second trial in a series of replicated spray efficacy pot trials that were established at the Yanco Agricultural Institute, Yanco NSW 2703. 'Target' variety lettuces were planted as seedlings on the 18th of July, 2003 in 100mm pots, with a 600ml volume. The pots were filled with a complete potting mix. The potted lettuces were then placed into a polyhouse, watered and allowed to establish.

On the 11th of August 2003, six 2nd instar *Helicoverpa armigera* were placed on each lettuce plant with a fine brush. As the larvae were reared on a bean diet, two days were let pass prior to the pre-treatment larvae counts. The two day wait prior to spraying gave the larvae time to adjust to their new diet of lettuce. The potted lettuce were carefully taken outside the poly house and placed on the ground for the spray application at a plant density similar to Hay field lettuce production. The pots were spaced 30cm within the row and there were two rows spaced 50cm apart. At the time of spraying the *H.armigera* larvae were 3rd instar.

The following six spray treatments were applied:

8. 250g/ha Proclaim® [Emamectin benzoate 50SG]; Syngenta
9. 1.6L/ha Prodigy® [Methoxyfenozide 240g/L]; Dow
10. 0.2L/ha S1812, [experimental]; Sumitomo-chemicals
11. 3L/ha Azamax® + 1L/ha Eco-oil® [Neem]; Organic Crop Protectants
12. 0.8L/ha Success® [Spinosyn 120g/L]; Dow
13. Control (water 600L/ha)

The sprays were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet TXVK-6 hollow cone nozzles delivering 600L/ha of water.

After spraying, the pots were placed in groups of seven into plastic trays. Seven pots were regarded as a plot. The trays with potted lettuce were then placed back in the polyhouse in a complete random block design (Figure 1).

Figure 1. Diagram of trial plots

Block1	2	5	3	1	4	6
Block2	3	6	2	4	5	1
Block3	1	4	5	3	2	6
Block4	4	2	6	1	3	5
Block5	6	1	5	4	2	3

The lettuces were irrigated twice a week with a slow running hand hose that was directed under the leaves into the top of each pot. This was done to avoid washing chemical and caterpillars off the leaves. Each lettuce was visually monitored for larvae 2, 5, 7 and 14 days after the spray treatment (DAS). A leaf damage count was also taken 14 DAS. The trial was then concluded and the potted lettuce discarded.

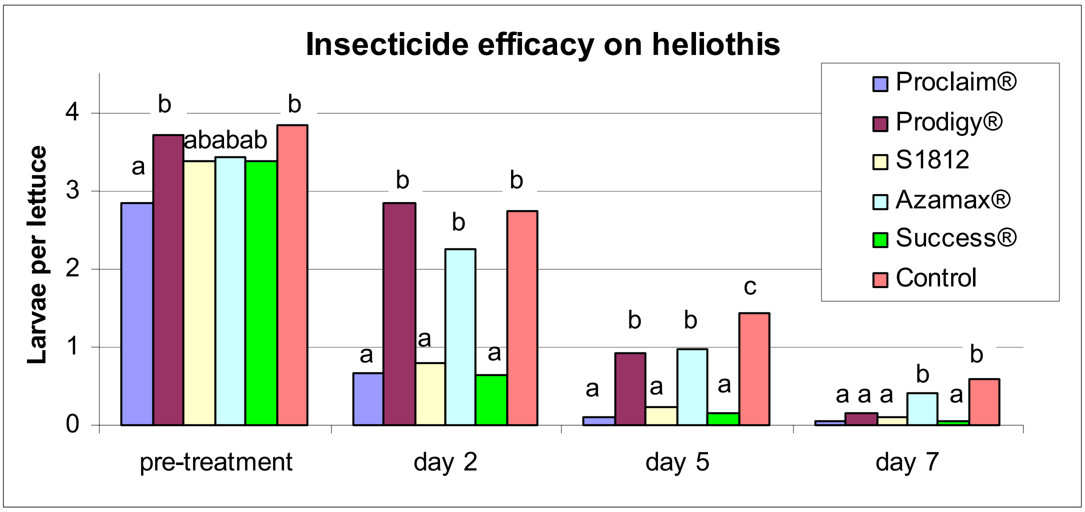
The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

The lettuces in the Proclaim® plots had significantly fewer heliothis in the pre-treatment counts than the Prodigy® and control plot pre treatment counts ($P > 0.05$). There was no significant difference in the heliothis pre-treatment counts between the control and the other four treatments (Figure 2). Proclaim®, S1812 and Success® all had a mean of less than one larvae per lettuce at 2 DAS. This was a significant reduction compared to the Prodigy®, Azamax® and the control, which all had an average of more than over two larvae per lettuce. The Prodigy® and Azamax® treatments were not significantly different to the control at 2 DAS.

At 5 DAS, both the Prodigy® and Azamax® treatments did show significant mortality with a mean number of larvae per lettuce of 0.9 and 1.0 respectively. They were not as effective at controlling the larvae as Proclaim®, S1812 and Success®, which had reduced to a mean number of 0.1 larvae per lettuce.

Figure 2. *Helicoverpa armigera* larvae means for sample days after insecticide treatments. Each treatment was applied to 35 potted lettuces, each having 3-8 larvae per lettuce at the beginning of the trial.



Means with the same subscript within a period are not significantly different at the 5% level.

Result from 7 DAS confirm that Prodigy® has a slower mode of action when compared to Proclaim®, S1812 and Success® as it had a significantly similar mortality. Azamax® was not significantly different to the control at 7 DAS.

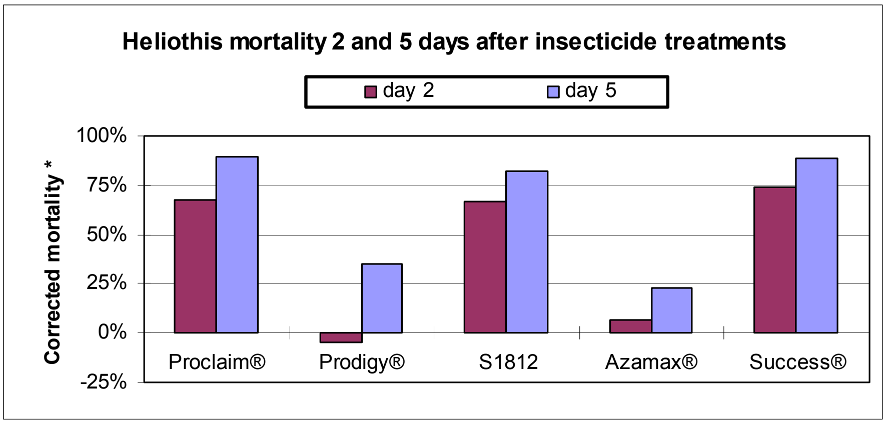
The *Helicoverpa armigera* larvae numbers declined over time in the control plots due to both cannibalism and also larva dropping off plants onto the poly house floor. Placing the pots in water baths is needed to determine what is causing the greatest reduction of larvae numbers in the control plots. At 14DAS the number of larvae had reduced to a level where we are unable to effectively separate the treatments.

Correction of the data using the Henderson-Tilton formula makes allowances for the reduction of larvae numbers in the control plots.
corrected mortality% = (1- (n in control before X n in treatment after) / (n in control after X n in treatment before))

Proclaim®, S1812 and Success® had the highest corrected mortalitys at 5 DAS, followed by Prodigy® (Figure 3). Prodigy® had a negative corrected mortality at 2 DAS because the reduction in the number of larvae in the control plot was far greater over the first two days of the trial. Prodigy® must have a relatively slow mode of action on medium sized heliothis larvae. When compared to the other insecticides, Azamax® had the lowest mortality at 5 DAS.

Applying the formula to data from 7 and 14 DAS gave negative mortalities for all treatments. Meaningful corrected mortalities were not obtained because over this period, the proportion of larvae decline in the control plots far outweighed the decline in the insecticide treatments.

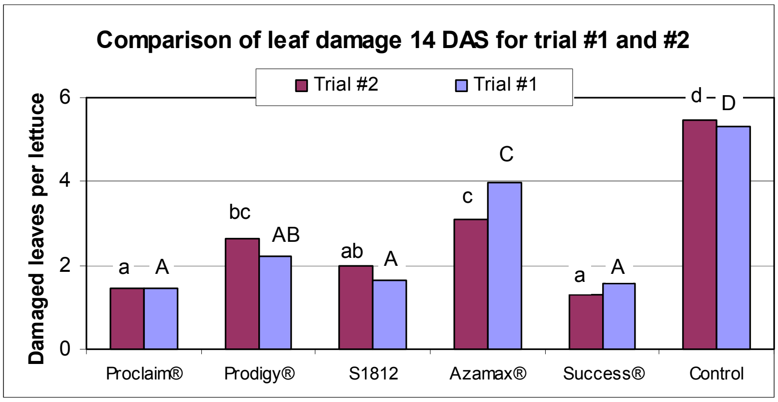
Figure 3. Corrected *Helicoverpa armigera* larvae mortality after various spray treatments.



* Data corrected using Henderson-Tilton formula

The leaf chew damage data at 14 DAS was not as clear as that from the previous trial, however the mean number of leaves chewed in each treatment was quite similar for both trials (Figure 4). In the second trial, Proclaim® and Success® had significantly the lowest number of damaged leaves per plant, closely followed by S1812 (Figure 4). Prodigy® and Azamax® had the two greatest amounts of leaf damage of the five insecticide treatments, however they had both had significantly less leaf chew damage than the control ($P > 0.05$).

Figure 4. Mean number of damaged leaves per lettuce plant 14 DAS.



Means with the same subscript within a period are not significantly different at the 5% level.

Conclusion

In keeping with the first efficacy trial, both 250g/ha of Proclaim® and 200ml/ha of S1812 were not significantly different in efficacy to 800ml/ha of Success® for *Helicoverpa armigera* control. For a second time, Prodigy® did not show the efficacy of Success® against 3rd instar *H. armigera* larvae. The spray of 3L/ha Azamax® + 1L/ha Eco-oil® again significantly showed a low level of heliothis larvae control, however it was far from the efficacy of Success®.

Acknowledgements

Thanks to Scott Munro and Meryl Snudden for monitoring assistance. Thanks to Dow Agroscience, Sumitomo Chemicals and Organic Crop Protectants for respectively providing Prodigy®, S1812 and Azamax® for our investigation. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Polyhouse Heliothis insecticide efficacy trial III, Winter 2003 (Yanco, NSW)

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Introduction

This insecticide trial compared the efficacy of low rates of Proclaim®, Prodigy® and S1812 on 3rd instar *Helicoverpa armigera* larvae. Success® was included as a grower standard and a water treatment was also included as the control. Laboratory reared larvae were used in this potted lettuce trial.

Materials and Methods

This was the third replicated spray efficacy trial done at the Yanco Agricultural Institute, Yanco NSW 2703 during the winter of 2003. 'Target' variety lettuces were planted as seedlings on the 18th of July, 2003 in 100mm pots, with a 600ml volume. The pots were filled with a complete potting mix. The potted lettuces were then placed into a polyhouse, watered and allowed to establish.

On the 11th of August 2003, six 2nd instar *Helicoverpa armigera* were placed on each lettuce plant with a fine brush. As the larvae were reared on a bean diet, two days were let pass prior to the pre-treatment larvae counts. The two day wait prior to spraying gave the larvae time to adjust to their new diet of lettuce. The potted lettuce were carefully taken outside the poly house and placed on the ground for the spray application at a plant density similar to Hay field lettuce production. The pots were spaced 30cm within the row and there were two rows spaced 50cm apart. At the time of spraying the *H. armigera* larvae were 3rd instar.

The following seven spray treatments were applied:

1. 150g/ha Proclaim® [Emamectin benzoate 50SG]; Syngenta
2. 800ml/ha Prodigy® [Methoxyfenozide 240g/L]; Dow
3. 100ml/ha S1812, [experimental]; Sumitomo-chemicals
4. 400ml/ha Success® [Spinosyn 120g/L]; Dow
5. Control (water 600L/ha)

The sprays were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet TXVK-6 hollow cone nozzles delivering 600L/ha of water.

After spraying, the pots were placed in groups of six into plastic trays. Six pots were regarded as a plot. The trays with potted lettuce were then placed back in the polyhouse in a complete random block design (Figure 1).

Figure 1. Diagram of trial plots

Block1	1	4	5	2	3
Block2	4	3	2	5	1
Block3	2	1	5	3	4
Block4	1	5	4	2	3
Block5	3	4	2	1	5

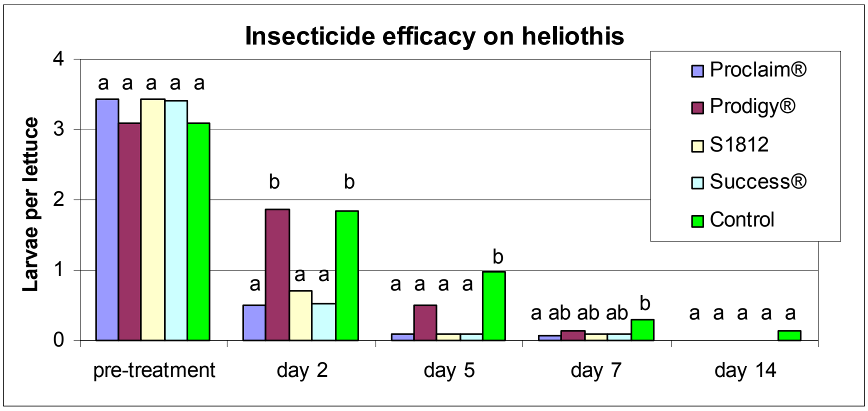
The lettuces were irrigated with Netafim® 2L/hr drippers to to avoid washing chemical and caterpillars off the leaves. Each lettuce was visually monitored for larvae 2, 5, 7 and 14 days after the spray treatment (DAS). A leaf damage count was also taken 14 DAS. The trial was then concluded and the potted lettuce discarded.

The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

Prior to the application of the insecticide treatments the mean number of larvae per lettuce ranged between 3.1 and 3.4 between the treatments. These pretreatment means were not significantly different ($P > 0.05$). At 2 DAS, Proclaim®, S1812 and Success® had a mean number of 0.5, 0.7 and 0.5 larvae per lettuce respectively. These were significantly different to the control, which had a mean number 1.8 larvae per lettuce (Figure 2). The Prodigy® treatment was not significantly different to the control at 2 DAS.

Figure 2. *Helicoverpa armigera* larvae means for sample days after insecticide treatments. Each treatment was applied to 30 potted lettuces, each having 1-6 larvae per lettuce at the beginning of the trial.



Means with the same subscript within a period are not significantly different at the 5% level.

By 5 DAS the efficacy of Prodigy® had increased. Prodigy® had a mean of 0.5 larvae per lettuce and was significantly different to the control which had a mean number of 1.0 larvae per lettuce. Proclaim®, S1812 and Success® each had 0.1 larvae per lettuce, which was not significantly different to the Prodigy® treatment.

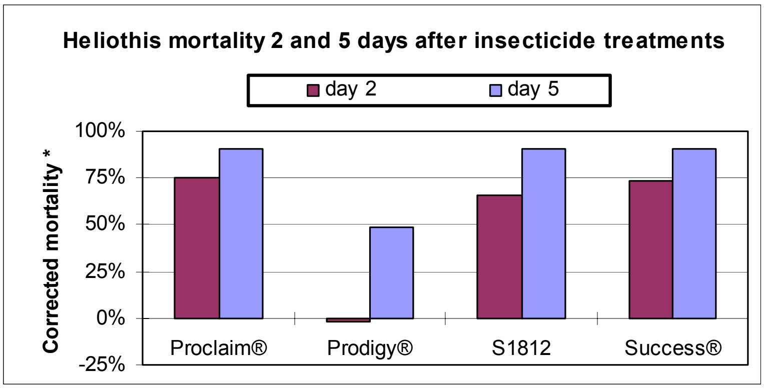
Due to the reduction of larvae in the control plots, the treatments cannot be effectively separated at 7 and 14 DAS. This reduction is mainly from larvae dropping off the lettuce and onto the polyhouse floor.

Correcting the data using the Henderson-Tilton formula makes allowances for the reduction of larvae in the control and gives a mortality comparison between treatments.
corrected mortality% = (1- (n in control before X n in treatment after) / (n in control after X n in treatment before))

Proclaim®, S1812 and Success® gave the highest corrected mortality at both 2 and 5 DAS. At 5 DAS the corrected mortality of Proclaim®, S1812 and Success® were all greater than

90%. Prodigy® had a negative mortality at 2 DAS because the decrease in the larvae numbers was greater in the control plot. However by 5 DAS Prodigy® had given close to 50% mortality (Figure 3). This shows that when compared to the Proclaim®, S1812 and Success®, Prodigy® has a relatively slow mode of action. When used at low rates, Prodigy® also gave a lower mortality than the other insecticide treatments against 3rd instar *Helicoverpa armigera* larvae.

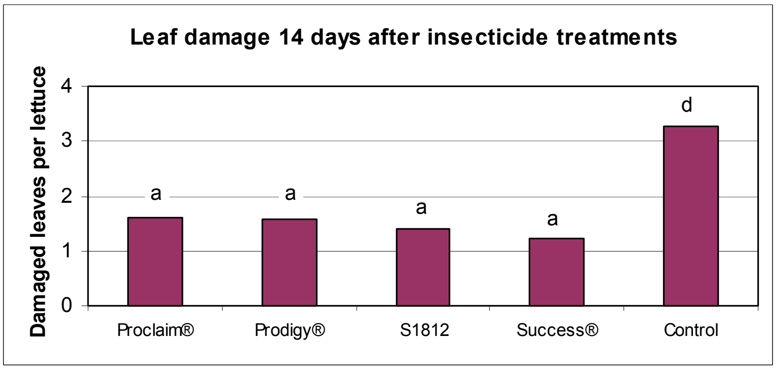
Figure 3. Corrected *Helicoverpa armigera* larvae mortality after various spray treatments.



* Data corrected using Henderson-Tilton formula

There was no significant difference between any of the insecticide treatments in the mean number of chew damage leaves per lettuce (P > 0.05). The mean number of damaged leaves per lettuce ranged from 1.2 to 1.6 for the insecticide treatments. All treatments were significantly different to the control, which had a mean number of 3.3 chew damaged leaves per lettuce.

Figure 4. Mean number of damaged leaves per lettuce plant 14 DAS.



Means with the same subscript within a period are not significantly different at the 5% level.

Conclusion

In this trial 150g/ha of Proclaim®, 100ml/ha of S1812 and 400ml/ha of Success® showed equal efficacy on 3rd instar *Helicoverpa armigera* larvae, with each showing greater than 90% corrected mortality at 5 DAS. Prodigy® applied at 800ml/ha showed less efficacy than the other insecticide treatments, although this was not significantly different in both mortality at 5 DAS and in the number of chew damaged leaves at 14 DAS. Prodigy® had a slower mode of action in killing larvae when compared to the other insecticide treatments.

Acknowledgements

Thanks to Scott Munro for monitoring assistance. Thanks to Dow Agroscience, Sumitomo Chemicals and Organic Crop Protectants for respectively providing Prodigy®, S1812 and Azamax® for our investigation. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Polyhouse Heliothis NPV efficacy trial, Spring 2003 (Yanco, NSW)

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Introduction

This insecticide trial compared the efficacy of range of rates of Gemstar® and Vivus®. Both products are biological insecticides with nuclear polyhedrosis virus (NPV) as their active constituent. Products like Gemstar® and Vivus® fit well into an integrated pest management (IPM) systems because they are highly specific *Helicoverpa spp.* larvae, with no disruption of beneficial insects. Success® was included in this trial as a grower standard and a water treatment was included as the control. Laboratory reared larvae were used in this potted lettuce trial.

Materials and Methods

This was the fourth replicated spray efficacy trial done at the Yanco Agricultural Institute, Yanco NSW 2703 during the winter and spring of 2003. 'Target' variety lettuces were planted as seedlings on the 18th of July, 2003 in 100mm pots, with a 600ml volume. The pots were filled with a complete potting mix. The potted lettuces were then placed into a polyhouse, watered and allowed to establish.

On the 15th of September 2003, five 2nd instar *Helicoverpa armigera* were placed on each lettuce plant with a fine brush. As the larvae were reared on a bean diet, two days were let pass prior to the pre-treatment larvae counts. The two day wait prior to spraying gave the larvae time to adjust to their new diet of lettuce. The potted lettuce were carefully taken outside the poly house and placed on the ground for the spray application at a plant density similar to Hay field lettuce production. The pots were spaced 30cm within the row and there were two rows spaced 50cm apart. At the time of spraying the *H. armigera* larvae were 3rd instar.

Both the Gemstar® and Vivus® products used in this trial contained 2 x 10^9 polyhedral occlusion bodies of the nuclear polyhedrosis virus of *Helicoverpa zea* per millilitre as their active ingredient. All treatments were applied with the addition of 4ml/20L Agral®, a non-ionic wetting agent to assist with thorough chemical coverage of the lettuce leaf surfaces.

The following eight spray treatments were applied:

1. 250ml/ha Gemstar® [NPV]; Bayer CropScience
2. 500ml/ha Gemstar® [NPV]; Bayer CropScience
3. 750ml/ha Gemstar® [NPV]; Bayer CropScience
4. 250ml/ha Vivus® [NPV]; Ag Biotech Australia
5. 500ml/ha Vivus® [NPV]; Ag Biotech Australia
6. 750ml/ha Vivus® [NPV]; Ag Biotech Australia
7. 400ml/ha Success® [Spinosyn 120g/L]; Dow
8. Control (water 600L/ha)

The sprays were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet TXVK-6 hollow cone nozzles delivering 600L/ha of water.

After spraying, the pots were placed in groups of seven into plastic trays. Seven pots were regarded as a plot. The trays with potted lettuce were then placed back in the polyhouse in a complete random block design (Figure 1). There was a 20cm gap between the different treatment trays.

Figure 1. Diagram of trial plots

Block1	7	5	1	8	3	4	2	6
Block2	1	3	8	2	7	6	5	4
Block3	7	6	5	4	3	2	8	1
Block4	1	4	3	2	6	7	5	8
Block5	6	8	7	5	1	2	3	4

The lettuces were irrigated three times a week with a slow running hand hose that was directed under the leaves into the top of each pot. This was done to avoid washing chemical and caterpillars off the leaves. Each lettuce was visually monitored for larvae 2, 5, 7 and 14 days after the spray treatment (DAS). A leaf damage count was also taken 14 DAS. The trial was then concluded and the potted lettuce discarded.

The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

Prior to the application of the insecticide treatments there was no significant difference in the mean number of larvae per treatment plot ($P > 0.05$). At 2 DAS there were only dead caterpillars on lettuce treated with Success®. The treatments were not monitored as it had been well proven in previous trials that Success® provides high heliothis mortality at 2 DAS. The rapid reduction of larvae numbers in all treatments made it difficult to effectively separate the treatments. At 5 DAS there was no significant difference between any of the Gemstar®, Vivus® and control treatments (Table 1). Only Success® had significantly fewer larvae than the control at 5 DAS, however most Gemstar® and Vivus® were not significantly different to Success® ($P > 0.05$). This is likely to be due to larvae dropping off the lettuces and onto the polyhouse floor.

Table 1. *Helicoverpa armigera* larvae means for sample days after various spray treatments (n=7 per replicate)

treatment	Pre-treatment		5 day		7 day		14 day	
250ml Gemstar®	15.2	a	4.2	c	2.8	c	0.0	a
500ml Gemstar®	15.8	a	1.4	ab	1.0	abc	0.0	a
750ml Gemstar®	15.4	a	1.6	ab	1.4	abc	0.0	a
250ml Vivus®	15.4	a	2.0	abc	2.4	bc	0.2	a
500ml Vivus®	16.2	a	2.8	abc	2.0	abc	0.2	a
750ml Vivus®	15.2	a	1.4	ab	0.6	ab	0.2	a
Success®	15.4	a	0.6	a	0.2	a	0.0	a
Control	16.0	a	3.6	bc	3.0	c	0.2	a

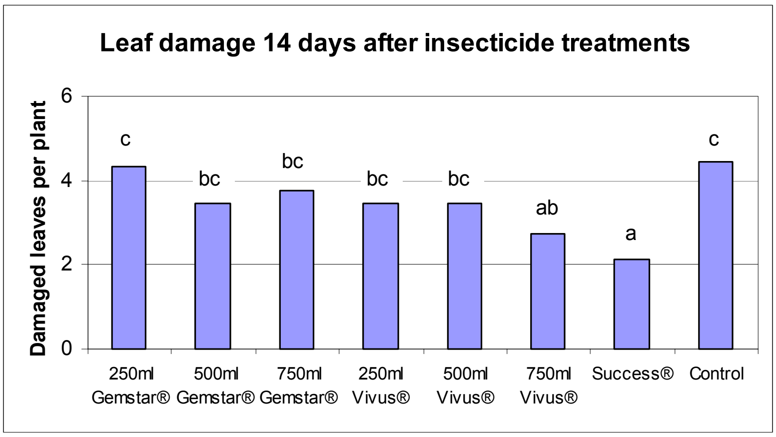
Means with the same subscript within a column are not significantly different at the 5% level.

At 7 DAS there was still no significant difference between the six NPV treatments. Both 250ml/ha of Vivus® and Gemstar® had significantly more larvae per lettuce the Success®

treatment. Larvae numbers were few at 14 DAS and no significant result was obtained. The NPV virus had been circulating throughout the polyhouse and all treatments had lettuce with larvae that had died a death with virus like symptoms.

Leaf damage data taken at 14 DAS showed that only Success® and 750ml/ha of Vivus® had significantly fewer chew damaged leaves per lettuce than the control. The six NPV treatments cannot be effectively separated based on leaf chew damage data (P > 0.05).

Figure 3. Mean number of damaged leaves per lettuce plant 14 DAS.



Means with the same subscript within a period are not significantly different at the 5% level.

Conclusion

This trial was not effective at comparing the efficacy of Gemstar® and Vivus®. The quick decline of larvae numbers in the treatments greatly reduced the effective separation of the treatments. Although the sprays were not applied in the polyhouse, by 14 DAS it was clear the air circulation inside a poly house had spread the NPV virus to all treatments. A field replicated trial combined with laboratory leaf bioassys may better compare the efficacy of Gemstar® and Vivus® against heliothis.

Acknowledgements

Thanks to Scott Munro and Meryl Snudden for monitoring assistance. Thanks to Dow Agroscience, Sumitomo Chemicals and Organic Crop Protectants for respectively providing Prodigy®, S1812 and Azamax® for our investigation. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Polyhouse Heliothis Efficacy Trial, Spring 2003 (Yanco, NSW)

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Introduction

The primary aim of this investigation was to obtain efficacy data on high and low rates of DC-041. Proclaim® and Success® were included as treatments to link the performance of DC-041 to previous pot trials. Laboratory reared *Helicoverpa armigera* were used in this potted lettuce trial.

Materials and Methods

A series of replicated pot trials were established at the Yanco Agricultural Institute, Yanco NSW 2703. 'Target' variety lettuces were planted as seedlings on the 3rd of September 2003 in 100mm pots, with a 600ml volume. The pots were filled with a complete potting mix. The potted lettuces were then placed into a polyhouse, watered and allowed to establish.

On the 15th of September 2003, three laboratory reared *Helicoverpa armigera* were placed on each lettuce plant with a fine brush. Each lettuce was monitored for larvae and sprayed two days after the larvae were placed. The two day wait prior to spraying gave the larvae time to adjust to their new diet of lettuce. The potted lettuce were carefully taken outside the poly house and placed on the ground for the spray application, in a formation similar to field lettuce production. The pots were spaced 30cm within the row and there were two rows spaced 50cm apart.

The following six spray treatments were applied:

1. 250g/ha Proclaim® [Emamectin benzoate 50SG]; Syngenta
2. 800ml/ha Success® [Spinosyn 120g/L]; Dow
3. 60ml/ha DC-041 [Experimental]; Bayer Crop Science
4. 90ml/ha DC-041, [Experimental]; Bayer Crop Science
5. Control (water 600L/ha)

The sprays were applied with a 14 litre Silvan battery powered backpack sprayer fitted with a dropper attachment. The droppers were 30cm long and configured so that there were three nozzles directing chemical over each row of lettuce. The boom was fitted with six TeeJet TXVK-6 hollow cone nozzles delivering 600L/ha of water.

After spraying, the pots were placed in groups of seven into plastic trays. Seven pots were regarded as a plot. The trays with potted lettuce were then placed back in the polyhouse in a complete random block design (Figure 1).

Figure 1. Diagram of trial plots

Block5	1	4	5	2	3
Block4	4	3	2	5	1
Block3	2	1	5	3	4
Block2	1	5	4	2	3
Block1	3	4	2	1	5

North ←

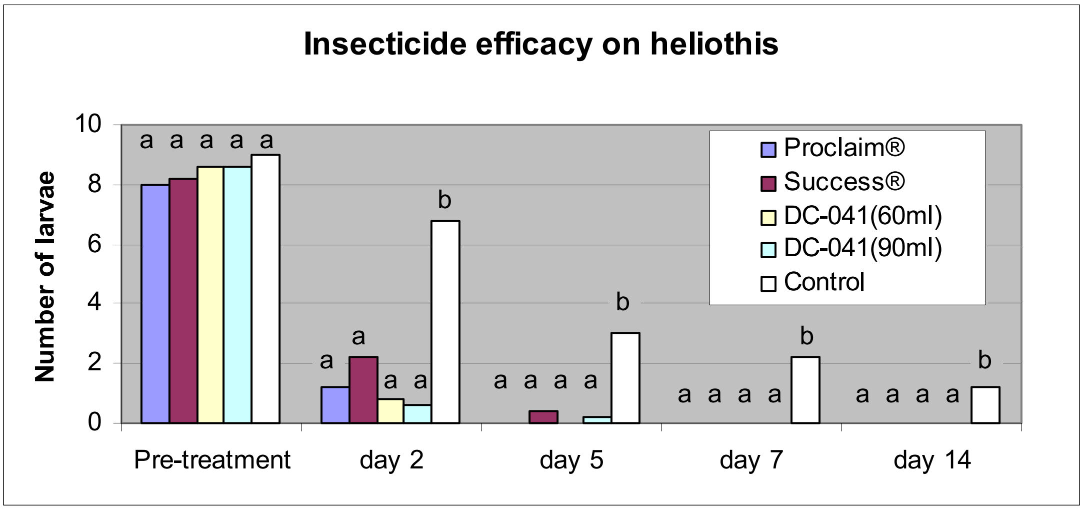
The lettuces were irrigated with Netafim® 2L/hr drippers to avoid chemical being washed off the leaves. Each lettuce was visually monitored for larvae 2, 5, 7 and 14 days after the spray treatment (DAS). A leaf damage count was also taken 14 DAS. The trial was then concluded and the potted lettuce discarded.

The insect data was analysed using ANOVA for the complete random block design. When significant differences were detected at $\alpha = 0.05$ the treatment means were separated by Duncan's new multiple range test.

Results and Discussion

Prior to the insecticide application, at a confidence level of 0.95, there was no significant difference between the treatment means for the number of heliothis larvae in each plot (Figure 2). Both the 60ml and 90ml rates of DC-041 performed equally as well as Proclaim® and Success®. In 7 days, the mean number of larvae recorded in the control plots decreased from 9.0 to 2.2 (Figure 2). Heliothis larvae dropping off the lettuce and onto the polyhouse floor were the reason for this reduction.

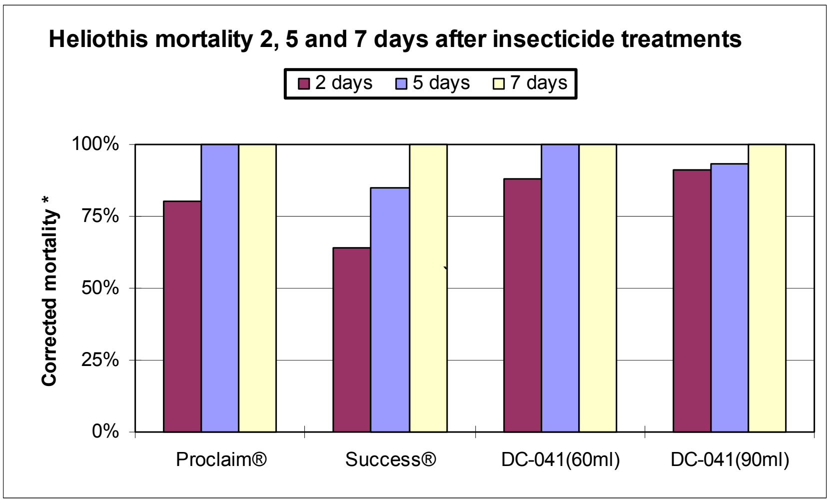
Figure 2. *Helicoverpa armigera* larvae means for sample days after insecticide treatments (n=7 per replicate).



Means with the same subscript within a period are not significantly different at the 5% level.

The data indicates that DC-041 is a relatively quick acting insecticide when compared to Success®, although the difference was not significant at the 5% level. Corrected data using Henderson-Tilton formula indicates DC-041 gave 88% larvae mortality 2 DAS. The larvae mortality increased to 100% 5 DAS for DC-041 (Figure 3).

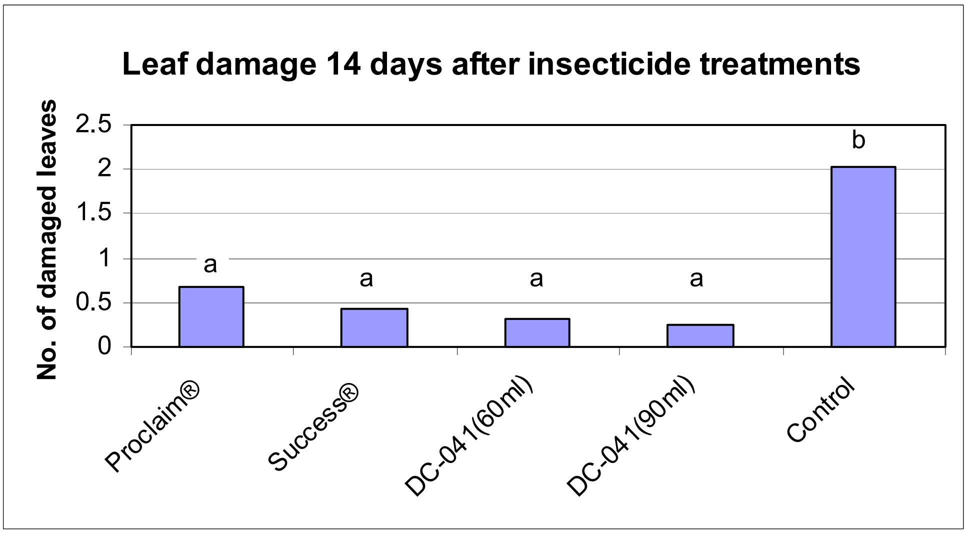
Figure 3. Corrected *Helicoverpa armigera* larvae mortality after various spray treatments.



* Data corrected using Henderson-Tilton formula

Leaf damage did not vary significantly between the insecticide treatments (Figure 4).

Figure 4. Mean number of damaged leaves per lettuce plant 14 DAS.



Conclusion

From this trial, it would appear that DC-041 applied at the lower rate of 60ml/ha gave similar *Helicoverpa armigera* control to 800ml/ha Success® and 250g/ha Prodigy®. The lower rate of 60ml/ha DC-041 needs to be trialled under field conditions. This will also help us understand the effects DC-041 may have on other insect groups.

Acknowledgements

Thanks to Scott Munro and Meryl Snudden for monitoring assistance. Thanks to Bayer Crop Science for providing DC-041 for our investigation. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Best Management Options (BMO) trials

Summary

Monitoring data from earlier projects indicated that beneficial insect numbers are often low in the inland lettuce crops of NSW. A combination of broad spectrum insecticide use, harsh summer climatic conditions and discontinuous cropping through the year is likely to be the cause. Some lettuce growers spray to a schedule that is seasonally adjusted to suit pest pressure which is observed whilst performing crop management tasks. In cropping regions that do not have active crop monitoring services for vegetable growers there are relatively few growers regularly monitoring their crops to a protocol or selecting “softer” insecticide sprays to encourage beneficials in the lettuce crop. Biologically based IPM systems rely on beneficials to keep pest numbers low and strategically use selective insecticides when pest numbers increase to levels that can cause economic damage.

The lettuce best management options (BMO) trials were designed to compare different insect pest and disease management strategies. The trials basically involved NSW DPI managing spray decisions and applications on a part of a lettuce planting, whilst the grower sprayed as they normally would on the rest of the lettuce planting. Insect and harvest data was gathered from both the DPI treatment and the grower’s crop to draw comparisons for cost and effectiveness. These BMO trials were conducted to see whether the adoption of some integrated pest management (IPM) principals would be of benefit to growers.

Regular crop monitoring to a protocol and the use of selective or ‘softer’ insecticide chemistry to promote beneficial insect activity were key principals to the pest management in the NSW DPI plots. Broad spectrum insecticide chemistry was used sparingly in some NSW DPI plots, for example, before harvest to clean up contamination pest insects like Rutherglen bugs. A fungicide for sclerotinia control was routinely applied after transplanting or chipping and all chemical applications were made with a spray boom that was fitted with droppers to improve spray coverage.

There were two BMO trial sites at Hay (NSW) during winter 2003, two BMO trial sites at Canowindra (NSW) during spring 2003, two trial sites at Hay during autumn 2004 and there were also two lettuce BMO comparisons during winter at Hay 2004. The trial results varied and differed between each trial as the insect pest and disease pressure varied between properties and also with the different seasons when the trials were done.

It was generally found that during winter regular crop monitoring could avoid unnecessary spraying. In trials during periods of consistently high insect pressure the cost saving diminished as spraying was necessary anyway and monitoring was an extra cost. In many trials the use of the ‘softer’, selective insecticide chemistry made the cost of the DPI’s pest management strategies far out weigh the grower’s cost. Beneficial insects were not necessarily controlling insect pests. In 2004 it became apparent that larger IPM plots or whole farm trials were needed to realize the full potential of beneficial insects.

In March 2004 western flower thrips was confirmed from Hay and at a meeting to discuss management options one of the growers strongly supported the trial of commercial crop monitoring. The only independent agronomist working at Hay was approached and indicated a willingness to be trained as a lettuce crop scout. In May 2004 Paul Horne and Jessica Page of IPM Technologies ran an IPM workshop at Hay. Four of the ten Hay

lettuce growers adopted IPM management strategies with Gibbs Rural Services gathering the monitoring data and IPM Technologies mentoring the pest management recommendations. Gibbs Rural Services was mentored in the field to ensure that he was familiar with the insects found in lettuce. Having commercial scale IPM trial allowed a realistic comparison between biologically based IPM and conventionally managed farms in the Hay area.

Hay lettuce growers only used the commercial IPM service for the 2004 season. The 2005 autumn season started with a locust plague and the regular locust sprays were not conducive to the continuation of an IPM system. Other reasons why growers discontinued the service were:

- Heliothis pressure was high at the end of the season and the use of biological insecticides like Dipel Forte® and Gemstar® was expensive as spraying frequency was increased. Field observations showed growers these biological insecticides did not have the efficacy of products like Avatar®, Success® or Proclaim®. Some growers switched back to using the broad spectrum insecticide chemistry during periods of high insect pest pressure as they were more cost effective.
- Some growers did not have the confidence in biological IPM for the autumn period as beneficial insect numbers were considered low because of temperature extremes.
- Some growers felt the consultant was not picking up pest problems early enough and heliothis 'got away' at the end of the season.
- One grower discontinued the commercial monitoring service because the consultant was going from one property to the next and may possibly be sharing strategic information with other growers.

Despite the apparent failure of biological IPM adoption in Hay, growers are using some of the IPM strategies and skills they learnt over the 2004 season. These include:

- less spraying to a schedule and less insecticide use over the winter.
- a greater knowledge of beneficial insects, their possible impacts on pests and the ability to recognize beneficials in the field
- some growers monitoring lettuce crops themselves and basing their pest management decisions upon the monitoring results.
- greater use of selective insecticide chemistries rather than always opting for broad spectrum insecticides.

The following BMO trial reports vary in their outcomes and results as local circumstances were different for most trials. Regular crop monitoring is recommended as a basis for an IPM strategy. Basing pest management decisions on monitoring results ensures insecticide sprays are only applied when necessary. Adopting an IPM strategy is a sustainable farming practice that can have cost advantages through less insecticide use and earlier detection of pest and disease issues.

Iceberg lettuce BMO, Spring 2003 (Hay, NSW)

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Introduction

This trial aimed to compare management of insect pests and diseases using an IPM protocol as defined by NSW DPI's Lettuce IPM team and Ruberto's Vegetable Farm's current practice.

Materials and methods

The trial block was 'Greenway' variety lettuce direct seeded at the start of June 2003. The host for the trial was Ruberto's Vegetable Farms, situated on University road, south Hay. The two main treatments in this BMO trial was "Grower" and "NSW DPI".

The NSW DPI plot was 40 beds wide extending the full length of the lettuce planting (20-120m), totalling 0.537ha. Monitoring began when the lettuce plants were 3 leaved seedlings. 80 lettuce were monitored during the seedling and preheart stage, whilst 40 lettuce were monitored from hearting until harvest. Monitoring data was not gathered from a 5-bed buffer between the grower and NSW DPI plot. Each monitoring visit was roughly every ten days and the grower was not provided with gathered data to make pest management decisions.

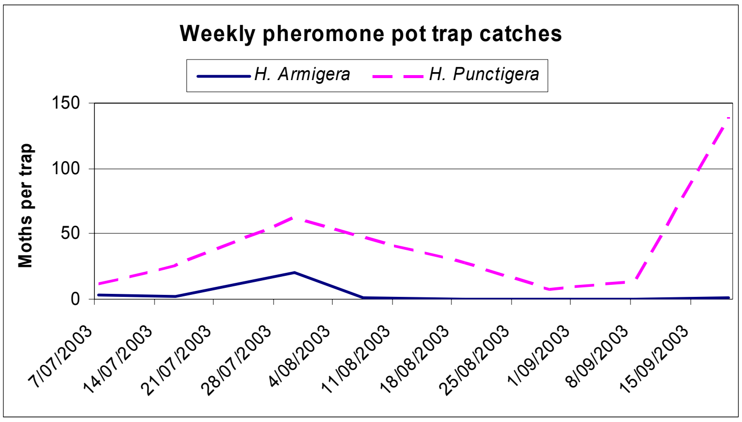
In the NSW DPI treatment a threshold of 1 egg or larvae in 20 plants was used to indicate whether the crop required treatment for Heliothis. Sprays in the NSW DPI plot were applied with an overhead boom modified with droppers. Three T-Jet hollow cone nozzels (TXVK-8 conejet) were directed per lettuce row and using an 800L/ha water rate. The grower used an overhead boom for spray applications, which was also modified with droppers.

At harvest 110 lettuce were visually assessed in each plot for heliothis or other caterpillar damage, aphid contamination and other sap sucking insect contamination. The diameter of these 110 lettuce was also recorded. Eleven 10m plots were used to score the lettuce treatments for disease, this equated to 600 lettuce in each plot. Twenty lettuce from each plot were completely stripped down to check the heart for thrips contamination

Results

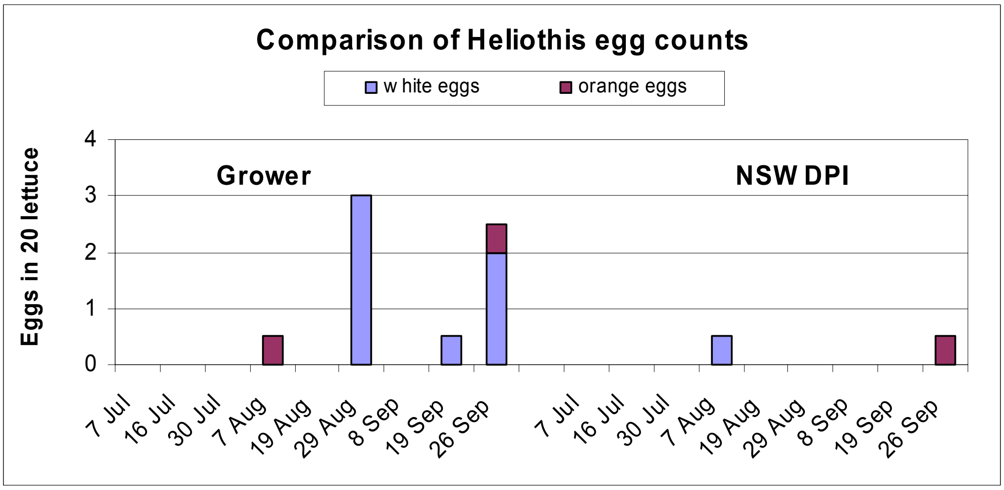
This trial was during spring and as expected, *Helicoverpa punctigera* predominated in pheromone trap catches (Figure 1).

Figure 1. Weekly catches of Heliothis moths in pheromone pot traps.



The number of heliothis eggs recorded per 20 plants was low throughout most of the crop's growth. The grower plot appeared to have higher counts on both the 29th of August and the 26th of September (Figure 2).

Figure 2. Weekly observations of moth egg counts (by age) sampled per 20 lettuce monitored for each treatment.



Relatively low numbers of larvae were found in the lettuce at each monitoring visit. At no times did the larval threshold exceed the level of one larva per 20 lettuce, according to NSW DPI's monitoring protocol for hearting lettuce (Figure 3). At harvest the NSW DPI plot had 12% of lettuce hearts damaged by heliothis compared to only 2% grub damage in the grower plot.

Figure 3. Weekly heliothis larvae numbers per 20 plants in the grower and NSW DPI plots.

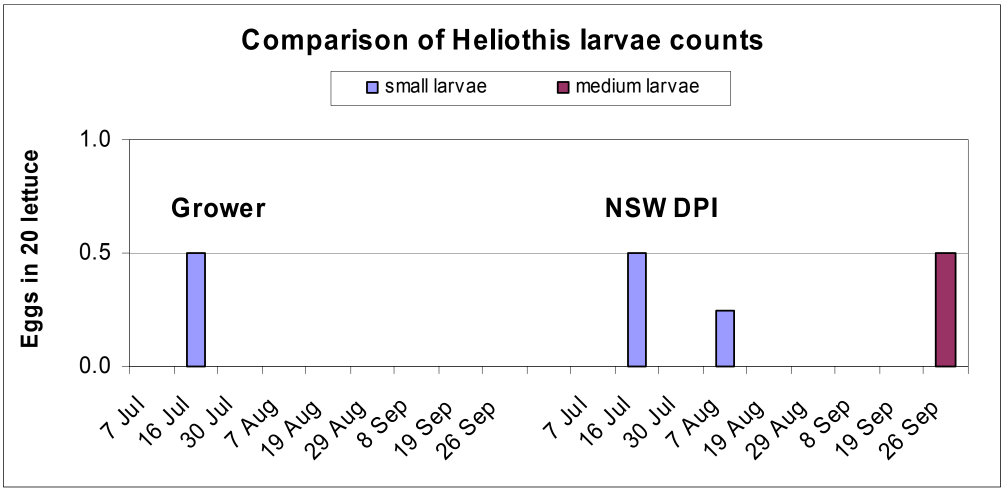


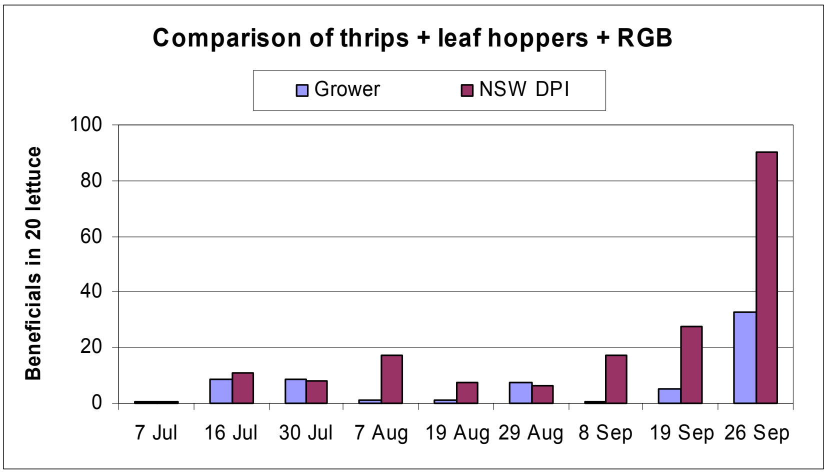
Table 1. Sprays and date of application for Grower and NSW DPI. plots

	Grower			NSW DPI		
Spray date	Chemical	Active	Target	Chemical	Active	Target
17/07/03	Dithane Rovral	mancozeb iprodione	fungus fungus	Dithane Rovral Sumisclex	mancozeb iprodione procymidone	fungus fungus fungus
1/08/03	Dithane Fastac	mancozeb alphacypermethrin	fungus heliothis +			
7/08/03				Sumisclex Pirimor	procymidone primicarb	fungus aphids
7/9/03	Dithane Sumisclex Fastac	mancozeb procymidone alphacypermethrin	fungus fungus heliothis +			
9/09/03				Dithane Sumisclex	mancozeb procymidone	fungus fungus
21/9/03	Sumisclex Fastac	procymidone alphacypermethrin	fungus Heliothis +	Sumisclex	procymidone	fungus
27/9/03				Lannate Fastac	methomyl alphacypermethrin	heliothis +

Heliothis + = registered for Heliothis but also shows activity on sap suckers and other caterpillars

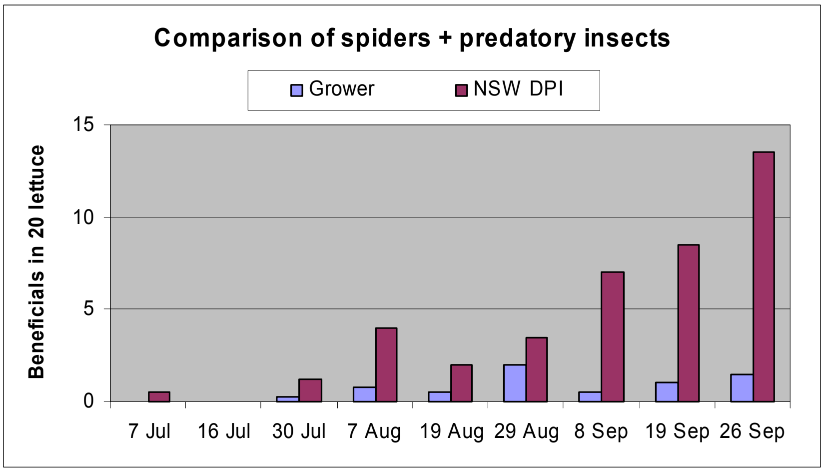
Aphid colonies were increasing in late July. By the months end, the 9 leaved, pre-hearted lettuce had some quite large aphid colonies. NSW DPI sprayed Pirimor® to reduce the numbers (Table 1), however some heavy frosts during the next week also equally reduced the aphid population in the growers plot. NSW DPI had consistently higher numbers of other sap sucking insect pests like thrips, leafhoppers and Rutherglen bugs (Figure 4). A spray of Fastac® and Lannate® a few days prior to harvest reduced sap sucking insect levels in the wrapper leaves in the NSW DPI plot to the same numbers of those in the grower plot. Besides heliothis, thrips were the only other insect to remain in the hearts at harvest. Harvest data from the stripping of lettuce hearts indicated numbers of 3 to 5 thrips per lettuce in both the NSW DPI plots and the grower plots.

Figure 4. Comparison of sucking insect pest numbers between the grower and NSW DPI treatment, i.e. the weekly counts of thrips, leafhoppers and Rutherglen bugs summed.



The most consistently seen beneficial organisms were spiders and carabid beetles. In the NSW DPI plot ladybird beetles (*Coccinella transversalis)*, red & blue beetles (*Dicranolaius bellulus)* and brown lacewings (*Micromus tasmaniae*) were seen on most monitoring days (Figure 5). These insects were very rarely seen in the grower plot. The grower treatment was the only plot to have dead carabid beetles recorded.

Figure 5. Spiders and beneficial insects recorded in 20 lettuce on each monitoring visit.



The data gathered at the harvest assessment indicated the grower had better heliothis control whilst NSW DPI had better sclerotinia control. 2% of lettuce in the grower plot had heliothis damage compared to 12% in the NSW DPI plot. Only 30% of these larvae could be found in the lettuce heart, so the clean up spray must have killed the majority, however the chewing damage was evident. The increased number of sap sucking insects in NSW DPI's plot did not affect the size of the lettuce at harvest. Both treatments had 2% of the lettuce showing symptoms of lettuce necrotic yellows virus. The grower plot had sclerotinia at an 8% level, compared to a 2% occurrence in the NSW DPI plot.

A comparison of spray treatments can be seen in Table 1. NSW DPI applied two early Sumisclex® sprays for sclerotinia control, and also a spray of Pirimor® for aphids. The grower used Fastac® for heliothis, thrips, leafhopper and Rutherglen bug control.

Table 1. Comparison of spray treatment costs.

	Grower			NSW DPI		
spray date	chemical	rate /ha	chem $/ha	chemical	rate /ha	chem $/ha
17/07/03	Dithane DF	2.200	$17.91	Dithane DF	2.200	$17.91
	Rovral	1.000	$38.50	Rovral	1.000	$38.50
				Sumisclex	0.600	$46.60
1/8/03	Dithane DF	2.200	$17.91			
	Fastac	0.400	$7.12			
7/08/03				Pirimor	1.000	$75.90
				Sumisclex	0.600	$46.60
7/09/03	Dithane DF	2.200	$17.91			
	Fastac	0.400	$7.12			
	Sumisclex	1.000	$77.66			
9/09/03				Dithane DF	2.200	$17.91
				Sumisclex	1.000	$77.66
21/09/03	Dithane DF	2.200	$17.91	Dithane DF	2.200	$17.91
	Fastac	0.400	$7.12	Sumisclex	1.000	$77.66
	Sumisclex	1.000	$77.66			
27/09/03				Lannate	2.000	$31.60
				Fastac	0.200	$3.56
TOTAL			$286.81			$451.80

Discussion

In this trial the grower treatment was the best management option for insect control, whilst the NSW DPI treatment gave better sclerotinia disease control.

The grower used Fastac® to control heliothis, thrips, leafhoppers and Rutherglen bugs each time the lettuces were sprayed. This broad spectrum insecticide negatively impacted on beneficial insect numbers in the lettuce crop, but it controlled the insect pests well. The continued use of an insecticide can lead to insect resistance. Insecticide resistance is less likely to develop in *H. punctigera*, the dominant heliothis species in spring at Hay, than in *H. armigera*. Because only a small proportion of *H. punctigera* populations are found in cropping areas any resistant individuals would have relatively little contribution to future populations. However from early summer onwards *H. armigera* is the dominant species in Hay and other lettuce growing areas, and most of their population are found in cropping areas so the potential for resistance developing and building in a population is very high. Resistance to synthetic pyrethroids and carbamates has been found in all *H. armigera* populations sampled from eastern Australia (Gunning *pers. com.*).

NSW DPI tackled the insect pests by monitoring to a protocol. At times, heavy rains and frosts impacted on insect activity. Not once did the monitoring data indicate an insecticide spray was necessary for heliothis. The harvest data indicated other wise, as the NSW DPI plot had 12% grub damage. The monitoring protocol used allows for up to 5% loss from grubs, assuming that 100% of the eggs produce a grub that successfully eats into the lettuce heart. On the 29/8/03 heliothis eggs were found above the threshold on the grower's plot, however no eggs were found in the NSW DPI plot and spray action was not taken. Heliothis moths do not lay eggs uniformly across a planting but are often found in patches, which suggests that sampling 40 or 80 lettuce was not sufficient on this occasion to find eggs. If these missed eggs were seen as larvae on the next monitoring visit and sprayed with a beneficial insect friendly spray NSW DPI may have reduced the grub damage to a level similar to the growers. The application of one newer generation chemistry insecticide would add an extra $70-100/ha for chemical.

The extra spray of Pirimor® NSW DPI applied to control the aphids, whilst preserving beneficial insects, turned out to be unnecessary as heavy frosts in south Hay kept the aphid population in check. It is possible that looking at the weather forecast for the following week may have predicted the frost and saved a spray.

By not using the cheaper, broad spectrum chemistry till near harvest, NSW DPI preserved beneficial insects throughout the crop's growth. The spiders, predatory beetles, damsel bugs and lacewings, however did not control heliothis, thrips, leafhoppers and Rutherglen bugs as well as the early Fastac® spray in the Grower plot. A clean up spray was still needed prior to harvest to reduce the live insect contamination of the consignment.

Twenty lettuces were completely stripped from each plot at harvest to determine lettuce heart live insect contamination. The NSW DPI plot had about 30% more thrips in the heart after the "clean up" spray, which made sense as throughout the hearting growth stage the NSW DPI plot had more than double the number of thrips than the grower plot. Live Rutherglen bugs may be a contamination issue in processed lettuce hearts, however thrips are such a small insect they may wash off easily or go through the processing unnoticed.

The early sprays of Sumisclex® by NSW DPI helped to prevent large losses from sclerotinia. The fungicide was applied early whilst the plants were at a pre-heart stage, especially after thinning and the few windy days in late July. Both thinning and wind damage, where the young lettuce rub the soil, can make damage sites where sclerotinia can attack. Late applications of Sumisclex® when the lettuces are wilting and showing symptoms of sclerotinia gives poorer disease control. Sprays for sclerotinia should also be made before the lettuce cover too much of the bed.

Acknowledgements

Thanks to Sam Ruberto from Ruberto's Vegetable Farm's for providing the trial site. This project was partially funded by Horticulture Australia and from AUSVEG levy funds.

Iceberg lettuce BMO II, Spring 2003 (Hay, NSW)

Andrew Creek, Sandra McDougall
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Introduction

This trial aimed to compare management of insect pests and diseases using an IPM protocol as defined by NSW DPI's Lettuce IPM team and Fontana Farm's current practice.

Materials and methods

The trial block was 'Greenway' variety lettuce direct seeded at the end of June 2003. The host for the trial was Fontana Farms, situated on Maude road Hay. The two main treatments in this BMO trial was "Grower" and "NSW DPI". The NSW DPI plot was randomly blocked and split into two treatments with four replicates. These two treatments being 400ml/ha Success® (spinosad) and 800ml/ha Success®.

The NSW DPI plot was 9 beds wide extending the full length of the lettuce planting (130m), totalling 0.175 ha. The trial began close to hearting so 40 lettuce were monitored from eight of the nine NSW DPI beds, one bed was left as a buffer. At each monitoring visit, (roughly every ten days), 40 plants were also monitored from the growers plot, although the grower was not provided with this data to make pest management decisions.

In the NSW DPI treatment a threshold of 1 egg or larvae in 20 plants was used to indicate whether the crop required treatment for heliothis. Sprays in the NSW Ag plot were applied with an overhead boom modified with droppers, with three T-Jet hollow cone nozzels (TXVK-8 conejet) directed per lettuce row and using an 800L/ha water rate. The grower used an overhead boom for spray applications.

Table 1. Sprays and date of application for Grower and NSW DPI Plots

	Grower			**NSW DPI**		
Spray date	Chemical	Active	Target	Chemical	Active	Target
10/09/03				Pirimor Sumisclex	*primicarb* *procymidone*	Aphids fungus
21/09/03	Fastac Sumisclex	*alphacypermethrin* *procymidone*	heliothis + fungus			
29/09/03	Lannate Ridomil gold MZ	*methomyl* *metalaxyl-m + mancozeb*	heliothis + fungus	Success Ridomil gold MZ	*spinosad* *metalaxyl-m + mancozeb*	heliothis fungus
10/10/03				Lannate	*methomyl*	heliothis +
11/10/03	Dominex Acrobat	*alphacypermethrin* *dimethomorph*	heliothis + fungus	Acrobat	*dimethomorph*	fungus

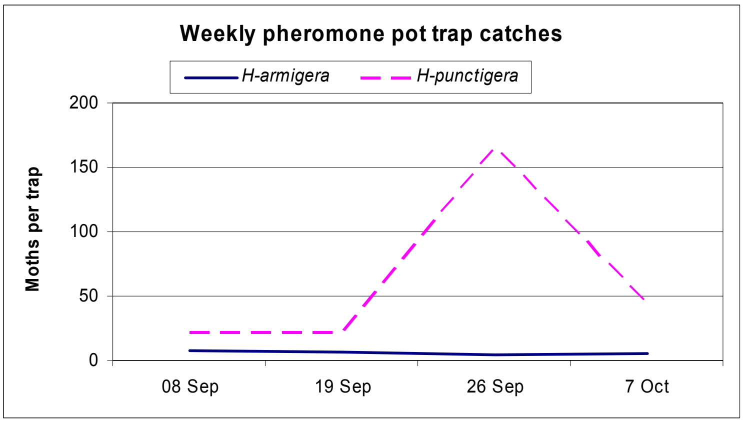
heliothis + = registered for heliothis but also shows activity on sap suckers and other caterpillars

At harvest, (17/10/2003), 70 plants were monitored and visually assessed in each plot for heliothis or other caterpillar damage, presence of sap sucking insects, beneficials and for the incidence of disease.

Results

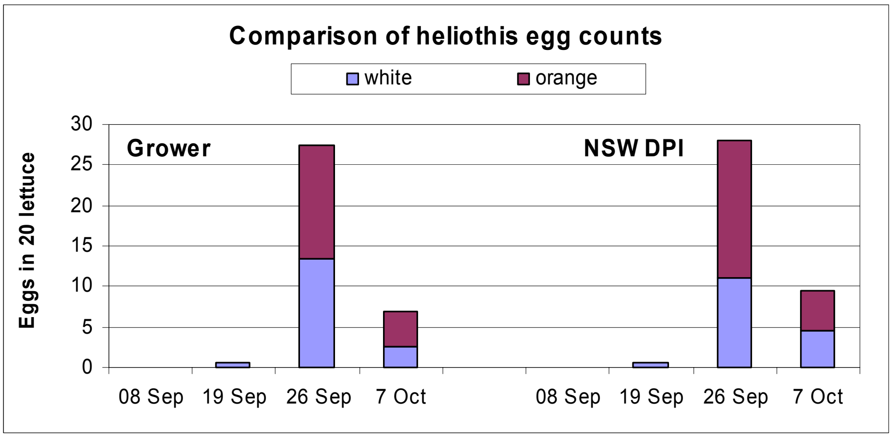
This trial was during spring and as expected *Helicoverpa punctigera* predominated in pheromone pot trap catches. (Figure 1)

Figure 1. Weekly catches of heliothis moths in pheromone pot traps.



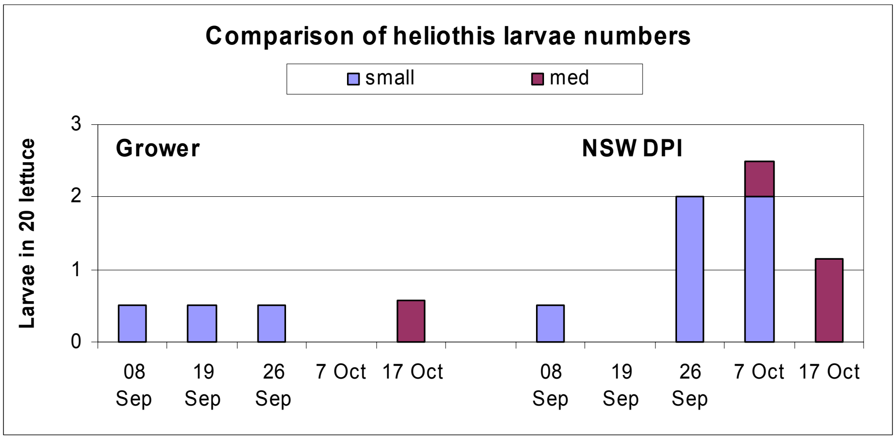
Heliothis eggs recorded per 20 plants were low throughout most of the growing season with a peak, sufficient to require control on the 26th of September (Figure 2). This correlated with the peak in moth catches (Figure 1), which suggests that the moth flight was soon after the 19th of September. As would be expected there was no real difference in egg counts between the grower plot and NSW DPI's plot.

Figure 2. Weekly observations of moth egg counts (by age) sampled per 20 lettuce monitored for each treatment.



Second instar larvae were actually found in the lettuce heart on 26th of September, suggesting an egg lay may have been missed during monitoring on 19th September. There were slightly more heliothis larvae in the NSW DPI plot, as we did not spray on the 21st September, where as the grower did (Figure 3). At harvest the grower had 3% grub damage compared to the 7% grub damage of the NSW DPI plot.

Figure 3. Weekly heliothis larval numbers per 20 plants in the grower and NSW Ag plots.



More than ¾ of the sap sucking insects in the grower plot were aphids, and the remainder were made up of thrips, leafhoppers and Rutherglen bugs (RGB). Early on in the trial the NSW DPI plot had considerably higher aphid numbers so an aphid insecticide was applied and this altered the sap sucking insect mix found in this plot. The NSW DPI plot had roughly equal numbers of aphids, thrips and leafhoppers and the remaining 10% of the sap suckers were Rutherglen bugs. Throughout the trial the grower plot had higher aphid numbers (Figure 4a). The NSW DPI plot had consistently higher numbers of thrips, leafhoppers and Rutherglen bugs as the insecticides used in these plots did impact on these insects. A spray of Lannate® prior to harvest on the NSW DPI plot sufficiently cleaned up these sap sucking insects (Figure 4b).

Figure 4a. Wingless aphid counts

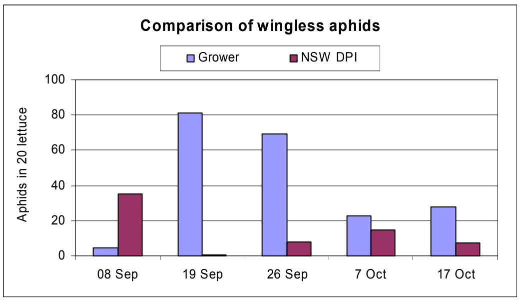
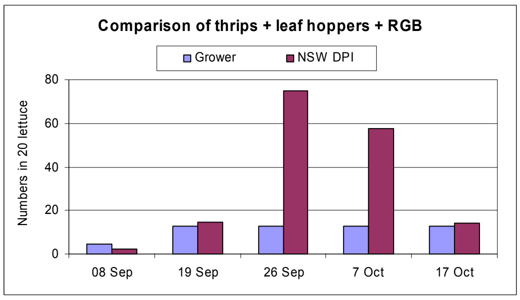
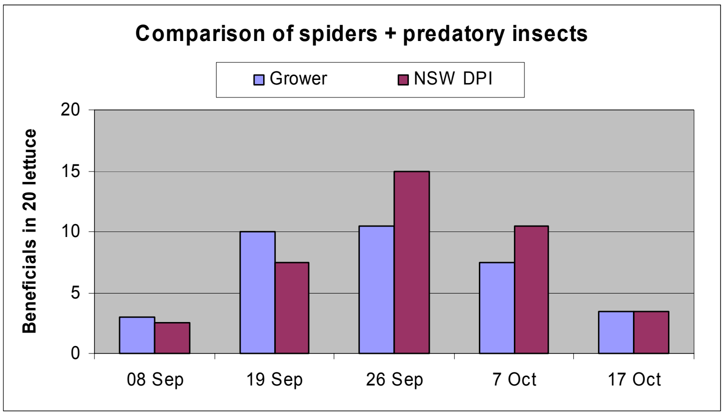


Figure 4b. Thrips, leafhopper and Rutherglen bug (RGB) counts



The NSW DPI plot had slightly more beneficial activity than the grower plot, however the broad spectrum spray of Lannate® prior to harvest equalised the numbers (Figure 5). More than 75% of the predators were spiders. Brown lacewings (*Micromus tasmaniae)* were the most commonly seen predatory insect, Red & blue beetles (*Dicranolaius bellulus)*, ladybird beetles (*Coccinella transversalis)* and carabid beetles were occasionally seen. Aphid parasitoid wasps (*Aphidiidae*) were also observed on most monitoring days.

Figure 5. Spiders and beneficial insects recorded in 20 lettuces on each monitoring visit



Data gathered from the 70 plants sampled at harvest indicated that the grower plot had 3% damage from heliothis compared to 7% in the NSW DPI plots. There was no difference in heliothis control between the 400ml/ha Success® and 800ml/ha Success® NSW DPI plots. There was no difference in lettuce size between the Grower and NSW DPI plots. There was also no difference between the treatments in sclerotinia infection and incidence of lettuce necrotic yellows virus.

A comparison of the spray treatments can be seen in Table 1 and 2. The grower used broad spectrum insecticides. Pirimor® is an aphid insecticide that has relatively short persistence and is soft on beneficials, whilst Success® is a newer generation insecticide that targets heliothis, whilst being softer on beneficials, when compared to Lannate® or Fastac®.

Table 2. Comparison of treatment costs

	Grower			NSW DPI		
spray date	chemical	rate /ha	chem $/ha	chemical	rate /ha	chem $/ha
10/09/03				Pirimor	1.000	$75.90
				Sumisclex	1.000	$77.66
21/09/03	Fastac	0.400	$7.12			
	Sumisclex	1.000	$77.66	Sumisclex	1.000	$77.66
29/09/03	Lannate	2.000	$31.60	Success	0.400	$66.88
	Ridomil gold MZ	2.500	$112.75	Ridomil gold MZ	2.500	$112.75
10/10/03				Lannate	2.000	$31.60
11/10/03	Dominex	0.400	$7.12			
	Acrobat	0.360	$101.38	Acrobat	0.360	$101.38
TOTAL			$337.63			$543.83

Discussion

In this trial the grower treatment turned out to be the best management option providing clearly better heliothis control and also being the cheaper spray option. The extra Sumisclex® spray NSW DPI plot received did not significantly enhance sclerotinia control.

The extra insecticide spray applied by the grower on the 21st of September killed heliothis larvae that must have been eggs that were missed in the previous weeks monitoring. This accounts for the difference of heliothis damage at harvest. Weather data indicates a week of warm – hot temperatures leading to the 26th of September, and the heliothis activity increased accordingly. On this monitoring visit there were 2nd instar heliothis larvae in the lettuce hearts. The NSW DPI plots showed that when targeting small larvae, with good spray coverage there was no difference in control levels between applying 400ml/ha Success® and 800ml/ha Success®.

It is hard to say wether the extra cost of the Pirimor® spray was worth it or not. The grower did not control the aphids, and late heavy frosts kept the aphid population below an economic damage threshold. On the other side, is the fact the NSW DPI plot had 8 times more wingless aphids than the grower plot at the start of the trial. The Pirimor® application significantly lowered the aphid population below that of the grower plot and it remained this way for the duration of the crop.

The because of the selective activity of the insecticides applied, the NSW DPI plots had consistently higher numbers of thrips, leaf hoppers and Rutherglen bugs. These extra sap sucker numbers did not impact on the final size or marketability of the lettuce. A broard spectrum spray of Lannate® a week prior to harvest controlled these pests.

Acknowledgements

Thanks to Anthony Perrotta from Fontana farms for providing the trial site. This project was partially funded by Horticulture Australia and from AUSVEG levy funds.

Iceberg lettuce BMO, Spring 2003 Trial 1(Cowra, NSW)

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Introduction

During the 2002/3 season lettuce growers in NSW central west were severely hit by lettuce mosaic virus. Weekly monitoring during the season had not shown a large influx of aphids at any time in the season, suggesting that the few winged aphids that were observed must have been very efficient vectors of the disease. In previous years various other viruses, including lucerne and turnip mosaic viruses have been observed in lettuce in the area and been responsible for significantly reduced yields (Kocanda *pers. com.*).

This trial aimed to compare management of insect pests and diseases using an IPM protocol as defined by NSW DPI's Lettuce IPM team and a grower's current practice.

Materials and methods

The trial block included 'Target' (hearting) and 'Cosmic' (cos) varieties of lettuce transplanted early in September 2003. The trial site was situated on the Forbes road, near Gooloogong in the southern tablelands of NSW. The two treatments in this BMO trial were "Grower" and "NSW DPI".

The NSW DPI plot was situated on the south-eastern end of the lettuce block. The plot was 13 beds wide and extending 60 metres down the lettuce rows, totalling 0.120ha. Monitoring began when the lettuce plants were seedlings, about a week after transplanting. 80 lettuce were monitored during the seedling and preheart stage, whilst 40 lettuce were monitored from hearting until harvest. Monitoring data was not gathered from a 20m buffer between the grower and NSW DPI plot. The plots were monitored to a protocol every week. The grower was not provided with gathered data to make pest management decisions.

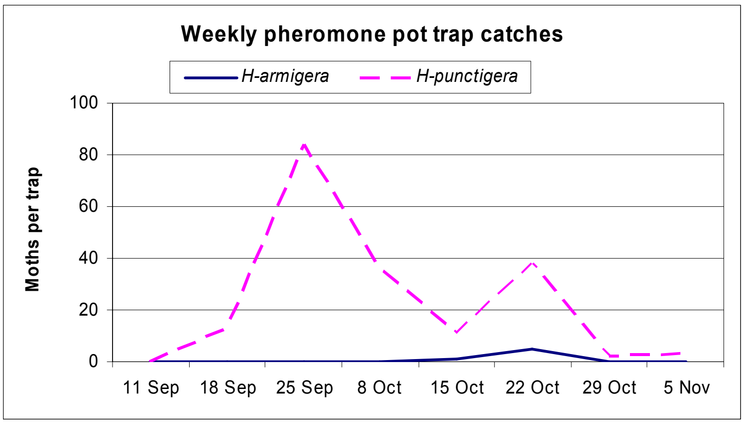
In the NSW DPI treatment a threshold of 1 egg or larvae in 20 plants was used to indicate whether the crop required treatment for heliothis. In this trial all the sprays in the NSW DPI plot were applied by the grower with an overhead boom fitted with hollow cone nozzles, using an 800L/ha water rate.

At harvest 100 lettuce were visually assessed in each plot for heliothis or other caterpillar damage and also scored for size and disease. Diseases scored included lettuce big vein virus, sclerotinia, lettuce mosaic virus and lettuce necrotic yellows.
After harvest 400 plant sites were monitored from each plot to determine scores for the unharvested lettuce. Factors score from these unmarketable lettuce included size, sclerotinia, sun burn, heliothis damage, speckled wrap leaves and bacterial soft rot.

Results

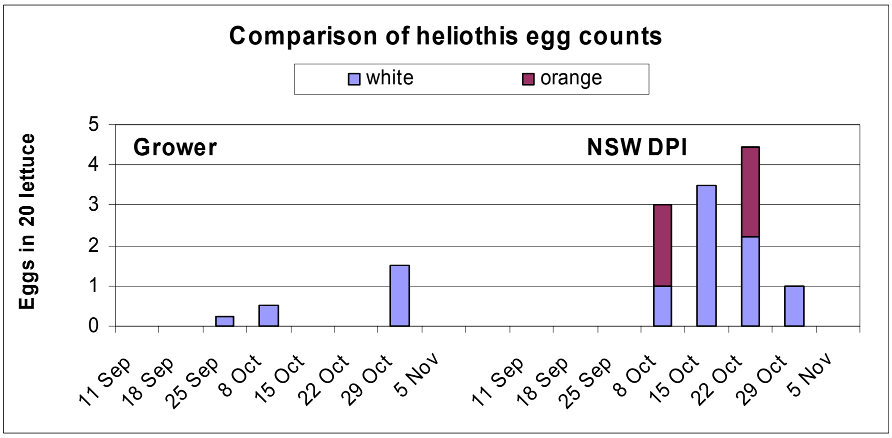
Helicoverpa punctigera dominated in pheromone trap catches because the trial was during spring (Figure 1). *Helicoverpa armigera* tend to dominate moth trappings over late summer and autumn periods.

Figure 1. Weekly catches of heliothis moths in pheromone pot traps.



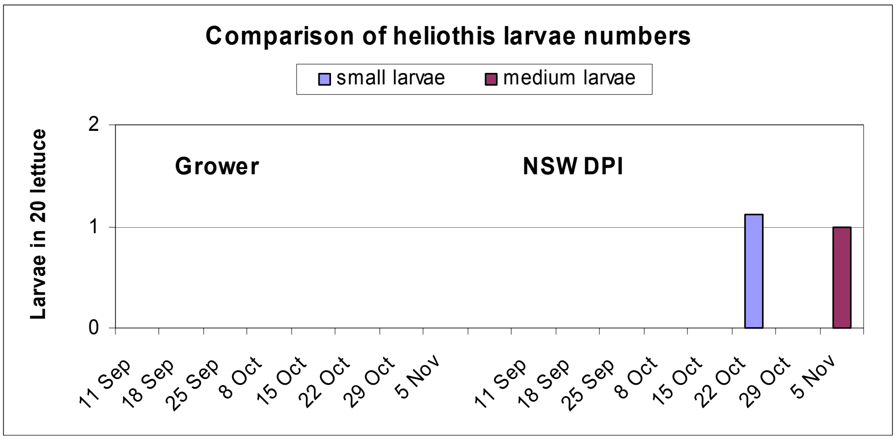
The numbers of heliothis eggs recorded per 20 plants was low throughout most of the crop's growth. The NSW DPI plot appeared to have higher heliothis egg counts during hearting than the grower plot (Figure 2). On three occasions NSW DPI plot had egg numbers greater than 1 egg in 20 lettuce, some of these were incidences where one lettuce may have had 2 or 3 eggs.

Figure 2. Weekly observations of moth egg counts (by age) sampled per 20 lettuce monitored for each treatment.



Heliothis larvae were not found in the grower plot. Small heliothis larvae were found in the NSW DPI plot on the 22nd of October, whilst the lettuces were hearting (Figure 3). On two occasions in the DPI plot the heliothis larvae numbers were equal to the threshold level of 1 larva per 20 lettuces.

Figure 3. Weekly heliothis larval numbers per 20 plants in the grower and NSW DPI plots.



NSW DPI sprayed once for heliothis, on 22nd of October (Table 1.). At harvest the NSW DPI plot had 5% of lettuce hearts damaged by heliothis compared to 0.5% grub damage in the grower plot. There was no heliothis damage in the cos lettuce

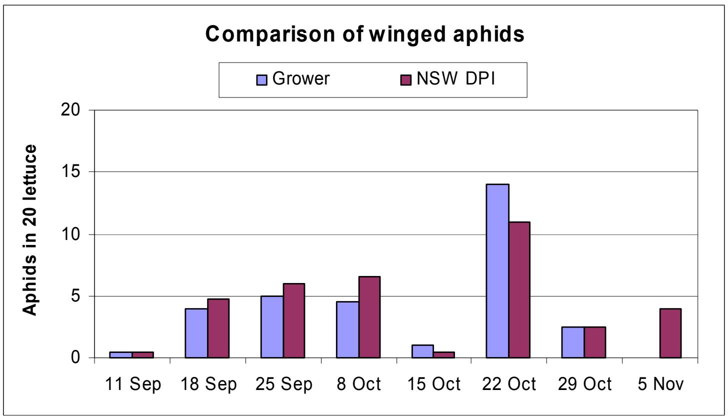
Table 1. Sprays and date of application for Grower and NSW DPI. plots

	Grower			**NSW DPI**		
Spray date	Chemical	Active	Target	Chemical	Active	Target
21/09/03	Rogor	*dimethoate*	Sap sucking insects	Rogor	*dimethoate*	Sap sucking insects
2/10/03	Dithane Sertin	*mancozeb* *sethoxydim*	fungus herbicide	Dithane Sertin	*mancozeb* *sethoxydim*	fungus herbicide
10/10/03	Dithane Lannate Pirimor	*mancozeb* *methomyl* *primicarb*	fungus heliothis + aphids			
22/10/03	Ridomil - Gold MZ Lannate Pirimor	*metalaxyl-M* + *mancozeb* *methomyl* *primicarb*	Fungus heliothis + Aphids	Ridomil - Gold MZ Lannate Pirimor	*metalaxyl-M* + *mancozeb* *methomyl* *primicarb*	fungus heliothis + aphids
1/11/03	Rogor	*dimethoate*	Sap sucking insects			

heliothis + = registered for heliothis but also shows activity on sap suckers and other caterpillars

Winged aphid numbers did not appear to vary much between the plots (Figure 4). The first Dimethoate spray applied on 21st September was not supposed to go on the NSW DPI block, however it did not appear to have much impact on the numbers of winged aphids. Similarly the Pirimor® spray on 10th of October in the grower's plot had a negligible effect 5 days later. The Dimethoate spray in the grower's plot on 1st of November did however knockout the few winged aphids compared to NSW DPI's plot. Spraying insecticides for migrating winged aphids may only kill the aphids present and hence have a short term effect on overall numbers a few days later. Wingless aphid colonies did not establish and lettuce mosaic virus was not recorded in the trial site.

Figure 4. Winged aphid numbers recorded in 20 lettuce plants.



NSW DPI had consistently higher numbers of other sap sucking insect pests like thrips, leafhoppers and Rutherglen bugs (Figure 5). Leafhoppers were by far the most common sap sucking insect pest. At times the lettuce plants had leaf speckling damage, you could touch a lettuce and 10 to 15 leafhoppers would jump away (Image 1). The grower sprayed three times for leafhoppers and NSW DPI sprayed just the once, the effects of which can be seen on 29th October (Figure 5). By harvest the NSW DPI plot had up to 20 leafhoppers per lettuce. Inspection of harvested lettuce from the cool room indicated several leafhoppers remained in the hearts of each lettuce after harvest.

Figure 5. Comparison of sucking insect pest numbers between the grower and NSW DPI treatment, i.e. the weekly counts of thrips, leafhoppers and Rutherglen bugs summed.

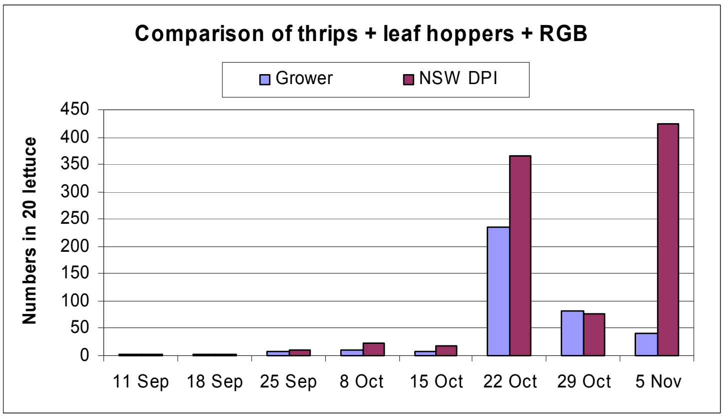
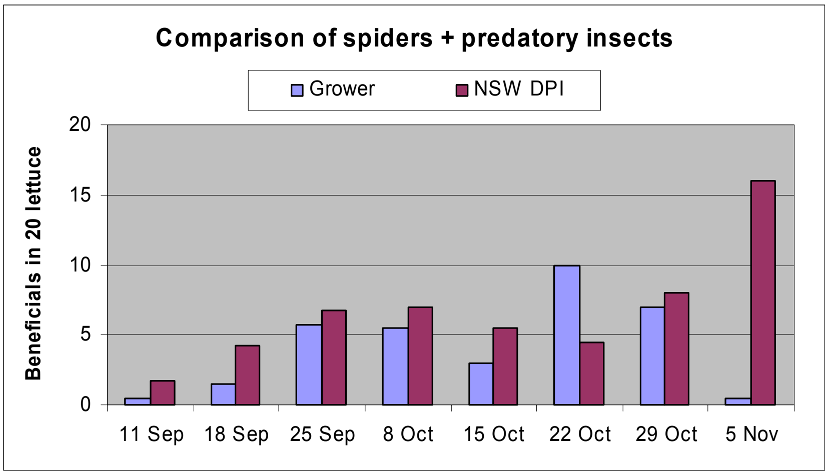


Image 1. Copmarison of leaf hopper damage to lettuce seedlings.
Left - lettuce with leaf hopper speckling, Right – undamaged lettuce, grower's plot

The most consistently seen predators were spiders. The mix of beneficial insects varied each monitoring visit. Wasps, brown lacewings (*Micromus tasmaniae)*, nabids and carabid beetles were present on most monitoring occasions. Prior to harvest white collared ladybird beetles (*Hippodamia variegata)* migrated into the crop, boosting the beneficial insect numbers (Figure 5). The beneficial insect mix was similar in both plots throughout most of the lettuce crop's growth, until near harvest when a spray of dimethoate clearly killed all the insects and spiders in the grower plot. The higher beneficial count in the grower plot on 22nd October is accounted for by more wasps seen in this plot, wasps are mobile insects.

Figure 5. Comparison of spiders and beneficial insects for each monitoring visit.



The data gathered at the harvest assessment indicated 40% of the lettuce was unmarketable from the NSW DPI plot compared to 26% form the grower plot. In both plots 15% was lost from sclerotinia, 5% undersized and another 5% loss due to sunscald and bacterial soft rot. The NSW DPI plot had extra yield loss caused by leafhopper damage (10%) and heliothis damage (5%). The NSW DPI plot also appeared to have smaller lettuce. Lettuce mosaic virus, lettuce necrotic yellow virus and big vein virus were not present in any lettuce.

The NSW DPI plot had a greater incidence of downy mildew than the grower plot, 3 in 20 lettuces compared to 1 in 20 lettuce infected.

A comparison of spray treatments and their costs can be seen in Table 2. The early dimethoate was targeting aphids and leafhoppers in the grower plot and accidentally went onto the NSW DPI plot. After this, NSW DPI applied only one broad spectrum insecticide, (Lannate®) late in the crop. This spray targeting leafhoppers and heliothis was delayed to a later period in the crops development to prolong the beneficial insect activity. Tank mixed into this spray was also Pirimor , an aphid insecticide that was applied to target the migrating winged aphids that may have had lettuce mosaic virus. The grower plot had three extra insecticide sprays and one extra protective fungicide applied.

Table 2. Comparison of spray treatment costs.

	Grower			NSW DPI		
spray date	Chemical	rate /ha	chem $/ha	Chemical	rate /ha	chem $/ha
21/09/03	Dimethoate	0.750	$8.55	Dimethoate	0.750	$8.55
2/10/03	Dithane DF	2.200	$17.91	Dithane DF	2.200	$17.91
	Sertin			Sertin		
10/10/03	Dithane DF	2.200	$17.91			
	Lannate	2.000	$31.60			
	Pirimor	0.500	$37.95			
22/10/03	Ridomil Gold MZ	2.500	$112.75	Ridomil Gold MZ	2.500	$112.75
	Lannate	2.000	$31.60	Lannate	2.000	$31.60
	Pirimor	0.500	$37.95	Pirimor	0.500	$37.95
1/11/03	Dimethoate	0.750	$8.55			
TOTAL			$304.77			$208.76

Discussion

The large numbers of leafhoppers in the trial caused speckling damage to the lettuce, especially the wrapper leaves. The lettuce appeared older and not a fresh green colour because of the speckling and callusing (Image 2 & 3). This speckling damage varies on the effect of whether it is a marketing problem or not. When the price is high, approximately $10 a box at the time of the trial, most of the lettuces could be sold, however if the price was low lettuce with speckled wrapper leaves may be difficult to sell. The leafhoppers and heliothis did not cause any damage to the cos lettuce.

The NSW DPI plot had more heliothis damaged lettuce than the grower in this trial. This may be explained by the fact the NSW DPI plot had greater heliothis pressure and was also the only plot to have larva recorded. Both plots received the Lannate® spray on the 22nd of October and there is no reason why it would work on the grower plot and not the NSW DPI plot. As the NSW DPI plot was on the edge of the paddock, it is possible that this plot was exposed to higher heliothis pressure, an edge effect.

The winged aphids appeared not to be a problem spring 2003 as they were not transmitting lettuce mosaic virus. The Pirimor® sprays were unnecessary, but could have also been cheap insurance if virus turned out to be around.

There was not a great difference between the two treatments in beneficial insect numbers because NSW DPI had applied broad spectrum insecticides to try and reduce the leafhopper numbers.

The extra protective Mancozeb applied on the grower plot on the 10th of October can be the only reason why the downy mildew infection was higher in the NSW DPI plot. This highlights the importance of regular protective spray programs when the conditions for disease development are present. Even though the NSW DPI plot had a systemic fungicide applied the following week, the disease may have been established and harder to control.

In this trial an earlier spray of a fungicide for sclerotinia may have helped to reduce the losses from sclerotinia. The best management option for this crop would have been a Sumisclex® spray after the crop was established with the sprinklers and switched to drip irrigation, plus the grower's sprays to prevent downy mildew & control the leafhoppers. A cost saving could have been made by leaving out the Pirimor®.

Iceberg lettuce BMO, Spring 2003 Trial 2 (Cowra, NSW)

Introduction

This trial aimed to compare management of insect pests and diseases using an IPM protocol as defined by NSW DPI's Lettuce IPM team and a grower's current practice. This second BMO trial was initiated because in the first trial broad spectrum chemicals were used. These chemicals impacted negatively on the possible beneficial insect population. In this second trial we aimed to preserve beneficials in the lettuce crops ecosystem. This trial also had a small plot within the NSW DPI plot where Pirimor® was not sprayed to control the winged aphids, this aimed to determine whether it was necessary to manage winged aphids for virus management in the central west of NSW.

Materials and methods

The trial block included 'Target' (hearting) and 'Cosmic' (cos) varieties of lettuce transplanted mid September 2003. The rial site was, situated on the Forbes road, near Gooloogong in the southern tablelands of NSW. The two treatments in this BMO trial were "Grower" and "NSW DPI". The NSW DPI plot also had a 6 metre plot within it where winged aphids were not controlled.

The NSW DPI plot was situated on the south east end of the lettuce block, right along side the first BMO trial. The NSW DPI plot was 13 beds wide and extended 70 metres down the lettuce rows, totalling 0.137ha. Monitoring began when the lettuce plants were seedlings, about a week after transplanting. 80 lettuce were monitored during the seedling and preheart stage, whilst 40 lettuce were monitored from hearting until harvest. Monitoring data was not gathered from a 20m buffer between the grower and NSW DPI plot. The plots were monitored to a protocol every week. The grower was not provided with gathered data to make pest management decisions.

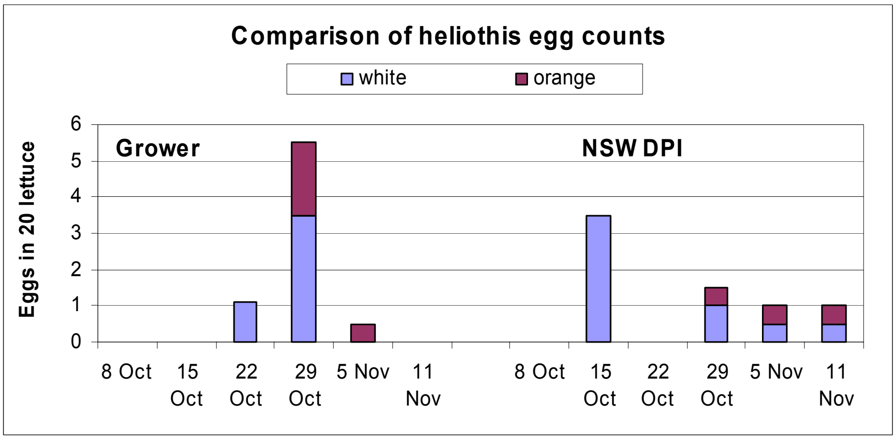
In the NSW DPI treatment a threshold of 1 viable egg or larvae in 20 plants was used to indicate whether the crop required treatment for heliothis. Sprays in the NSW DPI plot were applied with an overhead boom modified with droppers. Three T-Jet hollow cone nozzles (TXVK-8 conejet) were directed over each lettuce row, applying a 800L/ha water rate. The grower used an overhead boom for spray applications, which was also fitted with hollow cone nozzles.

Just prior to harvest 100 lettuces were visually assessed in each plot for heliothis or other caterpillar damage, leafhopper damage and also scored for size and disease. Diseases scored included lettuce big vein virus, sclerotinia, lettuce mosaic virus, lettuce necrotic yellows virus and bacterial soft rot.

Results

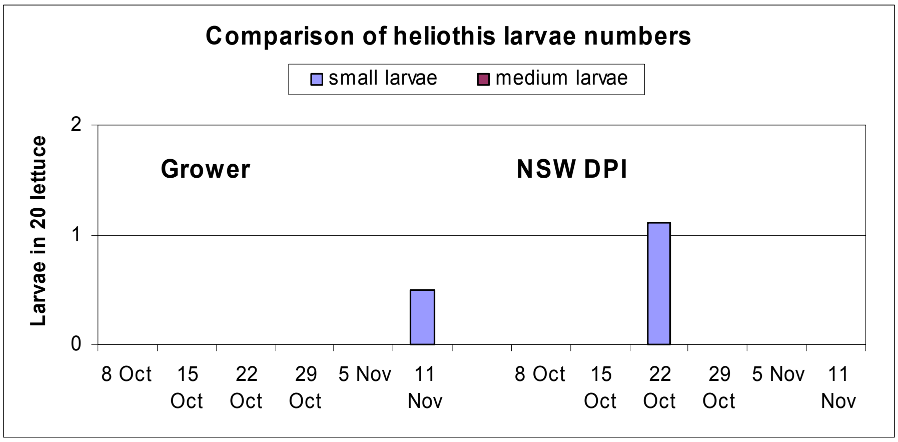
This trial was during spring and as expected, *Helicoverpa punctigera* dominated in pheromone trap catches (Figure 1). Heliothis eggs recorded per 20 plants were low throughout most of the crop's growth. The highest heliothis egg lays were between the 15th and 29th of October (Figure 6). Although the graph indicates on a number of occasions where plots had egg numbers greater than 1 egg in 20 lettuce, some of these were incidences where one lettuce may have had 2 or 3 eggs. NSW DPI did not necessarily spray in these cases as only 1 lettuce would be damaged in the 20, also as it was spring, late frosts were having an impact on heliothis egg and small larvae survival.

Figure 6. Weekly observations of moth egg counts (by age) sampled per 20 lettuce monitored for each treatment.



In the NSW DPI plot, heliothis larvae exceeded the protocol threshold level of one larva per 20 lettuce on the 22nd of October (Figure 7), so Success®, a newer generation insecticide that is soft on beneficials was applied (Table 3). The grower's plot seemed to have less heliothis pressure.

Figure 7. Weekly heliothis larval numbers per 20 plants in the grower and NSW DPI plots.



NSW DPI sprayed once for heliothis, whilst the grower sprayed twice. At harvest the NSW DPI plot had 1% of lettuce hearts damaged by heliothis compared to nil grub damage in the grower's plot. None of the Cos lettuce hearts were damaged by heliothis in either plot.

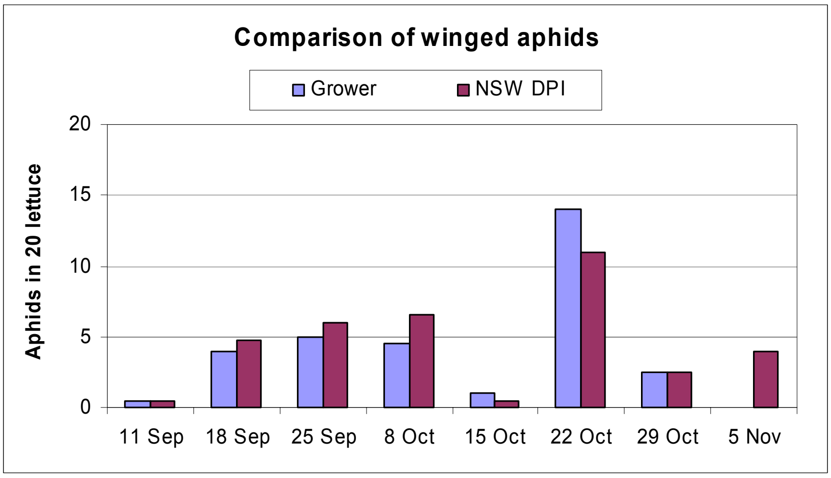
Table 3. Sprays and date of application for Grower and NSW DPI. plots

	Grower			**NSW DPI**		
Spray date	Chemical	Active	Target	Chemical	Active	Target
2/10/03	Dithane Sertin	*mancozeb* *sethoxydim*	fungus herbicide	Dithane Sertin	*mancozeb* *sethoxydim*	fungus herbicide
10/10/03	Dithane Lannate Pirimor	*mancozeb* *methomyl* *primicarb*	fungus heliothis + aphids			
22/10/03	Ridomil - Gold MZ Lannate Pirimor	*metalaxyl-M + mancozeb* *methomyl* *primicarb*	Fungus heliothis + Aphids	Ridomil - Gold MZ Success Pirimor	*metalaxyl-M +mancozeb* *methomyl* *primicarb*	fungus heliothis aphids
1/11/03	Rogor	*dimethoate*	Sap sucking insects			
8/11/03	Rogor	*dimethoate*	Sap sucking insects			

heliothis + = registered for heliothis but also shows activity on sap suckers and other caterpillars

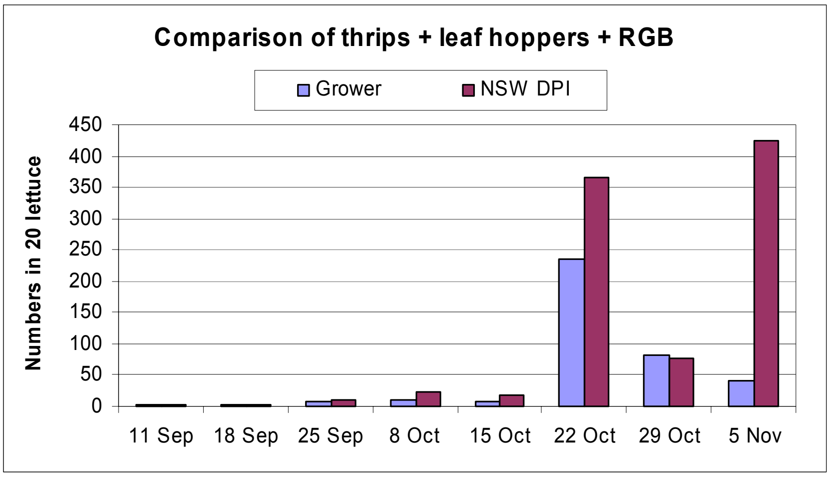
Winged aphid numbers recorded on the lettuce peaked on the 22nd October with an aphid on every second plant (Figure 8). At this stage NSW DPI decided to spray their plot in case these aphids were carrying virus (Table 3). A small plot was left unsprayed with the aphid insecticide to determine the effect of the spray in virus management. The effects of the grower's aphid sprays can be seen, with the grower having fewer aphids recorded on 15th October, 5th November and the 11th of November. Wingless aphid colonies did not establish and lettuce mosaic virus was not recorded in any of the trial plots at harvest, including the small plot where the aphids were never sprayed. Although every second lettuce had a winged aphid at one stage, no lettuces developed symptoms. The aphid sprays were not necessary.

Figure 8. Comparison of winged aphid numbers recorded in 20 lettuce plants.



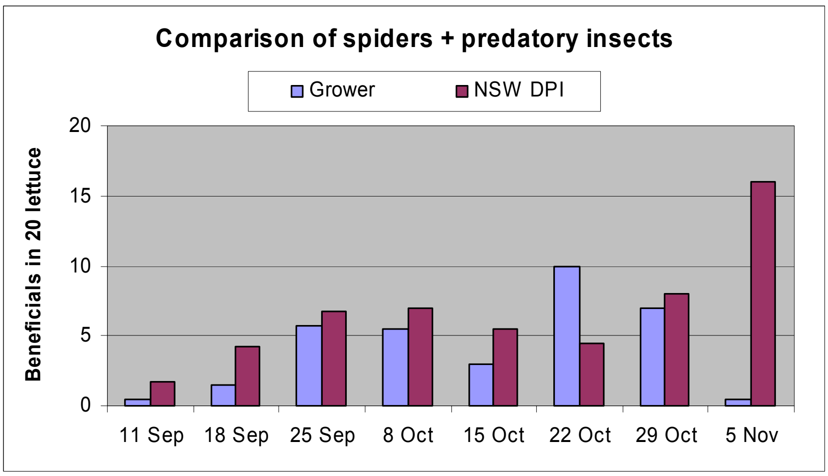
The NSW DPI plot generally had higher numbers of other sap sucking insect pests like thrips, leafhoppers and Rutherglen bugs (Figure 9). Leafhoppers were by far the most common sap sucking insect pest. From hearting onwards the lettuces were attractive and numbers rapidly increased to 10-15 leafhoppers per plant. By harvest this number was up to 20 leafhoppers per lettuce in the NSW DPI plot. In figure 9, the sap sucker numbers were the same in both plots on the 29th of October. On this day NSW DPI still had greater numbers of leafhoppers, however Rutherglen bugs had migrated heavily into the crop and for some reason the grower plot had 50% more, equalising the total sap sucker count. Figure 9 also shows how the grower's dimethoate sprays kept insect activity low in the later stages of the lettuce crop.

Figure 9. Comparison of sucking insect pest numbers between the grower and NSW DPI treatment, i.e. the weekly counts of thrips, leafhoppers and Rutherglen bugs summed.



The beneficial insect population was slow to build up. By hearting differences could be seen between the grower and the NSW DPI plot because the broad spectrum insecticide sprays the grower was applying were having an impact on beneficials, (Figure 10). The NSW DPI plot had more predatory beetles including, (red and blue beetles, transverse lady bird beetles, minute two spot ladybird and white collared ladybird beetles), brown lacewings, nabids and spiders. Spiders were the most consistently seen predator. On the 11th of November half of the beneficial insect count was white collared ladybird beetles that had migrated into the lettuce crop.

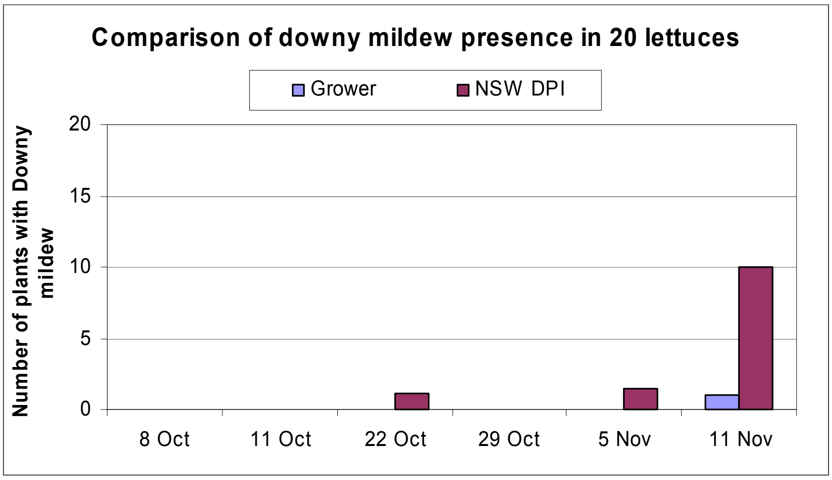
Figure 10. Comparison of spiders and beneficial insects recorded in 20 lettuces



The data gathered at the harvest assessment indicated 27% of the lettuce were assessed unmarketable or damaged from the NSW DPI plot compared to 18% form the grower plot. There were similar losses caused by sclerotinia in both plots (10%). Undersized lettuce was the next greatest loss, 7% grower and 12% NSW DPI. The NSW DPI plot appeared to have smaller lettuce. Losses from sunscald and bacterial soft rot were negligible in both plots. Lettuce mosaic virus, lettuce necrotic yellow virus and big vein virus were not present in any lettuce.

The extra yield loss in the NSW DPI plot were caused by leafhopper damage (7%) and the greater numbers of small lettuce. The difference in the number of heliothis damaged lettuces was negligible between treatments. At harvest the 50% of the plants in the NSW DPI plot had downy mildew present compared to only 5% of the lettuce in the grower's plot (Figure 11).

Figure 11. Comparisons of downy mildew presence in the grower and NSW DPI treatments.



A comparison of spray treatments and their costs can be seen in Table 4. The growers Lannate® sprays were targeting leaf hoppers and heliothis, whilst the Pirimor® targeted winged aphids. The dimethoate sprays were targeting aphids and leaf hoppers. NSW DPI used Success® for heliothis control. The grower plot had four more insecticide sprays and one extra protective fungicide applied than the NSW DPI plot.

Table 4. Comparison of spray treatment costs.

	Grower			NSW DPI		
spray date	chemical	rate /ha	chem $/ha	chemical	rate /ha	chem $/ha
2/10/03	Dithane DF	2.200	$17.91	Dithane DF	2.200	$17.91
	Sertin			Sertin		
10/10/03	Dithane DF	2.200	$17.91			
	Lannate	2.000	$31.60			
	Pirimor	0.500	$37.95			
22/10/03	Ridomil Gold MZ	2.500	$112.75	Ridomil Gold MZ	2.500	$112.75
	Lannate	2.000	$31.60	Success	0.400	$66.88
	Pirimor	0.500	$37.95	Pirimor	0.500	$37.95
1/11/03	Dimethoate	0.750	$8.55			
8/11/03	Dimethoate	0.750	$8.55			
TOTAL			$304.77			$235.49

Discussion

The best management option in this trial was essentially what the grower did. Regular protectant fungicide sprays for downy mildew and an application of a systemic fungicide when the first signs of the disease were present. Using the cheaper broad spectrum chemistry to control the heliothis (*Helicoverpa punctigera*), and selecting chemistry that also killed the leafhoppers was a cost effective option. When the heliothis pressure was off due to frost and rain, using dimethoate to control both the winged aphids and the leafhoppers was another cost effective option. Further yield increases may have been made by applying a fungicide early in the crop's growth to prevent sclerotinia. Addition of droppers to the grower's present boom given the present growing situation would increase chemical coverage and efficacy.

The large numbers of leafhoppers in the trial caused speckling damage to the lettuce in both trials, especially the wrapper leaves. The lettuce appeared older and not a fresh green colour because of the speckling and callusing (Image 2 & 3). The speckling damage would be a problem if market demand for lettuce were low. At the time of the trials the price for lettuce was $10 so most of the speckled lettuce was marketable. It is interesting to note that the speckled lettuces from trial 1 were not marketable, however the following week similarly speckled lettuce from trial 2 were marketable.

Image 2. Left close up of leafhopper damage to lettuce leaf at harvest. Right a healthy lettuce leaf.

Image 3. Left, An older looking lettuce from the NSW DPI plot at harvest and Right, a fresh looking lettuce from the grower plot.

The drop in leaf hopper numbers on 29th of October in the NSW DPI plot trial 2 may because of the fact that Lannate® was sprayed all around the plot. As leaf hoppers are mobile insects many would have migrated to the cleaner lettuce over the next week, reducing the numbers in the NSW DPI plot.

The leafhopper damage has been buffered in these trials because these plots are small, a proportion of leaf hoppers would have migrated to the surrounding lettuce in the grower plot & be killed. The true effects of leaf hoppers left uncontrolled have not been shown.

The greater proportion of small lettuce in the NSW DPI plots could be an effect from the constant feeding by the leafhoppers. The downy mildew infection could have also limited the size of the lettuces.

Lettuce mosaic virus did not show up in any of the trials even though we had one winged aphid in every two lettuces. We cannot be certain why virus was not present this year. In the spring of 2002, where virus pressure turned out to be high, at times the winged aphid population averaged 2 to 3 aphids per lettuce. We cannot be certain wether or not winged aphids are carrying virus or not, so if the area has a history of virus disease, the best option may be to control migrating aphids to prevent movement from plant to plant.

The beneficial insect population increased with the pest numbers, however beneficials alone were unable to prevent the leafhopper damage to the lettuce. A chemical spray to control leafhoppers, yet be relatively soft on beneficial insects is needed to achieve quality lettuce whilst preserving the beneficial insects. Pests needed to be selectively controlled to give the beneficials the upper hand. In these small trials the maximum benefit from beneficial insects may not be attained. It took time for the beneficials to build up in a small plot that was essentially surrounded by an insect desert. If there were beneficials in surrounding blocks, numbers may have been greater in the trial plot.

Heliothis caused 5% losses in the NSW DPI plot in trial one, yet in the second trial, heliothis had caused only negligible losses in a plot that was adjoining and also sprayed on the same date as the first trial. Why? Is it the droppers, or the Success® or the edge effect of the heliothis pressure?

In the second trial an edge effect cannot be seen with the heliothis, both plots had similar heliothis pressure. The rain and some heavy late frosts impacted on the heliothis activity, resulting in a spring with relatively low heliothis larvae pressure. Few sprays were required for heliothis control and both management options displayed similar heliothis control at harvest.

In the second trial the downy mildew was clearly worse in the NSW DPI plot. The extra protective mancozeb applied on the grower plot on the 10th of October is the only difference. This highlights the importance of regular protective spray programs when the conditions for disease are right. Even though the NSW DPI plot had a systemic fungicide applied the following week, the disease may have been established and harder to control.

Acknowledgements

Thanks to James Schembri for providing the trial site. Thanks to Greg Kocanda for monitoring assistance and Meryl Snudden for helping with the harvest assessment. This project was partially funded by Horticulture Australia and from AUSVEG levy funds.

Iceberg lettuce BMO, Spring 2003 Trial 3 (Canowindra, NSW)

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Introduction

This trial aimed to compare management of insect pests and diseases using an IPM protocol as defined by NSW DPI's Lettuce IPM team and growers, current practice.

Materials and methods

The trial block was 'Assassin' variety lettuce transplanted at the start of September 2003. The host for the trial site was situated on the Eugowra road, near Canowindra in the southern tablelands of NSW. The two treatments in this BMO trial were "Grower" and "NSW DPI".

The NSW DPI plot was 5 beds wide extending the full length of the lettuce planting (120m), totalling 0.1ha. Monitoring began just after transplanting. 80 lettuce were monitored during the seedling and preheart stage, whilst 40 lettuce were monitored from hearting until harvest. Data was only gathered from 4 of the NSW DPI beds, leaving one as a buffer between the plots. Monitoring visits were every seven days and the grower was not provided with data gathered to make pest management decisions.

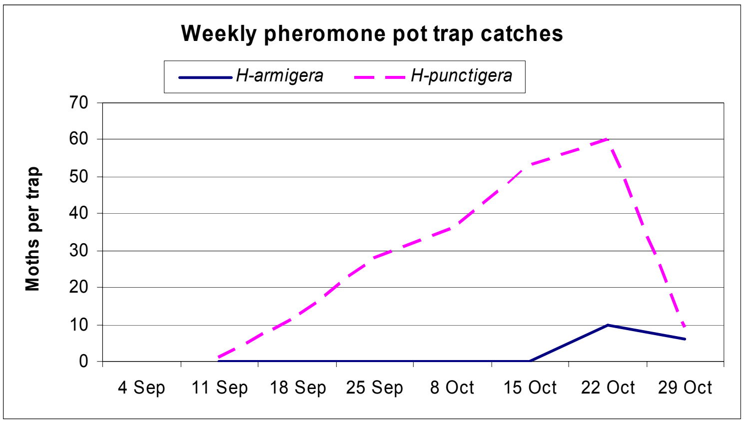
In the NSW DPI treatment a threshold of 1 egg or larvae in 20 plants was used to indicate whether the crop required treatment for heliothis. Sprays in the NSW DPI plot were applied with an overhead boom with a T-Jet twin fan nozzle (TJ60-11004VS) directed over each lettuce row and using an 800L/ha water rate. The grower used an overhead boom with hollow cone nozzles for spray applications.

Prior to the first harvest, 100 lettuce were visually assessed in each plot for downy mildew presence. At this time 40 lettuce from each plot were also monitored for heliothis or other caterpillar damage, aphid contamination and other sap sucking insect contamination. After the first cut, another 40 lettuce from each plot was monitored to the protocol to determine insect and disease occurrence. A group of 20 plants at 20 different locations within each plot, totalling 400 plants were monitored to determine the percentage of lettuce harvested in the first cut, and of those lettuce unharvested how many had sclerotinia, big vein virus, lettuce mosaic virus or heliothis damage.

Results

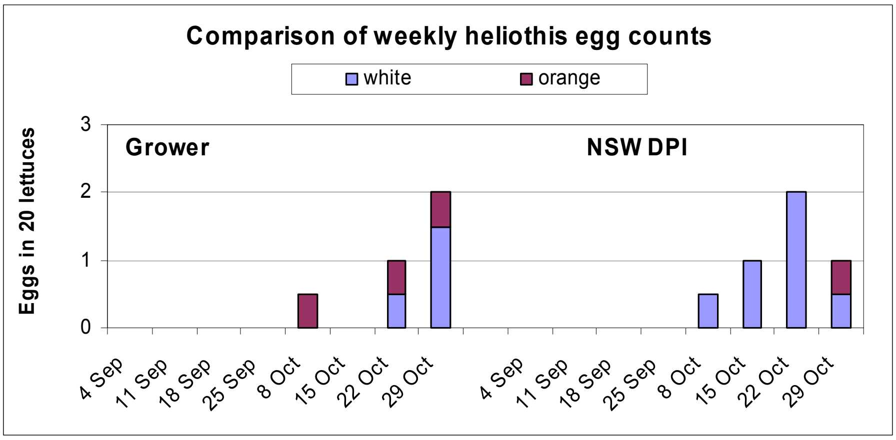
This trial was during spring and as expected *Helicoverpa punctigera* dominated in pheromone trap catches (Figure 1).

Figure 1. Weekly catches of heliothis moths in pheromone pot traps.



Heliothis eggs recorded per 20 plants was low throughout the most vulnerable lettuce growth stages, (pre-heart & hearting). A week before harvest, the heliothis egg count was higher than the action threshold, however this was not a problem in the late crop stage. Eggs were only observed in the last four weeks of the crop (Figure 2). These heliothis eggs did not develop to larvae as rain and frosts impacted on egg viability and neonate survival. Heliothis larvae were not seen in the lettuce during the weekly monitoring visits and the number of lettuces damaged at harvest by grubs was negligible.

Figure 2. Weekly observations of moth egg counts (by age) sampled per 20 lettuce monitored for each treatment.

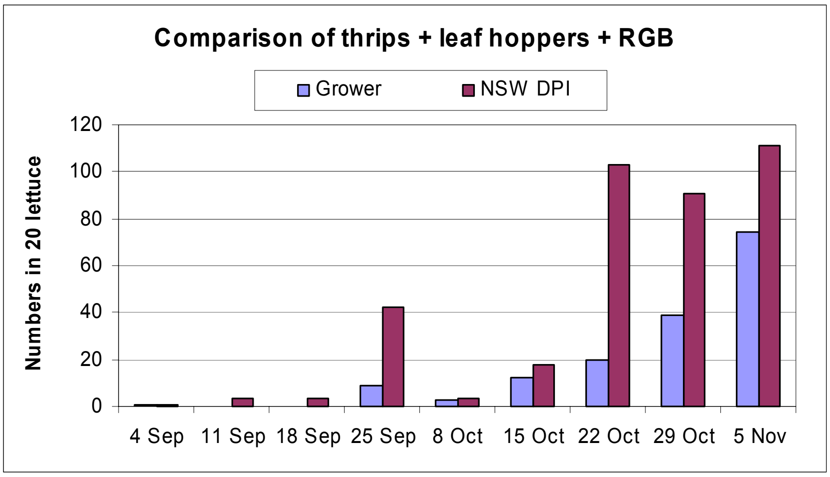


Throughout the crops growth winged aphids were only present in low numbers, 5 aphids in 20 lettuce was the peak in this trial. These adult aphids did not establish colonies and lettuce mosaic virus was not present in the crop at any stage. On most monitoring occasions, NSW DPI had consistently higher numbers of other sap sucking insect pests like thrips, leafhoppers and Rutherglen bugs (Figure 3). Except on the 8th & 15th of October when sap sucking insect numbers were similar in both plots. This was when the grower was unable to do their weekly dimethoate spray due a breakdown and repairs to the grower's spray equipment (Table 1).

Table 1. Sprays and date of application for Grower and NSW DPI. plots

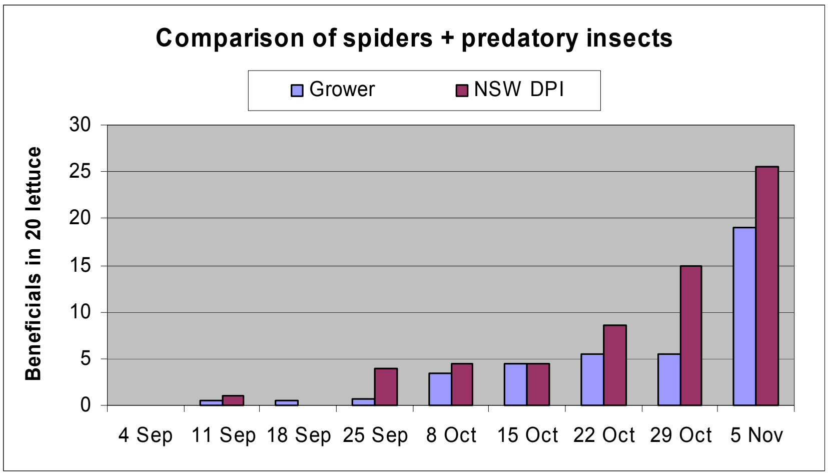
	Grower			**NSW DPI**		
Spray date	Chemical	Active	Target	Chemical	Active	Target
4/09/03	Rogor	*dimethoate*	Sap sucking insects			
10/09/03	Rogor	*dimethoate*	Sap sucking insects			
11/09/03				Zee-mil	*metalaxyl* + *mancozeb*	Fungus
16/09/03	Rogor	*dimethoate*	Sap sucking insects			
23/10/03	Rogor Dithane Acrobat	*dimethoate* *mancozeb* *dimethomorph*	Sap sucking insects fungus			

Figure 3. Comparison of sucking insect pest numbers between the grower and NSW DPI treatment, i.e. the weekly counts of thrips, leafhoppers and Rutherglen bugs summed.



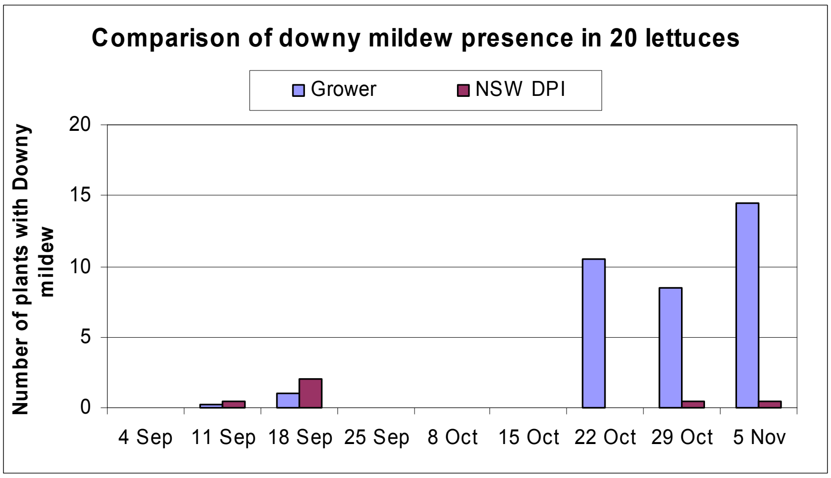
The most consistently seen predators were spiders. The beneficial insects recorded included wasps, brown lacewings and nabids. Near harvest white collared ladybird beetles had migrated into both plots, further increasing the numbers of beneficials in the crop. Generally the NSW DPI plots had higher numbers of beneficial insects. (Figure 4). The dimethoate insecticide sprays impacted on the spider and beneficial insect numbers in the grower plot (Table 1). When dimethoate was not sprayed for a few weeks, the numbers of beneficials were similar in both plots.

Figure 4. Spiders and beneficial insects recorded in 20 lettuce on each monitoring visit.



Early in the crops growth downy mildew was present in both plots, its' presence disappeared for three weeks whilst weather conditions were not suitable for the disease. The downy came back and spread rapidly throughout the grower's plot in the last three weeks (Figure 5). At harvest 70% of the lettuce in the grower's plot had downy mildew, whilst the disease was only just present in the NSW DPI plot.

Figure 5. Comparison between treatments of lettuces infected with downy mildew.



Sclerotinia infection was low in both plots. Lettuce mosaic virus was not recorded and lettuce necrotic yellows virus only had a low incidence, less than 1% of the lettuce. Lettuce big vein virus was present in both plots. In the NSW DPI plot 5% of the lettuces were severely infected compared to 12% in the grower plot.

Harvest assessment after the first cut indicated that 85% of the lettuce was taken from the NSW DPI plot compared to 68% from the grower plot. The grower plot had more lettuce remaining for the second pick. The grower indicted that the lettuce from the NSW DPI plot were larger.

A comparison of spray treatments can be seen in table 2. The grower used dimethoate weekly, a broad-spectrum insecticide and sprayed late in the crops life for downy mildew with a curative and protective fungicide. NSW DPI only sprayed once throughout the crop's growth, and this was very early with a protective & curative fungicide for downy mildew.

Table 2. Comparison of spray treatment costs.

	Grower			NSW DPI		
spray date	chemical	rate /ha	chem $/ha	chemical	rate /ha	chem $/ha
4/9/03	Dimethoate	0.750	$8.55			
10/09/03	Dimethoate	0.750	$8.55			
11/09/03				Zee-mil 680	2.500	$98.00
16/09/03	Dimethoate	0.750	$8.55			
23/10/03	Dimethoate	0.750	$8.55			
	Acrobat	0.360	$101.38			
	Dithane DF	2.200	$17.91			
TOTAL			$153.48			$98.00

Discussion

Insect pests were not a problem in this spring trial and insecticide control was not really necessary. Heliothis flights resulted in only low egg pressure, and these eggs did not seem to develop into caterpillars. Throughout the crops growth there was some rain and there were regular late frosts. Both of these may have had an impact on the viability of the eggs and heliothis larval survival.

The winged aphid numbers were quite low compared to other years and lettuce mosaic virus was not around. The high levels of thrips and leafhoppers in the NSW DPI plot caused some speckling of leaves on the young lettuce, however the lettuces out grew this damage and it did not appear to effect yields. The true effect of these sap-sucking insects is buffered in this trial because of the narrow five bed plot design. Insects like leafhoppers and Rutherglen bugs are relatively mobile and would have moved readily between the plots.

The grower used Dimethoate® to control the aphids, thrips, leafhoppers and Rutherglen bugs each time the lettuces were sprayed. The continued use of an insecticide can lead to insect resistance, and if species like Western Flower thrips were present control failures may occur.

The Dimethoate® use impacted negatively on beneficial insect numbers in the lettuce crop, however this trial does not indicate whether the NSW DPI plot benefited greatly by preserving these insects. Different circumstances may show clearly that the preservation of beneficial insects is important and can save money.

The lettuces from the NSW DPI plot were 20% larger, eleven lettuces were packed in the box rather than twelve, however from this trial the reason why this has happened cannot be certain. In the last few weeks of the crop downy mildew was active the grower's plot, but the grower plot was also regularly sprayed with dimethoate. Was it the chemical impacting on lettuce development or the disease?

The results from this trial clearly indicate that controlling downy mildew during the early stages of the infection is critical, otherwise the disease may impact on yields and be hard to control. By regularly monitoring to a protocol the downy mildew was found whilst the lettuce were small and at an 8 leaf stage. The disease was only just establishing when a curative + protective fungicide was applied to the NSW DPI plot. The disease seemed to disappear from both plots, even though the grower did not spray a fungicide, however when weather conditions were right the downy mildew rapidly built up infecting up to 70% of the grower's lettuce. Late applications of curative fungicides did little.

It is not understood whether downy mildew on the wrap leaves can dramatically effect lettuce size and yields. It is also uncertain why the grower plot had more lettuce big vein virus than the NSW DPI plot.

Acknowledgements

Thanks to Sam D'Anastasi and his sons for providing the trial site. Thanks to Greg Kocanda for monitoring assistance and Meryl Snudden for helping with the harvest assessment. This project was partially funded by Horticulture Australia and from AUSVEG levy funds.

Lettuce BMO comparison, Autumn 2004 (Hay, NSW)

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Introduction

This trial compares the management of insect pests using Integrated Pest Management (IPM) strategies to a conventional lettuce grower's current practice. The IPM strategy included regular monitoring to a protocol and the use of selective insecticide chemistry, whereas the conventional practice was to regularly apply broad spectrum insecticides.

Materials and Methods

The host farm for this BMO trial was situated off Maude road Hay, NSW 2711. A 1.2ha planting of 'Target' variety lettuces were direct seeded and watered on the 4th of February, 2004. This was the third planting in a 3.0ha block of lettuce. The IPM plot that NSW DPI managed was 50m long by 19 beds wide 0.14ha, the northern end of the planting.

In the 'IPM' lettuce spray decisions were based upon the results of a monitoring protocol as defined by NSW DPI. Spray decisions in the 'conventional' lettuce were based on experience, lettuce field observations and weather conditions. To compare the results of the different insect pest management strategies both the grower 'conventional' treatment and the 'IPM' treatment were to a protocol by NSW DPI staff. The lettuce plants were monitored weekly from an early rosette stage of development until harvest. Pre-hearting, 80 lettuces in total from a number of sites were randomly monitored, this was reduced to 40 lettuces during hearting (3 weeks from harvest). All of the heliothis eggs, insects and spiders seen on the lettuces were recorded.

Prior to harvest an assessment was made on 100 lettuces from both the conventional and IPM lettuce crops. The lettuces selected for assessment were from 10 random sites in each crop. The harvest assessment scored the plants for size, heliothis damage, scelerotinia, lettuce big vein virus, tomato spotted wilt virus (TSWV), bolting and leafhopper damage (leaf speckling).

Results and Discussion

The conventional lettuce crop was generally sprayed on a weekly basis with an insecticide. A total of five insecticide sprays were applied to the conventional lettuce (Table 1). Weekly monitoring of the IPM lettuces showed continued heliothis larvae pressure and five insecticides in total were applied for their control. The IPM lettuces were also given a precautionary fungicide application after chipping for sclerotinia control.

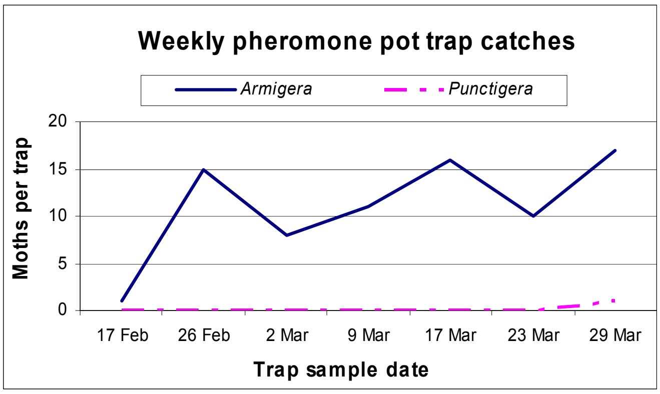
Table 1. Comparison of sprays and date of application for IPM and conventional lettuce

	Conventional Lettuce			IPM Lettuce		
Spray date	Chemical	Active	Target	Chemical	Active	Target
19/02/2004	Fastac	*alpha-cypermethrin*	heliothis*			
20/02/2004				Success	*spinosad*	heliothis
26/02/2004				Dipel forte DF	*Bacillus thuringiensis*	heliothis
27/02/2004	Fastac	*alpha-cypermethrin*	heliothis*			
4/03/2004	Fastac	*alpha-cypermethrin*	heliothis*	Dipel forte DF Sumisclex	*Bacillus thuringiensis* *procymidone*	heliothis fungus
12/03/2004				Avatar	*indoxacarb*	helioths
13/03/2004	Fastac	*alpha-cypermethrin*	heliothis*			
18/03/2004				Success	*spinosad*	heliothis
19/03/2004	Lannate	*methomyl*	heliothis*			

Heliothis* registered for heliothis but also has activity on (thrips, leaf hoppers and Rutherglen bugs)

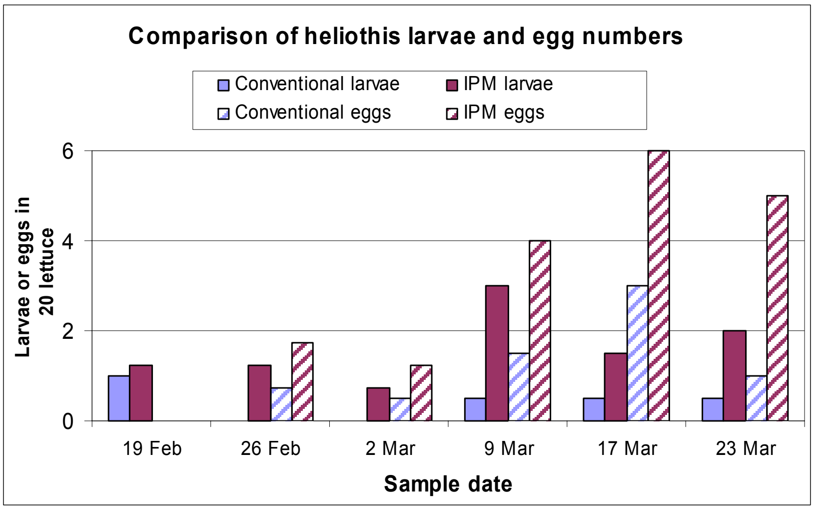
Data from pheromone pot traps indicated that there was consistent *Helicoverpa armigera* moth pressure at the trial site (Figure 1). *H. armigera* is the predominant heliothis moth species at Hay during late summer and autumn.

Figure 1. Comparison of Heliothis moth trappings for conventional and IPM lettuce sites



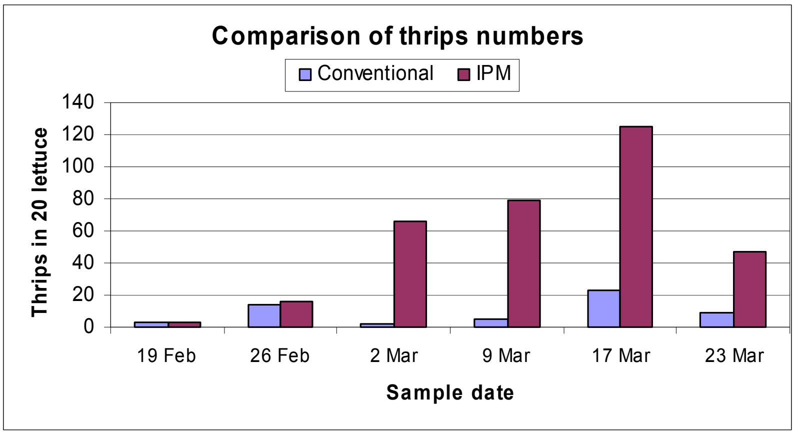
Prior to the first insecticide spray, February 19, there was equal heliothis larvae pressure in both treatments. For every subsequent monitoring event the IPM plot had more than double the larvae numbers compared to the conventional plot (Figure 2). On the 9th of March the conventional lettuces had a mean of 0.5 larvae in 20 lettuces compared to a mean of 3.0 larvae in the IPM lettuces. A comparison of heliothis eggs shows the lettuces in the IPM treatment consistently had double the heliothis egg pressure compared to the conventional treatment. The data suggests that the synthetic pyrethroid insecticides may deter moth oviposition compared to the insecticide chemistry used in the IPM plot. A replicated trial in lettuce would be needed to prove this hypothesis. At harvest there was a 0.5% loss due to heliothis damage in the growers plot compared to a 3.0% loss in the IPM plot (Table 2).

Figure 2. Comparison of heliothis larvae and egg numbers for conventional and IPM lettuce



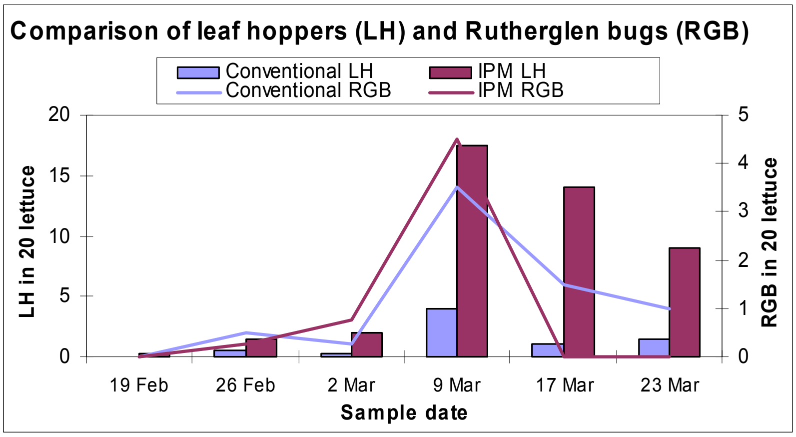
All the grower insecticide applications assisted in thrips control. Only the Success® application on the 18th of March impacted the thrips numbers in the IPM treatment and as a result the IPM plot had tenfold more thrips than the grower plot (Figure 3). Tomato spotted wilt virus was not present in either treatment at harvest (Table 2). Western flower thrips (WFT) were first discovered in the Hay area in March 2004. From the monitoring event on the 17 March, it was noted that the thrips species in the grower treatment was predominantly WFT. Four successive Fastac® insecticide applications had been made to the conventional treatment over a one month period. During this month, there could have been up to three generations of WFT.

Figure 3. Comparison of thrips numbers in conventional and IPM lettuce



Aphid pressure was low in both treatments for the duration of the lettuce crop, with 15 winged aphids being the highest mean number of aphids in 20 lettuces. Wingless aphid colonies did not establish in either treatment. Leafhopper (*Cicadellidae*) numbers were low during the prehearting stage of the lettuce crop's development and there was little difference between the treatments. Leafhopper pressure increased and the IPM treatment clearly had greater leafhopper numbers for the last four weeks of the trial period. The Fastac® and Lannate® insecticide applications in the grower treatment reduced the leafhopper numbers (Figure 4).

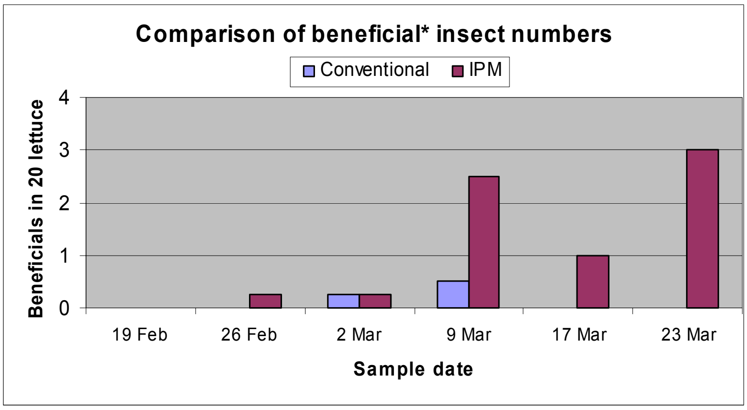
Figure 4. Comparison of leafhoppers and Rutherglen bugs in conventional and IPM lettuce



Rutherglen bug (*Nysius vinitor*) pressure was low for the entire trial period, with their numbers peaking at mean of 4 Rutherglen bugs per twenty lettuces on March 9. Due to the low Rutherglen bug pressure, no real differences can be seen between treatments (Figure 4). Rutherglen bug pressure is more common during spring.

The beneficial insect species recorded in the trial site were red & blue beetles (*Dicranolaius bellulus)*, ladybird beetles (*Hippodamia variegata* and *Coccinella transversalis)*, wasps, brown lacewings (*Micromus tasmaniae)*, damsel bugs (*Nabis kingbergii)*, big eyed bug (*Geocoris lubra*) and pirate bug (*Orius spp.)*. The beneficial insect numbers would have to be considered low in both treatments; with 3 per 20 lettuces being the highest numbers recorded in the IPM plot. However the data does suggest there was a greater number of beneficial insects in the IPM treatment (Figure 5).

Figure 5. Comparison of beneficial insects in conventional and IPM lettuce



Beneficial* insects included the sum of red & blue beetles, ladybird beetles, wasps, lacewings, nabids, big eyed bugs and pirate bugs.

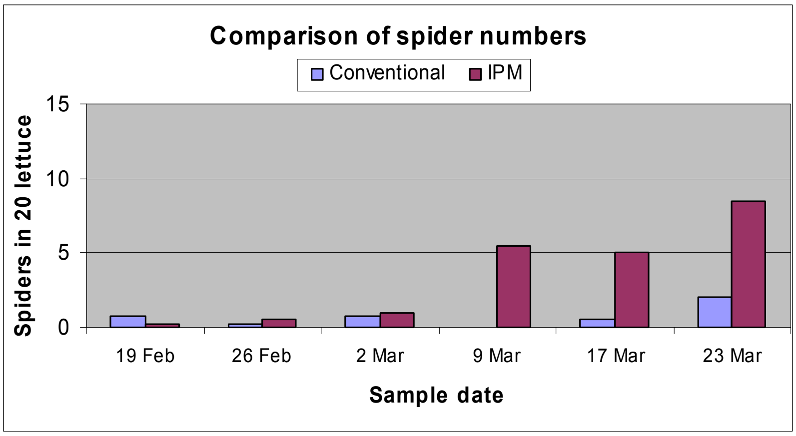
In this trial the full potential of beneficial insects was not realised for two reasons, they are:

1. The IPM plot was a comparatively small area that was surrounded by a crop environment that was sprayed heavily with broad spectrum insecticides. Both the Fastac® and Lannate® broad spectrum insecticides used by the grower killed beneficial insects as well as the target pests.

2. Some of the insecticides used in the IPM plot also impacted the beneficial insect population. The Avatar® and Success® sprays are known to impact some beneficial insect species. Avatar® impacts negatively on lady bird beetles and predatory bugs, whereas Success® impacts negatively on wasps, red & blue beetles and big eyed bugs (Deutscher, S.A. etal, 2004). The Avatar® spray on March 12, followed by a Success® spray on the March 18 would have killed many of the beneficial insects (Table 1).

Spiders are territorial so they do not tend to move as much between plots as other non-territorial beneficial insects. The continued use of the broad spectrum insecticides in the conventional treatment impacted negatively on the spider population in the conventional plot. The IPM treatment clearly had a greater number of spiders during the last three weeks of the trial (Figure 6).

Figure 6. Comparison of spiders in conventional and IPM lettuce



The harvest assessment data showed that the IPM treatment had 3.0% losses from heliothis damage, this compared to a 0.5% loss in the conventional treatment (Table 2). There was no difference between the treatments in lettuce size, bolting, sclerotina losses and in the occurrence of viral diseases. The fact there was no difference in the occurrence of sclerotinia meant that the Sumisclex® spray applied to the IPM treatment was not necessary.

Table 3. Percentage of lettuce undersize, with disease or caterpillar damage at harvest.

Treatment	small	Heliothis*	sclerotinia	bigvein	TSWV	LNYV	bolting	speckle
Conventional	34.0%	0.5%	0.0%	0.0%	0.0%	0.0%	24.0%	0.0%
IPM	35.0%	3.0%	0.0%	0.0%	0.0%	0.0%	22.0%	0.0%

(n=100); (n=200 for heliothis)

Whilst accounting for the cost of monitoring, the cost of insect pest management for the IPM treatment was $450 per ha, seven times greater than the cost in the conventional treatment of $60 per ha (Table 3). The unnecessary Sumisclex® treatment in the IPM plot added further to the total cost.

Table 3. Comparison of treatment costs

	Conventional			IPM		
spray date	chemical	rate L/ha	cost $/ha	chemical	rate L/ha	cost $/ha
19/02/2004	Fastac	0.400	$7.12			
20/02/2004				Success	0.400	$66.88
26/02/2004				Dipel forte DF	1.000	$67.10
27/02/2004	Fastac	0.400	$7.12			
4/03/2004	Fastac	0.400	$7.12	Dipel forte DF	1.000	$67.10
				Sumisclex	1.000	$77.66
12/03/2004				Avatar	0.180	$66.92
13/03/2004	Fastac	0.400	$7.12			
18/03/2004				Success	0.800	$133.76
19/03/2004	Lannate	2.000	$31.60			
6 weeks				Monitoring*		$50.00
Insecticide sub total			$60.08			$451.76
TOTAL			**$60.08**			**$529.42**

NB. The insecticide sub total includes the cost of monitoring.
* Monitoring cost is based on an average cost per ha from Gibbs Rural Services, Hay 2004.

Conclusion

This BMO trial clearly demonstrated that at during autumn at Hay, whilst there is continued heliothis pressure, the use of the more expensive and selective insecticide chemistries are a costly option. An application of a fungicide for sclerotinia control during these early crops was not necessary. The most cost effective IPM strategy for period of high insect pressure would have been regular crop monitoring to keep watch on the insect pressures, use of the cheaper broad spectrum insecticide chemistries and the strategic use of newer generation insecticide chemistry at a critical time. For example, high heliothis pressure at hearting. The strategic use newer generation insecticide chemistry will also assist with insect resistance management.

References

Deutscher, S.A., Wilson, L.J. & Mensah, R.K. – 2004. Integrated Pest Management Guidelines for Cotton Production Systems in Australia, 2nd edition – *The Australian Cotton Cooperative Research Centre*, Narrabri

Acknowledgements

Thanks to Frank Perotta for providing the trial site. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Lettuce BMO case study, Autumn 2004 (Hay, NSW)

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Introduction

A lettuce crop of a similar growth stage in south Hay was monitored on the same dates as the autumn BMO trials at north Hay. This monitoring occurred to give a comparison of the insect pressures in south Hay to what was occurring at the north Hay autumn BMO trial site. The case study also allowed comparison of another grower's insect management strategies to the BMO trial treatments.

Materials and Methods

The host farm for this study was situated off University road Hay, NSW 2711. The lettuce planting monitored was a planting of 'Raider' variety lettuces that were direct seeded in the first week of February, 2004. This was the fourth planting in a 4.0ha block of lettuce.

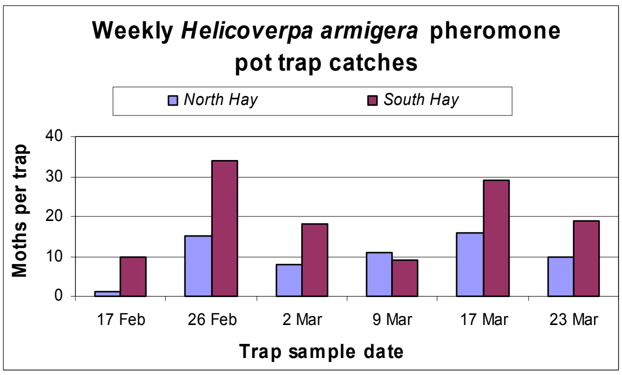
The growers spray decisions were upon on experience, lettuce field observations and weather conditions. To compare the growers insect management with the BMO trial in north Hay, the case study lettuce crop was monitored weekly to a protocol by NSW DPI staff. Pre-hearting, 40 lettuces in total from a number of sites were randomly monitored, this was reduced to 20 lettuces during hearting. All of the heliothis eggs, insects and spiders seen on the lettuces were recorded.

Prior to harvest an assessment was made on 100 lettuces from the case study lettuce crop. The lettuces selected for assessment were from 10 random sites. The harvest assessment scored the plants for size, heliothis damage, scelerotinia, lettuce big vein virus, tomato spotted wilt virus (TSWV), bolting and leafhopper damage (leaf speckling).

Results and Discussion

Data from Scentry® pheromone traps indicated that *Helicoverpa armigera* was the heliothis moth species active at the south Hay case study site during late summer and autumn (Figure 1). This was also the case at the north Hay BMO trial site. The south Hay pheromone trap yielded double the moths than the north Hay trap for 5 of the 6 sampling dates (Figure 1). This indicates the heliothis moth pressure may have been greater in the South Hay area.

Figure 1. Comparison of Heliothis moth trappings for conventional and IPM lettuce sites



The south Hay case study lettuce crop was generally sprayed on a weekly basis. When the grower observed high moth activity, the spray interval was shortened. A total of six insecticide sprays, (7 insecticides) were applied to the south Hay conventionally managed lettuce crop. The frequency of insecticide application did not differ greatly from the conventional grower in the BMO trial site at north Hay (Table 1).

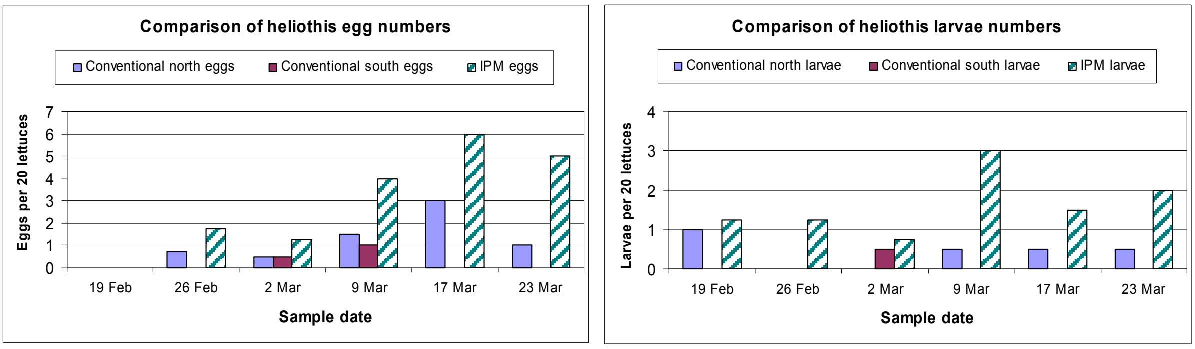
Table 1. Comparison of sprays and date of application for two conventional lettuce sites.

	North Hay site Conventional Lettuce			**South Hay site Conventional Lettuce**		
Date	Chemical	Active	Target	Chemical	Active	Target
17/02/2004				Fastac	*alpha-cypermethrin*	heliothis*
19/02/2004	Fastac	*alpha-cypermethrin*	heliothis*			
26/02/2004				Success	*spinosad*	heliothis
27/02/2004	Fastac	*alpha-cypermethrin*	heliothis*			
2/03/2004				Fastac	*alpha-cypermethrin*	heliothis*
				Lannate	*methomyl*	heliothis*
4/03/2004	Fastac	*alpha-cypermethrin*	heliothis*			
8/03/2004				Success	*spinosad*	heliothis
10/03/2004				Lannate	*methomyl*	heliothis*
13/03/2004	Fastac	*alpha-cypermethrin*	heliothis*			
19/03/2004	Lannate	*methomyl*	heliothis*			
21/03/2004				Fastac	*alpha-cypermethrin*	heliothis*

Heliothis* registered for heliothis but also has activity on (thrips, leaf hoppers and Rutherglen bugs)

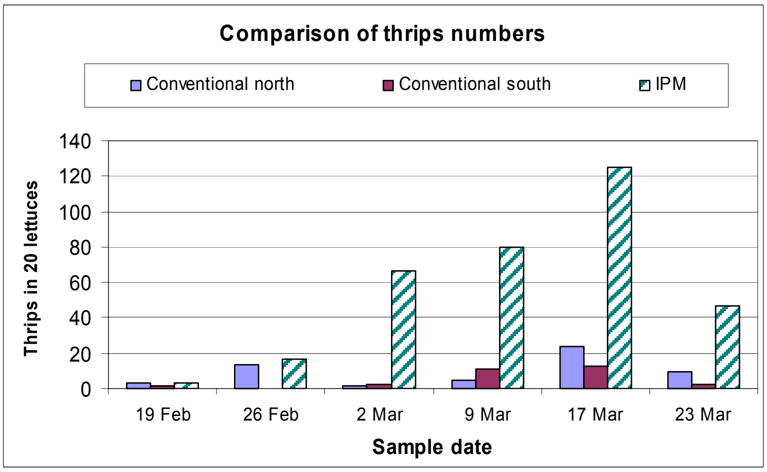
When compared to the north Hay BMO trial site, the heliothis egg and larvae counts were relatively low for the south Hay case study site (Figure 2). At every monitoring event the heliothis larvae and egg counts were less than one egg or larvae per 20 lettuces for all monitoring events, even though the south Hay pheromone trap indicated greater heliothis moth pressure. This may be a result of the regular insecticide sprays applied by the south Hay grower. When compared to both grower treatments, the IPM managed plot clearly had greater heliothis egg and larvae numbers at all monitoring events (Figure 2).

Figure 2. Comparison of heliothis larvae and egg numbers for conventional and IPM lettuce



The use of broad spectrum insecticides by the south Hay grower meant that there was very little sap sucking insect activity in the lettuce crop. This result was very similar to the data from the grower treatment in the BMO trial at north Hay. From the 7 leaf, preheart stage of growth till harvest, both conventional grower treatments had low numbers of thrips when compared to the IPM treatment of the BMO trial (Figure 3).

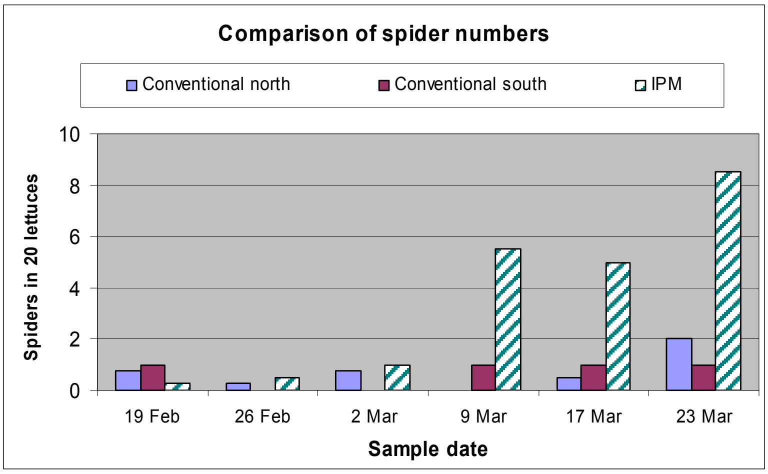
Figure 3. Comparison of thrips numbers in conventional and IPM lettuce



Beneficial insects were generally not present in the south Hay case study site. A solitary red & blue beetle (*Dicranolaius bellulus)* was the only beneficial insect recorded in the 180 lettuces monitored over the six week trial period. Data from the grower treatment in the north Hay BMO trial showed similarly low beneficial insect numbers, with only 2 beneficial insects recorded from the 360 lettuces monitored over the same time period. This likely to be a direct result of the broad spectrum insecticide use growers.

Predatory spiders were present in the south Hay case study site and their numbers were similarly low like the grower treatment in the north Hay BMO trial. From hearting onwards, the IPM treatment had four times as many predatory spiders than both the conventional grower treatments individually (Figure 4).

Figure 4. Comparison of spiders in conventional and IPM lettuce



The harvest assessment of the south Hay case study lettuce crop showed that 'Raider' was a lettuce variety more suited to the early autumn production, with only 2% bolting compared to almost 25% in the target at north Hay (Table 2). Insect pest damage at harvest was minimal for both grower treatments. The use of droppers, higher water volumes and alternating insecticide groups may be the reason why the south Hay lettuce grower had less heliothis damage than the north Hay grower. The 4% heliothis damage in the IPM plot may be attributable to the reduced efficacy/longevity of *Bacillus thuringiensis* (Bt) based insecticides during the high temperatures and UV light conditions late summer at Hay. During periods of high heliothis pressure under these conditions a 6 day application interval for Bt based sprays may be to long.

Table 2. Percentage of lettuce undersize, with disease or caterpillar damage at harvest.

Treatment	small	Heliothis*	sclerotinia	bigvein	TSWV	LNYV	bolting	speckle
Conventional grower north	34.0%	1.0%	0.0%	0.0%	0.0%	0.0%	24%	0.0%
Conventional grower south	11.0%	0.0%	1.0%	0.0%	0.0%	0.0%	2.0%	0.0%
IPM	35.0%	4.0%	0.0%	0.0%	0.0%	0.0%	22%	0.0%

(n=100)

Insect pest management for the Hay case study lettuce crop totalled $352 per ha (Table 3). Economically, this compares favourably to $451 in the IPM treatment of the autumn BMO trial at north Hay, however the grower treatment in the BMO trial at north Hay was only $60 per ha. Both the conventional grower treatments appeared to apply insecticides to a schedule during this period of high insect pressure. The difference in cost between the two growers is due to the grower in south Hay applying more expensive, newer generation insecticide chemistry. Consistent use of older synthetic pyrethroid insecticide chemistry may be cheaper; however this insect pest control strategy is likely to fail due to insect resistance. Alternating insecticide groups and including the newer chemistry is a more sustainable way to use insecticides.

Table 3. Spray treatment costs for the south Hay case study lettuce crop

	Conventional		
spray date	chemical	rate L/ha	cost $/ha
17/02/2004	Fastac	0.400	$7.12
26/02/2004	Success	0.800	$133.76
2/03/2004	Lannate	2.000	$31.60
	Fastac	0.400	$7.12
8/03/2004	Success	0.800	$133.76
10/03/2004	Lannate	2.000	$31.60
21/03/2004	Fastac	0.400	$7.12
TOTAL			**$352.08**

Conclusion

In this trial weekly spraying to a schedule with broad spectrum insecticides was the most economical insect pest management option, but not necessarily the best management option. Such pest management is flawed as given time, insect pests will develop resistance and control failures will occur. The use of older chemistry combined with the rotation to different and new insecticide groups at a critical insect pressure period or growth stage of the lettuce crop is a better insect pest management strategy. Combining a chemical resistance management strategy with regular crop monitoring and only spraying when chemical intervention is necessary is ultimately the best management option.

Acknowledgements

Thanks to John Langley for providing the case study trial site. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Seeded iceberg lettuce BMO comparison, Winter 2004 (Hay, NSW)

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Introduction

This observation trial or case study compares the management of insect pests by a grower that had adopted whole farm Integrated Pest Management (IPM) strategies to a conventional lettuce grower's current practice. The IPM strategies included regular monitoring and the use of selective insecticide chemistry, where as conventional practice was to use the broader spectrum insecticides.

Materials and Methods

Both the IPM lettuce grower and the conventional lettuce grower had a planting of 'Greenway' variety lettuce that was direct seeded on the 17th of April, 2004. The 'IPM' lettuce planting was the third planting in a block of lettuce 7.7ha in area, with three plantings. The 'conventional' lettuce planting was the fourth lettuce planting in a block of lettuce that was 10ha in area, with six plantings. The host farms for this observation trial were both situated on Maude road Hay, NSW 2711 and were only 2 km apart.

In the 'IPM' lettuce spray decisions were based upon the results of a monitoring protocol as defined by Gibbs Rural Services Pty Ltd, IPM Technologies Pty Ltd and the IPM grower. Spray decisions in the 'conventional' lettuce were based on experience, lettuce field observations and weather conditions.

To compare the results of the different insect pest management strategies both lettuce plantings were monitored to a protocol by NSW DPI staff. The lettuce plants were monitored weekly from a seedling stage of development until harvest. There is one 14 day gap in the data when 30mm of rain fell whilst the plants were at an early hearting stage. The monitoring protocol included both visual monitoring and vacuum sampling.

Prior to hearting 40 lettuces in total from a number of sites were randomly monitored each week. During hearting 20 lettuces were monitored. All heliothis eggs, insects and spiders that were seen on the lettuce were recorded. The vacuum sampling data was gathered to compliment the visual data. One hundred lettuce plants in total, from 10 random sites, were vacuum sampled weekly in each treatment. The contents of the sampling bag were tipped onto a white tray and all the insects and spiders were recorded. A clear perspex cover was placed on the tray when the insects were numerous, this prevented them escaping before being recorded. Hand tally counters were used to assist with the tally.

Prior to harvest an assessment was done on 100 lettuce in total, from 10 random sites, for both the conventional and IPM lettuce crops. After the grower's first harvest cut, another assessment was done on 200 lettuce plant sites in total, from 10 random sites at both crops. The harvest assessments scored the plants for size, heliothis damage, scelerotinia, lettuce big vein virus, tomato spotted wilt virus (TSWV), bolting and leaf hopper damage (leaf speckling).

Results and Discussion

Different sprays were applied to the lettuce crops at varying dates and for different reasons (Table 1). Similarities were that both growers sprayed their lettuce for aphids, thrips and heliothis at some time during the crops growth. The conventional lettuce grower applied 2 more insecticide sprays than the IPM lettuce grower.

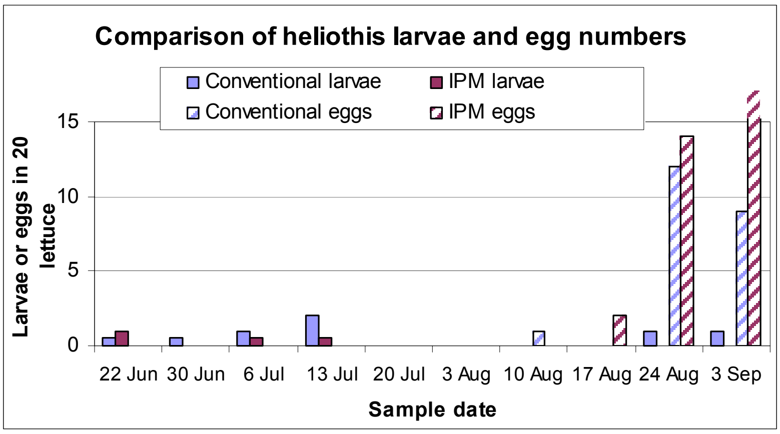
Table 1. Comparison of sprays and date of application for IPM and conventional lettuce

	Conventional Lettuce			IPM Lettuce		
Spray date	Chemical	Active	Target	Chemical	Active	Target
24/06/04	Rogor Sumisclex	*dimethoate* *procymidone*	aphid fungus			
28/06/04				Success Pirimor	*spinosad* *primicarb*	heliothis, thrips aphids
8/07/04	Rogor Sumisclex	*dimethoate* *procymidone*	sap suckers fungus			
30/07/04				Ridomil gold MZ	*metalaxyl-m* + *mancozeb*	fungus
11/08/04	broad spectrum	*broad spectrum*	cutworm thrips			
20/08/04	Rogor	*dimethoate*	sap suckers			

sap suckers (thrips, leaf hoppers, Rutherglen bugs and mirrids)

Data from a pheromone pot trap indicated that there was very little heliothis moth activity until the 17th of August when *Helicoverpa punctigera* started to fly into the district. In this and the following two weeks most of the moths trapped were *H. punctigera* (335 moths) compared to *H. armigera* (105 moths). The late increase of heliothis moth activity resulted in an increase in the number of eggs laid on the lettuce (Figure 1).

Figure 1. Comparison of heliothis larvae and egg numbers for conventional and IPM lettuce

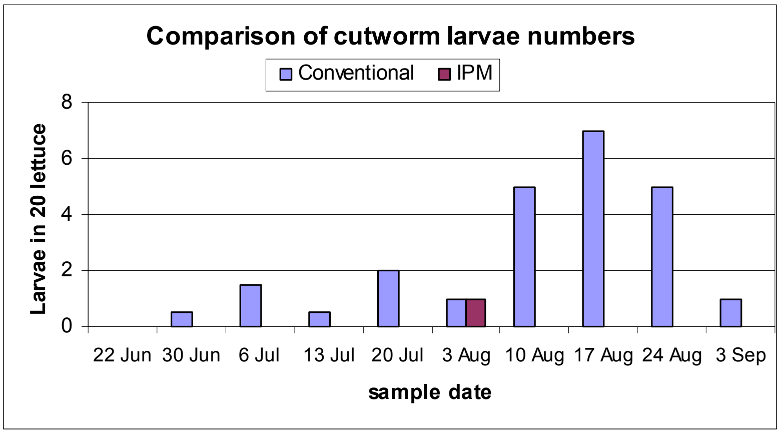


* Heliothis data from visual monitoring

Heliothis eggs were only recorded from the lettuces in both treatments late in the crop. Both treatments showed 1st and 2nd instar heliothis larvae pressure in the prehearting stages of the lettuce crop (Figure 1). Whilst the lettuce were hearting, it likely the heliothis were not seen during the monitoring because they were hidden, feeding in the heart. Some larger sized larvae were recorded in the conventional lettuce crop near harvest as the damage to lettuces from larger larvae has greater visibility.

Cutworm larvae (*Agrotis spp*.) were only present in the conventional trial site (Figure 2). The conventional trial site may have had a different paddock history than the IPM site. Low lying fields that are newly out of pasture are likely to support higher cutworm populations.

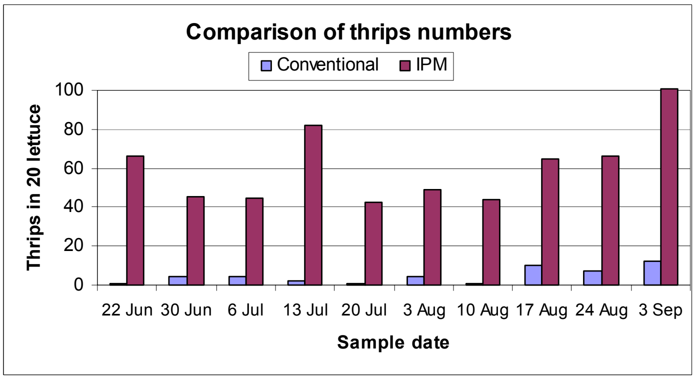
Figure 2. Comparison of cutworm larvae for conventional and IPM lettuce



Sprays were not applied for caterpillars in the conventional block until the 11th of August, when the lettuces were hearting, which was too late to be completely effective. The cutworm were difficult to contact as they were feeding in the lower wrapper leaves, similarly heliothis larvae were feeding in the protected lettuce heart. The harvest assessment data supports this theory; with the conventional treatment incurring a greater number of heliothis damaged lettuce (Table 3). The IPM treatment had similar heliothis pressure throughout the crops growth however an effective caterpillar spray was applied just before hearting.

The IPM lettuce crop consistently had 10 times more thrips than the conventionally sprayed lettuce crop. Some of the greatest difference in thrips numbers were at early hearting, where the conventional and IPM treatments had 2 and 80 thrips respectively (Figure 3).

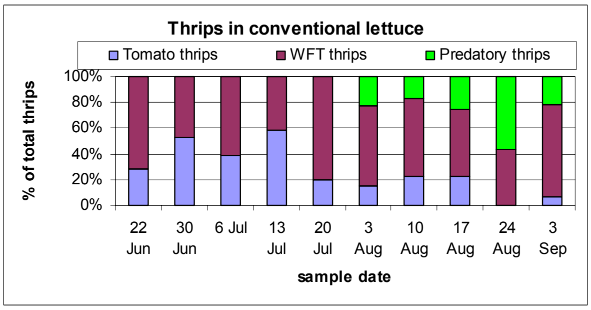
Figure 3. Comparison of thrips numbers in conventional and IPM lettuce

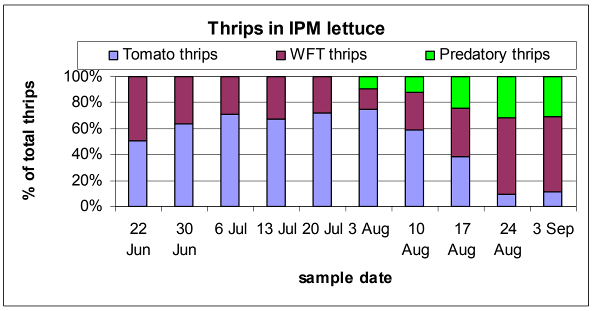


The thrips numbers were managed in the conventional treatment with four insecticide sprays that were predominantly Dimethoate®. The IPM grower sprayed for thrips once with Success®, when the lettuces were at a pre-hearting, 12 leaf stage of growth (Table 1). The higher thrips numbers in the IPM treatment resulted in a greater incidence of tomato spotted wilt virus (TSWV) at harvest compared to the conventional treatment (Table 3).

During the monitoring the thrips were recorded at a species level. There was a mix of Tomato thrips *Frankliniella schultzei*, Western Flower Thrips (WFT) *Frankliniella occidentalis* and Predatory thrips (*Desmothrips sp*. and *Haplothrips sp*.) in the lettuce. In the conventional lettuce WFT were the most predominant thrips, whereas in the IPM lettuce tomato thrips were the most predominant thrips until two weeks before harvest (Figure 4).

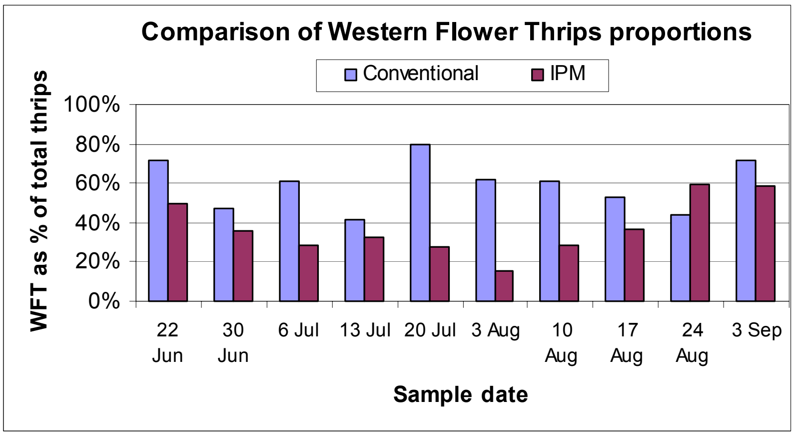
Figure 4. Comparison of thrips species proportions in conventional and IPM lettuce





A direct comparison of WFT proportion shows that the conventional lettuce consistently had a greater proportion of WFT compared to the conventional lettuce (Figure 5). Reasons for this could be insecticide resistance or different thrips migration pressure between properties.

Figure 5. Comparison of WFT proportions in conventional and IPM lettuce



Dimethoate® featured regularly for thrips control on the conventional farm. World wide WFT have a history of developing insecticide resistance. There was a low level of dimethoate resistance detected in bioassays on Australian sourced WFT samples. (Herron etal 2004). For the older insecticide chemistries tested there was little variation in WFT resistance levels between crops. This suggests that resistance for many insecticides was already present in the WFT when they were introduced to Australia. Consistent insecticide pressure without a WFT resistance management strategy will regionally select resistant thrips strains.

Differing levels of migrating thrips pressures between properties could also be a reason for the higher proportion of WFT in the conventional property. It is possible greater numbers of tomato thrips could well have been migrating to the IPM farm.

Yellow sticky traps were found to be inaccurate for monitoring thrips populations in the field lettuce. A comparison of sticky trap and visual monitoring data from the IPM lettuce farm shows no correlation between the two monitoring methods (Table 2). The yellow sticky traps caught predominantly Plague thrips *Thrips imaginis* and Dandelion thrips *Tenothrips frici*, whereas visual monitoring shows a mix of Tomato thrips, WFT and Predatory thrips in the lettuce. This was also the case for two other monitoring sites at Hay in 2004 (see the Hay winter transplant BMO trial).

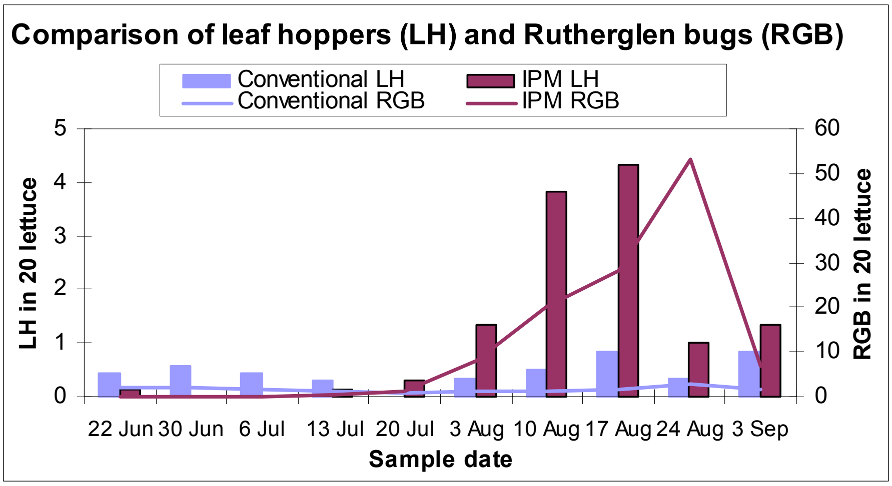
Table 2. Comparison of thrips species from sticky trap and visual monitoring

	Yellow sticky trap (75cm^2)					Visual monitoring (20 plants)				
Sample date	Predatory thrips	WFT thrips	Tomato thrips	Dandelion thrips	Plague thrips	Predatory thrips	WFT thrips	Tomato thrips	Dandelion thrips	Plague thrips
22 Jun	1	3	0	2	3	0	33	34	0	0
30 Jun	1	4	0	4	5	0	17	29	0	0
13 Jul	0	0	0	4	6	0	26	57	0	0
3 Aug	0	0	0	0	5	6	11	32	0	0
17 Aug	0	0	0	0	4	18	25	22	0	0
3 Sep	0	14	0	0	30	36	56	9	0	0

Aphid pressure was never high because the cold winter conditions helped to prevent aphid colonies establishing. Five wingless aphids in twenty lettuces, while the plants were seedlings were the greatest aphid pressure was. Both growers applied an aphid insecticide in late June to prevent colony establishment.

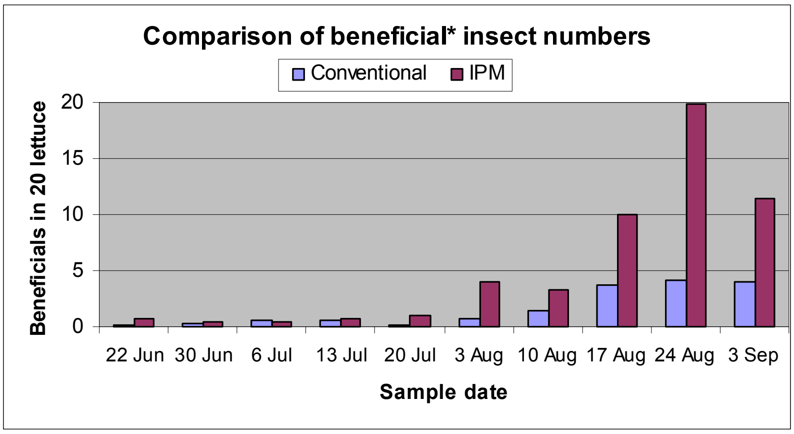
The IPM lettuce crop generally had greater numbers of leafhoppers *Cicadellidae* and Rutherglen bugs *Nysius vinitor* than the conventionally sprayed lettuce crop (Figure 5). All four insecticide sprays applied to the conventional lettuce crop killed both leafhoppers and Rutherglen bugs. The IPM lettuce treatment had an average of four, (visual monitoring), Rutherglen bugs per plant whilst the lettuce were hearting, this did not result in any leaf speckling damage at harvest (Table 3).

Figure 5. Comparison of leafhoppers and Rutherglen bugs in conventional and IPM lettuce



Beneficial insect numbers were higher in the IPM grown lettuce than the conventionally grown lettuce (Figure 6). Predatory thrips, *Desmothrips sp*. and *Haplothrips sp*. generally accounted for half of the total beneficial insects. The broad spectrum insecticide sprays applied by the conventional grower whilst the lettuces were young had a short impact on beneficial insects. Until early hearting, predatory insects like brown lacewings (*Micromus tasmaniae*) could be found back in the conventional lettuce field a week after a Dimethoate® spray. The broard spectrum insecticide sprays used in the conventional lettuce appeared to have a greater impact on the beneficial insect numbers during hearting. The IPM lettuce crop had three times as many beneficial insects than the conventional lettuce crop in the crop's later stages, however at the same time it also had ten times more sap sucking insect pests.

Figure 6. Comparison of beneficial insects in conventional and IPM lettuce



Beneficial* insects included the sum of predatory thrips, red & blue beetles, ladybird beetles, wasps, lacewings and nabids.

The insecticide sprays applied in the conventional lettuce crop had little impact on the spiders. Both the IPM and conventional treatments had similar numbers of spiders throughout the trial. There were less than two spiders in twenty lettuces until hearting. The spider numbers then gradually increased in both treatments to a maximum of five spiders in twenty lettuces at harvest.

The harvest assessment data showed the conventional lettuce had 2.7% of the lettuce hearts damaged by heliothis compared to no damage in the IPM monitored lettuce (Table 3). The caterpillar spray was incorrectly timed in the conventional lettuce planting. No fungicides were applied for sclerotinia in the IPM lettuce crop and it had considerably higher sclerotinia losses at harvest. The IPM lettuce crop only had a 1% loss from TSWV, even though it had ten times more thrips than the conventional block.

Table 3. Percentage of lettuce undersize, with disease or caterpillar damage at harvest.

	small	heliothis	sclerotinia	bigvein	TSWV	LNYV	bolting	speckle
Conventional	3.0%	2.7%	0.3%	4.0%	0.0%	0.0%	0.0%	0.0%
IPM	4.0%	0.0%	5.7%	2.3%	1.0%	0.0%	0.0%	0.0%

(n=100) for undersized lettuce (small)
(n=300) for heliothis damage, sclerotinia, bigvein, Tomato spotted wilt virus (TSWV), Lettuce necrotic yellows virus (LNYV), bolting and leaf sap sucker damage (speckle)

The cost of monitoring and the extra cost of using the more expensive, selective insecticide chemistry resulted in the IPM treatment costing 400% more per hectare for insect control than the conventional treatment (Table 4). The trial was over winter and insect activity was low. The lettuce crop could have been monitored every two weeks rather than weekly, however this would only reduce the cost of monitoring from \$50/ha to \$30/ha. Even though crop monitoring resulted in less insecticide spray applications, these savings were far outweighed by the expensive selective insecticide chemistry used to preserve beneficial insect activity.

Table 4. Comparison of treatment costs

	Conventional			IPM		
spray date	chemical	rate /ha	chem \$/ha	chemical	rate /ha	chem \$/ha
24/06/04	Dimethoate	0.750	\$8.55			
	Sumisclex	1.000	\$77.66			
28/06/04				Success	0.600	\$100.32
				Pirimor	1.000	\$75.90
8/07/04	Dimethoate	0.750	\$8.55			
	Sumisclex	1.000	\$77.66			
30/07/04				Ridomil gold MZ	2.500	\$112.75
11/08/04	Unknown	2.100	\$26.25			
20/08/04	Dimethoate	0.750	\$8.55			
9 weeks				Monitoring*		\$52.80
Insecticide sub total*			\$51.90			\$229.02
TOTAL			**\$207.22**			**\$341.77**

* Insecticide sub total includes the cost of monitoring.
Monitoring was a weekly vacuum sample of two sites and if needed, a quick visual check of the lettuce. The 7.5ha site took 0.5hr per week for nine weeks at a fee of \$88 per hr.

Conclusion

This trial showed that regular crop monitoring to a protocol can save insecticide spray applications by only spraying when pests are at a level that may cause economic damage. Regular crop monitoring also allows timely insecticide applications that can result in greater efficacy. The IPM treatment used selective insecticides to control insect pests, whereas the conventional treatment regularly sprayed broad spectrum insecticides. In this trial during winter at Hay, the conventional treatment was a far cheaper insect pest management option, however it must be noted that in other circumstances this may not be the case.

References

Herron G, Broughton S, Cook D and Clift A – 2004 Final Report HG000115: Bioassays and field trials on WFT to maintain industry access to pesticides– *Horticulture Australia*, Canberra

Acknowledgements

Thanks to John Mirabelli and Tony Domaille for allowing use their lettuce crops in this study. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Transplanted lettuce BMO comparison, Winter 2004 (Hay, NSW)

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Introduction

This observation trial or case study compares the management of insect pests by a grower that had adopted whole farm Integrated Pest Management (IPM) strategies to a conventional lettuce grower's current practice. The IPM strategy included regular monitoring and the use of selective insecticide chemistry, where as the conventional practice was to regularly apply broad spectrum insecticides.

Materials and Methods

Both the IPM lettuce grower and the conventional lettuce grower had a planting of 'Greenway' variety lettuce that was transplanted near to 11th of May, 2004. The 'IPM' lettuce planting was the second planting in a block of lettuce 12ha in area. The 'conventional' lettuce planting was the second lettuce planting in a block of lettuce that was 6ha in area, with five plantings. The host farms for this observation trial were both situated off Maude road Hay, NSW 2711 and the trial sites were 5km apart.

In the 'IPM' lettuce spray decisions were based upon the results of a monitoring protocol as defined by Gibbs Rural Services Pty Ltd, IPM Technologies Pty Ltd and the IPM grower. Spray decisions in the 'conventional' lettuce were based on experience, lettuce field observations and weather conditions.

To compare the results of the different insect pest management strategies both lettuce plantings were monitored to a protocol by NSW DPI staff. The lettuce plants were monitored weekly from an early rosette stage of development until harvest. There is one 14 day gap in the data when 30mm of rain fell whilst the plants were at an early hearting stage, 5 weeks form harvest. The monitoring protocol included both visual monitoring and vacuum sampling.

Pre-hearting, 40 lettuces in total from a number of sites were randomly monitored each week, this was reduced to 20 lettuces, during hearting (4 weeks from harvest). All heliothis eggs, insects and spiders that were seen on the lettuce were recorded. The vacuum sampling data was gathered to compliment the visual data. One hundred lettuce plants in total, (from 10 random sites), were vacuum sampled weekly in each treatment. The contents of the sampling bag were tipped onto a white tray and all the insects and spiders were recorded. A clear perspex cover was placed on the tray when the insects were numerous, this prevented insects escaping before being recorded. Hand tally counters were used to assist with the tally.

Prior to harvest an assessment was on 100 lettuces from both the conventional and IPM lettuce crops. The lettuces selected for assessment were from 10 random sites in each crop. The harvest assessments scored the plants for size, heliothis damage, scelerotinia, lettuce big vein virus, tomato spotted wilt virus (TSWV), bolting and leafhopper damage (leaf speckling).

Results and Discussion

The conventional lettuce crop appeared to be sprayed on a 2 or 3 week basis with both a fungicide and an insecticide. A total of five insecticide sprays were applied to the conventional lettuce (Table 1). The IPM lettuces were monitored on a weekly basis and the need for an insecticide application did not arise, only one fungicide spray was applied.

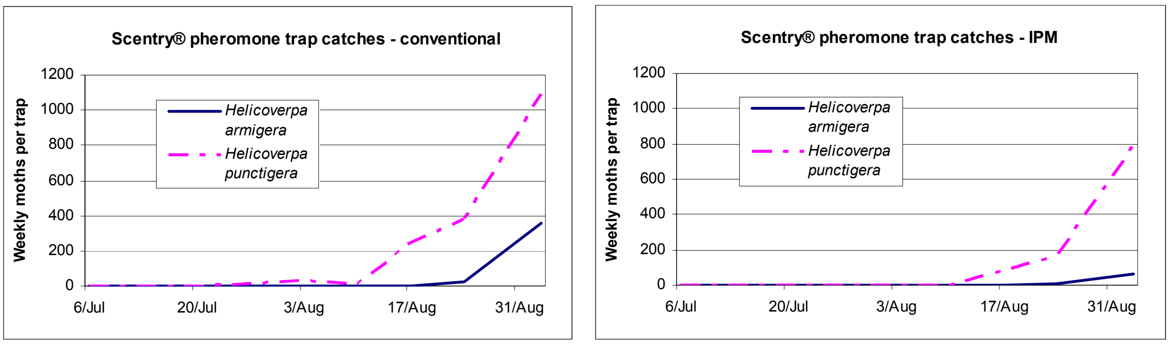
Table 1. Comparison of sprays and date of application for IPM and conventional lettuce

	Conventional Lettuce			**IPM Lettuce**		
Spray date	Chemical	Active	Target	Chemical	Active	Target
24/06/04	Rogor Lannate Sumisclex	*dimethoate* *methomyl* *procymidone*	aphid heliothis fungus			
11/07/04				Dithane DF	*mancozeb*	fungus
12/07/04	Rogor Lannate Sumisclex	*dimethoate* *methomyl* *procymidone*	aphid heliothis fungus			
30/07/04	Rogor Dithane DF	*dimethoate* *mancozeb*	aphid/thrips fungus			
9/08/04	Lannate Acrobat Dithane DF	*methomyl* *dimethomorph* *mancozeb*	heliothis* fungus fungus			
21/09/04	Fastac Dithane DF	*alpha-cypermethrin* *mancozeb*	heliothis* fungus			

Heliothis* registered for heliothis but also has activity on (thrips, leaf hoppers and Rutherglen bugs)

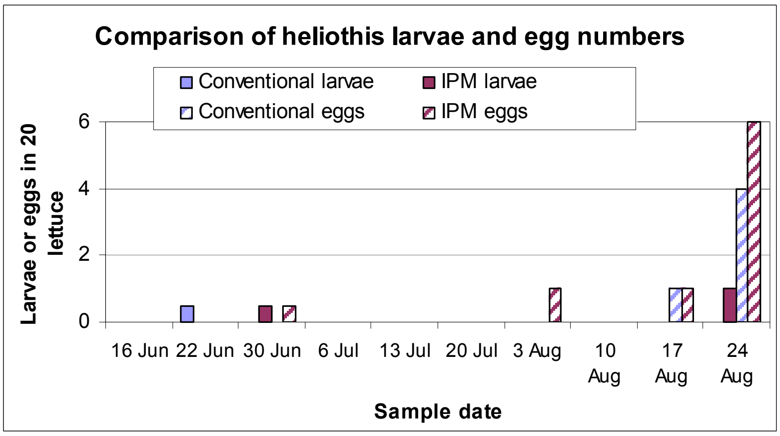
Data from pheromone pot traps indicated that there was little variation in heliothis moth activity between the two sites (Figure 1). There was no moth activity until the 17th of August when *Helicoverpa punctigera* started to fly into the district. Most of the moths trapped were *H. punctigera* with only a few *H. armigera*.

Figure 1. Comparison of Heliothis moth trappings for conventional and IPM lettuce sites



The increase of heliothis moth activity during the later stages of the crop correlated with an increase in the number of eggs laid on the lettuce. As the egg pressure was late in the lettuce crop's development it did not result in larvae pressure for this crop. The effective heliothis egg and larvae pressure was low in both the conventional and IPM lettuce crops for the duration of the crop (Figure 2). As a result of the low pressure no heliothis insecticide sprays were applied to the IPM crop. Both the IPM and conventionally grown lettuce crops had zero losses from heliothis at harvest (Table 3). In this trial, the monitoring data indicates that the conventional lettuce did not require the heliothis sprays during winter.

Figure 2. Comparison of heliothis larvae and egg numbers for conventional and IPM lettuce

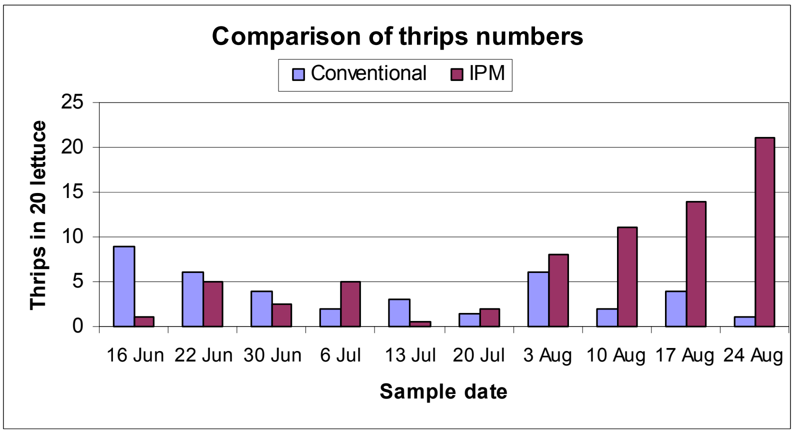


* Heliothis data from visual monitoring

At the first monitoring event the conventional lettuce crop had a mean of 9 thrips in 20 lettuces compared to a mean of 1 thrips in 20 lettuces in the IPM treatment (Figure 3). The deference in thrips pressure was not as great for the monitoring events on June 22 and June 30. Even though a tank mix insecticide spray of Lannate® and Rogor® was applied to the conventional lettuce two days after the second monitoring event, the conventional block still had slightly greater thrips pressure at June 30. This indicates that the thrips pressure may have been greater at the conventional site.

During hearting the lettuce crop managed with IPM principles had many times more thrips than the conventionally managed crop. Regular insecticide applications in the conventional lettuce crop kept thrips numbers low. A comparison of the occurrence of tomato spotted wilt virus (TSWV) could not be made at harvest as the IPM grower chipped lettuces with TSWV symptoms whilst they were at rosette growth stage.

Figure 3. Comparison of thrips numbers in conventional and IPM lettuce



* Thrips data from visual monitoring

Yellow sticky traps were used at both sites to compliment the monitoring data. A yellow sticky trap was not placed at the conventional site for collection on June 22 (Table 2a). There was no difference between the conventional and IPM treatments in the total numbers of thrips caught on sticky traps (Table 2a and 2b). This indicates that there was no difference in thrips pressure between the trial sites.

Table 2a. Comparison of thrips species data from sticky traps and visual monitoring at the Conventional trial site

	Conventional Yellow sticky trap (75cm^2)					**Conventional** Visual monitoring (20 plants)				
Sample date	Predatory thrips	WFT thrips	Tomato thrips	Dandelion thrips	Plague thrips	Predatory thrips	WFT thrips	Tomato thrips	Dandelion thrips	Plague thrips
22 Jun						0.0	7.0	2.0	0.0	0.0
30 Jun	0.0	2.0	0.0	0.0	5.0	0.0	4.0	0.0	0.0	0.0
13 Jul	0.0	0.0	0.0	1.0	2.0	0.0	3.0	0.0	0.0	0.0
3 Aug	1.0	0.0	0.0	0.0	3.0	0.0	6.0	0.0	0.0	0.0
17 Aug	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0
3 Sep	0.0	3.0	0.0	0.0	14.0	0.0	1.0	0.0	0.0	0.0

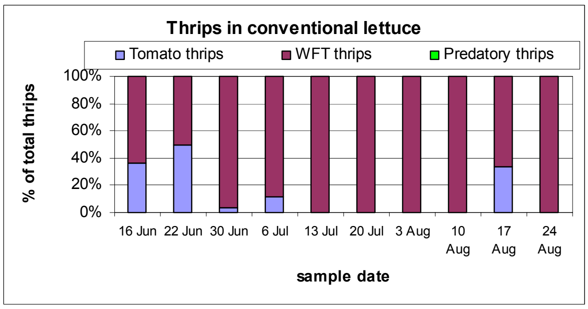
Table 2b. Comparison of thrips species data from sticky traps and visual monitoring at the IPM trial site

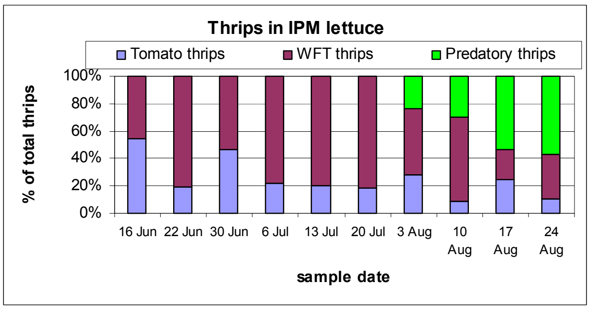
	IPM Yellow sticky trap (75cm^2)					**IPM** Visual monitoring (20 plants)				
Sample date	Predatory thrips	WFT thrips	Tomato thrips	Dandelion thrips	Plague thrips	Predatory thrips	WFT thrips	Tomato thrips	Dandelion thrips	Plague thrips
22 Jun	0.0	1.0	0.0	2.0	4.0	0.0	0.0	1.0	0.0	0.0
30 Jun	0.0	1.0	0.0	0.0	3.0	0.0	1.5	1.0	0.0	0.0
13 Jul	0.0	0.0	0.0	5.0	4.0	0.0	0.5	0.0	0.0	0.0
3 Aug	0.0	0.0	0.0	0.0	4.0	2.0	5.0	1.0	0.0	0.0
17 Aug	0.0	1.0	1.0	0.0	8.0	5.0	6.0	0.0	0.0	0.0
3 Sep	2.0	1.0	0.0	0.0	24.0	14.0	5.0	2.0	0.0	0.0

The use of yellow sticky traps to gather data on thrips species in a field lettuce crop is questionable. Sticky traps that were sited in the lettuce field indicated that Plague thrips *Thrips imaginis* and Dandelion thrips *Tenothrips frici* were the dominant thrips. Visual monitoring indicates that Western Flower Thrips (WFT) *Frankliniella occidentalis* and Tomato thrips *Frankliniella schultzei* were actually the dominant thrips species in the lettuce crops. This was the case for both the conventional treatment (Table 2a) and the IPM treatment (Table 2b).

Thrips were recorded at a species level for both the visual and vacuum sampling monitoring methods. In the conventional lettuce WFT accounted for greater than 90% of the thrips for 7 of the 9 monitoring events (Figure 4). Tomato thrips were present in the conventional plot prior to the first insecticide spray however WFT were clearly the most dominant thrips in the conventional treatment. WFT were also the most dominant thrips species in the IPM lettuce however tomato thrips were consistently present. The IPM block also had Predatory thrips, *Desmothrips sp*. and *Haplothrips sp*. present during hearting. Predatory thrips accounted for more than 50% of the thrips population at 2 weeks prior harvest.

Figure 4. Comparison of thrips species proportions in conventional and IPM lettuce



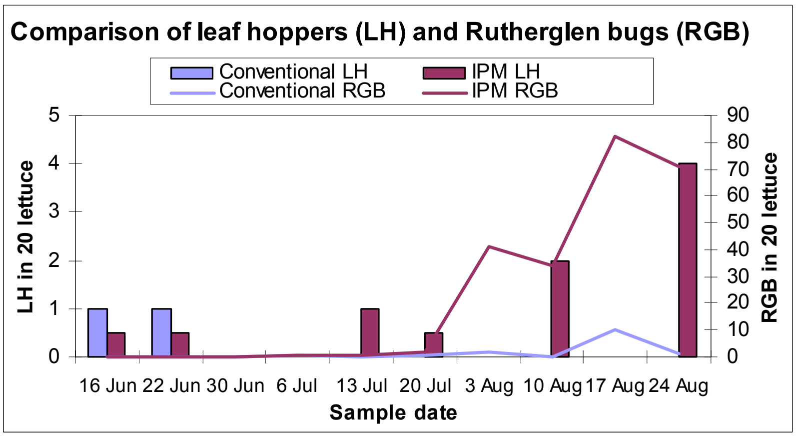


* includes monitoring data from both visual and vacuum sampling

Aphid pressure was low in both treatments for the duration of the lettuce crop, with 3 aphids in 20 lettuces being the highest mean for a sample date. The cold and frosty winter conditions prevented aphid colonies establishing in the lettuce. The conventional lettuce crop had a total of 3 dimethoate sprays applied for aphid control.

Prior to the first insecticide application in the conventionally managed lettuce crop, both treatments had similar numbers of leafhoppers (*Cicadellidae*) and Rutherglen bugs (*Nysius vinitor*). Regular insecticide applications in the conventional lettuce ensured that leafhopper and Rutherglen bug numbers were kept to a very low level in the conventional treatment (Figure 5). During August, rising day temperatures led to greater leafhopper and Rutherglen bug activity in the lettuce crops. In the IPM managed lettuce crop Rutherglen bug numbers peaked with 80 bugs in 20 lettuce. Apart from their presence, there was no physical damage to the lettuce at harvest caused by Rutherglen bugs.

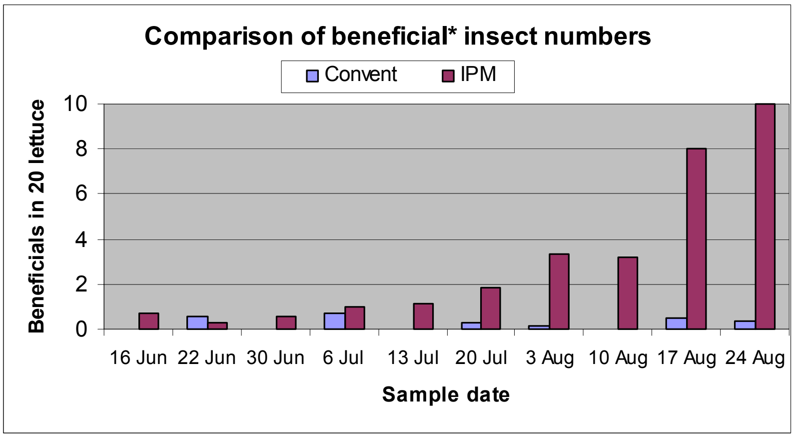
Figure 4. Comparison of leafhoppers and Rutherglen bugs in conventional and IPM lettuce



* LH and RGB data from visual monitoring

Beneficial insect numbers were low in the conventionally grown lettuce throughout the entire duration of the crop (Figure 6). In the IPM managed lettuce the beneficial insect numbers increased as the crop grew. Their number peaked a week before harvest with a mean of 10 beneficial insects in 20 lettuces. Red & blue beetles (*Dicranolaius bellulus)*, ladybird beetles (*Hippodamia variegata* and *Coccinella transversalis)*, wasps, brown lacewings (*Micromus tasmaniae)* and damsel bugs (*Nabis kingbergii)* were common. At the last three sampling dates predatory thrips *Desmothrips sp*. and *Haplothrips sp*. accounted for 50% of the beneficial insects in the IPM lettuce crop.

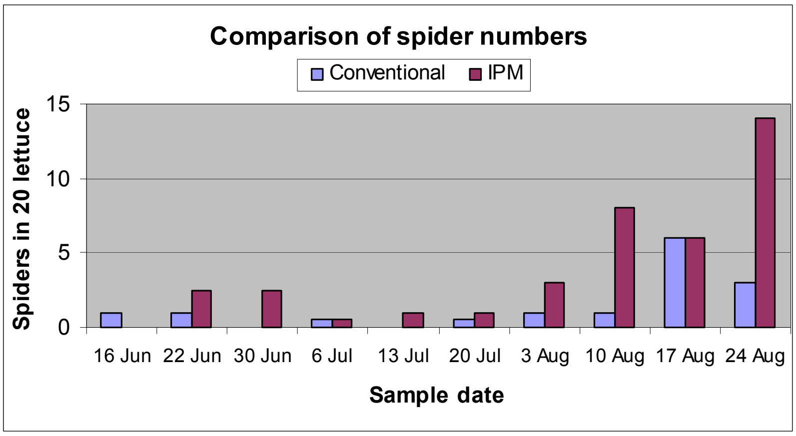
Figure 5. Comparison of beneficial insects in conventional and IPM lettuce



Beneficial* insects included the sum of predatory thrips red & blue beetles, ladybird beetles, wasps, lacewings and nabids. (includes monitoring data from both visual and vacuum sampling)

The Lannate® and Rogor® insecticide sprays applied in the conventional lettuce crop appeared to have little impact on spiders, however the Fastac® spray applied on August 21 halved their numbers (Figure 6). The IPM managed lettuce had almost 15 spiders in 20 lettuces near harvest.

Figure 6. Comparison of spiders in conventional and IPM lettuce



The harvest assessment data showed the conventional farm had greater sclerotinia disease pressure and the Sumisclex® sprays were needed. Heliothis was not present in either crop and there was no difference in the occurrence of lettuce bigvein virus (Table 3). Lettuce with TSWV symptoms in the IPM managed lettuce crop were chipped out so no comparison can be made for TSWV. Lettuce necrotic yellows virus (LNYV) was not present in either trial and the leafhoppers did not cause any leaf leaf speckle damage in the IPM treatment.

Table 3. Percentage of lettuce undersize, with disease or caterpillar damage at harvest.

	small	heliothis	sclerotinia	bigvein	TSWV*	LNYV	bolting	speckle
Conventional	5%	0%	7%	4%	1%	0%	1%	0%
IPM	2%	0%	3%	3%	0*%	0%	0%	0%

(n=100); TSWV* the IPM grower chipped out lettuces with TSWV symptoms.

In this trial the cost of insect pest management for the conventional treatment was more than double the cost in the IPM treatment (Table 4). Regular crop monitoring to a protocol provided data that showed insect pest pressure was low and as a result the IPM grower did not apply any insecticides. The monitoring costs incurred calculated to $49 per ha. When fungicides are included then the conventional crop cost 6 times the IPM crop.

Table 4. Comparison of treatment costs

	Conventional			IPM		
spray date	chemical	rate /ha	chem $/ha	chemical	rate /ha	chem $/ha
24/06/04	Dimethoate	0.750	$8.55			
	Lannate	2.000	$31.60			
	Sumisclex	1.000	$77.66			
11/07/04				Dithane DF	2.200	$17.91
12/07/04	Dimethoate	0.750	$8.55			
	Lannate	2.000	$31.60			
	Sumisclex	1.000	$77.66			
30/07/04	Dimethoate	0.750	$8.55			
	Dithane DF	2.200	$17.91			
9/08/04	Lannate	2.000	$31.60			
	Acrobat	0.360	$101.38			
	Dithane DF	1.500	$12.21			
21/08/04	Fastac	0.400	$7.12			
	Dithane DF	2.200	$17.91			
9 weeks				Monitoring*		$49.09
Insecticide sub total*			$127.57			$49.09
TOTAL			**$432.29**			**$67.00**

* Monitoring was a weekly vacuum sample of three sites and if needed, a quick visual check of the lettuce.

The 12.1ha site took $^{3}/_{4}$hr per week for nine weeks at a fee of $88 per hr.

NB. The insecticide sub total includes the cost of monitoring.

Conclusion

This BMO trial clearly showed that regular crop monitoring to a protocol prevents unnecessary insecticide spray applications. There were no insecticide sprays applied to the IPM treatment and the quality of lettuce cut was comparable to the conventionally managed lettuce. The only pest related cost incurred by the IPM treatment was $49 per ha for a consultants monitoring services.

Acknowledgements

Thanks to both Gravina and Fontana farms for allowing use of their lettuce crops for this study. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Best Management Options (BMO) Trial, spring 2003 (Lockyer Valley, QLD)

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Introduction

Over the past 4 years and as part of an industry funded project, Best Management Options have been trialled in a number of lettuce growing regions, drawing on research conducted using integrated pest management tools in lettuce as well as a number of other vegetable crops. In the Lockyer Valley 4 such trials have been carried out on grower properties to try and develop better pest management strategies in lettuce and to show growers alternatives to the traditional calendar spraying. Knowing just what is actually in the crop through crop monitoring, the corner stone to any good pest management practice in a cropping situation, a grower can benefit enormously by better timing and targeting of an insecticide against an insect pest. With a better understanding of how the insect pest(s) behaves within the crop and the way insecticides work to control these pests, a grower or even consultant can make a better informed choice as to the most appropriate insecticide, resulting in the greatest impact upon the pest while at the same time limiting the impact upon any beneficial insects that might be within the crop.

The most recent on these BMO trials was conducted on a grower property near Lake Clarendon in the Lockyer Valley and was the 3rd last planting for the season, being planted on the 25th August and harvested on the 22nd October 2003. This trial consisted of a BMO, a grower practice treatment and an unsprayed treatment. Monitoring was carried out weekly until hearting and then twice weekly during the next 3 weeks when it is vital that neonate larvae are prevented from crawling into the developing heart.

Materials and Methods

The monitoring for all pests and recording any beneficial insects present in the crop was carried out in each plot. Best management option insecticides included, either *Bacillus thuringiensis* or Success early in the crop life, then either Success or Avatar during hearting of the crop. Methomyl would also be used in combination with one of the above insecticides if required, to help with any large egg lays. The 2 products work in concert with one another, the methomyl reducing the egg load and having a short residual, while the other insecticides would then work to clean up any eggs that do manage to hatch after the sprays have been applied. An adjacent planting was also monitored at the same time and used as the grower practice, to which the grower applied what he thought was appropriate from his own monitoring program.

Both the BMO and unsprayed plots were replicated 4 times while the grower block consisted on one large planting which suited the grower. At harvest, 20 plants would be destructively sampled from each plot to count the larval pests on the wrapper leaves and in the heart.

Beneficial insect were recorded when monitoring and also by using yellow stick traps. The traps were replaced weekly and the numbers and types of beneficial insects counted in the laboratory.

Results

Figures 1 below shows what the egg and larval pressures were like during this trial period. The egg numbers are an average across the trial area and were very high for the majority of the trial, particularly during the hearting up stage of the crop when it is vital the larvae are prevented from making their way into the developing heart, and out of the reach of the insecticides used to try and manage them. This was the case for all three treatments. Larval numbers were also high with the exception of the grower treatment as seen in the graph below.

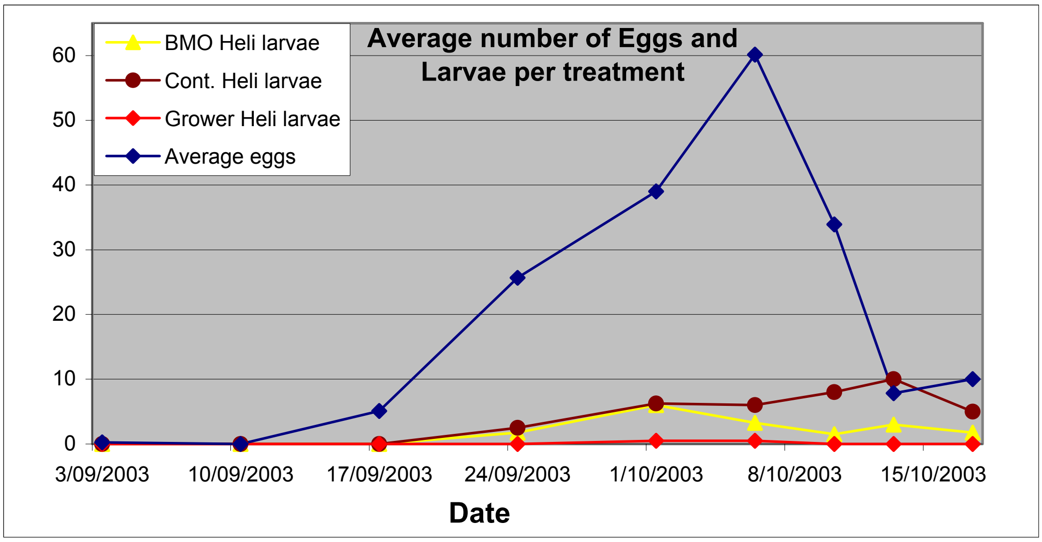

Figure 1. Eggs and larval numbers found in the individual treatments on an average of 10 plants.

The BMO treatment was sprayed 4 times from planting until harvest while the grower planting was sprayed 7 times before harvest.

Table 1. Number of sprays used on lettuce crop and approximate costs per hectare.

Treatments	Number of sprays applied	Cost/ha of insecticides	% crop with larvae
Best management option	5	$234.77	8.75
Grower practice	7	$496.75	1
Untreated control	0		75

The plants were destructively sampled at harvest to count the larval pests on the wrapper leaves and in the heart. Unfortunately the grower practice planting was harvested early by the grower before we could sample the plants for ourselves. From what remained after harvest, about 1% of the crop was infested with heliothis larvae, the remainder or about 5% of the planting were either too small to be harvested or infected with *Sclerotinia* rot. The BMO and unsprayed plots also had about 5% Sclerotinia rot. The BMO treatment, as shown in Figure 2 below, had approximately 8.75% of the crop infested with heliothis larvae compared to 75% with the unsprayed control.

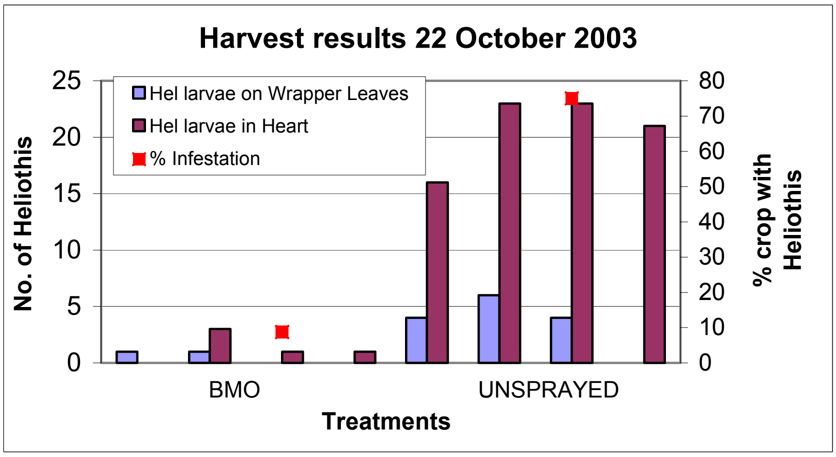

Figure 2. Harvest results for BMO trial at Lake Clarendon in the Lockyer Valley

There was a wide range of beneficial insects found in the lettuce plots both from monitoring and using the yellow sticky traps. Figure 3 below shows the number of predatory beneficial insects found in each of the 3 treatments during the crop life. Numbers were highest in the untreated control as might be expected with the grower treatment harbouring the lowest number of beneficial insect population. The predators found within the lettuce crop included spiders, transverse ladybird beetles, white collard ladybird beetle, minute 2-spotted ladybird beetle, brown lacewing, big-eyed bug, pirate bug, apple dimpling bug, broken-backed bug and damsel bug. There were other beneficial insects found on the yellow sticky traps such as Trichogramma and earwigs which were not found during the weekly monitoring exercise.

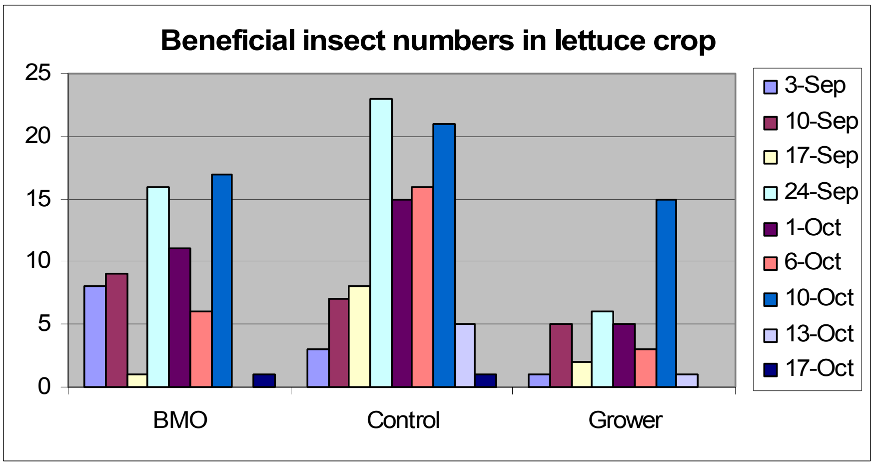

Figure 3. Predatory beneficial insects found in the BMO, untreated control and grower treatment plots from the 3 September until the 17 October 2003.

Discussion

This trial showed that Best Management Options do have a place and that the softer option insecticides do work well against heliothis. Success and Avatar were the main insecticides relied upon during the crop life with methomyl being used when the egg pressure was high close to harvest. This was used to clean up any eggs that were present as methomyl has only a 1 day withholding period.

The cost comparisons of the 2 practices showed that the BMO can be a far cheaper option than repeated sprays. Knowing just when to spray and willing to take wait that extra day or 2 can make a difference in the number of insecticides applied and the type of insecticide needed to manage the insect pest. There is ample information out there now, as a result of this project, that growers and consultants can use to make informed decisions on how best to manage a pest or pests. Monitoring is by far the most important tool that a grower can have in the fight against insect pests and a knowledge of when the best time to apply an insecticides to manage a certain pest will enable the grower to produce a crop that is both free from pests and one that has been produced using sound integrated pest management practices which benefit the environment, the grower and the consumer.

This trial also demonstrated that the softer option insecticides do help in maintaining beneficial insect populations. The graph on predator numbers show that by using the harder insecticides such as methomyl and malathion, as was the case in the grower plot, the beneficial population remains low in comparison to the untreated control and the BMO which used predominantly softer option insecticides. The large number of predators could also help in the management of the insect pest population. The BMO treatments did have more Heliothis present in the crop at harvest but at the same time the cost of insecticides was half that of the grower treatment. Was the slight increase in percentage loss of crop offset by the reduced insecticide bill of the grower. This was not investigated and perhaps should be looked at in subsequent trials. The rapid reduction in beneficial insect numbers towards the end of the crop life could be as a result of reduced insect pest activity and the beneficial insects moving to a younger patch of lettuce with more insect pest activity and more food for them.

The biggest challenge in Queensland will be with the management of new insect pests. One which is becoming more of an issue for lettuce growers and that is silver leaf whitefly or *Bemicia tabaci*. Lettuce aphid or *Nasonovia ribisnigri* is the other pest, which will pose some issues for local growers in coming years. Is it possible to implement suitable control strategies for these pests using currently available insecticides and/or biocontrol options or do we need to look at additional products? Perhaps with the large beneficial insects populations that can be found in this area, the lettuce aphid impact may not be as severe as is expected.

Efficacy Trials Discussion

This project screened the efficacy of 23 new products and some novel applications of old chemistry against various sap suckers and/or lepidoptera (Table 2). A variety of polyhouse pot and field trials were conducted. Some trials were conducted on field stations (Yanco or Gatton) and some were conducted in commercial lettuce growers fields. In trying to tie together the various combinations of new chemistry 'best management option' BMO trials were conducted. Some BMOs were incorporated into replicated small plot trials, some were as unreplicated commercial-scale trials paired to 'grower controls'.

For aphid management the neonicotinyl insecticides were effective as as foliar (acetamiprid, clothianidin and thiacloprid), soil or seedling drenches (imidacloprid, thiomethoxam and clothianidin) and/or granular band applications (thiomethoxam). Seedling drenches were quickest to take effect. Soil or seedling drenches and granular band had aphid activity for life of crop/trial at recommended rates but for a shorter period at lower rates. Foliar sprays had knockdown and some residue for a week or so.

In trials where leafhoppers were present neonicotinyl insecticides were effective, and had some reduction on Rutherglen bugs and mirids. Thrips activity was mixed between trials and products. Imidacloprid reduced whitefly numbers, however acetamiprid seemed to promote development of whitefly. Pirimicarb and dimethoate used as soil or seedling drench had good activity although serious phytotoxicity problems were noted at higher rates of dimethoate. Pymetrozine as a foliar was slow to show activity, reducing for aphid and leafhopper numbers but not whitefly or western flower thrips. Pyriproxyfen as a foliar showed no western flower thrips activity but reduced whitefly egg production.

Of the experimental foliar products DC068 showed aphid and leafhopper activity for 2 weeks, and DC027 showed some thrips but not whitefly activity. MTI446 as a furrow spray not properly tested.

Parrifin oil, SilicaK, Natrasoap, kaolin and azadiractin showed no aphid activity. DC041, S1812, emamectin benzoate and methoxyfenozide were all effective against heliothis, although prodigy is slower to act. Emamectin and S1812 were good at controlling lucerne leafroller (LLR), although the lower rate of S1812 was not as good at getting LLR in lettuce heads. The heliothis virus products Gemstar® and Vivus® did eventually kill virtually all heliothis, however many larvae continued to feed for days and in some cases weeks.
Best management option trials were variable in methodology and results but tended to give reasonable control. However BMOs proved to be more costly when compared to the 'grower' control.

Table 2. Summary of insecticide efficacy in field and pot trials

Target	Rate	Insecticide	Application	Trials	Efficacy in trials
Sucking	4g/100m	Actara®	Furrow Spray band	2	Good on aphids, not as effective on LH or RGB
	8g/100m		Furrow Spray band	1	Good on aphids > 14 weeks, leafhoppers, reduced RGB
	8g/100m		Furrow Granular	2	Good on aphids > 14 weeks, leafhoppers, reduced RGB
	9g/100m		Furrow Spray band	2	Good on aphids > 5weeks, leafhoppers, reduced RGB and mirrids
	12g/1000 plants		Seedling drench	1	but not effective on thrips, good aphid control > 6 weeks
	27g/1000 plants		granule band	1	Good on aphids > 13 weeks, slower for activity to show
	27g/1000 plants		Seedling drench	1	Good on aphids > 13 weeks
Sucking	11.6ml/100m	Confidor®	Soil spray band	1	
	12ml/100m		Soil spray band	1	Good aphid activity but reduced activity on LH and RGB
	25ml/100m		Soil spray band	6	Aphid, leafhopper, WFT control > 5 weeks, Repelled adult whitefly reduce RGB and mirrids but effective on thrips
	175ml/100L		Seedling drench	1	WFT control for 3 weeks, reduced whitefly adult numbers
	35ml/1000 plants		Seedling drench	1	
	55ml/1000 plants		Seedling drench	1	Good on aphids > 13 weeks
Sucking	100ml/ha	Intruder®	Foliar	1	Seem to promote development of whitefly, ># than control
	200ml/ha		Foliar	2	Some control of WFT, aphid and leafhopper control for 2 weeks
	400ml/ha		Foliar	1	No reduction in adult whitefly but fewer eggs, some reduction in thrips
Sucking	0.30ml/L	Calypso®	Foliar	1	Aphids controlled
Sucking	300ml/ha	TI-435	Foliar	1	WFT control for 3 weeks , no whitefly control
	175ml/100L		Seedling drench	1	WFT control for 2 weeks, no whitefly control
	10g/100m		Furrow	1	Aphid and leafhopper control > 5weeks, reduce RGB and mirrids but
	25ml/100m		Furrow	1	effective on thrips
Sucking	200g/ha	Chess®	Foliar	2	No WFT control, reduced whitefly egg production, slow to act gave some control for aphids and leafhoppers for 2 weeks
Sucking	500ml/ha	Admiral®	Foliar	1	No WFT control, reduced whitefly egg production
Sucking	200ml/ha	DC-068	Foliar	1	Aphid and leafhopper control for 2 weeks
Sucking	200ml/ha	DC-027	Foliar	1	No reduction in adult whitefly but fewer eggs, some reduction in thrips
Sucking	25g/100m	MTI446	Furrow Spray	1	Possibly some aphid activity, no obvious thrips activity
Broad spectrum	11.6ml/100m	Fastac®	Seedling drench	1	Not effective as a seedling drench
Sucking	11.6ml/100m	Dimethoate®	Seedling drench	1	Good on aphids >6 weeks, no phytotoxicity
	71ml/1000 plants		Seedling drench	1	Good on aphids > 13 weeks, serious phytotoxicity
	142ml/1000 plants		Seedling drench	1	Good on aphids > 13 weeks, serious phytotoxicity
	0.75 ml/L		Foliar	2	Fast knockdown aphids and leafhoppers

Aphids	1.8g/100m 3.6g/100m 7.3g/100m 14.6g/100m 22g/1000 plants	Pirimor®	Soil spray band Soil spray band Soil spray band Soil spray band Seedling drench	1 1 1 1 1	Good on aphids, declining in week 6, not as good as higher rates Good on aphids, declining in week 6, not as good as higher rates Good on aphids, declining in week 6, not as good as higher rates Good on aphids > week 8 not quite as good as seedling drench Good on aphids > week 8
	10ml/L	BioPest Parrifin Oil®	Foliar	1	No aphid activity
	500Kg/ha	SilicaK®,	mixed into top 10cm of loam	1	No aphid activity
	50g/L	Surround(R)	Foliar	1	Did not delay or prevent aphid colonies forming
Sucking	20ml/L	Natrasoap + agral	Foliar	1	No aphid activity
Broad spectrum	4ml/L	Azamax® [Neem] + 5ml/L Eco-oil®	Foliar	1	No aphid activity
Lepidoptera	60ml/ha 90ml/ha	DC-041	Foliar Foliar	2 1	Good on Heliothis, not quite as effective as higher rate in pot trials Good on Heliothis
Broad spectrum	3L/ha 1.35L/ha	Azamax® + 1L/ha Eco-oil® Azamax® + Aminogrow® + Acadian®	Foliar Foliar	3 1	Some activity on Heliothis in pot trials No better than unsprayed control for Heliothis
Lepidoptera	150g/ha 250g/ha	Proclaim®	Foliar Foliar	2 5	Good control of Heliothis Good control of Heliothis and LLR
Lepidoptera	800ml/ha 1600ml/ha	Prodigy®	Foliar Foliar	2 3	Good control of Heliothis, slower to act than other options Good control of Heliothis, slower to act than other options
Lepidoptera	100ml/ha 200ml/ha 800ml/ha	S1812	Foliar Foliar Foliar	3 4 1	Good control of Heliothis, control of LLR in wrappers but not so good in head Good control of Heliothis and LLR
Helicoverpa spp.	250ml/ha 500ml/ha 750ml/ha	Gemstar®	Foliar Foliar Foliar	1 1 1	Kills Heliothis but they may feed for awhile before sucumbing
Helicoverpa spp.	250ml/ha 500ml/ha 750ml/ha	Vivus®	Foliar Foliar Foliar	1 1 3	Kills Heliothis but they may feed for awhile before sucumbing More effective when put through sprinkler system than from boom over drip irrigated lettuce
Lepidoptera, thrips,	400ml/ha 800ml/ha	Success®	Foliar Foliar	3 4	Good control of Heliothis, stops Heliothis larvae feeding immediately

Other Trials

Evaluating Lettuce Varieties, Spring 2002 (Central West NSW)

Tony Napier, Andrew Creek and Sandra McDougall,
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Introduction

Currant-lettuce aphid, *Nasonovia ribisnigri* was detected in New Zealand in March 2002, the potential for it to move to Australia was of concern to lettuce growers. Rijk Zwaan has lettuce varieties that are resistant to *Nasonovia ribisnigri*, however their performance in the Central West was unknown.

The vegetable growing districts near the towns of Cowra and Canowindra are located along the Lachlan River in the Central West of NSW. These vegetable growing districts are emerging as the fastest growing vegetable production areas in NSW. The rapid increase is due to a number of growers relocated from the Sydney basin to the Central West in search of cheaper land costs and better water availability. Climatic and environmental conditions in the Sydney Basin allows for lettuce production during most of the year. Lettuce production in the Central West is more restricted and is based around two 12-week harvest windows in spring and autumn.

Temperature and day length throughout the growing period has the greatest influence on how a variety performs. Varietal selection in the Central West can be difficult with these environmental conditions changing over time during both the spring and autumn production windows. Central West lettuce growers mainly use warm weather varieties, including Target, Magnum and Assassin, that are less likely to bolt and less likely to get too large and unmanageable. The variety a grower chooses to use is based both upon physiological considerations and personal preferences for a particular variety. All varieties are bred for early vigour, size, earliness and uniformity of maturity, shape, texture, and disease resistance. A few varieties have insect resistance, specifically for the Currant-lettuce aphid.

The majority of lettuce harvested in the Central West is for the fresh market and is sold in waxed cardboard cartons. Achieving the correct heart size is important with 12 hearts required in every carton. Too small is obviously undesirable in the market and too large becomes unmanageable and difficult to get 12 the lettuce per carton. Lettuce is also grown for processing which is harvested and transported in large bins with heart size not as critical.

Three lettuce variety trials were established near Canowindra with a primary objective to give local growers and seed companies an opportunity to see new varieties perform under local conditions. The varieties were subsequently assessed for their suitability for a late spring harvest.

Materials and Methods

The varieties were sown into seedling trays at Yanco and planted out into a grower's commercial field when ready. The trials were sown as unreplicated observation plots using the Yates variety of Target as the standard comparison. After sowing, the trial sites were treated by the grower as part of his crop, receiving the same fertiliser, chemicals, irrigation etc as his normal crop. The information on sowing dates, harvest times etc are shown in Table 1.

Table 1: Summary of lettuce trials

	Trial 1	Trial 2	Trial 3
Number of varieties	13	15	15
Sowing date	22/07/02	02/08/02	12/08/02
Transplant date	20/9/02	20/09/02	09/10/02
Inspection date	20/11/02	20/11/02	20/11/02
Approx harvest date	10/11/02	10/11/02	25/11/02

Twenty one lettuce varieties were assessed from 4 different seed companies and are listed in table 2.

Table 2: Varieties sown in 2002 Central West lettuce variety trials

Variety	Seed company	Trial one	Trial two	Trial three
LuLu	SPS	Yes	Yes	Yes
587-0	SPS	Yes	Yes	Yes
Titanic	SPS	Yes	Yes	Yes
Silverado	SPS	Yes	Yes	Yes
Leo251	Syngenta	Yes	Yes	Yes
Leo250	Syngenta	Yes	Yes	Yes
Leo215	Syngenta	Yes	Yes	Yes
Musketeer	Yates	Yes		
Grenadier	Yates	Yes		
Magic	Yates	Yes		
Marksman	Yates	Yes		
LE 169	Yates	Yes		
LE 150	Yates	Yes		
LE156	Yates		Yes	Yes
LE155	Yates		Yes	Yes
Patagonia	Rijk Zwaan		Yes	Yes
Brisbane	Rijk Zwaan		Yes	Yes
Toronto	Rijk Zwaan		Yes	Yes
Mirette NAS	Rijk Zwaan		Yes	Yes
Lagunas NAS	Rijk Zwaan		Yes	Yes
Variety 12	Rijk Zwaan		Yes	Yes

NAS- resistant to *Nasonovia ribisnigri* aphids

Results

Trial one

Trial one was transplanted out into the field 20th September 2002 and inspected on 20th November 2002. The inspection was conducted approximately 10 days after the optimum harvest time. Results of the inspection are listed in table 3

Table 3: Results of trial one

Variety	Comment	Rating
Musketeer	medium	7
Grenadier	medium	7
Magic	small	4
Marksman	medium	6
LE 169	small	4
LE 150	even sizes, medium to large	8
Leo251	even sizes, medium to large	7
Leo215	medium	7
Leo250	Uneven sizes, medium	6
LuLu	medium	5
Titanic	Very large	8
Silverado	uneven sizes, small to medium	6
587-0	uneven sizes, small to medium	6

Titanic was given the highest rating in this trial with its very large frame and hearts. There was some concern that it may have been slightly too large. LE 150 was the other highest rated variety with a very even stand of medium to large hearts.

Trial two

Trial two was also transplanted out into the field 20th September 2002 and inspected on 20th November 2002. The inspection was again conducted approximately 10 days after the optimum harvest time. Results of the inspection are listed in table 4

Table 4: Results of trial two

Variety	Comment	Rating
LE156	medium size	6
LE155	medium size	7
Toronto	Large size	7
Brisbane	medium size	7
Patagonia	Large size with loose hearts	5
Variety 12	Even sizes, small to medium	6
Lagunas NAS	Large size	8
Mirette NAS	Large size	8
Leo251	even sizes, medium	4
Leo250	uneven sizes, medium	4
Leo215	even sizes, medium to large	6
Silverado	Uneven sizes, medium	4
Titanic	Even medium to large	6
LuLu	Very small size	4
587-0	small size	4

NAS- resistant to *Nasonovia ribisnigri* aphids

Two of the new nasonovia resistant varieties from Rijk Zwaan rated the highest in this sowing. Both Lagunas and Mirette had an even stand of dark green lettuce with large hearts.

Trial three

This trial was transplanted out into the field 9th October 2002 and inspected on 20th November 2002. The inspection was conducted approximately 5 days before the optimum harvest time. Results of the inspection are listed in table 5

Table 5: Results of trial three

Variety	Comment	Rating
LuLu	medium size and a bit loose	4
587-0	Uneven sizes, mostly medium size and a bit loose	4
Titanic	medium	6
Silverado	Uneven sizes, small to medium size and a bit loose	4
Leo251	Small to medium and loose hearts	5
Leo250	Small and loose hearts	4
Leo215	Small size and some loose hearts	4
LE156	Small and loose hearts	5
LE155	Small size and some loose hearts	4
Mirette NAS	Medium to large and firm hearts	8
Lagunas NAS	Medium to large and firm hearts	8
Variety 12	Small and firm hearts	4
Patagonia	Uneven sizes, mostly medium size and some loose hearts	5
Brisbane	Uneven sizes, mostly small size with loose hearts	4
Toronto	Medium to large with hearts starting to firm	7
Target	Large size with firm hearts	6

NAS- resistant to *Nasonovia ribisnigri* aphids

The two the new nasonovia resistant varieties of Lagunas and Mirette again rated the highest in this sowing. Toronto also looked promising and was still about a week from harvest.

Discussion

In the advent that the Currant-lettuce aphid arrives in the Central West the growers have an option of growing either of the two *Nasonovia* resistant varieties trialled, both proved to be the best performers overall for the spring planting. The trials have given some indication of the varieties most suited for a late spring harvest in the Central West. Varieties that produced large to medium/large firm hearts at the time of harvest were suited for that time slot in the Central West. Lettuce varieties that had small under sized hearts or formed loose hearts were not marketable and not suited for production in that time slot. When a lettuce becomes very large and fails to produce a firm heart (or worst if it bolts) it indicates the environment was to warm for that variety and may be better suited to production in a cooler environment. If the lettuce produces only a small heart it indicates the environment was to cold for that variety and may have been better suited to production in a warmer environment. The results from the three trials are an indication only as other factors including irrigation and fertilizer management have a large influence on the crops development.

New lettuce varieties are continually being released and it is recommended that growers trial them on-farm against their standard varieties. Trialing 2 or 3 new varieties in every 2nd sowing, by planting them beside one of the standard varieties, allows for easy comparison. Every farm is slightly different and lettuce is sensitive to weather changes. If growers test varieties over several seasons, it will help develop a variety plan for their own far.

Sticky Trap Comparison, 2004 (Hay, NSW)

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Objectives

Commercial yellow and blue sticky traps (240 cm^2 with 2.5 x 2.5 cm grid, Bugs for Bugs, Mundubbera, Queensland) were evaluated for trapping small flying insects in lettuce.

Materials and Methods

The sticky traps were placed on three separate properties at Hay during the period 24^{th} of August 2004 to 7^{th} October 2004. They were originally mounted in pre-hearting lettuce on each property. The traps were collected and replaced with new ones every week. The collected traps were labelled and wrapped in clear cling wrap before storage. The trap monitoring sites were shifted on each property when the lettuce at a site was near harvest maturity. The trap monitoring sites were relocated to younger lettuce plantings. The sticky trap monitoring sites were at Yanco, NSW from the 28^{th} October 2004 to 29^{th} November 2004. In total 25 yellow and 25 blue sticky traps were collected over the 3 month spring period at Hay and Yanco NSW.

The sticky trap monitoring sites were in lettuce crops that were sown on beds that had 1.5m row centres, with two rows of lettuce per bed. There was 40cm between the two rows of lettuce and 30cm between the lettuces within the row. The sticky traps were sited down the bed, 30m from the row end. One row of lettuce on the bed would have the yellow trap, whilst the other row had the blue trap (40cm between traps). Both coloured traps were mounted on canes, 10cm above the crop canopy, with the same orientation.

The sticky traps had two halves and insect data was recorded from the centre six grid squares on each half, (12 squares from each trap). The insect data was gathered with the aid of a dissecting microscope. The insect data was analysed using a paired t-test for each insect group.

Results and Discussion

Aphids (*Aphididae)*, thrips (*Thysanoptera*), leafhoppers (*Cicadellidae*)*,* Rutherglen bugs (*Nysius vinitor*), green mirrids (*Creontiades dilutus*), ladybird beetles (*Hippodamia variegata*, *Coccinella transversalis, Diomus notescens)*, wasps (*Hymenoptera*), brown lacewings (*Micromus tasmaniae)* and syrphids (*Syrphidae*) were recorded from the sticky traps.

There were significantly more winged aphids caught on the yellow sticky traps. A trap area of 75cm^2 (12 squares) from the yellow sticky traps had a mean of (36 ± 8.1) winged aphids compared to a mean of (11.4 ± 2.3) caught on the blue sticky traps ($P<0.05$, $n=25$).

Thrips preferred the blue sticky traps with significantly more thrips caught on the blue traps. A trap area of 75cm^2 (12 squares) on the blue sticky traps had a mean number of 136.4 ± 23.7 thrips compared to a mean of 110.4 ± 19.0 thrips caught on the yellow sticky traps ($P<0.05$, $n=25$). The thrips species caught in the traps were a mix of Plague thrips *Thrips imaginis*, Western Flower thrips *Frankliniella occidentalis* and Tomato thrips *Frankliniella schultzei* .

There was no significant difference in the number of leafhoppers (*Cicadellidae*) caught on the blue (6.56 ± 1.4 per $75cm^2$) and yellow sticky traps (6.9 ± 1.5 per $75cm^2$) ($P > 0.05$, n=25). Neither were there significant differences in the number of Rutherglen bugs, green mirrids, ladybird beetles, wasps, brown lacewings and syrphids between the two colour traps. However the insignificance of the differences could be due to low number of these insects on sticky traps (< 1 per $75cm^2$)

Conclusion

In lettuce crops, yellow sticky traps caught significantly more aphids whereas blue sticky traps caught significantly more thrips. There was no significant difference in leafhoppers caught.

Acknowledgements

Thanks to Bugs for Bugs for providing the blue sticky traps for this investigation. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Comparison of Monitoring Methods (Hay, NSW)

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Introduction

Throughout the lettuce project insect monitoring methods have been based on visual monitoring protocols. Vacuum sampling lettuce plants may be an efficient alternative to visual monitoring. This study compares visual and vacuum sampling data gathered from Hay lettuce crops.

Materials and Methods

During winter of 2004, four lettuce crops were concurrently monitored at Hay, NSW. All crops were at a similar stage development and were the lettuce variety 'Greenway'. The crops were monitored on weekly basis between the 22nd of June and 3rd of September to both a visual and a vacuum sampling monitoring protocol.

The visual monitoring protocol was to monitor 40 lettuces in total (pre-hearting) from a number of sites in each planting, this was reduced to 20 lettuces, during hearting (4 weeks from harvest). All heliothis eggs, insects and spiders that were seen on the lettuces were recorded.

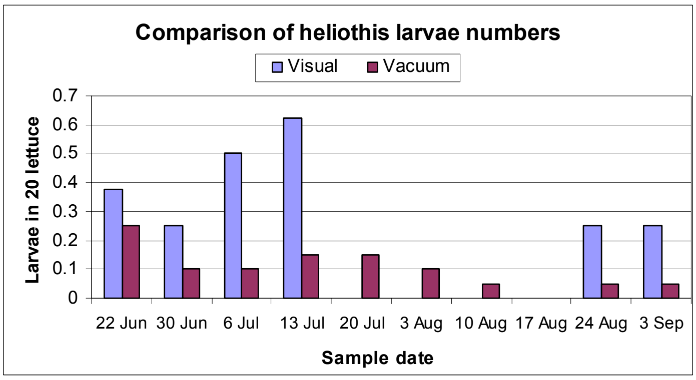
The vacuum sampling protocol was to vacuum one hundred lettuce plants in total, (from 10 random sites) in each planting. A 2-stroke Stihl® BG 65 garden blower with a sucking attachment was used to do the sampling. The sucking attachment had a fine weave material 'sock' attached to the end that caught the insects. The contents of the sampling sock were tipped onto a white tray and all the insects and spiders were recorded. A clear perspex cover was placed on the tray when the insects were numerous, this prevented insects escaping before being recorded. Hand tally counters were used to assist with the tally.

Results and Discussion

Vacuum sampling is generally an efficient way to monitor lettuce crops and it gave an indication of most insect population trends over time. Whilst vacuum sampling, it was important to be consistent from week to week with the sampling method in both the suction force applied and how briefly you skim over the plants. It was also important to only sample whilst the leaves were dry.

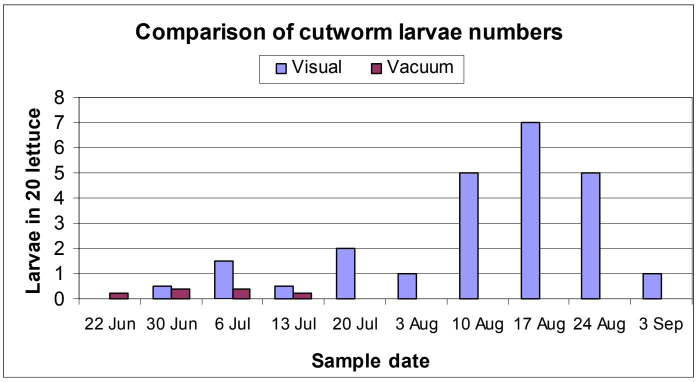
Vacuum sampling gave an indication when small larvae were present, although visual appeared to have greater accuracy in determining larvae presence (Figure 1). Heliothis larvae pressure was low and spray thresholds for vacuum sampling could not be set from the data. Neonate larvae were difficult too see in the tray if you had also happened to catch dirt. Dirt was only a caught whilst the lettuces were seedlings. The odd heliothis egg could be in the vacuum sample tray, however visual monitoring was the most accurate method to obtain data on heliothis egg numbers.

Figure 1. Comparison of heliothis larvae numbers between two different monitoring methods



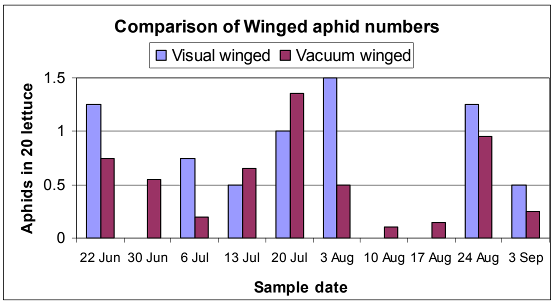
Until an early rosette stage of development, vacuum sampling was good method for assessing the presence of small cutworm *Agrotis spp.* larvae (Figure 2). Visual monitoring was clearly the most accurate method for monitoring cutworm, especially from a rosette onwards. During hearting to harvest, cut worm larvae were not picked up with the vacuum sampling protocol because the cutworm larvae were sheltered down in the leaf axis and under the wrapper leaves feeding.

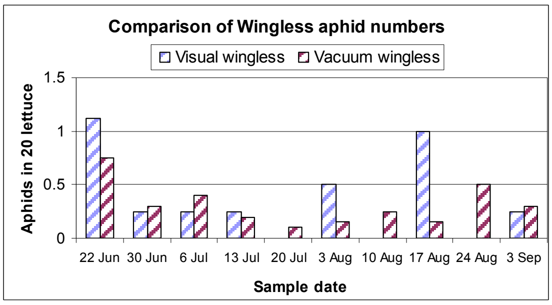
Figure 2. Comparison of cutworm larvae numbers between two different monitoring methods



Uroleucon sonchi was the main aphid species present in the lettuce crops at Hay during the trial. The aphid data could be misleading because the aphid pressure was very low throughout winter, with a mean of only 1.5 winged aphids in 20 lettuces being the highest mean for a sample date (Figure 3). The winged aphid vacuum data seemed quite comparable to the visual data, however aphid colonies never established in the lettuces. Aphid colonies in the heart and under wrapper leaves would not be detected by the vacuum sampling method.

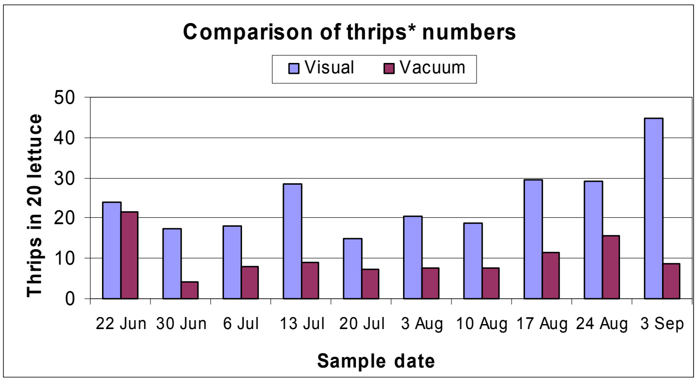
Figure 3. Comparison of aphid numbers between two different monitoring methods





Western Flower thrips *Frankliniella occidentalis* and Tomato thrips *Frankliniella schultzei* were the predominant thrips species in the lettuce crops monitored. Whilst the lettuces were pre-heart, vacuum sampling was quite accurate for an indication of thrips population trends. The accuracy of the thrips vacuum sampling data declined as the lettuces hearted (Figure 4). That thrips shelter inside the hearting lettuce is likely to explain this.

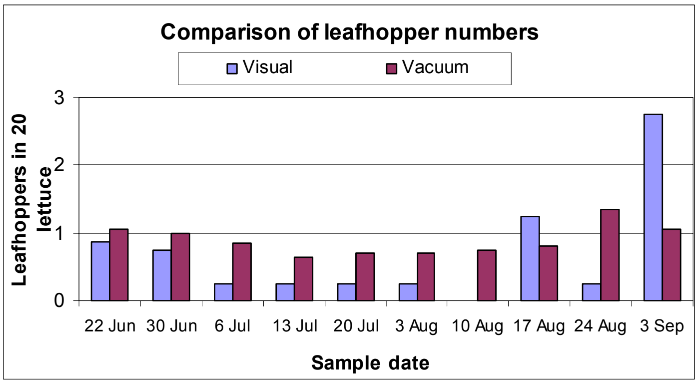
Figure 4. Comparison of thrips numbers between two different monitoring methods



* thrips is the sum of tomato thrips, western flower thrips and predatory thrips.

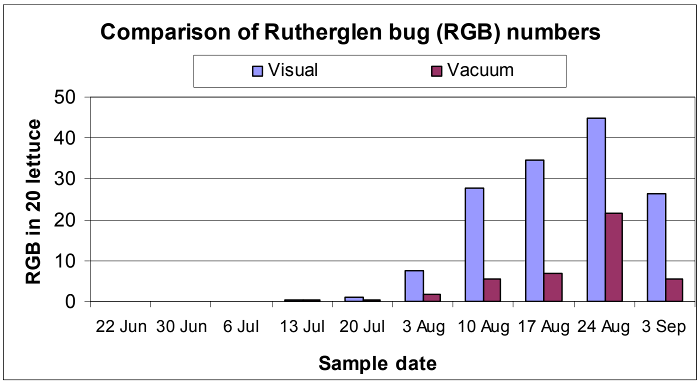
Although leafhopper (*Cicadellidae*) numbers were low, vacuum sampling was a very accurate way to determine leafhopper population trends. Even during hearting, vacuum sampling recorded a greater number of leafhoppers than visual sampling (Figure 5). Leafhoppers tend to 'jump' away when a lettuce is approached for visual monitoring. When a lettuce is disturbed during vacuum sampling leafhoppers 'jump' up and many get caught in the sample.

Figure 5. Comparison of leafhopper numbers between two different monitoring methods



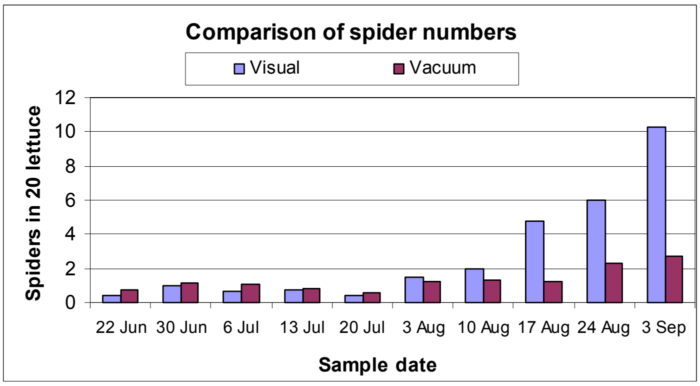
Rutherglen bug (RGB) (*Nysius vinitor*) pressure was low with a mean of less than 2 RGB per lettuce recorded on each sample date during hearting (Figure 6). The RGB data indicates that the vacuum monitoring protocol does not record as many RGB as the visual protocol, however this is not important as it is relative population trends of insects that crop management decisions are based upon. The peak of RGB numbers for both the visual and vacuum sampling data was on the 24th of August.

Figure 6. Comparison of Rutherglen bug numbers between two different monitoring methods



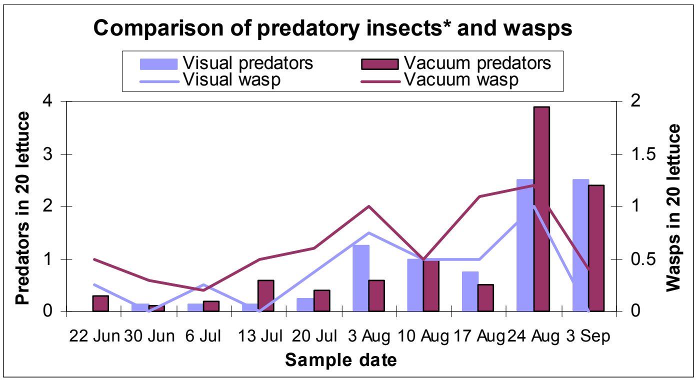
During the early stages of crop development and up to early hearting, vacuum sampling was as accurate as visual monitoring for monitoring predatory spider populations in the lettuce. This accuracy decreased as the lettuces hearted because small jumping spiders tended to be hiding amongst the wrapper leaves hunting prey (figure 7).

Figure 7. Comparison of spider numbers between two different monitoring methods



The data from vacuum sampling monitoring techniques for both predatory insects and wasps tended to correlate well with the visual sampling data (Figure 8). Predatory insects such as Red & blue beetles (*Dicranolaius bellulus)*, ladybird beetles (*Hippodamia variegata* and *Coccinella transversalis)*, brown lacewings (*Micromus tasmaniae)* and damsel bugs (*Nabis kingbergii)* were present in low numbers throughout the winter period. Small aphid parasitic wasps (*Aphidiidae*) were the most common wasps recorded in the lettuce. Wasp numbers were low during winter, reflecting the low aphid pressure during this period.

Figure 7. Comparison of predatory insects and wasp numbers between two different monitoring methods



* Predatory insects were red & blue beetles, ladybird beetles, brown lacewings and damsel bugs

Conclusion

Vacuum sampling to a protocol is an accurate method of monitoring lettuce plants up till an early hearting growth stage. Throughout the complete development of the lettuce crop, vacuum sampling was particularly good for monitoring small heliothis larvae, leafhoppers and beneficial insects. An indication of population trends for winged aphids, thrips, Rutherglen bugs and predatory spiders can be obtained whilst the lettuces are hearting. The effectiveness of vacuum sampling decreases for aphids, thrips and Rutherglen bugs as the lettuces heart.

Incorporating vacuum sampling methods into lettuce monitoring protocols greatly improves the efficiency of monitoring. A small number of plants should still be checked visually to obtain an indication of heliothis egg pressure and to also confirm the insect population trends the vacuum sampling data provides.

It must be noted that a consistent vacuum sampling protocol is important, and that the lettuce leaves also need to be dry. Vacuum sampling too vigorously can gather dirt, tear leaves and damage lettuce plants.

Acknowledgements

Thanks to those Hay lettuce growers that allowed us to monitor their lettuce crops. This project was partially funded by the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Technology Transfer

Introduction

This project followed on from a previous project VG98048 that began as an active collaboration between growers in the Hay area and involvement with QDPI and southern eastern Queensland growers to address a range of crop protection and IPM issues. Following the recommendations of the AUSVEG leafy committee this follow-on project was to focus on the insect pest management issues only.

There are a range of adult learn principles or models that have been utilized within agriculture. The project team understand that the greater the involvement of farmers in the research process the larger the commitment of time and resources, the greater the ‘ownership’ of the outcomes and therefore the greater the likelihood of adoption. However the growers have limited time and unless there is a pest crisis and crops are threatened the proportion of their variable costs that go towards pest management is quite small.

Adoption of an Integrated Pest Management (IPM) strategy involves understanding a complex of issues relating to management of pests. Growers successfully operate in a complex environment of which pest management is one, often small component. It is however a critical component that if not done successfully negates all others, i.e. when crop is unsaleable due to pest damage. This project had the dual focus of developing IPM tools for growers and developing awareness and skill levels in the industry for adoption of IPM strategies.

Activities

To address the different levels of awareness of and skills in IPM, and the various complex issues involved a range of extension activities were undertaken within this project. The project team endeavoured to make these activities interesting, informative and where possible interactive. Project activities can be classed as group activities, print activities and advisory activities. Group activities included: workshops (Table 1), presentations (Table 2), and conferences. Print activities (Table 3) were a bimonthly newsletter, field identification guide, proceedings of the 2nd Australian Lettuce Industry conference and an assortment of articles in print media. Advisory activities included individual grower, consultant or industry calls, and technical input relating to the lettuce aphid incursion.

Workshops

Workshops were a key method used in this project to combine presenting of some information, practical activities and discussion (Table 1). In NSW they were organised at a grower’s property so a farm walk was included or part of the activity. In QLD they were at the research station using station lettuce plantings and in other locations they were at other facilities where live material needed to be brought in.

Spray application workshops covered some spray application theory, a practical demonstration of key points using fluorescent dye sprayed on lettuce and UV lights to show the spray patterns to the participants. The pest, beneficial and disease identification workshop was a formal workshop working with growers and consultants on correctly identifying pest and beneficial insects and diseases of lettuce. IPM workshops usually had components of the identification workshop, general principles of IPM and depending on the location covered heliothis, thrips and/or lettuce aphid management. The IPM workshops in Victoria, SA and WA were organised in conjunction with the state vegetable IDO and in the case of Victoria with collaboration with the lettuce project VG01038. A range of topics were available as workshops at the 3rd Australian Lettuce Industry conference (Appendix 6) and the 330 participants could attend 3. Most of these conference workshops were run by people outside the project on topics broader than insect pest management.

Table 1 Workshops organised as part of the Lettuce IPM project

Date	Location	Topic	Attendance*
7th May 2002	Gatton QLD	Spray application	100+
26th September 2002	Windsor NSW	Spray application	
27th September 2002	Camden NSW	Spray application	
22nd November 2002	Cowra NSW	Spray application	
8th May 2002	Gatton QLD	Pest, beneficial and disease ID	30
22nd November 2002	Cowra NSW	IPM	
28th November 2002	Camden NSW	IPM	
29th November 2002	Windsor NSW	IPM	
24th March 2004	Werribee VIC	IPM	2
25th March 2004	Cranbourne VIC	IPM	2
31st March 2004	Virginia SA	IPM	5
1st April 2004	Wanneroo WA	IPM	30
14th April 2004	Camden NSW	IPM	15
15th April 2004	Windsor NSW	IPM	11
3rd May 2005	Werribee VIC	IPM	3 x ~35
3rd May 2005	Werribee VIC	Disease management	3 x ~35
3rd May 2005	Werribee VIC	Recycled water	3 x ~35
3rd May 2005	Werribee VIC	Compliance – OH&S, Enviroveg & QA	3 x ~35
3rd May 2005	Werribee VIC	Irrigation technology	3 x ~35
3rd May 2005	Werribee VIC	Marketing	3 x ~35
3rd May 2005	Werribee VIC	Processing & Packaging	3 x ~35
3rd May 2005	Werribee VIC	Growing for shelf-life	3 x ~35
3rd May 2005	Werribee VIC	Aquaponics	3 x ~35
3rd May 2005	Werribee VIC	Chemical residues in Hydroponics	3 x ~35

Presentations

All but three of the presentations were organised by groups other than the project team. Most were on informing interested parties about the lettuce aphid arrival in Australia together with information on the biology, ecology and management of the aphid. A similar presentation was on western flower thrips when it was first found in Hay in March 2004.

Date	Location	Topic	Attendance*
6th May 2002	Gatton QLD	Project update	120
20th November 2002	Canowindra NSW	Season update	8
21 August 2003	Gatton QLD	SLWF	58 (11 lettuce growers)
8th October 2003	Cowra NSW	Season update	8
18th March 2004	Hay NSW	WFT alert	5
26th March 2004	Davenport TAS	Lettuce Aphid	15
6th April 2004	Knoxfield VIC	Lettuce Aphid	~100
7th April 2004	Richmond NSW	Lettuce Aphid	~75
15th April 2004	Gatton QLD	Lettuce Aphid	52
14th April 2004	Hay NSW	Lettuce Aphid	
19th May 2005	Gatton QLD	Lettuce Aphid	54
16th February 2005	Virginia SA	Lettuce Aphid	~25
30th March 2005	Richmond NSW	Lettuce Aphid	13
31st March 2005	Camden NSW	Lettuce Aphid	15
4th May 2005	Werribee VIC	Lettuce Aphid	330
5th 6th May 2005	Werribee Expo	Lettuce Aphid	2x 5
19th May 2005	Applethorpe QLD	Lettuce Aphid	18

*including growers, consultants and industry people but not including presenters or organisers

Grower visits

Regular visits were made to growers in Hay, central west, Sydney basin and around Gatton. When travelling to other locations we made a point to visit local growers and consultants including a grower at Robinvale VIC, Murraybridge SA, 2 growers at Virginia SA, a grower and a processor in Wanneroo WA. Key consultants in SA and Victoria were met.

Lettuce Conferences

The first Australian lettuce industry conference was organised in the previous project and the feedback received from that conference was that further conferences were desirable (see final report VG98048). Participants indicated they wanted biennial conferences and two were written into this project. Organizing the 2nd Australian lettuce industry conference began before the project formally started and was the first activity for the project.

5-8th May 2002 University of Queensland, Gatton

The conference was held 5-8th May 2002 at the University of Queensland Gatton campus, with field trials over the road at the QDPI field station and at the neighbouring Expo site. The conference attracted 179 delegates, 52% were growers, 38.5% were industry people and 9.5% were researchers. Of the growers present 44% were from Queensland, 25% were from Victoria, 19% from NSW, 5% from New Zealand, and the remaining came from SA, WA, Tasmania and New Caledonia.

John Duff, QDPI chaired the conference organizing committee which included 3 grower representatives: Kerry Gierke, Jay Parchert, and Luke Rickuss; Sandra McDougall from NSW DPI as chair from first conference and a professional conference convenor, Sally Brown. This conference was well supported by industry sponsorship. Perfection Fresh was the ‘Platinum’ sponsor, Dow Agrosciences the ‘Silver’ sponsor, and GSF, Dupont, Harvest

Fresh Cuts, Rijk Zwaan, Walshs Rural, Yates, Landpower Australia and Withcotts Seedlings as 'Bronze" sponsors.

The 179 participants attended formal presentation sessions, field trips, planning sessions, workshops, Gatton Expo and social functions (Appendix 1). Attendees were individually surveyed for R&D priorities and a group session facilitated by John Tyas (HAL) was conducted on R&D priorities for lettuce (Appendix 2).

The conference proceedings were produced and available for the delegates at the conference and posted to all other lettuce growers who did not attend the conference. A summary of the R&D priorities and the short report on the conference was also published in the "Lettuce Leaf" newsletter that was similarly sent to all known lettuce growers. Good Fruit & Vegetables published an article on the conference.

Evaluations of the event by participants, the organizing committee and sponsors suggested that another conference in two years would be too soon and that the organizing committee should also involve industry people (Appendix 3). An offer by Angela and Frank Ruffo from Bacchus Marsh in Victoria to help organize the 3rd conference in conjunction with the Werribee Expo in 2005 was accepted. A committee was established for the organizing of the 3rd Australian Lettuce Industry Conference to be held in Werribee in 2005 immediately after the Gatton conference.

3-5th May 2005 Werribee

Formal committee meetings began in December 2003. The organizing committee included: Dr Sandra McDougall and Andrew Creek, NSW DPI; Arie Baelde, Rijk Zwaan Seeds; Frank Ruffo, Tripod Farms; Alec Berias, then President, VGA; Stephanie Ogilvie, Convenience Foods; Paul Gazzola, Gazzola Farms; Michael Simonetta, Perfection Fresh; Les Giroud, Werribee South and Joce Williams as the professional conference convenor.

Key changes from the previous conferences were to look to overseas experiences and have more workshop opportunities (Appendix 5). Field trips were again a feature as was the demonstration plantings at the Expo. A poorly attended industry priority session was held on the final day (Appendix 6). Participant numbers exceeded expectations. 325 people participated in the conference, 169 were full registrations and 156 were day registrations, of which 45 were Horticultural students. with 330 growers (40%), consultants and researchers (19%), industry people (27%) and horticultural students (14%) turning up for the event. The largest numbers were from Victoria (35%) and NSW (27%), followed by Queensland (13.5%) and New Zealand (11%), between 3-4% each came from Western Australia, Tasmania, and South Australia. Feedback from the event was positive overall (Appendices 7 and 8).

Print Activities

Lettuce Leaf newsletters were produced on a bimonthly basis throughout the project, in all 17 newsletters were distributed (example Appendix 10). In the first 2.5 years the newsletters were produced alternately with Vic DPI and VG01038. Each edition was typically double A4 size had information from around the lettuce growing regions, trial summaries, short articles, snippets of information on changes in pesticide registrations or permits, and upcoming events. They were posted to all lettuce growers and industry people associated with lettuce on the various vegetable IDO data bases. They are also available via NSW DPI and AUSVEG web sites.

The *Pests, Beneficials, Diseases and Disorders in Lettuce: Field Identification Guide* was produced as a companion to the *IPM in Lettuce Information Guide* that was produced in the previous project VG98048. The field guide was published in September 2003 and distributed to all lettuce growers. After lettuce aphid was found in Tasmania in early 2004, supplementary stickers were produced and distributed with photos and information on the aphid to be stuck into the inside back cover and previous page.

VEGEnotes were produced by ARRIS based on information gathered as part of this project covering *Lettuce Integrated Pest Management* Summer 2003 and *Lettuce Aphid Threat* Autumn 2004.

Articles were written or interviews were given to journalists on aspects of the project. These include:

Good Fruit and Vegetables: March 2002, June 2002, June 2003, April 2004, April 2005, July 2005
AUSVEG Review 2004 *One step ahead of a voracious lettuce eater* p 4
Australian Vegetable Review 2005 *Managing lettuce pests in the 3rd Millennium* p16-17
Vegetables Australia 1.1 July/August 2005: *Competing with an ancient giant* p 14
Growth is key to future for local lettuce p15
Tasmanian experiment gives new hope for lettuce aphid control p16
Putting research into practice p17
Practical Hydroponics March/April 2004, May/June 2004, March/April 2005,
Rural News *Researchers one step ahead of devastating lettuce aphid* Dec 2003
Agriculture Today Lettuce Aphid Dec 2003

Technical advice

The discovery of the currant-lettuce aphid, *Nasonovia ribisnigri* in Tasmania in March 2004 prompted a series of meetings where technical advice was needed on the lettuce aphid. Although none of these were or could have been planned they became part of the project work. Other meetings relating to NSW DPI's response to lettuce aphid are not included in Table 3.

Table 3 Lettuce aphid meetings

Date	Location/teleconference	Group
26th March 2004	teleconference	CCOEPPD*
29th March 2004	teleconference	CCOEPPD
30th March 2004	teleconference	CCOEPPD-TWG#
7th April 2004	teleconference	CCOEPPD
14th April 2004	teleconference	CCOEPPD
15th April 2004	Windsor NSW	AUSVEG -LA
21st April 2004	teleconference	CCOEPPD
28thApril 2004	Melbourne VIC	LAAG^
19th January 2005	Devonport TAS	AUSVEG -LA
28th January 2005	Pukakoe NZ	NZ IPM project
28th February 2005	Melbourne VIC	LAAG
29th June 2005	Melbourne VIC	LAAG

*CCOEPPD- Consultative committee on exotic plant pests and diseases – currant-lettuce aphid
#Technical Working Group on the currant-lettuce aphid
^ Lettuce Aphid Advisory Group

Crop consultant training

One of the major impediments for implementation of IPM is the availability of consultants to monitor crops. Growers can monitor their own crops but have usually too many other duties to consistently monitor. In large operations a staff member may take on monitoring as part of their duties but more typically growers employ a consultant. In NSW there are very few consultants available for growers to use. In Hay there is only one local independent agronomist and he was approached to see if he was interested in monitoring lettuce crops in the area. Under the agreement this project would assist with training in pest and benefical identification and monitoring. IPM Technologies Pty Ltd from Victoria was invited to Hay to meet with growers and the consultant, to discuss implementing commercial scale IPM. The consultant then maintained contact with IPM Technologies for advise on management recommendations based on field monitoring.

Evaluation

There are a number of methods for evaluating the success or otherwise of a project. A useful planning and evaluation tools for extension related projects is Bennett's hierarchy (Bennett and Rockwell, 1995). It is a seven step process used to describe the program, capture the level of involvement, identify the level of change desired and that achieved. The steps include inputs; activities; people; reactions; knowledge, aspirations, skills and attitudes; changes in practice; and end results. In this instance we will use Bennett's hierarchy as an evaluation tool. The summary of the Bennett's hierarchy for this lettuce IPM project is in Figure 1. The inputs, activities and people have been described earlier in this report hence the following discussion will be of the remaining four steps

Reactions

Reactions were gleaned both formally through written evaluations of events or responses to a formal questionnaire as well as informally in the course of doing the work and interacting with growers or industry people. Both conferences had questionnaire style evaluations (Appendices 3 and 7) and an overall questionnaire was conducted via post with Queensland growers and as a telephone survey of other lettuce growers (Appendix 9 and following section).

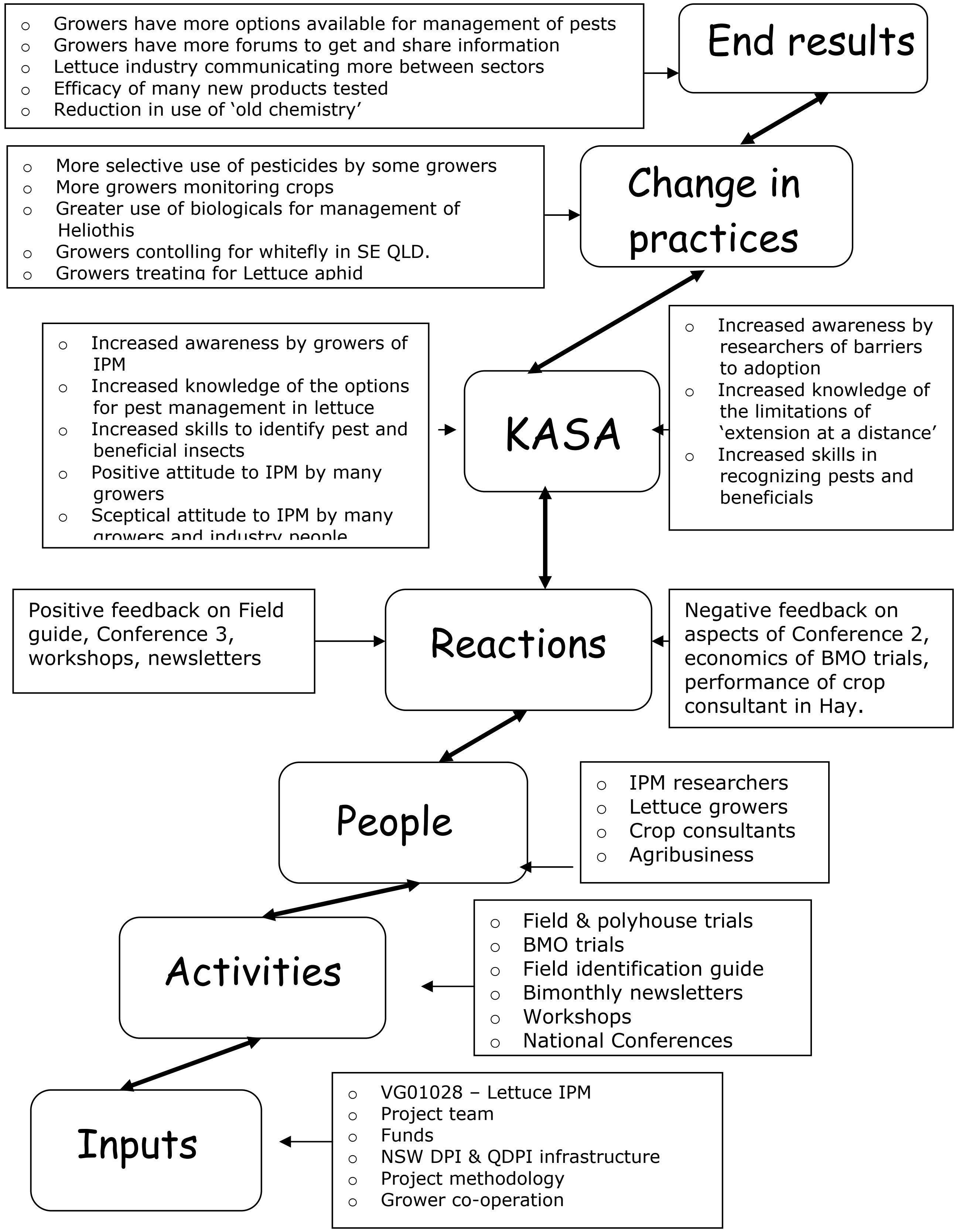
The formal evaluations indicated a highlevel of satisfaction with the activities of the project, with ratings of good to excellent for the written materials, e.g. newsletters and field guide and field days. The conferences had generally good to excellent ratings although a couple surveyed were not so happy in hindsight. The conference evaluations taken at the conferences rated the interactive or workshop, field trip activities and networking opportunities very highly but were less universally happy with formal presentations. Criticism ranged from being too technical to being not technical enough, although generally growers wanted less on project methods and more focus on practical outcomes for their farm management.

Close to 20% of the growers who responded to the phone survey said they did not receive the field guide, 10% said they did not receive the newsletter and 50% said they did not receive the 2nd Conference proceedings. Given they were all on our and the IDO contact lists the publications would have been sent but either were so unremarkable that they were not remembered or that another member of the business opened and the information was not passed around all members of the business.

In NSW, SA and WA growers were more concerned about the potential for pest damage and the economic costs of adopting IPM. The costs of the new chemistry were of concern and having the additional cost of a consultant particularly at times of high insect pressure and hence little opportunity to save on sprays.

Throughout the project and at group activities opinions were sought and generally positive. Feedback could be contradictory and reflecting the growers different learning preferences or grasp of technical issues. Typical conflicting feedback was on the level of detail of reports, talks, newsletter and information guide; some felt it was very general and not technical enough but more often they were criticised as being too technical. Likewise some preferred written information over interactive workshops and vis versus.

Figure 1. Bennett's hierarchy for "improving lettuce pest management"



KASA- Knowledge, aspirations, skills and attitudes

The formal surveys suggest that growers have increased their knowledge of the components of IPM, have a broad understanding of the concept of IPM and have developed more skills in crop monitoring, pest and beneficial recognition and use of new chemistry or biologicals. Regional differences are apparent in attitudes to IPM. In QLD and Vic independent crop consultants are available and used for IPM consulting and growers are far more likely to use new chemistry. In Hay NSW growers did trial a crop consultant for a season and were pleased with the results over winter when heliothis pressure was low but found the high cost of the new chemistry during the higher pressure periods for no better control than cheaper chemistry disappointing. They did not re-engage the consultant the following season when plague locusts required intensive spraying with OPs through first few plantings.

IPM when compared to a calendar spray program is a more complex management strategy. Those that had adopted an IPM strategy, particularly those with experienced consultants were happy with the strategy. Those that had yet to adopt IPM were more anxious about the complexity and potential for failure.

The researchers on the project also increased their knowledge on the sap sucking insects in the lettuce system and see management of insect transmitted viruses as difficult to manage using biological methods at this point. We also have increased our understanding of the importance of skilled IPM consultants to assist growers with day to day crop monitoring and management decisions. We've come to appreciate more the changing operating environment for growers and particularly the profit squeeze from increasing input costs without a corresponding increase in produce price. However the combination of new pests arriving and insecticide resistance, as well as old chemistry being withdrawn are re-enforcing the importance of developing a biologically based IPM option for growers to manage their pests into the future.

Changes in practice

Formal evaluations can be problematic in that there is some level of self-selection in those that participate, particularly if it involves returning a survey. There is also often an urge by respondents to say what they think you want and not be a true reflection of their thoughts or actions. Nevertheless the formal surveys have indicated an increase in adoption of IPM practices, including: crop monitoring, recognition of pests and beneficials, use of new chemistry and biologicals. Although there is some confusion in what IPM actually is there was widespread awareness of IPM.

Since the Chemical Use Survey in August 2002 (Appendix 4) growers have decreased their use of the older chemistry, particularly in Queensland, and increased use of the newer chemistry or biologicals. 75% of growers surveyed indicated they were 'IPM' growers and they all monitored their crops on a regular basis and an increased number use consultants or a standardised protocol compared to 2002. More than 50% of growers surveyed who indicated that they used IPM monitored for beneficials.

There has been some adoption of droppers to boom sprayers although most still use overhead boom sprayers.

End results

This project has enhanced the ability of lettuce growers and the lettuce industry to respond to the changing pest spectrum infesting lettuce and increased the potential for growers to meet market requirements and manage their pests more sustainably. As new pests arrive growers and industry have better information networks to learn about the pest, had specific research on efficacy of old and new chemistry and skills development for managing pests in a more complex environment.

Nevertheless there is still relatively few growers using biointensive IPM. Management of tomato spotted wilt virus through a biointensive IPM strategy has yet to be demonstrated in the SA and WA lettuce growing areas or in the Sydney basin during periods of high western flower thrips pressure. The movement of silverleaf whitefly and currant-lettuce aphid into new lettuce growing areas will continue to provide challenges.

References

Bennett C. and Rockwell K. (1995) Targeting outcomes of programs (TOP): an integrated approach to planning and evaluation. Unpublished manuscript http://citnews.unl.edu/TOP/english/overviewf.html

Lettuce IPM Survey SE QLD growers (2005)

John Duff
Queensland Department of Primary Industries and Fisheries, Gatton

Vegetable growers in Queensland have been participating in IPM programs to varying degrees since the early 1990's when Diamond back moth first became an issue in Brassica vegetable crops. This lead to a change in grower practices from calendar spraying and reliance solely on insecticides to solve all their insect problems, to an alternative more radical approach of strategic spraying using monitoring tools and the understanding of the role that beneficial insects have on insect pest populations and how better to look after them and encourage their development. In short the early implementations of Integrated Pest Management (IPM) in vegetables in Queensland.

Lettuce growers have been employing some aspects of IPM for a number of years, depending on their circumstances and understanding of the term IPM and what it can do for their business and whether they see a benefit to them, generally at a financial level.

This survey was sent out to QLD lettuce growers, both field and hydroponic growers, to determine the extent of IPM being used within the lettuce industry and the extent of knowledge, experience, and understanding of the term IPM. This survey was also used to see if there were any areas of neglect and what weaknesses if any growers see when using IPM as part of their production system.

Survey results:

14 growers spent the time to go through the survey and respond to the questions below.
2 other growers indicated that they were not growing lettuce anymore and so didn't fill in the survey form. Of the 14 that did reply, 11 of then indicated that they were carrying out some form of IPM on their crop with only 3 growers indicating that they were not, which is almost an 80% acceptance of IPM as part of their farm management practice.

The 3 responses that did not feel they used IPM on their farm could still be considered as employing some of the tools that are considered as part of an IPM strategy. Only one of these growers failed to fill in the survey form fully and that was only because they felt they couldn't do the survey a creditable service due to a lack of crop in the ground during the year. This was due mainly in part to a lack of water.

The other 2 growers that felt they did not use IPM on their properties clearly do not know enough about IPM and what tools can actually be used to help combat insect pest problems. One grower uses a number of horticultural sized insect zappers, does his own monitoring of his crop and feels that this is a cost effective way to help reduce insecticide usage by better timing of his sprays. This grower tends not to tank mix pesticides but does only use of the harsher type insecticides such as methomyl and recently pyrethroids to combat insect pests.

The other grower that feels he does not use IPM also carries out his own monitoring on a weekly basis inspecting 20 plants at a time. This grower considers this to be worth while in helping to reduce the number of insecticides applied, again by better timing of his sprays. It is possible for this grower to go a fortnight or longer during the winter months without having to apply any insecticides, but during the warmer months this is quite different. Up to 3 sprays a fortnight may be required but only depending on the monitoring results. This grower also uses the new generation insecticides that are soft on beneficial insects, such as Bt, Gemstar®, Avatar® and Success®. This grower also considers spray coverage to be important as well as the size of the Heliothis caterpillar that he is targeting. He knows that once the caterpillar gets a little bit of size to it he experiences poor control, so he targets the smaller caterpillars. This clearly shows that he does have some understanding of integrated pest management, even if he feels he needs to learn a lot more about IPM before he is confident about using the various tools in an IPM system. He does have some sort of IPM system in place as does the other grower.

Table 1. The range of IPM tools used by growers.

Tools	Gr 1	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Gr 10	Gr 11	Gr 12	Gr 13	Gr 14
Crop Monitoring	√	√	√	√	√	√	√	√	√	√	√	√	√	
Beneficial insects		√				√				√				
Monitor beneficial insects		√		√	√	√	√			√				
Yellow stick traps									√	√				
Pheromone traps				√						√	√			
Modified boom sprayer				√		√	√				√			
Traditional insecticides						√	√	√				√	√	
New generation insecticides	√	√	√	√	√	√	√	√	√	√	√	√		√

Gr1-Gr11 indicated they used IPM

Gr12-Gr14 indicated they did not use IPM.

Almost all the growers that responded to this survey used the newer generation insecticides including 2 of the 3 growers that felt they did not undertake IPM practices on their crop. Likewise almost all these growers undertook some type of crop monitoring which is an important component of IPM. If you do not know what is out there in the crop why do you spray and how do you know when to spray. Almost half the growers also monitored for beneficial insects with 3 of these growers also releasing beneficial insects. Although this was later found out to be the silverleaf whitefly parasitoids, which has recently be released in the Lockyer Valley in a number of locations. This is a particularly important sap sucking pest early in the season as high numbers can seriously stunt and delay the harvest of lettuce plantings.

IPM does not rule out the use of the less environmentally friendly insecticides such as methomyl and SP's and from this survey there are still some growers who will use them but generally only as a last resort or when a quicker response is needed. Only 2 growers, Gr7 and Gr13, of the 14 that responded, indicated that they rely more on the traditional insecticides such as methomyl and SP's than the newer insecticides that have been registered since the start of the Lettuce IPM projects. There appears to be a very high acceptance of the newer insecticides being released for use in lettuce including the use of Bts and Gemstar®.

Table 2. Who carries out crop monitoring and how often?

	Gr 1	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Gr 10	Gr 11	Gr 12	Gr 13	Gr 14
Crop consultant		√						√			√			
Chemical reseller			√			√								
Grower	√		√		√	√	√	√	√	√	√	√	√	
Weekly		√					√		√			√	√	√
Twice weekly	√		√		√	√	√	√			√	√		
Other										√				
10 plants						√		√						
20 plants	√				√				√			√		
Other		√	√			√	√			√	√		√	
Cost effective	√	√	√		√	√		√	√	√	√	√	√	
Not cost effective						√	√							

All except two of the 14 growers actually monitor there crop in some fashion. Whether it be by a consultant, reseller or by themselves, the crop is checked either weekly or twice weekly, with one grower, a hydroponic grower checking 4 times a week. I would assume this would be when the crop is being harvested on a regular basis. Grower 4 failed to fill in this part of the survey form so I can't say how they conduct their monitoring if any. Those growers that felt they did not carry out IPM practices still found the time to monitor their crop which is an important component of any IPM system. The number of plants that were checked did vary somewhat with only 2 growers checking as few as 10 plants and 2 other growers not indicating how many they checked. Some growers did find the time to check as many as 50 and 100 plants when they ventured forth in to their lettuce field, a well done effort. Monitoring for beneficial insects is also an important aspect of IPM and 6 growers did indicate that they carried this out as part of their IPM program. Knowing what beneficial insects are in the field helps in the selection of the most appropriate insecticide as some are harsher than others against beneficial insect populations.

Table 3. How long have the growers been carrying out IPM practices.

Duration (years)	Gr 1	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Gr 10	Gr 11
1-5	√	√	√		√						
6-10						√	√				
>10								√	√	√	√

Growers have clearly been carrying out IPM practices in lettuce for a number of years, with more than 70% of respondents indicating they use IPM for managing their insect pest problems in their lettuce crops. This could be as high 85% of respondents if 2 of the growers that indicated they did not use IPM are now considered as using IPM from the above evidence in Tables 1 and 2.

If only the respondents that indicated they used IPM are considered then over 28% of respondents have taken up the IPM banner in the last 5 years while more than 14% of respondents have been carrying out IPM practices for between 6 and 10 years. As the IPM in lettuce projects have been running since late 1998, 7 years ago, these results indicating that 4 and possible 6 of these growers (nearly 43% of respondents) have taken up using IPM strategies during the life of these projects and most likely as a result of these projects. These IPM in lettuce projects have shown how IPM can play a role in farm management practices and how beneficial IPM is to growers in the areas of better pest control, a greater understanding of their insect pests and being able to recognise the range of beneficial insects found in the crop, as well as reducing insecticide usage and hopefully their insecticide costs.

The table below shows that this is not always seen as a given. Only 36.4% of respondents felt that IPM helped reduce their insecticide costs even though 81.8% felt that monitoring was a cost effective exercise for them. Even though growers would be reducing their insecticides usage through better monitoring and timing of their sprays, the cost of the newer generation insecticides are higher than those traditional insecticides such as methomyl and the SP's, which could increase the growers insecticide costs.

Certainly the newer insecticides are more expensive but with a greater understanding of IPM and the role that beneficial insects play in insect pest management, growers are happier to use the biological insecticides and the newer insecticides as they are softer on the beneficial insect population resulting in just as good an outcome or better than when they traditionally used the older type insecticides and nothing else.

Table 4. Benefits of adopting an integrated approach to insect pest management.

Benefits	No. Growers that agree	% of growers that agree
Better pest control	9	81.8
A greater understanding of insects pests	10	90.9
Ability to recognise beneficial insects	8	72.7
Reduced insecticide usage	9	81.8
Reduced costs of insecticides	4	36.4
Monitoring is cost effective	9	81.8

It would appear that lettuce growers in Queensland do have a better understanding of their insect pests as well as the beneficial insects that can be found in their cropping system. This is evident over a range of vegetable crops in Queensland as a result of pest and beneficial insect workshops that have been run over the past years for growers and resellers and the grower's acceptance that not all insects that fly into a crop are bad, some are actually good, looking for the bad ones to munch upon. Over 70% of respondents were confident in being able to recognise the beneficial insects found on their farm and now a great deal more about the insect pests that they find within their crop, over 90% of respondents. All positive outcomes for IPM in vegetable crops.

Table 5. Insecticides used by lettuce growers.

Chemicals	Gr 1	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Gr 10	Gr 11	Gr 12	Gr 13	Gr 14
Bt		√	√	√		√		√	√	√	√	√		
Gemstar				√								√		
Success	√	√	√	√	√	√	√	√			√	√		
Avatar	√		√	√		√		√			√	√		
Proclaim			√	√		√		√			√			
Methomyl							√						√	
SP's							√						√	
Volume water	800		500	200	349	500-1000	100-120	500-1000				425-550	200	

Integrated pest management does not preclude the use of the traditional insecticides over the biological and new generation environmentally friendly insecticides, but rather allows for there strategic use. This could be if the grower feels the pest pressure is just too high and there is a need for a quick knock down, or the grower can better time their application according to monitoring results. Only 2 of the 14 respondents indicated a need to use the traditional insecticides such as methomyl and SP's to help in controlling their insect pest problems. Grower 7 also felt that he was using IPM to manage insect pests present in the crop through monitoring for both insect pests and beneficial insects. It could be assumed that this grower is using better timing of his insecticide sprays to target insect pest problems in the lettuce crop. Bt is being used more widely by growers as are the newer insecticides Success®, Avatar® and Proclaim®. Gemstar® was only being used by 2 growers indicating that growers either don't yet have the confidence with this product, through a lack of knowledge about the product, or simply don't like it and the speed with which it kills the Heliothis caterpillars.

There are growers out there that are still using excessively high volumes of water to apply their insecticides, up to 1000L per hectare. This is however only 21% of those that responded to the survey. Previous work in a range of vegetable crops has shown that high volume applications are not necessarily any more effective than lower volumes. In fact it is quite likely that the high volumes would cause excessive run off of product from the target leaves instead of an even distribution of spray droplets on the leaf surface resulting in less product on the plant than might be expected. Instead it is in the ground where it is of no use to the grower.

This survey also asked growers what weaknesses they see by using IPM. The responses included comments such as;

- trying to educate the consumer about the beneficial insects that they see when they buy a lettuce in the super markets;
- a slight reduction in marketable produce;
- if Heliothis are laying under the leaves or in the centre, it is possible to miss them;
- moths seem to be constant at certain times of the year and therefore spray on a regular basis to keep under control;
- being prepared to deal with outbreaks;
- take up time of effectiveness of some methods;
- and none.

Certainly some of the IPM tools and newer insecticides do take time to kill the pest but once the pest has consumed the newer insecticides they generally stop feeding and slowly die. Growers and consultants need to remember that some insecticides take a few days for the caterpillars to die and just because they see a caterpillar on the plant that it is healthy. The role of beneficial insects can also be a slower process to manage pests but if beneficial insects are left to build up in numbers they can have an impact upon insect pest populations. *Trichogramma* is a good example of an egg parasitoid which can be found attacking a range of caterpillar pests that lay their eggs on lettuce plants as well as a wide range of other vegetable crops. These tiny wasps will find most eggs no matter where they may be hidden on the plant leaf. Having a good understanding of beneficial insects is important as they are out in the crop seven days a week searching for something to consume keeping the crop relatively clean. Educating the public about the role of beneficial insects and insects in general is always going to be difficult. There are no easy answers to this one.

Another questions put to growers was "Are there any other techniques/tools that you would like to be developed to enhance a lettuce IPM strategy?" The responses included the following:

- as a hydroponic grower I would like to see more work done on application of some biological agents through irrigation water.

- don't really know
- no, its all been good so far
- all information gathered so far I feel has been very beneficial and heading in the right direction
- you tell me the possibilities

Certainly the hydroponic growers are in need of extra help, especially with regards the application of certain insecticides and possible residue issues associated with hydroponic systems.

The question, "What is the biggest threat to the ongoing success of lettuce IPM?" generated the following responses:

- time
- lettuce aphid
- if you don't keep it up
- pest outbreaks
- insecticide resistance
- demands by buyers that produce should be 100% insect free

Insecticide resistance is the main reasoning being the introduction of an IPM system. Certain insects have the ability to develop resistance to a wide range of insecticides over time both new and old. Heliothis is the most widely know insect for being able to accomplish such a task, thus the need to look at alternative control options put forward by integrated pest management and not relying upon only one control option to manage an insect pest problem. The introduction of exotic pests into the system would in the short term be an issue but if an IPM system were in place with the use of beneficial insects, then it could be assumed that these beneficial insects would also help in dealing with exotic pest incursion. Lettuce aphids is certainly one such occurrence where the role of beneficial insects is seen as a vital component of an IPM system for lettuce aphid control.

This survey also asked growers to give feed back on the various publications and events generated as a result of the lettuce IPM projects which are tabulated in Table 6 below.

Table 6. Number of growers that indicated their rating preference for a number of project outputs.

	Rating scale				
	1 (very poor)	**2 (poor)**	**3 (good)**	**4 (very good)**	**5 (excellent)**
Lettuce leaf newsletter			3	1	6
Lettuce conferences			2	2	
Conference proceedings			1	1	
Lettuce IPM information guide				3	4
Ute/Field guide				2	4

Those growers that did respond thought that the information generated by the projects was good to excellent, with the majority of responses indicating very good to excellent, especially for the newsletter, IPM information guide and the UTE guide. Information generated from these projects is clearly getting out to the growers where it is needed. This information helps to keep them informed of project results and how to combat the range of pests and diseases that are an issue for lettuce growers across Australia.

The last question asked of the growers was “Any other comments?” and the responses received included:

- Keep up the good work
- At the end we need $ for the finished crop
- You do very good work

Although only 3 responses were forthcoming from growers it is heartening that the work this project has done to date has been welcomed and appreciated. More money for the crop is what all growers are after and if the use of IPM helps to reduce the cost of one component of the overall dollar inputs of producing a crop of lettuce then this project has achieved this goal by putting more dollars into the growers pocket. As shown in Table 4 more than 81% of respondents found monitoring to be cost effective with more than 36% of respondents actually reducing their cost of insecticides. This would also have a flow on effect to reducing the amount of insecticides onto the crop with over 81% of responses indicating this, which would in turn reduce the time needed to spray the crop, wear and tear on machinery needed to spray the crop as well as the fuel for the tractor. All of which adds up to more dollars staying in the growers pocket.

Conclusions

As with most survey forms sent out to growers or other industry groups, the response is usually low unless individuals are contacted and talked through the survey, drawing out the answers through such a discussion. Even though only 14 growers responded to this survey the results were very positive about IPM, the perceived direction that it is heading and the confidence that growers seem to have in this management practice. It was also heartening to find that there were growers from the hydroponic and organic sectors represented in the 14 respondents. Follow up discussions were held with a small number of the respondents to try and draw out additional information to what was supplied in the survey form.

The responses show that the majority of growers, 92.8% of responses, monitor their lettuce crops in some fashion. This is an important aspect of any IPM system. Without an understanding of what is in the crop a grower can not make a reliable decision on what to spray or when to spray. Calender sprays are very rarely carried out by growers today as they are generally a waste of time, money and chemicals. Growers are developing a better understanding of the type of insect pests they have in their crops (90.9% of respondents) and also the range of beneficial insects (72.7% of respondents) that can help to manage their insect pest problems. This has helped in a better understanding of the range of soft option insecticides that are gentle on the beneficial insect but harmful to the insect pests, with the majority of respondents (85.7%) using the newer softer options insecticides instead of the harsher insecticides such as methomyl and the SPs.

Integrated pest management is a vital component of grower farming practices with some growers using IPM tools without realising they are using them. Education is still required in some regions to help explain IPM to growers and what can be achieved by following IPM practices on the farm. Perhaps with some discussions, growers will realise that they are already part way there and just need that little bit more confidence in what they are doing and what they expect to get out of using IPM. The growers that have been using IPM for up to 10+ years have seen a reduction in insecticide usage and found crop monitoring to be a cost-effective exercise, although not all growers have found an obvious reduction in their insecticide costs. Spray application is an area that could do with a bit more research to show the benefits or otherwise, of using various spray volumes against insect pest control. Spray volumes are variable according to the 14 respondents even though there is an indication of better pest control by using IPM. This would indicate that those growers using the high volumes may be in fact wasting product unnecessarily.

Pest outbreaks or preparedness for these outbreaks came up a number of times in last few questions of this survey, lettuce aphid being the most recent example. It is hoped that growers that have been practicing IPM for a number of years and have developed a good understanding of soft option insecticides and beneficial insects will be in a good position to deal with most new pest outbreaks including lettuce aphid when it arrives in Queensland

Lettuce IPM Survey 2005

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Introduction

A telephone survey of lettuce growers was conducted late October 2005. The aim of the survey was to get an understanding of the level of Integrated Pest Management (IPM) in the Australian lettuce industry and the value of the lettuce IPM project.

The telephone survey was done by clerical staff from the NSW Department of Primary Industries. The growers contacted were randomly selected by clerical staff from a list of lettuce growers that was compiled by NSW DPI throughout the duration of the lettuce IPM project. There were over 200 growers on the list, with the majority of growers being from New South Wales and Victoria. Queensland growers were excluded since they had already been survey by John Duff. In total 34 growers were contacted and 20 participated in the survey. The survey participant's regional spread was NSW (Cowra 3, Sydney 3, Hay 6, Tamworth 1), Vic (Werribee 3), SA 2, WA 1 and Tas 1.

The survey form used in the DPI NSW survey was essentially the form that was used in the 2005 postal survey of Queensland lettuce growers (Appendix 9).

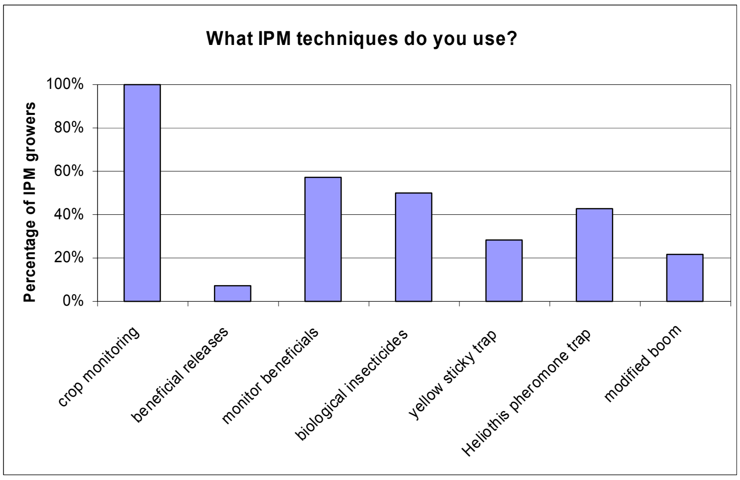
NSW DPI survey results

Regionally based influences were clearly apparent as growers from states other than NSW were not as receptive to a NSW DPI survey. Telephone surveys are difficult as a select few people are either contactable or take the time to participate. Hence this survey is not a complete evaluation of the Australian lettuce industry; however it gives an idea of grower attitudes to IPM and their opinions on specific outcomes of the lettuce project.

IPM strategies were used in the production of lettuce by 14 of the 20 responding growers. Over 25% of the growers felt they did not use IPM techniques. The term "IPM" is actually open to interpretation and all growers are likely to use some IPM techniques in their lettuce production. Ploughing in old crop residues, growing disease resistant varieties, insecticide rotation are actually IPM strategies that most growers do as part of their crop management.

Crop monitoring was done by all of the growers that indicated they were using IPM techniques as part of their lettuce production (Figure 1). Half of these growers also monitored for beneficial insects and indicated that they used biological insecticides. Beneficial insect releases were used by a hydroponic lettuce grower. The yellow sticky traps were mainly used in areas where western flower thrips (WFT) was an issue.

Figure 1. IPM Techniques used by growers that indicated they used an IPM strategy as part of their lettuce production.



All 6 of the 20 responding growers who indicated they did not use an IPM strategy as part of their lettuce production sprayed weekly for insect pests. Generally this was seasonally adjusted to observed pest pressure and seasonal weather influences. At times when insect pest pressure is high some growers indicated insecticide applications 2 times per week were needed (Table 1). A majority of the growers that did not use IPM strategies used some of the new insecticide chemistry.

Table 1. Ways that non IPM growers manage insect pests in lettuce.

Grower percentage	Crop management factor
117%	weekly insecticide spray
17%	insecticide application 2 times per week
33%	old chemistry only e.g. Lannate®, Fastac®, Dimethoate
67%	some new chemistry e.g. Success®, Avatar®, Bts
100%	conventional over the top boom sprayer
17%	modified boom sprayer
100%	spray to observed pest pressure / weather influences

The growers that were not using IPM strategies were asked, "What would it take for you to adopt an IPM strategy?" Responses included:

- Evidence that IPM will always be as reliable as chemicals. Growers can not afford to have a break in supply as they may lose contracts / markets.
- A market demand for IPM produced vegetables. Growers need compensation for the extra costs that can be incurred with IPM strategies that use expensive insecticides.
- Greater financial return for IPM produced lettuce.
- Low levels of product damage by insects or contamination with Rutherglen bugs and beneficial insects to be accepted in the market.

Ninety percent of the growers using IPM strategies indicated that they have been using them for 1-5 years. The remaining growers had been using IPM strategies for a period greater then five years. Most growers indicated they adopted an IPM strategy to save money on spray applications. Other growers indicated that they adopted IPM strategies for sustainability and to better manage insect pests like WFT or heliothis (*Helicoverpa armigera*).

Almost all the surveyed growers (95%), indicated that they monitored their lettuce crops. Crop monitoring was predominantly done by the growers themselves (58%) and 32% of growers had their crops monitored by an independent crop consultant (Table 2). Growers that monitored themselves generally checked the crops weekly for insect pests, however in hydroponics or when insect pest pressure was high in the field crops they were checked twice per week, or even three times per week. Generally the growers using consultants and resellers had their lettuce crops checked once per week.

Table 2. Who carries out the crop monitoring in your crop?

Percentage	Person who does the lettuce crop monitoring
32%	crop consultant
10%	chemical reseller
58%	yourself

Some growers indicated they were monitoring their crops to a protocol, whilst others were checking the perimeter of the lettuce whilst doing other crop management tasks. The monitoring protocols varied greatly between growers. Field lettuce growers indicated they checked 10 lettuces per planting, 12 lettuces per planting, 20 lettuces per planting, a zigzag check of 50 lettuces per acre, or do not really count lettuces and just look to observe the pest pressure. The growers using crop consultants or resellers were not all aware of the monitoring protocol used. Some consultants combined vacuum sampling of lettuce with visual checks.

Hydroponic growers used different monitoring protocols to the field growers. Some indicated they checked 10/500 lettuces (2%), 20 lettuces per $100m^2$ and or used sticky traps. Hydroponic growers generally monitored more frequently than field lettuce growers and indicated thrips as their most damaging insect pest through the transmission of virus.

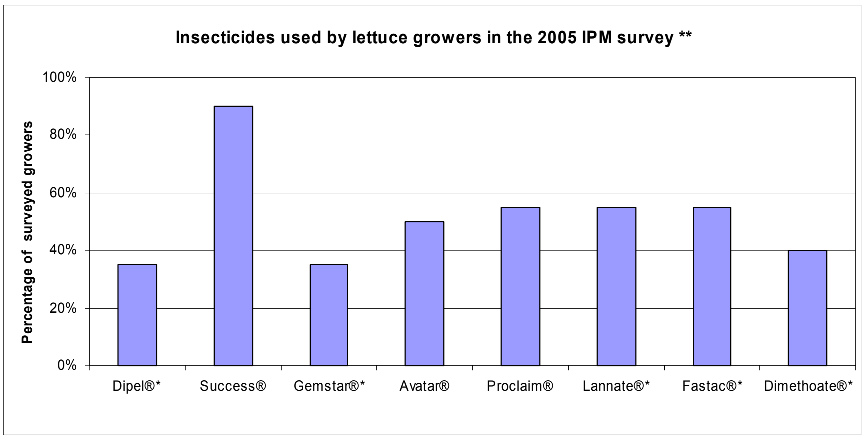
Of the growers that used crop monitoring as part of their crop management program, only 75% felt that monitoring was effective at reducing the number of insecticides applied. The other growers felt that at times of high pest pressure monitoring was a waste of time, as you have to spray anyway.

The grower that indicated they did not monitor their crops determined the right time to apply insecticide and fungicide treatments through experience, and knowing at what time of year certain pest pressures occur. Observation of moth activity at night also helped to indicate the right time to spray.

Most growers (90%), indicated that they used new generation insecticides, all these growers actually used Success® (Figure 2). The reason for most lettuce growers using Success® would be due to the products efficacy against both heliothis and WFT. Half of the surveyed growers used Avatar® and Proclaim®, where as only a third of the growers indicated they were using biological insecticide products like Dipel® and Gemstar® or Vivus®. Survey results from Victoria indicated the use of Gemstar® through both the irrigation system and spray boom for heliothis control.

Some growers do not use the older chemistry because they have established IPM techniques and do not wish to harm the beneficial insect population. Quality assurance was also another reason given by a grower for not using the older insecticide chemistry.

Figure 2. Insecticides used by lettuce growers.



* Indicates the growers may use different products with similar active ingredients (Table 3).
** This is not a complete list of insecticides used in the Australian lettuce industry as the surveyed growers were predominantly from NSW and VIC. The listed insecticides were the products growers were prompted or specifically asked about. Some growers also indicated the use of Pounce®, Pirimor® and Confidor®.

Table 3. Table of selected insecticides and their active ingredients.

Active Ingredient	**Product** (Not a complete list)
Bacillus thuringiensis (Bt)	Dipel®, Xentari®, MVP®, Biobit®
Spinosad	Success®
Helicoverpa NPV	Gemstar®, Vivus Gold®
Indoxacarb	Avatar®
Emamectin	Proclaim®
Methomyl	Lannate®, Electra®, Marlin®, Electra®
Alpha-cypermethrin	Dominex®, Fastac®, Astound®, Dictate®
Dimethoate	Dimethoate®, Rogor®, Roxion®
Permethrin	Ambush®, Pounce®, Hellfire®
Pirimicarb	Pirimor®, Aphidex®
Imidacloprid	Confidor®

Just over half of the growers used older insecticide chemistry like Lannate® Fastac® and Dimethoate® (Figure 2). The main reason why growers chose to use the older (carbamate, organo-phosphate and synthetic pyrethroid) insecticide chemistry is because the newer generation insecticides are too expensive. Whilst the older insecticide chemistry effectively kills insect pests, many growers will use these products. The use of new generation insecticides like Success® Avatar® and Proclaim® is sometimes limited to hearting or during periods of high insect pressure. Poor efficacy with biological type insecticides (Dipel® and Gemstar® or Vivus®) and a lack of product knowledge are other reasons growers gave for not using newer generation insecticides.

Very few growers tank mixed insecticides that had activity for the same insect pest and mixing appeared to be regionally specific. Of the growers that did tank mix, Lannate® and Fastac® was the most common mix.

Some growers do not use the older chemistry because they have established IPM techniques and do not wish to harm the beneficial insect population. Quality assurance was another reason given by a grower for not using the older insecticide chemistry.

The majority (85%) of the surveyed growers applied their insecticides with a conventional boom sprayer. Spray booms with short droppers are used by some growers in Hay, NSW. A few growers are using air assist sprayers in NSW and VIC. Spray water application rates varied greatly. Some growers varied the water rate with the stage of the lettuce crop development whilst others always used the same water rate. The water rates used in lettuce crops varied from 400 to 1000L/ha.

Growers that had experienced benefits by adopting an integrated approach to pest management usually indicated a number of benefits rather than one single benefit. Better pest control and reduced insecticide usage were the main benefits. Growers also indicated that they had a greater understanding of insect pests, were able to recognise beneficial insects and saved money on insecticide sprays.

A lack of confidence in IPM and the fact insect pests may get away was clearly the most common weakness growers see in using an IPM strategy. The question was asked as an open question and it is interesting that 60% of the weaknesses given related to pests getting away (Table 4). Most of the reasons stated actually relate in some way to a pest getting away and causing crop losses. Some growers are committed to supplying markets and a crop failure is likely to lead to loss of buyer confidence. This is a risk most growers are not willing to take.

Some growers felt that an IPM strategy would be an extra cost to lettuce production and others were concerned about insect spread viruses or beneficial insect consignment contamination. In Victoria the currant-lettuce aphid *Nasonovia ribisnigri* interstate trade restrictions are certainly a weakness of using IPM strategies in Victoria as an IPM strategy would prevent marketing lettuce in some states.

Table 4. Weaknesses that growers see in using an IPM strategy.

Grower number	Weakness of using an IPM system
2	extra cost (monitoring & new chemistries)
10	lack confidence in IPM, pests may get away
1	beneficial consignment contamination
1	inconvenience of consultant monitoring, wait for furrow irrigation
1	thrips spreading tomato spotted wilt virus (TSWV)
1	aphids spreading cucumber mosaic virus (CMV)
1	Lettuce aphid regulations on Victoria, no recognition of IPM by some states.

Other tools and techniques/tools that growers would like to be developed to enhance a lettuce IPM strategy included:

- local / regional technical support
- better biological insecticides that give comparable efficacy to regular chemistry
- strategies for effective Rutherglen bug and thrips management
- fail proof IPM so growers can use IPM with confidence

Growers indicated that beneficial insect contamination of lettuce as the greatest threat to the ongoing success of lettuce IPM. The buyers and the consumers need to be educated about beneficial insects and accept that lettuces grown with an IPM strategy may have some insects present. Uncertainty surrounding the lettuce aphid and the use of Confidor® were also identified as important threats to lettuce IPM (Table 5).

Table 5. Threats to the ongoing success of lettuce IPM.

Grower number	Perceived threats
2	Lettuce aphid and Confidor® drenching
4	Lettuce aphid uncertainty
5	Beneficial insect contamination, no market tolerance for insects
3	RGB damage and contamination
3	Thrips and transmission of TSWV
1	Conventional, broad spectrum insecticides are cheaper to use during periods of high insect pest pressure than the new chemistry
2	No market recognition of IPM, no price premium for the effort

Thrips and virus management under an IPM system was also considered an important threat. Currently Success® is the only 'soft' chemical option available to growers using IPM strategies and WFT have a history of developing insecticide resistance. Some growers were also concerned about the risks they take whilst developing IPM strategies on their properties. Whilst both the consultant and the grower are learning about regionally specific lettuce IPM there may be some crop failures. There is no price premium in the market for the extra effort a grower puts in to grow lettuce with an IPM strategy.

The last question of the survey asked growers to rate specific publications and activities of the lettuce project. Generally all of the project outcomes were rated highly by the surveyed growers except for the conference proceedings (Table 6). Many growers did not receive conference proceedings. Those growers that did receive the second lettuce conference proceedings felt the publication was too technical and that growers generally did not have time to read such wordy publications. This may explain why the brief 'lettuce leaf' newsletter and the ute/field guide were rated slightly better than the larger lettuce IPM information guide.

Table 6. Grower ratings for lettuce project publications and activities.

	Did not receive or attend	Rating				
		1 (very poor)	2 (poor)	3 (good)	4 (very good)	5 (excellent)
Lettuce IPM information guide	4			6	5	4
Ute/Field guide	4		1	1	5	8
Lettuce leaf newsletter	2		1		8	8
Lettuce IPM field days	7			1	4	7
Lettuce conferences	7	1	1	2	3	5
Conference proceedings	10	2	2	5		

Only 60% of the growers surveyed had attended lettuce workshops/field days or a lettuce conference. The majority of the growers that had attended lettuce workshops/field days or a conference, indicated attendance was worth while as they generally rated these activities as very good to excellent. Some growers surveyed felt some aspects of the lettuce conference were disappointing and rated the conference lower. The conference criticisms revealed in this survey were similar to the findings from the comprehensive lettuce conference evaluation / survey of lettuce conference delegates (Appendices 3 and 7).

Conclusion

This survey of predominantly New South Wales and Victorian lettuce growers has quite similar findings to the survey of Queensland lettuce growers. More than 75% of lettuce growers are using IPM techniques as part of their lettuce growing practices. Regular crop monitoring was common to all growers that indicated they used IPM strategies. Consultants and chemical resellers did 40% of this monitoring, whilst 60% of grower monitored their own lettuce crops. Monitoring frequency, methods and protocols varied greatly between growers and districts.

Conventional spray booms were used by 85% of growers to apply crop sprays. The water rates used varied greatly, between 400L/ha and 1000L/ha. There appeared to be no general preference for either higher or lower water rates. New generation insecticides are popular, with 90% of growers using them, mainly due to their efficacy. Older, synthetic pyrethroid and carbamate insecticide chemistry is still used by 50% of the surveyed growers. Biological type insecticides like Bt's or Gemstar® were only used by 30% of the growers. Characteristics of insect pest management in lettuce are regionally specific as insect pest pressure varies. For example, older insecticide chemistry may be used less in Victoria than New South Wales or South Australia because thrips are less of a problem and IPM is more widely adopted.

Effective Rutherglen bug and thrips management strategies are needed to enhance lettuce IPM. Growers also indicated that regional support and expertise is essential to the future success of lettuce IPM. The greatest perceived threat to IPM was pests or disease getting away, resulting in crop failures. The pest growers were most concerned about was currant-lettuce aphid and virus spread by thrips. Growers rightly perceive these pests as a threat due to a lack of confidence in IPM systems. There is a lack of regional IPM expertise and support in many lettuce production districts and growers who are developing IPM systems are experiencing some crop losses.

Rutherglen bug or beneficial insect contamination of lettuce was another threat to lettuce IPM that growers considered important. The issue is that the market buyers, processors and consumers all have low tolerances for insect contamination. The adoption of an IPM strategy that uses more selective insecticide chemistry generally results in greater numbers of these coincidental insects in the lettuce crop.

The growers that were randomly chosen for this survey acknowledged their appreciation of publications generated by the lettuce projects. The IPM in lettuce: Information Guide, the field identification guide and the lettuce newsletter were generally rated very good to excellent. Growers also positively rated the lettuce workshops/field days and lettuce conferences. This indicates such extension activities are valued by growers. The bimonthly lettuce newsletter should continue as a medium to extend relevant information to lettuce growers and also to encourage other growers to participate in field days and conferences.

Acknowledgements

Thanks to Leonie Napier for assisting with the survey. This project was funded by NSW DPI, the AUSVEG levy, Horticulture Australia Limited and a voluntary contribution from South Pacific Seeds and Convenience Foods.

Recommendations

1. That effort be put to identifying the needs of crop consultants to develop skills in biointensive IPM, for training of new and existing consultants as IPM consultants and to investigated the potential of accrediting IPM consultants.
2. That case studies be conducted on growers who have adopted IPM, including an economic analysis of IPM adoption
3. That large scale demonstration/trials of IPM be conducted in major lettuce growing areas where little IPM adoption has occurred.
4. That there continue to be on-going efficacy trials of new chemistry, novel uses of old chemistry and the potential for adjuvants to allow reduced rates for managing key pests.
5. Research conducted on habitat management to either reduce pest havens or increase beneficials
6. That research into 'soft' options for managing insect transmitted viruses
7. That IPM consultants and IPM strategies include insect, disease and weed management as part of the equation.
8. Industry lobby for chemical companies to pursue registrations of the new softer chemistry
9. Bioassays of all new chemistry against key beneficial insects
10. Discussions with the lettuce market chain about quality specifications, particularly numbers of live and dead insects allowable in lettuce

Appendices

Conference Program

Sunday 5th May 2002

6-8.30pm Registration and Welcome Reception Foundation Building - UQ Gatton Campus

Monday 6th May 2002

7.30am Registration desk open in the MultiPurpose Hall
9.00am Welcome and opening – *John Duff & Grant Hall, QDPI Gatton Research Station*
9.15am Opening address - *Rob Robson, Harvest Fresh Cuts*
10.00am Good Agricultural Practice - *Tim McAuliffe, Harvest Fresh Cuts*

10.30am Morning Tea/View Trade Displays

11.00am **State Roundups**
QLD – *Max Durham*
NSW - *Eddie Galea*
VIC - *Marco Mason*
SA - *Joe De Ruvo*
WA - *Andrew Tedesco*
American lettuce production overview - *Greg Kocanda , Elders*

12.00pm Azadirachtin - "Organic Snake Oil" or Effective IPM Tool? - *Paul Moorhouse, Organic Crop Protectants*

12.30pm Lunch/View Trade Displays

Marketing and Post Harvest Issues
1.30pm The changing demands of quick service restaurants industry- *Michael Berman, GSF Australia*
1.50pm Making Australian export lettuce competitive again - *Dennis Phillips, Department of Agriculture WA*
2.10pm Low temperature storage prevents browning in crushed lettuce - *Donald Irving, UQ Gatton*

National Research Projects Roundup and IPM Related Issues
2.30pm Outcomes of Lettuce IPM project 1998-2001 and beyond - *Sandra McDougall, NSW Agriculture and John Duff, QDPI*
2.50pm Exploring new frontiers in IPM - *Bronwyn Walsh QDPI*

3.10pm Afternoon tea/View Trade Displays

3.45pm Decreasing Tipburn in Lettuce Part 2 - *Craig Murdoch, Agriculture Victoria*
4.10pm Disease issues arising from Lettuce IPM project 1998-2001 - *Andrew Watson, NSW Agriculture*
4.35pm Integrated control of Sclerotinia rot - *Ian Porter, Agriculture Victoria*

5.00pm Discussions and close

7.00pm **Conference Dinner** Gatton Shire Hall
Guest speaker: *Tony Biggs, Editor of Good Fruit and Vegetables*

Conference Program

Tuesday 7th May 2002

Field trips – Paddock to Plate

8.00am Buses depart from Foundation Building
Participants split into 3 groups, all to visit the 3 sites.
Site 1: Withcott Seedling Nursery
Site 2: Grower property (planting and harvesting)
Site 3: Field demonstration site (insecticide)

12.45pm Lunch UQ Gatton Campus

1.45pm Variety trial inspection Gatton Research Station QDPI site
Henderson seeds, Fairbank Selected Seeds, Yates, SPS, and Syngenta Seeds
Presentation by *Dan Trimboli, Yates Seeds*

3.30pm Afternoon tea Gatton Research Station

4.00pm Spray application demonstration - *Glen Geitz, QDPI*

4.30pm Genetic transformation of lettuce for resistance to viruses -*Ralf Dietzgen, QDPI*

5.00pm **BBQ dinner** Gatton Research Station
Evening inspection of spray application demonstration (observe dye on leaves using UV lights)

Wednesday 8th May 2002

8.30am **R&D Priorities session**
Future directions, new projects, key issues facing lettuce industry – *John Tyas HAL*

10.00am Conference close

10.15am Conference evaluation sheets Morning tea View Trade Displays.

Expo 17 Tickets given out after close at registration desk to those who have purchased them.

Afternoon: Pest, beneficial and disease identification workshop Gatton Research Station

Lettuce Industry Research & Development Priorities

2nd Australian Lettuce Industry Conference

Gatton, May 5-8, 2002

Summary

Priority areas for research and development, identified by lettuce growers at the 2nd Australian Lettuce Industry Conference were:

- Marketing
- Standardised Quality Assurance and packaging
- Pest and disease mangagement
- Fertiliser and irrigation management
- Lettuce industry statistics
- Communication
- Harvest efficiency
- Post-harvest management

Introduction

At the 2nd Australian Lettuce Industry Conference (Gatton, 5-8 May, 2002) conference attendees were invited to take part in a *Lettuce Industry Research & Development Priority Setting Workshop*, facilitated by John Tyas (Program Manager, Horticulture Australia). Conference attendees were also invited to complete a survey to identify research and development needs for the lettuce industry.

The aim of the workshop was to identify the key research and development issues for the Australian Lettuce Industry and which of these needs to be given priority for funding from the National Vegetable Levy/Horticulture Australia Research & Development Program over the next 3 to 5 years.

44 conference attendees took part in the workshop, consisting of 21 growers, 12 researchers, and 11 from industry. Horticulture Australia's Key Result Areas were outlined to workshop attendees.

Workshop attendees were split into four groups to undertake a SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis of the Australian Lettuce Industry. Attendees then rejoined to compile a list of identified strengths, weaknesses, opportunities and threats for the Australian Lettuce Industry.

Taking into consideration the issues raised in the SWOT Analysis attendees were then asked (within their 4 groups) to identify six priority issues and identify what needs to be done to address the issues/what the desired outcome is. The groups rejoined and compiled a list of priority issues. Where the groups identified the same or similar issues the issues were listed together if the workshop attendees felt they should be addressed together. When the final list of priority issues was completed each lettuce grower (non-growers excluded for this activity) was given 5 red dots and asked to assign the dots to the issues that were of highest priority to them (more than one of the dots could be placed on an issue).

The group was in agreement that the final list was representative of their priority issues.

For the survey conducted earlier, conference attendees were asked to identify issues and at what growth stage they were a problem, prioritise them (low, medium or high) and indicate whether they were a lettuce grower, researcher or from industry. This survey was not used directly in the workshop process, but was used to check the list of issues raised.

SWOT Analysis Results

Strengths

- Geographic diversity
- Year round supply
- Health benefits
- Range of products: head, hydro, freshcuts
- Quality and continuity of supply
- Key salad ingredient
- Good product
- Good value for money
- Supportive State and Federal Gov.
- Most lettuce growers are good growers
- Perishable product

Weaknesses

- Oversupply
- Communication failure between growers and researchers, consumers and other growers
- Transport costs (export and domestic) and availability
- Lack of grower unity
- Too many varieties – confuses the consumer
- Distance to markets
- Large headed lettuce
- Too few independent retailers
- Not understanding whole supply chain
- Cost of packaging
- Market size is not increasing
- Business sizes are too small – economies of scale
- Production systems not sustainable
- Competition between growing regions
- Lack of promotion of lettuce as a health product
- Difficulty accessing export incentives
- Labour shortages
- Too much bureaucracy
- High export freight rates
- Lack of consumer knowledge about optimum storage conditions and time
- Use of second hand cartons

Opportunities

- Growth potential – Australia has the land, water and climate
- Global position – proximity to Asia and Middle East for Export
- Fresh cut lettuce
- Simplified Quality Assurance systems
- Promotion of reduced chemical inputs (IPM)
- Consumer survey/information
- Marketing with complimentary industries
- Development of lettuce with a smaller head

- New products: lettuce juice, wrapped lettuce
- Grower cooperation in marketing
- Marketing groups to improve grower return
- Promoting our superior food safety in export markets
- Post-harvest disinfestation
- Consumers demanding reduced use of pesticides
- Growing demand for convenience foods
- Branding
- Health-based marketing – functional foods
- GMO lettuce development
- Environmental labelling: MPS (Dutch prgm)

Threats

- Over production
- Quality Assurance misused
- Pest and disease problems, along with loss of available chemicals
- Food safety based litigation
- Imports, competition from overseas and competition out export markets
- Too many varieties – threat to head lettuce production
- World Trade Org. – e.g. inclusion of China
- Decrease in consumption of vegetables
- Shortage of labour
- Urban/rural conflict
- Secondary pests e.g. aphids
- Consumer demand for fewer chemicals
- Water quality
- Exotic pests and diseases
- Chemical resistance development
- GMO lettuce

Identification of priority issues

1. Marketing (34 votes)
   a) Quantify size and value of whole lettuce industry for marketing
   b) National marketing strategy for lettuce
   c) Market research on retailer attitudes (independent research)
   d) Improved marketing methods based on consumer research (e.g. smaller heads)
   e) Market research/analysis to identify future consumer needs and trends
   f) Market research of consumer requirements and expectations of growers (independent of retailers research)
   g) Study of export markets and import competitors

2. Standardised Quality Assurance and packaging (27 votes)
   a) Development of uniform Quality Assurance standards
   b) Implementation of uniform packaging standards and development of uniform and consistent Quality Assurance systems for lettuce
   c) Alternative packaging development

3. Pest and disease management (24 votes)
   a) Control of western flower thrips in IPM – biologicals/new chemistry
   b) Lack of suitable chemicals for sucking pest control
   c) Identify and expand chemical options, including hydroponics
   d) Identify virus management options for big vein, mosaic and yellows
   e) Better data and understanding of inter-relationships between different crops and IPM systems
   f) Completely integrated IPM strategies – key pest, secondary pests and beneficials

4. Fertiliser and irrigation management (10 votes)
   a) More independent research for new input products (e.g. crop nutrition products)
   b) Improved soil management for whole of farm production – improved disease control and product quality
   c) Optimise fertiliser and nutrition needs in all growing districts in conjunction with IPM strategies
   d) Irrigation management for disease control/management

5. Industry statistics (1 vote)
   a) Industry statistics for justification of investment by Government

6. Harvest efficiency (0 votes)
   a) Labour efficiency studies, harvest mechanisation – to reduce unit cost of production

7. Communication (0 votes)
   a) Development of an extension network between growing areas (e.g. internet, conferences, meetings, study tours)

8. Post-harvest management (0 votes)
   a) Improved post-harvest management of lettuce to allow export by sea - what is done and what needs to be done to extend shelf life

Survey Results

Issue	Priority	Growth Stage*	G/R/I**
Heliothis	H	PH, H	R, G4
Sclerotinia	H	PH, H	G3
Insect control – aphids, thrips (WFT)	H	EE	G2, I
Anthracnose	H	T, PH, H	G2
Hydroponics nutrient solution	H	PH	G
Suitable IPM products	H	H	I
Thrips	H	T to Harv	G
Varnish spot	H	PH, He, Harv	G, R
Jelly butt	H	H, Harv	G
Technology adoption	H	PoH	I
Resistant varieties	H	PP	I
Softer chemicals for aphids and heliothis	H	H	I
High levels of nitrate (health issue – bad publicity)	H	PoH	I
Sap analysis	H	PP	R
Fertiliser use	H	PP	R
Compaction – soil structure and physics	H	PP	G
Sudden increase in N in spring when cold Tassie soil start to warm – lettuce becomes slimey	H	H	G
Irrigation scheduling/ moisture levels – for disease control	H		G
Whitefly	M	EE	G
Tipburn	M	H	G, I
Trickle irrigation and use of recycled water	M	PP	I
Big Vein	M	PH, H	G2
Use of manure	M	PP	G
Rutherglen Bug	L to M	Harv	G2, R
Weed control		EE	I
Labour		Harv	G
Ideal transplant depth		T	G
Growing in cold soil – getting initial vigour and good root development		EE, PH	G
Bacterial spot		H	G
Sclerotinia resistant varieties			R, I
Viral resistant varieties (LNYV, LMV)			R, I
Market research – can we increase export by improving our product (what varieties?)			R, I
Increasing shelf life and improving packaging			R,I
Harvest method to suit export market			R,I
Big vein info to growers – management strategy – often treated as a viral disease rather than a fungal one			R, I

* PP = Pre-Plant; T = Transplant; EE = Early Establishment; PH = Pre-Heart; H = Hearting; Harv = Harvest; PoH = Post Harvest
** G = Grower; R = Researcher; I = Industry (number specifies the number of people who raised the issues)

Other general comments:
- Information to reach all growers.
- Prices.
- Some levy money should be allocated to promotion of vegetables.
- Projects at the moment are too generalised – too much crossover in projects – whole lettuce research program needs more focus and management (researchers need to work together).

Horticulture Australia Key Result Areas

1. Market Requirements and Opportunities
   - whole of market identification, investigation and evaluation
   - understanding end users

2. Industry Development Services
   - planning and strategy development
   - dissemination and adoption of R&D outcomes
   - people development

3. Product Development
   - varietal improvement
   - value added and derived products

4. Production
   - production efficiency
   - natural resource management

5. Product to End User
   - market impediments
   - quality supply systems

2nd Lettuce Industry Conference Evaluation

(5-8 May 2002, Gatton, QLD)

- 31 of the 179 conference participants completed the evaluation forms.
- Numbers given below are actual numbers (not all survey participants answered all the questions)

Question	1 poor	2	3	4	5 excellent	Comments
1. Opportunity to make contact		2	7	14	9	
2. Format	1	3	11	14	2	• too many presentations on the first day • split the field trips over two days • split the initial day so that the afternoons are easier • would like to visit a hydroponic farm • Didn't need to see transplanter at end of field visit
3. Quality of presentations	1	3	16	9	2	• the presentations were too similar to the Hay conference, little new info. • Too much advertising of products during presentations – best for display area • Please preview presenters involvement (one presenter caused offence) and carefully analyse papers to avoid mis-interpretations
4. Value of information	1	6	12	9	4	
5. Timing		4	7	11	10	• busy time of year, not convenient (local grower) • co-insides well with farm field trips • co-insides with field days
6. Length	1	4	8	13	6	• third day is to light on if not going to the field day (*better for travel*) • only be two days (a comment made on 4 surveys) • 3 days is good but break the days with field trips
7. Attendance						
- growers		5	13	9	5	
- scientific officers	1	4	5	15	6	
- industry representatives		7	10	11	6	
8. Location	1		4	15	11	
9. Attend another conference?		1	5	11	11	

Where?
- Werribee, Vic 12
- WA 5
- Sydney basin, NSW 2
- Adelaide, SA 1

When?
- 2 years 15
- 3 years 4
- Werribee - Sept, Nov (March?)

Other comments:
- Have R&D session on the second day between field trip & BBQ, not promotional talks.
- Tour guides on the buses, more information is required on the tour.
- Very good need it for the future of the industry
- Very well organised. A lot of information to take home
- I suggest a theme for the next conference to give it more structure, summarise scientific results and then focus on what future projects / industry requirements are needed.
- Less marketing emphasis

CONFERENCE EVALUATION – TRADE DISPLAYS

Question	1 poor	2	3	4	5 excellent	Comments
1. Opportunity for access to you/your site		2	2	2	1	
2. Siting of display within venue			2	4	1	
3. Area (space) available			3	3	1	
4. Attendance						
- growers		2	2	1	2	
- scientific officers	1	3	1	2		
- industry representatives	1	2	1	3		

Trade display comments:
- value for money and time
- thankyou as a trade display, good value

Lettuce survey of current insecticide practices

Compiled by John Duff, QDPI & Andrew Creek, NSW Agriculture.

Introduction

As part of the lettuce IPM project a survey has been conducted to present a snapshot of the current pest management practices in the Australian lettuce Industry. This report has been compiled after consultation with ‘key’ local agronomists and some growers from each of the lettuce growing districts.

All growers have a different approach to pest management in their lettuce crops. Pest pressure, climatic influences and agronomic situations vary between individual blocks and lettuce production areas. The district summaries included in this report are only generalisations and trends that appeared throughout the survey of lettuce growers and consultants. They are not an indication of an individual grower’s approach to pest management.

Response to the Survey

The insect pest species differed and the level of damage individual species caused varied around the country. Generally Heliothis was the main target pest in Queensland, New South Wales and Victoria, whilst Western Flower Thrips (WFT) was the main target pest in Western Australia and South Australia.

The insecticide use practices and products used varied as much in number as there are varieties of lettuce. Naturally the chemicals used varied depending upon the pest species being targeted and also with the individual grower’s approach to pest control. District trends or approaches to pest management were evident and some generalisations could be made about each district.

The majority of Australian lettuce growers take a responsible approach to pest management. Only a minority of growers always sprayed the same product, or used unregistered chemicals, or applied unnecessary tank mixes. Such practices should be discouraged through out the industry.

No insecticide should be used repeatedly as resistance is likely to occur. Insect resistance can occur with the new generation insecticides. Always follow a product’s label directions and only apply the product as many times as stated. Follow an appropriate resistance management strategy for the target pest.

The WFT insecticide management plan in lettuce is currently being changed due to residue concerns. A national web site will soon be available detailing the latest control strategy. Alison Medhurst is coordinating the extension activities for the National Strategy for WFT and TSWV management. Alison can be contacted on (03 9210 9246) or email: alison.medhurst@nre.vic.gov.au

Spinosad is a very efficacious chemical against WFT and it appears that many growers are using Success® for this purpose. Dow AgroSciences is not pursuing registration for WFT in lettuce. Growers should apply as an industry body or through their state department of agriculture for a permit. The permit will state the critical use requirements of the product against WFT. This will help limit the chance of Spinosad resistance developing in WFT.

Most growers still use the older chemistry, being products from the Carbamate, Organo-Phosphate and Synthetic Pyrethroid chemical groups. Products from these groups appear to still have some efficacy and are generally cheaper to purchase. However many growers have found a place for the new generation chemistry in their pest control strategy.

After applying a new generation insecticide**, do not spray the day after because the grubs are not dead**. Caterpillar larvae stop feeding within hours of ingestion of new chemistry products like Avatar® and Success®, but these products take time to kill larvae. Wait at least four days before checking the lettuces again for caterpillars. Gemstar®and Bt's work in a similar way, however larvae may feed for a longer period before being over come by the chemical.

Tank mixing insecticides occurred in most districts, especially when heliothis pressure is high. Tank mixing with Methomyl is the most popular mix. The Methomyl is being used as an ovicide, whilst the other insecticide is being used to kill the larvae. Discussions with Crop Care Australia yielded that whilst tank mixing with another insecticide at a full larvicide rate Methomyl should only be applied at 1L/Ha. Methomyl should only be used at 2L/Ha as a stand-alone product otherwise larvae may be selected for carbamate resistance.

Spinosad applied at 800ml/Ha has about two thirds of the ovicidal activity of Methomyl at 1L/Ha. Spinosad is also translaminar, it enters the leaf and moves between the upper and lower surfaces of the leaf. Under normal conditions larvae that hatch will ingest chemical from the sprayed leaves and die. Given these facts, it should not be necessary to add a recognised ovicide with products such as Success®

Many growers spray to a schedule that is adjusted to suit seasonal conditions and pest pressure that is observed around the paddocks. An increasing number of growers are using crop scouts to monitor their lettuce. By monitoring crops growers have been able to reduce their insecticide use and achieve better pest control through strategic chemical application. Some Victorian growers have implemented a complete Integrated Pest Management approach to their pest management.
Monitoring data from lettuce at Hay indicates that heliothis moth flight data varies around the district, even between neighbouring properties. The traps only catch male moths and are not necessarily an indication of the number of eggs laid in the lettuce crop. Crop monitoring is necessary to target insecticide sprays to eggs and newly hatched larvae. Moth traps can only be used as an indication of a flight and also which Helicoverpa species is around.
To get the maximum benefit from an insecticide it is very important to ensure thorough spray coverage of the lettuce. The addition of droppers or air assist to a spray boom has been proven to improve spray coverage, given they are adjusted and used correctly. Appropriate water rates, droplet size, uniformity and density are important factors in obtaining optimum spray results. A pamphlet on spray application in lettuce is available from NSW Agriculture.
Frequent boom calibration is important to ensure application uniformity. Knowing the amount of water that should be applied over lettuce block does not indicate that the spray boom is perfectly calibrated.

For further information contact Andrew Creek, NSW Agriculture on (02 6951 2653) or e-mail: andrew.creek@agric.nsw.gov.au

Table of insecticide groups

The product trade names in this report are supplied on the understanding that no preference between equivalent products is intended. The inclusion of a product does not imply endorsement by NSW Agriculture over any other equivalent product from another manufacturer.

The table below shows common insecticides used in lettuce production and their chemical grouping. This table may be useful for interpreting parts of the following report. Inclusion of a product in the table does not imply registration in your State.

Insecticide Group	CLASS	ACTIVE	PRODUCT *(Not a complete list)*
1A	Carbamate	Carbaryl	Bugmaster®
		Methomyl	Lannate®, Nudrin®, Marlin®, Electra®
		Pirimicarb	Aphidex®,Pirimor®
1B	Organo - Phosphate	Acephate	Orthene®
		Chlorpyrifos	Chlorfos®, Lorsban®
		Diazinon	Diazinon®
		Dimethoate	Rogor®, Roxion®,
		Fenamiphos	Nemacur ® (Pre-plant)
		Fenitrothion	Fenitrothion®, Sumithion®
		Maldison	Maldison 500®, Hymal®
		Methamidophos	Nitofol®, Monitor®
		Methidathion	Supracide®
		Trichlorfon	Dipterex®
2A	Organo-Chlorine	Endosulfan	Nufarm Endosulfan®, Thionex 350EC®
3A	Synthetic Pyrethroid	Alpha-cypermethrin	Dominex®, Fastac®, Astound®
		Permethrin	Ambush®, Pounce®, Hellfire®
5A	Spinosyn	Spinosad	Success®
11C	Bts	Bt kurstaki, aizawai	Dipel®, Xentari®, MVP®, Bobit®
22A	Oxadiazine	Indoxacarb	Avatar®
Biological	Virus	Helicoverpa NPV	Gemstar®

New South Wales

Hay

Heliothis is the most common insect pest with aphids and onion thrips occasionally building up to numbers that require control.

Chemicals most commonly used for insect control are:

- Dominex®, Fastac®
- Ambush®
- Lannate®, Marlin®
- Endosulfan
- Dimethoate (aphids)
- Bugmaster®
- Success®
- Avatar®
- Bt's (both Bta and Btk)
- Showdown®

The most commonly used products are from the Synthetic Pyrethroid, Carbamate and Organo-Chlorine groups. Dimethoate is the only chemical that is regularly used from the Organo-Phosphate group. Success® has been used by 70% of the growers. It tends to be used later in the crops life, if the heliothis pressure is very high or when a spray with the older chemistries has failed to kill larvae. Many growers commented about the greater expense of the newer chemistries like Success® and Avatar® when compared to the older chemistries.

Only a few growers are using Avatar® and the Bt's. Avatar® has only been registered for one season and some growers were not aware of the product's availability. A combination of greater cost and the fact that the newer chemistries take longer to show a result may also have an impact. A couple of growers commented upon how long it took the newer chemistries to kill the grubs. It needs to be understood that heliothis sprayed with chemicals such as Success® and Avatar® stop feeding within 0-4 hours after ingestion and larvae death generally occurs within two to three days. This is different to traditional older type insecticides where death is within a couple of hours.

More than half of Hay lettuce growers use insecticide tank mixes. During conditions of high heliothis pressure Methomyl is commonly added to another insecticide to target some of the young larvae and unhatched eggs. The most common tank-mix is Methomyl and a Synthetic Pyrethroid, for example:

- Lannate® + Fastac®, or Lannate® + Ambush®

Other insecticide tank mixes used include:

- Lannate® + Success®
- Lannate® + Bugmaster®
- Lannate® + Dimethoate
- Dimethoate + Fastac®
- Dimethoate + Success®

Most growers mix compatible fungicides with their insecticide sprays to save time and reduce the costs associated with chemical application.

Generally growers are rotating insecticides between the Synthetic Pyrethroid, Carbamate and Organo-Chlorine chemical groups until the lettuce crops are hearting, and depending upon heliothis pressure, they then switch to Success®.

Hay lettuce crops are generally sprayed to a schedule. The first spray is usually after thinning and then every 5 to 7 days in the summer and extending to every 10 to 14 days in the winter. The frequency of the spray schedule is altered according to seasonal conditions and pest observations the grower may make whilst tending to other crop management tasks. Very few of the crops are monitored to a protocol as there are no professional consultants monitoring lettuce crops in the Hay district and growers would rarely get the time to monitor crops weekly.

Sixty percent of Hay lettuce growers apply sprays with standard hydraulic booms, whist the rest have added droppers to their booms aiming to improve chemical coverage. One grower is using an air assist sprayer. Some growers are calibrating spray rigs every three months to meet their Quality Assurance certification guidelines, whilst the majority of grower's change their nozzles and calibrate their spray booms annually.

Cowra / Canowindra

Heliothis is the most common insect pest. Aphids can build up to numbers that require control.

Chemicals most commonly used for insect control are:

- Avatar®
- Success®
- Gemstar®
- Bt's (both Bta and Btk)
- Lannate®, Marlin®
- Dominex, ® Fastac®
- Dimethoate (aphids)

Some of the districts lettuce crops are monitored to a protocol with spray recommendations made by a consultant, whilst the rest are sprayed to a schedule. The growers that spray to a schedule alter the schedule according to field observations and discussions with the crop consultant about what has been happening in the district. Depending upon the insect pressure, the lettuce crops are sprayed every 4 to 7 days.

Products like Avatar®, Success®, BT's or Gemstar® are sprayed 7 –10 days after transplanting and are used until hearting. During hearting growers prefer to use conventional chemistry such as Dominex®, Fastac® and Methomyl.

An insecticide tank mix of Methomyl and a Synthetic Pyrethroid is used under high heliothis egg pressure. Some growers will use a mix of Success® + Fastac® when the lettuce crop is under very high pressure from heliothis larvae.

Compatible fungicides are added to the insecticide application when weather conditions are favourable for disease development.

All the lettuce crops are sprayed with standard hydraulic booms that are calibrated annually at a minimum.

Sydney Basin

Throughout spring heliothis can be a problem and thrips numbers also start to increase. Both Western flower thrips and onion thrips can be a problem. During summer & autumn heliothis pressure reaches a peak and is the most common insect pest. Aphids can become a problem over the winter.

Chemicals most commonly used for insect control in Sydney basin lettuce crops are:

- Avatar®
- Success®
- Dominex®, Fastac®
- Ambush®
- Lannate®
- Endosulfan
- Pirimor® (aphids)
- Dimethoate (aphids / thrips)
- Orthene® (WFT)
- Nitofol® (WFT)

Growers tend to use chemicals that are registered in both brassicas and lettuce. Success® and Avatar® are the most commonly used products to control heliothis. Pirimor® is the most widely used Aphid insecticide. Endosulfan use is declining, as it becomes a hassle to apply, ie. restrictions and paper documentation. Consultants surveyed indicated that growers would most likely use Proclaim® when it becomes registered.

Fungicides are commonly applied with insecticides. When heliothis pressure is high Methomyl is commonly added to a tank mix to kill some of the eggs laid during moth flights and reduce larvae pressure. The following insecticide tank mixes are used:

- Methomyl + Synthetic Pyrethroids
- Methomyl + Avatar®
- Success® + Pirimor®

Insecticide practices vary greatly as there are over one hundred lettuce growers in the Sydney basin. Some are old and traditional growers that tend to spray on a calender basis without scouting their crops. There are a few growers that use unregistered products. Some growers use the same product, Avatar® for example, all season on their lettuce. However these practices are of a minority and most growers rotate chemical groups and only use products registered for use in lettuce according to the label guidelines.

The majority of growers spray to a schedule altered by seasonal conditions and crop observations made whilst tending to other farm management tasks. During summer and autumn lettuce crops can be sprayed one to two times per week, whilst during winter crops may be sprayed once every two weeks.

Ten percent of growers, predominantly the larger growers, are adopting IPM techniques. There are no professional crop scouts in the district but rural service / supply stores have horticultural agronomists regularly monitoring lettuce crops as part of their merchandising business. The crop monitoring aims for strategic insecticide application, leading to better pest control and reduced pesticide use.

Most growers are using hydraulic booms to spray lettuce crops. The consultants surveyed did not report the use of any droppers on booms. The larger growers out Camden way are using air assist sprayers.

The frequency of spray boom calibration varies between growers. Some may rarely calibrate whilst other growers may calibrate their spray booms one or two times per year to meet Quality Assurance certification guidelines.

QUEENSLAND (Compiled by John Duff, QDPI)

The insecticides that are currently used for the control of Heliothis and other insects in lettuce have increased in number due to the fact that there are now more products registered for use in lettuce. Growers are willing to try the newer products, particularly if they do work, even though they are more expensive than the traditional older type chemistries.

Insecticides used in the control of insect pests in lettuce (particularly Heliothis) include:

- Bt's (both Bta and Btk)
- Success®
- Avatar®
- Lannate®
- Ambush®
- Dominex®, Fastac®
- Diazinon®
- Dimethoate

Consultants surveyed indicated that Avatar® is currently not a widely used product and would probably be used in the medium to high heliothis pressure range, but not used after the hearts have started to harden. A fair percentage of farmers lean to the cheaper products when Heliothis pressure is low. Indications are that Proclaim® will be used when it becomes available.

Mixtures of insecticides are still being used and it would be difficult to convince some growers not to mix their insecticides. It is probably a cultural practice, which will be difficult to curtail. It is probably viewed like an insurance policy by those growers that do mix their insecticides. Those products that are used in tank mixtures include the following;

- Lannate® + Dominex® (or other registered Synthetic Pyrethroid's)
- Lannate® + Rogor®
- Lannate® + Success® (used under high Heliothis pressure)
- Lannate® + Avatar® (this combination of products will also likely used)

It could be said that the more progressive growers are willing to listen to their crop consultants and only rely on one product.

There are however benefits to using Lannate® in a mixture as it is quick to degrade, usually in 24 hours, leaving the other product to clean up any eggs or larvae that do manage to escape and therefore may not be as bad an option to use. With the eggs being the target or neonate larvae, resistance to this particular product or any other product should not be an issue or of low risk.

With the ever increasing cost of production, growers will however mix fungicides with insecticides if they are compatible to help save time and costs of application. This is particularly the case during periods of humid, overcast and rainy weather.

Frequency of spraying depends on the pest pressures within the crop, typically Heliothis. During the winter periods of light pest pressure, sprays are 7 to 10 days apart and sometimes up to 14 days. During the warmer periods of the year pest pressure is heavier and lettuce crops are sprayed every 4 to 5 days. At times it has been necessary to spray twice a week.

The most widely used sprayers that farmers are using are still the conventional hydraulic type sprayers with a few air assist boom sprayers being used. There doesn’t appear to be any growers using droppers on their booms at this stage. Information from local consultants indicates that boom sprays are being calibrated at least one to two times a year.

VICTORIA

Heliothis appears to be the predominant pest in the Victorian lettuce production areas. Aphids, loopers, light brown apple moth and vegetable weevils can also be a problem. Insecticides used to control these pests in lettuce include:

- Avatar®
- Success®
- Gemstar®
- Bt's (both Bta and Btk)
- Lannate®
- Dominex® Fastac®
- Ambush®
- Dimethoate (aphids)
- Pirimor® (aphids)

The products used varies between the growing districts, however many growers use the newer chemistry like Success® and Avatar®.

Growers in the Cranbourne area and the larger growers from the Werribee district tend to be more IPM orientated. They use products like Gemstar®, BT's, Success®, Avatar® and Pirimor® instead of the broader spectrum chemicals like Methomyl, Synthetic Pyrethroids and Dimethoate.

Methomyl is the most popular chemical to tank mix with another insecticide. It is most commonly added to Synthetic Pyrethroids or Success® to act as an ovicide when there is high heliothis pressure. The IPM orientated growers do not tank mix any insecticides other than Pirimor®. All growers add compatible fungicides with their insecticide applications when there is disease pressure.

A larger proportion of growers spray to a schedule rather than monitor their crops to a protocol. The spray schedules are altered to suit seasonal conditions and the pest pressure observed around the paddocks. Some growers are using district moth trapping data from DNRE to get an idea of when there has been a heliothis moth flight. Growers generally spray every 5 to 7 days during the summer depending upon heliothis pressure. Insecticide sprays are less frequent during winter.

The growers that are spraying to a schedule tend to use Carbamates and Synthetic Pyrethroids pre-heart. Success® and Avatar® are the products most commonly used during hearting. Successive applications are usually applied of either product before switching to the other product. There is a small proportion of growers that may use the same chemical or spray program all year.

As chemical costs increase and chemicals are becoming more of an environmental issue, an increasing number of growers are investing in crop scouts and basing their spray decisions upon what they've found. By monitoring crops growers have been able to reduce their insecticide use and achieve better grub control through strategic chemical application.

Twenty of the larger growers from the Werribee / Gippsland area have implemented compete IPM systems where each planting is monitored and sprayed differently. The relationship between beneficial and pest insects is considered before each decision to spray. Heliothis moth traps are used on each property to assist with the monitoring of moth flights.

A diverse range of spray equipment is used to apply chemicals including standard hydraulic booms, hydraulic booms with droppers and air assisted booms. Standard hydraulic booms are common and many growers have increased their total spray volume from 200L/Ha to 500L or more /Ha. Most growers calibrate their spray booms twice per year to meet Quality Assurance certification guidelines.

WESTERN AUSTRALIA

Areas surveyed included Wunnaroo, Perth metropolition area, Caraboota

Western flower thrips (WFT) and the spread of tomato spotted wilt virus was Western Australian lettuce grower's biggest problem last year. The intense spraying to control thrips tends to keep other pests such as heliothis and aphids under control. However heliothis can still be a problem in the summer.

Chemicals most commonly used for insect control are:

- Dominex®, Fastac® (heliothis & WFT)
- Ambush® (heliothis & WFT)
- Lannate®, Nudrin® (heliothis & WFT)
- Success®
- Bt's (Xentari)
- Supracide® (WFT)
- Orthene® (WFT)
- Nitofol ® (WFT)
- Chlorpyrifos® (WFT)
- Dimethoate (aphids / WFT)
- Pirimor® (aphids)

Generally the cheaper older chemistry is used, with only small amounts of Success® and the BT's being used. Growers using Success® tend to use it during hearting of the lettuce crop. Avatar® does not appear to be used.

There is very little tank mixing of insecticides, the practice is generally discouraged by local agronomists. The only mix reported was Dimethoate + Ambush®. When there is disease pressure compatible fungicides are usually added to the tank whilst spraying insecticides.

Very few growers would regularly monitor their lettuce crops to a protocol and keep monitoring records. Many lettuce growers could not justify the money spent on a professional crop consultant to monitor their crops as they farm small areas and the monetary return on lettuce crops can be low at times.

Lettuce crops tend to be sprayed to a schedule that is adjusted according to the pest numbers observed. Under high insect pressure crops may be sprayed every 5 to 7 days, but as insect activity slows in the winter the time between insecticide applications is extended to 10 days. Last season whilst the crops were under extremely high pressure from western flower thrips some growers found they had to spray every 3 days.

Chemical rotations vary between growers. Some rotate between groups each spray, whilst other growers may use a chemical from each group two or three times before switching groups. For example, 2 X Synthetic Pyrethroids to 2 X Organo Phosphates before switching to Spinosyn,(Success®).

Growers are using standard hydraulic booms for spraying. Generally between 600 and 1000L/Ha of water is applied during spraying.

Some growers calibrate their booms once per year, whilst others never really calibrate. Many of the fixed irrigated blocks are a known area and from experience growers know the total amount off water they should be using over each block. Many growers do not calibrate their booms for this reason. This is fine for understanding total out put over the paddock however the chemical application rate may vary between nozzles and is not a true indicator of a spray booms performance.

SOUTH AUSTRALIA

Western flower thrips, (WFT) appears to be the main target pest in South Australian lettuce production areas. Heliothis, leaf hoppers and white fly can also be problems, however insecticide applications for thrips tend to keep these pests in check.

Chemicals most commonly used for insect control are:

- Dominex®, Fastac®
- Ambush®
- Lannate®
- Nitofol®, Monitor®
- Endosulfan
- Success® (heliothis + thrips)
- Pirimor®
- Dimethoate

Survey results indicate that South Australian growers are not tank mixing insecticides to control pests. Compatible fungicides are added with insecticide applications when there is disease pressure.

More than half of the growers have their crops monitored to a protocol by professional crop consultants. Yellow sticky traps are used to assist monitoring for Western flower thrips. Data from yellow sticky traps, the average number of WFT per lettuce head and the activity of WFT around the crops boundary are the factors considered when deciding to spray or not.

The growers that do not have their crops professionally monitored are spraying to a schedule that is altered according to seasonal conditions and pest pressure. During spring when thrips pressure can be high, the frequency of sprays can be every 4 days. The spray schedule changes to every 7 days during winter.

Two to four spray applications from within a chemical group are applied to a lettuce crop before rotating to another chemical group. A typical group rotation is:

Carbamate > Organo Phosphate > Organo Chlorine > Synthetic Pyrethroid > Spinosyn

Generally a standard hydraulic boom is used for spraying. About 10% of the growers have added droppers to their booms to improve coverage. The majority of growers calibrate their spray booms 1 to 2 times a year.

Date _ _ /_ _ /_ _

Lettuce Grower / Consultant Survey (2002)

Interview method

Consultants are to be given semi-structured personal interviews, generally over the telephone. The purpose of the interview was to assess the current insect pest management practices of lettuce growers in Australia.

Consultant / Grower Details

Name: Address: Contact numbers: (Office) (Mobile)

Agronomic practices

Area of Lettuce grown (Ha)_ _ _ _ _ Furrow / overhead / drip irrigation

Direct seed / Transplants

	Early Season	Mid Season	Late Season
Varieties grow			

What has the recent insect damage been?

What insecticide products are growers using against what pests?

What insecticide tank mixes are used?

•Insecticide + Insecticide

•Insecticide + Fungicide

IPM implementation

Do growers A: spray to a schedule?

B: spray based on observations made whilst tending to other crop management tasks?

C: monitor to a protocol?

Are monitoring records kept?

Do you use insect thresholds? What are they?

Insecticide spray program details

If crops are not monitored, what is the spray program? (Frequency of insecticide sprays, chemical rotations?)

Spray equipment

What type of spray equipment is used? Hydraulic Boom + droppers / air assist / micron air / air sheer / CDA

How frequently do growers calibrate their spray rigs?

3rd Lettuce Industry Conference Program

Front Cover
When folded

Reverse
Panel 4

3rd AUSTRALIAN LETTUCE INDUSTRY CONFERENCE

Paddock to Plate

3-5 May 2005
Werribee, Victoria

Combining with the National Vegetable Expo
5-6 May 2005

(Photo Of Werribee Lettuce)

REGISTRATION BROCHURE
3RD AUSTRALIAN LETTUCE INDUSTRY CONFERENCE

Inside Panel 1

Welcome to the 3rd Australian Lettuce Industry Conference

It has been three years since our last conference was held in Gatton, Queensland. For the first time, Victoria is hosting our industry Conference and has linked its program with the National Vegetable Expo. This was formerly the Werribee Vegetable Expo: the decision to position this event at the national level aligns it to the national orientation of the Australian Lettuce Industry Conference.

The Conference has set out to give participants:

- Contact with international and key Australian presenters
- Choice in the program to match individual interests
- Opportunities to discuss current industry issues
- Value for money to justify time away from work

Conference Venue: Werribee, Victoria

The Conference will be held at a conference venue: the Wyndham Leisure and Events Centre, Werribee. The Centre has excellent meeting facilities, and adjoins a Leisure Centre that can be used by participants as they choose.

Werribee is a major centre located about 20 minutes from Melbourne. Its population is growing towards some 250,000, and is a major centre for vegetable growers. Werribee is about 40-50 mins drive from Tullamarine Airport. Victoria in May can be cold! Temperatures can drop to 12°C at night, and it is advisable to bring a warm jacket, wet weather gear and boots for the field trips.

An Australian Conference Planned by the Australian Industry

Dr Sandra McDougall has headed up a Planning Committee including Arie Baelde, Rijk Zwaan Seeds; Frank Ruffo of Tripod Farms; Alec Berias, President of VGA; Stephanie Ogilvie from Convenience Foods; Paul Gazzola of Gazzola Farms; Michael Simonetta of Perfection Fresh; Les Giroud, Werribee South; Andrew Creek, NSW Department of Primary Industry. Every effort has been taken to give delegates a valuable experience with international presenters, a varied program, useful learning and networking opportunities, at an economical cost.

Registration: $150 all inclusive Conference and Expo
Wednesday day session: $75 or $30 (Student rate)

Registration is now invited, and registrations preferred before **4 March 2005**:

- Lettuce growers
- Fresh food processing industry
- Packaging industry
- Wholesale and retail markets: distributors, providors, retailers
- Equipment, irrigation, and tractor distributors
- Wholesale Nurseries and Seedlings Suppliers
- Chemical, Fertiliser suppliers
- Hydroponics industry

Inside Panel 2

CONFERENCE PROGRAM

Tuesday 3 May 2005

5:00-6:30 pm	Registration, Wyndham Events Centre
7:00-8:30 pm	Welcome Reception, Wyndham Events Centre

Wednesday 4 May 2005

7:30 -9:00 am	Registration, Wyndham Events Centre
9:00 - 9:30	Official Opening, John Landy, Governor of Victoria
9:30 -10:30	Fredy Leuenberger, Lettuce Growing-Marketing in Europe
10:30 - 11:00	Morning Tea – view posters
11:00 - 12:00	Howard Poole, Lettuce Growing, China, Sth East Asia
12:00 - 12:30 pm	Panel: Open Forum for Questions, Discussion
12:30-1:15	Lunch
1:15-2:15	Lettuce Aphid Panel
2:20-3:05	Elective Workshops: Round 1
3:05 – 3:30	Afternoon Tea – view posters
3:30 – 4:15	Elective Workshops: Round 2
4:20 – 5:05	Elective Workshops: Round 3
Evening	Free evening

Thursday 5 May 2005

Various	Half Day Industry Tours
12:30 – 1:30 pm	Lunch
1:30 – 3:00	Industry Planning: AUSVEG
3:00 pm	Closing Session
6:30 – 10:30	Dinner Function: Lettuce Conference, Vegetable Expo

Friday 6 May 2005

8:00 - 4:30	National Vegetable Expo, University of Melbourne, Werribee

Fredy Leuenberger, Eisberg Group, Germany

The Eisberg Group is an international company that deals with the cultivation, processing and distribution of vegetables and salads in several European countries. The philosophy of the organization is "Grown to Please" and has its own network of production businesses and contracted farmers to allow product availability throughout the year. Produce is seasonally grown to be as close in proximity as possible to consumer markets. Quality Assurance is managed through Eisberg's trademarked network: e-quan, providing guaranteed traceability right back to the seed, maintained through a central data base. Latest technologies are used to ensure excellent quality and optimum shelf life. The customer base includes all important companies from the catering sector to the retail trade. McDonalds Europe awarded the Eisberg ™ Group the Value Award 2003 for its outstanding services.

Howard Poole, Poole's Produce, Stanthorpe, Queensland, Australia

Howard, the principle of Poole's Produce, started growing lettuce 24 years ago. Lettuce accounts for 25% of their vegetable production at Stanthorpe. For many years Poole's were involved in exporting to Asia but the rising dollar, and greater competition from local vegetable production made it difficult to compete. Howard was then approached to become a partner in a company to grow and source product in China for the Hong Kong market. Howard has spent a lot of time in China's Yunnan Province organizing the growing and procurement of product for Shang Hai and Guangzhou markets and for export to Hong Kong. He will discuss his experiences and observations about developments in this market, bringing to the conference a regional perspective for Australian growers.

Inside Panel 3

ELECTIVE WORKSHOPS

Participants can choose 3 workshops from a choice of 9 themes. Each workshop runs for 45 minutes; each is led by key leaders in their field. All workshops set out to encourage participation and discussion.

Workshop 1: Recycled Water: Andrew Osborne (Earthtech)
"What does it mean to be a customer of a recycled water scheme?"
Case studies will be used to show how a recycled scheme can be developed to realise a sustainable business. The workshop will include discussion on customer needs, water quality, pricing models, risks and their management and the environmental framework necessary for sustainable production. The workshop will draw heavily on Australian projects with some reference to projects in Israel and California.

Workshop 2: The business of QA business: Joe Ekman (NSW DPI), EnviroVeg Coordinator & Grower
Get the latest information in on-farm management programs such as EnviroVeg, Freshcare and other food safety/QA/environment/OH&S programs. This interactive workshop is designed to: inform you on developments and identify emerging industry issues; identify costs and other overheads to expect when getting into a program; and provide an opportunity for you to get your questions answered.

Workshop 3: Making Water Work Better: Mark Hickey & Rob Hoogers (NSW DPI), Phil Charlesworth (CSIRO)
This workshop will focus on the tools available to lettuce growers for measuring soil water, and making good decisions on when to water. There is a swag of technology out there, but which is most appropriate and cost effective for shallow rooted crops such as lettuce. This is a hands on workshop that will give growers an opportunity to operate the hardware and software of the more complex tools, and appreciate the ease of the simple tools used for soil moisture monitoring.

Workshop 4: Marketing: Michael Simonetta (Perfection Fresh) and others.
Each lettuce product line has different quality specifications. Do you understand the requirements for the markets you grow for? Hear what are consumer trends in lettuce products and which areas are growing. In this workshop you will hear the perspectives of different market sectors from major supermarkets to niche marketers.

Workshop 5: Hydroponics: Aquaculture: Lennard Wilson (RMIT) and **Residues in Hydroponic Lettuce: Sophie Parkes (NSW DPI)**
This workshop is in two parts. The first part covers the potential to value-add to a hydroponic system with fish production or aquaculture. The second part reports on recent research findings and opens discussion about residues from chemical applications in hydroponics.

Workshop 6: Lettuce Disease management: Andrew Watson & Len Tesoriero (NSW DPI), Ian Porter (Vic DPI)
This workshop will discuss current and recently finished research projects on diseases of hydroponic lettuce and field lettuce. The information will include recent trial results on Sclerotinia management in field lettuce, results of the varnish spot scoping study and research results looking at pythium and fusarium in hydroponic lettuce. Discussion time will also be available to discuss disease issues.

Workshop 7: Integrated Pest Management for Lettuce: Dr Sandra McDougall (NSW DPI), Dr Paul Horne (IPM Technologies)
IPM- Heard the name but not really sure what it is or how you could implement it? This workshop will bring together three perspectives - researcher, commercial consultant & researcher, and IPM grower. Hear how lettuce growers are using fewer insecticides, encouraging beneficial insects and cutting quality lettuce. Bring your questions and problems for discussion.

Workshop 8: Processing and Packaging Developments: Bruce Tomkins (Vic DPI)
Have you ever wondered why some fresh-cut lettuce looks old and brown? Whether it is nutritious? If it is safe to eat? Find the answers to these questions and lots more at this interactive, hands on workshop.

Workshop 9: Agronomic Practices and their Impact on Shelf Life on Iceberg & Cos lettuce: Mike Titley, Brad Giggins & Simon Boettiger (AHR)
Results from data collated during the first 18 months of trials from a three year HAL funded project in four major lettuce growing regions; East Gippsland, Robinvale, Toowoomba and Gatton. The influence of varieties, fertilizer rates, seedling size, irrigation type, irrigation scheduling and strict adherence to correct post harvest cooling on shelf life to be outlined during the workshop.

Inside Panel 4

HALF DAY INDUSTRY TOURS

Five outstanding field trips are offered: each taking a half day; participants choose one tour that matches their interests. All tours will depart from the Events Centre, and all arrangements are coordinated: bus schedule, host organisations, safety at the destination. Catching the bus is essential!

<u>Tour 1: Boomaroo Nurseries, Tripod Farms</u>
Boomaroo Nurseries is the largest vegetable seedling nursery in Australia, and the tour will include the entire process of growing seeds to distribution to growers. Morning tea will be provided and the tour will then go to Tripod Farms in Bacchus Marsh. Lettuce production, field kitchens, innovative approaches to OHS, and security of water supply are just some of the issues to emerge.

<u>Tour 2: Pinegro, Melbourne Water, Vegetable Expo</u>
Pinegro is a company that receives and composts biosolids, a product that is regulated through the Environment Protection Authority. Biosolids have the capacity to re-generate soils: this visit gives our group an opportunity to observe & discuss future applications. From here, the tour goes to Melbourne Water: a destination of significant interest with regard to recycled water. The tour concludes at the National Vegetable Expo, with time available to visit seed and nursery suppliers, the static display, and seed growing trials.

<u>Tour 3: Convenience Foods, Costa's Logistics Centre, Melbourne Water</u>
Convenience Foods is a major fresh food processing organization, and the tour will include an overview from the point of arrival to distribution. Costa's Logistics Centre receives, sorts, and distributes fresh produce to major retailers. The use of computer technology, the culture of organizational performance, and the efficiency of handling fresh produce offers significant interest to visitors. On the return trip, the tour will include Melbourne Water treatment plant, a key product of which is recycled water.

<u>Tour 4: Melbourne Markets, Costa Logistics Centre, Pinegro</u>
The Market is the largest wholesale fresh produce complex in Victoria with 600 grower stands, 110 wholesale businesses and in excess of 2,500 wholesale buyers. Our tour will be hosted by experienced vegetable growers. Included in this tour will be an opportunity to visit Pinegro, a company that receives and composts biosolids. This process is regulated through the EPA and represents emerging technology for regeneration of soils. A visit to Costa Logistics Centre follows and time at the National Vegetable Expo to complete this tour.

<u>Tour 5: Werribee South, Portagello Nurseries, Expo, Pinegro</u>
Werribee South is a major centre for vegetable and lettuce growing in Victoria. The tour includes a stop over at Portagellos Nursery, then time at the National Vegetable Expo to meet seed suppliers and inspect lettuce growing trials, static displays, other exhibits before going to Pinegro, allowing our group to observe and discuss an innovative process for composting biosolids.

Reverse Side 1: Panel 4

Tear off indicated

REGISTRATION FORM
(This form becomes a Tax Invoice on payment of the Registration Fee)

3RD AUSTRALIAN LETTUCE INDUSTRY CONFERENCE
3-5 MAY 2005

Surname ……………………………………………………
First Name ……………………………………………………
Organisation ……………………………………………………
Address ……………………………………………………..
……………………………………………………..
Town/City …………………………Postcode ……………..
Telephone ……………………… Fax ………………
Mobile ……………………………………………………
Email ……………………………………………………
Dietary Requirements ……………………………………………

TOUR CHOICE (1) **Tour No:**

WORKSHOP CHOICES (3)
Workshop Numbers

R&D Project Poster for display (Wednesday and Expo) ☐
Title____________________

REGISTRATION PAYMENT:

Registration including field trip & Expo **AUD $150** ☐

Wednesday Day session **AUD $75** ☐ **AUD $30** ☐ **Student**

Extra Dinner Ticket for Thursday 5th May **AUD $50** ☐

Sub TOTAL _____________
+ 10% GST_____________
TOTAL _____________

Please make cheques payable to NSW Agriculture – Lettuce Conference. Overseas bank cheques must be AUD$ Australian Dollars, drawn on an Australian Bank and free of all charges. ABN 51 734 124 190-004

Cheque enclosed for AUD$_________
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NSW Agriculture: Lettuce Industry Conference
Private Mail Bag, Yanco NSW 2703 or fax with your
credit card details to: 02 6951 2692 Telephone: 02 6951 2611
Email: sandra.mcdougall@agric.nsw.gov.au

Reverse Panel 2

PROGRAM INFORMATION

Registration
A registration desk will operate at the Wyndham Events Centre on Tuesday afternoon 3 May from 5:00-6:30 pm. For the remainder of the conference, all secretariat activities will be managed through the administration staff at the Centre, open daily from 9:00-5:00 pm. Contact with the Centre, Telephone: 03 9748 2555.

Welcome Reception: Tuesday 3 May, 7:00-8:30 pm
All delegates are welcome! No extra charge, all included in your registration fee. The reception will be held at the Events Centre, and it's a fully hosted function with hot finger food and drinks service. At this time, our international presenters will be introduced, and we have asked the Mayor of Wyndham to officially welcome all delegates to this national event.

Research & Development session: Thursday 5 May, 1:30-3:00 pm
This session allows growers and industry to comment on the funding directions for research and development. This session will be facilitated by Jonathan Eccles, formally of HAL Ltd and now Industry Development Manager for AUSVEG. Also to be discussed is the 4th Australian Lettuce Industry conference – should there be one, when and who will organize it.

Research & Development Poster display
Posters of lettuce R&D will be displayed at the conference on Wednesday with viewings during morning and afternoon tea, and they will be displayed in the Lettuce IPM marquee at the Expo.

Combined Dinner: Thursday 5 May, 6:30 – 10:30 pm
Again, no extra charge for delegates, and partners are welcome to attend ($50:00 per head). Trade exhibitors and industry representatives from the National Vegetable Expo will be able to join delegates to the Australian Lettuce Industry Conference for a 3 course dinner with entertainment. The function will be held at the Events Centre, and the official sponsor for the evening is Perfection Fresh. Michael Simonetta CEO of Perfection Fresh, is also member of the Planning Committee for the Conference, and has actively supported the industry through his personal contributions and sponsorship. This promises to be a great night!

National Vegetable Expo: Thursday 5 and Friday 6 May
No extra fee, delegates to the Conference have fully paid entrance tickets for this 2 day event. The Expo Planning Committee has positioned the event at the national level, and takes place at its usual venue: Gilbert Chandler Campus of The University of Melbourne – about 10 minutes away from the Events Centre. There'll be lettuce and vegetable seed growing trials, a static display, a range of other trade exhibits, and most importantly, seed suppliers and other industry service providers on site to discuss business and product issues. Further information: Vicki Langdon, Expo Coordinator, mobile: 0417 136 983

Leisure Centre: Open daily
As part of the Conference complex, a full Leisure Centre facility can be used by delegates for a small daily fee. Facilities include a 50m swimming pool, rapid river, hydrotherapy pool, steam/spa – and café for café au lait!! Check it out when you check into the Conference on Tuesday 3 May!

WE'RE LOOKING FORWARD TO MAKING YOUR TIME WITH US USEFUL, VALUABLE, ENJOYABLE

(LOWER PART OF THIS PANEL RESERVED FOR CONFERENCE LOGOS AND SPONSOR LOGOS AS PRESENTED FOR GATTON)

Reverse Panel 3

This forms back of brochure when folded.

ACCOMMODATION

Accommodation is limited in the Werribee area, and other events are taking place on the same dates. Early booking is essential. Melbourne central is only 20-30 minutes away, accessed by a major freeway. Contact with local accommodation is listed below, and arrangements can be separately made regarding check in times, standard of accommodation, meals, payment of deposits.

Best Western Werribee Motor Lodge	(03)	9741 9944
Monte Villa Motor Inn	(03)	9748 7700
Werribee Park Motor Inn	(03)	9741 7222
The Mansion Hotel	(03)	9731 4000
Quest Inn Apartments	(03)	9393 5300

TRAVELLING TO CONFERENCE VENUE

Travelling time by car from Tullamarine Airport to Wyndham Events Centre is approximately 1 hour. Please note that transport from your accommodation and the Conference venue is the responsibility of the delegate.

WYNDHAM EVENTS CENTRE

Princes Freeway (to Geelong), exit Werribee turn-off and travel on Princes Highway, right turn into Derrimut Road, and Events Centre 1 km on right hand side. There is ample free parking space. Telephone: (03) 9748 2555.

CANCELLATION POLICY

Delegates unable to attend may send a substitute without further charge, subject to written advice to the Conference Secretariat. No refund will be given for cancellation after 26th April 2005.

FURTHER INFORMATION

Jocelyn Williams
21 Franklin Street, Bacchus Marsh. Vic 3340
Phone: (03) 5367 2582
Email: jwilliams@victeach.com.au

(LOWER PART OF THIS PANEL RESERVED FOR CONFERENCE LOGOS AND SPONSOR LOGOS [NSW DPI, HAL, AUSVEG, SPS, Convenience Foods, Perfection Fresh, Rijk Zwaan, GSF] all logos on 2nd Conference Registration or Proceedings)

3rd Lettuce Industry Conference Priorities

1.30 – 3.00pm Thursday 5 May 2005

Outcomes from an Open Workshop facilitated by Jonathan Eccles, National Industry Development Manager, AUSVEG

Issues raised: (not necessarily in order of priority)

1.	IPM education and labelling? for customers and consumers Zero tolerance for insects versus insecticide use
2.	Biocontrol of thrips, whitefly and Rutherglen bug
3.	Build skills of new and existing consultants who offer pest management advice
4.	Procymidone (Sumisclex ®) loss in lettuce - what are the alternatives?
5.	Disinfestation processes for processing lettuce
6.	Chemical use in hydroponics – what are recommended uses & residues?
7.	International imports & competitiveness
8.	Diseases: Big Vein, pinking, varnish spot, downy mildew
9.	Bagged lettuce – what is the consumer preference?
10.	Biological farming: need to have independent assessment of 'snake oil'/additives etc

3rd Lettuce Industry Conference Participant Evaluation

3rd – 5th May 2005

Process of Evaluation
Pro forma distributed in registration envelopes for participants attending Wednesday only, and distributed at final session of Conference for full delegates. Only 25 participants present at this session from a group of some 160 delegates. Evaluations were then distributed and collected at Combined Dinner. 75 returns in total.

RESPONSES AND PROFILE

Growers	27
Processors	6
Distributor	1
Supplier	25
Marketing	3
Research	10
Industry Support, Regulation	3
Media	0
Total	**75**

MAJOR PRESENTERS

FREDY LEUENBERGER

Responses from Sectors	Nil Return	Not Good	OK	Terrific
Growers			7	20
Processors			2	4
Distributor	1			
Suppliers			13	12
Marketing			2	1
Research		1	3	6
Industry Support, Regulation			3	
Totals	**1**	**1**	**30**	**43**

HOWARD POOLE

Responses from Sectors	Nil Return	Not Good	OK	Terrific
Growers		11	12	4
Processors	1	3	2	
Distributor		1		
Suppliers	2	5	14	4
Marketing		1	2	0
Research	1		9	
Industry Support, Regulation			2	1
Totals	**4**	**21**	**41**	**9**

- Speaker nervous, talk disjointed, message ambiguous

ELECTIVE WORKSHOPS

WORKSHOPS: RETURNS FROM GROWERS

Responses from Sectors	Nil Return	Not Good	OK	Terrific
1: Recycled Water			3	2
2: QA			2	
3: Irrigation: Water				5
4: Marketing		1	6	5
5: Hydroponics, Aquaculture			3	1
6: Lettuce Deseases			2	9
7: Lettuce: Pests: IPM		1	2	7
8: Processing, Packaging		1	6	6
9: Agronomic Practices, Shelf Life		8	4	
Totals re ratings		11	28	35

- Good variety of workshops and would have been good to go to a couple of other workshops
- Loved them all

WORKSHOPS: RETURNS FROM DISTRIBUTOR (1) SUPPLIERS

Responses from Sectors	Nil Return	Not Good	OK	Terrific
1: Recycled Water			3	0
2: QA				
3: Irrigation: Water			1	
4: Marketing		1	1	6
5: Hydroponics, Aquaculture			3	1
6: Lettuce Diseases		2	3	2
7: Lettuce: Pests: IPM			6	2
8: Processing, Packaging		1	2	1
9: Agronomic Practices, Shelf Life		3	3	2
Totals re Ratings		7	22	14

- Workshops needed more time
- Lettuce Aphid discussion very poor
- More discussion required from seed companies and varieties and use of Confidor from Bayer
- IPM discussion appeared to lack critical analysis
- Workshops too quick
- (With reference to Workshop 9 – Agronomic practices and Shelf Life) No results, very unimpressed on the research undertaken
- With reference to Processing and Packaging: few recent results, relied a lot on old work. Compromised by confidentiality
- Workshops should have been longer
- Whilst I did not attend the workshops, the feedback I received was excellent
- More discussions groups
- More on innovation in marketing

WORKSHOPS: RETURNS FROM PROCESSORS

Responses from Sectors	Nil Return	Not Good	OK	Terrific
1: Recycled Water				1
2: QA				
3: Irrigation: Water				
4: Marketing	1		2	2
5: Hydroponics, Aquaculture				
6: Lettuce Diseases			1	
7: Lettuce: Pests: IPM			3	
8: Processing, Packaging			4	
9: Agronomic Practices, Shelf Life	1		2	
Totals re Ratings	2		12	3

WORKSHOPS: RETURNS FROM MARKETING (nil return); RESEARCH (10) & INDUSTRY SUPPORT/REGULATION (3)

Responses from Sectors	Nil Return	Not Good	OK	Terrific
1: Recycled Water			1	
2: QA			2	
3: Irrigation: Water				2
4: Marketing		2	1	1
5: Hydroponics, Aquaculture		2	2	3
6: Lettuce Diseases			2	1
7: Lettuce: Pests: IPM			2	1
8: Processing, Packaging				1
9: Agronomic Practices, Shelf Life		1	2	
Totals re Ratings		5	12	9

- Workshops were excellent
- Some problems with workshop presentations in hall at same time

WORKSHOPS: CONSOLIDATED RETURNS

Responses	Nil Return	Not Good	OK	Terrific
1: Recycled Water		0	7	2
2: QA		0	4	0
3: Irrigation: Water		0	1	7
4: Marketing	1	5	8	14
5: Hydroponics, Aquaculture		2	8	5
6: Lettuce Diseases		2	7	13
7: Lettuce: Pests: IPM		1	10	13
8: Processing, Packaging		2	8	12
9: Agronomic Practices, Shelf Life	1	13	9	4
Ratings Totals	2	25	62	70

HALF DAY INDUSTRY TOURS

TOURS: RETURNS FROM GROWERS

Responses	Nil Return	Not Good	OK	Terrific
1: Boomaroo, Tripod Farmers			1	4
2: Pinegro, Melbourne Water, Expo				1
3: Convenience Foods, Costas, Melb Water				5
4: Melb Markets, Pinegro, Costas, Expo			1	4
5: Werribee Growers, Expo, Pinegro			1	4
Nil Return	6			
Totals re Ratings	**6**		**3**	**18**

- Tour host was ace (4)
- These sessions required more time
- Tour No 3 was wonderful

TOURS: RETURNS FROM PROCESSORS (6) DISTRIBUTOR (1)

Responses	Nil Return	Not Good	OK	Terrific
1: Boomaroo, Tripod Farmers				4
2: Pinegro, Melbourne Water, Expo				
3: Convenience Foods, Costas, Melb Water				
4: Melb Markets, Pinegro, Costas, Expo				1
5: Werribee Growers, Expo, Pinegro			1	
Unspecified			1	

TOURS: RETURNS FROM SUPPLIERS

Responses from Sectors	Nil Return	Not Good	OK	Terrific
1: Boomaroo, Tripod Farmers				
2: Pinegro, Melbourne Water, Expo		1	1	1
3: Convenience Foods, Costas, Melb Water				1
4: Melb Markets, Pinegro, Costas, Expo				
5: Werribee Growers, Expo, Pinegro		1	1	1
Unspecified	15	1	1	1

TOURS: RETURNS FROM MARKETING; RESEARCH; INDUSTRY SUPPORT

Responses from Sectors	Nil Return	Not Good	OK	Terrific
1: Boomaroo, Tripod Farmers				2
2: Pinegro, Melbourne Water, Expo		1	1	1
3: Convenience Foods, Costas, Melb Water				1
4: Melb Markets, Pinegro, Costas, Expo			1	
5: Werribee Growers, Expo, Pinegro			1	1
Unspecified	6		1	

GENERAL CONFERENCE ISSUES

	Not Good	OK	Terrific
Conference Venue	0	11	43
Welcome Reception	3	38	34

Food and venue brilliant

FINAL AFTERNOON SESSION

Responses from Sectors	Not Good	OK	Terrific
Results discredited: more responses than were present at the session!!			

- Poor attendance
- Didn't go as we had to attend the Expo due to flying back Friday morning
- Did not attend – we've got enough R & D topics now
- Should have planning session earlier as only small number of people attended compared to those that registered.
- Need to bring the R & D session to a more prominent time slot
- Final afternoon session may have benefited from a time change to end of first day
- Final session at Expo?
- Have the planning meeting as a workshop to get more feedback
- Final afternoon session may need to be timed differently to attract more attendees

COMBINED DINNER

Responses from Sectors	Nil Return	Not Good	OK	Terrific
Growers	2		9	16
Processors	6			
Distributor			1	
Suppliers	8		6	11
Marketing			1	2
Research	8			3
Industry Support, Regulation				3
Totals	**24**	**0**	**17**	**34**

- Yummy – high standard
- Great opportunity to meet people

COST

Responses from Sectors	Nil Return	Not Good	OK	Terrific
Growers	2		5	20
Processors			4	2
Distributor				1
Suppliers	3		14	8
Marketing			2	1
Research			6	4
Industry Support, Regulation	1		1	1
Totals	**6**		**32**	**37**

- Cost: money well spent
- Good value

ORGANISATION

Responses from Sectors	Nil Return	Not Good	OK	Terrific
Growers			2	25
Processors			1	5
Distributor			1	
Suppliers	2		6	17
Marketing			1	2
Research	1		2	7
Industry Support, Regulation				3
Totals	**3**		**13**	**59**

- Really well done
- Tops
- Brilliant!
- Well organized conference: venue and registration info

OPPORTUNITIES TO NETWORK, HAVE SHARED DISCUSSION

Responses from Sectors	Nil Return	Not Good	OK	Terrific
Growers			7	20
Processors				6
Distributor				1
Suppliers	1	1	11	12
Marketing				3
Research				10
Industry Support, Regulation			1	2
Totals	**1**	**1**	**19**	**54**

PROMOTION OF THE LETTUCE INDUSTRY

Responses from Sectors	Nil Return	Not Good	OK	Terrific
Growers	1		9	17
Processors			2	4
Distributor			1	
Suppliers	2	2	14	7
Marketing				3
Research			6	4
Industry Support, Regulation		1	1	1
Totals	**3**	**3**	**33**	**36**

- Fantastic

NEXT CONFERENCE: RECOMMENDATIONS RE DATE AND LOCATION

	2006	2007	2008	2009	Totals
Tasmania		3	1		4
Queensland		7	4		11
Western Australia		5	5	2	12
Victoria		14	2		16
South Australia		6	11	2	19
NSW (Sydney)		6	4	2	12
New Zealand		1			1
Eastern Seaboard		1	1		2
AusVeg, Brisbane	1				1
Totals	**1**	**43**	**28**	**6**	**78**

Notes:

- Multiple listings included
- Wording of pro forma said "At this state location" combined with the evaluation being undertaken at Victorian conference, resulted in a number of ticks of affirmation. This was taken to mean hold the next conference in Victoria.

OVERALL SUMMARY

Responses	Nil Return	Not Good	OK	Terrific
Conference Venue			11	43
Welcome Reception		3	38	34
Fredy Leuenberger	1	1	30	43
Howard Poole	4	21	41	9
Elective Workshops	2	23	79	61
Half Day Tours	27	4	12	32
Final Afternoon Planning Session	0	0	0	0
Combined Dinner	24		17	34
Cost	6		32	37
Organisation	3		13	59
Opportunities to Network, Discuss	1	1	19	54
Promotion of Lettuce Industry	3	3	33	36
Total Ratings from returns	**71 (8%)**	**56 (6.3%)**	**325 (36.4%)**	**442 (49.4%)**

GENERAL COMMENTS

Suggestions

- Interesting speaker required, good to have an overseas perspective on growing techniques, harvesting and pathogens in a bit more detail with a European perspective
- I found most interesting, real life operation stories. If the possibility of including more, it would be great!
- Should be more presentations on the first day eg., presentations (Day 1); half day workshops and half day industry tours. Then onto Expo on the next day = 3 days
- More talks please
- More time for networking would be good
- Very useful from a new grower's point of view. Need more of them even if piggy backed onto others
- Workshops – more chance to attend extra workshops
- Dedicated field trials and demos – similar to Hay field trials
- Conference must continue to combine with field trials
- I thoroughly enjoyed the event. The workshops were a little condensed for the time allocated. Some flexibility with the timing would help
- Maybe have more static displays in conference building – sponsors and DPI displays
- Very good – suggest that we needed more time at Tripod to see farm as well as visit to shed
- Polish up introduction of presenters and the gift-giving of presenters, otherwise wonderfully organized
- More food stands for lunch

Criticisms

- Stop pushing the IPM barrow and consider the livelihoods of the growers who pay the wages in a round about way
- Expo was disappointing due to lack of diversity in exhibits in regards to industry comparisons for machinery especially
- Dependence on hire cars was a problem. Bus collection from motels possibly needed. Booze bus/transport can help!
- Please: the opportunity lost is not to stage a media event at the Expo site. One of the major food personalities should present a show right in the middle of the lettuce. PS: Go for 2 and 5, can make this a major "fresh food promotion".
- We need to motivate people: stop boring us!
- Insufficient technical content
- Motels – need quieter location, backing onto freeway = no sleep!

Happy

- Organisation was excellent. People were great fun!
- Great opportunity to meet people and see all sections of the lettuce industry
- Excellent conference: congrats to the organizers
- Gained a lot of knowledge – very helpful
- Congratulations to Joce and team
- Job well done to all concerned. It's a shame we won't see more unity within the industry
- Really well organized and presented. A great chance to network with other industry members. Ties in perfectly with Vegetable Expo
- Run the Conference at the same place
- Very happy
- Very well organized
- All in all, very good
- All good
- Thanks very much

Statements

- I enjoyed the presentations. I do believe that more funding should be spent on educating people about their food commodities, especially lettuce. I do believe that this is the only way to create market pull instead of supply push. And I do believe that it is the best way to help the whole industry.
- As an industry, it is imperative that more solidarity is achieved, particularly in the short term. Lobbying groups need to be joined to concrete the future for the long term
- More speakers to push barrow for a better deal for growers

3rd Lettuce Industry Conference Committee Evaluation

Prepared on the basis of 4 evaluation returns from Committee members. Designed to assist with Committee meeting, and to be used as a source of advice for incoming Committee: the 4th Australian Lettuce Industry Conference.

Section 1: Planning
Section 2: Program
Section 3: Organisation
Section 4: Summary of recommendations from Committee

SECTION 1: PLANNING

Background

Two previous Conferences held; decisions taken at Gatton were to:-

1. hold 3rd Conference in Victoria (3 year interval);
2. combine the event with the Werribee Vegetable Expo; and
3. improve on participant experiences through program design and management.

Planning Committee formed to plan and deliver the event. Local organizer identified early 2004.

Organisational Framework

Function of Committee was to make decisions affecting the Conference design, venue, budget, content, delivery. Committee membership covered growers (members bridged planning committee for Vegetable Expo), suppliers, hydroponics sector, processors, and was convened through NSW Dept of Primary Industries. The Committee met by teleconference, the first held on 7 June 2003. Bi-monthly meetings commenced in December 2003: monthly meetings in 2005.

Committee attendance:

Conference Committee	2003	2004						2005			
	Dec	Feb	April	June	Aug	Oct	Dec	Feb	Mar	Apr	June
Dr S McDougall	√	√	√	√	√	√	√	√	√	√	
Frank Ruffo	√	√	√	A	√	A	A	√	√	√	
Les Giroud	√	√	A	A	A	A		A			
Alec Berias	√	√	√	√	√	A		√			
Michael Simonetta	√	√	A	A	√	A	√	√		√	
Paul Gazzola	√	A	A	√	√	√		A	√		
Arie Baelde	√	√	√	√	√	√	√	√	√	√	
John Duff											
Steven Carruthers		√	√	A		A		A			
Tony Napier		√									
Stephanie Ogilvie		√	√	A	A	√	√		√		
Paul Heseltine		√	√	A	A		√	√	A		
Andrew Creek	√	√	√	√	√	√	√	√	√	√	
Patrick Ulloa							√	√	√		
Total	**8**	**11**	**8**	**5**	**7**	**5**	**7**	**8**	**7**	**5**	

Gatton evaluation (7 June 2002) recommended Expo membership link. However, this strategy divided manpower resources for planning (and divided sponsorship capacity)

- Committee membership seemed to change as we went along
- No responsibility portfolios allocated to Committee members.
- Decisions were consensus based
- Committee communications assumed use of email
- Preparation of agendas and minutes were via Chair for approval/adjustment before being distributed to members. This seemed to work.
- Coordinating function of the Chair important to Committee productivity

Decision-Making

Gatton evaluation (6 June 2002) noted: "Have everything in place 12 months before" Meetings were productive, and following summarises:

Conference	**2003**	**2004**						**2005**			
Decision-Making	Dec	Feb	April	June	Aug	Oct	Dec	Feb	Mar	Apr	June
Conference Venue	2002										
Major Presenters	√	√	√	√	√	√					
Welcome Reception			√								
Combined Dinner		√									
Trade Exhibits		√									
Program timetable		√									
Catering and costs		√									
Workshop topics		√	√								
Workshop speakers				√	√	√	√				
Half Day Industry Tours			√								
Official Opening			√								
Lettuce Aphid Symposia			√					√		√	
Conference Budget				√							
Registration Fee				√							
Sponsorship strategy				√	√						
Conference publications				√	√	√	√	√			
Promotions, Advertising				√		√			√		
Key dates to Conference				√							
Bus Tender					√						
Audio-Visual Tender									√		
Registration brochure, process						√					
Gifts to Presenters							√	√			
Official Guests							√				
Meeting dates 2005							√				
Workshop & Tour Minders									√		
Conference Evaluation process									√		
Conference manual										√	
Final Afternoon Session										√	
Review of Conference 2005											√
Early planning: 4th Conference											√

<u>Observations:</u>

- Major decision-making issues included: resolving keynote presenters, resolving workshop topics and presenters; deciding on form and cost of publications
- Major organizational time required for simultaneous interpreting, planning of and communications about itinerary for international presenter; chasing up workshop presenters for CVs and conference handouts; locating available and suitable minders for workshops and tours; arrangements for half day industry tours
- It helped to have 3 members in reasonable geographic distance to get together to plan itinerary for Fredy Leuenberger

Committee Comments

- Excellent meetings, frequency was good to keep things moving
- Good
- If you had to take action on a follow up from a meeting, do the task straight up after the meeting or the next day. Otherwise you forget and have other priorities until Joce's next meeting reminder notice. By then it is too late to achieve.
- Joce ran them remarkedly efficiently, were useful. May have done it with fewer meetings, didn't need more. Broader membership this time excellent & contributed to being more inclusive

SECTION 2: PROGRAM DESIGN

Welcome Reception	Initial doubts as to the usefulness of this activity.
Official Opening	Involved enormous amount of work re protocols, organization. Future openers could come from the industry, government sector, major consumers of lettuce eg., Crown Casino, major hotel chain with possibility of gaining sponsorship involvement.
Major presenters	**Gatton** review indicated that "a 'wow' factor was needed; that keynote speakers needed to be booked 12 months ahead; aim for international speaker; link the program to the consumer; take an international focus; add an international link; put on a show to attract participation". **Werribee review** by committee**:** • Excellent generally. Howard's talk was a bit drawn out and without a punch line. His material was interesting. We could probably have helped him. • We ran ahead of time in the morning program and had about half an hour extra to fill without contingency. Luckily the questions kept going reasonably well. • Tables over the back were long way from podium. Translation and headsets worked well but probably plenary sessions are better with an auditorium style set up. It is harder to retain people's attention in the table set up • Thought having international perspective was good and should be repeated at next one
Lettuce Aphid	Session held immediately after lunch on Day 1 and had a time imperative with workshops immediately after. Wyndham Events Centre advised of poor stage lighting for panel presentation.
Workshops	**Gatton review** indicated "organize speakers for mornings, be more grower oriented because the gap has got wider from consumer to grower and this info must be fed back to grower, try to have some market focus, no ground breaking information in content, content way over their head, regional round up waste of time, nothing was market oriented, fresh cuts will never be 100% of sales, speaker introductions to be done properly; try to have some market focus, workshops optional, ". **Werribee review:** participants generally valued workshops which aimed to

provide choice and increase their interaction with presenters. Time limited; venue variables affected group size and location. Committee seemed to value handouts which in turn, assumed the style of workshop.

- Could have more focus on business management issues, eg., recruiting and compliance issues. I enjoyed the presenters but many people I talked to were not as happy. Perhaps a more local focus on our industry and issues which are more contentious.
- I really do feel we pushed the **biological** IPM barrow a little too hard. Lettuce aphid is now on mainland. As it establishes in production areas, I can tell you 98.9% of growers will be using the chemical alternative.

Workshops (Cont)

- Workshop No 9: - never again present commercial-in-confidence work. No information was given, delegates were disappointed. We did not give what our brochure promised
- Workshops did feel a bit rushed.

Half Day Industry Tours

Gatton Review indicated "difficult with each conference to make it more interesting, hold conference half day, field trip other half day, full day in conference too long.

Werribee Review: The aim of these was to offer choice, allow participants to be actively engaged in local industry activities. The tours were fairly difficult to organize: eg., Venue limitations; Locating appropriate tour captains; Drawing on a reduced manpower workforce given that tour captains came from the same pool sought by the organizers of the Vegetable Expo; Previewing of participants to manage commercial confidentiality; Participants believing that they could make their own arrangements regardless of the Committee's preparation; trying to be fair in allocation of participants to both workshops and tours.

- Depending on venue, tours are a great way of learning more about the local industries relating to lettuce issues.
- General feedback from tours was good.

Final Afternoon

Gatton review: regional round up waste of time, we need different ideas and different technology or we will be extinct, the industry needs to get its act together so we can research into the correct channels, give some more concrete ideas for R & D projects, try to have some market focus, round up needed a structure as to what the organizers wanted them to deliver, it needed to provide info on trends in buying etc – it is our responsibility to get back to the grower what drives the $, supply chains are feeding back data, one from a processing industry enough.

Werribee Review Attended by 25 participants out of number of delegates with full registration (about 150?)

Committee Observations

- I think we need a stronger finish to the second day.
- The afternoon session might have been changed to lettuce aphid discussions.
- The R & D session needed to be on Wednesday – options of having as one of the workshops might have been better?

Combined Dinner

Gatton review: no comments from 7 June 2002 meeting.

	Werribee Review: Think social events worked well
General Committee Views of Overall Program Design and Content	• More quality control on speakers and workshops. Content to be approved by Committee and ready 4 weeks before conference • Could have more focus on business management issues, eg., recruiting and compliance issues. I enjoyed the presenters but many people I talked to were not as happy. Perhaps a more local focus on our industry and issues which are more contentious. • I really do feel we pushed the **biological** IPM barrow a little too hard. Lettuce aphid is now on mainland. As it establishes in production areas, I can tell you 98.9% of growers will be using the chemical alternative • Workshop concept worked well. Stress keep presentations short, no technical graphs. Pictures, pictures, growers love pictures. • Limit presenter numbers in workshops so as no more than 30 minutes of presentation • Content was generally excellent. Could have more focus on business management issues eg., recruiting and compliance issues. • We ran ahead of time in the morning program and had about half an hour to fill without contingency. Luckily the questions kept going reasonably well. • Excellent program, snappy to the point. Do not need more time. • Tables over the back were long way from podium. Translation and head sets worked well but probably plenary sessions are better with an auditorium style set up. It is harder to retain people's attention in the table set up. • A main speaker on Australian lettuce production might have been interesting. • Best design yet. Most comments have been positive. • Timetable was very tight. Pity Tripod's farm tour was short of time. I had quite a few complaints of 'they saw nothing'. • Format of program allowed for a range of issues to be addressed • Felt program was very balanced – good mix • Thought there was lots of opportunity for participation and that it was used

SECTION 3: ORGANISATION OF CONFERENCE

Attendance

This is best guess by Joce:

	NSW	Vic	Tas	WA	Q	SA	NZ Other	Total
Growers	37	43	8	5	24	7	4	128
Services to Growers	29	38	1	4	17	4	28	121
Tertiary	1	44				1	1	47
Government	14	10		1	1			26
Industry	1	6	1	1			1	10
	82	**141**	**10**	**11**	**42**	**12**	**34**	**332**

Profile compared to Gatton

(Estimated from registrations)	Gatton	Werribee
Growers	43%	39%
Government Depts	10%	7.8%
Services	45%	36.5%
Tertiary Sector	2%	17%

Geographic Profile	Gatton	Werribee
NSW	31%	24.7%
Victoria	28%	42.5%
Tas, WA, ACT, O/S	8%	20.2%
Queensland	33%	33%

Gatton review: "more difficult with each conference to make it more interesting. Hay was the easiest because it was the first, we would like to have everything in place 12 months before, hydroponic industry to be included, the third time will be more difficult, disappointed with the number of people attending, try to look at a time when the growers are not busy producing"

Werribee Review

- The lettuce conference is large enough to be viable but there needs to be a driver i.e., the lettuce IPM project (Sandra) was the driver. It was written in the IPM project to facilitate 3 conferences. All her time was paid for by NSW DPI. A voluntary committee member just cannot afford the time to do what Sandra did
- Fantastic participation, the number of people who participated on the first day was fantastic.
- Keep the time between conferences no less than 3 years – easier on sponsors and more time for new issues and research to develop in the industry.
- Big time commitment
- I thought we got the message out there but there were still people close to the conference that heard via word-of-mouth not through fliers or advertising

Sponsorship	**Gatton Review:** "Sally Brown to help with contacts from Victoria, in reference to helping organize the conference, sponsorship matched with federal funds? Organise a program structure then seek out sponsorship for each aspect" **Werribee Review:** • A bit disappointing that CHEP were not included, partly my fault. Sponsorship on the whole very good. • Sponsorship recruitment was a long drawn out affair spread over a number of people. I thought more would have liked to be involved. Should be easier next time with conference profile • Can we send sponsor an evaluation form and check if they feel they received value for money? • Out of all conferences I go to, the lettuce conference has the lowest sponsor profile. This makes for a very pleasant environment and a better quality program. • We can do with more sponsor money but do we need to? • Promotion through suppliers worked well • Sponsorship was down on previous conference but financially we didn't need more than we got.
Industry Profiling	**Gatton Review**: no comment recorded **Werribee Review:** • GF&Veg article was good, many enquiries "I'm calling about the lettuce conference in GFV" (pity about the claim of the lettuce harvester)
Organisation	**Gatton Review:** "…not introduced properly, field tours 3 mins before to be a tour leader, more preparation." **Werribee Review:** • Registration desk was inefficient. Needed two desks A-K, L-Z. A red sticker dot on registration envelopes for when a delegate owed money or something. This saves looking up a name in a list. • Joce did a great job and got us all to concentrate on the job • The Committee was a good mix of people who actively mixed with the group • Great opportunities for networking • Great work, need to have a professional like Joce and team involved to pass the sleepless nights on to • Catering and tech support was excellent • Thought the conference venue looked visually ordinary the previous day. This changed totally when the people came in! • Joce did a fantastic job. Were some problems with credit card payments – batch accidently charged twice. Issues with not having sent out receipts of confirmation of payment.

SECTION 4
SUMMARY OF COMMITTEE RECOMMENDATIONS 2005
(4 returns from Committee in period 8 - 29 May 2005

Committee	1. Meeting frequency was spot on 2. Productivity was fine. Sticking to the agenda good 3. May have been better to have weekly meetings the month before the conference 4. Have at least one face-to-face meeting early in the piece
Content	5. Do not appear to be pushing solutions for industry issues in growers' faces. Try to present more balanced research. Represent all sides of the dice. 6. More quality control on speakers and workshops. Content to be approved by Committee and ready 4 weeks before conference
Industry Profile	7. Approach the combined list of sponsors from all conferences for sponsorship. Include Seminis Seeds and Bayer. 8. Again, get suppliers organizing grower groups. Also promotion in vegetable markets 9. Clearer invoicing and contact people for sponsorship 10. Appoint sponsorship coordinator who reports to each meeting 11. If the national Vegetable Expo were to circulate with the conference host city, we can use this as a lettuce promotion event for consumers. If this is not going to be the case, then perhaps we should cater for static sponsor displays at the conference venue 12. Can probably do more with the media 13. Need to offer sponsorship packages to interstate tours that helps them with organization eg., hotel bookings and transport 14. Put information more broadly through trade magazines for sectors other than growers
Program Design	15. Depending on venue, tours are a great way of learning more about the local industries relating to lettuce issues 16. We are very dependent on our major presenters. If one pulls out or indulges too heavily the previous night, we need to have a back up scenario which probably would be the presentation read by a designated person. 17. Workshop concept worked well. Stress keep presentations short. No technical graphs. Pictures, pictures growers love pictures. Limit presenter numbers in workshops so as no more than 30 minutes of presentation. 18. Trade displays and field trials will need to be considered if the next one is not held in association with an expo-like event 19. The R & D discussion on the Thursday can probably be changed or deleted. HAL is choosing a different formula for setting research priorities. We can use a final session for summarizing, closing notes, thank yous and canvassing new conference ideas. 20. Somehow check presenters' ability to effectively present at the level they are expected 21. I enjoyed the presenters but many people I talked to were not as happy. Perhaps a more local focus on our industry and issues that are more contentious.

Organisation	22. Some people missed out on a conference show bag. Need to have show bag ready by name at registration so that if we are short this will be borne by the late registrations 23. Need lettuce product displays at venue 24. Need to look at transport from hotels to the venue 25. Our hospitality was fine. 26. Longer meal times would give day registrants more time for networking. But how does one fit it all into a program that is already jammed tight? 27. Send confirmation and receipts are registration payments processed
General	28. Frequency: 2 years is good but definitely need to continue with core team of professional organizers to achieve this 29. Need to include industry promotion opportunity, devote one session to this 30. Keep the time between conferences no less than 3 years – easier on sponsors and more time for new issues and research to develop in the industry

SECTION 5: SPONSOR'S EVALUATIONS

It was suggested that the advice of sponsors be sought as to whether they thought they got value from their financial support. Email forwarded to: Rijk Zwaan, Tripax Engineering; TotalPak Solutions; Withcott Seedlings; Du Pont Australia; GSF Australia. SPS Seeds. Three responses received:

<u>Qn 1: Do you believe that your organization got value for money?</u>

- Yes
- GSF felt we definitely got value for money. To sponsor the conference as major users of lettuce was sufficient in our opinion
- From a company point of view, we paid for satchel inserts and provided 200 of inserts as requested only to find out later that in fact over 300 delegates attended. So our coverage was not 100% and so was disappointing.

<u>Qn 2: Did you feel informed?</u>

- Yes
- GSF was definitely informed and kept up to date with all proceedings.
- I did not have much to do with the conference, only the exhibition. Our General Manager did attend the conference and found it informative
- Not knowing the exact timing of the workshops and visits (and indeed, our General Manager didn't get his first preference of tours) made the organizing of the day awkward from a time management point of view.

<u>Qn 3: Did you feel acknowledged?</u>

- Potentially during the presentations and the workshops, maybe a slide show of the logos of the sponsoring companies and/or maybe a company brief may have also been relevant, however, not necessary – just for some exposure

<u>Qn 4: How could relations and outcomes for sponsors be improved next time around?</u>

- All in all it was an excellent conference, executed extremely professionally. Regards, and thanks, and looking forward to the next conference
- We found the exhibition successful
- The option is to have booths in a separate area, or in the lunch tea break area. If these booths are restricted to major sponsors, it would not take much space and it may provide more incentive to become a major sponsor. The other possibility is to provide space for flags, banners of the major sponsors on the podium

Lettuce Insect Pest Management Survey Form

Questions: **Please tick where appropriate otherwise one or two sentences may be required. More than one box may be ticked per question. Not all questions will be relevant to you. Each will depend on whether you carry out Integrated Pest Management on your crop. If a question is not applicable to your situation please write N/A and proceed to the next question.**

1. Do you use an Integrated Pest Management (IPM) strategy as part of your lettuce production? Yes No

If **yes**: What IPM techniques do you use?

- ☐ Crop monitoring
- ☐ Beneficial insect releases
- ☐ Monitor for beneficial insects
- ☐ Biological insecticides
- ☐ Yellow sticky traps
- ☐ Pheromone traps for Heliothis
- ☐ Modified boom sprayer eg. short droppers, air assist
- ☐ Others, please state____

____

If **no**: How do you traditionally manage your insect pest problems?

- ☐ Weekly sprays
- ☐ Twice weekly sprays
- ☐ Use only traditional insecticides such as methomyl and synthetic pyrethroids
- ☐ Use some newer generation insecticides such as Success®, Avatar® or Bts
- ☐ Conventional over the top boom sprayer
- ☐ Modified boom
- ☐ Other please state____

____

What would it take for you to adopt an IPM strategy?

____

____

____

2. How long have you been practicing IPM strategies?

   1-5 years 6-10 years 10+ years

3. Why did you adopt an IPM strategy?

____

____

4. Is crop monitoring part of your lettuce crop management program?

   Yes No

   If **yes**: Who carries this out on your crop?

   - ☐ Crop consultant
   - ☐ Chemical reseller
   - ☐ Yourself
   - ☐ Other

   How often is the crop monitored or checked?

   - ☐ Weekly
   - ☐ Twice a week
   - ☐ Other, please state

   ____

   How many plants per planting or area are checked?

   10 20 Other, please indicate______________

   If **no**: Then how do you determine the right time to apply an insecticide/fungicide treatment?

____

____

____

5. Is crop monitoring cost effective in terms of a reduced number of insecticides applied?

   Yes No

6. Do you currently use the newer generation insecticides including biological insecticides? Yes No

   If **yes**: What insecticides?

   Bt Success Nuclear polyhedrosis virus or Gemstar

   Avatar Proclaim Others, please indicate

If **no**: Then why not?

- ☐ Poor efficacy with biological insecticides
- ☐ New chemistries too expensive
- ☐ Don’t know enough about the new chemistries to rely upon them
- ☐ Other reasons

What insecticides do you rely on?

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7. How do you apply your insecticides/fungicides to your lettuce crops?

- ☐ Conventional boom sprayer
- ☐ Air assist sprayer
- ☐ Control droplet application (CDA) sprayer
- ☐ Boom sprayer with short droppers

What water rate (per ha) do you use?__________________

Do you tank mix older generation insecticides & fungicides? Yes No

Do you tank mix newer generation insecticides & fungicides? Yes No

8. What benefits have you found by adopting an integrated approach to insect pest management?

- ☐ Better pest control
- ☐ A greater understanding of insect pests
- ☐ Ability to recognise beneficial insects
- ☐ Reduced insecticide usage
- ☐ Reduced costs of insecticides
- ☐ Other____

9. What weaknesses do you see by using an IPM strategy?

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10. Are there any other techniques/tools that you would like to be developed to enhance a lettuce IPM strategy?

11. What is the biggest threat to the ongoing success of lettuce IPM?

12. How would you rate the following on a scale of 1 (very poor) – 5 (excellent)

Are there any other techniques/tools that you would like to be developed to enhance a lettuce IPM strategy?	1	2	3	4	5	
Lettuce conferences	1	2	3	4	5	didn't attend
Conference Proceedings	1	2	3	4	5	
Lettuce IPM information guide	1	2	3	4	5	
Ute/Field guide	1	2	3	4	5	

13. Any other comments?....

Issue No.21 Lettuce Leaf July 2005
National Vegetable Industry Centre Newsletter

Lettuce Aphid in Victoria

Andrew Creek

In late April 2005, lettuce aphid (*Nasonovia ribis-nigri*) was detected on the mainland in the Melbourne metropolitan area. Due to the out break, movement of lettuce and other host plant material from Victoria has been subject regulations. NSW, QLD, SA and WA have placed restrictions on the entry requirements for lettuce and lettuce products. Copies of the regulations can be obtained from the respective state departments.

It is important that growers who send susceptible produce interstate are aware of the importing state's requirements because the regulations vary between states. If a consignment of produce enters a state without the correct documentation, the consignment may be impounded and destroyed.

DPI Victoria are actively monitoring a network of aphid traps and regularly doing intensive crop surveys to maintain area freedom for Victoria's lettuce production zones. At late June 2005, lettuce aphid had been confirmed in Templestowe, Eltham, Scoresby and most recently in a commercial crop at Kooweerup.

Lettuce Aphid or Currant Lettuce Aphid
Nasonovia ribisnigri

A wingless lettuce aphid

A winged lettuce aphid

The time it will take for the aphid to spread through out the country is unknown. Respective state departments are surveying lettuce production areas quarterly to maintain the lettuce aphid regulations. Growers are advised to check the Ausveg website for the latest information on the lettuce aphid's movements and the state regulations. http://www.ausveg.com.au

Victorian growers with long established biological IPM systems on their farms are disgruntled with the regulations. They are left with very few options to trade lettuce interstate. The irony is that last year in Tasmanian lettuce aphid trials, biological IPM was proven to be almost as effective as Confidor® in controlling lettuce aphid.

No super aphid

Andrew Creek

"super-aphid" image by Brian Pribble and Paul Horne

Nasonovia is not a super aphid, just another aphid. Lettuce aphid is a great food source for brown lacewings, ladybird beetles and hoverflies. It was proven in the Tasmanian trials last year that predatory insects can control lettuce aphid to commercial standards.

Like the other aphid species we commonly find in lettuce, *Nasonovia* too can spread viruses. The only difference is that *Nasonovia* prefer to colonise the lettuce heart or be hidden in leaf curls and folds of fancy lettuce. This difference in habit catches out unprepared growers where traditionally applied aphid insecticides fail due to lack of contact with the pest. Hence the "super aphid".

Lettuce aphid is manageable with the following methods:

- Biologically based IPM
- Resistant varieties
- Confidor® seedling drench

There is no bet each way. Integrated Pest Management (IPM) just will not work with Confidor® seedling drenches. A trial earlier this year proved that low rates of Confidor® applied as a seedling drench was toxic to predatory brown lacewings. For IPM to control lettuce aphids, both juvenile and adult beneficial insects need to be present in the lettuce crop. Insecticide drenches do not allow this.

Nasonovia resistant lettuce varieties are available and it is recommended growers contact seed companies and trial varieties suited to their area.

A Confidor® seedling drench is likely to be the most popular choice for lettuce aphid control. APVMA permit number 7416 outlines the details for Confidor® use in lettuce, chicory, endive and radicchio. http://www.apvma.gov.au

Lettuce Industry Conference

Sandra McDougall

The 3rd Australian Lettuce Industry Conference held at Werribee turned out to be the largest ever, with 330 registrations. This reflects the excellent support from all sectors of the industry for a lettuce conference. Growers came from all Australian states, New Zealand and New Caledonia.

The major sponsors and many of the minor sponsors from the two previous conferences again showed their commitment to the industry. A few new sponsors also supported the conference.

Frederic Leuenberger, the principle of Eisberg group based in Switzerland gave a fascinating overview of the Eisberg operation. The breadth and scale of their operation is unlike any in Australia but then their market is many times the size of ours. Howard Poole gave a pictorial talk of his experience of growing lettuce in China. Although the individual farms are tiny by our standards, the collective scale of vegetable production is enormous.

Conference delegates wore head phones to hear the simultaneous interpretation of Frederic Leuenberger's presentation.

New Zealand's Stuart Davis from LeaderBrand and head of the NZ lettuce IPM project told of the reliance on Confidor® for lettuce aphid-free lettuce and of the potential of brown lacewings and an aphid fungus for control of lettuce aphid in Pukekohe. Lee Peterson told the story of how Houston's have managed to continue to sell babyleaf lettuce to all states of Australia. Lionel Hill told us of the success of seven sequential 0.1ha IPM demonstration plots in Devonport to control lettuce aphid. He also spoke of the imminent failure of the last two plots where 2/3 of each plot was used to test low rates of two chemical treatments.

The afternoon of workshops allowed for smaller groups to be more involved in discussion or hands-on activities. Similarly the Thursday morning field trips gave delegates a range of businesses to see in operation. After lunch a much smaller group discussed Research & Development issues affecting the lettuce industry. Many conference participants spent the afternoon and much of Friday at the National Vegetable Expo site viewing the extensive plantings of leafy and brassica vegetables.

Thursday night was the combined conference and Expo dinner. John Baressi entertained all with his Italian and Greek characters.

As chair of the 3rd Australian Lettuce Industry Conference organising committee I would like to thank the organising committee, the conference convenor, sponsors, workshop presenters, tour hosts, NSW Department of Primary Industries staff and the staff of the Wyndham Events Centre.

Arie Baelde, Howard Poole and Sandra McDougall amongst the extensive leafy vegetable plantings at the Expo site.

The conference evaluations indicated the overall success of the conference and a desire for it to happen again. The next conference is likely to be in three years time in either Adelaide or Perth. If you have an interest assisting with the organisation of the next Australian lettuce industry conference please contact:

Sandra McDougall,
NSW Department of Primary Industries
Ph (02) 6951 2728
e-mail sandra.mcdougall@agric.nsw.gov.au

Harvesting technology

Andrew Creek

Growers Anthony Staatz and Jamie Buckel of Koala Farms in the Lockyer Valley have developed a new low impact vegetable harvest aid. Starks Engineering will manufacture the harvester. The new harvest aid has been used to pick lettuce, cauliflowers, melons and butternut pumpkins. Produce can be efficiently bagged and packed on the harvest aid.

Anthony Staatz and Jamie Buckel from the Lockyer Valley have developed a new low impact harvester.

A ski lift-like carrying cradle replaces the traditional belts that many harvest aids have. Produce is placed on a cradle, rather than being thrown on a belt. Belts also have the disadvantage of build up points that accumulate produce, leaves and dirt.

Lettuce are efficiently harvested, sanitised and bagged in the field with minimal damage. The produce comes off the back of the harvester, packed ready for market.

For more information about harvester contact:
Julianne on Ph (07) 4696 1951
e-mail thebuckels@in.com.au