Integrated pest management in the green bean industry

John Duff
QLD Department of Primary Industries & Fisheries

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Integrated Pest Management in the Green Beans Industry

Final Report

John Duff *et al.*

Queensland Department of Primary Industries and Fisheries

HAL Project VG02030

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This summarises the results of a four year project investigating the Integrated Pest Management options for growing green beans. This report provides information on the range of insect pests and beneficial insects likely to be found in green beans and looks at a number of best management options trials to determine if an IPM system can be developed for green beans.

The research team gratefully acknowledges the financial support of Sumitomo Chemical Australia Pty Ltd, Horticulture Australia Limited and the Queensland Department of Primary Industries and Fisheries.

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Queensland **the Smart State**

Final report

Horticulture Australia Project VG02030

Integrated Pest Management in the Green Beans Industry

John Duff
Queensland Department of Primary Industries and Fisheries

Queensland Government
Department of Primary Industries and Fisheries

Media summary

The majority of the Australian French or green bean[1] industry is situated in Queensland. The Australian industry is valued at $62.1M with Queensland accounting for about 40% of this value (ABS 2003-04). Insect pest management is becoming an increasing problem, with heliothis topping the list in a number of production regions. Insecticide resistance and access to only a small range of effective broad spectrum insecticides are limiting the level of insect pest control achieved by growers in this industry. The issues investigated in this project centred on developing an Integrated Insect Pest Management system suitable for the green bean industry.

Bean plantings were grown at the Gatton Research Station 4-5 weeks apart without insecticides to encourage the widest possible variety of pest and beneficial insects at different times during the growing season. Grower properties were also monitored throughout the growing season with the majority of the sampling carried out in Lockyer Valley and Gympie regions with one visit to North Queensland during their northern growing season.

These plantings were monitored by direct visual sampling, the use of sentry pheromone traps for heliothis adult males, yellow sticky traps, sweep netting and/or suction sampling using a motorised leaf blower/sucker. Thirty seven pests and potential pests were observed from these plantings and twenty nine potential beneficial insects were collected including both predators and parasitoids.

Six efficacy trials were undertaken to aid the registration of new insecticides that could be used to control the range of insect pests, heliothis in particular, while preserving the suite of beneficial insects. A number of insecticides gave excellent control of a number of green bean pests. Avatar® and a new product from Bayer DC-041 gave good control of the caterpillar pests heliothis and bean pod borer during flowering and pod fill, while Confidor® gave good control of silverleaf whitefly, bean fly and jassids on newly emerged plants.

On farm and research station trial work was established to compare conventional pest management systems with a Best Management Options (BMOs) program. These BMOs included modified cultural practices, synthetic and biological insecticides, insect monitoring, augmentation of beneficial insects where possible and modified pesticide application techniques. The results were variable but did show that growers don't really need to spray just because they see an insect flying within their crop. The number of insecticides in one trial was reduced to only two in the BMO while the grower had applied four, three of which included mixtures of two or more pesticides. Another BMO had a poor result due to high bean pod borer which are very hard to find at the egg stage and so more work is needed with this pest.

Pesticide application equipment efficacy was looked at and showed that increasing volumes will not necessarily increase spray deposits on the flowers and pods, especially if the pods are drenched and run-off occurs. Hollow-cone nozzles appeared to be the most effective when targeting spray deposition onto flowers and pods, particularly when used with an air assisted curtain which blows the spray deposits into the crop.

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[1] The names French beans and green beans are technically the same and will henceforth be referred to as green beans.

Information in the form of DPI Notes have been produced and made available to the industry as part of this project and have been placed on the Department of Primary Industries and Fisheries web site. These DPI notes help growers who want to start an Integrated Insect Pest Management system in Green beans with options that they can use to develop this type of crop management system.

Flower thrips are still a big issue for growers with very few insecticides which will effectively manage the suite of species that can be found in bean flowers and have a minimum impact on the beneficial insect population. The need to further investigate management options for bean pod borer is also required. A new pheromone lure is available that could help in determining just when this pest is about. This needs to be trialled especially with respects to the type of suitable traps. A Ute Guide on the full range of pest and beneficial insects as well as diseases is also needed for the Green bean industry.

Technical summary

The majority of the Australian green bean industry is situated in Queensland. The Australian industry is valued at $62.1M with Queensland accounting for about 40% of this value (ABS 2003-04). Insect pest management is becoming an increasing problem, with heliothis topping the list in a number of production regions. Insecticide resistance and access to only a small range of effective broad spectrum insecticides are limiting the level of insect pest control achieved by growers in this industry. The issues investigated in this project centred on developing an Integrated Insect Pest Management (IPM) system suitable for the Green bean industry.

Bean plantings were grown without insecticides to encourage the widest possible variety of pest and beneficial insects at different times during the growing season. Plantings commenced at the Gatton Research Station from October 2002 with seven plantings 4-5 weeks apart until the end of the season. Two additional plantings were put in at the start of the 2003 growing season to catch those pest and beneficial insects that might occur early in the season and were missed the previous year. Grower properties were also monitored throughout the growing season with the majority of the sampling carried out in the Lockyer Valley and Gympie regions with one visit to North Queensland during their northern growing season.

These plantings were monitored by direct visual sampling, the use of heliothis sentry pheromone traps, yellow sticky traps, sweep netting and/or suction sampling using a motorised leaf blower/sucker. Direct Sampling consisted of checking five plants at each of five sites for pests and beneficial insects. Any unusual insects were collected for latter identification. Thrips specimens were collected from both the leaves and from the flowers for identification. Larvae were collected and reared to see if they were parasitised and to collect the adults for accurate identification. *H. armigera* and *H. punctigera* were monitored by using the pheromone traps with lures being replaced every four weeks. Yellow Sticky Traps were placed in the green bean crops and replaced every week. Only one side of the trap was exposed and later scanned for known pest and beneficial insects. These traps were used to help determine when the pest and beneficial insects were most prevalent during the growing season. A total of thirty seven pests or potential pests were observed within these plantings and twenty nine potential beneficial insects including both predators and parasitoids were found.

Six efficacy trials were undertaken to aid the registration of new insecticides that could be used to control the range of insect pests, heliothis in particular, while preserving the suite of beneficial insects. A number of useful insecticides gave excellent control of a number of green bean pests. Avatar® and a new product from Bayer DC-041 gave good control of the caterpillar pests heliothis and bean pod borer, while the neo-nicotinoid Confidor® applied as a furrow treatment, gave good control of silver leaf whitefly, bean fly and jassids, which are major pests on newly emerged crops. Two other neo-nicotinoids TI-435 a Sumitomo Chemicals product and Actara® also gave good control of these three early pests when applied as furrow treatments.

On farm and research station trial work was established to compare conventional pest management systems with Best Management Options (BMOs). These BMOs included modified pesticide use, synthetic and biological insecticides, insect monitoring, augmentation of beneficial insects where possible and modified pesticide application techniques. The results were variable but did show that growers needn't spray just because they see an insect flying within their crop. The number of insecticides in one trial was reduced to only two in the BMO while the grower had applied four, three of which included mixtures of two or more pesticides. There was very little difference between these options when comparing the harvested pods. The BMO treatment had more beneficial activity mainly in the form of predatory beetles. Another BMO had a poor result due to high bean pod borer activity, which are very hard to monitor for at the egg stage. As a result there was more damage to the pods than was felt acceptable at harvest. This BMO had 59% marketable pods compared to 76% for the grower managed block. The BMO did have less thrips damage, 15.8% compared to 22.3% for the grower block. No specific insecticides were applied for thrips in the BMO block.

Pesticide application equipment efficacy was looked at and showed that increasing volumes will not necessarily increase spray deposit on the flowers and pods, especially if the pods are drenched and run-off occurs. Hollow-cone nozzles do appear to be the most effective when targeting spray deposition onto flowers and pods, particularly when used with an air assisted curtain which blows the spray deposits into the crop.

Information in the form of DPI Notes has been produced and made available to the industry as part of this project on the Department of Primary Industries and Fisheries web site. http://www2.dpi.qld.gov.au/thematiclists/1182.html These DPI Notes cover the range of insect pests and beneficials and the IPM tools (pesticide application, cultural, biological and chemical options) that growers can use to better apply an IPM system to green beans.

Flower thrips are still a big issue for growers with very few insecticides which will effectively manage the suite of species that can be found in bean flowers. The need to further investigate management options for bean pod borer is also required. A new pheromone lure is available that could help in determining just when this pest is about. This needs to be trialled especially with respect to the type of suitable traps. A Ute Guide on the full range of pest and beneficial insects as well as diseases is also needed for the industry.

Product formulations used during this project

Insecticides

Product	Active ingredient	Chemical group	Chemical company
Actara	thiamethoxam	4A	Syngenta Crop Protection
Ambush	permethrin	3A	Syngenta Crop Protection
Avatar	indoxacarb	22A	DuPont Australia
Chess	pymetrozine	9A	Syngenta Crop Protection
Confidor	imidacloprid	4A	Bayer CropScience
DC-041			Bayer CropScience
DC-068/027			Bayer CropScience
Dimethoate	Dimethoate	1B	Nufarm
Dipel	Bacillus thuringiensis	11C	Valent Biosciences
Gemstar	nuclear polyhedrosis virus		Bayer CropScience
Intruder	acetamiprid	4A	DuPont Australia
Lannate	methomyl	1A	Crop Care Australasia
Proclaim	emamectin benzoate	6A	Syngenta Crop Protection
Success	spinosad	5A	Dow AgroSciences
Symphony (S1812)	pyridalyl		Sumitomo Chemicals
TI-435	clothianidin	4A	Sumitomo Chemicals

Fungicides

Product	Active ingredient	Chemical group	Chemical company
Dithane M45	mancozeb	Y	Dow AgroSciences
Filan	boscalid	G	Nufarm
Folicur	tebuconazole	C	Bayer CropScience
Plantvax	oxycarboxin	G	Uniroyal Chemical
Thiovit	sulphur	Y	Syngenta Crop Protection

Other products

Product	Active ingredient	Chemical company
Agral	nonyl phenol ethylene oxide	Syngenta Crop Protection
Hasten	fatty acid esters	Victorian Chemical Co.
Magnet	plant volatile blend	Biotech Australia
Mobait	food flavourings	Nufarm
Amino feed	sucrose	AgriChem

Abbreviations used throughout report

BMO	- Best Management Option
Bt	- Bacillus thuringiensis
CDA	- Control Droplet Application
HAL	- Horticulture Australia Limited
IPM	- Integrated Pest Management and has traditionally referred to the control of insect and will remain so in this report
IPDM	- Integrated Pest and Disease Management
OPs	- Organophosphates
QDPI&F	- Queensland Department of Primary Industries and Fisheries
SLWF	- Silverleaf Whitefly
SPs	- Synthetic Pyrethroids
UV	- Ultra-violet
WSP	- Water Sensitive Paper
®	- Registered Trademark
µg	- micrograms (10^{-6})
ng	- nanograms (10^{-9})

Project Introduction

The majority of the Australian green bean industry is situated in Queensland. The Australian industry is valued at $62.1M with Queensland accounting for about 40% of this value (ABS 2003-04). Insect pest management (IPM) is becoming an increasing problem, with heliothis topping the list in a number of production regions. Insecticide resistance and access to only a small range of effective broad spectrum insecticides are limiting the level of insect pest control achieved by growers in the bean industry.

The development of an IPM system in Green beans has been initiated by growers who are aware of the benefits of an integrated approach and have seen the benefits in the sweet corn industry through HAL project VG97036 (Insect Pest Management in Sweet Corn) and brassicas ACIAR project 9213 (Improvement in Integrated Pest Management of Brassica Vegetable Crops in China and Australia). Heliothis resistance to organophosphates and synthetic pyrethroids is already well documented, leaving little room for growers to manoeuvre when it comes to trying to manage heliothis and other pests currently found attacking green bean crops. With the small number of insecticides currently registered for use in green beans, increasing resistance to these insecticides is a distinct possibility.

Growers have noted that their control of heliothis in particular has declined in recent years. This could be attributed to increased insecticide resistance as a result of the same or few insecticides being used repeatedly with little choice of an effective insecticide rotation program. New narrow spectrum and beneficial friendly insecticides are needed to help growers implement an integrated insect pest management system. This project undertook efficacy trials to aid the registration of some of these newer insecticides especially those that are effective on heliothis and a range of other bean pests.

A clearer understanding of the pest and beneficial insect spectrum found with in any crop is needed, as once an integrated insect pest management system is put in place, other minor insect pests tend to increase in their importance as has been the case with IPM in the sweet corn industry. An understanding of the pest spectrum and how beneficial insect populations may be augmented will benefit growers and crop consultants in deciding what management practices need to be undertaken to minimise the insect pest levels and crop damage.

As has been the case in other integrated insect pest management related projects, Best Management Options (BMOs) were conducted using a range of control methods/strategies that impact on the insect pest(s) populations while at the same time safe guarding the suite of beneficial insects likely to be found in the bean crop. These demonstration plantings were trialled on the Gatton Research Station and then taken into the field on growers properties during times of expected high pest pressure as determined from the seasonal abundance studies conducted earlier in the project.

A national grower database was also developed to allow the dissemination of information on the outcomes of this project, and to promote field days, which demonstrate the effectiveness of narrow spectrum insecticides and the benefits of implementing an IPM system in Green beans

Pest and beneficial insect abundance studies

Introduction

Heliothis, *Helicoverpa armigera* and to a lesser extent *H. punctigera*, and bean pod borer *Maruca vitrata* are the most important pests found in green beans causing damage to the flowers, developing pods and mature pods. They can frequently be found harbouring within the flowers and pods making it a difficult task to control them with the small number of registered insecticides available for use in green beans. *H. armigera* can be doubly difficult to manage as it is known to be resistant to a wide range of insecticides, making the selection from the small number of registered products even more difficult. Numerous publications, (Cantrell *et al*. 1983; Llewellyn 2000; McDougall *et al*. 2002; Pyke and Brown 1996; QDPI 1996; Scholz 1999 and Wood *et al.* 2000), have reported the range of predators and parasitoids known to attack heliothis and other insect pests in a number of crops. It is likely that the same range of beneficials would be present in green beans, which would be attacking the wide range of insect pests known to damage green beans. Knowledge of these naturally occurring beneficial insects is essential in formulating an integrated pest management program for green beans, as has been the case with Brassica crops (Heisswolf *et al*., 2004), sweet corn (Deuter *et al*., 2005) and cotton (Pyke and Brown, 1996).

Materials and methods

Green bean plantings were grown without insecticides to encourage the widest possible variety of pest and beneficial insects at different times of the growing season. Plantings commenced at the Gatton Research Station from October 2002 with seven plantings 4-5 weeks apart until the end of the season. Two additional plantings were put in at the start of the 2003 growing season to catch those pest and beneficial insects that might occur early in the season. Grower properties were also monitored throughout the growing season with the majority of the sampling carried out in Lockyer Valley and Gympie regions with one visit to North Queensland during their northern growing season.

Sampling methods

Four sampling methods were used during this project in order to find as many pest and beneficial insects during the crop growth as possible. They included in-field monitoring, the use of pheromone traps, yellow sticky traps and sweep netting.

1. Direct in-field monitoring consisted of checking five plants at each of five sites for pests and beneficial insects. Any unusual insects were collected for latter identification. Thrips specimens were collected from both the leaves and from the flowers for identification. Lepidopteran larvae were collected and reared to see if they were parasitised and to collect the adults for accurate identification. Crop monitoring results were graphed to help determine when the pest was most prevalent during the growing season.
2. Sentry Pheromone Traps were used to monitor for heliothis moth numbers throughout the season in both the Lockyer Valley and Gympie regions. *H. armigera* and *H. punctigera* were monitored for. Pheromone lures were replaced every four weeks.
3. Yellow Sticky Traps were placed in the green bean crops and replaced every week. Only one side of the trap was exposed and later scanned for known pest and beneficial insects. These traps were used to help determine when the pest and beneficial insects were most prevalent during the growing season.

4. Sweep Netting/Suction Sampling was carried out in the various growing regions on grower properties and on the Gatton Research Station. Specimens were collected and placed in the freezer before sorting, pinning and identification. Specimens were then cross referenced with the insect collection at the Indooroopilly Department of Primary Industries and Fisheries.

Results

Pest and beneficial insects collected during the surveys are listed in Tables 1, 2 and 3 below. The list of pests in Table 1 also includes those pests (with an asterisk *) that have been recorded in the Department of Primary Industries Insect Collection records, but not specifically found in the bean plantings on the research station or on grower properties as part of this research work. The part of the plant attacked is compiled from direct field observations, rearing specimens from host material, from published records and the host/pest records kept at the Department of Primary Industries Indooroopilly Insect Collection. Table 2 and 3 lists predators and parasitoids which were found during the surveys either by observations in the field, sweep netting or on the yellow sticky traps. The Department of Primary Industries Insect Collection has an even greater list of beneficial insects recorded from bean pests, which was used as a cross reference to what was found in the current field surveys. A general host list was added to Table 2 and 3 of the insects most likely attacked by the various beneficial insects, which was supplemented from various publications (Cantrell *et al.* 1983; Llewellyn, 2000; Pyke and Brown, 1996; QDPI, 1996; Scholz, 1998 and Wood *et al.,* 2000).

<u>Green Bean Pests</u>

Coleoptera

Only three types of beetles were consistently found feeding on this crop and only on the leaves. They were *Apion* species, *Chaetocnema* species or a flea beetle and *Phyllotreta undulata* the striped flea beetle. These three pests were seen causing either small holes in the leaves, as with the flea beetles, or eating the outer most layer of leaf tissue causing a small crater in the leaf, as with the *Apion*. The bean weevil, *Acanthoscelides obtectus*, lucerne crown borer, *Corrhenes stigmatica* and the red-shouldered leaf beetle, *Monolepta australis* were all observed in the crop but signs of damage were not evident.

Table 1. Pests found and likely to be found in green bean crops and the part of the plant attacked if known.

Recorded pest of green beans	Common name	Family	Plant part attacked
Beetles			
Acanthoscelides obtectus	Bean weevil	Bruchidae	Seeds
Apion species		Brentidae	Leaves/pods
Chaetocnema species	Flea beetle	Chrysomelidae	Leaves
Corrhenes stigmatica	Lucerne crown borer	Cerambycidae	Stems
Monolepta australis	Red-shouldered leaf beetle	Chrysomelidae	Leaves
*Neodon pecuarius**		Scarabaeidae	Roots
Phyllotreta undulata	Striped flea beetle	Chrysomelidae	Leaves
*Rhyparida discopunctulata**	Black swarming leaf beetle	Chrysomelidae	Leaves
Sucking bugs			
*Amblypelta nitida**	Fruit spotting bug	Coreidae	Pods
Austroagallia torrida	Spotted leafhopper	Cicadellidae	Cotyledons/leaves
Austroasca alfalfae	Lucerne leafhopper	Cicadellidae	Cotyledons/leaves
Austroasca viridigrisea	Vegetable leafhopper	Cicadellidae	Cotyledons/leaves
Bemisia tabaci Biotype B	Silverleaf whitefly	Aleyrodidae	Cotyledons/leaves
Cicadulina bimaculata	Maize leafhopper	Cicadellidae	Cotyledons/leaves
Creontiades dilutus	Green mirid	Miridae	Flower buds
*Fabrictilus gonagra**	Passion vine bug	Coreidae	
*Macrosiphum euphorbiae**	Potato aphid	Aphididae	Cotyledons/leaves
Myzus persicae	Green peach aphid	Aphididae	Cotyledons/leaves
Nezara viridula	Green vegetable bug	Pentatomidae	Pods
Nysius vinitor	Rutherglen bug	Lygaeidae	Shoots
Riptortus serripes	Brown bean bug/pod sucking bug	Alydidae	Pods
*Smynthurodes betae**	Bean root aphid	Aphididae	Roots and base of stem
Toya dryope	Turf plant hopper	Delphacidae	Cotyledons/leaves
*Trialeurodes vaporariorum**	Green house whitefly	Aleyrodidae	Cotyledons/leaves
Flies			
Atherigona orientalis	Tomato fly	Muscidae	
Ophiomyia phaseoli	Bean fly	Agromizidae	Stems/petioles
Moths and butterflies			
Chrysodeixis argentifera	Vegetable/tobacco looper	Noctuidae	Leaves
*Chrysodeixis eriosoma**	Green looper	Noctuidae	Leaves
*Conogethes punctiferalis**	Yellow peach moth	Pyralidae	
Helicoverpa punctigera	Native budworm	Noctuidae	Leaves/flowers/pods
Helicoverpa armigera	Corn earworm	Noctuidae	Leaves/flowers/pods
Maruca vitrata	Bean pod borer	Pyralidae	Pods
Mocis alterna	Looper	Noctuidae	Leaves
*Omiodes diemenalis**	Legume web spinner	Pyralidae	Leaf roller
Zizina labradus labradus	Grass blue/common grass-blue butterfly	Lycaenidae	Young leaves
	Hawk moth eggs	Sphingidae	Leaves?

Thrips			
Desmothrips tenuicornis		Aeolothripidae	Leaves/Flowers/Thrips
Frankliniella occidentalis	Western flower thrips	Thripidae	Flowers
Frankliniella schultzei	Tomato thrips	Thripidae	Leaves/Flowers
Haplothrips gowdeyi	Gold tipped tubular thrips	Phlaeothripidae	Flowers
Megalurothrips usitatus	Bean blossom thrips	Thripidae	Flowers
Pseudanaphothrips achaetus	Hairless flower thrips	Thripidae	Flowers
Thrips imaginis	Plague thrips	Thripidae	Flowers
Thrips safrus	Similar to plague thrips	Thripidae	Flowers
Thrips palmi	Melon thrips	Thripidae	Leaves
Thrips tabaci	Onion thrips	Thripidae	Leaves
Mites			
*Polyphagotarsonemus latus**	Broad mite	Tarsonemidae	Leaves
*Tetranychus lambi**	Strawberry spider mite	Tetranychidae	Leaves
*Tetranychus ludeni**	Bean spider mite	Tetranychidae	Leaves
Tetranychus urticae	Two-spotted mite	Tetranychidae	Leaves
Other			
Locusta migratoria	Migratory locust	Acrididae	Leaves

*Recorded elsewhere as a pest of green beans

Hemiptera

There was a large number of sap sucking bugs collected from green beans with nearly a third of these called plant or leafhoppers. Leafhoppers are predominantly pests of green beans early in the crop life, attacking the new leaves. They caused pale green markings also known as silvering or stippling of the leaves. The vegetable leafhopper *Austroasca viridigrisea* and the lucerne leafhopper *A. alfalfae* were the most common of these pests and are also the most difficult to distinguish apart. Figure 1 is the number of all leafhoppers on the yellow sticky traps and those found by direct monitoring of the plants in the field. The leafhopper numbers increased from a low of about 25 per yellow sticky trap in October to a high of over 350 per yellow sticky trap in April with numbers falling after that time (Figure 1).

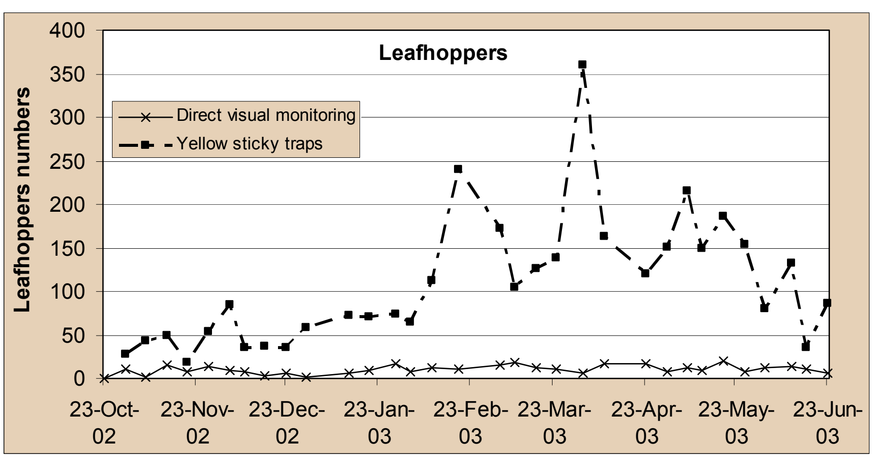

Figure 1. Leafhopper numbers during the 2002/2003 growing season at the Gatton Research Station comparing the yellow sticky traps and direct visual monitoring in the field.

The other most common sap sucking insect pests were the aphids (Figure 2), various species, and silver leaf whitefly, *Bemisia tabaci* Biotype B (Figures 3). The aphids were found predominantly during the autumn months and primarily on the young plants. Although *Myzus persicae* was the only aphid identified from this survey, the graph represents the total numbers of aphids on either the yellow sticky traps or found on the plants.

Silver leaf whitefly was most prevalent during January to April. Grower properties however had very few whiteflies at the start of these surveys with numbers increasing in recent years. The unsprayed plantings at the Gatton Research Station showed silver leaf whitefly building up in numbers in January. As the numbers increased on the plants, the numbers caught on the sticky traps also increased soon after, peaking in March and gradually falling off as the cooler weather approached (Figure 3).

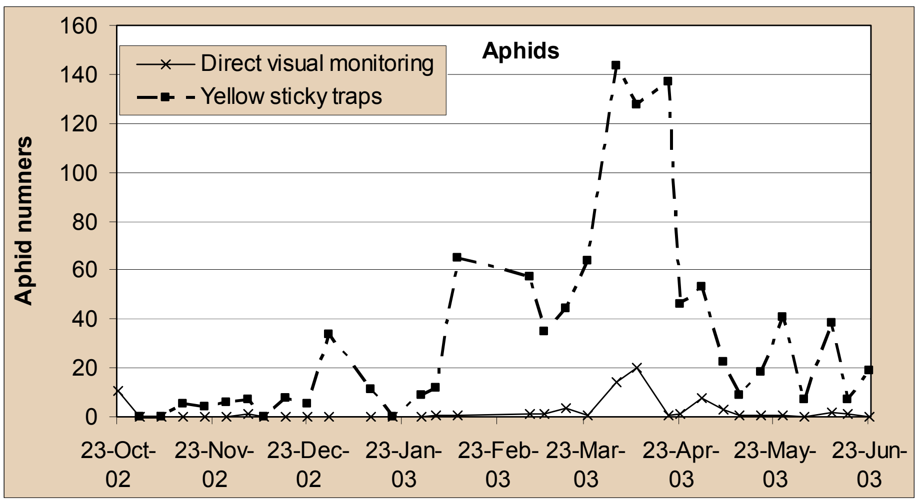

Figure 2. Aphid numbers during the 2002/2003 growing season at the Gatton Research Station comparing the yellow sticky traps and direct visual monitoring in the field

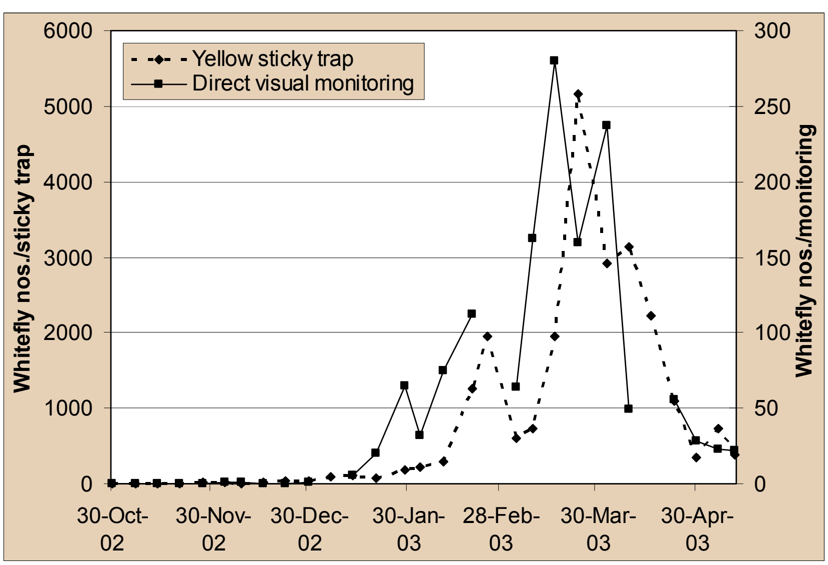

Figure 3. Whitefly numbers during the 2002/2003 growing season at the Gatton Research Station comparing the yellow sticky traps and direct visual monitoring in the field.

A number of other sucking pests were observed in green beans, Green vegetable bug *Nezara viridula* being the most common of these. However numbers were still fairly low and a number of these were found to be parasitised by *Trichopoda pennipes* a parasitic fly. Egg rafts of this pest were also found to be parasitised by *Trissolcus basalis* and *Coruna* species. Green vegetable bugs were most common on one grower property around Gympie but they were also being parasitised by the *Trichopoda* fly. The brown pod sucking bug, *Riptortus serripes* was found in the unsprayed plantings at the Gatton Research Station but only in low numbers and is generally not considered a pest of green beans. Likewise Rutherglen bug, *Nysius vinitor* which was only found in any great numbers on the Gatton Research Station.

Diptera

There was a large number of flies found within the green bean crops, which were either found on the yellow sticky traps, caught using sweep nets or reared from the stems of plants, as with bean fly *Ophiomyia phaseoli*. Bean fly was found in the Gatton Research Station plantings during most of the growing season but was only causing significant plant losses late in the season. Monitoring using the yellow sticky traps (Figure 4) revealed bean fly present in the individual plantings well after the plants were established and were able to withstand any infestation that may occur in the older plants.

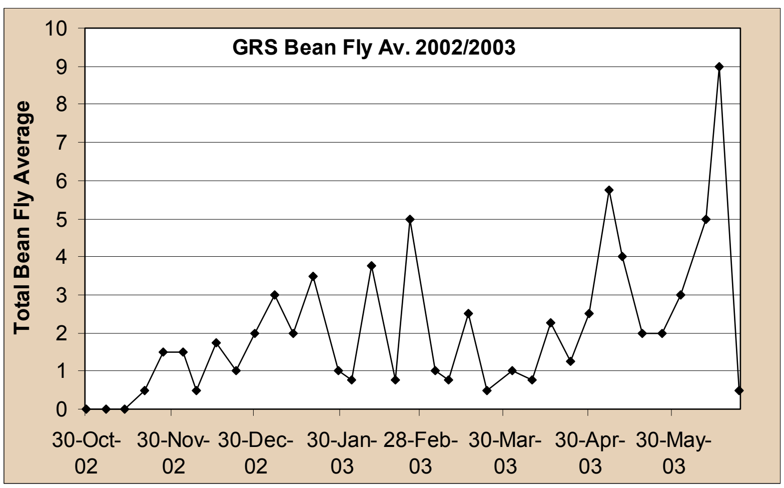

Figure 4. Bean fly numbers during the 2002/2003 growing season at the Gatton Research Station.

Bean fly were only present at planting from late March early April, with the last Gatton planting in May exhibiting over 50% seedling loss soon after emergence. Figure 4 shows as steady increase in bean fly numbers to a peak in June but were most active during the summer autumn months. Gympie and Bowen growers also experienced this pest at the start of their growing seasons in autumn. The unsprayed plantings at the research station also experienced severe petiole and stem damage from this pest even when the plants were flowering, however this was not observed on grower properties.

Lepidoptera

There were five pests belonging to this group of insects known to attack green bean crops. The Common grass blue butterfly, *Zizina labradus labradus* is the first such pest to attack green beans, causing damage to the new growth in the way of holes to the leaves. It was also found causing small holes on the developing pods but the larvae did not venture into the pods as do heliothis and Bean pod borer. This pest was only found in the unsprayed plantings at the Gatton Research Station or where a crop was not sprayed early in its growth. Vegetable looper, *Chrysodeixis argentifera* was also found attacking the leaves of green beans. The green looper *C. eriosoma* is also known to attack green beans but this pest was not found in this study. The larvae of both pests need to be reared through to adults, as the moths are used to separate the species. They both cause the same damage and are controlled using the same control techniques and pesticides.

The most serious pests of green beans would be heliothis, both *H. armigera* and *H. punctigera*, and Bean pod borer, *Maruca vitrata*. Pheromone trap data from regions (Figures 5 and 6) helped in identifying when heliothis was active within the area.

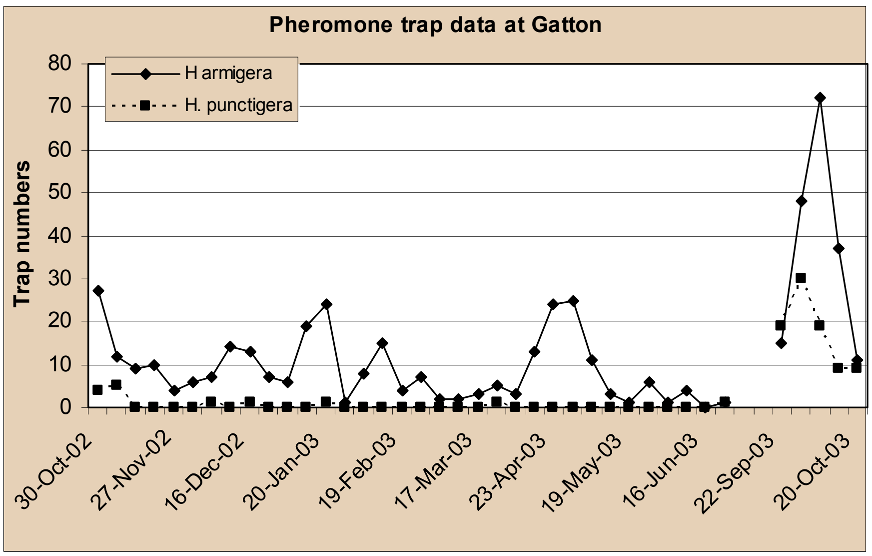

Figure 5. Pheromone trap catches at the Gatton Research Station during the 2002/2003 growing season.

Numbers in the Lockyer Valley peaked at the beginning of the growing season with *H. armigera* numbers reaching a high of 72 moths in the trap after one week and 30 *H. punctigera* moths for the same period in October. There were a number of smaller peaks during the growing season for *H. armigera* but *H. punctigera* numbers dwindled to zero in November, soon after the initial peak, and remained close to this level for the remainder of the growing season. *H. armigera* was the dominant pest for the majority of the season.

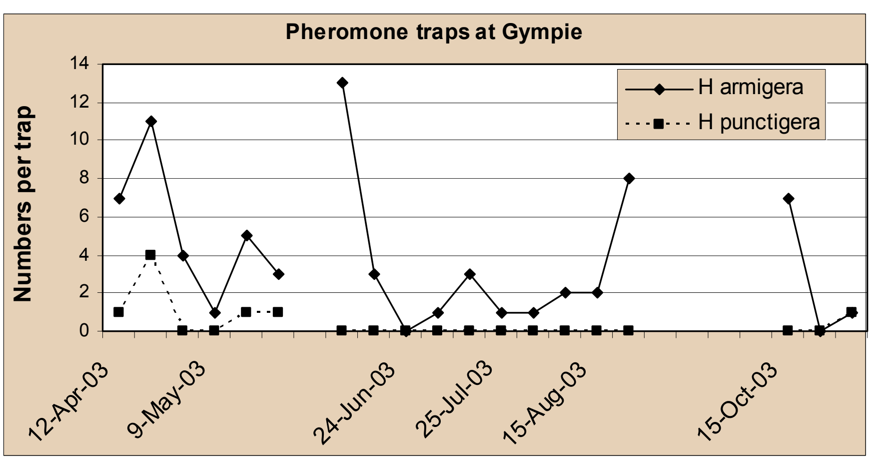

Figure 6. Pheromone trap catches for a grower property in the Gympie region during the 2003 growing season.

Pheromone trap numbers in the Gympie region showed very little activity during the winter months. *H. punctigera* was present in the Gympie region during the initial autumn plantings even though the numbers were low and again in October when they are expected to appear.

Bean pod borer, the other major green bean pest, only appeared in the unsprayed plantings at the Gatton Research Station during late summer and autumn months. Damaged pods with larvae were collected and reared through until the adults emerged for an accurate identification. Pod borer eggs are very small and difficult to find. The female lays small cream-yellow scale-like eggs on the sepals or petals of the flowers as well as the flower stalk, but will also lay her eggs on the leaves (Swain *et al.* 1991). Larvae were only ever found in the flowers and the pods and could be easily found, as the larvae would web together adjacent pods, flowers and leaves.

Thysanoptera

Ten thrips species have been recorded from green beans as a result of the survey work undertaken in Queensland and with Tasmanian bean growers. *Desmothrips tenuicornis* is thought to have some predatory activity (Mound and Gillespie 1997) and may have been feeding on other thrips larvae. The most significant of the pest thrips found would be western flower thrips, *Frankliniella occidentalis*, and the melon thrips, *Thrips palmi*. The thrips in Figure 7 have not been separated in to the individual genera or species. The graphs are a total number of thrips found on either the yellow sticky traps or those found on the plant while monitoring in the field. There does appear to be a close correlation between the field counts and the yellow sticky trap counts with the peak activity occurring during October and again from January to March, with smaller peaks in activity during April and May.

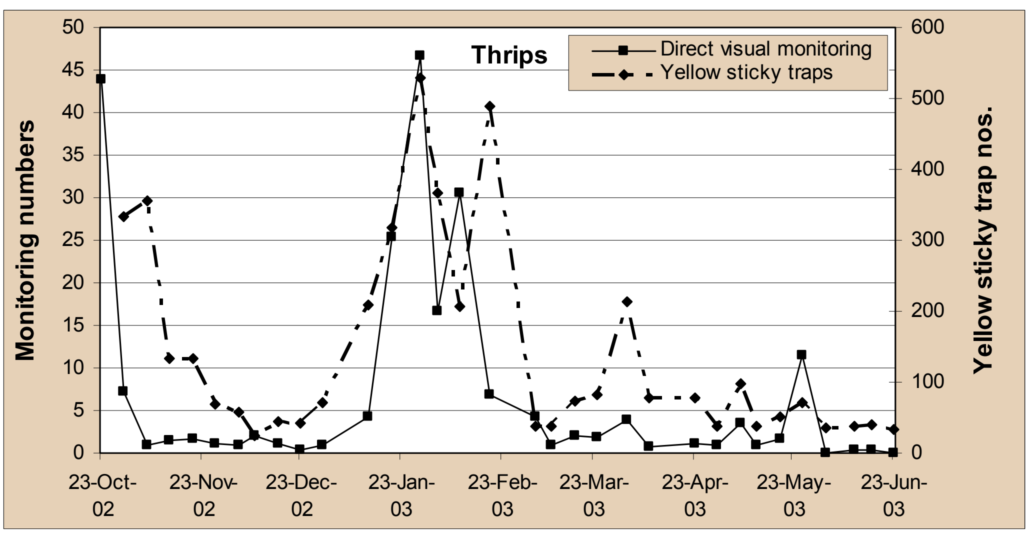

Figure 7. Thrips numbers during the 2002/2003 growing season at the Gatton Research Station comparing the yellow sticky traps and direct visual monitoring in the field.

Acari-mites

Only one type of mite was found attacking the foliage of green beans during this survey. That was the two-spotted mite, *Tetranychus urticae*, which was found in very low numbers and usually on the older leaves and predominantly during the summer months.

Others

The only other insect that was found to attack green beans was the migratory locust, *Locusta migratoria*. It was an occasional pest and generally only caused minor damage to the foliage.

<u>Beneficial Insects</u>
General predators

There was a large number of generalist predators found within the green bean crops grown at the Gatton Research Station (Table 2). There was only one pest specific predator found, a hoverfly. Only a small number of hoverfly larvae were found feeding on aphids, while the adult flies were caught on a number of occasions on the yellow sticky traps.

With an increase in aphid numbers during April, there was a corresponding increase in the number of predators, both beetles as well as bugs, found on the yellow sticky traps (Figure 8).

There doesn't appear to be any direct correlation between the yellow sticky trap numbers (Figure 8) and the predators found while monitoring the plants in the field (Figure 9). Total predator numbers ranged from a high of 27 per yellow sticky trap to a low of 1.5 per yellow sticky trap. Predatory beetles were the most numerous during spring and early summer when the predatory bugs became the more numerous. Ladybird beetles were the most common of the predatory beetles with four types being found in green bean crops. Of the potential predatory bugs in green beans, the pirate bug and apple dimpling bug were the most prevalent with others including the damsel bug, smudge bug and broken backed bug also being found within the crop.

Table 2. Beneficial predatory insects found within green beans and what insects and insect life stage they will attack.

Beneficial insect group	Common name	Family	Hosts
General predators			
Campylomma liebknechti	Apple dimpling bug	Miridae	Mites, heliothis eggs and very small larvae
Coccinella transversalis	Transverse ladybird	Coccinellidae	Aphids, mites, moth eggs and very small larvae
Deraeocoris signatus	Brown smudge bug	Miridae	Heliothis eggs and aphids, mites
Dicranolaius bellulus	Red and blue beetle	Melyridae	Heliothis eggs and very small larvae
Diomus notescens	Minute two-spotted ladybird	Coccinellidae	Aphids, mites, moth eggs and very small larvae
Geocoris lubra	Big eyed bug	Lygaeidae	Soft-bodied insects, heliothis eggs, larvae
Hippodamia variegata	White collared ladybird	Coccinellidae	Aphids, mites, moth eggs and very small larvae
Mallada species	Green lacewing	Chrysopidae	Soft-bodied insects and eggs
Micromus tasmaniae	Brown lacewing	Hemerobiidae	Soft-bodied insects and eggs
Nabis kinbergii	Damsel bug	Nabidae	Soft-bodied insects, eggs and moth larvae
Orius species	Pirate bug	Anthocoridae	Thrips, aphids and moth eggs
Taylorilygus pallidulus	Broken backed bug	Miridae	Heliothis eggs and very small larvae
Various species	Hover flies	Syrphidae	Aphids
	Predatory ground beetle	Carabidae	Possibly small larvae and slow moving insects

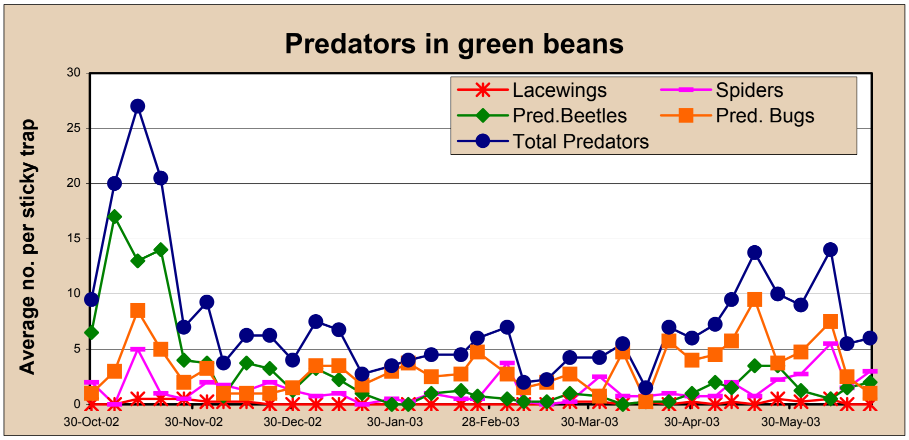

Figure 8. Range of predators found on yellow sticky traps in the unsprayed plantings at the Gatton Research Station during the 2002/2003 growing season.

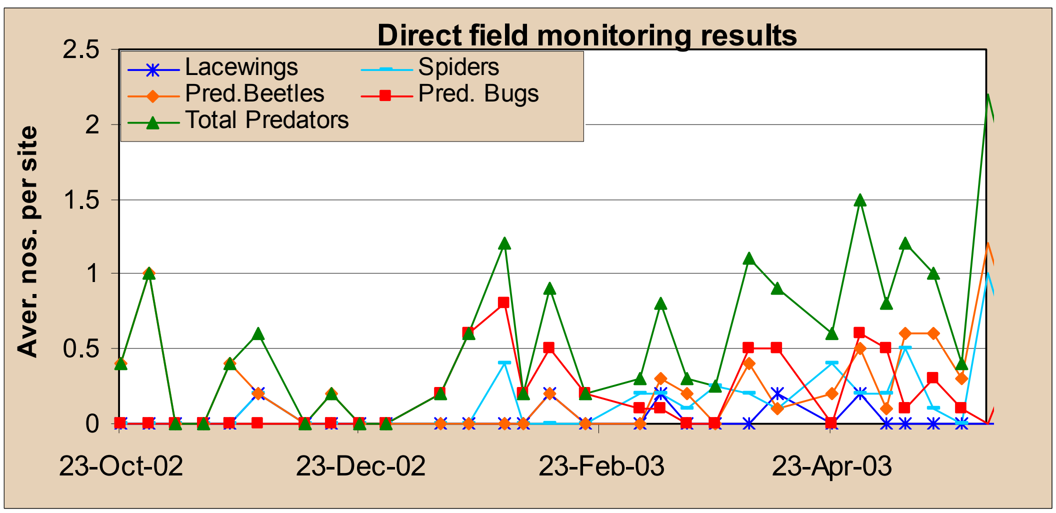

Figure 9. Range of predators found during direct visual monitoring in the unsprayed plantings at the Gatton research Station during the 2002/2003 growing season.

Parasitoids

The range of parasitoids from this project were collected using either a sweep net or by rearing insect pests collected from the crop. The yellow sticky traps also added to the list of parasitoids that were not collected or reared throughout the growing season such as the Tachinid flies and the numerous larval parasitoids, *Heteropelma*, *Lissopimpla*, and *Netelia*, which were all trapped on the yellow sticky traps periodically throughout the growing season.

The heliothis egg numbers at the Gatton Research Station were low throughout the season and it was only by using the yellow sticky cards that Trichogramma was observed. Numbers were as high as 1400 wasps on one side of these cards by late November and were consistently high throughout the summer months, falling to on average of around one hundred, and gradually falling to near zero towards the end of the season as seen in Figure 10.

There was a range of larval parasitoids known to attack heliothis larvae as well as other larvae plus a number reared from the green vegetable bug, either from the egg rafts, *Coruna* sp. and *Trissolcus basalis*, or from the adults, *Trichopoda pennipes*. One larval parasitoid of specific interest was the *Litomastix* species reared from a looper larva. One looper larva had in excess of 500 parasitoids emerge from it.

Table 3. Beneficial predatory insects found within green beans and what insects and insect life stage they will attack.

Beneficial insect group	Common name	Family	Hosts
Parasitoids			
Coruna species	Egg parasitoid	Pteromalidae	Green vegetable bug eggs
Various genera	Aphid parasitoids	Braconidae	Aphids
Eretmocerus species		Aphelinidae	Whitefly
Goniozus species		Bethylidae	Small moth larvae
Heteropelma scaposum	Two-toned caterpillar parasite	Ichneumonidae	Heliothis larvae/pupae
Lissopimpla excelsa	Orchid dupe	Ichneumonidae	Moth larvae
Litomastix species		Encyrtidae	Looper larvae
Mesochorus species		Ichneumonidae	Moth larvae
Microplitus demolitor		Braconidae	Moth larvae
Netelia producta	Orange caterpillar parasite	Ichneumonidae	Moth larvae
Telenomus species	Telenomus	Scelionidae	Heliothis eggs
Trichogramma species	Trichogramma	Trichogrammatidae	Moth eggs
Trichopoda pennipes	Trichopoda	Tachinidae	Green vegetable bug
Trissolcus basalis	Green vegetable bug egg parasitoid	Scelionidae	Green vegetable bug eggs
Various species	Tachinid flies	Tachinidae	Moth larvae/pupae

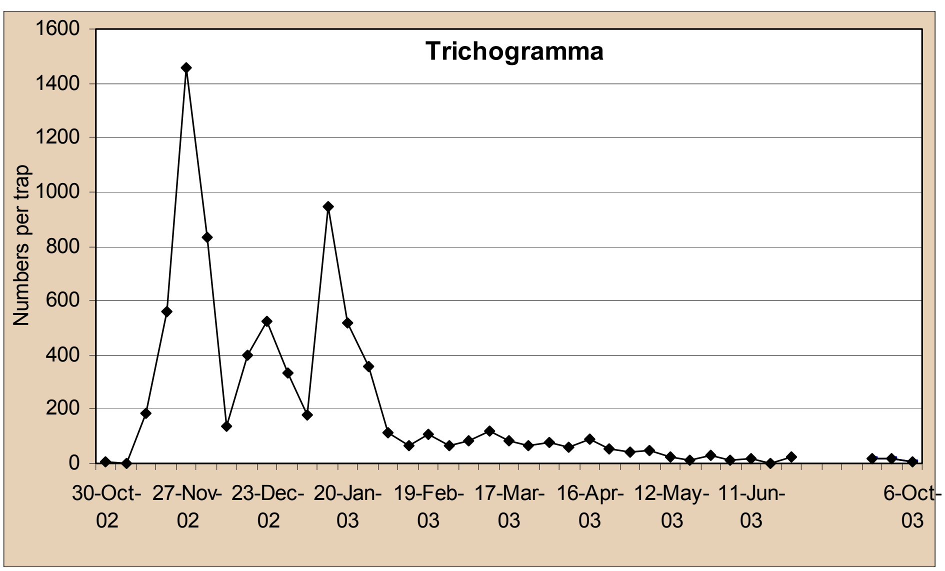

Figure 10. Trichogramma found on yellow sticky traps at the Gatton Research Station during the 2002/2003 growing season.

This is similar to previous seasons where the population numbers is low during the beginning of spring and gradually building up late spring and summer and then falling off again in autumn and winter.

Discussion

The survey work of green bean was designed to help create a picture as to when the insect pests were most abundant and when growers/consultants would need to be more vigilant in checking for these insect pests. The yellow sticky traps proved to be an invaluable tool for detecting insects that are difficult to observe in the field, such as the egg parasitoid *Trichogramma* (Figure 10). The yellow sticky traps were also useful in catching those highly mobile insects such as white fly (Figure 3), thrips (Figure 7), and leafhoppers (Figure 1) showing distinct peaks and troughs throughout the growing season. Not all insects pests observed in the field caused significant damage to the plants. Such pests would generally be considered as minor pests, as the damage they inflict on the plants would not affect the yield of a green bean crop. The insect pests identified within this survey work have been grouped under the headings Coleoptera, Hemiptera, Diptera, Lepidoptera, Thysanoptera, Acari -mites and others such as grasshoppers and as such will be discussed further under these headings.

Coleoptera

This survey work has shown that beetles are not major pests of green beans. Although swarms of the red-shouldered leaf beetle, *Monolepta australis*, can decimate the foliage of green beans as well as other crops, this is extremely rare. The few that were found were most likely causing minor damage to the foliage and as such would not warrant any remedial action against them. This is likely the case with the other leaf feeders found in this survey work (the two flea beetles and the *Apion* weevil). According to the Department of Primary Industries and Fisheries insect collection at Indooroopilly, there are two other beetles that have been known to attack bean crops but were not observed in these surveys. They were a root feeding beetle or scarab, *Neodon peccaries,* and another leaf feeder *Rhyparida discopunctulata* or black swarming leaf beetle. It would appear that beetles are only of minor importance to bean crops in respect to the damage that they can cause and will most likely remain so. The type of insecticides used by growers could be contributing to the minor importance of this group of insects. The increased use of more environmentally friendly insecticides or pest specific insecticides could see this change. Integrated insect pest management approaches in other crops have seen what were once minor pests become more important and difficult to control using the newer type insecticides. Care needs to be taken when developing integrated insect pest management tools for green beans, making sure that these once minor insect pests do not become major insect pests.

Hemiptera

A number of insects were found in this insect order that do cause damage to green beans including leafhoppers, aphids and whitefly. Of all the plant and leafhoppers found on green bean plants, the lucerne leafhopper (*Austroasca alfalfae*) and the vegetable leafhopper (*A. viridigrisea*) were the most common. They both cause the same damage and are both controlled using the same insecticides, as are the other plant and leafhoppers. The yellow sticky traps were superior indicators of what numbers were present in the field. It is difficult to try and show a correlation between the two types of monitoring tools, yellow sticky traps and field counts as seen in Figure 1. The yellow sticky traps were catching between 2 and 55 times more leafhoppers than was actually counted on the plants. There were some slight increases in field counts that did appear to correlate with the yellow sticky trap peaks but this was not consistent throughout the growing season. The amount of damage caused to the young plants is generally what growers depend upon when determining the need to treat this group of insect pests. The plants can withstand some degree of damage and once they are into the vegetative stage of growth, leafhopper activity is generally not considered as significant a problem for the plant or crop.

Aphids are another insect pest in this order that are also known to attack green beans. This survey work however only found them in low numbers, not causing any significant damage to the young plants, when they are considered more of a problem. There appeared to be some type of relationship between the two methods of monitoring, in-field monitoring and the yellow sticky traps, but only during the autumn months (Figure 2). These peaks in activity seen on the plants did relate to peaks in activity found on the yellow sticky traps. This was particularly evident during the autumn months when the greatest number of aphids seen on the plants corresponded to the highest peak on the yellow sticky traps.

At the time of this survey work, silver leaf whitefly was an emerging pest of green beans and a particularly difficult insect pest to control due to its ability to develop resistance to a wide range of insecticides. Subsequent work to this survey has shown silver leaf whitefly to be a major insect pest from late summer through to autumn with the adults attacking the plants as soon as they emerge from the ground. Large numbers can severely stunt the young plants and cause the new growth to curl and distort to such and extent that the plant is not able to grow and product a crop of beans. As seen in Figure 3 this pest started to increase in numbers from the beginning of January with a close correlation between the in-field plant counts and the yellow sticky trap counts. The peaks in activity between the two methods were a week apart. The plant counts were actually a week ahead of the yellow sticky trap counts, although the yellow sticky traps caught far more than what could be counted on the plants. Due to the highly mobile nature of this pest the yellow sticky traps may be a good indicator of activity in this crop or even within a growing area, it is always difficult to count all the adults on a plant before they take flight for the next plant.

It is hoped that the recent release of the beneficial insect *Eretmocerus hayati*, will have an impact on future whitefly populations in the major green bean growing regions of Queensland. The worry is the range of insecticides that growers tend to use to control other insect pests within green beans and other crops that are also attacked by silver leaf whitefly. These insecticides inadvertently kill the parasitoids allowing the silver leaf whitefly to increase in numbers affecting the green bean crops as well as other susceptible crops. The damage that is caused by this pest late in the crop is thought to be stunting of the pods and a reduced pod colour.

Diptera
Only one fly is known to cause any damage to green beans and that is the Bean fly (*Ophiomyia phaseoli*). This pest is predominantly a late season pest in the south east part of Queensland while it is a pest at the start of the season further north when the growing season starts in autumn. If left unchecked it can cause severe seedling loss with a recent trial exhibiting almost 80% infestation and seedling collapse. Bean fly is readily controlled at the seedling stage and is generally not a problem after that. However the type of insecticide used to control bean fly and other early sap sucking pests does have a detrimental affect on the establishment of beneficial insect populations. A recent trial has shown that a soil applied neo-nicotinoid at planting will not only help in the fight against silver leaf whitefly but will also protect the seedlings against bean fly. The used of such an insecticide would allow beneficial insects to build up in bean crops as there would be little reason to apply a foliar insecticide early in the crop's life.

Lepidoptera
There were five lepidopteran pests found during this project, the most serious of which would be heliothis, both *Helicoverpa armigera* and *H. punctigera* and Bean pod borer, *Maruca vitrata*. These pests attack the flowers and developing pods as well as burrow into the pods to feed on the developing seeds. Once in the pods, it is impossible to control them with

conventional insecticides, and once the pod is damaged, the pickers or sorters reject the pods. Heliothis is considered a problem during most of the growing season in the Lockyer Valley region but was only an issue for growers in the Gympie region during the autumn and spring months. Pheromone trap catch data varies from year to year and location to location and can only be used as a guide and indicator to what might be happening within the adjoining crop. When pheromone trap counts are high, extra care should be taken when looking for eggs within the crop.

The other lepidopteran pests such as loopers and the Grass blue butterfly damage the foliage of the crop. There is really no need to try and control them as they don't appear to affect the yield or damage the pods. The exception is the Grass blue butterfly which can leave small pin head sized holes on the pods. The majority of insecticidal treatments for heliothis or bean pod borer will also control the other lepidopteran pests.

Thysanoptera
Of the ten thrips found on this crop only *Desmothrips tenuicornis* is thought to have some predatory activity (Mound and Gillespie 1997) and may have been feeding on other thrips larvae found in the flowers. The two thrips that are of most concern are the Western flower thrips (*Frankliniella occidentalis*) and Melon thrips (*Thrips palmi*) as these two thrips are both very difficult to control with registered insecticides. Thrips control is particularly important during the flowering as any activity in the flowers and on the developing pods can seriously affect the quality of the pods causing them to scar and twist to varying degrees. Thrips activity on the leaves does not seem to have an affect on the plant or plant yield and are generally confined to the seedling stage of the plant.

Acari - Mites
The lack of mites from this survey could be as a result of the reduced usage of some broad spectrum insecticides such as synthetic pyrethroid insecticides, which tend to kill off natural enemies of mites allowing them to rapidly increase in number. A lack of numbers could also be a direct result of the large diversity of predators, some of which are known to attack mites as indicated in Table 2.

Others
The only other insect found in green beans was the migratory locust and only in low numbers causing damage to the leaves. It may have only been present due to the drought and a lack of other suitable green plant material at the time it was observed.

General predators
Such diversity of beneficial insects could have had an impact on the number of heliothis eggs and larvae, mite and aphid numbers as well as the range of other insect pests, which growers might encounter within a green bean crop. The lack of any large numbers of aphids within the unsprayed plantings at the Gatton Research Station could be a direct affect of the large number of predators known to attack aphids, in particular the predatory beetles, ladybird beetles and the red and blue beetle. The increase in predator numbers during October and November could have been a result in an expected increase in heliothis egg numbers as a result of an observed increase in pheromone trap catches during September and October as shown on Figure 5. However field observations for heliothis eggs resulted in very low to none during this time, which could be attributed to the increased number of predators devouring them before they could be counted.

There doesn't appear to be any direct correlation between the yellow sticky trap numbers (Figure 8) and those found while monitoring the plants in the field (Figure 9). This could be due to the mobility of the predators making it difficult to count what is actually on the plants, as was observed with a number of highly mobile insect pests. The only common factor between the use of the yellow sticky traps and the in field monitoring was the general increase in predator activity during late summer and autumn.

Parasitoids

The *Trichogramma* egg parasitoid is extremely small and is generally found by collecting heliothis eggs to observe rates of parasitism. There are a number of other parasitoids known to specifically attack aphids, some of which are very aphid specific. At this stage it is unclear as to which parasitoids have been reared from aphids in green beans. A full list of specimens collected from this survey work still needs to be properly identified and cross referenced using the Department of Primary Industries insect collection. It was disappointing not to find any larval parasitoids of the bean pod borer. Arodokoun *et al.* (2006) found 8 such parasitoids naturally attacking this pest in Africa and it was hoped that there would have been some present in this study.

Conclusion

There is potential for biological control of certain green bean pests such as heliothis, loopers, aphids and mites to be effective in an IPM system due to the wide range of beneficial insects found within this crop. The large diversity of predators and parasitoids that are part of the crop environment could play a significant role in pest management through biological control that enhances grower production practices. Beneficial insects may not eliminate the need for insecticides, but could reduce the reliance upon them in an IPM system. The next step is to modify grower practices to accommodate beneficial insects and to educate growers on the impact these beneficial insects have in reducing pest damage and what impact the currently available insecticides have upon the beneficial insect numbers. A best bet management system needs to be developed in consultation with growers so that under an IPM system present productivity is maintained. That is the end product, the bean pod quality, is just as acceptable as growing the crop using current insect pest management practices that generally don't take into consideration the role that beneficial insects play in managing insect pest populations.

Technology Transfer

The technical information from this research has been transferred to industry stakeholders through:

- Reports
- Web based database
- Newsletters
- Email reports
- Electronic Notes on the DPI&F website http://www2.dpi.qld.gov.au/thematiclists/1182.html
- Farmnotes
- Workshops

Recommendations

There is potential for biological control of certain green bean pests such as heliothis, loopers, aphids and mites due to the wide range of beneficial insects found within this crop. The large diversity of predators and parasitoids that are part of the crop environment could play a significant part in pest management. Beneficial insects will not eliminate the need for insecticides but will help reduce the reliance upon them. Growers need to modify their pest management practices to accommodate these beneficial insects by minimising the toxic effect that currently available insecticides have upon them. The soft option insecticides and fungicides should be used to allow for the build up of the beneficial insect populations. A table that documents the most effective insecticide for pest control, and lists those with limited impact on beneficial insects is under development for industry use. This will assist growers in their chemical choices to minimise beneficial losses and will be a part of the 12 months extension to this project. As well this a UTE Guide will be published which will include the wide range of insect pests and beneficials found in Green beans. It is hoped that the range of bean diseases can also be incorporated into this publication. These documents will assist growers and consultants to identify what they are finding within their crop and make better management decisions that select pesticides which are ‘soft’ on the beneficial insect population.

Acknowledgments

Many thanks to Carolyn Lee (Research Assistant) for her help with the monitoring for these pests and beneficial insects. I would like to thank the farm staff at the Gatton Research Station for helping with the planting and maintenance of the unsprayed plots. I would also like to thank Mulgowie Farming Company, Hoods Farming, Jim Lucas and Martin Wilson, for allowing access to their crops for observing pest and beneficial insect numbers during the growing season. I would also like to thank Marlene Elson-Harris for her assistance with the identification of parasitoids collected during this survey work.

Insecticide efficacy trials

Introduction

Green beans are attacked by numerous insect pests at various stages of the plants' growth, from the newly emerging seedling to the flowering and pod set stage of growth. Jassids and most recently whitefly, are causing problems at the younger growth stages along with bean fly in a number of production districts, while the lepidopteran pests and flower thrips are the main cause of pod damage. Although whitefly are also starting to become a problem to the pods, affecting their quality by what appears to be a reduced colouration or bleaching of the pods. This has been seen in both the green types and the yellow butter bean varieties.

A number of field trials were conducted (Table 4 below) to test the effectiveness of a number of new and currently registered insecticides on the control of jassids, whitefly and thrips early in the crop growth and then the lepidopteran pests, flower thrips and whitefly later in the crop growth from flowering through to harvest. It is proposed that the efficacy data generated by these trials will assist the registration of some of these new and alternative insecticides in an IPM system for green beans.

Table 4. Trials set up over an 18 month period on grower properties and the Gatton Research Station to look at a range of insect pests in green beans.

Trial number	Trial start date	Trial location	Stage of crop assessed	Pests targeted
Efficacy trial 1	22 October 2003	Laidley - grower property	Flowers and pods	Heliothis/pod borer
Efficacy trial 2	7 January 2004	Gatton Research Station	Seedlings	Jassids, whitefly, thrips and aphids
Efficacy trial 3	6 April 2004	Laidley - grower property	Flowers and pods	Heliothis/pod borer
Efficacy trial 4	22 October 2004	Gatton Research Station	Flowers and pods	Heliothis/pod borer/flower thrips
Efficacy trial 5	19 November 2004	Gatton Research Station	Flowers and pods	Heliothis/pod borer/flower thrips
Efficacy trial 6	5 April 2005	Gatton Research Station	Seedlings	Silverleaf whitefly/bean fly

Materials and Methods

<u>Efficacy trial 1 for caterpillar pests</u>

Trial site.

A green bean crop was selected that was close to flowering on a grower property close to Laidley. The crop was grown using conventional grower practices which consisted of pre-emergent herbicide, fertiliser applications, fungicides when needed and regular watering during the life of the crop. The trial area was marked out just prior to flowering and left unsprayed by the grower, with the exception of any fungicides and foliar fertilisers needed by the crop.

Treatments.
Gemstar® at 500ml/ha
Avatar® – 170g/ha + Agral®
Avatar® - 250g/ha + Agral®
DC-041 – 100ml/ha + Agral®
Symphony® (S1812) – 200ml/ha + Agral®
Unsprayed

Plot sizes were six rows wide plus a buffer row either side by 10m long, with four replications per treatment. The treatments were applied using a SOLO powered back pack sprayer with a 1.2m wide hand held boom with four equally spaced twin-jet nozzles. Treatments were applied at the equivalent rate of 500L/ha of water.

Trial set up, spray dates and harvest date were as follows:
Set up trial 22nd October 2003
All treatments sprayed on the 30th October 2003
Gemstar® only applied on the 3 November 2003
All treatments sprayed on the 6th November 2003
Harvest 13th November 2003.
Gemstar® was applied three times as this product quickly breaks down with UV and so has a short residual on the crop and it was hoped that three applications would be effective in managing Heliothis in the crop. Harvest was earlier than expected due the uneven nature of the developing crop with the processor wanting to try and limit the quantity of over mature pods.

Monitoring.
Monitoring started at the budding/early flowering stage of the crop. The middle four rows were used for assessments with two plants from five sites per plot assessed weekly looking at the flowers and developing pods, predominantly for heliothis eggs and larvae. At harvest, two plants from five sites were collected and taken back to the lab and checked for the presence of heliothis in pods or damage caused by heliothis. This was then used to give a percentage of the crop rejected due to heliothis. Other insect damage such as thrips and pod sucking bugs were also assessed at this time.

<u>Efficacy trial 2 for early sap sucking pests</u>
Trial site.
Green beans were planted at the Gatton Research Station on the 7th January 2004. The crop was grown using conventional grower practices by the research station farm staff. Plots sizes were six rows wide plus a buffer row either side by 10m long with four replications of each treatment.

Treatments.
DC-068 – 200ml/ha + Hasten®
Confidor® foliar application – 300ml/ha + Agral®
TI-435 foliar application – 300ml/ha + Agral®
Intruder® - acetamiprid – 200ml/ha + Pulse®
Intruder® - acetamiprid – 400g/ha + Pulse®
Chess® – 200g/ha + Agral®
Dimethoate as grower standard – 800ml/ha + Agral®
Unsprayed control

Treatments were applied using a SOLO powered back pack sprayer with a 1.2m wide hand held boom with four equally spaced twin-jet nozzles. Treatments were applied at the equivalent rate of 432L/ha of water.

Trial set up and spray dates were as follows:
Set up trial 7th January 2004
All treatments applied on the 20th January 2004
All treatments applied on the 27th January 2004

Monitoring.
Plants were monitored weekly until leafhopper symptoms appeared on the cotyledons or new leaves. Once the treatments were applied to the crop the plants were then monitored 1, 3 and 6 days after the 1st and 2nd applications. Two plants at five locations in each plot where checked for the vegetable leafhoppers, whitefly, thrips or aphids by carefully turning the leaves over and visually counting the pests present.

<u>Efficacy trial 3 for caterpillar pests</u>
Trial site.
A green bean crop was found near Laidley that was at the flower bud stage for this trial to look at the control of lepidopteran pests in the flowers and developing pods. The crop was grown using conventional grower practices by the grower. Plots sizes were six rows wide plus a buffer row either side by 10m long with four replications of each treatment.

Treatments.
Gemstar® 500ml/ha + Amino Feed® 1L/ha
Avatar® – 250g/ha + Agral®
DC-041 – 100ml/ha + Agral®
Symphony® (S1812) – 200ml/ha + Agral®
Proclaim® – 250g/ha + Agral®
Unsprayed control

Treatments were applied using a SOLO powered back pack sprayer with a 1.2m wide hand held boom with either two equally spaced twin-jet nozzles on the first application or four equally spaced twin-jet nozzles on the second application. Treatments were applied at the equivalent rate of 230L/ha of water on the first application and then at 437L/ha of water on the second application.

Trial set up, spray dates and harvest date were as follows:
Set up trial 6th April 2004
All treatments sprayed on the 8th April 2004
All treatments sprayed on the 14th April 2004
Harvest 23rd April 2004

Monitoring.
Plants were assessed prior to the initial spraying of the trial by checking two plants at 40 locations throughout the whole trial area. The only subsequent assessment was at harvest on the 23rd April 2004 where two plants from five locations in each plot were cut off at ground level and placed into plastic backs and taken back to the lab for assessment. All the pods were then pulled from the plants and assessed as to the type of damage present and the number of marketable pods.

Efficacy trial 4 for caterpillar pest and flower thrips

Trial site.

Green beans were planted at the Gatton Research Station on the 25th August 2004. The crop was grown using conventional grower practices by the research station farm staff. Plots sizes were six rows wide plus a buffer row either side by 10m long .

Treatments.

DC-068 – 200ml/ha + Hasten®
Confidor® as a seed treatment – 25ml per 100m row equivalent
TI-435 as a seed treatment – 25g per 100m row equivalent
Dimethoate/Lannate® as a grower standard – 800ml/ha + 2L/ha +Agral®
Gemstar® 500ml/ha + Amino Feed® 1L/ha
Avatar® – 250g/ha + Agral®
DC-041 – 100ml/ha + Hasten®
Symphony® (S1812) – 200ml/ha + Agral®
Proclaim® – 250g/ha + Agral®
Unsprayed control

Treatments were replicated four times. However only two replicates were harvested due to poor growth in the other two replicates. Foliar treatments were applied using a SOLO powered back pack sprayer with a 1.2m wide hand held boom four equally spaced twin-jet nozzles. Treatments were applied at the equivalent rate of 497L/ha of water.

Trial set up, spray dates and harvest date were as follows:
Set up trial 22nd October 2004
The Confidor® and TI-435 were applied at planting as seed dressing
All treatments sprayed on the 30th October 2004
All treatments sprayed on the 5th November 2004
Harvest 10th November 2004

Monitoring.

Monitoring started at the budding/early flowering stage of the crop. The middle four rows were used for assessments with two plants from five sites per plot assessed weekly looking at the flowers and developing pods, predominantly for heliothis eggs and larvae. Flowers were also collected, ten from each plot and taken back to the lab for dissection and counting of the thrips in the flowers. At harvest, ten plants were collected at random from the middle two rows and taken back to the lab. Replicates 1 and 2 were only assessed due to the poor stand and growth of the other two replicates. All the pods were then pulled from the plants and assessed as to the type damage present and the number of marketable pods.

Efficacy trial 5 for caterpillar pests and flower thrips

Trial site.

Green beans were planted at the Gatton Research Station on the 1st October 2004. The crop was grown using conventional grower practices by the research station farm staff. Plots sizes were six rows wide plus a buffer row either side by 10m long with four replications of each treatment.

Treatments.
DC-068 – 200ml/ha + Hasten®
Confidor® as a seed treatment – 25ml per 100m row equivalent
TI-435 as a seed treatment – 25g per 100m row equivalent
Dimethoate/Lannate® as a grower standard – 800ml/ha + 2L/ha +Agral®
Gemstar® 500ml/ha + Amino Feed® 1L/ha
Avatar® – 250g/ha + Agral®
DC-041 – 100ml/ha + Hasten®
Symphony® (S1812) – 200ml/ha + Agral®
Proclaim® – 250g/ha + Agral®
Unsprayed control

Treatments were applied using a SOLO powered back pack sprayer with a 1.2m wide hand held boom with four equally spaced twin-jet nozzles. Treatments were applied at the equivalent rate of 530L/ha of water.

Trial set up, spray dates and harvest date were as follows:
Set up trial 19th November 2004
The Confidor® and TI-435 were applied at planting as seed dressing
All treatments sprayed on the 26th November 2004
All treatments sprayed on the 3rd December 2004
Harvest 13th December 2004

Monitoring.
Monitoring started at the budding/early flowering stage of the crop. The middle four rows were used for assessments with two plants from five sites per plot assessed weekly looking at the flowers and developing pods, predominantly for heliothis eggs and larvae. Flowers were also collected, ten from each plot and taken back to the lab for dissection and counting of the thrips in the flowers. At harvest, ten plants were collected at random from the middle two rows and taken back to the lab. All the pods were then pulled from the plants and assessed as to the type damage present and the number of marketable pods.

Efficacy trial 6 for Silverleaf Whitefly
Trial site.
Green beans were planted at the Gatton Research Station on the 5th April 2005. The treatments were applied at planting in the seed furrow. The crop was grown using standard grower practices for a period of four weeks. This was deemed to be sufficient time to determine if the individual treatments were going to be effective at managing SLWF. It was hoped that once the plants reach flowering they would be able to withstand some SLWF activity, although pod colour could be affected, as observed by growers in previous seasons. Plots sizes were six rows wide by 10m long with four replications of each treatment.

Treatments.
Confidor® 200SC (imidacloprid) - 25ml/100m of row
TI-435 (clothianidin) - 25g/100m of row (10g/100m of row)
Actara® (thiamethoxam) - 10g/100m of row
Control

The treatments were applied at planting in the furrow created by the planter and covered over as part of the planting operation. TI-435 was supposed to be applied at the equivalent rate of active constituent as imidacloprid but was accidentally applied at two and a half time the suggested rate.

Monitoring.
Plants were monitored weekly, with the first assessment occurring once the plants were fully emerged (Table 5). This took about 10 days. Cotyledons were initially monitored for adult activity, as this is the most critical stage of the pest this early in the crop's life. Adult numbers were assessed by carefully turning the cotyledons over and counting them before they flew off. 10 plants from each plot were assessed for the first three weeks of the trial, at which time the numbers were too great to count before they took flight. Cotyledons were also collected, 1 each from 10 plants selected randomly from the middle two rows of each plot. Two leaf discs were marked on each cotyledon using a hole punch with total area of about $1cm^2$. Each disc was checked for both eggs and nymphs on the underneath side of the cotyledon using a dissecting microscope. The first true leaf was also examined for egg and nymph activity by selecting one of the leaflets from each of 10 plants selected at random in each plot and punching two leaf discs from each as with the cotyledons and counting the numbers of eggs and nymphs on the underneath side

The data collected were statistically analysed using the analysis of variance as part of the Genstat 6th Edition program supplied by the Queensland Department of Primary Industries and Fisheries.

Table 5. Assessment dates for SLWF and Bean fly activity.

Beans planted on the 5 April 2005

Assessment dates	SLWF egg counts	SLWF nymph counts	SLWF adult counts	Bean fly infested plants
15 April 05	√	√		
18 April 05			√	
22 April 05	√	√	√	
29 April 05	√	√	√	
5 May 05	√	√		
13 May 05	√	√		
17 May 05				√

Results

Efficacy trial 1 for caterpillar pests
Significant numbers of eggs were found within the crop throughout the trial period from flowering until just prior to harvest, the last assessment being carried out on the 12th November 2003. There was no significant difference in egg numbers between treatments during the spray period. Egg numbers and larval numbers fluctuated during the 3 week period with only a general appearance that there was more eggs or larvae in the unsprayed control treatment, although this was not significant. Heliothis eggs and larvae can be difficult to find in green beans and so the harvest assessment was by far the better indictor of how the various treatments performed.

There was no significant difference between treatments for the control of thrips damage as seen in Figure 11 below. Percentage damage was quite high, between 10 and 14 percent. A reduction in heliothis damage was by far the most noticeable between treatments. There was no significant difference between the unsprayed, Gemstar® and Symphony® treatments.

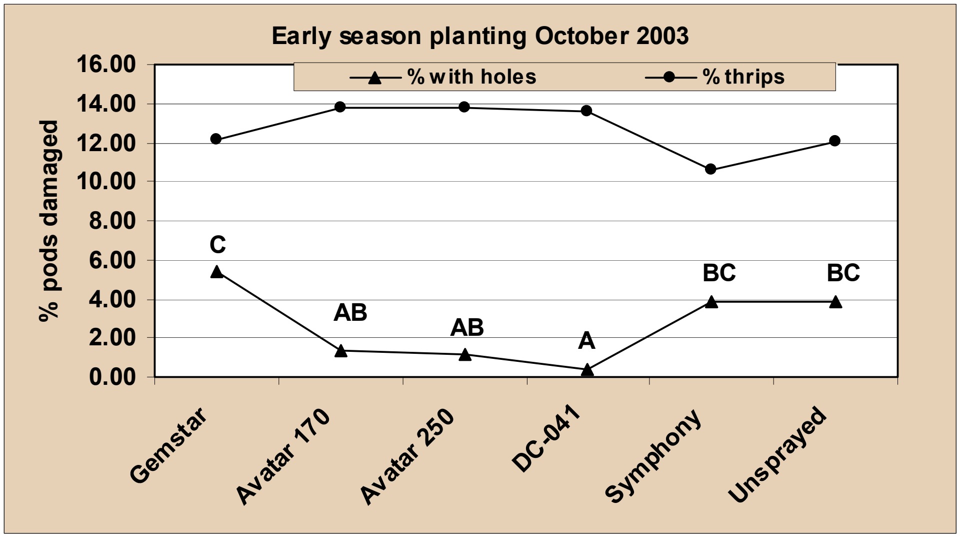

Figure 11. Quality of pods at harvest looking for holes in pods and damage due to thrips. The treatments followed by the same letter are not significantly different at P=0.05.

The two rates of Avatar® and DC-041 were far better at controlling heliothis and the damage that they cause to the pods, although Avatar® was not significantly different from the unsprayed treatment. Gemstar® was the poorest performer with over 5 percent damage being recorded, while DC-041 resulted in less that half a percent of the pods showing damage due to heliothis.

Efficacy trial 2 for early sap sucking pests

Jassid (vegetable leafhopper) numbers throughout the early growth period of the crop were low but still significant enough to cause damage to the cotyledons and young leaves. Dimethoate was the best and most consistent performer of the insecticide treatments as shown in Figures 12 and 13. TI-435 was showing some significant benefits by week 2 as was the high rate of Intruder®. After 2 applications, the TI-435 and the Intruder® appeared to be the better performers of the newer insecticide treatments at reducing the jassid numbers. By the end of the second week only dimethoate and TI-435 exhibited a significant difference from that of the control at keeping jassid numbers low. All other treatments were not significantly different from the control at the end of the second week.

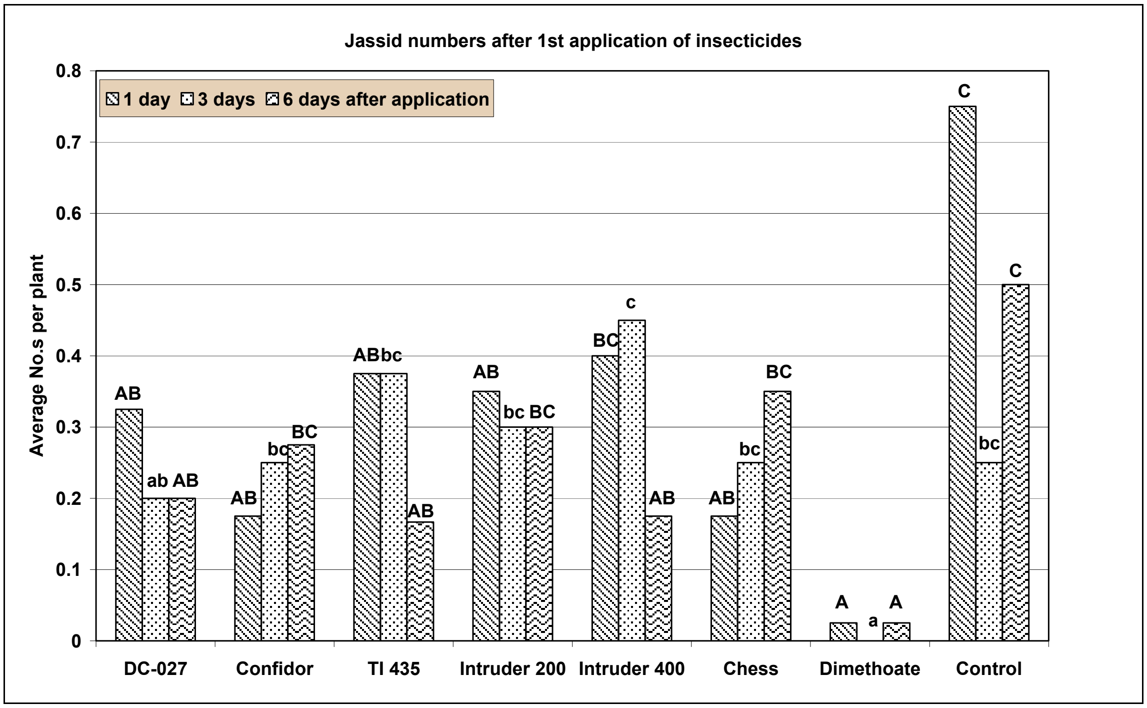

Figure 12. Jassid numbers after 1st application of insecticides. Columns on the same dates that have the same letters are not significantly different from one another.

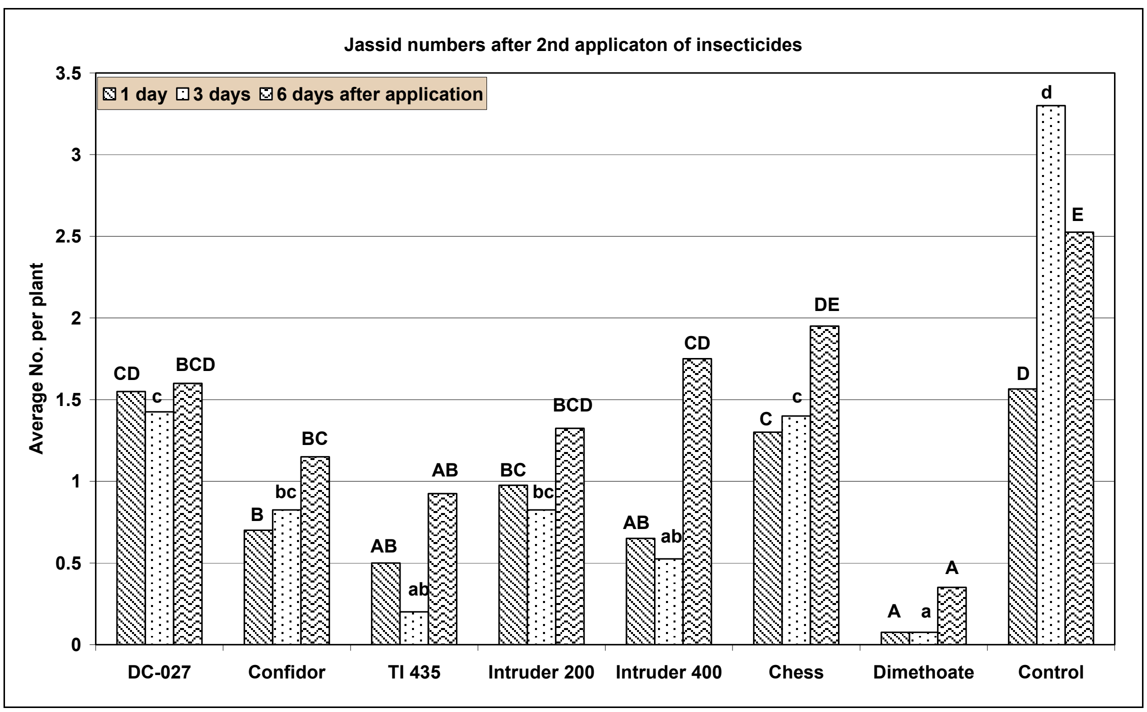

Figure 13. Jassid numbers after 2nd application of insecticides. Columns on the same dates that have the same letters are not significantly different from one another.

Thrips numbers, although low on the young plants, were controlled using the various insecticidal treatments in this trial. One day after the first application there was no significant difference between treatments. There did however appear to be a visual difference as seen in Figure 14 below with the control and Intruder® 400 being the worst performers. Days 3 and

6 started showing significant differences between treatments with Confidor®, TI-435, the two rates of Intruder® and dimethoate showing significantly better results than the DC-027, Chess® and the control treatments. After the second application the two rates of Intruder, Confidor® and dimethoate were the most consistent of the insecticides used as managing thrips on green beans. They were significantly better than the control treatment at least until the third day after application. The drop in thrips number in the control could be a result of the presence of predators in the crop keeping thrips numbers in check while the gradual increase in thrips numbers in the other treatments after the second application could be due to the various insecticides controlling potential predators as well as thrips numbers in the crop.

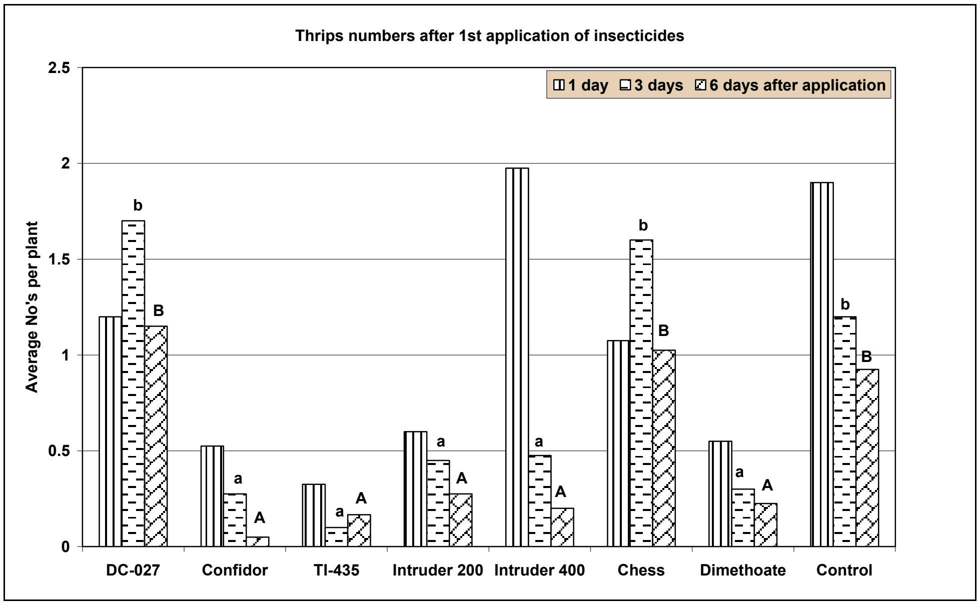

Figure 14. Thrips numbers after the 1st insecticide application. Columns on the same dates that have the same letters are not significantly different from one another.

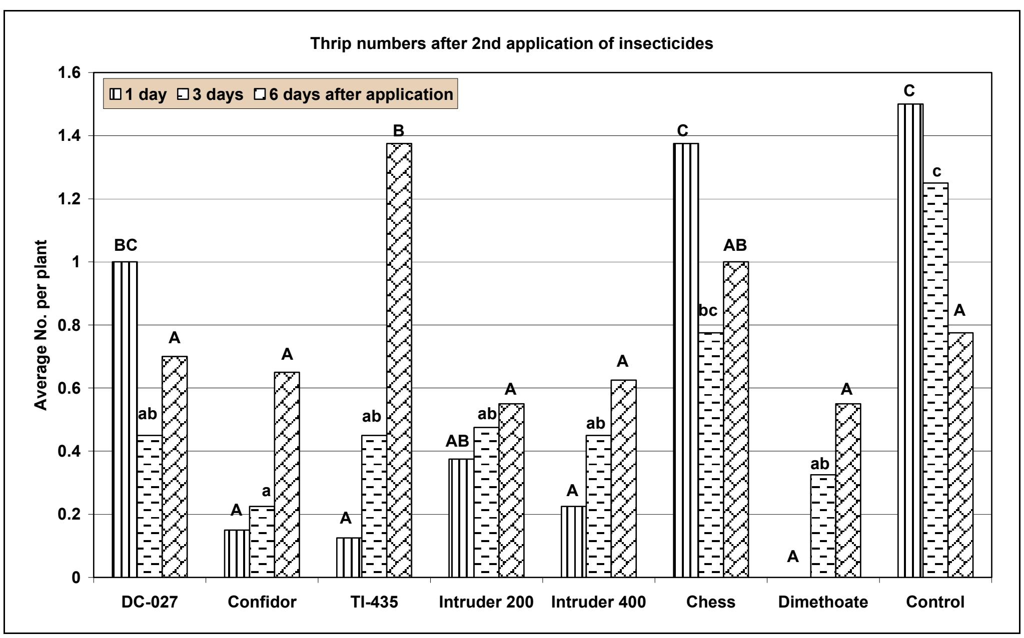

Figure 15. Thrips numbers after the 2nd insecticide appliction. Columns on the same dates that have the same letters are not significantly different from one another.

Chess® was the only product that was significantly better at controlling whitefly than the unsprayed control right up until three days after the second application as seen in Figures 16 and 17. During the first week of observations all other treatments were either not significantly different from the control or significantly worse than the control as was the case with the dimethoate treatment. After the second appliction most products performed in a similar manner, with Chess® still being a better performer than most other products, with the TI-435 and the DC-027 products showing some benefit in whitefly control. Day six saw a general across the board increase in whitefly numbers with no significant difference between treatments apart from the lower rate of Intruder® being significantly better than the control at keeping whitefly numbers down. Aphids were not an issue during this trial.

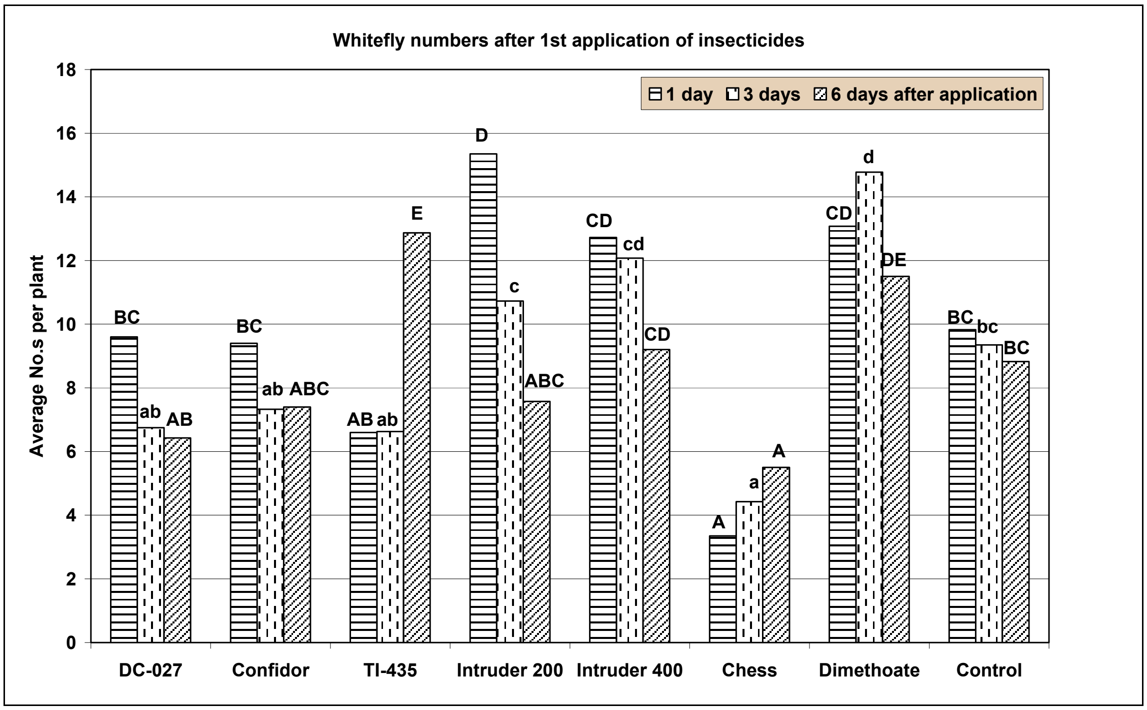

Figure 16. Whitefly numbers after 1st application. Columns on the same dates that have the same letters are not significantly different from one another.

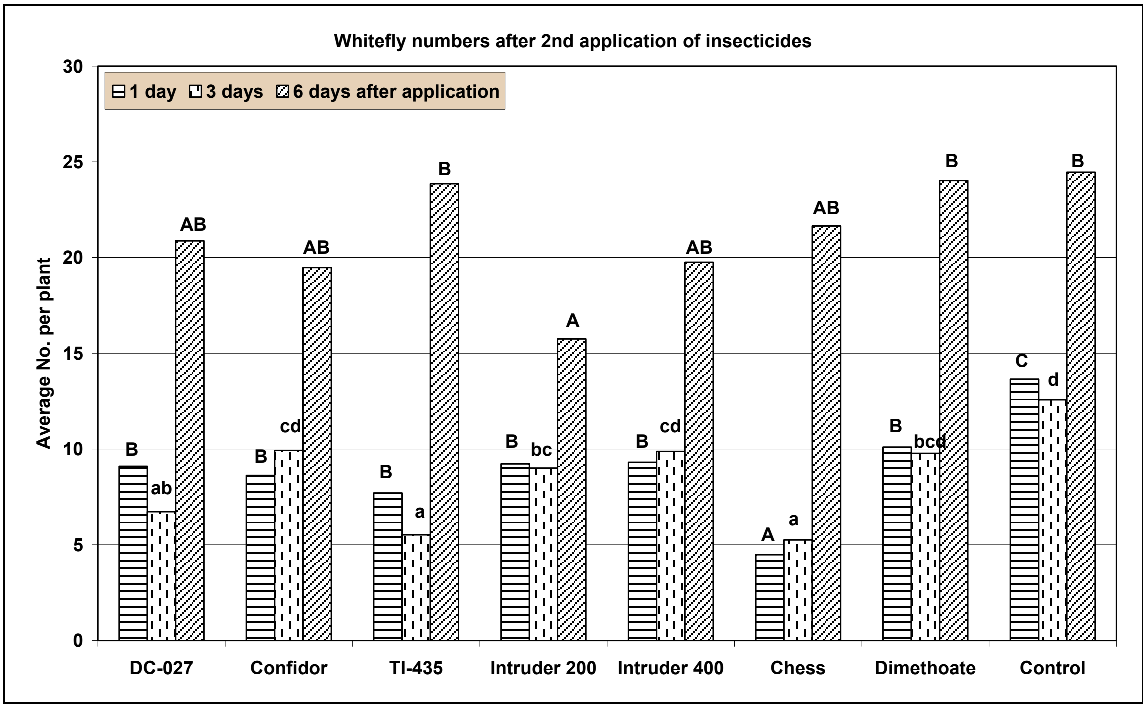

Figure 17. Whitefly numbers after 2nd application. Columns on the same dates that have the same letters are not significantly different from one another.

Efficacy trial 3 for caterpillar pests

Treatment DC-041 performed the best of all the treatments with just over 2% pod damage due to caterpillars as seen in Figure 18 below. This was significantly better than most of the other treatments with the exception of Avatar®. The untreated control was the worst performer, although this was not significantly different from Symphony®, Gemstar® or the Proclaim® treatments.

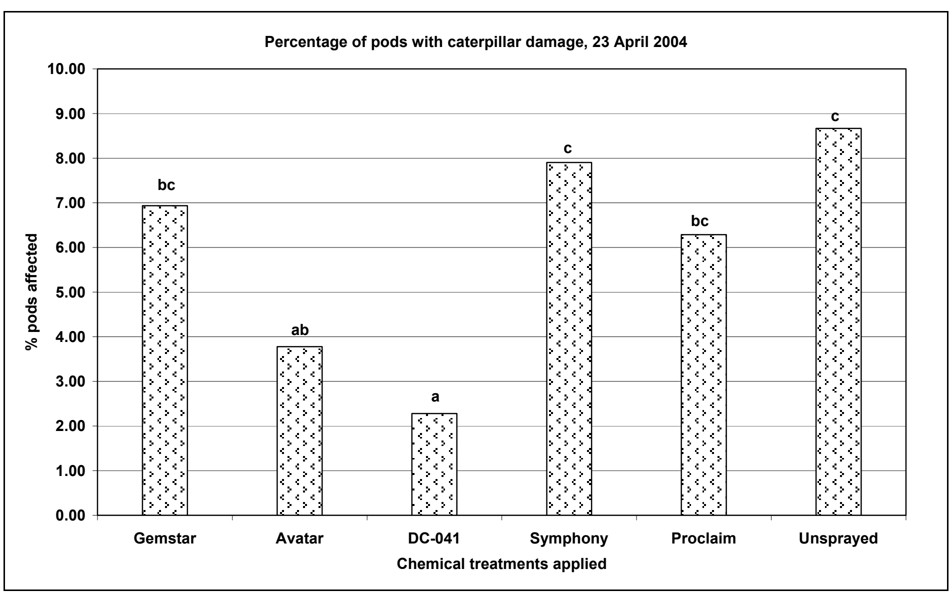

Figure 18. Caterpillar damage to pods after only 2 spray applications prior to harvest. Columns that have the same letters are not significantly different from one another.

Efficacy trial 4 for caterpillar pest and flower thrips

Due to the uneven nature of this planting only 2 replication could be assessed and as such the graph below represents averages from these 2 replications only and could not be statictically analysed with a .reasonable degree of accuracy. All that can be drawn from the graph are trends in performance. Heliothis pressure during this trial was fairly low with egg numbers ranging from less than one up to 3.5 eggs per 10 plants while the larval numbers were only as high as 1 in 40 plants. Magnet® insect attractant was applied to this trial to try and encourage adult moths to migrate into the trial site but it is unclear if this was actually successful. The harvest data as seen in Figure 19 below shows that only 2 products had caterpillar damage greater than 2 percent, DC-027 which is supposedly a sap sucking insectcide and Symphony® which hasn't performed well in other trials. All other treatments sustained less than 1 percent damage or just over 1 percent damage as with the Gemstar® treatment. Given only 2 replications and the low pressure it is however difficult to draw any conclusion on efficacy from this trial.

This trial also looked at the effect of certain chemicals on the control of flower thrips with damage ranging from only 11% in the DC-041 treatment to just over 20% in the control treatment. There is no clear trend as to which treatment is a better performer over the other, the control treatment being about 5% more than most other treatments.

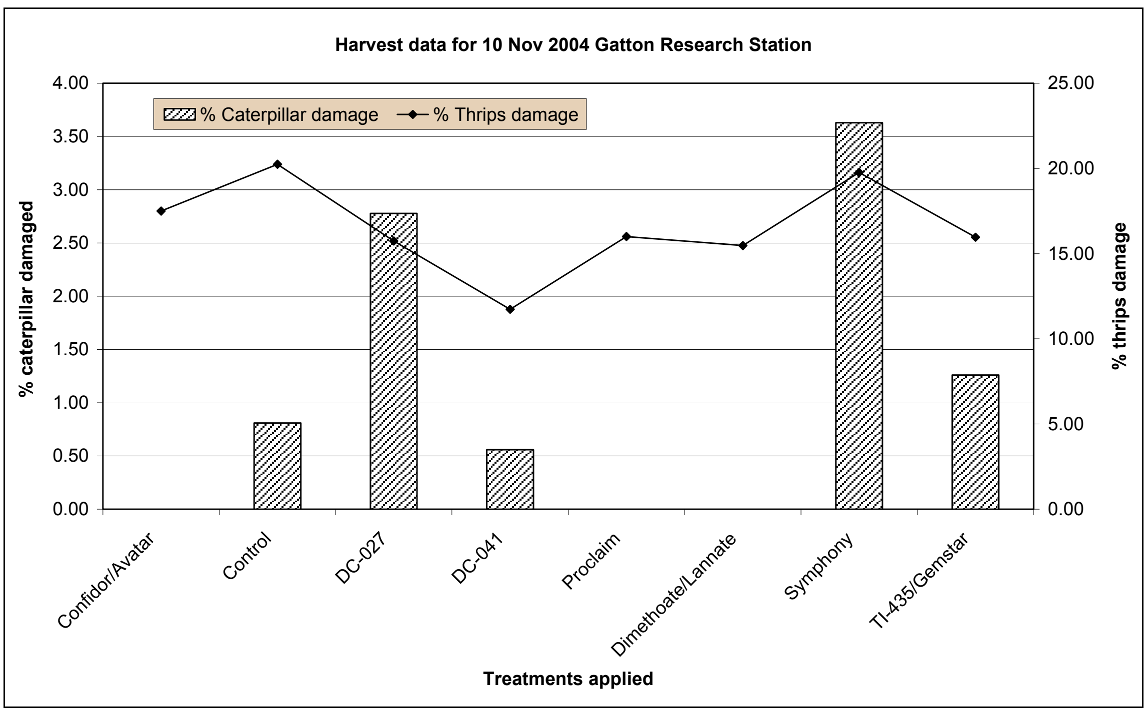

Figure 19. Caterpillar and thrips damage to pods at harvest on the 10 November 2004 at the Gatton Research Station.

Efficacy trial 5 for caterpillar pest and flower thrips

As with trial 4 there was very low heliothis pressure during this trial which made it difficult to assess the effectiveness of the various treatments. There is not significant difference between treatments for the control of caterpillar pest damage to the bean pods. All treatments exhibited less than 2.5% damage. DC-041, Proclaim® and Avatar® treatments have performed consistently well between trials with the other treatments exhibiting up and down trends in their ability to control caterpillar pests during flowering and pod set.

There was however significant differences between treatments when looking at thrips control at flowering as shown in Figure 20 below. The DC-027 and DC-041 as well as the Symphony® treatments were significantly better at controlling thrips than the control treatment. The seed treatments Confidor® and TI-435 were not significantly different to the control, likewise the Proclaim® and the dimethoate/Lannate® combination treatments.

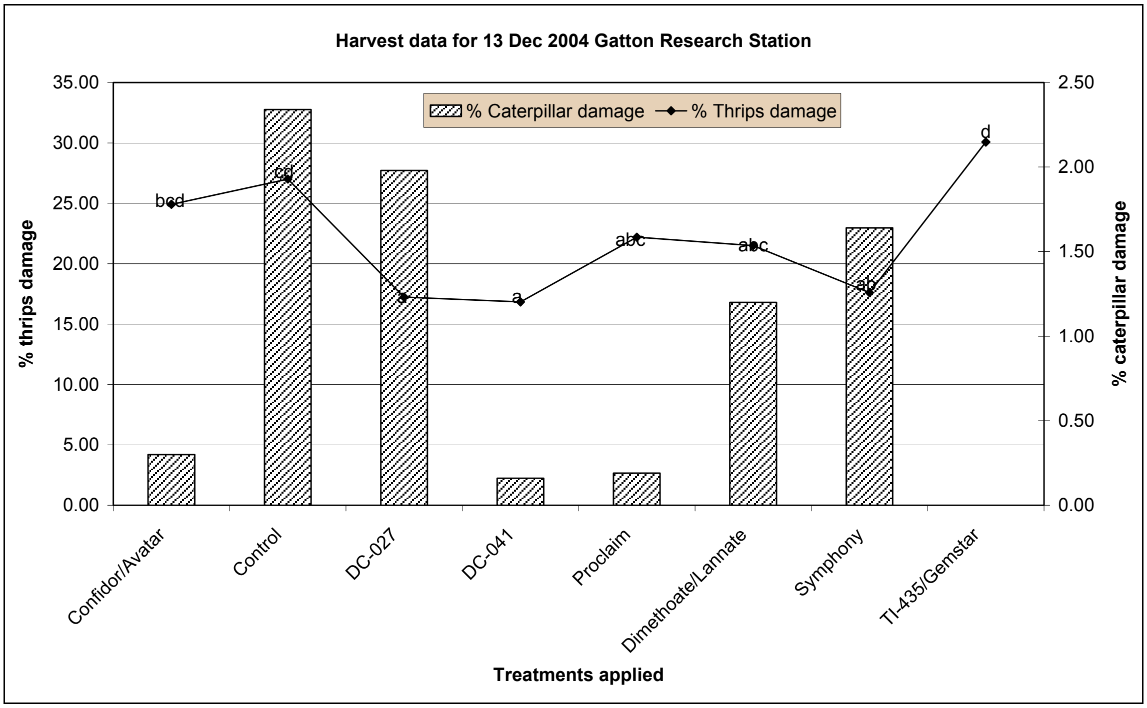

Figure 20. Caterpillar and thrips damage to pods at harvest on the 10 November 2004 at the Gatton Research Station. Treatments with the same letter are not significantly different from one another.

Efficacy trial 6 for Silverleaf Whitefly

Adults. Silverleaf whitefly adults were present from day one after emergence. Adult numbers were significantly less in treated plots than in the untreated control plots as seen in Figure 21. Numbers remained low until about week three when they seemed to explode. Although all treatments were still significantly better at managing adults numbers, TI-435 and thiamethoxam were also significantly better at managing adults numbers compared to Confidor®.

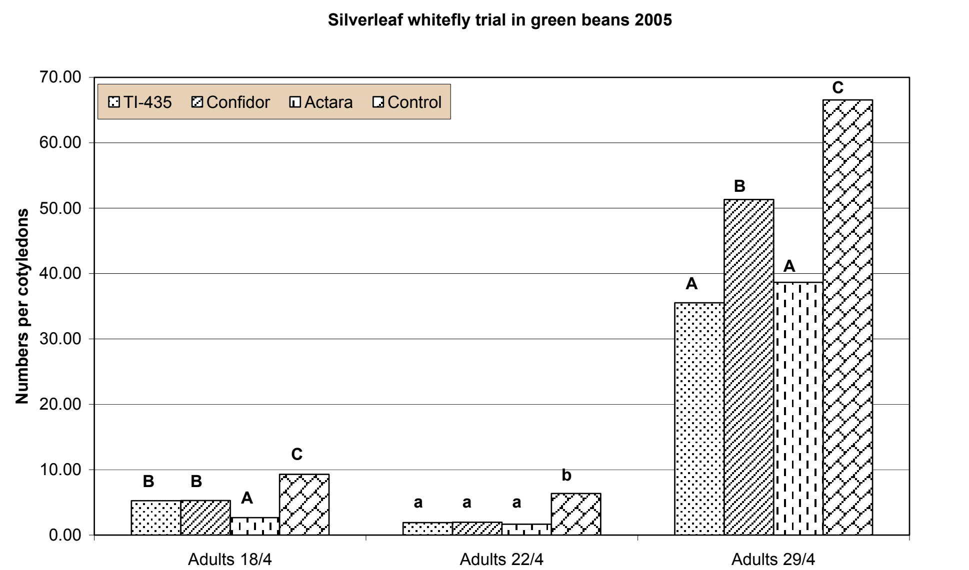

Figure 21. Adult silverleaf whitefly numbers recorded over a 3 week period.

Eggs. All three products were significantly better than doing nothing at reducing the number of eggs laid on the cotyledons or the first true leaf as seen in Figures 22 and 23. All products were significantly better than the control up until about the three to four week period when Confidor® and then TI-435 started to loose their effectiveness in the cotyledons. All three products were still however effective at limiting egg laying on the first true leaf that was used for assessments, even five weeks after planting (Figure 23).

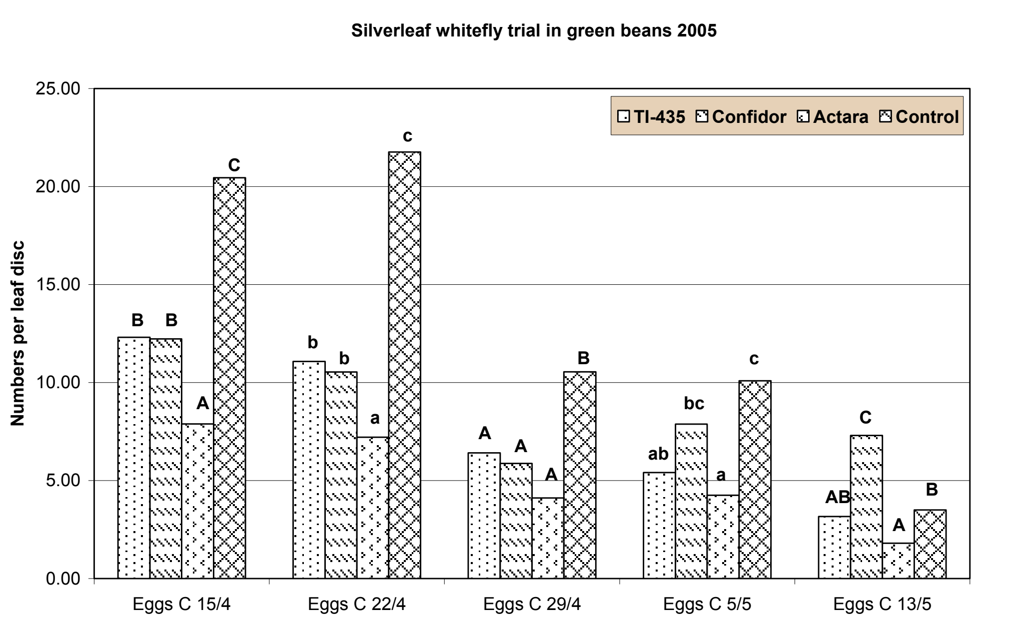

Figure 22. Egg counts on cotyledons taken over a 5 week period.

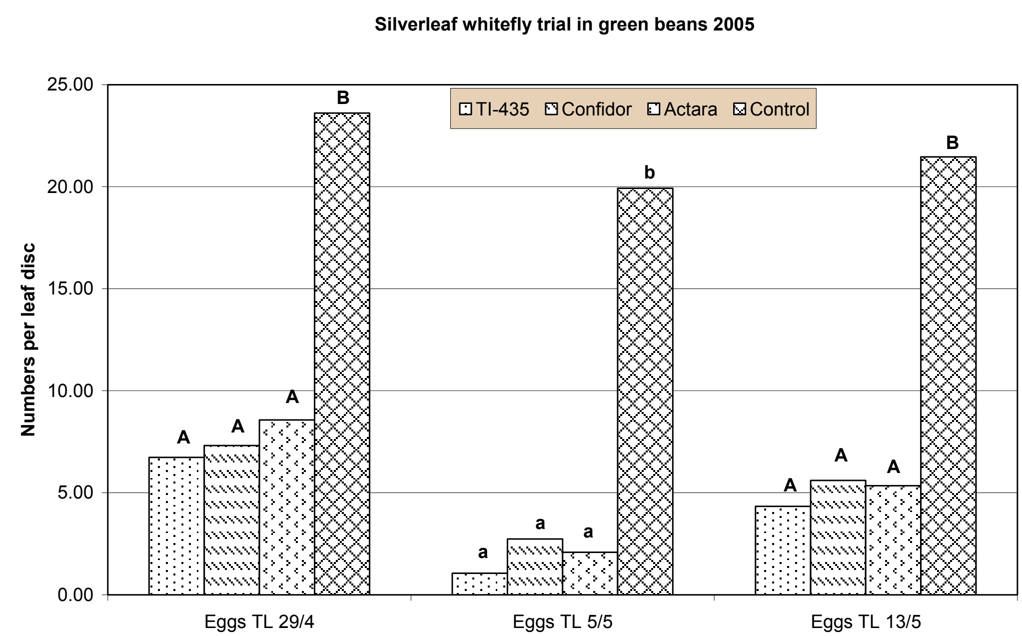

Figure 23. Egg counts on one of the first true leaf leaflets over a 3 week period.

Nymphs. Nymphs were not an issue until two to three weeks after planting and one week after the plants were fully emerged. TI-435 was the only product that was significantly better than the control treatment at reducing the number of nymphs on the cotyledons. Numbers were however very low at this stage. All three neo-nicotinoids were significantly better at reducing the numbers of whitefly nymphs on the cotyledons as well as the first true leaves for the duration of the trial, five to six weeks after planting as shown in Figure 24.

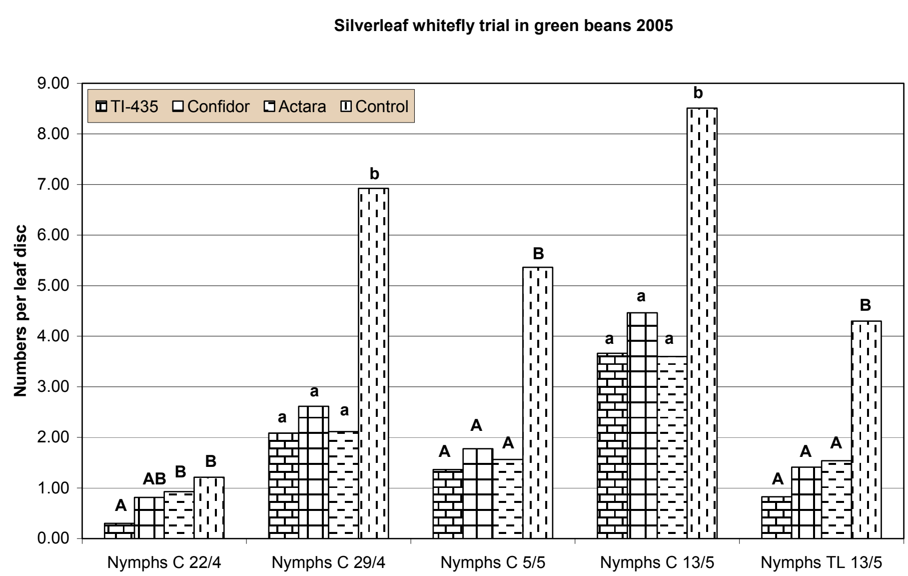

Figure 24. Nymph counts on cotyledons and the first true leaf leaflets.

All chemical treatments gave close to 100% control of Bean fly as seen in Figure 25. Percentage infestation in the control treatment reached 79.4% while Actara® was the poorest performer of the neo-nicotinoids at 0.8% infested plants. Confidor® had 0.2% infested plants while TI-435 resulted in no infested plants, remembering that this product was applied at 2.5 times the suggested rate.

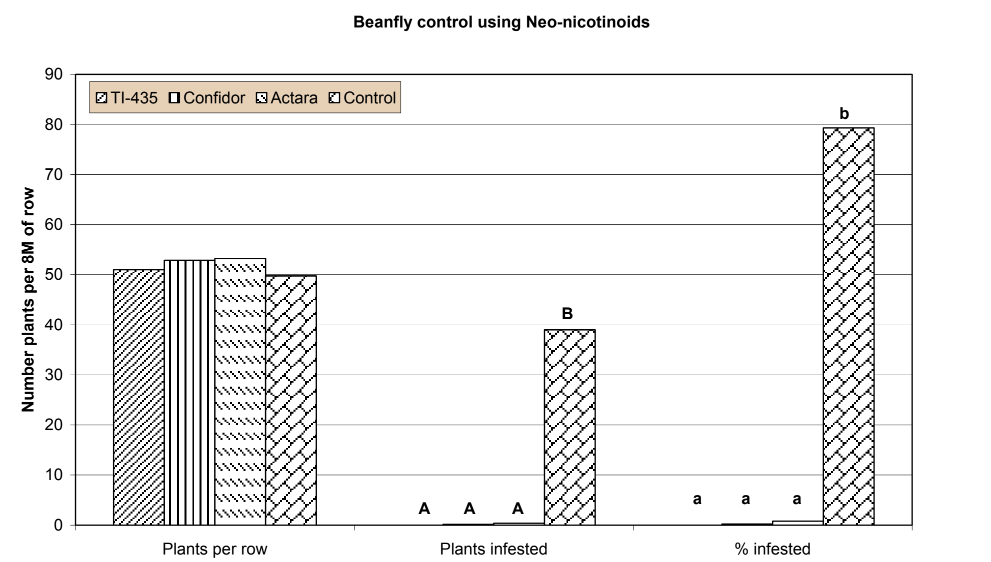

Figure 25. Beanfly infestations six weeks after planting and treatment.

Discussion

Insect pest problems associated with green bean production can be placed into two production periods. Insect pests such as silverleaf whitefly, thrips, aphids, vegetable leafhoppers or jassids and bean fly, which attack the seedlings and young plants, then the later insect pest problems such as flower thrips, heliothis and Bean pod borer from flowering until harvest. There are a number of other insect pests that are found infrequently in green beans, but have not been an issue during these series of trials on either the Gatton Research Station or on grower properties.

Early pest issues in green beans can be difficult to manage and the management options available to the grower are limited to the use of insecticides. These insecticides invariably have a detrimental affect on the beneficial insect populations that can develop within green beans. The use of organophosphates, such as dimethoate, to manage jassids and bean fly is very effective against a number of target pests, as well as at reducing the beneficial insect population. Silverleaf whitefly is a recent insect pest which is problem early in the bean crops' life, especially during the late summer and autumn months in south east Queensland.

Dimethoate has been the insecticide of choice for the management of the traditional early pest problems such as jassids and bean fly. Jassids are problems in virtually all growing regions at some time during the growing season, whereas bean fly is predominantly an issue during the late summer and autumn months.

The trials undertaken at the Gatton Research Station, especially against SLWF, have shown that the neo-nicotinoids Confidor®, TI-435 and Actara®, are all very effective at managing the SLWF adult populations that attack the newly emerging crop. The application of these insecticides at planting as an in-ground application appears to be the most effective way to apply these products. The products are readily available for the plant to take it up via the root system and transport to where they are most needed, the new leaves of the young plant. These insecticides not only control SLWF but have show to give nearly 100% control of bean fly. The impact on jassids is not yet understood, but they do appear to have some effect on this group of leafhoppers. The need to use dimethoate could be substantially reduced which would in return allow the beneficial insect population to build up earlier in the crop. Currently there is a permit to use Confidor® in green beans as an in-ground application only. It would be beneficial to growers if this product were registered for use in green beans due to the limited choices for control of SLWF and to help rotate those chemicals currently being used for bean fly and jassid control.

The use of neo-nicotinoids would in turn allow beneficial insect numbers to increase in the crop early as there would be very little need to apply foliar insecticides until such time as the crop starts to flower. Any foliar caterpillar pests could be managed by the use of a soft option insecticide such as Bt or even spinosad. Very high SLWF numbers were found in February 2005 during a trial, which resulted in the crop being virtually destroyed, similar to the attached photo of a follow-up trial in April/May 2005.

Photo 1. Silverleaf whitefly damage. Plants are nearly six weeks old and have hardly grown. They were planted on the 5 April 2005 with the photo taken on the 16 May 2005.

Adjacent treatments of neo-nicotinoids were flowering by this time. Foliar sprays of Confidor® and TI-435 did not have a significant impact on the overall populations of SLWF, as shown in Trial 2. The effect of this whitefly on the crop towards harvest is still not clearly understood. It may cause stunting of the pods and even a reduced colour to the pods but this has not been confirmed.

Chess® appeared to be the only insecticide to have some impact on SLWF when applied as a foliar spray as shown in Trial 2. This product is not yet registered for use in green beans and whether the chemical company will pursue registration is doubtful due to the overall size of the green bean industry. Of all the other insecticides trialled for the various sucking pests the only products that have shown any promise have been the neo-nicotinoids as well as Chess® for SLWF and possibly Intruder® for thrips and jassid control. The results associated with Intruder® were up and down and were not convincingly significant compared to the control treatments.

There are only two groups of pests associated with the flowering to harvest stage of the crop. Thrips are a major problem during flowering as they hide within the flowers which makes them very difficult to target, resulting in distorted pods. There was no single product in this series of trials that consistently out performed the other when it came to reducing the pod damage caused by thrips. Thrips are notoriously difficult to control due to their reclusive nature and the inability of contacting them with an insecticide. The current practice of using dimethoate and methomyl also resulted in varying degrees of damage. More work is still needed to try and find alternatives to the broad spectrum insecticides currently used by growers. Some of the trials conducted to date ignored the thrips in flowers issue and still managed the same level of thrips damage to pods compared to the grower's insect pest management practice

The other insect pests present during the flowering to harvest period are the caterpillar pests, heliothis, loopers and Bean pod borer. Loopers are not generally an issue as they only chew the leave and are readily controlled with the insecticides used to control heliothis. The range of soft option insecticides that have a minimal impact against beneficial insects while still delivering control of caterpillar pests in green beans, in particular heliothis control, are increasing. The insecticides trialled in this series of trials has found a new product DC-041 to be very effective at reducing caterpillar damage to the pods in all the trials carried out. Although only two trials could be analysed statistically to show this improved performance, the other trials showed improved trends compared to a number of other treatments including an untreated control. Avatar® has also performed well in a number of trials. These performances have generally been a result of only two applications of the various insecticides soon after the start of flowering. Other insecticides including Proclaim® have given mixed results.

It would also be beneficial to see how the neo-nicotinoids perform against the flower thrips and if they actually are robust enough to last until flowering helping in the management of thrips in the flowers. Due to the nature and size of the plant there may not be much active ingredient translocated to the flowers to have an impact on numbers as it would likely be very dilute by this stage in the plant. The use of Success® for the control of caterpillar pests also has an impact against western flower thrips (*Frankliniella occidentalis*) which are present in bean flowers, along with a number of other thrips. It is therefore possible that this product could also have an impact on pod damage due to thrips.

The work conducted in these trials will go a long way to helping with registration of these products in green beans making it easier for growers to manage their insect pest problems into the future.

Technology Transfer

Results from the efficacy trials have been presented in the 3rd and 4th editions of the newsletter sent out to all stakeholders on our beans database. Results have also been sent to the various chemical companies about the effectiveness of their products in the hope that they will look favourably towards registration in Green beans.

Recommendations

As a result of the efficacy trials, a number of products have potential against a number of insect pests found attacking green beans. Registration of Confidor® for whitefly problems would also control bean fly and possibly jassid numbers, Avatar®, Proclaim® and the new Bayer product DC-041, would be useful additions for the management of heliothis and Bean pod borer. The only other insect pest that still needs further work carried out on it is thrips at flowering. The control of this group of insect pests, as more than one species can be found in the flowers, could seriously disrupt an IPM program that a grower might wish to implement in green beans. Work done by Saxena and Kidiavai (1997) found neem seed extract useful in controlling flower thrips. Perhaps this could be investigated for its efficacy under Australian conditions. Thrips activity is looked at in a little more detail in the BMO trials. Bayer is doing more work against thrips with another of their products in beans, but additional work is still needed to address this insect pest problem.

Below is a table which represents the overall outcomes from the number of trials carried out as part of this project and are compared to three registered products in green beans, Confidor® has a permit for use only in this crop. The effect of the sap sucking insecticides on thrips is not all that clear and need further research into timing and application methods as some insecticides appear to perform better as a soil drench or soil injection.

Table 6. Effectiveness of insecticides against Green bean pests in the series of trials carried out as part of this project.

	Silver leaf whitefly	Jassids	Bean fly	Thrips in flowers	Heliothis/ bean pod borer/ loopers
Confidor® (soil)	✔✔✔✔✔	✔✔✔	✔✔✔✔✔	?	
TI-435 (soil)	✔✔✔✔✔	✔✔✔	✔✔✔✔✔	?	
Actara® (soil)	✔✔✔✔✔	✔✔✔	✔✔✔✔✔	?	
DC-068/027	✔✔	✔✔✔		✔✔?	
Intruder®	✔✔	✔✔✔		✔✔?	
Chess®	✔✔	✔✔✔		✔✔?	
dimethoate	✔	✔✔✔✔✔	✔✔✔✔✔	✔✔✔	
Gemstar®					✔✔
DC-041					✔✔✔✔✔
Avatar®					✔✔✔✔
Proclaim®					✔✔✔✔
Symphony®				✔✔	✔✔
methomyl				✔✔	✔✔✔✔
Success®				✔✔	✔✔✔✔

Those insecticides highlighted in green are registered for use or permitted for use in green beans.

Acknowledgments

Many thanks to Carolyn Lee, Sandra Dennien, Luke Jackson, David Schofield and the DPI&F with some of these trials. Also thanks to Mulgowie Farming Company for letting us use some of their bean fields to undertake some of these trials.

Best Management Options evaluated.

Introduction

The Australian green bean industry is situated in locations that have quite diverse environments, ranging from the dry tropics of North Queensland to temperate Victoria and Tasmania. The timing of production, the level of insect pest pressures and different environments can significantly influence management measures.

Heliothis, Bean pod borer and thrips in flowers would be the most damaging pests with which the green bean industry has to contend with in the majority of growing regions. Control of these insect pests by way of insecticides is limited due to a lack of registered products, resistance developing from the over use of these limited products and a reluctance of chemical companies to invest new products into green beans.

To reduce the dependence on synthetic insecticides for managing these insect pests in green beans, this project has looked at alternative control options that growers can use as part of a Best Management Option (BMO) system. A BMO system is a practical strategy, that utilises a broad range of appropriate insect management tools that are most suited for the problems encountered and are incorporated into a system designed to achieve the lowest level of crop damage from insect and mite arthropods. These options can be used by growers and consultants and improved upon depending on the regional insect pest issues.

To evaluate a BMO system's ability to reduce damage and crop loss from a range of green bean pests, farm trials were conducted comparing what a grower would do and what tools might be used in a BMO system in green beans. These trials were conducted in a number of locations in Queensland to allow for the different growing conditions in these regions. The aim in these trials were to reduce the number of insecticides applied to green bean crops, use softer option insecticides to manage insect pests, encourage the build-up of beneficial insect and ensure there is no reduction in yield. Two earlier trials were abandoned, one due to severe *Macrophomina phaseolina*, ashy stem blight, disease affecting a large percentage of the crop which was subsequently ploughed in, and the other from severe silverleaf whitefly numbers and the inability to manage such high numbers at the seedling stage. The whitefly issue arose before the use of imidacloprid as a soil drench was considered as an important part of a BMO system.

Materials and Methods

Trial 1 Gympie, QLD

This trial was planted in September 2005 which was towards the end of the growing season. Pest pressure was expected to be on the increase during this period.

Integrated Pest Management Options used

Confidor® was applied at planting in the furrow with the seed.
A small spray tank was attached to the planter with a pump and pressure gauge with spray lines attached to the back of the planting shoes which directed a jet of liquid into the ground along with the seed as shown in Photo 2.


Photo 2 Spray tank on top of planter box and spray lines attached to the back of the planting shoe with a jet of liquid being directed forward under 1 Bar of pressure.

The crop was monitored weekly by checking two plants at ten sites at random throughout the plot. Both insect pests and beneficial insects were counted. Insecticide applications were made according to the monitoring records on a weekly basis which the grower would then apply. Yellow sticky traps were used to identify beneficial insects and hard to find insect pests. Two traps were placed 15m in from either end of the plot and replaced weekly. Heliothis pheromone traps were used to monitor moth flights. Both *Helicoverpa armigera* and *H. punctigera* pheromone lures were used and were placed at opposite ends of the trial site.

Grower Management Options used

The crop was also monitored weekly in conjunction with the IPM options block for comparison. The grower checked his own crop and applied insecticide(s) when he felt it was necessary. Yellow sticky traps were used to identify beneficial insects and hard to find insect pests and compare the results with the IPM options site. Two traps were used and placed 15m in from either end of the plot and replaced weekly.

This trial was harvested on the 15th November 2005. Ten plants from five sites were collected from each plot and the pods were assessed for damage from caterpillars and thrips and marketability as well as their weights.

<u>Trial 2 Lockyer Valley, QLD</u>

This trial was set up on a grower property in the Lockyer Valley and was planted late January and harvested 18th March 2006. This trial was also set up during an expected peak insect pest period, particularly for bean pod borer activity. Two bays were allocated by the grower approximately 120m long and 28 rows wide.

Integrated Pest Management Option used

Confidor® was not applied at planting as the whitefly situation at the time was not very high and the grower felt it not necessary to apply this product at this stage. The crop was monitored weekly by randomly selecting two plants at ten sites. Yellow sticky traps were used to identify beneficial insects and hard to find insect pests. These traps were placed 20m in from either end of the plot and changed weekly. Heliothis pheromone traps were used to monitor moth flights. *Helicoverpa armigera* and *H. punctigera* were both used and were placed at opposite ends of the trial site.

Beneficial friendly insecticides were the first choice of insecticides and were apply by the growers when the monitoring results indicated a need to manage insect pest numbers. Magnet plus methomyl was applied to the outside rows of the IPM options block weekly from flowering until just prior to harvest.

Grower Management Options used
The grower would check the crop adjacent to the BMO plot and apply insecticide(s) when it was deemed necessary. This crop was also monitored weekly by their own crop consultant and by us to compare insect pest numbers. Yellow sticky traps were used to identify beneficial insects and hard to find insect pests and compare the results with the IPM options site. These were placed 20m in from either end of the plot and changed weekly.

Fungicides and other agronomic practices were taken care of by the grower for both the BMO plot and the grower managed plot.

This trial was harvested on the 17th March at which time ten 1 meter strips of row were harvested from each plot and assessed for insect pest damage from caterpillar pests and thrips.

Trial 3 Gatton Research Station, Lockyer Valley, QLD
This trial was set up on the QDPI&F research station on the 22nd February 2006 during a time of the growing season when silverleaf whitefly activity was expected to be high and as such the management of this pest was considered essential when designing an BMO options program for this time of the year. Bean pod borer was also considered an issue for this time of year so a different approach to managing this pest was to be trialled from flowering until harvest unlike Trial 2 where monitoring was used to determine when a spray was required. Plot sizes were 50m long and 32 rows wide.

Integrated Pest Management Option
Confidor® was applied at planting by applying a steady stream of solution just behind the planting shoe. This was delivered from a spray tank on the front of the tracker and delivered at 1 Bar pressure. Crop monitoring was carried out weekly by checking two plants at ten random sites. Yellow sticky traps were used to identify beneficial insects and hard to find insect pests. These were placed 10m in from either end of the plot and 6 rows in from either side of the plot. Heliothis pheromone traps were used to monitor moth flights. *H. armigera* trap was placed at the end of the BMO plot and the *H. punctigera* was placed at the end of the traditional grower managed plot.

Appropriate soft options insecticide treatments, eg. Bts, were applied according to the monitoring results up until the flowering stage. Once flowering starts then an appropriate insecticide (in this case Success®) was applied on a weekly basis to help in the management of bean pod borer.

Traditional Grower Management Options used
This crop was also monitored weekly by checking two plants ad ten random sites. Yellow sticky traps were used to identify beneficial insects and hard to find insect pests. These were placed 10m in from either end of the plot and 6 rows in from either side of the plot. This plot would have an appropriate insecticide(s) applied when monitoring results indicated an increase in insect pest activity and damage, with the emphasis on the use of the carbamates, OPs and SPs.

Fungicides and other agronomic practices were taken care off as required for both the BMO block and the grower managed block.

Trial was harvested on the 21st April 2006 at which time five 1 meter strips of row were assessed for insect pest damage from caterpillars and thrips.

Results

Trial 1 Gympie, QLD

The range of pest and beneficial insects found during this trial:
Insect pests;
Heliothis, loopers, Common grass blue butterfly, hawk moth eggs only, jassids, small numbers of thrips and aphids, Rutherglen bugs, flea beetles.
Beneficial insects;
Brown smudge bugs, Striped ladybird beetles, Transverse ladybird beetles, Minute 2-spotted ladybird beetles, White collard ladybird beetles, Red and blue beetles, Brown lacewings, spiders.

As a result of monitoring the BMO plot only had one caterpillar insecticide applied, Dipel® plus Mobait®, which was applied four weeks after planting. Two fungicides were applied for rust control, Dithane® M45 and Plantvax®. The grower treated plot in comparison had four applications of insecticides, three of these as mixtures of insecticides, as well as a number of fungicides for rust control including Dithane M45, Folicur®, Filan® and Plantvax®.

Jassid damage was less in the BMO plot that had the Confidor® applied at planting compared to the grower plot that did not have any Confidor® applied to the soil. Figure 26 shows the percentage of young plants with damage to the new leaves with upto 45% of plants suffer damage due to Jassid activity in the grower managed plot while for the same period less than 5% of plants were exhibiting signs of Jassid damage. The grower decided to apply dimethoate at this stage to the grower treated plot.

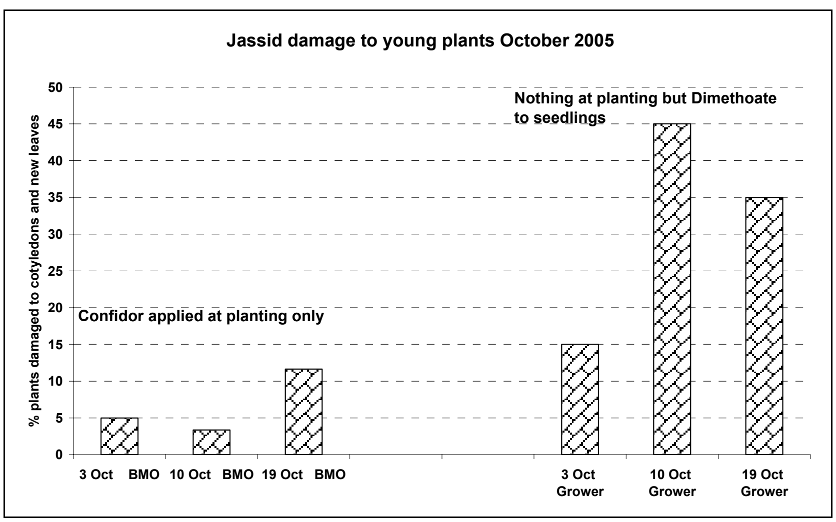

Figure 26. Visible jassid damage to the young plants was far less when imidacloprid was applied at planting with the seed.

Thrips numbers were too low to warrant any special treatments being applied in either plot. There was more beneficial insect activity in the BMO plot than in the grower managed plot as seen in Figure 27. The spray that the grower applied on the 10th October to manage jassid numbers also managed beneficial predator numbers with no predators being caught on the sticky traps during the following week, which was collected on the 19th October. Predator numbers remained low in the grower managed plot but were 50-100% higher for the majority of the time in the BMO plot.

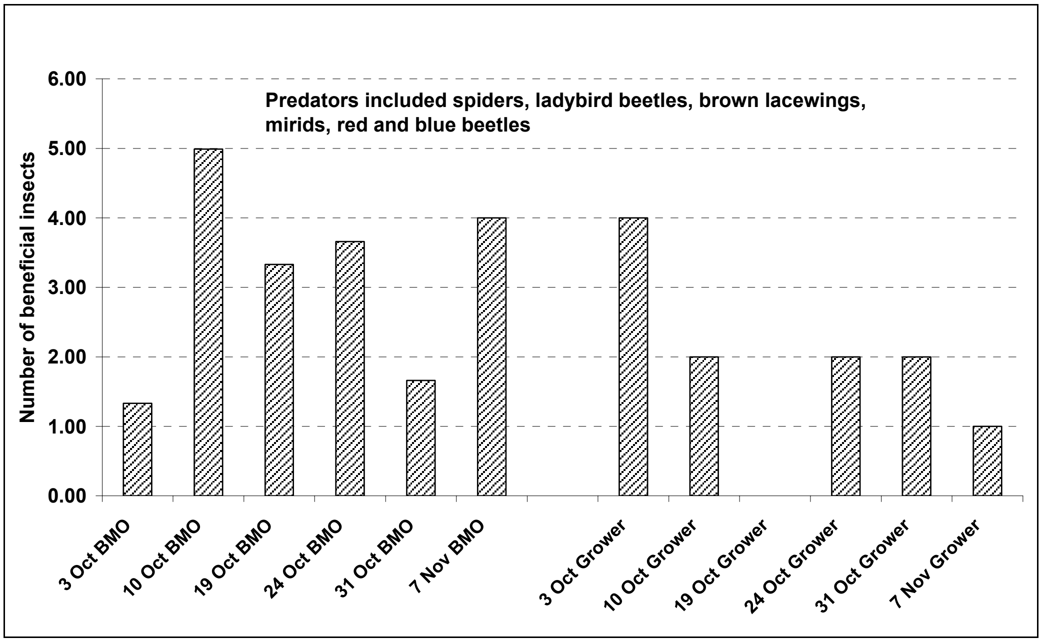

Figure 27. Average numbers of beneficial insect in the BMO and grower maintained plots over time as found on yellow sticky traps placed in the crop.

At harvest there was very little difference between the two types of treatments when looking at their over all weights. The BMO suffered slightly more caterpillar damage than the grower managed plot but there were more pods that were marketable in the BMO plot. Even though there was very few thrips seen in the field in the flowers some damage was still evident to the pods at harvest. The BMO plot had less thrips damaged pods than in the grower managed plot, 2.44% compared to 6.47% respectively. The grower managed plot had a greater marketable yield and consequently a slightly higher yield (Table 7).

Table 7. Harvest results showing average numbers per ten plants on 15th November 2005.

	% with Holes	% Thrips damage	% Marketable	Aver. Marketable Wts/10 plants (grams)	Approximate tonnes/ha
BMO plot	3.65	2.44	72.26	446.372	6.696
Grower choice	0.88	6.47	75.45	447.65	6.715

Trial 2 Lockyer Valley, QLD

The range of pest and beneficial insects found during this trial:
Insect pests;
Heliothis, loopers, Cluster caterpillars, hawk moth eggs only, jassids, small numbers of thrips and aphids, Rutherglen bugs, flea beetles.
Beneficial insects;
Big-eyed bugs, Pirate bugs, Striped ladybird beetles, Transverse ladybird beetles, Minute 2-spotted ladybird beetles, Red and blue beetles, Trichogramma, spiders

As a result of monitoring no insecticides were applied to the BMO block until the start of flowering, whereas the grower managed block had dimethoate applied early as well as a Confidor® application for whitefly activity. The dimethoate spray was primarily for jassid numbers but the amount of damage in the BMO block was considered to be low and not in need of an insecticide treatment. The grower then applied 3 insecticide sprays of mixtures during flowering to keep the crop clean.

The BMO block had two insecticide applications from early flowering until harvest. Bean pod borer activity was only evident close to harvest and only when a great deal of damage to the pods was evident. Magnet® and methomyl was applied as band sprays weekly for three weeks but this did not seem to manage the pod borer levels in the crop.

There was more *Trichogramma* activity in the BMO block than the grower managed block, particularly from about three weeks prior to harvest as seen in Figure 28. The predator activity fluctuated with a jump in activity close to harvest.

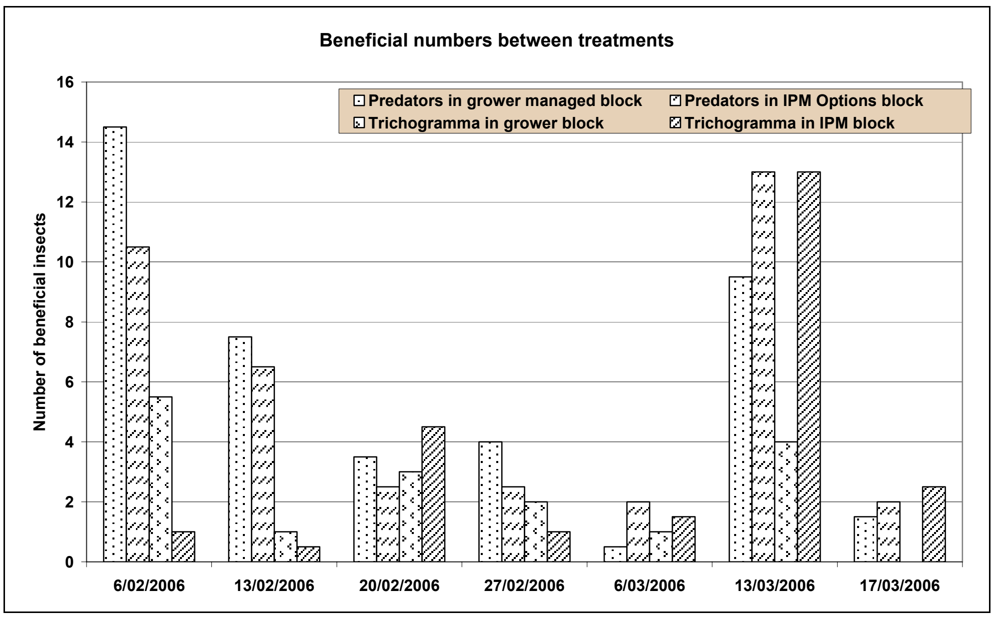

Figure 28. Average beneficial insect populations over time for predators and Trichogramma wasps found on yellow sticky traps placed in the crop.

Heliothis pressure was low during this trial but bean pod borer established and caused a great deal of damage to the pods. This is a very difficult pest to monitor for as the eggs are extremely difficult to find, unlike the heliothis eggs which can be readily found on the leaves or stems. Thrips activity was significantly less in the BMO block in the form of a reduced number of deformed pods as shown in Figure 29.

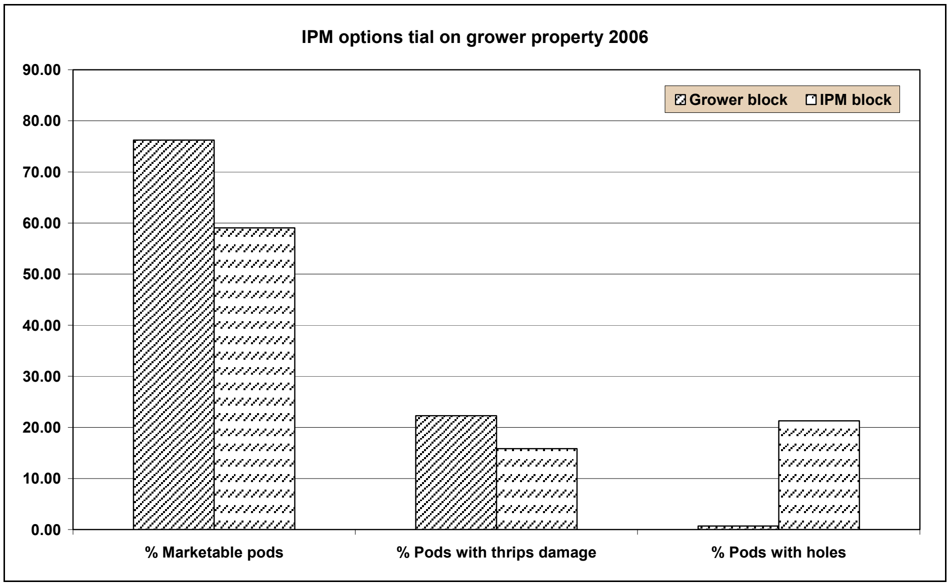

Figure 29. IPM options trial comparison with adjacent grower managed block.

Although there was a variety of beneficial insect activity within the BMO block, this was not enough to help with the insecticides used to try and manage the caterpillar pests, in particular the bean pod borer, which was the major contributor of the damage to the pods. The eggs of this moth are very hard to near impossible to find as they are generally laid on the sepals or petals of the flower, are pale to translucent and ovate and may resemble a small droplet of water. It is generally not until some damage is seen on the pods that you know you have a problem. Management at this stage can always be difficult as once the larvae are in the pods they are very hard to control. Even though there was significantly more damaged pods due to caterpillars, this was slightly offset by the reduced number of pods affected by thrips damage.

Trial 3 Gatton Research Station, Lockyer Valley, QLD

The range of pest and beneficial insects found during this trial:
Insect pests;
Heliothis, loopers, hawk moth eggs only, jassids, thrips, whitefly and aphids, Rutherglen bugs, flea beetles, Green vegetable bugs.
Beneficial insects;
Apple dimpling bugs, Big-eyed bugs, Pirate bugs, Smudge bugs, Striped ladybird beetles, Three-banded ladybird beetles, Transverse ladybird beetles, Minute 2-spotted ladybird beetles, Red and blue beetles, Brown lacewings, Trichogramma, spiders

Confidor® application at planting helped in the management of the vegetable leafhopper or jassid as shown in Figure 30. The BMO block had relatively small amounts of jassid damage compared to the grower management options block, which needed a dimethoate application twelve days after emergence.

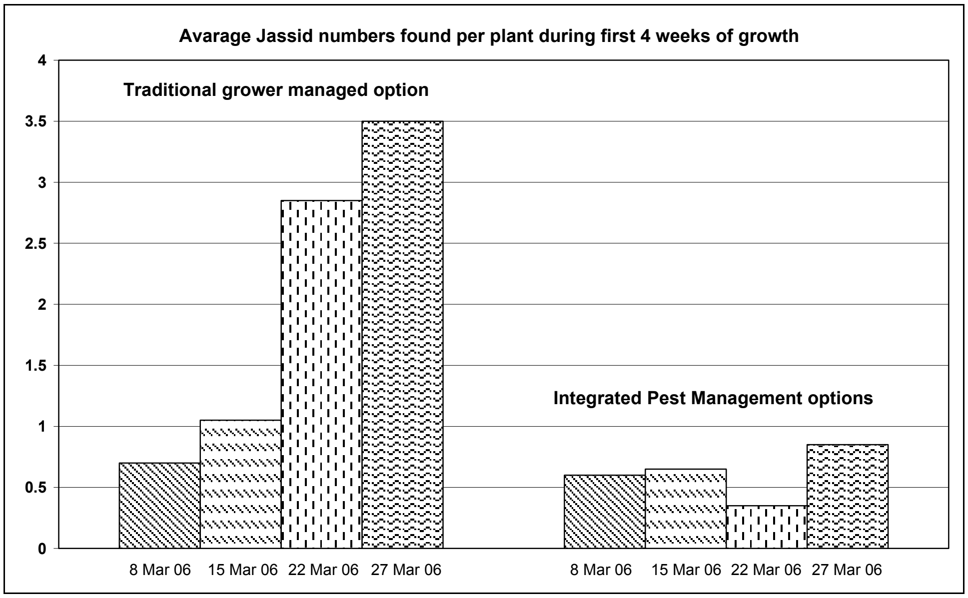

Figure 30. Jassid numbers on young plants up until about five weeks after planting.

There were very few silverleaf whitefly in this trial. The reason for the low whitefly activity is unclear and could be a result of a number of factors such as environment (e.g. rainfall), reduced crop hosts (due to drought), beneficial insects (e.g. parasitic wasps), and improved management practices by growers in the region.

Yellow sticky trap counts also reflected the difference in sucking pest numbers between blocks as seen in Figure 31. The BMO block yellow sticky traps caught fewer thrips, jassids, whitefly and aphids for the majority of time that the traps were in the crop with little difference between thrips and jassid numbers close to harvest. Whitefly and aphid numbers remained relatively low throughout the trial in both treatments.

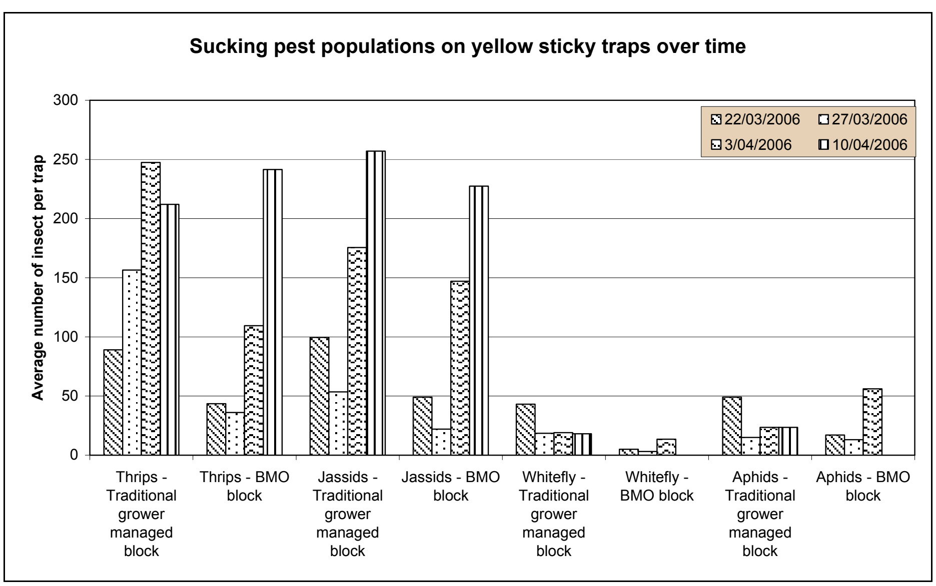

Figure 31. Sucking pest populations captured on yellow sticky traps.

The number of beneficial insects in the BMO block increased as the crop matured compared to the traditional grower managed block as shown in Figure 32. The fall in beneficial numbers the traditional grower block could be attributed to the use of the old style insecticides such as carbamates and SP's, especially during the flowering and pod development stage of growth when three insecticide applications were carried out, two of them mixtures of a carbamate and SP.

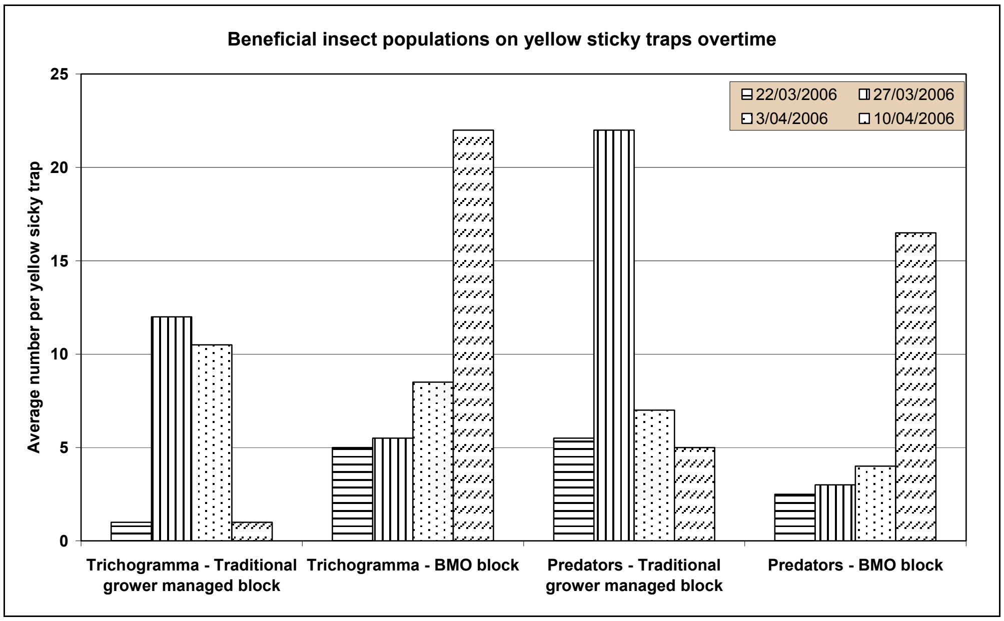

Figure 32. *Trichogramma* wasp and general predatory beneficial insect populations using IPM options and Traditional grower management options.

There was no significant difference between the BMO block and the block that was treated using the older chemistries to manage the range of insect pests found during this trial as seen in Figure 33. Percentage damage ranged from under one percent using the traditional chemistries to two percent using the softer options approach. The percentage marketable pods were not significantly different between the two pest management options with both treatments producing between 79-80% undamaged pods. The three weekly sprays of Success® had a far better outcome on the bean pod borer with this trial compared to the previous trial and also the unsprayed block of beans as part of this trial.

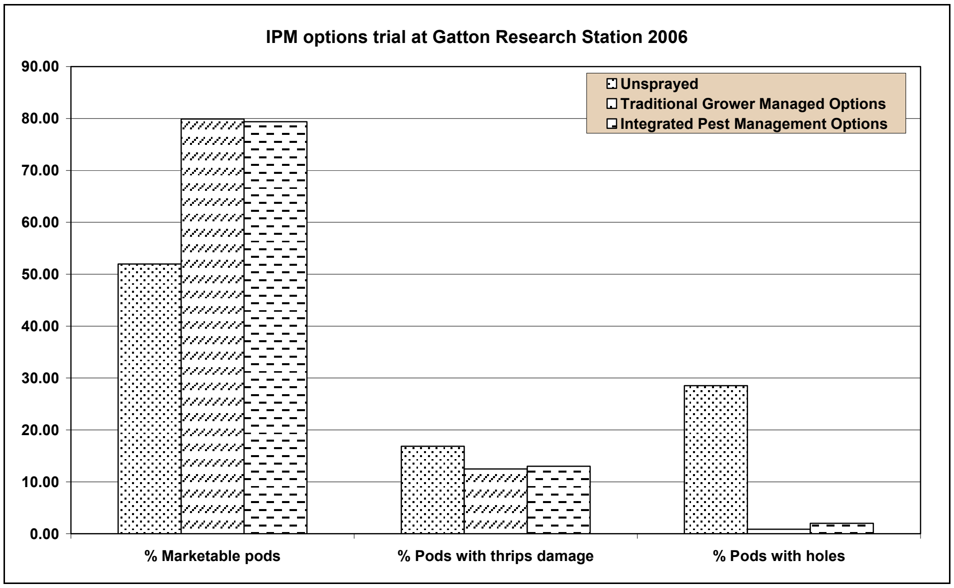

Figure 33. Effect of BMO and traditional grower management option on percentage damage and marketable pods at harvest.

Discussion

Developing a Best Management Options program for any vegetable crop is a complex task. This is due to the wide range of insect pests that can attack the crop, the range of beneficial insects that attack the insect pests and possibly one another, the seasonal abundance of the particular insect pest and beneficial insects, what non-chemical control options can be used to varying degrees of effectiveness and how much damage the grower and the end consumer are willing to accept as part of a BMO/IPM system. There is the added difficulty of developing a BMO system in only four years of a project such as this. BMO systems are constantly being refined, as new techniques for managing certain insect pest problems present themselves. Differences between regions can also affect how a BMO system will work. Certain management option may work well in the Lockyer Valley but be totally ineffective in another region such as north Queensland or not be required at all.

Developing a BMO system for green beans, as this project has been trying to do over the past four years, should not be looked at as a recipe for success. It should be an on going process with individuals using the following information as a starting point for their own individual purposes/situations. BMO systems evolve over time.

Green beans has a diverse population of insects both pests and beneficial, with activity throughout the life of the crop from the seedling to harvest.

Where silverleaf whitefly is known to be a problem, Confidor® as a soil applied insecticide at **planting** is the only viable option for managing this insect pest. This can be done either as a narrow band or a trickle just behind the planting shoe before the seed is covered over. The photo below is of a forward facing jet put together by a grower, where the chemical is injected into the soil at the rear of the planting shoe.

Photo 3. Soil application of imidacloprid showing position of injection line at rear of planting shoe.

Confidor® will give good control of silverleaf whitefly for about four weeks by which time the plant has reached a stage of growth where whitefly activity can be tolerated. The only sign of damage at harvest may be a reduced colour of the developing pods unlike the early stunting and distortion of the growth at the seedling stage as seen in Photo 4. This product will also give excellent control of bean fly and also aid in reducing the damage caused by jassids. Confidor® effectively manages three insect pests with one application at planting. Where whitefly is not an issue then it is a far cheaper option to use a dimethoate application for jassids and bean fly as an over the top spray soon after the plants have emerged. The use of dimethoate will however have an adverse impact on the beneficial insect populations early and could delay their development within the crop.

Photo 4. Damaged caused by very high silverleaf whitefly activity from the moment the plant emerged from the soil. These plants were about 3 weeks old.

Once the plants have started to **branch out** and are growing rapidly the pests that are of concern are generally caterpillars such as loopers and heliothis, both known to attack the foliage causing the plants to look a little tattered. This does not seem to affect the overall yield of the plants as shown in the Gympie trial where the BMO block was left to suffer some leaf damage before a Bt spray was applied (Table 7). There are a number of beneficial insects found in a green bean crop that can help clean up eggs and small larvae or caterpillars so care must be taken to use only those insecticides that have a minimum impact on beneficial insects. A Bt spray just prior to flowering will help knock the caterpillar numbers down while saving the beneficial insect populations. The use of more broad spectrum insecticide(s) such as Lannate® or Ambush® will have a detrimental affect on the beneficial insect population.

Once **flowering** starts then greater care should be taken with regards timing and insecticide selection. Thrips in the flowers have the potential to cause distorted pods while the caterpillars, heliothis and bean pod borer, chew holes in the pods. The time of the year is important as to the insect pest likely to be encountered. Heliothis are present during most of the growing season whereas bean pod borer is only a problem during late summer and autumn months becoming more of a pest than heliothis. Monitoring for bean pod borer eggs is extremely difficult, so a spray schedule may be the better option during this time. The use of pheromone lures to determine when bean pod borers are around, have only recently been available. Their effectiveness under local conditions needs to be tested before they can be recommended as an IPM tool to aid in the management of this pest.

The first BMO trial during late summer in the Lockyer Valley resulted in an unacceptably high level of pod borer damage. Only two insecticide applications were applied from the start of flowering until harvest with the first application about one week after the start of flowering and the second application once damage was evident six days prior to harvest. The second BMO trial, planted late February followed a spray schedule from the start of flowering with three applications of an appropriate insecticide. The traditional grower managed block was also sprayed three times on a weekly schedule. The first application was soon after the start of flowering and then weekly after that. The BMO treatment used spinosad while the traditional grower managed block relied on the use of carbamates and SP insecticides with very little difference between both insect pest management options. Due to the limited number of available insecticides for caterpillar pests registered in green beans, a strategy whereby Success® is used for the first two applications followed with a synthetic insecticide such as Lannate® or Ambush® or even a mixture of both if it was felt necessary, would help limit any insect resistance issues.

When heliothis is the only caterpillar pest of significance, from spring to late summer, then monitoring for this pest can save you time and money with regards insecticides. The trial carried out in Gympie from September to November only had one insecticide, a Bt spray, applied for caterpillars and that was before flowering with the plot only suffering 3.6% damage due to caterpillar pests. An earlier insecticide trial also during this time of the year in the Lockyer Valley only suffered 3.9% damage due to heliothis and just over 12% damage due to thrips when left unsprayed during flowering. Each region will most likely be different with regards beneficial insects which help reduce the impact from heliothis and other insect pests. The use of the yellow sticky traps will help in the identification of beneficial insects even if they can not be found while monitoring. Two yellow stick traps in the paddock will help to show what pest and beneficial insects are present.

Without more research it is difficult to quantify how effective beneficial insects are at reducing the overall populations of insect pests. What is clear is the wide range of beneficial insects that can be found in a green bean crop which in turn needs a food source to sustain themselves, namely other insects, either eggs, larvae or nymphs of insect pests.

Pesticide application is also an area that needs more work carried out on it, particularly with regards the selection of nozzles and the spray volumes used. High volumes cause too much runoff of the insecticides resulting in poor control and a need to reapply the insecticide. More does not mean better control. All the above trials used between 400 L/ha and 500L/ha with very good results. This was the same with the insecticide efficacy trials already discussed.

The above information is designed to help growers better understand the possibilities behind using an Integrated Pest Management Options approach with green beans. There are a number of growers achieving the same results by continually using only the synthetically registered insecticides. However the repeated use of these insecticides will in the long term result in control difficulties and increased levels of damage due primarily to the caterpillar pests, heliothis in particular, developing resistance to the small number of registered insecticides. As has been shown with other cropping situations, there are alternative control strategies that can give just as good a return on clean healthy produce.

The short term cost of changing to more environmentally friendly insecticides can be greater than the reliance on more environmentally toxic insecticides. Table 8 below shows the insecticide costs associated with two of the BMO trials at Gympie and on the Gatton Research Station.

Table 8. Insecticide costs only of implementing a BMO in green beans.

Mgt practice	Gympie trial costs per hectare $	Gatton trial costs per hectare $
Grower	170.98	112.96
BMO with Confidor	1031	1270.76
BMO without Confidor	87.88	327.64

The need to use Confidor® will depend on the whitefly populations before planting, and if this product was not required then insecticide costs could be drastically reduced and in some situations become less than those used in a traditional manner as seen in the Gympie trial.

Technology Transfer

The technical information from this research has been transferred to industry stakeholders through:

- Reports
- Newspaper article (Appendix 1)
- Newsletters Volume 5
- Email reports
- Electronic Notes on the DPI&F website http://www2.dpi.qld.gov.au/thematiclists/1182.html
- Farmnotes
- Farmer field day at Gympie November 2005

Recommendations

The usefulness of the pheromone lures for bean pod borer still needs to be evaluated and developed. This could help growers better understand when this pest is present in their crop and when they need to be more vigilant when looking for it. A paper by Downham *et al.* (2004) describes trap designs to use and where in the crop to place them, and so would be a good starting point.

Acknowledgments

Thanks to Martin Wilson (Calbean Fresh Produce) and Mulgowie Farming Company for using some of their crop to demonstrate Best Management Options. Also thanks to Dave Schofield and the DPI&F farm staff for maintaining research trials on the Gatton Research Station. Thanks also to Carolyn Lee for her assistance with these trials.

Pesticide Application Technology

Introduction

Green-bean production throughout Queensland and Australia requires the application of insecticides to manage insect pests. Controlling insect pests during the flowering and pod development stages is critical, as insect damage to the flower and immature pod can cause severe distortion of the pod resulting in an un-marketable product.

Sufficient concentrations of non-systemic insecticides must hit the targeted area harbouring the insect pest(s) to ensure enough exposure or ingestion occurs to effectively reduce the pest population. Increasing the quantity of pesticide applied to a field to ensure sufficient concentrations hits the targeted area is neither economically, socially or environmentally acceptable in modern farming systems. Increased deposition of pesticides onto targeted areas can be attained by utilising the most appropriate spray equipment and spraying techniques. As part of an integrated insect pest management program, maximising spray deposition on the targeted area should be of high priority.

Insecticide sprays targeting green bean flowers and pods are typically applied via either a tractor or aircraft mounted spray boom. Boom sprayers use one of three mechanisms for the production of spray droplets: hydraulic nozzles; controlled droplet application (CDA); and air-sheer nozzles (air-sheer nozzles are not used on aircraft mounted spray booms). Air assistance may be incorporated with the use of hydraulic nozzle and CDA spray booms to increase deposition of spray droplets onto the plant target.

The operation of spray equipment impacts upon the rate of deposition onto targeted areas. Operating variables include the application volume, operating pressure and spray/boom angle. Environmental factors such as wind, temperature and relative humidity can also influence the ability of spray equipment to deposit chemical onto the desired target.

Even though equipment plays a significant role in the effectiveness of coverage, particularly on the pods, the interaction between the plant canopy and application equipment is also important. Unfortunately if the flowers and pods are critical targets, only small proportions of spray released from over the top will actually find its way to the pod. Leaves filter out a large proportion of spray applied from overhead. Equipment that directs spray closer to the pods has a much better chance of getting greater and more even deposits. There is tremendous scope for improvement in application techniques with both aerial and ground based spray equipment.

Assessment of Commonly Used Pesticide Application Techniques for Efficiency in Targeting of Insecticides to Flowers and Pods of Green Beans.

<u>Background to application equipment used for insect pest management in Green Beans.</u>

Ground Based Sprayers

The sprayers used to apply insecticides to beans by ground rigs are:-

i) Over the top booms with hydraulic nozzles or air-shear outlets,
ii) Over the top booms with hydraulic nozzles and air-assistance,
iii) Spray directed from the side across multiple rows using an air-shear cannon.

The two main principles used for droplet formation on these booms are hydraulic pressure and air-shear. Hydraulic pressure is used to produce droplets from nozzles such as flat fans and hollow cones. Sprayers using the air-shear principle produce droplets by using high velocity air (> 200 km/hr) to shatter the spray liquid into droplets.

Techniques for Assessing the Performance of Spray Equipment

Numerous tools are available for checking the performance of spray application equipment used in beans. Growers assessing the efficiency of application equipment in beans can also use some of the techniques that are used by researchers.

Fluorescent dyes for visual observation

Fluorescent dyes that show up under black lights are ideal for visually inspecting the spray deposit throughout a green bean canopy. A pink coloured dye is best for observing the droplet deposits on flowers and pods. Yellow coloured dyes show up well on leaves but are very hard to see on flowers. The spray deposit is best viewed on the crop in the field and at night. This requires a 'black' light and generator or power supply nearby. Viewing deposits in the paddock makes it possible to observe the interaction between adjacent plants on the spray deposit. For instance, leaves from adjacent plants may be completely covering the flowers and pods thus making spray deposits on these targets near impossible to achieve. If plants are removed and taken back to a dark room an appreciation of the influence of neighbouring plants is difficult and may lead to misleading evaluation of the equipment's performance.

Water Sensitive paper

Although water sensitive paper (WSP) is useful, it has many limitations and the interpretation of spray deposit results can be misleading. WSP is produced on small cards of varying sizes depending on the situation where they are to be used. WSP has a yellow surface and when water based droplets hit the surface the droplet leaves a blue stain. Although WSP is relatively cheap and can be placed almost anywhere in the bean canopy, they should be cut to size to match the target.

Some key points to remember when using water sensitive paper:

- The card surface is sensitive to moisture and high humidity. Care must be taken when handling cards (wear gloves) and the cards must be stored in sealed plastic bags if you wish to keep them for extended periods.
- Spray droplets impacting the surface of the card leave a stain that is larger than the actual droplet size. This is called the spread factor. A spread factor of two means that the stain size is twice the true droplet size. For water sensitive paper the spread factor varies and depends on droplet size. Water sensitive paper should not be used to determine droplet size.
- Droplets smaller than 50µm will evaporate before leaving a stain on water sensitive paper. The card is therefore biased towards collecting larger droplets and will not give a true indication of the fine end of the droplet spectrum.
- To give a true indication of spray deposit and penetration, cards need to be the same size and orientation as the target. Simulating the flower or bean pod with WSP is very difficult.

Quantitative recovery of fluorescent tracer

Fluorescent tracers can be used to provide a relatively cost and time effective method for obtaining quantitative spray deposits. They are generally used at very low rates (30 to 50g/ha). This was the main technique used to assess spray deposits on various parts of the bean canopy, including flowers, pods and other artificial targets placed above, in or at ground level. When a fluorescent tracer is applied to a crop, the target of specific interest can be collected and washed using a solvent that extracts the tracer. The quantity of tracer present on the target can then be quantified using a fluorometer. The process is similar to pesticide residue testing however in this case the residue is the tracer. The technique has inherent disadvantages, i.e. the tracers used are sensitive to sunlight and will break down over time. This makes it is important to collect samples quickly usually within 1 hr of spraying. The spray deposit can then be expressed as the volume or quantity of tracer recovered per unit target size (cm^2 or weight).

The Basics of Application

Know your product

Insecticides used to control insect pests in green beans have different modes of action. A sound knowledge of the mode of action for a particular product may help in understanding the application requirements. Contact insecticides kill insects by direct contact at the time of application or by contact with the insect, after application, with the spray residue layer on the plant surface. Other products that have a stomach poison action need to be eaten by the larvae and the pest must consume a lethal dose of the pesticide for it to work and the dosage required relates to the size of the larvae. Larger larvae require higher doses than smaller larvae. After application, pesticides will persist for varying periods of time on the plant before breaking down.

Another consideration is the impact of insecticides on beneficial insects. Products that have a broad action can decimate a range of beneficial insects. The contribution that beneficial insects play in controlling pests should not be underestimated.

What is Your Target?

The target will vary depending on the plant growth stage and this can change from leaves, to flowers, to pods or even the actual pest. Ultimately the aim of growing green beans is to produce pods with minimal damage. Therefore it is important to control insects and other pests early when they are exposed on the leaves pods or flowers. Other growth stages such as seedling emergence, the vegetative growth stage may be equally important in certain production regions.

Spray deposit uniformity will influence the ability of insecticides to effectively control insect pests. There are several issues, which influence spray uniformity:

1. The influence of application equipment on spray distribution.
2. The influence of crop canopy on spray distribution.
3. The influence of target position on spray distribution.

If the application equipment used to spray the crop is not delivering a uniform dose across the paddock then you are probably wasting your money by overdosing some sections and under dosing others. Blocked nozzles, worn nozzles or even subtle changes in travel speed are factors that will contribute to variable application across the paddock.

The crop canopy has a large influence on the spray penetration and spray distribution on the plant. The distribution on the plant is very difficult to manipulate when spraying over the top with a boom. When spraying from over the top, the deposit is highest in the top part of the canopy and reduces rapidly as you move down the canopy. Unfortunately the plant canopy is dense with flowers and pods being located down in the canopy and a large proportion of the spray volume will be filtered out by leaves before getting anywhere near the pods.

Know Your Equipment

The most expensive sprayer will perform poorly if used inappropriately. Regular calibration of equipment is important, (measuring individual nozzle outputs, replacing worn nozzles and calculating the sprayer output), so the correct quantity of pesticide can be added to the tank. A range of nozzle types are available and each have specific operating requirements such as pressure, spacing and height to perform optimally. Controlled droplet application (CDA) equipment and sprayers using the air-shear principle for generating droplets have specific operating parameters to work efficiently.

Research trials on ground based spraying equipment

Where is the spray distributed in the crop?

Often the expectation is that most of an applied spray hits the intended targets. Unfortunately if the targets are the pods, then leaves above the flowers and pods filter out most of the spray applied. Only a proportion of the spray finds it way to the flowers and pods. Figure 34 shows a comparison of the deposit levels on various parts of a green bean canopy relative to the deposit on the pods. This data was collected from a bean trial conducted using a ground-based sprayer with air assistance delivering 300 L/ha. These values may vary for different application systems. This data shows there is variation in the deposit level between each of the surfaces, including the pods. The leaves above the pods collect 30 percent of the total spray recovered from the whole plant. The amount to the pods is considered to be very good, which is a result of the air being able to penetrate into the bean canopy. Now compared to Figure 35 the deposit on the beans is reduced and receives less than the other zones within the plant canopy. This reduction is due to the lack of spray penetration into the bean canopy with just over the top spraying.

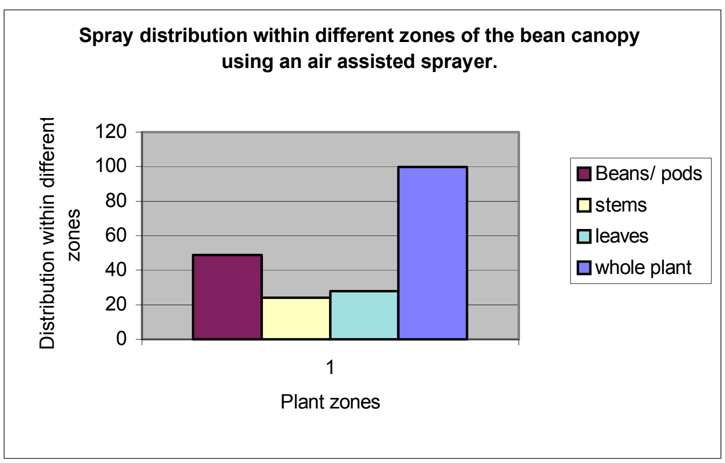

Figure 34. The percentage distribution of the total spray recovered from different zones within the bean canopy.

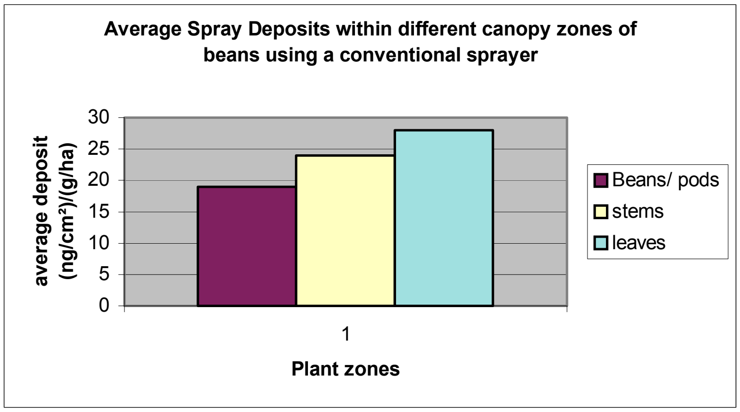

Figure 35. The average spray deposits and distribution of the total spray recovered from different zones within the bean canopy.

Air-assisted sprayers improve penetration and coverage

Air-assisted sprayers offer many advantages compared to conventional spray booms. An axial flow fan, usually hydraulically powered, is used to create air and this is then ducted through a bag attached along the boom. Along the bottom of the air bag this air is released as an air curtain. The air curtain produced by these sprayers assists in the reduction of drift and improves spray penetration into the canopy of crops. The air curtain also produces turbulence within the crop which can result in improved coverage on the undersides of leaves and hard to get at targets such as the flowers and pods. Some sprayers have the capability to alter the direction of the air curtain. Rather than straight down it may be orientated forward or backward to the direction of travel. This enables spraying to be undertaken in less than optimum conditions when strong wind may otherwise cause large spray losses. Even under ideal spraying conditions, spray penetration and coverage may also be improved in parts of some crops by having the air curtain directed forwards or backwards.

Ground based non- air assisted sprayers - penetration and coverage

With over the top spraying without air assistance, it is harder to get spray into the bean canopy as the leaves cover most of the pods and flowers and as a result filter out significant amounts of the spray being applied. Trials at the Gatton Research Station have looked at spray deposition on the pods and flowers to get some base level readings of what standard over the top sprayers can achieve. The results of this base level data is shown is Figure 36. From this we can use the data when comparing improvements to see if a greater proportion of the spray being applied to the crop is increased in the flowers and pods.

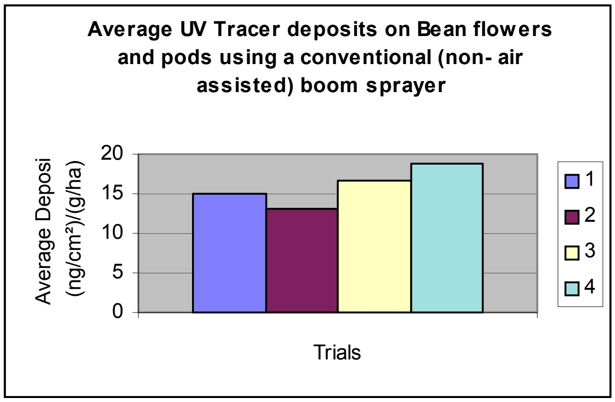

Figure 36. Baseline data –4 trials looking at conventional spraying of beans without air assistance. This data will set a base trend line for conventional spraying in beans.

<u>Improving application – nozzle selection</u>

Spray nozzles are the most important component of your spray boom. They not only meter the pesticide mixture emitted and hence determine the application volume and pesticide dose per hectare but also produce droplets of an appropriate size for obtaining optimum coverage. Nozzles wear, which means they need replacing. The frequency depends on the products used through them, the nozzle material and the amount of use they get. Nozzles also come in a range of types (i.e. hollow cone, flat fan, twin-fan patterns and many more). All nozzles are designed for a specific job and this often relates to the spray quality they produce. If off-target drift is a concern then you will be particularly interested in the spray quality of a nozzle as this relates to the range of droplet sizes produced especially at the fine end of the droplet spectrum.

Nozzles can be important in achieving increased deposition within the canopy of different crops including beans. Trials have been conducted at Gatton Research Station in the Lockyer valley Qld, to assess the effects of using different nozzles to increase penetration into the bean canopy.

These trials showed that there was no significant difference between using air and no air for each nozzle treatment. Figure 37 shows the result of these trials, from which it can be seen that, although there was no significant difference, there was a slight increase in deposit using hollow cone nozzles with air assistance compared to other nozzles trialled. There was a significant difference between nozzles when using air assistance with hollow cones found to be significantly better than twinjet or flat fan nozzles.

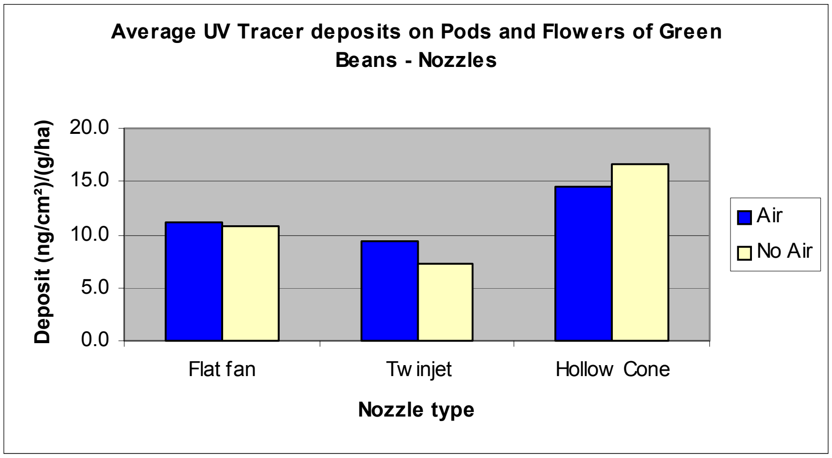

Figure 37. - Nozzles assessed with and without air assistance.
This work was conducted at Gatton Research Station.

<u>Improving application when using aircraft</u>

The main areas where the performance of aircraft can be improved are: (i) improving the uniformity of a single deposit pattern; (ii) flying an appropriate swath width; (iii) maintaining a consistent swath across the field; and (iv) selecting nozzles that produce an appropriate droplet size range. Aircraft set up to apply insecticides to broadacre crops are not necessarily optimised for spraying green beans. Aerial operators should have their aircraft calibrated (pattern tested) so that the swath width they select for applying insecticides to green beans produces uniform deposits across a field.

Additional application experiments

Additional experiments were conducted at Gatton Research Station (October & December 2004) to determine how best to target flowers and immature pods in green-beans with a tractor mounted hydraulic boom spray. Variables that were further assessed included nozzle types, air assistance and spray boom angle. Residue analysis of a fluorescent tracer from flower and pod samples was used to quantitatively assess application efficacy.

Materials and Methods

An experiment were conducted at Gatton Research Station to determine how best to target flowers and immature pods in green-beans with a tractor mounted hydraulic boom spray (Table 9). The experiment was a three-way factorial designs with six replicated samples of five flowers and five pods taken from single treatment blocks (6m x 20m).

Table 9. Experimental parameters for spray trial conducted at the Gatton Research Station on the 6th December 2004.

Nozzles
Fine hollow-cone (medium droplet)
Medium hollow-cone (medium droplet)
Low-drift flat-fan (medium droplet)
Twin flat-fan (medium droplet)
Air assistance
On
Off
Boom angle
Straight down
Slightly forward
Other detail
Water volume 470L/ha

Figure 38. Nozzles used in trial. From left to right Hardi 1553-40 with blue swirl plate (fine hollow-cone), Hardi 1553-14 with black swirl plate (medium hollow-cone), Hardi ISO LD-110 03 (low-drift flat-fan)& Tee Jett TJ-110 03 (twin flat-fan).

Nozzles were checked for flow-rate uniformity (+/-5%) before spraying. The spray boom consisted of ten nozzles at 50cm intervals. The boom was operated 0.5m above the crop canopy. Hydraulic pressure in the spray line was maintained at four bars and the application rate was controlled via the tractors traveling speed. The spray application rate was monitored in real-time with an electronic control unit in the tractor cab.

A fluorescent tracer (Ciba-Geigy Fluorescent tracer stardust) was added to the water in the spray tank. A sample of the spray tank solution was kept and the tank concentration later measured using a fluorometer.

Plots were then sprayed according to their relevant treatments. Flower and pod samples were taken within 30 minutes of spraying to minimise UV-degradation of the fluorescent tracer. Samples were kept refrigerated and extraction of the fluorescent tracer from the samples was conducted within 48 hours of collection.

A fluorometer measured the quantity of fluorescent tracer extracted from the samples. A stock solution of 400µg fluorescent tracer per litre of chosen solvent and a control solvent solution were used to calibrate the fluorometer. Ethyldigol was used for all other extractions. Samples were placed in a glass jar with an adequate volume of solvent to thoroughly cover the sample and remove the fluorescent tracer (10-20ml) and shaken vigorously fifty times. The solvent was then poured through filter paper into a curvette and its fluorescence measured (if samples measured greater than 400µg/l then this solution would require further dilution, this was not necessary in these experiments).

Results expressed as nanograms (ng) of active ingredient per flower or pod at an application rate of 100g/ha, were calculated using a combination of solvent volume, tank concentration and spray application volume. Results were analysed using multiple ANOVA and LSDs ($P \leq 0.05$) in Genstat 6.1 for Windows.

Results and Discussion

Nozzle selection

Flowers. Deposition with air assistance "ON" provided a slightly higher average chemical deposition per flower than with air assistance off, although increases were not significant in this experiment (Figure 39). It was expected that air assistance should have increased deposition on flowers by allowing more spray to penetrate the leaf canopy through disturbance of the leaves as well as from the reduced chemical drift, which is minimised when using an air assistance curtain. The beneficial effect of using the air-assisted curtain was best highlighted when combined with the fine hollow-cone nozzle. In this case, poor deposition from the fine hollow-cone nozzles without the air-assisted curtain increased vastly to become comparable with the other nozzles when combined with the air-assisted curtain (Figure 40).

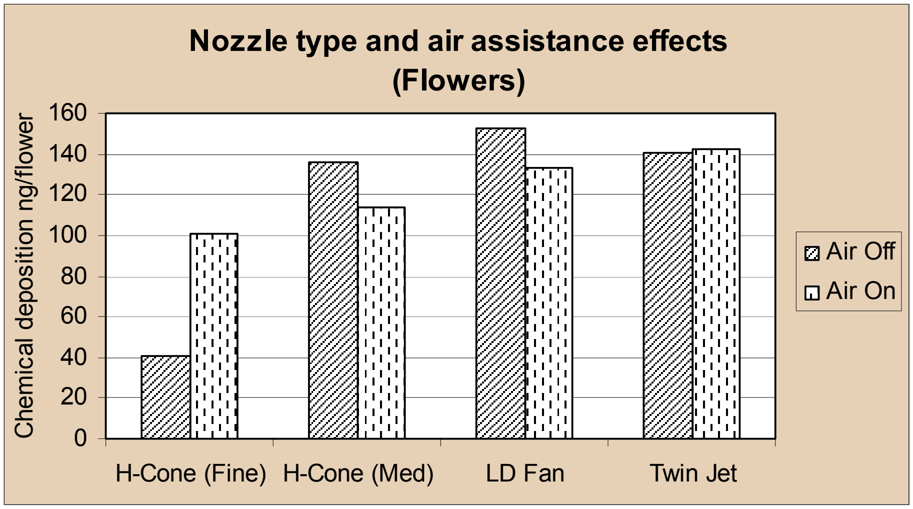

Figure 39. Fluorescent tracer recovered from flowers looking at nozzle selection with air assistance "ON" and "OFF" using 570L/ha at 4bar pressure.

Air assistance possibly increased deposition on pods because of a number of factors including increased spray penetration of the leaf canopy via disruption of the leaves. Air turbulences aiding interception of spray onto vertically orientated pods and less drift allowing more spray to reach the crop.

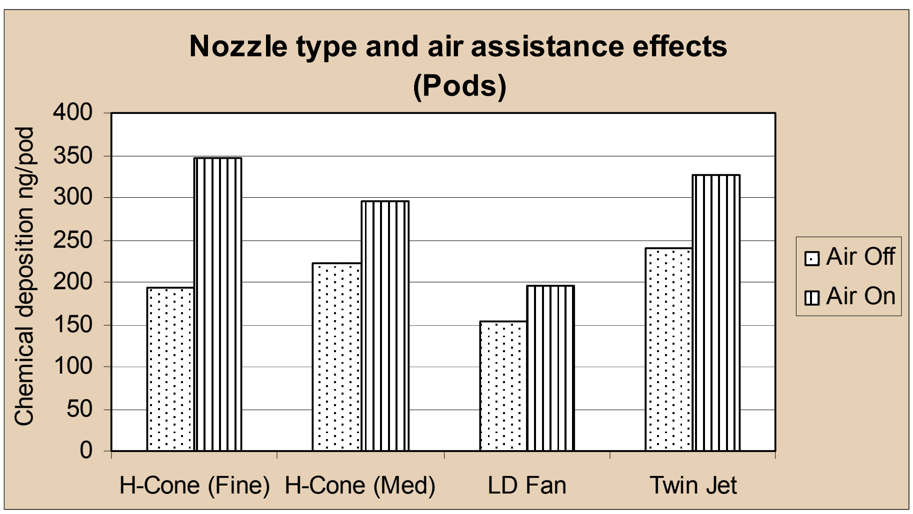

Figure 40. Fluorescent tracer recovered from pods looking at nozzle selection with air assistance "ON" and "OFF" using 570L/ha at 4bar pressure.

Boom angle

Titling the boom forwards marginally increased the chemical deposition on flowers but was not significant (Figure 41). Titling the boom forwards increased deposition of chemical on pods, the increase in deposition was significant when combined with the fine hollow-cone and twin-jet nozzles (Figure 42). Tilting the boom forward changes the trajectory of spray droplets possibly allowing them to better intercept the vertically orientated pods. When using the air-assisted curtain with the boom tilted forwards, the turbulence from the air curtain appears to turn the leaves over which would allow better penetration of the droplets below the leaf canopy?

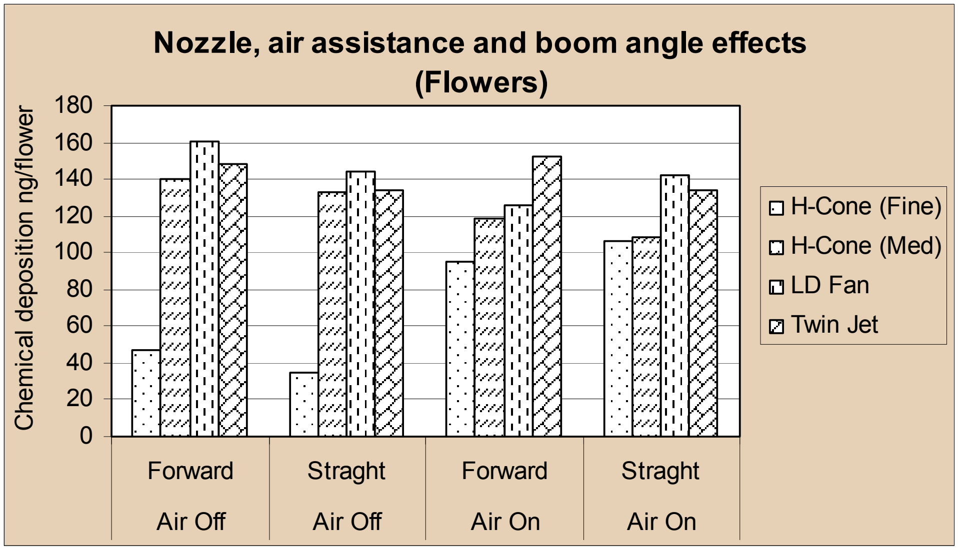

Figure 41. The effect that air assistance, boom angle orientation and nozzle selection has on spray deposits on green bean flowers.

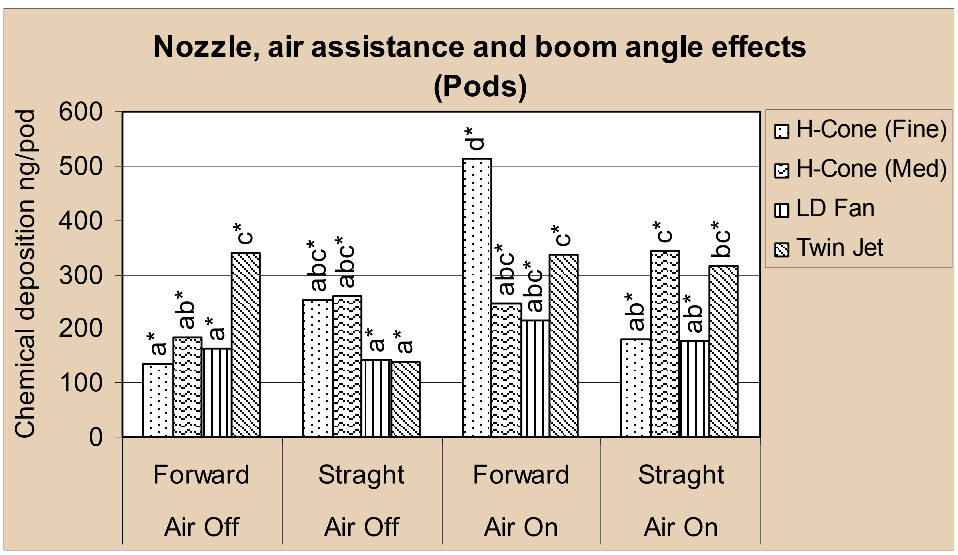

Figure 42. The effect that air assistance, boom angle orientation and nozzle selection has on spray deposits on green bean pods.

Conclusions

Many commonly used pesticide application techniques have been evaluated for their efficiency in targeting insecticides to flowers or pods. Using fluorescent tracers, spray deposits on pods and flowers have been collected for a range of equipment types. Some of the techniques evaluated have produced improvements to conventional application methods. Even though the equipment used is important when applying insecticides to green beans the bean canopy also has a large influence on the spray penetration and spray distribution on the plant. The distribution on the plant is difficult to manipulate when spraying over the top with a boom. The following conclusions can be drawn from the field trials undertaken so far.

- The type of nozzles to use.
  Most nozzles used on sprayers employed to spray commercial bean crops are wide-angle flat fans. There is considerable scope to investigate a range of different nozzle types (hollow cones, twin-fans and even fan nozzles) to determine whether they produce better spray deposit levels on pods compared to tapered flat fan nozzles. Nozzle pressure may also have a large effect on penetration into the bean canopy. The trials carried out in this project looked at four bar pressure. Hollow-cone nozzles appear to be the most effective when targeting spray deposition onto flowers and pods, particularly when used with an air assisted curtain.
- Application Volumes.
  Wide ranges of application volumes are used when applying insecticides to beans (100 L/ha to 1300 L/ha). Increasing volumes will not necessarily increase spray deposit on the flowers and pods, especially if the pods are drenched and run-off occurs. Further trials are still required to assess the efficiency of different application volumes.
- Air-assisted boom sprayers and angling the boom sprayer.
  Using an air-curtain and angling the boom forwards will allow better targeting of the spray to the flowers and pods. The use of an air curtain increased deposition on bean flowers and pods, possibly by reducing chemical loss through wind drift (visually observable during the trials), disruption of the leaf canopy allowing better penetration of spray droplets into the crop and air turbulence within the crop increasing spray droplet interception with flowers and pods. Angling the boom forward would change the trajectory of the droplets increasing their chance of intercepting a vertically orientated bean pod.

Technology transfer

An article on spray application as part of this project was produced in the "Fruit & Vegetable New" May 2004 Appendix 2. Spray application was discussed as part of a grower field day at Gympie in November 2005. Unfortunately a scheduled night walk was washed and blown away literally by a severe storm. This part of the pesticide application demonstration was conducted at a varietal field day just outside Gympie with growers impressed by the results. A fluorescent dye was added to a standard boom and a CDA sprayer. A Milestone No 4 report was produced and sent out to all stakeholders on the beans database titled "Improving Pesticide Application Technology – Green Beans". An article on the spray application work was also presented in volume 3 of the green bean IPM newsletters.

Recommendations

Spray application is an area which still needs a great deal of work carried out on it. There are so many variables that need to be taken into account when dealing with this topic which could help growers better understand the pros and cons behind the different types of equipment and how best to use what they current have.

Acknowledgments

Thanks to Glenn Geitz and Peter Scholl for carrying out the work needed for the spray application part of this project. Thanks also to Carolyn Lee, Sandra Dennien and Luke Jackson for their assistance in collecting spray samples and to David Schofield and the DPI&F farm staff for their assistance with trial sites and spraying of the trials.

Grower Database

Introduction

In order to make sure all the information generated from this trial and a closely related trial in green beans was communicated to growers in particular, a database was created and stored on the server at the Gatton Research Station, Department of Primary Industry and Fisheries. This database was updated when new stakeholders notified us or when contact details for existing stakeholders changed. The initial newsletter included a questionnaire for information including contact details and whether stakeholders were still interested in receiving information on green beans as part of this project. Email was the preferred means of communicating information, newsletters and reports, but not all stakeholders had this option so some stakeholders still received hardcopies of the various newsletters and reports created from this project.

Green beans database

A breakdown of those on the green beans database is as follows;

Queensland	82	
NSW	30	
NT	1	
SA	2	
Tasmania	23	
Victoria	9	
WA	5	
Others	5	(Stakeholders that have not included postal addresses, only email)
Total	**156**	

A breakdown of stakeholders according to industry type includes;

Growers	67
Consultants	14
Grower groups	7
Researchers	16
Extension officers	7
Field officers	7
Seed Co.	7
Chemical Co.	7
Managers	2 (1 of which is Mulgowie Farming Company)
Others	22 (Include HAL, Ausveg, misc.)

Mulgowie Farming Company has a number of growers that grow green beans for them and so may not be on our database even though the questionnaire went out at the start of the project seeking grower information. There is some indication that there could be in excess of 50 additional green bean growers out there that are not on this database. Mulgowie Farming Company asked early in the project if they could deliver the newsletter themselves to their own growers.

As the information became available from this project, for example newsletters and reports, the preferred method of distribution was via email. Not all stakeholders in the database had this as an option so hardcopies of the various newsletters and reports was posted out to them.

A breakdown of numbers follows;

Stakeholders with email	99
Stakeholders without email	57

Technology transfer

Five newsletters (Appendix 3) have been sent out to all stakeholders on the database with a sixth newsletter in production. Two reports, one on the seasonal abundance of insect pests and beneficials and the other on the BMO trials were also sent out to all stakeholders. A series of DPI notes have been produced and placed on the DPI's web site http://www2.dpi.qld.gov.au/thematiclists/1182.html

Recommendations

This database will be kept and used as part of the extension to this project to help with the distribution of a proposed Ute Guide and the dissemination of information from the disease project in green beans.

Acknowledgements

I would like to thank Peter Deuter for designing the database and maintaining it during the life of this project.

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Appendix 1

On The Land

Field day looks at bean quality

Story: Peter and Bevly Hughes

HANDPICKED fresh Gympie beans attract a premium on the wholesale markets.

The handpicked beans are marketed as an exclusive quality product.

To help maintain that high level of quality and to reduce the dependence on continuous spray regimes for pest and disease control, Gatton DPI&F entomologist John Duff has been conducting field work in the Gympie area.

He explained some of his findings at a field day on Martin Wilson's Lagoon Pocket farm attended by about 40 growers representing a bit less than half that number of farms.

"We have been trying to find the 'best management options'," he said, "trying to get away from the previous reliance on a rigid chemical control operation."

Mr Duff said that the experimental blocks were split between the "best management option" and current Wilson farm practice.

"A lot of research emphasis was placed on getting the best control for serious pests such as bean fly, white fly and jassids," he said.

"These are insects that can wipe out a potential crop."

Regular insect pest monitoring was carried out in both experimental blocks. The 'bmo' consisted of a soil application of Confidor™ at planting and a single application of Bt at four weeks. The 'farm' application consisted of four insecticide sprays during the same period and there was no discernible difference in plant growth or yield on the bush.

Both areas had fungicide applied for rust control.

Unfortunately, shortly after the end of the field day the Wilson property was hit by a damaging hail and wind storm that destroyed the bean crop so crop weights will not be possible.

In a pre storm grower inspection of the two blocks the general opinion was that there was no discernible difference in yield or plant growth.

Mr Duff said that Confidor™ is a systemic insecticide that is taken up as soon as the seed germinates.

"This gives the seedling protection, especially against bean fly, from the moment it emerges from the ground," he said.

"The timing is critical as a crop can be ruined within a few days by bean fly infestations."

Mr Duff said that the 'bmo' treatment may be seen as a bit more risky system but regular monitoring and use of yellow sticky traps can give indications of insect conditions in the crop.

"While the trial result will vary at different locations and at different times the overall principles will remain the same.

"The 'bmo' system can reduce the number of insecticide applications, a big saving in chemicals and time, without reducing bean yield."

An important result of 'bmo' is that there has been a large increase in the prevalence of beneficial insects in the crop.

Mr Duff said that these insects are there and can make a difference in pest control.

"The use of regular harsh chemical agents kills off the beneficial populations very quickly," he said.

Confidor™ was applied at the rate of 25ml per 100m of row by a direct spray jet into the planting furrow before it was covered. The spray jet is a relatively easy adaptation to make on most planter types.

NSW DPI plant pathologist Andrew Watson gave a brief run down on Sclerotinia management in fresh beans.

He said that stopping afternoon or evening irrigation, and strategic fungicide use at flowering can reduce the incidence.

"If you have a problem each year you may have to consider your bean growing future as the disease can persist for five years or more in the soil," he said.

A demonstration of spray coverage effectiveness using ultra violet was not possible due to the storm.

"A lot of research emphasis was placed on getting the best control"

APPLICATION: Martin Wilson points out the Confidor™ application jet retro fitted to the bean planter.

EXPERIMENT: Craig Mellor, of Goomboorian (left), Department of Primary Industries and Forestry entomologist John Duff (centre) and Scott Tramacchi, of Kia Ora in front of a 'bmo' experimental block. Last week's damaging storm was approaching in the background when this photograph was taken.

IN THE FIELD: Department of Primary Industries and Forestry advisor Paul O'Hare (left) and Mooloo bean grower Ken Buchardt check the yield from the 'bmo' plants.

www.gympietimes.com.au

THE GYMPIE TIMES, Wednesday, November 23, 2005. Page 25

Appendix 2

and endosulfan off-label permit use are the current means of controlling fruit spotting bug.

Further, caterpillars are managed with an off-label permit for *Mimic* but using a monitoring system in conjunction with sprays improves the effectiveness of the application. Earwigs are predators to other pests but cultural methods are employed—including removing mulch and trunk protectors at the base of the tree—to prevent earwigs from chewing off new buds. Applying sticky substances to the tree trunk can also deter earwigs but is a time consuming practice. Fruit fly species are managed through baiting, exclusion netting and cover sprays with *Lebaycid*.

There are few diseases affecting persimmons. *Mancozeb* is the main disease management tool with chlorothalonil as an alternative. It is recommended care be taken when using chlorothalonil, as some burn may result.

Cultural management practices such as maintaining plant nutrition and pruning are also practiced.

QFVG has received a permit for the use of *Chlorpyrifos* to control ants on persimmons – valid until 31 March 2009. QFVG has also received a permit for the use of *Buprofezin* (Applaud) to control scale and mealy bug on persimmons – valid until 31 March 2008.

For information contact QFVG Pest Management Officer Janine Clark on 07 3213 2444 or growerchampions@qfvg.org.au

Horticulture Australia

The air assisted spray rig used in the bean spraying trial at Gatton

Making the most of pesticide spraying

Spray trials are pointing the way to getting top efficiency when applying pesticides to a range of vegetable groups.

The trials, supported by Horticulture Australia, were part of a national integrated pest management (IPM) project to provide information to bean growers on maximising spray efficiency.

Spray rigs and nozzles were matched to the special requirements of crops such as beans, under different weather conditions. Similar work was conducted with sweet corn, onions, brassicas, lettuce and onions.

The plan was to minimise off-target losses and at the same time maximise canopy deposits where they were needed.

The latest trial with beans recently finished at Gatton and was being repeated at Stanthorpe. The information from the trial will be relayed to growers through field days and demonstrations later this year.

In the Gatton bean trial, an air assisted boom sprayer was used with different configurations to apply pesticides to the canopy, particularly the flowers and the beans.

The crop was sprayed at two weeks after flowering with bean pod sizes around 1–5cm long.

Fluorescent tracers were used to measure the amount of spray deposited on each plant at different locations.

The spray rig was run with full, partial and no air assistance and flat fan nozzles at an application rate of 300 litres per hectare.

There were three important issues to emerge from this and other trials:

- increasing the spray volume to up to 500L/ha until there was run-off gave improved coverage in affected areas
- the most appropriate nozzles to use depended on wind conditions and should be varied accordingly
- an application pressure of 3-6 bars gave best results.

For information contact QFVG Grower Services Manager Richard Ross on 07 3213 2444 or growerchampions@qfvg.org.au

Appendix 3

green beans IPM newsletter

keeping you up to date with Insect Pest Management (IPM) in green beans

Volume 1 August 2003

Integrated Pest Management in the Green Bean Industry
[HAL Project – VG02030]

Project Leader

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Welcome to the first edition of the Green Beans IPM Newsletter. Over the next few editions of this newsletter we will bring you up to date with the outcomes of the joint DPI - HAL "Integrated Pest Management in the Green Been Industry" project. This project aims to develop a clearer understanding of the pest and beneficial insect spectrum found with in the crop; assess a range of Best Management Options including Application techniques; and undertake efficacy trials to aid the registration of some of these newer insecticides.

This project has been initiated by growers, who were aware of the requirements for an integrated approach, and have seen the benefits in the sweet corn industry through VG97036 (Insect Pest Management in Sweet Corn) and the brassica industry (Improvement in Integrated Pest Management of Brassica Vegetable Crops in China and Australia.

Growers have noted that control of heliothis in particular has declined in recent years. New narrow spectrum and beneficial friendly insecticides are needed so that an integrated pest management system can be implemented. In this project we will undertake efficacy trials to aid the registration of some of these newer insecticides, especially those that are effective on heliothis and a range of other green bean pests.

An understanding of the pest spectrum and how beneficial insect populations may be increased, will benefit growers and crop consultants in deciding what management practices need to be undertaken to minimise the pest levels and crop damage.

As has been the case in other successful IPM projects, Best Management Options (BMO's) will be assessed. These BMO's will include a range of management options that will impact on the pest(s) populations while at the same time safe guarding the suite of beneficial insects likely to be found in green bean crops.

A national stakeholder database will be developed to assist in the dissemination of information on the outcomes of this project, and to promote the benefits of implementing an IPM system in green beans.

Future newsletters will cover the following topics :-

- Pests and Beneficial Insects in Green Beans
- Biological Insecticides
- Pesticide Application

Project Team Members

John Duff, Peter Deuter, Paul O'Hare, Glenn Geitz, Bronwyn Walsh, Carolyn

Horticulture Australia

Pesticide Application Grower Survey - **see p 3.**

Queensland Government
Department of Primary Industries

Other Technology Transfer

Results from the project were presented at the AusVeg conference in May 2006 in an aural presentation and 2 posters on the range of insect pests and beneficial found in green beans. An article was also written for the Vegetable Australia magazine Vol. 1.6 which is below.

Queensland growers lead Australia's green bean industry, producing crops worth more than $60 million annually, yet, as Jodie Powell discovered, they are also plagued by more pests than anywhere else in the country.

With Australia's green bean industry worth more than $60 million, growers nationwide are keen to find a better solution to pests that strip millions of dollars in profits from plants in the field.

A four-year project spearheaded by researchers at the Queensland Department of Primary Industries and Fisheries based at Gatton, west of Brisbane, is yielding good results in the search for new methods.

Among the findings is promising research that shows in-soil chemical applications can dramatically reduce the occurrence of three major pests that destroy green bean crops each season.

"We particularly wanted to find out about beneficial insects, because they're the guys that work 24 hours a day as free labour which help to manage other insect pests."

Project leader and entomologist John Duff said the pests cost growers hundreds of thousands of dollars each year in unsaleable crops.

Growers have traditionally relied on insecticides to control persistent seasonal pests such as heliothis and other caterpillar pests, as well as the silverleaf whitefly.

But John said his team had found a combination of insecticides that could reduce the number of applications needed throughout the growing season – potentially cutting the cost to growers and vastly improving yields.

When John's project began just over three years ago, the aim was to find alternative ways of managing insect pests.

"Once heliothis gets into the bean, you can't sell it," John said.

The team began with a series of plantings without chemicals to find the full range of insects and pests attracted to bean plants.

"We particularly wanted to find out about beneficial insects, because they're the guys that work 24 hours a day as free labour which help to manage other insect pests.

"With the beneficial insects, we looked at their use in other cropping situations because integrated pest management is being looked at in a whole range of crops, and we want to try to encourage growers to look for those insects."

Most of Queensland's green beans are grown in the state's south east and in the north around the Bowen and Burdekin area, with smaller growing areas around Bundaberg and Gympie.

It was at Gympie that a field trial demonstrated the effectiveness of in-soil pesticide application at the time of sowing, careful insect pest monitoring and timing of appropriate insecticides.

In October and November last year, John and his team compared their methods of planting and pest control with those of a local grower.

The grower produced his crops using more traditional methods, while John's team took an alternative approach based on their research.

"We put chemicals on at the time of planting and one insecticide application four weeks later for heliothis control, whereas the grower put five applications of insecticides, but no in-soil applications," John said.

"We found in-soil pesticides don't only control silverleaf whitefly, but they also control bean fly and appear to manage the vegetable leaf hopper, or jassids."

More than 30 growers from the region attended a field day at which the team explained its findings and showed the two crops for comparison.

"The growers couldn't see any difference between [the quality of] the crops.

"We did the harvest on our trial and on his [the local grower's] block and there was very little difference between the results as to [pest] damage and yield.

"They were very impressed with the fact that you can reduce your insecticides."

As a result of the success in Gympie, John is now looking at further trials near the department's research station at Gatton.

The team is also looking at the use of a product called Magnet, which is an attractant laced with an insecticide and applied sporadically throughout the crop, and John said the results from other research looked good.

"We're trying to reduce the number of sprays a grower might need to put on."

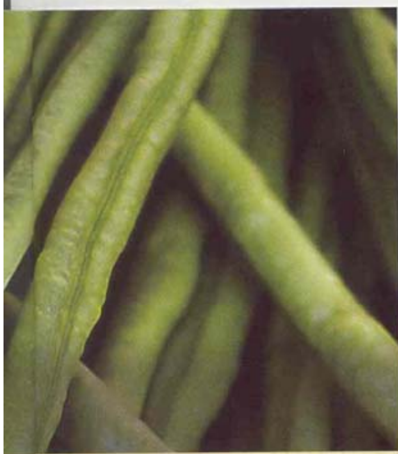
As part of the project, a series of farm notes and fact sheets will be made available to growers.

Source: Peter and Bevly Hughes

Above: L-R Craig Mellor, Goomboorian; John Duff, DPI&F Entomologist; Scott Tramacchi, Kia Ora, in front of Best Management Options experimental block of green beans near Gympie.

Below: Martin Wilson points out the Confidor application jet retro fitted to his bean planter.

Source: Peter and Bevly Hughes



The bottom line:

- Researchers have trialled in-soil chemical applications for controlling a range of pests in green beans.
- These new methods may reduce the need for heavy insecticide use.

For more information: Visit www.ausveg.com.au/levy-payers/login.cfm
Project number: **VG02030**
Keywords: **Green beans**

The main pests

The insidious heliothis moth tops the list of green bean crop pests in many regions.

The moth lays its eggs on bean plants and when they hatch, caterpillars chew their way though flowers and developing pods, in some cases worming their way inside the pods themselves.

Queensland entomologist John Duff said the heliothis caterpillars could be very difficult to control because they were present for most of the growing season, although numbers reduced in winter growing regions.

John said growers also faced crop damage from bean pod borers, which wreaked the same havoc as heliothis, although borer caterpillars were only found inside the pods.

He said the occurrence of silverleaf whitefly had increased dramatically since it was first discovered in the Northern Territory in 1989.

"It originally came in from the States in the late '80s and has spread around the country - it prefers hot conditions," John said.

"The problem is it's very resistant to a lot of insecticides and you have to throw everything you've got at it."