Thrips management in the green beans industry

John Duff
Department of Employment, Economic Development & Innovation

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HAL **VG07017**

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This project investigated alternative chemical control options for thrips in Queensland and Tasmania. This project also looked at the nature or "wind scorch" under Tasmanian growing conditions and the role that thrips play in this disorder: do they exacerbate the symptoms, cause the symptoms or is wind the sole contributor to this disorder.

Report Completed –9 January 2012.

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Contents

Product formulations used during this project

Insecticide Product	Active ingredient	Chemical group	Chemical company
Actara®	thiamethoxam	4A	Syngenta Crop Protection
Confidor®	imidacloprid	4A	Bayer Crop Science
Dimethoate	dimethoate	1B	Nufarm Australia
Durivo®	thiamethoxam + chlorantraniliprole	4A/28	Syngenta Crop Protection
HGW86 (Cyazypyr)	cyantraniliprole		DuPont Australia
Karate® with Zeon technology	lambda-cyhalothrin	3A	Syngenta Crop Protection
Lannate®	methomyl	1A	Crop Care Australasia
Movento®	spirotetramat	23	Bayer Crop Science
Samurai®	clothianidin	4A	Sumitomo Chemical
Success™ 2	spinosad	5	Dow AgroSciences

Abbreviations used throughout report

ABS – Australian Bureau of Statistics
APVMA – Australian Pesticides and Veterinary Medicines Authority
BBCH - Biologische **B**undesanstalt, Bundessortenamt and **CH**emical industry
The extended BBCH-scale is a system for a uniform coding of phenologically similar growth stages of all mono- and dicotyledonous plant species.
CaCV – Capsicum Chlorosis Virus
HAL - Horticulture Australia Limited
ICM - Integrated Crop Management
IYSV – Iris Yellow Spot Virus
QDPI&F - Queensland Department of Primary Industries and Fisheries
® - Registered Trademark
SLWF - Silver leaf Whitefly
SPs - Synthetic Pyrethroids
™ - Trade Mark
TSWV – Tomato Spotted Wilt Virus

Media Summary

Thrips in green beans are a continuing problem for bean growers from north Queensland all the way to Tasmania, with the majority of fresh market beans grown in Queensland and the majority of processing beans grown in Tasmania. Thrips damage the developing pod while it is still enclosed within the flower making it extremely difficult to target the pest with appropriate insecticides. There have been 13 different thrips recorded from bean flowers, some of which may be using the flowers for shelter, but others that are regularly found within the flower and are known pests of crops. The thrips found to date include;

- *Megalurothrips usitatus* or bean blossom thrips
- *Frankliniella occidentalis* or western flower thrips
- *F. schultzei* or tomato thrips
- *Thrips tabaci* or onion thrips
- *T. imaginis* or plague thrips and possibly
- *Pseudanaphothrips achaetus* or hairless flower thrips

The trial work in Queensland concentrated on finding suitable insecticide control options in addition to those currently recommended for use in green beans. Different application methods were also investigated, such as ground application at planting and foliar application at flower bud formation.

Thrips populations in spring, although more than 5 thrips per flower, equated to 10% unmarketable pods in the untreated control. In contrast, the autumn plants suffered severe pod damage, with on average 50% of pods unmarketable, resulting from on average 1 thrips per flower. The Success™ (spinosad) treatment during the autumn 2008 trial appeared to give the best return on healthy pods, however this was not the case when applied as a mix with dimethoate during the 2010 autumn trial. No other treatment performed significantly better than the unsprayed control treatment. Movento® (spirotetramat) and those treatments with spinosad significantly reduced the larval populations, especially during the autumn trials. This reduced larval count increased the percentage of clean pods slightly but was not significantly better than the other treatments.

The Tasmanian component of this project was designed to determine if 'wind scorch' damage in Tasmanian green bean crops is at least partly the result of thrips feeding on the developing pods inside the bean flowers. This type of damage can be as high as 10% scaring which would result in the complete crop being rejected by the processor due to the increased cost associated with sorting at the processing plant. The ideal level of damage would be less than 4% damage whether it is due to thrips and/or wind scorch symptoms. The Tasmanian trials focused on the effect of wind and thrips populations on damage to pods. The results showed that the major cause of wind-scorch is wind and that the incidence of these symptoms may be reduced and the yield of marketable pods increased by installing wind-breaks. However, this may increase the incidence of disease such as *Sclerotinia* rot, and since there are many variables involved the severity of the disease will be unpredictable. When thrips numbers are high, insecticidal control resulted in only 6.4% thrips damage compared to between 14.2 -22.1% pod damage in untreated plots. The use of strip plantings with taller crops or wind breaks around paddocks could help in reducing the severity of wind scorch on Tasmanian properties.

A better understanding of thrips population dynamics is a must for future research due to the large number of thrips genera and species found within bean flowers as well as the numbers required to trigger a spray decision depending on the species identified at the different times of the year.

Technical Summary

Thrips species in green beans are a continuing problem for bean growers from north Queensland all the way to Tasmania, with control options interfering with any Integrated Crop Management, ICM, program that growers may wish to implement on their farm. This project leads on from HAL projects VG02030 "Integrated Pest Management in the Green Bean Industry" and VG06016 "Green Bean Ute Guide". This project concentrated on alternative insecticides under Queensland growing conditions with limited insecticide trial work undertaken in Tasmania. The bulk of the Tasmanian work centred around clarifying the difference between thrips damage and wind scorch and whether growers could increase their yield if an appropriate insecticide was used to manage their thrips populations.

Thirteen (13) different thrips from seven (7) genera have been identified from green beans to date, from both leaves and flowers, including:

- *Desmothrips tenuicornis* (QLD)
- *Frankliniella occidentalis* Western flower thrips (QLD)*
- *Frankliniella schultzei* Tomato thrips (QLD)*
- *Haplothrips spp.* Gold tipped tubular thrips (QLD and TAS)
- *Limothrips cerealium* Grain thrips (TAS)
- *Megalurothrips usitatus* Bean blossom thrips (QLD)*
- *Pseudanaphothrips achaetus* Hairless flower thrips (QLD and TAS)*
- *Thrips imaginis* Plague thrips (QLD and TAS)*
- *Thrips palmi* Melon thrips (QLD)
- *Thrips parvispinus* Taiwanese thrips (QLD)
- *Thrips safrus* Plague thrips (QLD)
- *Thrips tabaci* Onion thrips (QLD and TAS)*
- *Thrips vulgatissimus* White flower thrips (TAS)*

Those with an asterisk were the major thrips found in green bean flowers.

The Success™ (spinosad) treatment during the autumn 2008 trial gave the best return on healthy pods, however this was not the case when applied as a mix with dimethoate during the 2010 autumn trial. No other treatment performed significantly better than the unsprayed control treatment with regards pod damage. Movento® (spirotetramat) and those treatments with spinosad significantly reduced the larval populations.

There was a distinct difference in the population make up over the season, particularly in the Queensland populations. Although there were high populations of thrips in spring (up to 5 thrips per flower in the unsprayed control) nearly 90% of the pods were still marketable regardless of the insecticide treatment. No work has been undertaken on thresholds, although one north Queensland crop consultancy business was recommending insecticidal control when thrips numbers were 10 per meter of row. Bearing in mind that one meter of row can have approximately 20 plants and each plant can produce approximately 10 flowers. That is potentially 200 flowers per meter of row or one thrips per 20 flowers, which is a very low threshold. A grower may end up spraying constantly with such a threshold.

In spring, *F. occidentalis* was the most prevalent thrips (2.8-27.6 thrips per 10 flowers) and *M. usitatus* numbers were very low (0-0.25 thrips per 10 flowers). In contrast, the autumn plants suffered severe pod damage with on average 50% of pods marketable. This period corresponded with higher numbers of *M. usitatus* in the flowers with between 1.9-3.3 thrips per 10 flowers during the autumn 2008 trial and 1.9-5.5 per 10 flowers during the autumn 2010 trial. *F.*

occidentalis numbers during the 2008 trial ranged from 0.3-1.2 thrips per 10 flowers but increased to between 3.5 and 23.8 thrips per 10 flowers during autumn 2010. This increase in *F. occidentalis* numbers in the 2010 trial did not significantly increase the amount of damage to the pods, with 51.05% marketable pods in 2008 compared to 49.91% marketable pods in 2010 for the unsprayed control treatments. These results suggest that *M. usitatus* might be more responsible for pod damage than *F. occidentalis*.

The Tasmanian component of this project was designed to determine if 'wind scorch' damage in Tasmanian green bean crops is at least partly the result of thrips. A series of trials were undertaken during the 2008/09 and the 2010/11 growing seasons to look at this problem. These trials focused on the effect of wind and thrips populations on damage to pods with the following treatments:

- Low wind and Low thrips
- High wind and Low thrips
- Low wind and High thrips
- High wind and High thrips

Maximum wind speeds of 52km/hr were recorded during the 2010/11 trial period. Low wind speeds would be close to zero due to the barriers protecting the plots.

Dimethoate was used to manage thrips numbers in these trials. There was no doubt that the spray program of dimethoate achieved its objective in creating two distinctly different sized populations of *Thrips* spp. The population of *Thrips* spp. in dimethoate treated beans was as low as 56 thrips in 25 flowers per plot compared to 178 thrips in 25 flowers in the untreated plots. In a later trial, the populations of thrips were much lower with the treated plots recording 0.4 thrips per 25 flowers while the untreated plots had up to 5 thrips per 25 flowers by trials end. This distinct reduction in numbers between trials is due to seasonal variation and may be temperature related.

At Site 1, the day before dimethoate was first applied there were significantly ($p \leq 0.050$) more adult *T. imaginis* in plants un-protected from wind than in plants protected from wind, 88 compared to 42 thrips per 25 flowers respectively. With adult *T. tabaci* there was no significant response to wind, 81 compared to 78 thrips per 25 flowers respectively, which suggested this species was less affected by wind than *T. imaginis*.

The results from these trials showed that the major cause of wind-scorch is wind and that the incidence of these symptoms may be reduced and the yield of marketable pods increased by installing wind-breaks. The use of windbreaks may however increase the incidence of disease such as *Sclerotinia* rot and since there are many variables involved, the severity of the disease will be unpredictable.

Although *Thrips* spp. did not cause typical wind scorch symptoms, wind may intensify the symptoms of damage caused by thrips, making them more visible, therefore reducing the marketable yield. Control of thrips, especially when thrips numbers are high will therefore help increase marketable yield, especially for Tasmanian bean growers.

Future work needs to concentrate on the thrips population dynamics due to the large number of thrips genera and species found within bean flowers as well as the numbers required to trigger a spray decision depending on the species identified at the different times of the year. What thrips are actually causing damage will also help in developing such a threshold.

1. Introduction

Value of green bean and runner bean production in Australia was $72.7 million and the 10th largest vegetable crop in 2008-09, accounting for 2.4% of total Australian vegetable production by value. Production is concentrated in Queensland (56%) and Tasmania (25%), with New South Wales, Victoria, Western Australia and South Australia producing the remainder of the Australian production (AUSVEG July 2011). The bulk of the Tasmanian production is for the processing industry while QLD is predominantly fresh market driven.

Green beans attract a range of insect pests (Duff 2008) (HAL Projects VG02030 and VG06016) from the moment they germinate. Thrips, silver leaf whitefly, leafhoppers and bean fly attack the small plants with varying levels of damage. Thrips and leafhoppers damage is generally mild and the plants quickly recover. However, silver leaf whitefly and bean fly can cause severe damage and even death of the plants making insecticide treatments vital if the plants are to survive. During the vegetative phase the plants can withstand some degree of damage to the foliage, caused predominantly by caterpillars chewing the leaves, while some sap sucking insects can also damage the foliage to various degrees. Once the flowers begin to develop and open then once again caterpillars can be an issue, with appropriate insecticides being required to prevent crop loss. However, during the flowering stage thrips are by far the greatest challenge in any farm management program.

The thrips species that are most important as crop pests belong to the two genera *Thrips* and *Frankliniella*, and these together with *Haplothrips* and *Liothrips*, are the largest genera in the Thysanoptera (Mound 1997). Thrips are very small insects, usually 1-2mm in length that can be found on various parts of the host plant: cotyledons, leaves, stems, buds, flowers and fruit. They puncture the plant cells and suck the sap that is released from these cells, causing silvering or stippling on the leaves, or death and scarring on the fruiting structures. A number of thrips transmit viral diseases, such as Tomato Spotted Wilt Virus (TSWV), increasing their potential to cause damage. Thrips can cause damage to crops under intensive horticulture, broad acre agriculture, cut flower production, glasshouse and nursery production.

Thrips are serious pests of a wide range of crops and alternative non-crop hosts such as weeds, laying their eggs on all above ground parts of the plant. On adzuki beans *Megalurothrips usitatus* lays its eggs on foliage, petals and sepals with larval aggregation within the flowers resulting from the concentration of eggs laid within the individual flowers (Chang 1992). It is therefore likely that this also happens in green beans when this particular thrips is present.

An understanding of the species of thrips in the flowers of crops, should allow growers and consultants a better chance of controlling them. This will also allow growers and consultants to determine if the thrips are responsible for the damage being found on the crop, whether it is direct feeding damage or secondary viral disease issues as a result of feeding. Thrips species can be identified by collecting flowers and placing them into small bottles of 70% alcohol to dislodge the adult thrips from the flowers. They can then be identified by the aid of a good microscope or sent off to a specialist taxonomist. Thrips numbers can also be assessed by using yellow sticky traps placed throughout the crop and examined regularly, as such traps can quickly become covered with a wide range of insects, both pests and beneficials.

Correct identification of the thrips is vital in order to implement an effective management program, as is an understanding of the damage caused by the different species. Just because one thrips is more common than another, does not necessarily mean they are the primary cause of any damage. They may be present to feed on pollen which is necessary for egg production, nectar or even other small insects such as mites (Pickett, Wilson et al. 1988).

The number of known pest thrips found within the flowers or on the plant can help in developing thresholds that can then be used when deciding whether to spray a crop. Such thresholds may increase or decrease during the season, as different thrips become more dominant. This will allow the grower to better tailor insecticide sprays. Thrips populations fluctuate with temperatures, rainfall and relative humidity (Harding 1961; Chellemi, Funderburk et al. 1994; Toapanta, Funderburk et al. 1996; Chyzik and Ucko 2002; Stacey and Fellowes 2002) making it difficult to accurately predict when one species will become dominant over another during the growing season.

Choosing the most appropriate insecticide is limited by what is registered in the crop and whether the thrips have a degree of resistance to the chemical chosen. Many factors also affect the performance of the pesticides under field conditions: plant and crop structure, pest behaviour, feeding and pupation sites, application methods and persistence of the pesticide, previous treatments and weather (Parrella and Lewis 1997). Control of thrips in green beans is particularly difficult. This is due to a number of factors: the diversity of the species of thrips, the presence of a dense crop canopy obstructing the pesticides from hitting the flowers, the thrips harbouring within the flowers, the limited number of registered and effective pesticides and now the selective nature of insecticides to control nymphs and not the adults such as spirotetramat.

This project will endeavour to find alternative insecticides suitable for use in green beans against thrips and investigate the importance of thrips to the Tasmanian processing green bean industry and the confusion it is causing with “wind scorch” symptoms. As such insecticide efficacy trials will be concentrated in QLD while the Tasmanian component of the project will predominantly look at thrips and wind interactions with limited insecticidal efficacy work.

1.1 Thrips classification/identification

Thrips are commonly thought of as flower dwellers, and it is thought that about 50% of all thrips species feed only on fungi, mostly on fungal hyphae in leaf litter or on dead wood (Mound and Kibby 1998). Some groups of thrips feed only in flowers while others feed on new and old leaves. There are those that are either opportunistic or facultative predators (Kirk 1984) as well as a few that are true or obligate predators of small arthropods (Mound and Kibby 1998).

The life cycle of a thrips involves an egg, two larval stages that are actively feeding, followed by a pre-pupal and pupal stage. These latter are non-feeding stages and generally take place in the soil or leaf litter. The emerging adults are generally winged, but can also have short wings or be wingless depending on the sex and species. Most thrips lay their eggs inserted into plant tissue by means of a serrated ovipositor. Eggs can take 2 to 5 days to hatch depending on the temperature but can take up to 10 to 12 days under cold conditions. The feeding larval stages can last between 3 to 12 days depending on the temperature and species, with the 2 pupal stages lasting between 3 to 13 days. The length of the life cycle depends on the temperature and the quality of the food source; as little as 10-12 days at 30ºC or as great as 19 days at 20ºC (Persley, Sharman et al. 2007). The female western flower thrips adult can live for 30-45 days and produce between 150 and 300 eggs (Caon and Burfield 2006), whereas the onion thrips female can live for up to 20 days and lay up to 80 eggs (Shelton and Reueda 1995).

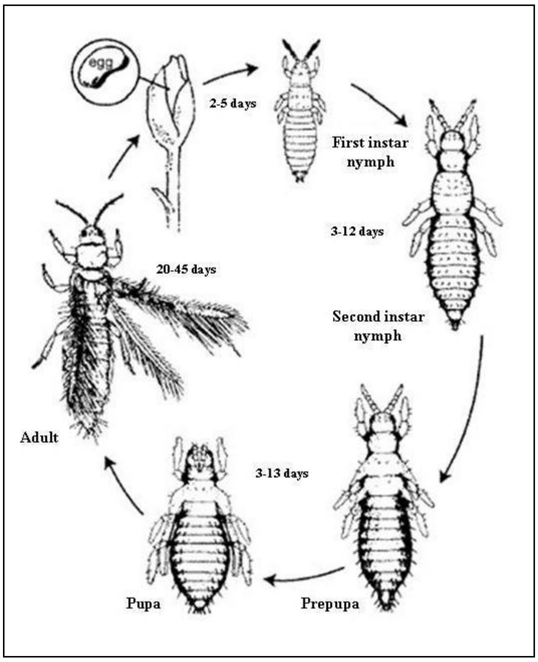


Figure 1.1. Typical life cycle of a flower thrips.
"From the UC Statewide IPM Program,
Adapted from Insects from USDA. 1952.
The Yearbook of Agriculture, 1935.
Calif. Agric. Exp. Sta. Circ. 337"

The feeding apparatus of thrips is unique amongst insects. Thrips have only one mandible which is used to punch a hole in to the plant surface through which paired maxillary stylets are then inserted. These stylets suck the contents of the damaged plant part inducing a range of symptoms on the plant tissue due to their feeding. Silvering is the most common symptom occurring as a result of the cell contents being removed, and is readily seen on leaf tissue.

Scarring to varying degrees is also common on a wide range of fruit and vegetables, causing large losses due to market rejection.

Pod and leaf damage found in green beans and egg fruit.

As well as the direct physical damage caused by thrips feeding, virus transmission can be a major concern. Viruses such as Tomato Spotted Wilt Virus (TSWV), Iris Yellow Spot Virus (IYSV) and Capsicum Chlorosis Virus (CaCV) are three such viruses known to be transmitted by tomato thrips, western flower thrips and onion thrips. These viruses cause major crop losses in several growing regions of Australia which increases the importance of trying to manage a pest of such a wide range of crops. Such crops may include tomatoes, capsicums, onions, leeks, lettuce, potatoes, celery as well as a number of flowering ornamental. Bean blossom thrips, plague thrips and hairless flower thrips are not known to be vectors of viruses.

Capsicum chlorosis virus in peanut

Tomato spotted wilt virus in peanut

Correct identification of thrips is important for a number of reasons; correct selection of insecticides, possible virus transmission concerns, history of when the thrips is most prevalent and whether the thrips is known to cause damage to the crop. This project has identified 13 different thrips from green bean to date, from both leaves and flowers.

Table 1.1. List of thrips found on green beans

Scientific name	**Common name**	**Family**	**Plant part affected**
Desmothrips tenuicornis		Aeolothripidae	Leaves/Flowers
Frankliniella occidentalis	Western flower thrips	Thripidae	Leaves/Flowers
Frankliniella schultzei	Tomato thrips	Thripidae	Leaves/Flowers
Haplothrips gowdeyi	Gold tipped tubular thrips	Phlaeothripidae	Flowers
Limothrips cerealium	Grain thrips	Thripidae	Flowers
Megalurothrips usitatus	Bean blossom thrips	Thripidae	Flowers
Pseudanaphothrips achaetus	Hairless flower thrips	Thripidae	Flowers
Thrips imaginis	Southern Plague thrips	Thripidae	Leaves/Flowers
Thrips palmi	Melon thrips	Thripidae	Leaves
Thrips parvispinus	Taiwanese thrips	Thripidae	Leaves/Flowers
Thrips safrus	Northern Plague thrips	Thripidae	Leaves/Flowers
Thrips tabaci	Onion thrips	Thripidae	Leaves/Flowers
Thrips vulgatissimus	White flower thrips	Thripidae	Flowers

The thrips collected from beans, and in particular the flowers were relatively straight forward to identify with practice. A key identifying factor was the presence or absence of long setal hairs on the section of body just behind the head (the pronotum). Large thrips with 4-5 pairs of these setae were consistently identified as *Frankliniella* species; if they were pale honey coloured they were *F. occidentalis* and if they were a dark brown they were *F. schultzei*. Those thrips with only 2 pair of setae on the back of the pronotum, were typically *Thrips* species, but if they were large dark brown with a distinct white band towards the apex of the forewing they were *Megalurothrips usitatus*. To differentiate the *Thrips* into species, individuals were mounted onto a microscope slide in order to look at more detailed characteristics such as microtrichia, the number of marginal setae on parts of the abdomen and the rows of setae on the forewings.

Basic key

The following section gives a brief illustration of the characters used in this process.

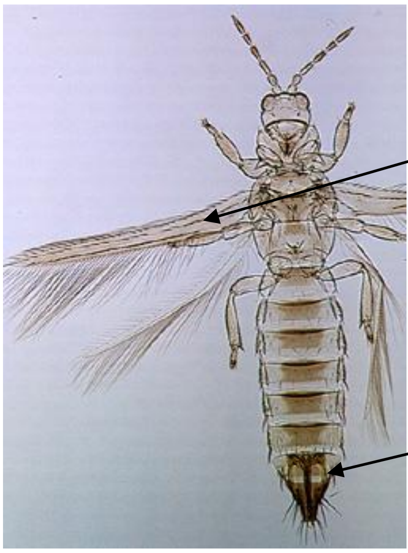
Thrips are placed into two suborders: the **Tubulifera** with a single family Phlaeothripidae, and the **Terebrantia** with seven families. Some key differences between those thrips currently identified from green beans are outlined below:

Tubulifera

Forewings lack longitudinal veins

10th abdominal segment is tubular, almost cylindrical

Terebrantia



Forewings have one or two longitudinal veins

10th abdominal segment is conical in shape with saw like ovipositor

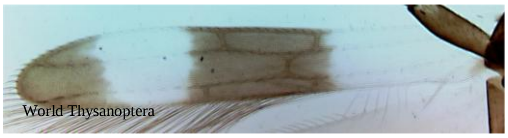
Terebrantia
The vast majority of thrips found in green bean flowers fell into this group of thrips.

Wings usually pointed at apex

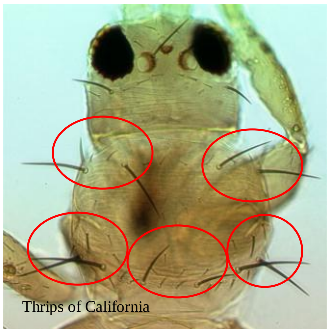
(Thripidae)

or

wings broadly rounded at apex with black and white bands
(Aeolothripidae)



Thripidae
Pronotum with 4 or 5 pairs of long setae (circled in red)



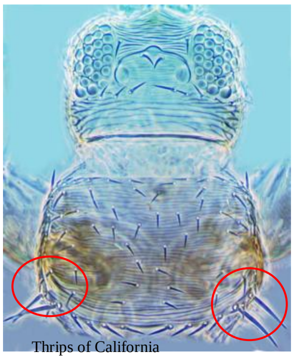
Frankliniella

F. occidentalis
(western flower thrips)

F. schultzei (tomato thrips)

or

Pronotum with 2 pairs of long setae along the posterior margin (circled in red)



Thrips
Megalurothrips

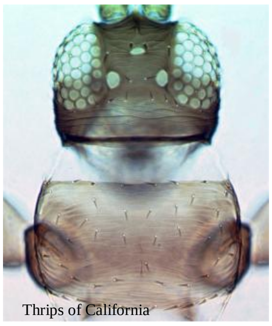
Thrips species

Megalurothrips usitatus

Additional features needed to be examined under a high powered microscope to further differentiate the *Thrips* species, especially as a number of them were similarly coloured (*T. imaginis*, *T. tabaci* and *T. palmi*). An exception was *T. vulgatissimus*, which could be identified easily due to its larger size, dark brown colouring and a pale patch near the base of the forewing.

or

Pronotum without any long setae



Pseudanaphothrips

This thrips was relatively easy to identify due to the brown colour and lack of long setal hairs on the pronotum.

This very simplified version of identifying thrips in green bean flowers was appropriate as we were dealing with large numbers of thrips, and we had only a few genera and species to deal with. Initially a proportion of the thrips were mounted onto slides to confirm identifications and sent to a thrips expert for confirmation. This helped to refine our identifications with only a very few needing further scrutiny.

Thrips were mounted on microscope slides with their wings spread either side of their body and examined under a dissecting microscope and higher powered light microscope. This allowed for those very small characters that can not be seen with a small 10x or 20x hand lens to be readily identified.

Below is a collection of the thrips currently identified from green beans. They have been mounted on slides showing the variability in appearance and colour.

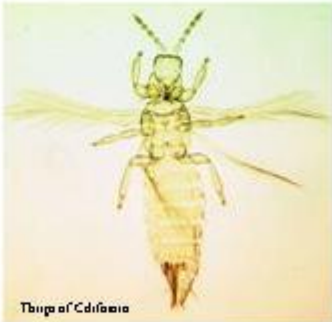
Haplothrips species

Desmothrips species

Frankliniella occidentalis

Frankliniella schultzei

Thrips imaginis



Thrips palmi

Thrips tabaci

Thrips parvispinus

Thrips vulgatissimus

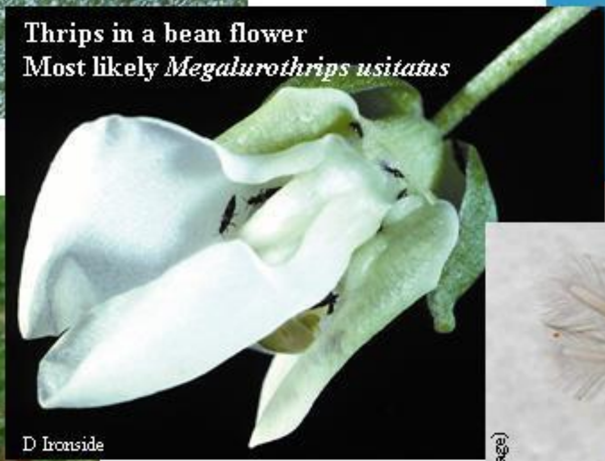
Pseudanaphothrips achaetus

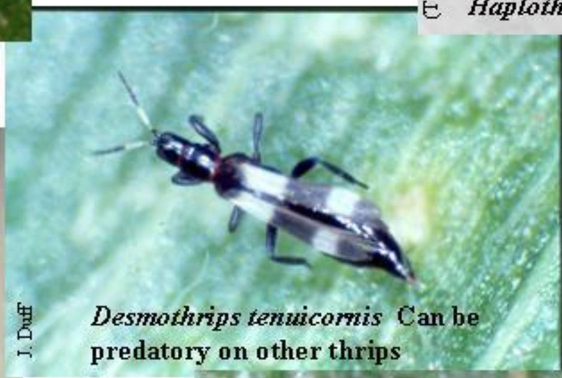
Megalurothrips usitatus

Limothrips cerealium

Images taken from the "Thrips of California" and "World Thysanoptera"

Identification of thrips cannot be readily carried out using colour alone. The collection of images below shows how similar colour is between certain thrips. With experience, it is possible to identify certain thrips genera on a particular crop. Microscope examination is usually necessary to determine species.





2. Queensland Project Activities

2.1 Insecticide efficacy trials

Introduction

Thrips are a continuing pest problem and a difficult pest to manage due to the habit of this small insect. Not only can it be found feeding on the foliage but also on the developing pods within the flowers. These flowers have a structure called a "keel" where the reproductive organs of the flower are positioned. This is a relatively enclosed part of the flower and also a safe place for thrips to hide from insecticide sprays. Queensland growers currently manage thrips by the use of traditional broad spectrum insecticides such as dimethoate and methomyl, which are very disruptive to an Integrated Pest Management program. There has been an increase in the use of spinosad for thrips control due primarily to western flower thrips being found in the flowers and the assumption that this thrips is causing damage to the plant (Caon and Burfield 2006) and likewise the pods.

Thrips have a very short life cycle with eggs being laid inside plant tissue, leaves or flowers, hatching within as little as 3 days and as long as 10 days depending on the temperature. Therefore for the thrips larva to be found within flowers, which are only open for a few days, the eggs would have to have been laid at the green bud stage of the flower development, hatching as the flower changes colour and opens allowing the small thrips entry. It is not clear when the adult gains entry into the flower. They may only be able to gain access as it is opening. This has not however been observed or recorded anywhere in the literature. Green bean flowers are only open for a very short period of time, a matter of days, until the flowers are pollinated, yet this is long enough for damage to take place and pods to be scarred.

The greatest damage caused by thrips at flowering and pod set is miss-shapen and distorted pods, which are rejected at harvest. Not all thrips will attack developing pods; some will be there to feed on the pollen and nectar produced by the flower. One species, *Desmothrips tenuicornis*, can also be a predator of other thrips, which might be why it is found within flowers as well as on the leaves. This potential thrips predator is found in very low numbers having minimal potential impact on the numbers of thrips found in bean flowers. As well as causing damage to flower parts, *Frankliniella occidentalis* has been observed preying on mites so acting as a predator and not a plant pest (González and Wilson 1982).

Growers are still reliant on the use of insecticides to manage thrips in green beans. Three insecticide trials were conducted on the Gatton Research Station looking at a range of insecticides and application techniques to try and find alternative products to manage thrips in flowers. Insecticides were chosen after consultation with chemical company researchers as to their potential to manage thrips populations. Insecticides were applied to the foliage just prior to flowering and during flowering, or at planting. Those applied at planting would allow the plant roots to uptake the product with the aim of having the product already in the plant before the thrips became an issue at flowering.

Trial 1 Autumn 2008

Material and Methods

Green beans variety Labrador, were planted at the Gatton Research Station on the 4th March 2008. The crop was grown using conventional grower practices by the research station farm staff. Plots sizes were four rows wide by 10m long.

Treatments

1. Control
2. HGW86 rate 1 15ml/100m row (soil applied at planting)
3. HGW86 rate 2 30ml/100m row (soil applied at planting)
4. Imidacloprid 14ml/100m row (soil applied at planting)
5. Biocontrol fungus
6. Spirotetramat rate 1 300ml/ha
7. Spirotetramat rate 2 400ml/ha
8. Spinosad 400ml/ha

Soil treatments 2-4 were applied at the rate of 3.6L of water per 100m of row and were applied at planting using a modified cone planter. This allowed the product to be delivered immediately behind the planting shoe before the planting furrow was closed over and wheel pressed. Foliar treatments 5-8 were applied using a SOLO powered back pack sprayer with a 1.2m wide hand held boom with four equally spaced twin-jet nozzles. Foliar treatments were applied at the equivalent rate of 453L/ha of water. The first spray was applied at 5% flowering with the second spray 10 days later.

Table 2.1. Application times for the various treatments used in this trial.

Treatments	4th March	4th March	16th April	26th April	12th May
Control	Beans planted				Harvest treatments
HGW86 rate 1 15ml/100m row		√			
HGW86 rate 2 30ml/100m row		√			
Imidacloprid 14ml/100m row		√			
Biocontrol fungus			√	√	
Spirotetramat rate 1 300ml/ha			√	√	
Spirotetramat rate 2 400ml/ha			√	√	
Spinosad 400ml/ha			√	√	

Monitoring.

Monitoring started at the early flowering stage of the crop. The middle two rows were used for assessments. Flowers were collected, 25 from each plot, placed in a specimen bottle with 70% alcohol and taken back to the lab for dissection and counting of the thrips. Flowers were collected weekly for three weeks. Adult thrips were identified at minimum to genus level to determine percentages of each type found within the bean flowers.

Due to poor quality, high salt content irrigation water, the crop suffered from poor growth, stunting and leaf scorching. Due to the severe damage it was only possible to harvest the equivalent of one replication of all the treatments. Two, one-metre sections of row from the middle two rows per plot were stripped of all their beans and taken back to the lab for assessment. All the pods were assessed as to the type of damage present and the number of marketable pods.

Statistical analysis

The data collected was statistically analysed using the analysis of variance as part of the Genstat 11th Edition program supplied by the Agri-Science Queensland.

Weather data

Daily maximum and minimum temperatures, rainfall, relative humidity, wind speed and direction is tabulated in Appendix 1.

Results

Thrips species

Eight different thrips were found within bean flowers in the unsprayed control plots as shown in Table 2.2 below. The most common thrips found was the bean blossom thrips or *Megalurothrips usitatus* followed by the hairless flower thrips *Pseudanaphothrips achaetus*. Although tomato thrips *Frankliniella schultzei* was not found in the unsprayed control plots, this thrips was found in a number of other treatments throughout the trial site as was the *Desmothrips tenuicornis*. Western flower thrips or *F. occidentalis* was also present in low numbers. The *Thrips* species was made up of *Thrips imaginis*, *T. parvispinus* and *T. tabaci*. These thrips can only be accurately identified by mounting them on microscope slides and using a high powered microscope. A proportion of these thrips were mounted and sent away for accurate identification by the department's taxonomist.

Table 2.2. Distribution of adult thrips within untreated green bean flowers during the trial period. Numbers are averaged from 25 flowers. The numbers in brackets ( ) represent the larvae, which were not identified to genus or species level.

Type of adult Thrips	21st April 08	28th April 08	6th May 08
	5 days after 1st application	2 days after 2nd application	10 days after 2nd application
Pseudanaphothrips achaetus	0	0.5	7
Megalurothrips usitatus	8	4.75	8.25
Thrips species	3	0.75	2
F. occidentalis	3	0.75	1.75
F. schultzei	0	0	0.25
Desmothrips tenuicornis	0	0	0
Others (including Tubelifera)	0.75	0.25	5.5
Total thrips in 25 flowers	14.75 (8.5)	7(16)	24.75 (33.5)
Total thrips per flower	0.59 (0.34)	0.28(0.64)	0.92 (1.34)
% *Pseudanaphothrips*	0	7.14	28.28
% *Megalurothrips*	54.24	67.86	33.33
% *Thrips*	20.34	10.71	8.08
% *F. occidentalis*	20.34	10.71	7.07
% *F. schultzei*	0	0	1.01
% others	5.08	3.58	22.23

There were also a number of other thrips which could not be readily placed into the list of known thrips. These could have been males or thrips that are rarely found in beans and therefore of little importance as a pest of beans. They could also be unusual forms of those already identified or just poorly prepared and mounted with missing diagnostic characters. A few belonged to the Tubelifera. These were listed as "Other thrips".

Data therefore represents thrips from all flowers from a treatment. There was no one treatment that performed better than the other at controlling the different species of thrips as shown in Tables 2.3 and 2.4 below.

Table 2.3. Percentage distribution of adult thrips across treatments and sampling dates at the Gatton Research Station 2008.

21st April 2008							
Treatment	*Pseudanaphothrips*	*Megalurothrips*	*Thrips*	*F. occidentalis*	*F. schultzei*	*Desmothrips*	Other thrips
Biofungi	3.85	76.92	5.77	13.46	0.00	0.00	0.00
Imidacloprid	38.10	19.05	14.29	28.57	0.00	0.00	0.00
HGW86 rate 1	12.07	44.83	12.07	22.41	8.62	0.00	0.00
HGW86 rate 2	6.67	83.33	3.33	3.33	3.33	0.00	0.00
Spirotetramat rate 1	10.34	37.93	20.69	24.14	6.90	0.00	0.00
Spirotetramat rate 2	0.00	50.00	23.68	21.05	5.26	0.00	0.00
Spinosad	16.67	50.00	16.67	16.67	0.00	0.00	0.00
Unsprayed control	0.00	54.24	20.34	20.34	0.00	0.00	5.08
28th April 2008							
Biofungi	2.78	73.61	6.94	13.89	1.39	0.00	1.39
Imidacloprid	22.22	44.44	9.26	18.52	3.70	0.00	1.85
HGW86 rate 1	4.44	46.67	8.89	11.11	20.00	0.00	8.89
HGW86 rate 2	0.00	83.33	6.25	0.00	0.00	0.00	10.42
Spirotetramat rate 1	12.82	53.85	10.26	15.38	2.56	0.00	5.13
Spirotetramat rate 2	9.68	64.52	16.13	6.45	3.23	0.00	0.00
Spinosad	41.38	20.69	27.59	0.00	0.00	3.45	6.90
Unsprayed control	7.14	67.86	10.71	10.71	0.00	0.00	3.58
6th May 2008							
Biofungi	22.22	38.89	9.26	7.41	3.70	0.00	18.52
Imidacloprid	34.78	25.00	2.17	18.48	2.17	1.09	16.30
HGW86 rate 1	18.75	43.75	7.50	8.75	2.50	7.50	11.25
HGW86 rate 2	4.08	60.20	11.22	13.27	0.00	0.00	11.22
Spirotetramat rate 1	40.35	40.35	5.26	8.77	3.51	0.00	1.75
Spirotetramat rate 2	27.69	33.85	15.38	13.85	3.08	0.00	6.15
Spinosad	27.91	34.88	8.14	13.95	2.33	0.00	12.79
Unsprayed control	28.28	33.33	8.08	7.07	1.01	0.00	22.23

Data was not statistically analysed

Table 2.4. Average number of different thrips found in 25 flowers on each assessment date at the Gatton Research Station 2008.

Treatment	*Pseudanaphothrips*	*Megalurothrips*	*Thrips*	*F. occidentalis*	*F. schultzei*	*Desmothrips*	Others
21st April 2008							
Biofungi	0.5	10	0.75	1.75	0	0	0
Imidacloprid	4	2	1.5	3	0	0	0
HGW86 rate 1	1.75	6.5	1.75	3.25	1.25	0	0
HGW86 rate 2	1	12.5	0.5	0.5	0.5	0	0
Spirotetramat rate 1	0.75	2.75	1.5	1.75	0.5	0	0
Spirotetramat rate 2	0	4.75	2.25	2	0.5	0	0
Spinosad	1	3	1	1	0	0	0
Unsprayed control	0	8	3	3	0	0	0.75
28th April 2008							
Biofungi	0.5	13.25	1.25	2.5	0.25	0	0.25
Imidacloprid	3	6	1.25	2.5	0.5	0	0.25
HGW86 rate 1	0.5	5.25	1	1.25	2.25	0	1
HGW86 rate 2	0	10	0.75	0	0	0	1.25
Spirotetramat rate 1	1.25	5.25	1	1.5	0.25	0	0.5
Spirotetramat rate 2	0.75	5	1.25	0.5	0.25	0	0
Spinosad	3	1.5	2	0	0	0.25	0.5
Unsprayed control	0.5	4.75	0.75	0.75	0	0	0.25
6th May 2008							
Biofungi	3	5.25	1.25	1	0.5	0	2.5
Imidacloprid	8	5.75	0.5	4.25	0.5	0.25	3.75
HGW86 rate 1	3.75	8.75	1.5	1.75	0.5	1.5	2.25
HGW86 rate 2	1	14.75	2.75	3.25	0	0	2.75
Spirotetramat rate 1	5.75	5.75	0.75	1.25	0.5	0	0.25
Spirotetramat rate 2	4.5	5.5	2.5	2.25	0.5	0	1
Spinosad	6	7.5	1.75	3	0.5	0	2.75
Unsprayed control	7	8.25	2	1.75	0.25	0	5.5

Thrips incidence

Data is presented as average thrips per 10 flowers due to the small number of thrips present. Thrips numbers in flowers increased over time from a low of nine thrips in ten flowers in the control plots to a high of 23 thrips in 10 flowers in just over two weeks. The spinosad treatment and spirotetramat rate 2 had significantly less thrips than the unsprayed control five days after the first spray application. All other treatments were not significantly different from the control at this stage. Spirotetramat at both rates was consistently better than the control plots at reducing total thrips numbers. Larvae were significantly lower in the spirotetramat rates compared to the control and most other treatments on the second and third assessment dates. Adults however, were not significantly reduced compared to the unsprayed control plots and most other treatments as shown in Table 2.5 and Figure 2.1 below. The biofungi was no better at controlling thrips than the unsprayed control. HGW86 appeared to cause an increase in the number of thrips in the flowers with significantly more thrips present by the last sampling date. This increase in number was attributed to the large number of larvae, with over 26 larvae being recovered from 10 flowers compared to 13 larvae in 10 flowers in the control treatment.

Table 2.5. Average number of thrips found in 10 flowers on three sampling dates.

Date	Treatment	Adult thrips	Larvae	Total thrips
21-Apr-08	Biofungi	7.3 ab	3.2 ab	10.5 a
	Imidacloprid	7.7 a	1.3 c	9 a
	Control	5.9 abc	3.4 a	9.3 a
	HGW86 rate 1	6.5 abc	3.7 a	10.2 ab
	HGW86 rate 2	5.7 bc	3.6 a	9.3 a
	Spirotetramat rate 1	5.6 bc	2.6 abc	8.2 ab
	Spirotetramat rate 2	4.9 cd	1.3 c	6.2 bc
	Spinosad	3 d	1.7 bc	4.7 c
28-Apr-08	Biofungi	7.8 a	9.2 a	17 a
	Imidacloprid	6.7 ab	5.3 b	12 b
	Control	2.8 c	6.4 ab	9.2 b
	HGW86 rate 1	5 bc	5.9 b	10.9 b
	HGW86 rate 2	5 bc	8.1 ab	13.1 ab
	Spirotetramat rate 1	4.1 c	0.4 c	4.5 c
	Spirotetramat rate 2	2.8 c	0.6 c	3.4 c
	Spinosad	2.8 c	0.7 c	3.5 c
6-May-08	Biofungi	6.9 b	18.2 b	25.1 b
	Imidacloprid	11.5 a	13.3 bc	24.8 b
	Control	9.9 ab	13.4 bc	23.3 bc
	HGW86 rate 1	9.6 ab	26.4 a	36 a
	HGW86 rate 2	13.5 a	27.6 a	41.1 a
	Spirotetramat rate 1	7.2 b	1.3 d	8.5 d
	Spirotetramat rate 2	6.5 b	0.5 d	7 d
	Spinosad	9.9 ab	7.7 c	17.6 c

Means followed by the same letter on the individual sampling dates are not significantly different from one another at the P=0.05 level.

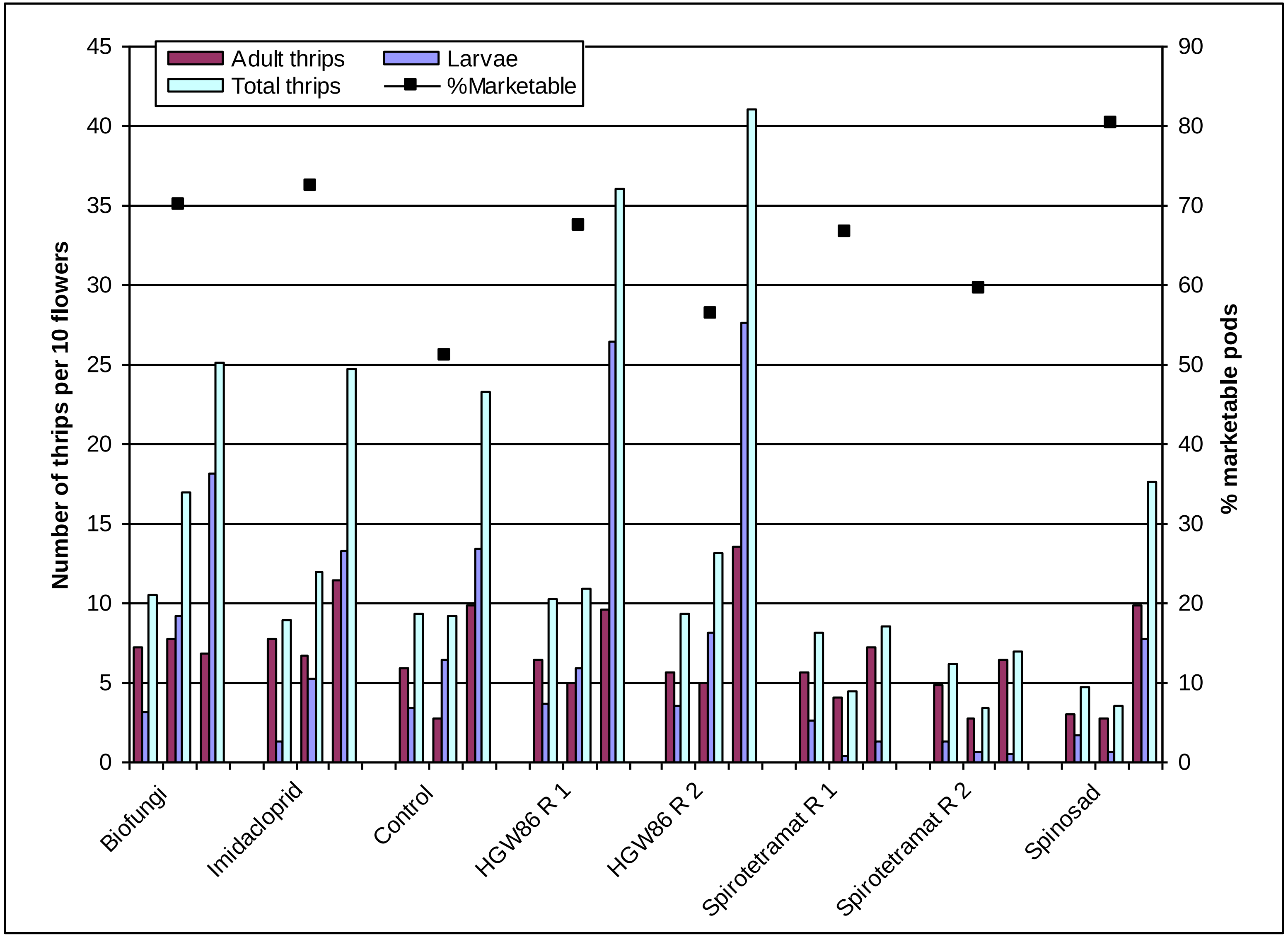


Figure 2.1. Thrips numbers per 10 flowers collected on 3 dates, 21st April, 28th April and the 6th May 2008 for each treatment. The percentage marketable pods are indicated above each treatment by a black box. The crop was harvested on the 12 May 2008.

Harvest assessment

Due to the poor growth of the crop, only one replicate of each treatment could be harvested. The results are therefore only an indication of the overall performance of each treatment. The untreated control had the least percentage of pods that were marketable with just over 51% and one of the highest percentage of unmarketable pods or just over 36%. Spinosad treatment resulted in the greatest number of marketable pods with just over 80% and just over 15% being unmarketable. Low thrips numbers in the spirotetramat treatments did not lead to an increase in marketable pods when compared with the Biofungi and imidacloprid treatments. The HGW86 treatments, which had the highest thrips populations, also had yields similar to the spirotetramat treatments.

Table 2.6. Levels of thrips damage to green bean pods and marketable pods.

Treatments	% No Thrips Damage	% Low Thrips Damage	% Med. Thrips Damage	% High Thrips Damage	% Total Thrips Damage	%GVB	% Marketable	% Unmarketable Thrips damage
Control	28.80	22.25	18.06	18.59	58.90	12.30	51.05	36.65
HGW86 rate 2	33.76	22.59	13.20	27.66	63.45	2.79	56.35	40.86
Spirotetramat rate 2	37.69	21.88	19.00	18.09	58.97	3.34	59.57	37.08
Spirotetramat rate 1	19.01	47.52	16.12	9.09	72.73	8.26	66.53	25.21
HGW86 rate 1	33.01	34.23	21.03	8.56	63.81	3.18	67.24	29.58
Biofungi	37.73	32.16	19.14	8.74	60.04	2.23	69.89	27.88
Imidacloprid	23.13	49.21	18.14	7.71	75.06	1.81	72.34	25.85
Spinosad	43.02	37.36	12.83	2.64	52.83	4.15	80.38	15.47

GVB is Green Vegetable Bug

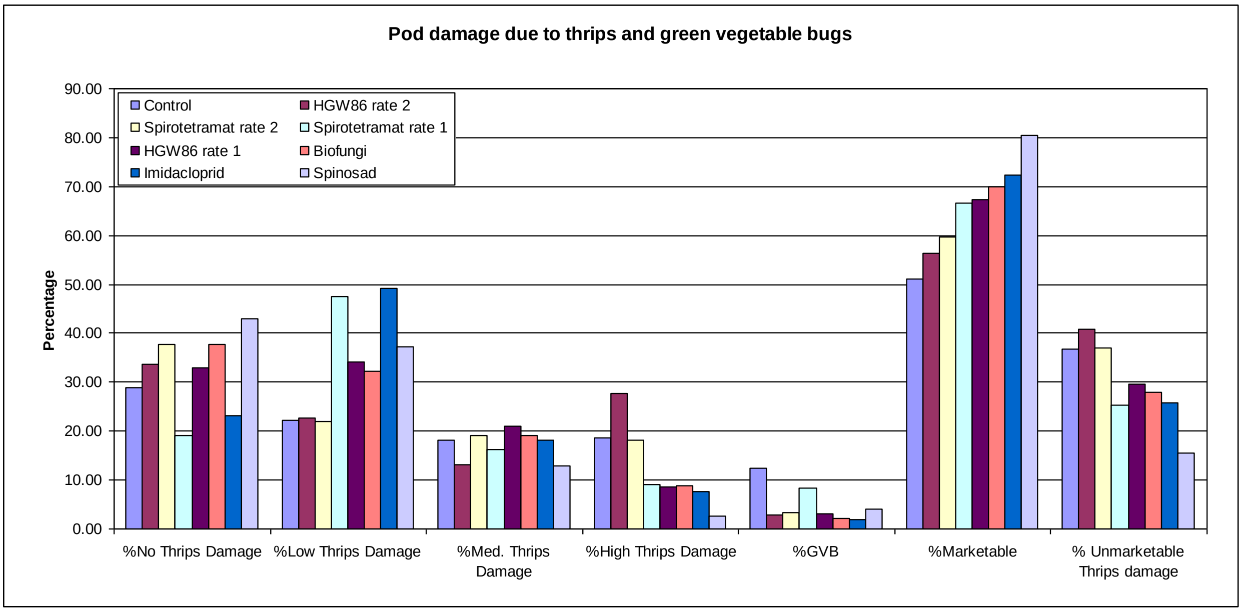


Figure 2.2. Pod damage due to thrips and green vegetable bugs including pods categorised as marketable. Marketable pods include those with no damage and those with low thrips damage. The unmarketable thrips damage includes the medium and high thrips damaged pods.

Discussion

Green beans require a high water quality and are very sensitive to salt damage resulting from poor water quality. Ideally green beans should be watered with water that has less than 700 micro siemen per cm if using overhead irrigation and up to 1200 micro-siemens per cm if using furrow or drip irrigation. The irrigation water used in this trial was far in excess of 1200 micro siemens due to drought conditions and poor water aquifer levels. The salinity class for this water was also measured at 3 which is considered as having a high salinity. This led to the poor growth of the trial plants leading to leaf scorching, stunting and very low yields. Even though this water was supplemented with dam water to try and reduce the levels of salts, plant growth was still severely affected.

It was for this reason that only one plot from each treatment could be harvested, representing one replication. This allowed for trends only to be discussed between treatments. Spinosad performed better than all other treatments with over 80% of the pods being marketable, compared to the untreated control with just over 50% of pods being marketable. So doing nothing could still result in clean straight pods. With thrips damage in the unmarketable pods reaching a high of 36% in the untreated control, with between 0.9 and 2.3 thrips per flower, this shows how very small thrips numbers can damage pods during autumn plantings of green beans in south east Queensland. The spirotetramat treatments, which had fewer than one thrips per flower, still had fewer marketable pods than the spinosad treatment. The larvae numbers were significantly less in the spirotetramat treatments than most other treatments, including the spinosad treatments, by the lst sampling date, while the adult numbers varied slightly between treatments.

This could indicate that the adults are the life stage most responsible for the damage seen on the developing pods. However this trial did not ascertain clearly what life stage of the thrips was responsible for damage to the bean pods. This work would best be undertaken in future research and be lab and glasshouse based.

Determining just what thrips species or combination of species is most responsible for pod damage could not be ascertained as part of this trial. There were six thrips species from five genera including one which is thought to be a predator of thrips *Desmothirps tenuicornis*, found within bean flowers. The *Thrips* species were predominantly *T. tabaci* and *T. imaginis,* plus some other *Thrips* species which were only very rarely found, such as *T. parvispinus* and *T. safrus*. *Megalurothrips usitatus* was the most common thrips found within the bean flowers with the *Pseudanaphothrips achaetus* and *Frankliniella occidentalis* the next most commonly found respectively. Towards the end of the flower sampling, the distributions of *M. usitatus* and *P. achaetus* were very similar across most of the treatments. The exception was with the HGW86 rates which had far more *M. usitatus* found in the flowers than *P. achaetus*.

Trial 2 Spring 2008

Material and Methods

Green beans variety Labrador, were planted at the Gatton Research Station on the 10^{th} September 2008. The crop was grown using conventional grower practices by the research station farm staff. The seed was overhead irrigated to allow for even germination and then watered with trickle tape there after when required. Plots sizes were four rows wide by 10m long and replicated four times.

Treatments

1. Control
2. Thiamethoxam 10g/100m row (soil applied at planting)
3. Dimethoate 800ml/ha and methomyl 2L/ha mixture (Grower standard)
4. HGW86 rate 1 750ml/ha plus Hasten at 0.2% v/v
5. HGW86 rate 2 1000ml/ha plus Hasten at 0.2% v/v
6. Clothianidin 25ml/100m row (soil applied at planting)
7. Spinosad 400ml/ha

Soil treatments were applied at the rate of 3.6L of water per 100m of row and were applied at planting using a modified cone planter. This allowed the product to be delivered immediately behind the planting shoe before the planting furrow was closed over and wheel pressed. Foliar 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. Foliar applied treatments were applied at the equivalent rate of 440L/ha of water. Three foliar sprays were applied to the crop; the first spray was applied at first flowering, the second 8 days later, and the third spray 9 days after the second application as outlined in the Table 2.7 below.

Table 2.7. Application times for the various treatments used in this trial.

<table>
<tr><th>Treatments</th><th>10^{th} Sept</th><th>10^{th} Sept</th><th>27^{th} Oct</th><th>4 Nov</th><th>13 Nov</th><th>19 Nov</th></tr>
<tr><td>Control</td><td rowspan="7">Beans planted</td><td></td><td></td><td></td><td></td><td rowspan="7">Harvest treatments</td></tr>
<tr><td>Thiamethoxam 10g/100m row</td><td>√</td><td></td><td></td><td></td></tr>
<tr><td>Dimethoate 800ml/ha/methomyl 2L/ha mixture</td><td></td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>HGW86 rate 1 750ml/ha</td><td></td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>HGW86 rate 2 1000ml/ha</td><td></td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Clothianidin 25g/100m row</td><td>√</td><td></td><td></td><td></td></tr>
<tr><td>Spinosad 400ml/ha</td><td></td><td>√</td><td>√</td><td>√</td></tr>
</table>

Monitoring.

Monitoring started at the early flowering stage of the crop. The middle two rows were used for thrips assessments. Flowers were collected, 20 from each plot, and placed in a specimen bottle with 70% alcohol. They were taken back to the lab for dissection and counting of the thrips. Flowers were collected weekly for three weeks. Adult thrips were identified to genus level and where possible to species to determine percentages of each type found within the bean flowers.

At harvest two, one-metre sections of row from the middle two rows per plot were stripped of all their beans and taken back to the lab for assessment. All the pods were assessed as to the type of damage present and the number of marketable pods.

Statistical analysis

The data collected was statistically analysed using the analysis of variance as part of the Genstat 11th Edition program supplied by the Agri-Science Queensland.

Weather data

Daily maximum and minimum temperatures, rainfall, relative humidity, wind speed and direction is tabulated in Appendix 2.

Results

Thrips species

Seven distinct species of thrips were collected from bean flowers in the unsprayed control plots as represented below in Table 2.8. The most common thrips found in this spring planting was western flower thrips *F. occidentalis* representing over half of the thrips collected from the flowers. Initial populations were 56.35% just prior to the first application of insecticides and reaching a high of 85.19% 2 days prior to harvest or 4 days after the 3rd insecticide application. The bean blossom thrips, *M. usitatus*, represented less than 2.5% on average from flowering to harvest. The hairless flower thrips, *P. achaetus* and the *Thrips* species were the next most prevalent after *F. occidentalis* up until harvest, at which time they were not found in the flowers. Tomato thrips, *F. schultzei*, was also found in low numbers, comprising 7.61% of the thrips population on the 10th November. *Desmothrips tenuicornis* was found in very low numbers in the flowers during this trial period. The Thrips species comprised of *T. imaginis* and *T. tabaci*. These thrips can only be accurately identified by mounting them on microscope slides and using a high powered microscope. There was only a small number of other thrips which could not be readily identified.

Table 2.8. Distribution of adult thrips within untreated green bean flowers during the trial period. Numbers are averaged from 20 flowers. The numbers in brackets ( ) represent the larvae, which were not identified to genus or species level.

Type of adult Thrips	27th Oct 08	3rd Nov 08	10th Nov 08	17th Nov 08
	Same day of 1st application	7 days after 1st application	6 days after 2nd application	4 days after 3rd application
Pseudanaphothrips achaetus	6.8	10.11	10.95	0
Megalurothrips usitatus	0.8	0.21	0	0.58
Thrips species	12	13.01	6.05	0
F. occidentalis	28.4	56.96	31.68	6.65
F. schultzei	2.4	2.48	4.03	0
Desmothrips tenuicornis	0	0.62	0.29	0.28
Others	0	0.41	0	0.29
Total thrips in 20 flowers	50.4 (50)	83.8 (24)	53 (27)	7.8 (2.8)
Total thrips per flower	2.52 (2.5)	4.19 (1.2)	2.65 (1.35)	0.39 (0.14)
% *Pseudanaphothrips*	13.49	12.07	20.65	0
% *Megalurothrips*	1.59	0.25	0	7.41
% *Thrips*	23.81	15.52	11.41	0
% *F. occidentalis*	56.35	67.98	59.78	85.19
% *F. schultzei*	4.76	2.96	7.61	0
% others (Including *Desmothrips tenuicornis*)	0	1.22	0.54	7.4

The use of dimethoate and methomyl mixture, while controlling all other thrips, left western flower thrips the only type to be found in the bean flowers on the 17th November as shown in Tables 2.9 and 2.10 below. There were no significant differences between the treatments and the individual species of thrips on any of the assessment dates as shown in Table 2.9.

Table 2.9. The average percentage of thrips species found in the flowers for each treatment.

27th October 2008							
Treatment	*Pseudanaphothrips*	*Megalurothrips*	*Thrips*	*F. occidentalis*	*F. schultzei*	*Desmothrips*	Other thrips
Pre spray count	13.49	1.59	23.81	56.35	4.76	0	0.79
3rd November 2008							
Thiamethoxam	10.76	0.00	15.12	72.74	0.75	0.39	0.24
Dimethoate/methomyl	7.13	0.12	12.38	75.65	3.56	0.68	0.48
HGW rate 1	10.69	0.12	9.28	75.39	4.22	0.31	0.00
HGW rate 2	12.41	0.23	14.79	68.82	3.30	0.45	0.00
Clothianidin	8.47	0.00	13.65	74.57	1.67	0.88	0.76
Spinosad	11.60	0.13	16.56	69.87	1.72	0.00	0.12
Unsprayed control	11.53	0.18	16.20	69.04	2.03	0.67	0.35
Lsd =	**6.972**	**0.401**	**6.417**	**8.92**	**3.19**	**0.926**	**0.73**
10th November 2008							
Thiamethoxam	22.07	0.00	9.52 ab	60.82 b	6.97	0.63	0.00
Dimethoate/methomyl	14.50	0.53	3.93 b	76.34 a	4.70	0.00	0.00
HGW rate 1	22.68	0.00	2.42 b	66.22 ab	7.70	0.97	0.00
HGW rate 2	26.17	0.00	2.23 b	66.15 ab	5.45	0.00	0.00
Clothianidin	17.50	0.00	2.19 b	75.94 a	3.69	0.68	0.00
Spinosad	15.36	0.00	4.94 b	64.73 b	14.36	0.61	0.00
Unsprayed control	18.79	0.00	15.44 a	58.32 b	6.99	0.45	0.00
Lsd =	**12.99**	**0.597**	**7.706**	**10.93**	**7.761**	**1.469**	
17th November 2008							
Thiamethoxam	4.68	0.00	22.50	70.56	2.08	0.00	0.00
Dimethoate/methomyl	0.00	0.00	0.00	100.00	0.00	0.00	0.00
HGW rate 1	3.57	0.00	10.80	83.36	2.27	0.00	0.00
HGW rate 2	0.00	0.00	10.00	90.00	0.00	0.00	0.00
Clothianidin	0.00	0.00	0.00	91.87	3.13	5.00	0.00
Spinosad	8.33	0.00	4.17	83.33	0.00	0.00	4.12
Unsprayed control	0.00	5.24	0.00	85.19	0.00	5.00	4.57
Lsd =	**10.64**	**3.819**	**18.46**	**30.90**	**4.785**	**8.158**	**4.679**

Values followed by the same letter for each of the individual dates are not significantly different at the 5% level according to LSD test.
Those columns with not letters showed no differences between treatments

Table 2.10. Average number of different thrips found in 20 flowers on each assessment date.

Pre spray 27th Oct 08	Pseudanaphothrips	Megalurothrips	Thrips	F. occidentalis	F. schultzei	Desmothrips	Others	Total
	6.8	0.8	12	28.4	2.4	0	0	50.4
3rd November 2008								
Treatment	Pseudanaphothrips	Megalurothrips	Thrips	F. occidentalis	F. schultzei	Desmothrips	Others	Total
Thiamethoxam	7	0	11	54	0.6	0.2	0.2	73
Dimethoate/methomyl	8.4	0.2	12.2	89.2	2.8	0.4	0.8	0.8
HGW rate 1	13.6	0.2	10.4	89.8	6.2	0.2	0	120.4
HGW rate 2	14.4	0.2	16.8	82.6	3.6	0.4	0	118
Clothianidin	8.6	0	12.6	73.4	1.8	0.6	1	98
Spinosad	13.4	0.2	16.4	88.2	2.4	0	0.2	120.8
Unsprayed control	9.8	0.2	12.6	55.2	2.4	0.6	0.4	81.2
Lsd =	**7.389**	**0.4561**	**5.597**	**30.05**	**3.583**	**0.7553**	**0.8858**	
10th November 2008								
Thiamethoxam	7	0	2.75 b	20.5	2.5	0.25	0	33
Dimethoate/methomyl	7.75	0.25	2 b	38.75	2.5	0	0	51.25
HGW rate 1	13.75	0	1.5 b	34.75	4.25	0.5	0	54.75
HGW rate 2	13.5	0	1 b	33.25	2.75	0	0	50.5
Clothianidin	13.25	0	1.75 b	49.25	2.25	0.5	0	67
Spinosad	7	0	2 b	24	4.5	0.25	0	37.75
Unsprayed control	9.5	0	5.25 a	27.5	3.5	0.25	0	46
Lsd =	**9.726**	**0.26**	**2.351**	**16.89**	**3.699**	**0.6342**		
17th November 2008								
Thiamethoxam	0.5	0	1.5	5.75	0.25	0	0	8
Dimethoate/methomyl	0	0	0	8	0	0	0	8
HGW rate 1	0.25	0	1	7.75	0.25	0	0	9.25
HGW rate 2	0	0	0.5	6	0	0	0	6.5
Clothianidin	0	0	0	5.75	0.25	0.25	0	6.25
Spinosad	0.25	0	0.25	3.5	0	0	0.25	4.25
Unsprayed control	0	0.5	0	5.75	0	0.25	0.25	6.75
Lsd =	**0.5673**	**0.4130**	**1.058**	**5.690**	**0.8733**	**0.4430**		

Values followed by the same letter for each of the individual dates are not significantly different at the 5% level according to LSD test.
Those columns with not letters showed no differences between treatments

Thrips incidence

Thrips numbers were greatest on the second collection of flowers or seven days after the first foliar insecticide application, with more than 5 thrips per flower (4 adults and 1 larva) on average, from the unsprayed control plots. Thrips numbers naturally declined over time as shown in both Table 2.11 and Figure 2.3. There was no significant difference between treatments for the control of adults on any of the three assessment dates as seen in Table 2.11. The product HGW at both rates gave better control of larvae than the dimethoate methomyl mixture on the 3rd and 10th November as well as the soil applied insecticides clothianidin on the 3rd November, and only when using the higher rate of HGW on the 10th of November. The dimethoate methomyl mixture or grower standard, had the highest number of total thrips for all three flower assessments, with significantly more thrips than the untreated control on the 10th November. No treatment was particularly effective or had significantly less thrips than the unsprayed control

Table 2.11. Average number of thrips per flower present during spring 2008 insecticide trial at the Gatton Research Station.

Date	Treatment	Adults	Larvae	Total
27th Oct 08	Pre-spray	2.52	2.5	5.02
3rd Nov 08	Thiamethoxam	4.98	1.24 abc	6.22
	Dimethoate/methomyl	5.53	1.61 ab	7.14
	HGW rate 1	6.13	0.54 c	6.67
	HGW rate 2	5.87	0.50 c	6.37
	Clothianidin	5.47	1.40 ab	6.87
	Spinosad	6.12	0.76 bc	6.88
	Unsprayed control	4.19	1.20 abc	5.39
LSD		1.822	0.7463	1.974
10th Nov 08	Thiamethoxam	1.94	1.71 bc	3.65 c
	Dimethoate/methomyl	2.90	5.08 a	7.98 a
	HGW rate 1	2.83	1.70 bc	4.53 bc
	HGW rate 2	2.99	1.25 c	4.24 bc
	Clothianidin	3.31	2.54 b	5.85 b
	Spinosad	1.91	1.44 c	3.35 c
	Unsprayed control	2.65	1.35 c	4.00 bc
LSD		1.408	0.9957	1.962
17th Nov 08	Thiamethoxam	0.43	0.36 ab	0.79
	Dimethoate/methomyl	0.45	0.54 a	0.99
	HGW rate 1	0.46	0.34 ab	0.80
	HGW rate 2	0.35	0.25 ab	0.60
	Clothianidin	0.36	0.48 a	0.84
	Spinosad	0.29	0.06 b	0.35
	Unsprayed control	0.39	0.14 b	0.53
LSD		0.2986	0.3171	0.4943

Values followed by the same letter for the individual dates are not significantly different from one another ($P<0.05$)

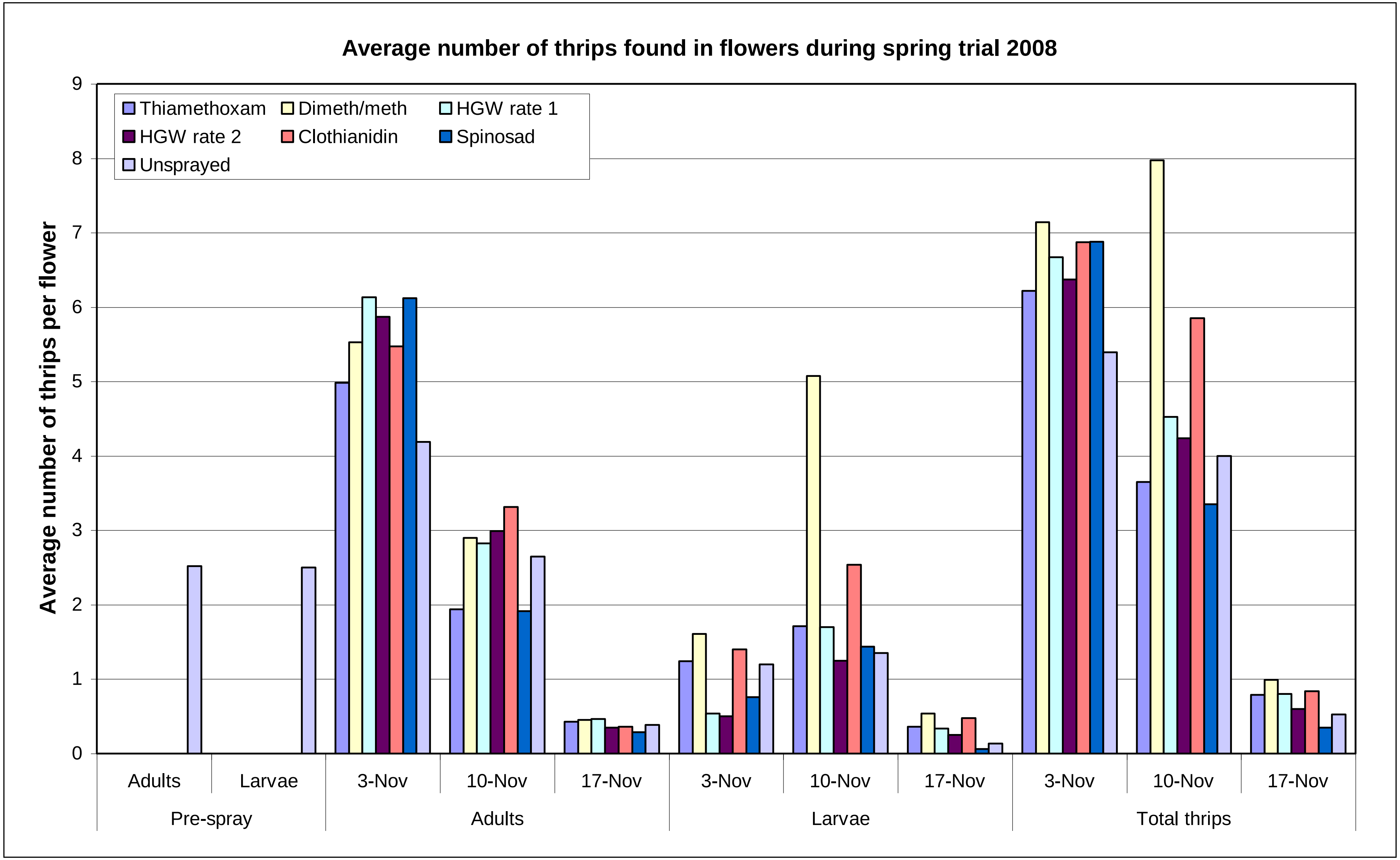


Figure 2.3. Average number of thrips found in flowers from the start of flowering until just before harvest, spring 2008 insecticide trial at the Gatton Research Station.

Harvest assessment

There was no significant difference between treatments when assessing the quality of pods or the levels of damage caused by thrips. Marketable pods ranged from 88.57% for the dimethoate methomyl mixture to 93.66% for the spinosad treatment. Only a small percentage of pods were too damaged by thrips to be marketable ranging from a low of 2.24% in the spinosad treatment to a high of 8% for the dimethoate methomyl mixture, as shown in Table 2.12 and Figure 2.4 below.

Table 2.12. Bean pod quality at harvest.

Treatments	Percentage (%)							
	No Thrips damage	Low Th. Damage	Med. Th. Damage	High Th. Damage	Total Th. Damage	GVB	Marketable pods*	Unmarketable**
Thiamethoxam	77.83	11.55	4.63	0.21	16.39	0.97	89.38	10.62
Dimethoate/Methomyl	76.82	11.75	7.51	0.49	19.75	0.23	88.57	11.43
HGW86 Rate 1	76.63	15.43	4.56	0.00	19.99	0.09	92.06	7.94
HGW86 Rate 2	79.58	10.38	4.07	0.47	14.92	0.11	89.96	10.04
Clothianidin	72.76	16.02	6.30	0.21	22.53	1.91	88.79	11.21
Spinosad	81.70	11.76	1.92	0.32	14.00	0.00	93.66	6.34
Unsprayed	76.32	12.93	5.35	0.24	18.52	0.19	89.26	10.74

*Marketable pods are the sum of no thrips damage and low thrips damage.
**Unmarketable pods includes the mediun and high thrips damage, green vegetable bug damage and damage related to grubs and disease.

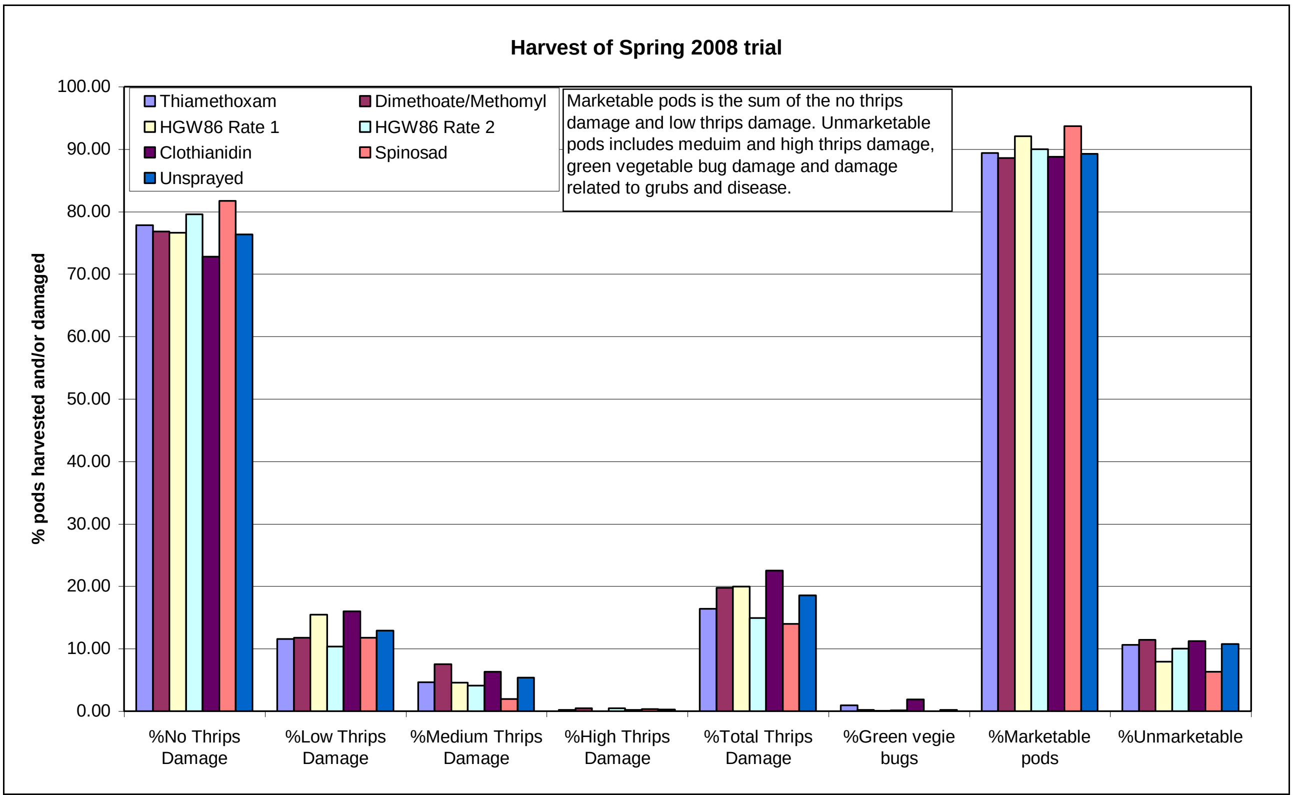


Figure 2.4. Pod damage due to thrips and green vegetable bugs at harvest on the 19th November 2008, Gatton Research Station.

Discussion

Thrips can cause various levels of damage to the bean pod, from light scaring to severly twisted and scared pods. This damage occurs within the flower when the pods are being fertilised and where the thrips are protected. Those thrips found within the flower can live on the pollen and nectar produced by the flower but can also feed on the developing pods which are soft green and easily damaged. The number of thrips required to cause damage is unclear, with damage thresholds generally being non-existent or given an arbitrary figure. To compound the diffculty a large number of thrips species have been recorded in bean flowers, 11 in total to date. It is not known whether they all cause damage or whether some just feed on the pollen and nectar or on other thrips (as may be the case with *D. tenuicornis)*. Whereas adults are easily spotted in the flower, larvae are difficult to find due to their pale colour and size, and can be easly overlooked. What level of damage do larvae contribute if any or is it soley adults that cause damage to the pods? This is really beyond the scope of this trial and project. The aim would be to cover this work in a future research project.

This spring trial found thrips numbers in flowers to be far greater compared to the previous autumn planting in the same location. On average, more that five thrips per flower were counted in spring flowers at the start of flowering compared to less than one thrips per flower in the autumn planting. Western flower thrips was the most common of the thrips to be found in flowers in this trial with numbers as high as 57 adult western flower thrips in 20 flowers or an average of 2.85 adult thrips per flower. Such large numbers would be of concern to growers as it would be assumed that this number of thrips would damage a large proportion of the developing pods. However, even with such high numbers the damage levels on the pods was still very low, with all treatments exhibiting less than 10% moderate to high thrips damage. The untreated control had only 5.59% of the pods unmarketable due to thrips damage, whereas a grower standard of dimethoate methomyl mixture recorded 8% damage. Spinosad, which is registered for the control of western flower thrips, had 2.24% moderate and high thrips damage and was one of the lowest total thrips damage with 14%. Whereas the high rate of the HGW product exhibited 14.92% total thrips damage and the unsprayed control had 18.52% total thrips damage.

No one treatment was significantly better than the unsprayed control. The spinosad and methomyl treatments, which are supposed to be effective in the management of western flower thrips in a range of cropping situations, still exhibited large proportions of this thrips. Western flower thrips was the only thrips that could be identified from the dimethoate methomyl treatment after 3 applications. Research has shown that dimethoate and particularly methomyl do not work against western flower thrips (Kay and Herron 2010).

The thrips populations within the flowers did naturally decline over time. The greatest populations occurred during peak flowering, with on average of between 5 and 7 thrips per flower. The unusually high numbers of larvae in the dimethoate methomyl treatment can not be easily explained. The distribution within the plot was uneven: there were a number of flowers in each of the four replications of that treatment that exhibited particularly large populations of larvae. Whether they were recently emerged larvae was not recorded. The next assessment showed the populations in this treatment to have declined considerably, however so did all the other treatments. So attributing this decline to the use of the treatment is not conclusive.

Again the question arises, why spray at all, especially during the spring period of production. Knowing the make up of the thrips populations would help in determining if there is a threat of pod damage. A high population of western flower thrips do not seem to contribute greatly to the damage of the pods even though there was a high population early season.

Results suggest that firstly, commercially available/commonly used treatments may be largely ineffective against common thrips pest species in beans and secondly, knowing the make-up of the thrips population is crucial in determining if there is a threat to pod damage: a high population of western flower thrips does not seem to produce a correspondingly high level of pod damage.

Trial 3 Autumn 2010

Material and Methods

Green beans, variety Labrador, were planted at the Gatton Research Station on the 4th February 2010. The crop was grown using conventional grower practices by the research station farm staff. The seed was overhead irrigated to allow for even germination and then watered with trickle tape there after when required. Plots sizes were four rows wide by 10m long and replicated four times.

Treatments

1. Control
2. Imidacloprid 14ml/100m row at planting
3. Imidacloprid 14ml/100m row at planting followed by same at pre-flowering
4. Thiamethoxam 10g/100m row at planting
5. Thiamethoxam 10g/100m row at planting followed by same to the soil at pre-flowering
6. Thiamethoxam 10g/100m row at planting followed by Durivo® which is a mixture of thiamethoxam/chlorantraniliprole 12ml/100m row to soil pre-flowering
7. Spirotetramat 400ml/ha plus 2ml/l of Hasten
8. Spinosad 400ml/ha plus Dimethoate 800ml/ha (used this season by growers)

Soil treatments were applied at the rate of 3.4L of water per 100m of row and were applied at planting using a modified cone planter. This allowed the product to be delivered immediately behind the planting shoe before the planting furrow was closed over and wheel pressed. The second soil application of product was applied at the base of the plants at the rate of 4.9L of water per 100m of row prior to watering the crop. Foliar 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. Foliar applied treatments were applied at the equivalent rate of 500L/ha of water.

Table 2.13. Application times for the various treatments used in this trial.

Treatments	4th Feb	4th Feb	10th Mar	15th Mar	23rd Mar	31st Mar	6th Apr
Control	Beans planted						Harvest treatments
Imidacloprid 14ml/100m row		√					
Imidacloprid 14ml/100m row followed by same at pre-flowering		√	√				
Thiamethoxam 10g/100m row at planting		√					
Thiamethoxam 10g/100m row at planting followed by same at pre-flowering		√	√				
Thiamethoxam 10g/100m row at planting followed by Durivo® at 12ml/100m row at pre-flowering		√	√				
Spirotetramat 400ml/ha			√		√		
Spinosad 400ml/ha plus Dimethoate 800ml/ha				√	√	√	

Monitoring

Monitoring started at the early flowering stage of the crop. The middle two rows were used for assessments where flowers were collected. Twenty five (25) flowers from each plot were collected and placed in a specimen bottle with 70% alcohol. They were then taken back to the lab for dissection and counting of the thrips. Flowers were collected weekly for three weeks. Adult thrips were identified to genus level and where possible to species to determine percentages of each type found within the bean flowers.

At harvest two one metre sections of row from the middle two rows of each plot were stripped of all their beans and taken back to the lab for assessment. All the pods were assessed as to the type of damage present and the number of marketable pods.

Statistical analysis

The data collected was statistically analysed using the analysis of variance as part of the Genstat 11^{th} Edition program supplied by the Agri-Science Queensland.

Weather data

Daily maximum and minimum temperatures, rainfall, relative humidity, wind speed and direction is tabulated in Appendix 3.

Results

Thrips species

There were six distinct thrips species from five genera found within bean flowers during this trial although not all were found in the unsprayed control plots as seen in Table 2.14 below. The most common thrips were western flower thrips *F. occidentalis* and *M. usitatus*. The hairless flower thrips *P. achaetus* and the tomato thrips *F. schultzei* were only present in low numbers with maximums of 5.32% and 8.33% respectively of numbers in the unsprayed plots. The only other known thrips pest was *Thrips* species, which can only be accurately identified by mounting them on microscope slides and using a high powered microscope. Previous trials have found that this genus comprised predominantly of *T. imaginis* and *T. tabaci*. Although no *Thrips* species were identified from the unsprayed control plots, it was present in other plots throughout the trial site. *Desmothrips tenuicornis* was the only other thrips found in the bean flowers and in very low numbers comprising less than 1% of the thrips identified.

Table 2.14. Distribution of adult thrips within untreated green bean flowers during the trial period. Numbers are averaged from 25 flowers per replication. The numbers in brackets ( ) represent the larvae, which were not identified to genus or species level.

Type of adult Thrips	17th Mar 2010	24th Mar 2010	31st Mar 2010
Pseudanaphothrips achaetus	0.25	4.00	2.00
Megalurothrips usitatus	4.75	10.75	13.75
Thrips species	0.00	0.00	0.00
F. occidentalis	8.75	55.25	59.50
F. schultzei	1.25	5.00	6.25
Desmothrips tenuicornis	0.00	0.25	0.50
Total thrips in 25 flowers	15 (6.25)	75.25 (48.5)	82 (43.25)
Total thrips per flower	0.6 (0.25)	3.01 (1.94)	3.28 (1.73)
% *Pseudanaphothrips*	1.67	5.32	2.44
% *Megalurothrips*	31.67	14.29	16.77
% *Thrips*	0.00	0.00	0.00
% *F. occidentalis*	58.33	73.42	72.56
% *F. schultzei*	8.33	6.64	7.62
% *Desmothrips tenuicornis*	0.00	0.33	0.61

M. usitatus and *P. achaetus* were the only thrips that showed effect of treatment as seen in Table 2.15 and 2.16 below. The spinosad/dimethoate mixture had consistently less *Megalurothrips* than most other treatments and was significantly better than the unsprayed control on all three assessment dates. The unsprayed control treatment had fewer thrips than the majority of other treatments for most of the thrips species. The number of adult thrips in 25 flowers was significantly lower in the spinosad/dimethoate mixtures than all other treatments on the first two assessment dates and was the lowest number on the third assesment date athough this was not a significant difference when compared to the unsprayed control.

Table 2.15. The average percentage values of thrips species found in 25 flowers for each treatment.

17th March 2010						
Treatment	*Pseudanaphothrips*	*Megalurothrips*	*Thrips*	*F. occidentalis*	*F. schultzei*	*Desmothrips*
Thiamethoxam	8.08	14.25 b	6.73	64.26	9.07	0.00
Thiamethoxam + Thiamethoxam	5.32	2.56 bc	2.00	81.73	7.44	0.00
Thiamethoxam + Durivo®	4.30	8.82 bc	0.81	73.64	12.44	0.00
Imidacloprid	7.14	9.49 bc	2.78	74.30	4.93	0.00
Imidacloprid + Imidacloprid	8.42	6.79 bc	0.00	82.46	3.88	0.00
Spirotetramat	5.81	13.67 b	4.32	72.39	3.98	0.00
Spinosad/Dimethoate	0.00	0.00 c	0.00	62.50	12.5	0.00
Unsprayed control	1.67	28.06 a	0.00	58.89	11.39	0.00
LSD =	**8.791**	**13.06**	**5.793**	**31.38**	**17.77**	
24th March 2010						
Thiamethoxam	15.65 abc	5.12 bc	2.45	67.70	9.09	0.00
Thiamethoxam + Thiamethoxam	19.82 ab	1.42 c	1.39	71.26	5.60	0.51
Thiamethoxam + Durivo®	23.75 a	2.74 bc	0.95	62.86	9.23	0.45
Imidacloprid	17.07 ab	8.22 b	1.46	63.95	9.30	0.00
Imidacloprid + Imidacloprid	22.18 ab	7.59 b	0.00	62.05	7.82	0.00
Spirotetramat	14.84 abc	7.45 bc	0.26	71.68	5.77	0.00
Spinosad/Dimethoate	11.83 bc	3.71 bc	0.00	75.05	2.27	7.14
Unsprayed control	5.70 c	14.96 a	0.00	72.93	5.93	0.47
LSD =	**10.72**	**6.197**	**2.695**	**11.27**	**5.853**	**7.427**
31st March 2010						
Thiamethoxam	3.79	16.73 ab	0.39	67.81	11.28	0.00
Thiamethoxam + Thiamethoxam	3.24	11.19 abc	0.78	78.31	6.31	0.17
Thiamethoxam + Durivo®	6.44	5.90 c	1.70	74.56	11.40	0.00
Imidacloprid	3.99	10.86 abc	0.33	79.14	5.68	0.00
Imidacloprid + Imidacloprid	7.05	8.11 bc	0.00	80.37	4.47	0.00
Spirotetramat	7.06	8.25 bc	0.00	78.10	6.59	0.00
Spinosad/Dimethoate	6.92	4.32 c	0.79	80.12	7.86	0.00
Unsprayed control	2.12	17.98 a	0.00	72.21	6.63	1.05
LSD =	**4.567**	**8.697**	**1.624**	**10.88**	**5.534**	**0.786**

Means followed by the same letter on the individual sampling dates are not significantly different from one another at the P=0.05 level.

Table 2.16. The average number of thrips species found in 25 flowers for each treatment.

17th March 2010							
Treatment	*Pseudanaphothrips*	*Megalurothrips*	*Thrips*	*F. occidentalis*	*F. schultzei*	*Desmothrips*	Total adults
Thiamethoxam	2	3.25 ab	1	15.5 ab	3		24.8 a
Thiamethoxam + Thiamethoxam	1.25	0.5 cd	0.5	19.75 a	1.5		23.5 a
Thiamethoxam + Durivo®	1	2 bcd	0.25	16.75 ab	3.25		23.25 a
Imidacloprid	1.25	1.25 bcd	0.25	14 ab	0.75		17.5 a
Imidacloprid + Imidacloprid	2	2 bcd	0	18.5 a	1.25		23.75 a
Spirotetramat	1.25	3 abc	1	15.5 ab	0.75		21.5 a
Spinosad/Dimethoate	0	0 d	0	1 c	0.25		1.25 b
Unsprayed control	0.25	4.75 a	0	8.75 bc	1.25		15 a
LSD =	**2.229**	**2.721**	**1.10**	**8.299**	**2.884**		**11.24**
24th March 2010							
Thiamethoxam	15 ab	3.25 cde	1	58.5 a	7.75	0	85.5 a
Thiamethoxam + Thiamethoxam	19.5 a	1.5 ef	1	65.25 a	5.25	0.5	93.0 a
Thiamethoxam + Durivo®	24.25 a	2.75 de	1	64 a	9.25	0.5	101.75 a
Imidacloprid	11.25 ab	4.5 bcd	1.5	45.75 a	6.5	0	69.5 a
Imidacloprid + Imidacloprid	21.25 a	5.75 b	0	51.75 a	7.5	0	86.25 a
Spirotetramat	12.5 ab	5 bc	0.25	55 a	4.75	0	77.5 a
Spinosad/Dimethoate	2 b	0.5 f	0	10.5 b	0.5	0.5	14.0 b
Unsprayed control	4 b	10.75 a	0	55.25 a	5	0.25	75.25 a
LSD =	**13.76**	**2.116**	**1.747**	**29.65**	**5.58**	**0.7158**	**44.87**
31st March 2010							
Thiamethoxam	5	23 a	0.5	91.25 a	15.25 a	0	135.0 a
Thiamethoxam + Thiamethoxam	2.75	10.5 bc	0.5	74.75 ab	6.25 b	0.25	95.0 bc
Thiamethoxam + Durivo®	7.25	7.5 bc	1.75	93 a	14.25 a	0	123.75 ab
Imidacloprid	4	7.5 bc	0.25	68.5 abc	4.5 b	0	84.75 bcd
Imidacloprid + Imidacloprid	6.25	7 bc	0	75.5 ab	4.25 b	0	93.0 bc
Spirotetramat	7	7.25 bc	0	76.5 ab	7 b	0	97.75 abc
Spinosad/Dimethoate	3.75	2 c	0.5	40.75 c	3.5 b	0	50.5 d
Unsprayed control	2	13.75 ab	0	59.5 bc	6.25 b	0.5	82.0 cd
LSD =	**3.79**	**9.448**	**1.279**	**30.95**	**5.656**	**0.3893**	**39.00**

Means followed by the same letter on the individual sampling dates are not significantly different from one another at the P=0.05 level.

Thrips incidence

Spinosad/dimethoate and spirotetramat were significantly better than all other treatments at controlling the number of larvae per flower as shown in Table 2.17 and Figure 2.5. Although the spinosad/dimethoate treatment was also significantly better at controling adults, spirotetramat was not as effective and was no better than any other treatment including the unsprayed control treatment. The spinosad/dimethoate treatment significantly controlled thrips in flowers during all assessments with a high of just over two thrips per flower 6 days before harvest (31st March 2010) compared to just over 5 thrips per flower in the unsprayed control and 7.7 thrips per flower in the thiamethoxam treatment.

Table 2.17. Average number of thrips per flower present during autumn 2010 insecticide trial at the Gatton Research Station.

Date	Treatment	Adults	Larvae	Total
17-Mar-10	Thiamethoxam	0.99 a	0.23	1.22 a
	Thiamethoxam + Thiamethoxam	0.94 a	0.18	1.12 a
	Thiamethoxam + Durivo®	0.93 a	0.21	1.14 a
	Imidacloprid	0.70 a	0.18	0.88 a
	Imidacloprid + Imidacloprid	0.95 a	0.36	1.31 a
	Spirotetramat	0.86 a	0.17	1.03 a
	Spinosad/Dimethoate	0.05 b	0.03	0.08 b
	Unsprayed control	0.60 a	0.25	0.85 a
LSD		**0.4498**	**0.2279**	**0.6231**
24-Mar-10	Thiamethoxam	3.42 a	1.39 a	4.81 ab
	Thiamethoxam + Thiamethoxam	3.72 a	1.81 a	5.53 a
	Thiamethoxam + Durivo®	4.07 a	2.00 a	6.07 a
	Imidacloprid	2.78 a	1.38 a	4.16 ab
	Imidacloprid + Imidacloprid®	3.45 a	1.26 a	4.71 ab
	Spirotetramat	3.10 a	0.16 b	3.26 b
	Spinosad/Dimethoate	0.56 b	0.06 b	0.62 c
	Unsprayed control	3.01 a	1.94 a	4.95 ab
LSD		**1.795**	**0.7485**	**2.093**
31-Mar-10	Thiamethoxam	5.40 a	2.33 ab	7.73 a
	Thiamethoxam + Thiamethoxam	3.80 bc	1.70 bc	5.50 bc
	Thiamethoxam + Durivo®	4.95 ab	2.70 a	7.65 a
	Imidacloprid	3.39 bcd	1.29 c	4.68 bc
	Imidacloprid + Imidacloprid	3.72 bc	2.12 ab	5.84 b
	Spirotetramat	3.91 abc	0.23 d	4.14 c
	Spinosad/Dimethoate	2.02 d	0.02 d	2.04 d
	Unsprayed control	3.28 cd	1.73 bc	5.01 bc
LSD		**1.56**	**0.8288**	**1.641**

Means followed by the same letter on the individual sampling dates are not significantly different from one another at the P=0.05 level.

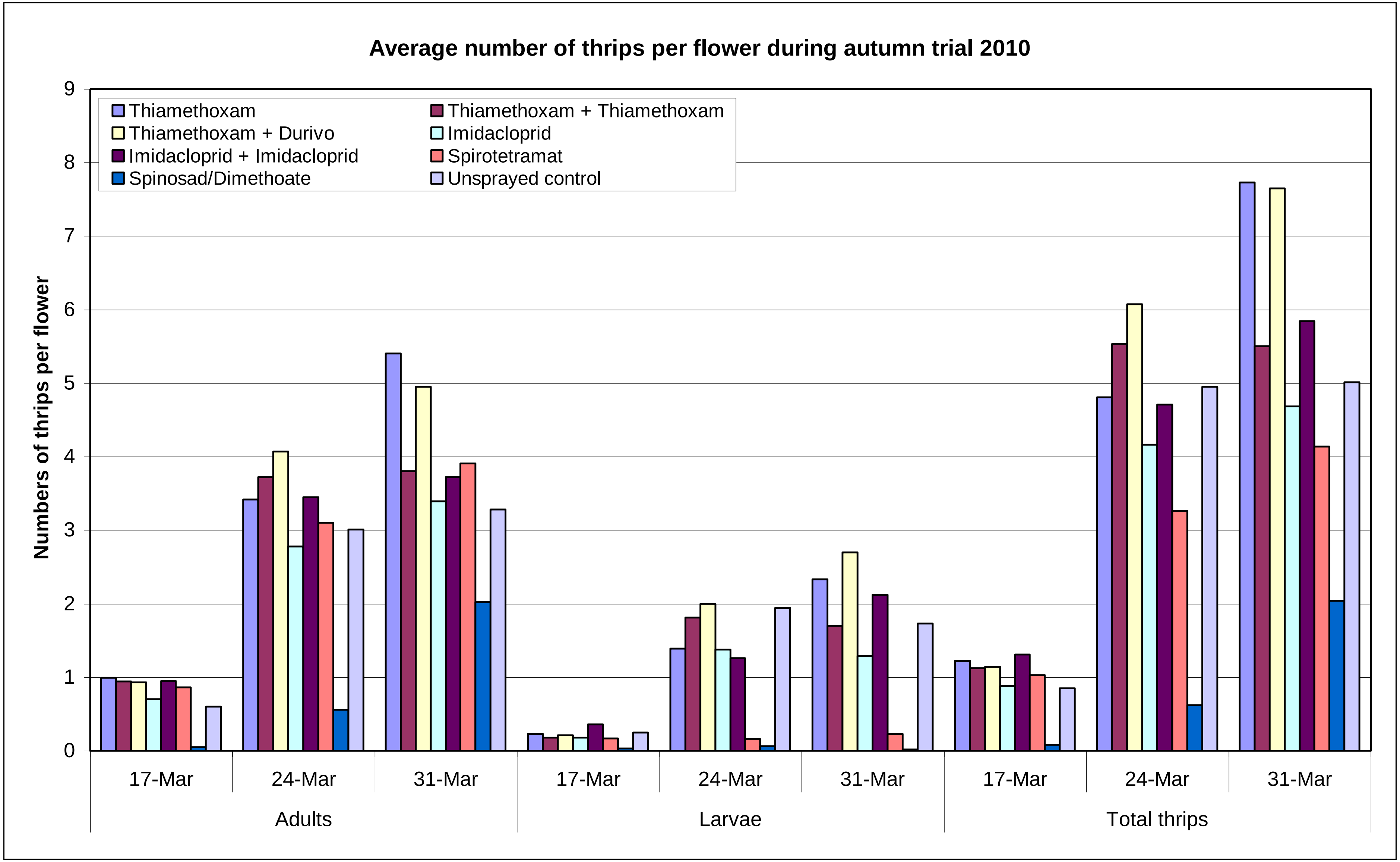


Figure 2.5. Average number of thrips found in flowers from the start of flowering until 1 week before harvest, autumn 2010 insecticide trial at the Gatton Research Station.

Harvest assessment

There was no significant difference between treatments when comparing the percentage of pods that were marketable. Marketable pods in this trial comprised those pods with no visible signs of thrips damage or any other damage and those with moderate levels of thrips damage. Broad mites were an unexpected pest this season causing damage to the pods as well as the leaves and new growth just before harvest. Numbers increased rapidly making this pest difficult to manage effectively.

Spinosad/dimethoate mixture and the spirotetramat treatments yielded the highest percentage of marketable pods with 39.26% and 41.73% respectively, while the unsprayed control performed the worst with 29.31% of pods that could be sold. The use of spinosad/dimethoate mixture significantly reduced the incidence of grubs with less than 1% of pods exhibiting grub damage. However the use of the spinosad/dimethoate mixture resulted in the greatest level of mite damage to the pods, 23.82% which was significantly worse than the unsprayed control treatment. Thiamethoxam plus Durivo® also resulted in a higher percentage of mite damaged pods. This is in contrast to the other two Thiamethoxam® treatments which exhibited considerably lower mite damaged pods. The unsprayed control treatment was not significantly different from the majority of other treatments in the level of mite damaged pods.

Table 2.18. Bean pod quality at harvest, 6th April 2010.

Treatments	Percentages (%)					
	No Th. Damage	Mod. Th. Damage	High Th. Damage	Grub Damage	Mites	Marketable*
Thiamethoxam	11.79	23.82	45.01	10.86 ab	8.19 bc	35.61
Thiamethoxam + Thiamethoxam	11.13	20.84	44.43	15.93 a	7.53 c	31.98
Thiamethoxam + Durivo®	10.73	23.10	36.60	9.76 ab	19.64 ab	33.82
Imidacloprid	5.09	28.48	47.55	9.13 ab	9.41 bc	33.57
Imidacloprid + Imidacloprid	8.45	22.40	46.01	15.24 a	7.89 bc	30.85
Spirotetramat	18.82	22.91	45.16	7.09 bc	5.91 c	41.73
Spinosad/Dimethoate	17.16	22.09	35.81	0.99 c	23.82 a	39.26
Unsprayed control	13.70	15.61	49.57	11.57 ab	9.03 bc	29.31
LSD	**8.595**	**11.47**	**23.33**	**7.351**	**12.00**	**15.16**

* Marketable pods is the sum of those pods with no signs of damage and moderate levels of thrips damage.

Means followed by the same letter on the individual sampling dates are not significantly different from one another at the P=0.05 level

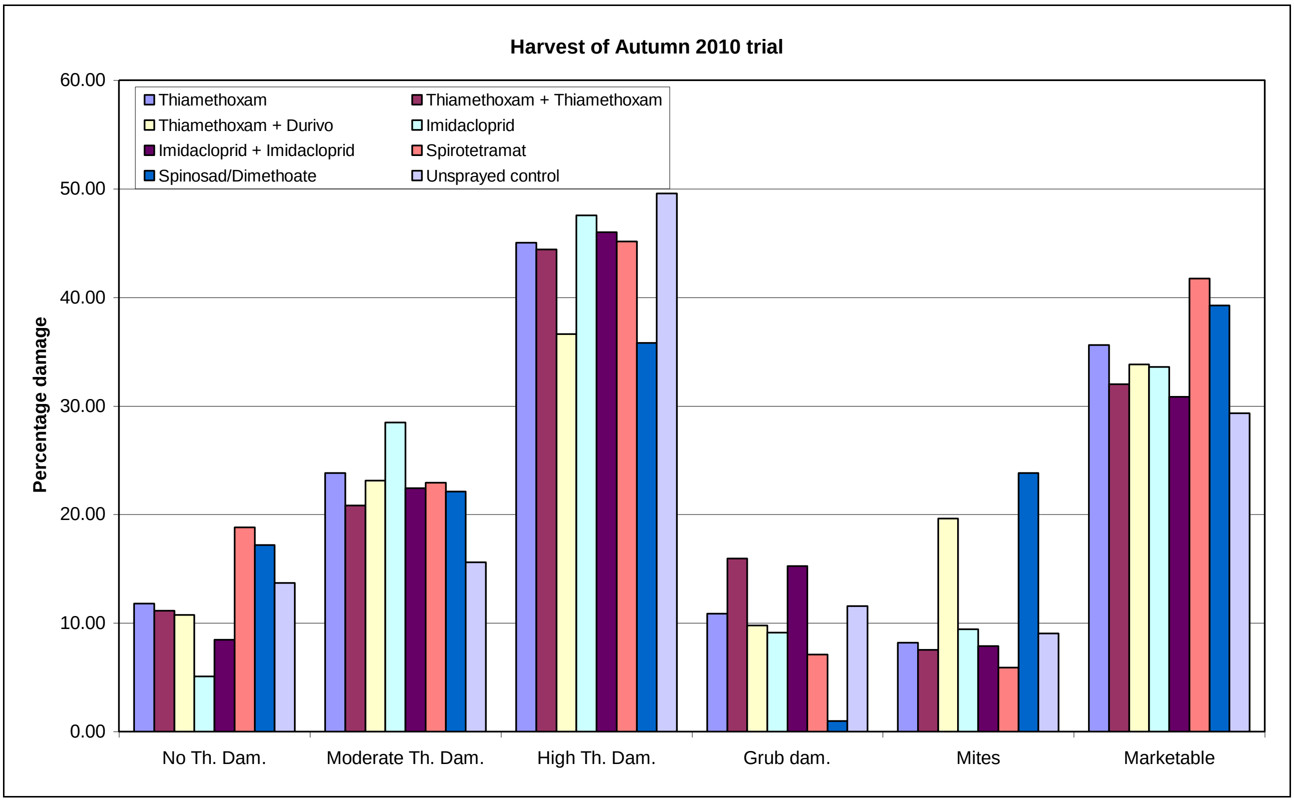


Figure 2.6. Pod damage due to thrips, grubs and mites at harvest on the 6th April 2010, Gatton Research Station.

Discussion

Thrips numbers were considerably higher in this trial than in previous autumn trials. This could be due in part to the weather with more rain and cooler conditions prevailing compared to previous seasons.

Broad mites *Polyphagotarsonemus latus* were an unexpected pest this season due to the unusually wet, humid and cooler conditions experienced as is shown in the weather data in Appendix 3. This particular mite causes severe bronzing on the foliage, stems, growing tips and pods. The damage to the pods particularly resembles that caused by thrips, with twisted misshapen pods, but they are bronzed in colour. This initially confused the assessments but with practice the pods damaged due to mites could be separated from that of thrips.

Broad mite damage on bean pods at different ages.

Thrips numbers per flower increased considerably during the flowering period up until harvest from an average of just under one thrips per flower at the start of flowering to over five thrips per flower just before harvest. The grower standard of spinosad/dimethoate treatment was the better performer of all the treatments for both larvae and adults. This treatment was particularly effective against both *M. usitatus* and *F. occidentalis* adults, although this was not always reflected in the proportion of these thrips recovered from the flowers. *F. occidentalis* was clearly the more dominant thrips during this trial followed by *M. usitatus*. *Thrips* species were the least abundant of the thrips with numbers consistently less than one thrips per 25 flowers. *P.achaetus* and *F. schultzei* were relatively equally proportioned in their numbers throughout the trial period, with the treatments having very little effect.

There were some inconsistencies between treatments particularly on the last assessment date. The fact that the thiamethoxam+thiamethoxam treatment was better than the thiamethoxam+Durivo® treatment at controlling the larvae and total numbers of thrips is hard to explain as Durivo® contains the same active ingredient as thiamethoxam. It would be expected that these two treatments should perform to the same degree. Another inconsistency was that one application of imidacloprid was better than two applications at controlling thrips larvae. Errors in counting could be considered an explanation. However thrips often dwell deep within the flower making it particularly difficult for insecticides to reach them and the difficulty in getting the insecticide to the flower, pollen, nectar and developing bean pod. However, thrips are not evenly distributed within the plot which could skew results. Such counts need to be considered in any analysis as this is a true representation of what happens in the paddock. It is unrealistic to expect an even distribution of thrips or any other insect within a plot or paddock.

The spinosad/dimethoate treatment clearly had an impact on the two major thrips species, significantly reducing their numbers. This however did not reflect in the percentage of marketable pods at harvest. A cumulative total of 2.74 thrips per flower in the spinosad/dimethoate treatment, represented just over 39% of the pods able to be marketed. If all other pests, grubs and mites, were managed effectively, then 64% of the pods would be marketable, which is not significantly different from the unsprayed control or any of the other treatments. Thiamethoxam+Durivo®, which had a cummulative total of 14.86 thrips per flower had the potential of achieving 63.22% marketable pods. You might have expected far more damage to the pods with such a large number of thrips, but this was not the case.

So the question that needs to be asked is, just how many thrips are too many, and what thrips is/are the true cause of the damage to the pods?

Conclusion

Thrips are a complex of individuals from multiple species spanning multiple genera. Those recorded from green bean flowers include 11 species from 7 genera. A number of these thrips are not thought to cause damage to green bean plants; *Desmothrips tenuicornis*, *Haplothrips gowdeyi*, and *Limothrips cerealium*. While others such as *Frankliniella occidentalis, F. schultzei, Megalurothrips usitatus*, *Pseudanaphothrips achaetus*, *Thrips imaginis*, *T. parvispinus, T. safrus, T. tabaci* and *T. vulgatissimus*, may cause damage to the developing bean pod or could be present only to feed on the nectar and pollen produced by the flower.

Both larvae and adults are found within the bean flower, which is generally only open for a few days. It is likely that the adults lay their eggs on the developing flower buds and adjacent soft stems (Caon and Burfield 2006) allowing the larvae quick access to the flower once the eggs hatch. Whether the larvae actually cause damage to the developing pod is not clear. This is illustrated by the fact that spirotetramat and spinosad are very effective at controlling the larvae, but damage levels on the pods are still relatively high and not much different to the unsprayed control plots. So are the larvae there for the nectar (energy) and pollen (protein) to aid their early development, only switching their preference for the developing bean pod or other plant tissue once the nectar has dried up and the pollen dies off or loses its nutritional qualities. Numerous articles indicate that larvae do attack plant tissue, especially western flower thrips as this is the stage of their life cycle that acquires the tomato spotted wilt virus (Kindt, Joosten et al. 2003; Caon and Burfield 2006; Persley, Sharman et al. 2007). Tamò et al. (1993) showed that the feeding activity of six larvae of a closely related *Megalurothrips* species *M. sjostedti* during five days induced the shedding of all flower buds of a cowpea inflorescence. Kirk (1985) showed that pollen greatly increased the rate of oviposition, compared with floral tissue or nectar for *Thrips fuscipennis* and suggests the results may also be found for other flower thrips.

The number of thrips per flower and the species distribution during the growing season in south east Queensland shows a great deal of variability. Bean blossom thrips *M. usitatus*, a known pest of green beans, is not always present in the green bean flowers. Spring plantings have the least number of this thrips present in the flowers, while large numbers are present during the autumn months. This could be due to the increased temperatures during the spring and summer months as temperatures above 29ºC are deleterious to larvae during hatching and adult longevity in *Megalurothirps sjostedti* legume flower thrips of cowpeas (Ekesi, Maniania et al. 1999). The hairless flower thrips *P. achaetus,* has greater numbers present during the spring planting as does the collection of *Thrips* species. Western flower thrips *F. occidentalis* is quite variable in numbers with the autumn 2008 planting having very few present in the flowers, while in spring 2008 this was the most common thrips in the flowers. In contrast, during the autumn 2010 planting western flower thrips was again one of the most commonly found thrips in bean flowers. Weather could be playing a part in thrips population dynamics, as the 2010 planting was wetter and more humid than the 2008 planting which may have contributed to more crops being grown in the region as well as more weeds in the paddocks harbouring thrips. Certain thrips such as *Frankliniella* species may be better adapted to wetter conditions as there numbers were greater in the 2010 season compared to the 2008 season while the *Thrips* species declined during the wetter year (Harding 1961; Chyzik and Ucko 2002). The other reason for the increased number of western flower thrips number could be that they were preying on the large number of broad mites present in the crop. Studies undertaken by (González and Wilson 1982; Pickett, Wilson et al. 1988) found that *F. occidentalis* was an omnivor or generalist predator and will probably attack prey smaller than itself including eggs of *Tetranychus* species or mites. The autumn 2010 trial crop was particularly hard hit by broad mites due to the cooler and more humid conditions favoured by this mite(Jones and Brown

1983). So were the increased number of *F. occidentalis* actually feeding on the mites as well as the flowers? The spinosad/dimethoate treatment had the lowest thrips population but the highest broad mite damage, which would tie in nicely with the theory that thrips were predators of mites. This predation was not observed but warrants investigation as a possible predator of mites in future trial work.

More detailed work on the population dynamics of the different species of thrips is needed during the growing season in each of the major bean producing regions to show when the different species are likely to be present and in what proportions to the rest of the population. Understanding what species also cause the damage to the bean pod may help growers better select an insecticide. Western flower thrips can build up resistance to insecticides quickly and so using dimethoate to manage western flower thrips could be ineffective, but may be of use if plague thrips *T. imaginis* or even hairless flower thrips *P. achaetus* were present in large numbers. The use of spinosad and methomyl either alone or as a mixture had very little effect against *F. occidentalis* even though these insecticides are known to affect this thrips. This is most likely due to the nature of the thrips living inside the flower where the various insecticides can not effectively penetrate. The fact that spinosad did have a positive effect against the larval population could be due to this product having some translaminar effect: if this were to happen on the flower petals, where thrips eggs are most likely laid, then this product could be responsible for affecting the newly hatched larvae before they move into the flowers.

The spinosad/dimethoate treatment was the best performer of all treatments at controlling the adult thrips, while the spinosad and the spirotetramat treatments on their own were the best overall at controlling the number of larvae in the flowers. When we look at the average numbers of adults and larvae per treatment over each trial (Table 2.19 below) the results are highly variable. When thrips numbers were high in spring, especially *F. occidentallis, Thrips* spp and *P. achaetus*, the percentage marketable pods was also high with no difference between treatments, including the control which had nearly 90% of marketable pods. *Megalurothrips* numbers were very low during this time of the year when temperatures were constantly above 29^{o}C. Such high temperatures have been shown to significantly affect adult longevity and larval survival (Ekesi, Maniania et al. 1999). During the autumn of 2008 the percentage marketable pods was relatively low in comparison, with the exception of the spinosad treatment. The only thrips that increased significantly in number during this time of the year was *M. usitatus,* increasing by an order of magnitude of at least 50 times, while all other thrips species fell in number, including *F. occidentallis*. When thrips numbers were again high, including *F. occidentallis* and *F. schultzei* as in the autumn 2010 trial, the marketable yield was still very low compared to the spring planting, when these two thrips were high in number. The lower values in the 2010 trials were due to the presence of the broad mite. If the broad mites were taken out of the equation then the percentage marketable values would have been close to those of the 2008 autumn trial even though there was an increase in *F. occidentallis* numbers.

These trials show that larvae are unlikely to contribute significantly to damage levels of bean pods as the best larval treatments of spinosad/dimethoate and spirotetramat still suffered serious losses during the autumn trials. Adults seem to be the major contributor to damage levels with *M. usitatus* being the main thrips pest responsible for this damage although not the only pest. During the spring 2008 trial, two treatments did not record any *Megalurothrips* (thiamethoxam and clothianidin), yet they still experienced over 10% damage to the pods. So what other thrips is the likely candidate? *F. occidentallis* seems unlikely due to the variablility throughout the season and between seasons with high numbers in spring 2008 corresponding to low damage levels and low numbers in autumn 2008 corresponding to high damage levels. *Thrips* spp numbers were the only other pest that had an increase in numbers during the spring 2008 trial planting. This group of thrips were not seperated into species so perhaps one or more of these species of *Thrips* could be contributing to damage levels in beans.

Thrips tabaci and *T. imaginis* are the most identified of this genera from bean flowers with *T. tabaci* a known pest of a wide range of crops, damaging plant tissue both during the larval and adult stages of its life cycle(Childers 1997; Hein and Peairs 2006; Mo, Munro et al. 2008). Which ever *Thrips* spp is responsible, if at all for the pod damage, does the degree of damage warrant a treatment being applied to the crop. An earlier trial spring 2004 season looking at caterpillar control had only 12% pod damage due to thrips in the unsprayed control plots. Knowing what species of thrips are present in the flowers could help growers decide on the need for an insecticide spray, especially if the damage levels expected during that time of the year fall within what they are willing to accept as losses.

Clearly no one chemical trialled was a stand out performer for the control of all species of thrips likely to be found within a bean flower. Spirotetramatand spinosad do very well on larvae but not so well on the adults in the flowers, while spinosad/dimethoate mixture performed well on both adults and larvae. With dimethoate under review, there is a cloud over its head and if it were to be withdrawn from the market, this would put further pressure on thrips control. As it appears that the adults are the likely stage responsible for the damage, perhaps the push should be trying to manage adult thrips before they enter the flower or even before the flowers open. Perhaps future work should be looking at applying insecticide from the late vegetative phase of the crop or the flower bud development, as once the thrips gain entry into the flower it is extremely difficult to control them and stop them from causing some level of damage to the pods, ultimately leading to a reduction in yield.

Table 19. Average number of thrips found in the flowers during the flowering period prior to harvest. Values are the averages of the assessments taken during flowering for each trial.

Date*	**Treatment**	***Pseudanaphothrips***	***Megalurothrips***	***Thrips***	***F. occidentalis***	***F. schultzei***	***Total adults***	***Total larvae***	***% Marketable***
A08	Biofungi	0.05	0.38	0.04	0.07	0.01	0.56	1.02	69.89
A08	Imidacloprid (soil)	0.20	0.18	0.04	0.13	0.01	0.57	0.66	72.34
A08	HGW86 rate 1 (soil)	0.08	0.27	0.06	0.08	0.05	0.55	1.2	67.24
A08	HGW86 rate 2 (soil)	0.03	0.50	0.05	0.05	0.01	0.63	1.31	56.35
A08	Spirotetramat 300	0.10	0.18	0.04	0.06	0.02	0.41	0.14	66.53
A08	Spirotetramat 400	0.07	0.20	0.08	0.06	0.02	0.43	0.08	59.57
A08	Spinosad	0.13	0.16	0.06	0.05	0.01	0.42	0.34	80.38
A08	Unsprayed control	0.10	0.28	0.08	0.07	0.00	0.53	0.77	51.05
S08	Thiamethoxam (soil)	0.19	0.00	0.20	1.07	0.04	1.51	1.10	89.38
S08	Dimethoate/methomyl	0.22	0.01	0.19	1.81	0.07	2.29	2.41	88.57
S08	HGW86 rate 1 foliar	0.37	0.00	0.17	1.76	0.14	2.45	0.86	92.06
S08	HGW86 rate 2 foliar	0.37	0.00	0.24	1.62	0.08	2.33	0.67	89.96
S08	Clothianidin (soil)	0.29	0.00	0.19	1.71	0.06	2.25	1.47	88.79
S08	Spinosad	0.28	0.00	0.25	1.54	0.09	2.16	0.75	93.66
S08	Unsprayed control	0.26	0.01	0.24	1.18	0.08	1.76	0.90	89.26
A10	Thiamethoxam (soil)	0.29	0.39	0.03	2.20	0.35	3.27	1.32	35.61(54.66)**
A10	Thiamethoxam + Thiamethoxam (soil)	0.31	0.17	0.03	2.13	0.17	2.81	1.23	31.98(55.44)
A10	Thiamethoxam + Durivo® (soil)	0.43	0.16	0.04	2.32	0.36	3.31	1.64	33.82(63.22)
A10	Imidacloprid (soil)	0.22	0.18	0.03	1.71	0.16	2.29	0.95	33.57(52.11)
A10	Imidacloprid+Imidacloprid (soil)	0.39	0.20	0.00	1.94	0.17	2.71	1.25	30.85(53.99)
A10	Spirotetramat	0.28	0.20	0.02	1.96	0.17	2.62	0.19	41.73(54.73)
A10	Spinosad/Dimethoate	0.08	0.03	0.01	0.70	0.06	0.87	0.04	39.26(64.07)
A10	Unsprayed control	0.08	0.39	0.00	1.65	0.17	2.29	1.31	29.31(49.91)

* A08 – Autumn 2008: S08 – Spring 2008; A10 – Autumn 2010

**Values in brackets represent the yield if broad mites were not an issue at harvest and were controlled early in the crop.

3 Tasmanian Research Activities

3.1 Tasmanian Trials: Determining the contribution that flower thrips make towards ‘wind scorch’ symptoms in Tasmanian green beans.

Introduction

Tasmania produces 36% of the Australian tonnage of green beans, the majority of which would end up as a processed product (ABS 2008/09). Scarring on Tasmanian green beans has long been attributed to "wind scorch" due to the high winds experienced when beans are grown in Tasmania. However, some of the damage experienced could also be due to thrips. Thrips are a continuing pest problem and a difficult one to control or manage due to the habit of this small insect, which can be found feeding on the developing pods within the flowers. Growers in Tasmania seem to be unaware of the full extent of this pest on their industry with limited research undertaken to date to understand this pest on their processing industry and the confusion of the damage caused by this pest and what is traditionally thought of as "wind scorch”. Where the percentage of the pods showing this ‘wind scorch’ damage exceeds figures upwards of about 5%, crops can be completely rejected by the processor, with significant financial consequences for the grower.

Wind exclusion trials were carried out in Tasmania to compare wind scorch with known thrips damage and the interaction of the two by trying to exclude thrips from plots by repeat applications of an appropriate insecticide. Two trials were therefore undertaken during the 2008/2009 growing season to look at this issue with a further two trials during the 2010/2011 growing season.

If these trials show that thrips damage can be a significant influence on the percentage of damaged pods, then Tasmanian bean crops could benefit from the application of insecticides targeting thrips. At present, thrips are not considered an issue by Tasmanian growers and specific treatments for their control are not used.

Aims:

The aim of this component of the project is to answer the following questions:

- Is the pod damage currently attributed to ‘wind scorch’ in Tasmanian green beans caused by wind, flower thrips, or a combination of both?
- If a combination, is it possible to apportion the contribution between the wind and thrips factors?
- In short, does excluding thrips from Tasmanian green beans at flowering cause a reduction in the pod damage currently attributed to ‘wind scorch’? If so, this would indicate that thrips are implicated in causing this damage.
- Also, does reducing the wind speed experienced by Tasmanian green beans reduce the percentage of pods exhibiting ‘wind scorch’ symptoms? If so, this would indicate they are at least partly caused by the wind, but if the percentage damaged pods is higher in the unsprayed than the sprayed plots, then thrips are still playing a role in causing these symptoms.

Material and Methods

SITE 1

Location:	Forthside, north-west Tasmania. Scott Langton (Jathneil Pty Ltd)
Trial conducted by:	Agronico Research Proprietary Limited
Participants:	Odin Fransenn, David McLaren
Crop (cultivar):	French beans (Montano)
Planting Method	Direct seeded on 12th November, 2008
Plant density:	50 mm in row 540 mm between rows
Soil:	Red ferrosol, 2% slope.
Fertilizer:	Standard for area: details not recorded
Irrigation:	Travelling gun, as required

Layout

The trial was laid out as a randomized complete block experiment with four blocks each containing one plot of each of the four treatments. Each plot was 5 meters by 2.5 meters (5 rows) and the centre of it was at the centre an untreated area 10 meters square i.e. there was an untreated buffer strip, 2.5 meters to 3.75 meters wide surrounding each plot. Thus each plot was at least 5 meters from its nearest plot. With the untreated areas included, the trial occupied an area 40 meters square.

Treatments

There were four treatments, two levels of wind by two levels of *Thrips* spp.; how this was achieved is summarised in the table below.

The treatments

Codes	Wind Level	Thrips Level
A (Red)	High = Plot open, no wind barrier	Low = Plot sprayed regularly with insecticide
B (Red-Green)	Low = Plot surrounded by wind barrier	Low = Plot sprayed regularly with insecticide
C (Green)	Low = Plot surrounded by wind barrier	High = Plot NOT sprayed with an insecticide
D (Blue)	High = Plot open, no wind barrier	High = Plot NOT sprayed with an insecticide

The wind barriers were installed the day after the crop was sown and 41 days later on 13 January 2009 (day 0) dimethoate 400 g/L EC was applied at 500 mL/ha, in 500 L/ha of fine to medium aqueous spray. Further applications were made on days 7, 14 and 21, in which time flowering increased from about 20 to 100%. All applications were made to dry plants in weather suitable for this purpose.

The wind barriers were a wall of hessian surrounding the plot to a height of one metre: the hessian was stapled to wooden posts driven firmly into the soil.

Wind speed in the open was measured and recorded every 5 minutes and these data are summarised in Appendix 4. The average wind speed over the 24 days of the trial was 6.1 km/h. Wind speed within the wind barriers was not recorded.

Dimethoate 400 g/L EC, was applied at 500 mL/ha on four occasions at intervals of seven days, from 13 January to 3 February. This insecticide is registered in all Australian states for the control of Thrips in beans at 800 mL/ha.

Application of the Treatments

A compressed gas powered sprayer fitted with a flat boom carrying four nozzles at 50 cm spacings.

Table 3.1 Settings and conditions

Application Date	13/01/09	20/01/2009	27/01/2009	03/02/2009
Day number:	0	7	14	21
Tips :	Hardi Flat Fan 110 02 VP	Hollow Cone: details not recorded		
Pressure (kPa):	200	200	200	200
Mean Discharge/Nozzle: and Range (mL/30s):	390	570 560-580	577.5 575-580	502.5 500-510
Spray Quality:	medium	probably fine to medium		
Time:	10:45 – 12:15	14:00 – 15:00	15:45 – 16:00	13:30 – 14:00
Plot Area Sprayed:	5m x 2.5 m	5 m x 2.3 m		
Spraying time per plot:	12.0	7.6	7.5	8.6
Temperature (0C):	18.5	29	22.5	n/a
Relative Humidity (%):	86	n/a	40	n/a
Wind speed in open: Wind speed in barrier:	4 kph 2 kph	7.6 – 14 n/a	2 – 3 n/a	n/a n/a
Wind Bearing:	N	NW	NE	W to SW
Crop development:	BBCH 61 10% Flowering		BBCH 63 30% Flowering	100 % Flowering

Non-experimental treatments

While the trial was being conducted no treatments known to affect the incidence of wind scorch or *Thrips* spp. were applied.

Weather

Over the 23 day interval that both treatments were in effect, there was five days of rain totalling 14.4 mm. The daily maximum temperature ranged from 18ºC to 30ºC and averaged 23ºC while the daily minimum temperature ranged from 5ºC to 19ºC and averaged 13ºC. (Appendix 4)

Assessments

Day 0 was the 13-January 2009, the day that dimethoate was first applied.

On day 0, 1, 5, 10 and 15 *Thrips* spp. were counted on 25 flowers picked from along the central rows of some or all plots: adult *T. tabaci*, adult *T. imaginis* and total juvenile *Thrips* spp. were recorded.

On day 1, 17 and 23 five plants were examined in some or all plots and the leaves, racemes and pods on them were counted. Additionally, on the first two occasions buds and flowers were counted while on the last two occasions the length of each of the upper five pods per plant was measured.

On day 23 the plots were harvested and the pods were divided into those too small to market and those of marketable length. Both groups were weighed and the marketable pods were sorted into four groups viz.
1. Clean – no Thrips damage and no Scorching
2. Thrips damaged only
3. Thrips damaged and scorched
4. Scorched only

Note: “Wind Scorch” is abbreviated as Scorch.

Each of these four groups was weighed and the pods in them were counted, during this activity any diseased pods were removed and subsequently counted and weighed.

The timing of assessments in relation to the application of the treatments is summarised in the table below:

Table 3.2 Application of treatments.

Date	Day #	Activity	Sample Size	Plots sampled
3-Dec	-41	Install wind barriers		
13-Jan	0	Count thrips	25 flowers/plot	All Block 2, 3, 4
13-Jan	0	Apply dimethoate		
14-Jan	1	Count thrips	25 flowers/plot	All
14-Jan	1	Agronomy	5 plants/plot	All
20-Jan	7	Apply dimethoate		
23-Jan	10	Count thrips	25 flowers/plot	All
27-Jan	14	Apply dimethoate		
28-Jan	15	Count thrips	25 flowers/plot	All
30-Jan	17	Agronomy	5 plants/plot	A1, B1&4, D1&2
3-Feb	21	Apply dimethoate		
5-Feb	23	Agronomy	5 plants/plot	All
5-Feb	23	Harvest: wt. #. damage		All

Agronomy = Height, #Leaves, #Buds, #Flowers, # Racemes, # and length of Pods

Results

Two species of thrips were present in the beans with *T. tabaci* more numerous than *T. imaginis*. The day before dimethoate was first applied (41 days after the wind barriers were installed) there were significantly ($p \leq 0.050$) more adult *T. imaginis* in plants un-protected from wind than in plants protected from wind as shown in Table 3.3, 88 thrips compared to 42 thrips per 25 flowers respectively. With adult *T. tabaci* there was no significant response to wind.

Averaged over the assessments on day 1, 5 and 15 (Table 3.4), there appeared to be 20% more adult *T. imaginis* under "High-Wind" than under "Low-Wind", however the difference was not significant.

The spray program of dimethoate achieved its objective in creating two distinctly different sized populations of *Thrips* spp. Between day 1 and 15 the population of *Thrips* spp. in dimethoate treated beans averaged 35% of the population in untreated beans and this differences was highly significant (Table 3.4). The total population of *Thrips* spp in each treatment, from day 1 to 15, is plotted in Figure 3.1.

The assessment on day 1, the day after dimethoate was first applied, showed that plants that had been protected from the wind were significantly taller than unprotected plants (Table 3.5). But no responses to wind were evident in the mean numbers of leaves, buds, flowers, racemes or pods per plant.

On day 1, there were significantly fewer flowers on the plants that had been treated with dimethoate than on untreated plants. Since dimethoate was only applied the previous day and at 40% lower than the highest registered dose for beans it was unlikely to be the cause.

On day 17 (Table 3.6), plants in treatment A ("High Wind"-"Low Thrips") carried significantly more leaves and flowers than plants in treatment B ("Low Wind"-"Low Thrips"). Additionally, on average, the pods on the plants in treatment A were significantly longer than the pods on the plants in Treatment B. Further, the plants in treatment A appeared to be shorter and carry more buds, racemes and pods than the plants in treatment B.

On day 17 the plants in treatment D resembled those in treatment A more closely than those in treatment B. The pattern of differences between D and B was similar to the pattern between A and D which suggested that the growth and development of the bean plants was affected more by wind than by *Thrips* spp.

On day 23, plants exposed to "High Wind" were significantly shorter than plants exposed to 'Low Wind" and plants subjected to "High Thrips" were significantly shorter than plants subjected to "Low Thrips" (Table 3.7). The number of leaves, racemes and pods per plant as well as the length of the pods did not vary significantly with the level of wind. With the exception of the number of racemes per plant this was also the case with the level of Thrips. But there were significantly fewer racemes on "High Thrips" plants than on "Low Thrips" plants.

The day 1 and 23 assessments showed that, averaged over "Thrips Level", "Low Wind" plants were significantly taller than "High Wind" plants. In contrast, on day 17, under "Low Thrips", on "High Wind" (A) plants, the pods were significantly longer and there were significantly more buds and leaves than on "Low Wind" (B) plants. Hence, compared with "High Wind", on day 1 and 23

“Low Wind” increased growth whereas on day 17 it decreased growth. Consequently there appeared to be a conflict between the two sets of assessments. This was weakened to some extent by absence of significant differences between plant heights on day 17, as well as assessment of only three of the four treatments.

Based on counts; the percentage of harvested pods with scorch, Thrips damage and both of these, increased significantly as “Wind Level” and “Thrips Level” increased (Table 3.8). Based on weight; the same pattern was evident but it was significant only with “Wind Level” (Table 3.9).

The total weight of harvested pods appeared to be greater under “Low Wind” than under “High Wind”: the difference was significant at $p = 0.096$ (Table 3.10). This was also the case with the large clean pods ($p = 0.085$). Consistent with these measurements of weight, the plants under “Low Wind” tended to produce more large pods than plants under “High Wind” (Table 3.11).

The weight of the four categories of pods (Table 3.10) did not respond significantly to “Thrips Level”, however the weight of pods under “High Thrips” tended to be greater than those produced under “Low Thrips”. Similarly the plants under “High Thrips” tended to produce more pods than plants under “Low Thrips” (Table 3.11). These tendencies are the opposite of the expected results of thrips control.

None of the treatments had any significant effect on the mean weight per large (marketable) pod.

Table 3.3. The population of *Thrips* spp. one day before the first application of insecticide

Treatment			Mean number per 25 flowers, on day -1							
Code	Wind Level	Thrips Level Intended	Adult *T. tabaci*		Adult *T. imaginis*		Juvenile *Thrips* spp.		Total *Thrips* spp.	
ANOVA										
A	High	Low	84	a	86	a	15	a	185	a
B	Low	Low	82	a	43	a	15	a	139	a
C	Low	High	74	a	40	a	20	a	135	a
D	High	High	78	a	90	a	15	a	182	a
Treatment F probability			0.616		0.068		0.793		0.235	
Significance level of Bartlett's test			0.454		0.252		0.242		0.526	
Factorial ANOVA (Wind by Thrips)										
Interaction F probability			0.940		0.657		0.537		0.919	
AD	High Wind		81	a	88	b	15	a	184	b
BC	Low Wind		78	a	42	a	17	a	137	a
Wind F probability			0.530		0.014		0.537		0.009	
CD	Intended High Thrips		76	a	65	a	17	a	158	a
AB	Intended Low Thrips		83	a	65	a	15	a	162	a
Thrips F probability.			0.221		0.936		0.537		0.472	

Letters indicate statistical separation (p=0.050) Tukey’s HSD test

Table 3.4. The population of *Thrips* spp. after application:

Treatment			Detransformed mean number per 25 flowers *1 Over 3 assessments: day 1, 5 and 15 *2							
Code	Wind Level	Thrips Level	*T. tabaci* Adults		*T. imaginis* Adults		*Thrips* spp. Juvenile		*Thrips* spp. All	
ANOVA										
A	High	Low	35.7	a	9.9	a	3.4	a	56	a
B	Low	Low	36.7	a	9.9	a	5.4	a	57	a
C	Low	High	100.2	b	30.5	b	16.6	b	155	b
D	High	High	100.6	b	36.3	b	20.4	b	178	b
Significance Bartlett's test			0.493		0.924		0.231		0.467	
Treatment F probability			<0.001		<0.001		<0.001		<0.001	
Factorial ANOVA										
Interaction F probability			0.932		0.704		0.328		0.696	
AD	High Wind		60.0	a	42.8	a	8.5	a	159	a
BC	Low Wind		60.6	a	35.7	a	9.6	a	149	a
Wind F probability			0.952		0.704		0.718		0.747	
CD	High Thrips		100.4	b	65.8	b	18.4	b	243	b
AB	Low Thrips		36.2	a	21.2	a	4.3	a	86	a
Thrips F probability			<0.001		<0.001		<0.001		<0.001	

*1 All means detransformed from X = ln(x+0.5).
*2 Before the treatments were applied the population of *Thrips* spp. averaged 160 / 25 flowers and there were no significant differences (p<0.050) between the means of the designate treatments.
Letters indicate statistical separation (p=0.050) Tukey's HSD test

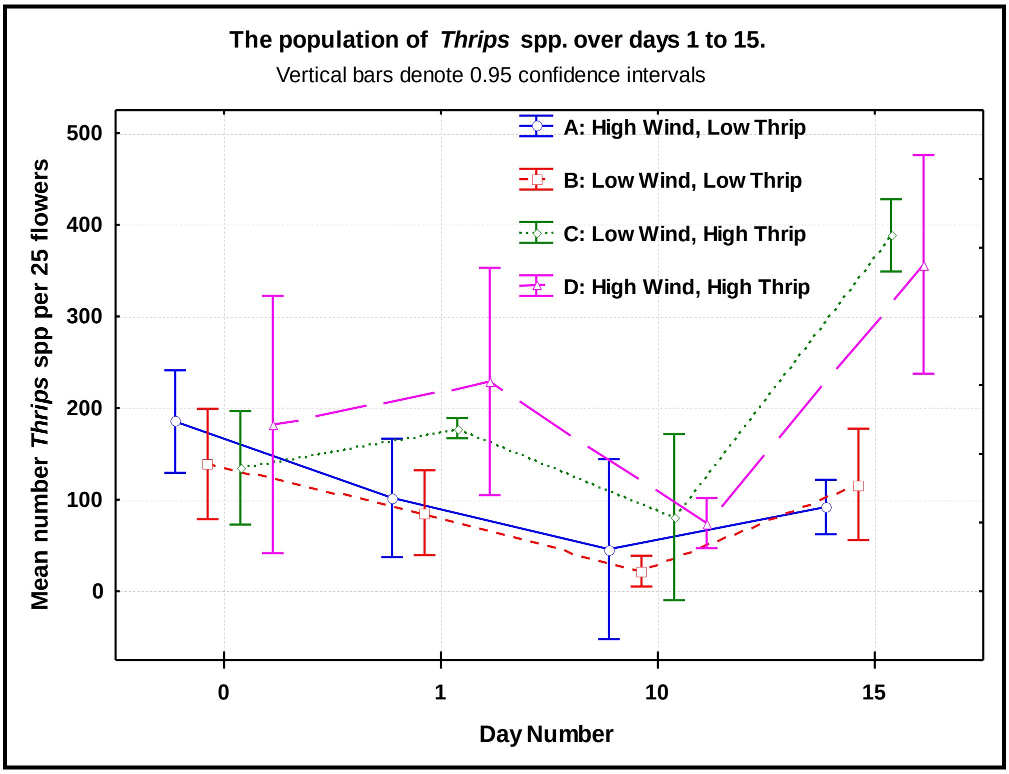


Figure 3.1. The total population of *Thrips* spp. from day 1 to 15. Arithmetic means of the observed data.

Table 3.5. The effect of the treatments on the development of the plants one day after the first application of insecticide and 42 days after the wind barriers were erected.

Treatment			Assessment means, day 1					
Code	Wind Level	Thrips Level	Plant Height (cm)	# Leaves per plant	# Buds per plant	#Flowers per plant	#Racemes per plant	#Pods per plant
ANOVA								
A	High	Low	20.3 a	21.0 a	4.0 a	3.7 a	8.4 a	0.9 a
B	Low	Low	26.0 b	22.0 a	4.6 a	4.0 a	8.4 a	1.0 a
C	Low	High	25.3 b	22.0 a	3.5 a	5.6 b	7.9 a	1.4 a
D	High	High	20.9 a	24.0 a	4.6 a	4.9 ab	8.2 a	1.4 a
Treatment F probability			<0.001	0.499	0.419	0.016	0.871	0.521
Sig. Bartlett's test			0.807	0.186	0.803	0.801	0.716	0.998
Factorial ANOVA (Wind by Thrips)								
Interaction F probability			0.348	0.279	0.138	0.606	0.677	0.719
AD	High Wind		20.6 a	22.5 a	4.3 a	4.3 a	8.3 a	1.1 a
BC	Low Wind		25.6 b	22.0 a	4.1 a	4.8 a	8.2 a	1.2 a
Wind level F probability			<0.001	0.713	0.642	0.261	0.460	0.911
CD	High Thrips		23.1 a	23.0 a	4.0 a	5.2 b	8.1 a	1.4 a
AB	Low Thrips		23.2 a	21.5 a	4.3 a	3.9 a	8.4 a	0.9 a
Thrips level F probability			0.981	0.278	0.566	0.003	0.623	0.166

Letters indicate statistical separation (p=0.050) Tukey's HSD test.

Table 3.6. The effect of the treatments on the development of the plants at day 17, 58 days after the wind barrier was erected.

Treatment			Detransformed (*1) means on day 17.						
Code	Wind Level	Thrips Level	Plant Height (cm)	# Leaves per plant	#Buds per plant	#Flowers per plant	#Racemes per plant	# Pods per plant	Length pods 1-5 (cm)
A	High	Low	32.0 a	34.8 b	7.2 a	11.8 b	5.8 a	6.9 a	7.3 b
B	Low	Low	34.3 a	23.9 a	5.9 a	6.6 a	2.8 a	4.6 a	5.1 a
D	High	High	30.6 a	34.5 ab	5.8 a	10.1 ab	4.3 a	6.6 a	5.8 ab
Treatment F probability			0.125	0.043	0.664	0.044	0.093	0.218	0.014
Sig. level of Bartlett's test			0.991	0.101	0.472	0.215	0.470	0.100	0.127
Transformation *1			none	ln(x)	none	none	none	ln(x)	none

All except the pod length data was analysed as a completely randomized experiment with 5 replicates (plants) of A and 10 of B and D.
Letters indicate statistical separation (p=0.050) Fisher’s protected LSD test.
The pod length data (pods from 5 positions / plant) was analysed as a Pod position x treatment factorial.
Letters indicate statistical separation (p=0.050) Tukey’s unequal N HSD test.

Table 3.7. The effect of the treatments on the development of the plants at day 23, 65 days after the wind barrier was erected.

Treatment			Assessment means on day 23									
Code	Wind Level	Thrips Level	Plant Height (cm)		# Leaves per plant		# Racemes per plant		# Pods per plant		Length Pods 1 to 5 (cm)	
ANOVA												
A	High	Low	32.0	a	31.6	a	8.6	a	16.4	a	8.2	a
B	Low	Low	39.6	c	29.2	a	9.1	a	17.5	a	7.7	a
C	Low	High	35.6	b	27.7	a	7.7	a	15.9	a	9.2	a
D	High	High	30.9	a	29.8	a	7.1	a	13.9	a	8.1	a
Treatment F probability			<0.001		0.585		0.144		0.394		0.409	
Sig. level of Bartlett's test			0.265		0.933		0.330		0.367		0.135	
Factorial ANOVA (Wind by Thrips)												
Interaction F probability			0.093		0.921		1.000		0.773		0.176	
AD	High Wind		31.4	a	30.7	a	7.8	a	15.2	a	8.2	a
BC	Low Wind		37.6	b	28.4	a	8.4	a	16.7	a	8.4	a
Wind F probability			<0.001		0.269		0.420		0.303		0.433	
CD	High Thrips		33.2	a	28.7	a	7.4	a	14.9	a	8.6	a
AB	Low Thrips		35.8	b	30.4	a	8.8	b	17.0	a	8.0	a
Thrips F probability			0.030		0.417		0.036		0.162		0.486	

Letters indicate statistical separation (p=0.050) Tukey’s HSD test.

Table 3.8. The effect of the treatments on the condition of the pods of marketable length at harvest

Treatment			Predicted *1 mean percentage (by number) of pods of marketable length at Harvest, day 23							
Code	Wind Level	Thrips Level	Scorched		Thrips Damaged		Scorched or Thrips Damaged or both		Diseased	
ANOVA										
A	High	Low	11.3	c	22.7	c	30.2	c	0.20	a
B	Low	Low	3.4	a	6.4	a	9.6	a	0.15	a
C	Low	High	8.2	b	14.2	b	20.4	b	2.00	b
D	High	High	13.6	c	22.1	c	30.8	c	0.55	a
Treatment Wald statistic probability			<0.001		<0.001		<0.001		<0.001	
Factorial ANOVA (Wind by Thrips)										
Interaction Wald statistic probability			0.002		<0.001		<0.001		0.873	
AD	High Wind		12.8	b	22.8	b	30.9	b	0.006	a
BC	Low Wind		4.9	a	9.1	a	13.6	a	0.070	a
Wind: Wald statistic probability			<0.001		<0.001		<0.001		0.907	
CD	High Thrips		9.8	b	16.6	b	23.9	b	0.090	a
AB	Low Thrips		6.6	a	12.8	a	18.3	a	0.005	a
Thrips: Wald statistic probability			<0.001		<0.001		<0.001		0.806	

*1 ANOVA: binomial distribution with logit link function.
Letters indicate statistical separation based on overlap of 95% confidence intervals.

Table 3.9. The effect of the treatments on the condition of the pods of marketable length at harvest

Treatment Code	Wind Level	Thrips Level	Scorched		Thrips Damaged		Scorched or Thrips Damaged or both		Diseased	
			Detransformed *1 mean percentage (by weight) of pods of marketable length at harvest, day 23							
ANOVA										
A	High	Low	13.6	a	26.1	b	35.5	b	0.2	a
B	Low	Low	4.4	a	8.2	a	12.5	a	0.1	a
C	Low	High	8.2	a	15.5	ab	23.2	ab	1.0	a
D	High	High	16.5	a	25.9	b	36.5	b	0.4	a
Treatment F probability			0.055		0.019		0.028		0.505	
Sig. level of Bartlett's test			0.584		0.052		0.131		0.962	
Transformation *1			LOG		Angle		Angle		LOG	
Factorial ANOVA (Wind by Thrips)										
Interaction F probability			0.577		0.284		0.311		0.492	
AD	High Wind		15.0	a	26.0	b	36.0	b	0.3	a
BC	Low Wind		6.0	a	11.6	a	17.5	a	0.4	a
Wind: F probability			0.081		0.025		0.029		0.626	
CD	High Thrips		11.6	a	20.4	a	29.7	a	0.7	a
AB	Low Thrips		7.7	a	16.2	a	23.0	a	0.2	a
Thrips: F probability			0.331		0.300		0.251		0.135	

Transformation: LOG = ln(x+0.01). Angle = Asin(Sqrt(x))
Letters indicate statistical separation based on overlap of 95% confidence intervals.

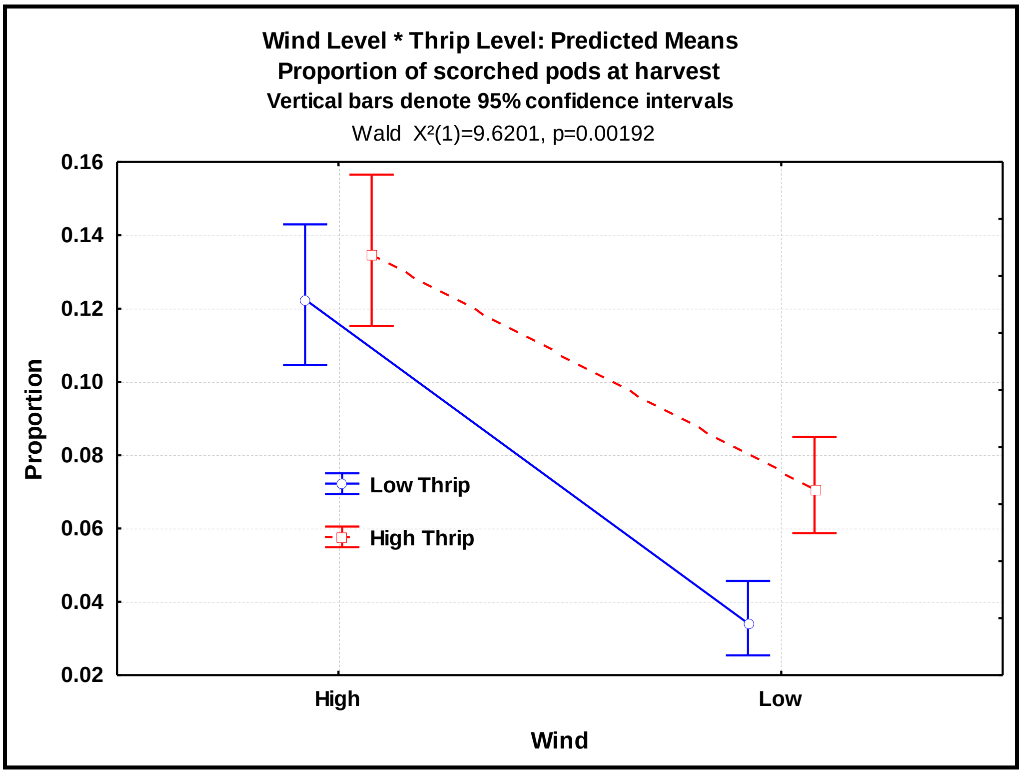


Figure 3.2. The effect of the treatments on the proportion of scorched pods at harvest (Based on counts)

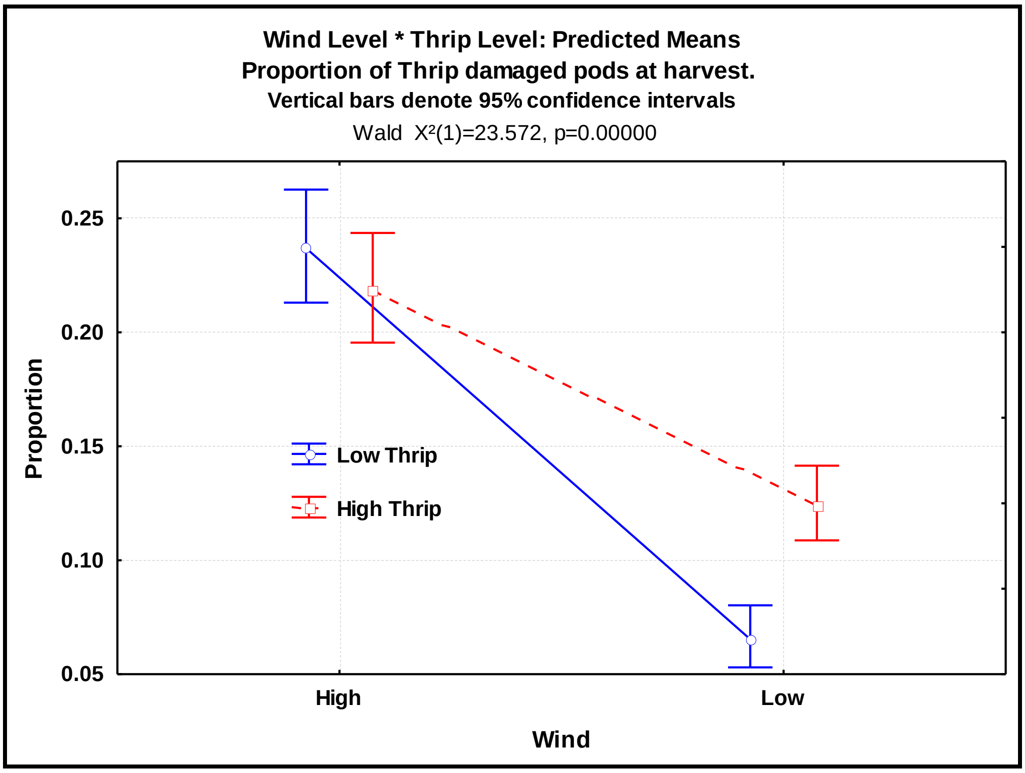


Figure 3.3. The effect of the treatments on the proportion of thrips damaged pods at harvest. (Based on counts).

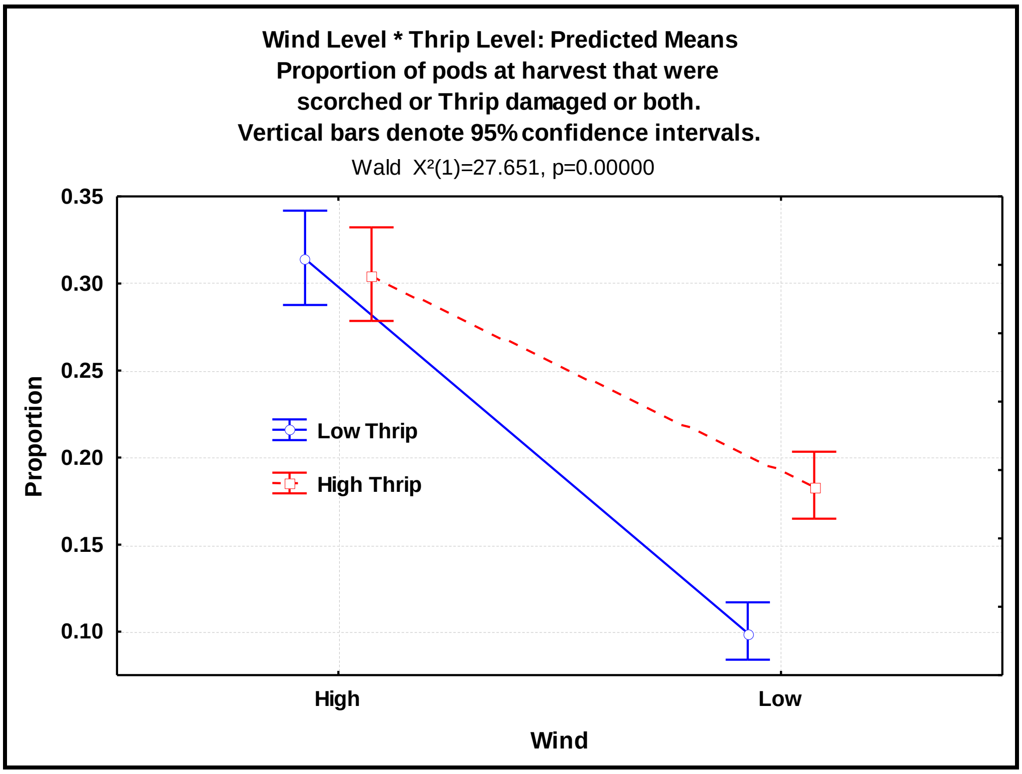


Figure 3.4. The effect of the treatments on the proportion of pods scorched or damaged by thrips or both at harvest. (Based on counts).

Table 3.10. The effect of the treatments on the weight of pods at harvest, day 23.

Treatment *1			Mean weight (g) of harvested pods / plot, day 23							
Code	Wind Level	Thrips Level	Total		Small		Large: marketable length All		Clean	
Treatment Effects ANOVA										
A	High	Low	1966	a	501	a	1464	a	959	a
B	Low	Low	2421	ab	665	a	1756	ab	1540	a
C	Low	High	3044	b	760	a	2284	b	1731	a
D	High	High	1952	a	470	a	1482	a	930	a
Treatment F probability			0.032		0.168		0.040		0.071	
Significance level of Bartlett's test			0.402		0.752		0.919		0.213	
Factorial ANOVA (Wind by Thrips)										
Interaction F probability			0.397		0.665		0.404		0.715	
AD	High Wind		1959	a	486	a	1473	a	944	a
BC	Low Wind		2732	a	712	a	2020	a	1635	a
Wind F probability			0.096		0.185		0.129		0.085	
CD	High Thrips		2498	a	615	a	1883	a	1330	a
AB	Low Thrips		2193	a	583	a	1610	a	1249	a
Thrips F probability			0.415		0.824		0.372		0.756	

*1 Wind barriers erected on 26 February 2009.
Insecticides applied to kill thrips in treatments A and B on 17/03, 23/03, 30/03 and 7/04.
*2 The area harvested per plot is unknown
Letters indicate statistical separation (p≤0.05) Tukey's HSD test

Table 3.11. The effect of the treatments on the number of pods of marketable length on day 23.

Treatment *1 Code	Wind Level	Thrips Level	Mean # of pods of marketable length / plot, day 23 All		Clean		Mean Weight (g) per pod	
Treatment Effects ANOVA								
A	High	Low	288	a	199	a	5.1	a
B	Low	Low	329	a	296	a	5.3	a
C	Low	High	445	a	353	a	5.2	a
D	High	High	300	a	204	a	5.0	a
Treatment F probability			0.061		0.058		0.524	
Significance level of Bartlett's test			0.613		0.464		0.321	
Factorial ANOVA (Wind by Thrips)								
Interaction F probability			0.414		0.669		0.970	
AD	High Wind		294	a	201	a	5.0	a
BC	Low Wind		387	a	324	a	5.3	a
Wind F probability			0.190		0.110		0.200	
CD	High Thrips		372	a	279	a	5.1	a
AB	Low Thrips		309	a	247	a	5.2	a
Thrips F probability			0.332		0.604		0.521	

*1 Wind barriers erected on day -41.
Insecticides applied to kill thrips in treatments A and B on day 0, 7, 14 and 21.
*2 The area harvested per plot is unknown

Discussion

Before the first application of dimethoate there were significantly more *T. imaginis* in plants exposed to wind than in plants protected from wind; however there was no indication that *T. tabaci* responded similarly to wind. Additionally, although not statistically significant, this pattern of differences was evident in the means of the three counts from day 1 to day15. Hence it appeared that, where both species are present, infestation by *T. imaginis* may be more assisted by wind than infestations by *T. tabaci*.

From day 0, irrespective of the species and assuming the wind barriers were effective; "Wind Level" had no significant ($p \leq 0.050$) effect on the population of *Thrips* spp. But where dimethoate was applied the population was significantly lower than where it was not applied: for example, over the interval day 1 to 15, the mean populations averaged 243 and 86 *Thrips* spp. per 25 flowers, respectively. The dimethoate sprays clearly achieved their objective.

The assessment on day 17 showed that under "Low Thrips", "High Wind" produced plants with significantly longer pods and significantly more leaves and buds than "Low Wind" i.e. "High Wind" increased growth. Hence the assessment on day 17 conflicted with the assessments on days 1 and 23. But, since only three of the four treatments were assessed on day 17 and the samples were smaller than on day 1 and 23, the day 17 results are the least reliable.

Assessment of the pods harvested on day 23 showed that, based on the number of pods, the percentage with scorch, thrips damage and with one or both of these, increased significantly as "Wind Level" and "Thrips Level" increased. The same pattern was evident based on the weight of pods, although it was only significant with "Wind Level". Hence there was little doubt that wind and *Thrips* spp. were a cause of scorch.

The positive response of thrips damage to "Wind Level" was unexpected, since from the start of flowering the population of *Thrips* spp. did not vary with "Wind Level". This suggested that wind may intensify the symptoms of damage and make them more visible. Another explanation was that there was a high level of mis-identification of symptoms.

The commercially important finding was that "Low Wind" and "Low Thrips" produced significantly the least percentage of pods that exhibited wind-scorch and damage by thrips or both. Based on numbers, the percentage of pods with wind-scorch in the Low Wind Low Thrips treatment was 3.4% compared with from 8.2% to 13.6% for the remaining treatments. For thrips damage the means were 6.4% and from 14.2% to 22.1%, respectively.

Plants subject to "Low Wind" and "High Thrips" carried a significantly higher proportion of diseased pods than the other plants as shown in Table 3.8. This was attributed to higher humidity within the canopy of "Low Wind" plants compared with the "High Wind" plants and higher feeding damage to pods on "High Wind" plants than to pods on "Low Wind" plants. Hence protecting plants from wind to reduce losses as a result of scorch may increase losses as a result of disease. The diseases identified included *Sclerotinia* and *Botrytis*.

Although the weight of the four categories of pods as shown in Table 3.10 did not respond significantly to "Thrips Level", the weight of pods under "High Thrips" tended to be greater than those produced under "Low Thrips". Similarly the plants under "High Thrips" tended to produce more pods than plants under "Low Thrips" (Table 3.11). These tendencies are the opposite of what might be expected of thrips control. It is possible that the effect of dimethoate at controlling the *Thrips* spp. populations had an adverse effect of reducing the potential of thrips to improve the pollination of the bean flowers as there were more large pods produced under the “Low Wind High Thrips” treatment than the other treatments. Overseas studies have shown that thrips can account for 50-70% viable seed set of the legume lablab bean - *Dolichos lablab* (Ananthakrishnan 1993), and can increase yields from between 6.7% and 41.6% under moderate thrips pressure on pigeon pea - *Cajanus cajan* (Yadav, Gangrade et al. 1974).

The results indicate that protecting bean plants from wind as well as controlling *Thrips* spp. should minimize the incidence of wind-scorch but does chemical control actually maximize the yield of marketable pods. Clearly more work needs to be undertaken to see if thrips do contribute to pollination in some way and just how many thrips per flower warrants a remedial insecticide treatment to reduce damage levels without adversely affecting the pollination potential of these small insects.

Material and Methods

SITE 2

Location:	Forthside, north-west Tasmania. Harvest Moon Pty Ltd
Trial conducted by:	Agronico Research Proprietary Limited
Participants:	Odin Fransenn, David McLaren
Crop (cultivar):	French beans (Unknown, not recorded by grower)
Planting Method	Direct seeded in early January, 2009
Plant density:	50 mm in row 540 mm between rows
Soil:	Red ferrosol, 2% slope.
Fertilizer:	Standard for area: details not recorded
Irrigation:	Travelling gun, as required

Layout

The trial was laid out as a randomized complete block experiment with four blocks each containing one plot of each of the four treatments. Each plot was 5 m long by 2.5 m (5 rows) wide and the centre of it was at the centre an untreated area 10 m long by 8 m wide i.e. there was an untreated buffer strip, 2.5 m to 2.75 m wide surrounding each plot. Thus each plot was at least 5 m from its nearest plot. With the untreated areas included, the trial occupied an area 40 m by 32 m.

Treatments

There were four treatments, two levels of wind by two levels of *Thrips* spp.; how this was achieved is summarised in the table below.

The treatments

Codes	Wind Level	Thrips Level
A (Red)	High = Plot open, no wind barrier	Low = Plot sprayed regularly with insecticide
B (Red-Green)	Low = Plot surrounded by wind barrier	Low = Plot sprayed regularly with insecticide
C (Green)	Low = Plot surrounded by wind barrier	High = Plot NOT sprayed with an insecticide
D (Blue)	High = Plot open, no wind barrier	High = Plot NOT sprayed with an insecticide

The wind barriers were a wall of hessian surrounding the plot to a height of one metre: the hessian was stapled to wooden posts driven firmly into the soil.

Wind speed in the open was measured and recorded every 5 minutes and these data are summarised in Appendix 5. The average wind speed over the 35 days of the trial was 6.0 km/h. Wind speed within the wind barriers was not recorded.

Dimethoate 400 g/L EC, was applied at 500 mL/ha on four occasions at intervals of six to eight days, from 17 March to 7 April. This insecticide is registered in all Australian states for the control of thrips in beans at 800 mL/ha.

Application of the Treatments

Equipment

A compressed gas powered sprayer fitted with a flat boom carrying four nozzles at 50 cm spacings.

Table 3.12 Settings and conditions

Calibration Date	17/03/09	23/03/2009	30/03/2009	07/04/2009
Day number:	0	6	13	21
Tips :	Hollow Cone: details not recorded			
Pressure (kPa):	200	200	200	200
Mean Discharge/Nozzle: (mL/15s):	270	270	270	260
Spray Quality:	probably fine to medium			
Application Date:	17/03/2009	23/03/2009	30/03/2009	07/04/2009
Time:	10:00 – 11:30	13:00 – 14:30	13:45 – 14:30	13:30 – 14:00
Target Spray Vol. (L/ha):	400			
Plot Area Sprayed:	5 m x 2 m			
Spraying time per plot:	5.5	5.5	5.5	5.8
Temperature (0C):	n/a	22	17	13
Relative Humidity (%):	n/a	n/a	95	90
Wind speed in open(km/hr):	n/a	8 to 10	16 (gusty)	no wind
Wind Bearing:	SW	N - NE	SE	
Crop development BBCH:	63	65	65	72

Non-experimental treatments

On 23 March (day6) herbicide damage was obvious in the treatment B plots in blocks 1 and 3. An examination of all plots showed that no other plots exhibited symptoms. A review of the records of the first application and an inspection of the equipment showed the cause was herbicide residues in the sprayer bottle used for the two plots. Residues were not found in the other bottles used at the first application.

The herbicide contamination of the first application of dimethoate precluded the use of treatment B in blocks 1 and 3 for assessments of crop growth and yield, but not for assessments of wind scorch or Thrips damage.

While the trial was being conducted no treatments known to affect the incidence of wind scorch or *Thrips* spp. were applied to or in the vicinity of the trial .

Weather

Over the 35 days both treatments were in effect, there were nine days of rain totalling 35 mm. The maximum temperature ranged from 15ºC to 25ºC and averaged 20ºC and the minimum temperature ranged from 4ºC to 17ºC and averaged 11ºC. (Appendix 5)

Assessments

Day 0 was the 17 March 2009, the day that dimethoate was first applied.

On day 7, 10, 14, 17, 20 and 23 *Thrips* spp. were counted on 20 or 25 flowers, depending on the assessment, picked from along the central rows of all plots: adult *T. tabaci*, adult *T. imaginis* and total juvenile *Thrips* spp. were recorded.

On day 14 five plants per plot were examined and the height of each was measured, the pods on them were counted and the length of the shortest, longest and average pod was measured. On day 20 five plants per plot were pulled and weighed and the height of each was measured. Additionally, the flowers, buds, racemes and pods on each plant were counted and the length of each of the five upper pods was measured.

On day 17, 20, 23 and 34, two plants per plot were examined and their height was measured; the scorched and un-scorched pods on them were counted and the length of the shortest, longest and average pod on each plant was measured.

On day 35 the plots were harvested: the area harvested per plot was constant but unknown since the record was lost. The harvested the pods were divided into those too short to market and those of marketable length. Both groups were weighed and the marketable pods were sorted into four groups viz.

1. Clean – no Thrips damage and no Scorching
2. Thrips damaged only
3. Thrips damaged and scorched
4. Scorched only

Each of these four groups was weighed and the pods in them were counted, during this activity any diseased pods were removed and subsequently counted and weighed.

The timing of assessments in relation to the application of the treatments is summarised in the table below:

Table 3.13. Application of treatments.

Date	Day #	Activity	Sample Size	Plots Sampled
26-Feb	-19	Install wind barriers		
17-Mar	0	Apply dimethoate		
23-Mar	6	Apply dimethoate		
24-Mar	7	Assess thrips and pods	25 flowers/plot	All
27-Mar	10	Assess thrips and pods	25 flowers/plot	All
30-Mar	13	Apply dimethoate		
31-Mar	14	Agronomy assessment	5 plants /plot	Block 2&3
31-Mar	14	Assess thrips and pods	25 flowers/plot	All
3-Apr	17	Assess pods	2 plants /plot	All
3-Apr	17	Assess thrips and pods	20 flowers/plot	All
6-Apr	20	Assess pods	2 plants /plot	All
6-Apr	20	Assess thrips and pods	25 flowers/plot	All
6-Apr	20	Agronomy assessment	5 plants /plot	Block 1&4
7-Apr	21	Apply dimethoate		
9-Apr	23	Assess pods	2 plants /plot	All
9-Apr	23	Assess thrips and pods	20 flowers/plot	All
18-Apr	32	Harvest		All
20-Apr	34	Assess pods	2 plants /plot	All
20-Apr	34	Dismantle trial	Dismantle trial	
21-Apr	35	Assess harvest: yield	Assess Harvest	All
21-Apr	35	Assess harvest: scorch and damage	Assess Harvest	All

Results

Based on the counts of thrips in flowers from plants not treated with dimethoate, *T. tabaci* were more numerous than *T. imaginis*: the grand means over all assessments were 2.04 and 0.85 adults per 25 flowers and the difference was significant at p = 0.0003 (paired t test, n = 48). The assessment means are plotted in Figure 3.5.

The population of *Thrips* spp was significantly lower in plants treated with dimethoate than in untreated plants. Over the six assessments, the population of adult and juvenile *Thrips* spp. per 25 flowers averaged 0.5 in the "Low Thrips" treatments and 4.8 in the "High Thrips" treatments (Table 3.14). There was no doubt the selective application of dimethoate achieved its objective. The means of the thrips assessments relevant to the effect of dimethoate are plotted in Figures 3.7 and 4.8.

The population of thrips did not vary significantly with Wind-Level (Table 3.14.). The means relevant to the effect of wind on *Thrips* spp are plotted in Figures 3.7 and 3.9.

There was a significant ($p \leq 0.050$) interaction between Wind Level and Thrips species which suggested that *T. imaginis* may be relatively more able to cope with windy conditions than *T tabaci* (Figure 3.6).

Plant growth

The height of the plants.

The assessments on five plants per plot on day 14 and day 20 (Tables 3.15 and 3.16) and the "in-field" assessment on two plants per plot on days17, 20, 23 and 34 (Table 3.17) showed that plants unprotected from wind were significantly shorter than plants protected from wind.

Where the population of *Thrips* spp. was controlled with dimethoate (Low Thrips) the plants appeared shorter (Tables 3.15 and 3.17) or were significantly shorter (Table 3.16) than where they were not controlled (High Thrips). While low populations of thrips may not affect plant growth higher populations often reduce plant growth. Hence dimethoate may be the cause of the shorter plants in the "Low Thrips" treatment compared with the "High Thrips" treatment.

At an earlier trial (Site 1), dimethoate appeared to reduce the growth of the bean plants whereas at this trial the response was statistically significant. Assuming dimethoate exhibits a degree of phytotoxicity to beans and control of *Thrips* spp. is beneficial to the growth of beans the difference between the trials was attributed to differences between the sizes of their infestations of *Thrips* spp. At the first trial the infestation averaged 166 per 25 flowers between day 1 and 15, while at this trial it averaged 5 per 25 flowers between day 7 and 23. Hence, at the first trial the gains from thrips control probably nearly balanced the loss from dimethoate whereas at this trial the gains from thrips control were probably substantially less than the loss from dimethoate.

The weight of the plants.

On day 20 (Table 3.16), although the weight of the plants did not vary significantly with the level of wind, consistent with effects on plant height, the plants in the "Low Wind" plots tended to be heavier than their counterparts in the "High Wind" plots.

Reflecting the suspected effect of dimethoate on plant height, the plants in the “High Thrips” (no dimethoate) plots were significantly heavier than their counterparts in the “Low Thrips” (dimethoate) plots.

Leaves, buds racemes and flowers

There were no significant differences between the treatments with respect to the number of leaves and buds per plant (Table 3.16), number of racemes per plant (Tables 3.15, 3.16 and 3.17) and number of flowers per plant (Table 3.16).

Number of Pods

On day 14 and 20, the number of pods per plant did not vary significantly between the treatments (Tables 3.15 and 3.16). However, averaged over four assessments from day 17 to 34 there were significantly fewer pods on plants treated with dimethoate (“Low-Thrips”) than on plants not treated with dimethoate (“High-Thrips”).

There were no significant responses to wind level (Tables 3.15, 3.16 and 3.17).

Length of Pods

There was no significant difference between the treatments on day 14 (Table 3.15). However the pods on plants treated with dimethoate (“Low-Thrips”) appeared shorter than pods on plants not treated with dimethoate (“High-Thrips”).

On day 20 (Table 3.16) the mean length of the pods on plants in the “Low-Wind” plus “High-Thrips” treatment was significantly greater than the mean length of pods on plants of the other treatments. Further, averaged over four assessments from day 17 to 34, plants subjected to low wind carried significantly longer pods than plants subjected to high wind. Additionally, plants in the “High-Thrips” treatments (no dimethoate) carried significantly longer pods than plants in the “Low-Thrips” treatments (treated with dimethoate).

Wind Scorch

There was no doubt that wind was the main cause of the symptoms identified as wind scorch (Table 3.19, 3.20 and 3.21): depending on the assessment 71 to 91% of the scorched pods were in the “High-Wind” treatments (mean = 87%). Additionally, there was no doubt that these symptoms were not caused by *Thrips* spp: depending on the assessment 36 to 51% of the scorched pods were in the “High-Thrips” treatments (mean = 45%).

Thrips Damage

The incidence of pods with symptoms identified as “Thrips-Damage” increased significantly with the level of wind and with the level of *Thrips* spp. (Table 3.20). Based on the weight of pods (Table 3.21), there was also a significant response to the level of wind but the response to the level of *Thrips* spp. was not significant.

The response of “Thrips Damage” to the level of *Thrips* spp. was expected, but the response to the level of wind was not expected. One explanation was that wind may increase the severity of

“Thrips Damage” making it easier to detect: perhaps *Thrips* spp. spend more time feeding (or make more attempts to feed) in higher winds than in lower winds.

Disease

The incidence of diseased beans was significantly lower in plots exposed to the wind than in plots protected from the wind. This was probably because humidity was lower in the exposed plots than in the protected plots

There was no evidence that the incidence of disease responded to the level of *Thrips* spp.

Yield

On average, the weight of pods of marketable length and free of blemish was significantly greater in plots protected from the wind than in plots exposed to the wind (Table 3.22). Although there was no significant response to the level of *Thrips* spp., there appeared to be a greater weight of pods in plots where *Thrips* spp. were uncontrolled (no dimethoate) than in plots where they were controlled with dimethoate.

As with the weight of pods, there were significantly more pods of marketable length and free of blemish in plots protected from the wind than in plots exposed to the wind (Table 3.23). Moreover, there were significantly more pods in plots where *Thrips* spp. were uncontrolled than where they were controlled with dimethoate.

The mean weight of pods of marketable length and free of blemish was significantly greater on plants not treated with dimethoate (“High-Thrips”) than on plants treated with dimethoate (“Low-Thrips”). Further there appeared to be more of these pods on plants protected from the wind than on plants exposed to the wind.

Bean plants protected from the wind and where thrips were not controlled with dimethoate produced significantly the greatest weight of pods and apparently the greatest number of marketable pods, compared with the other three treatments.

Table 3.14. The effect of the treatments on population of *Thrips* spp.

Treatment *1 Code	Wind Level	Thrips Level	Mean number of Thrips *2 per 25 flowers (6 assessments) Day 7 to Day 23	
Main Effects ANOVA				
A	High	Low	0.6	a
B	Low	Low	0.4	a
C	Low	High	5.0	b
D	High	High	4.7	b
Treatment: F probability			<0.001	
Sig. Level of Bartlett's test			0.431	
Factorial ANOVA (Wind by Thrips)				
Interaction: F probability			0.492	
AD	High Wind		1.9	a
BC	Low Wind		1.8	a
Wind: F probability			0.711	
CD	High Thrips		4.8	b
AB	Low Thrips		0.5	a
Thrips: F probability			<0.001	

*1 Wind barriers erected on 26 February 2009.
Insecticides applied to reduce population in treatments A and B on 17/03, 23/03, 30/03 and 7/04.
*2 De-transformed from X = ln(x+0.5) Letters indicate statistical separation (p = 0.050),
Tukey's HSD test

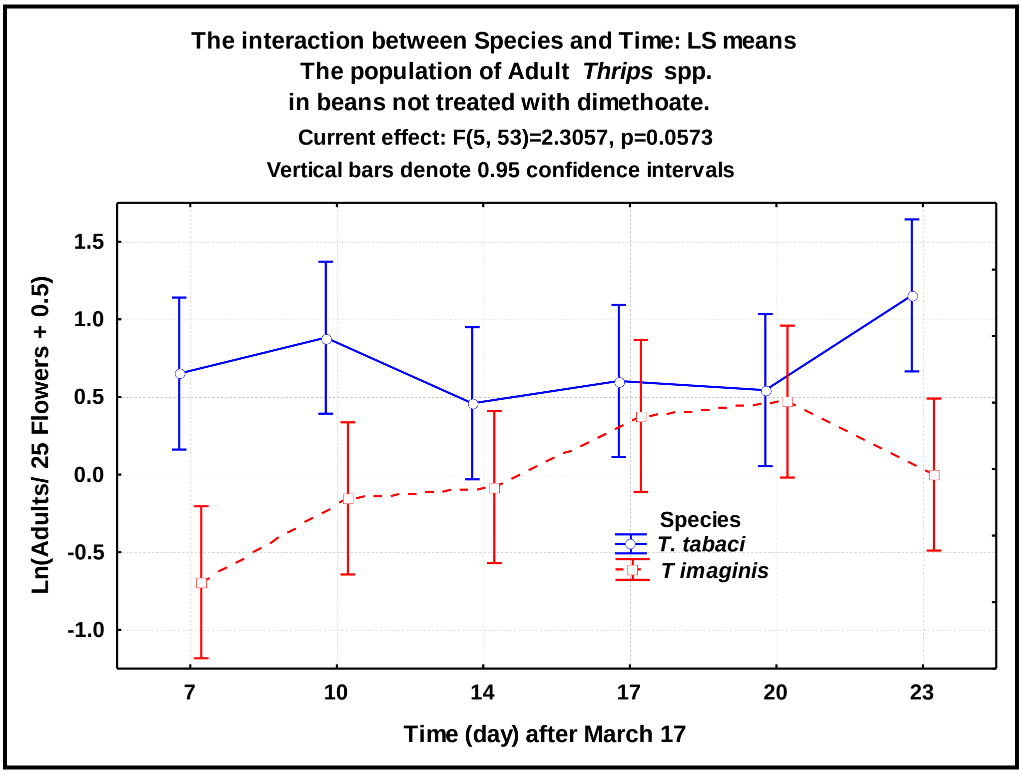


Figure 3.5. The interaction between Time and Species on the population of thrips. ReferSAR1.1

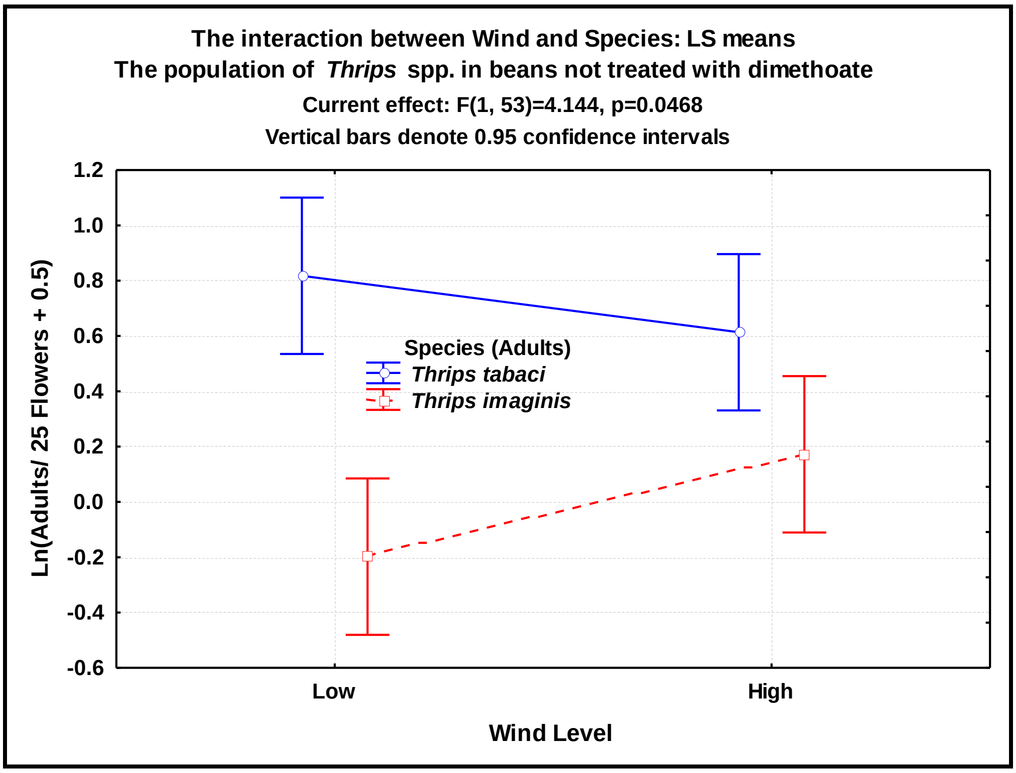


Figure 3.6. The interaction between wind and species on the population of *Thrips* spp. (SAR1.1)

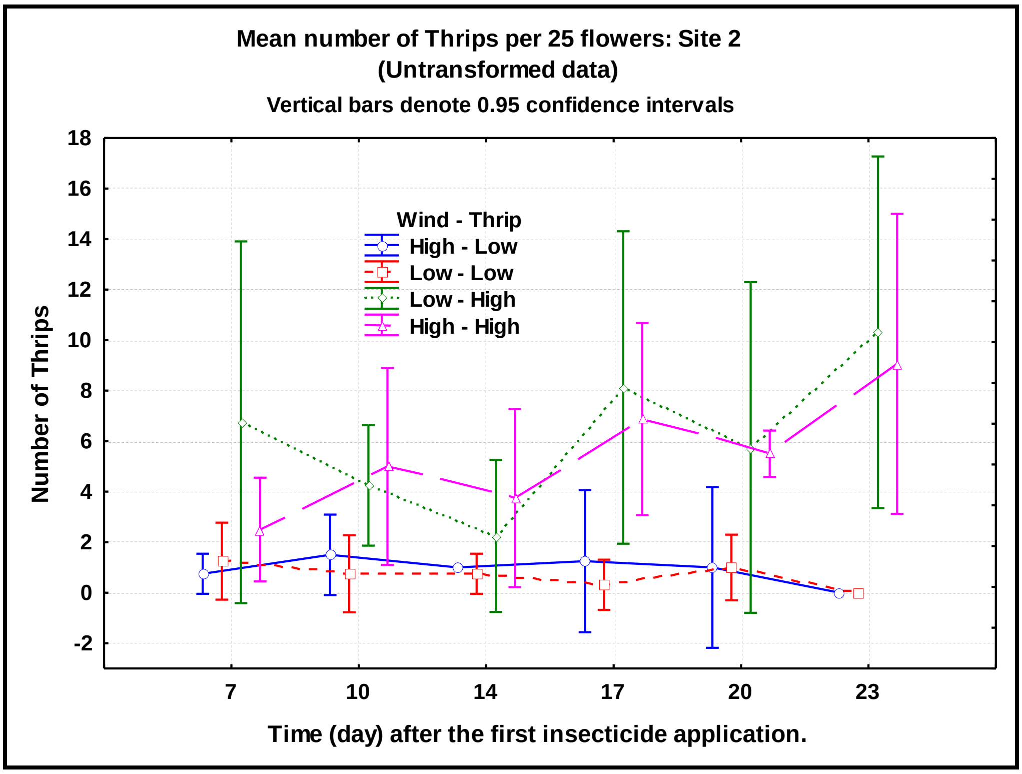


Figure 3.7. The effect of the treatments on the population of *Thrips* spp.
Refer SAR 1.2.

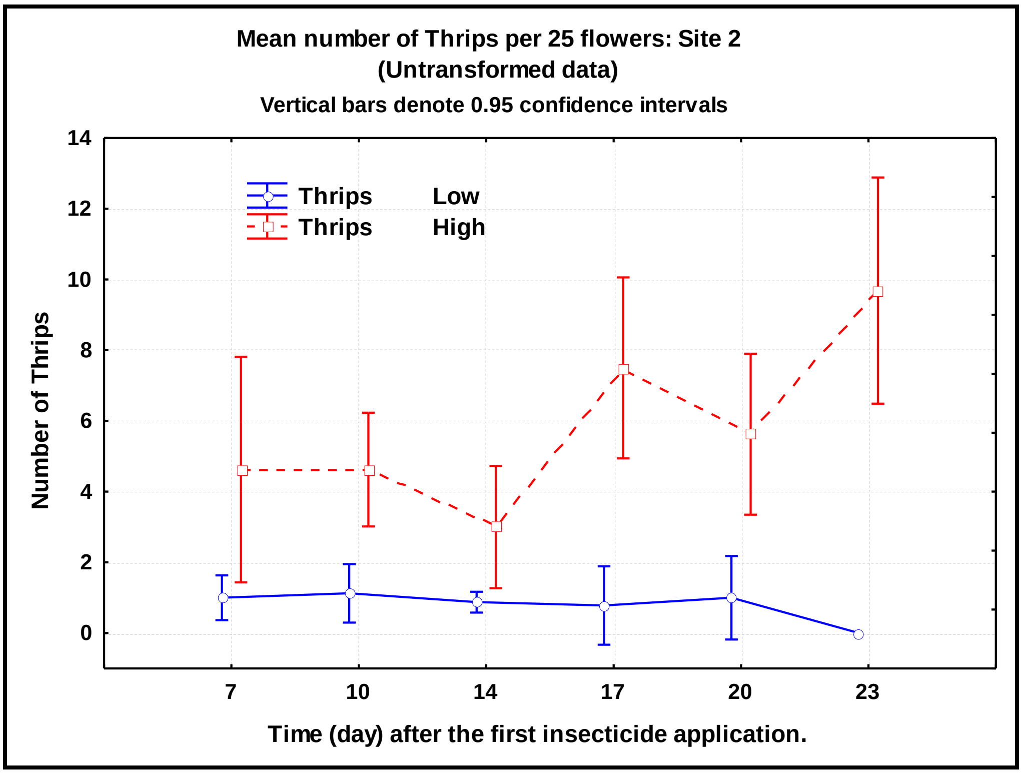


Figure 3.8. The effect of dimethoate on the population of *Thrips* spp.
("Thrips Low" = all plots treated with dimethoate and "Thrips High"= remaining plots)

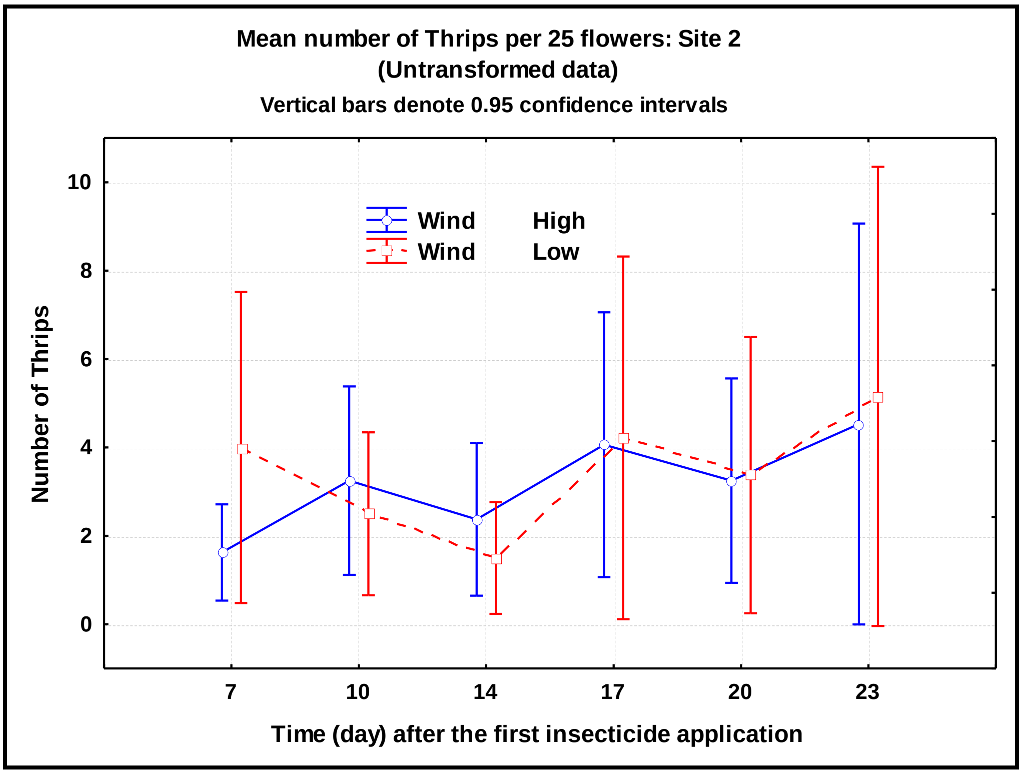


Figure 3.9. The effect of wind on the population of *Thrips* spp.
(“Wind High” = all plots without barriers and “Wind Low” = remaining plots)

Table 3.15. The effect of the treatments on plant growth and development on 31 March.

Treatment Code	Wind	Thrips	Assessment on Day 14 *1 Mean plant height (cm)		Mean # racemes per plant		Mean # visible pods per plant		Mean length of the longest pod per plant (cm)		Mean length of the shortest pod per plant (cm)	Mean length of the average pod per plant (cm)	
Treatment Effects ANOVA													
A	High	Low	38	a	5.0	a	12	a	5.4	a	1.2	2.8	a
B	Low	Low	47	bc	4.0	a	9	a	4.5	a	1.3	2.7	a
C	Low	High	48	c	5.3	a	14	a	7.3	a	1.0	3.6	a
D	High	High	41	ab	4.6	a	12	a	5.9	a	1.9	3.5	a
Treatment F probability			<0.001		0.396		0.467		0.241		n/a *2	0.431	
Sig. Level of Bartlett's test			0.437		0.874		0.661		0.668		0.002	0.913	
Factorial ANOVA (Wind by Thrips)													
Interaction F probability			0.004		0.187		0.172		0.464		n/a	0.993	
AD	High Wind		39	a	4.8	a	12	a	5.7	a	1.5	3.2	a
BC	Low Wind		48	b	4.9	a	13	a	6.4	a	1.1	3.3	a
Wind F probability			<0.001		0.688		0.590		0.582		n/a	0.894	
CD	High Thrips		44	a	5.0	a	13	a	6.7	a	1.4	3.6	a
AB	Low Thrips		41	a	4.7	a	11	a	5.1	a	1.2	2.8	a
Thrips F probability			0.051		0.424		0.122		0.220		n/a	0.203	

*1 Sampling: five plants in each of Blocks 2 and 3 (No samples from Blocks 1 and 4)
Results for treatment B in block 3 discarded because of herbicide damage.

*2 Unable to reduce heterogeneity of variances to meet requirements for the ANOVA
Letters indicate statistical separation Tukey's unequal HSD test (p = 0.050)

Table 3.16. The effect of the treatments on plant growth and development on 6 April, Day 20.

Treatment			Assessment on Day 20 *1							
Code	Wind Level	Thrips Level	Mean weight of 5 plants (kg)	Mean plant height (cm)	Mean # leaves per plant	Mean # flowers per plant	Mean # buds per plant	Mean # racemes *2 per plant	Mean # visible pods per plant	Mean pod length (cm)
Treatment Effects ANOVA										
A	High	Low	4.4 a	35 a	39 a	7.3 a	8.8 a	7.2 a	28 a	5.4 a
B	Low	Low	5.1 ab	41 ab	33 a	8.0 a	8.4 a	6.4 a	23 a	6.1 a
C	Low	High	7.2 b	47 b	30 a	7.8 a	6.5 a	6.7 a	21 a	7.6 b
D	High	High	6.1 ab	40 a	35 a	10.1 a	8.7 a	6.6 a	26 a	5.5 a
Treatment F probability			0.028	<0.001	0.647	0.798	0.755	0.961	0.685	0.017
Sig. Level of Bartlett's test			0.892	0.769	0.362	0.245	0.413	0.103	0.434	0.687
Factorial ANOVA (Wind by Thrips)										
Interaction F probability			0.809	0.915	0.734	0.422	0.427	0.744	0.955	0.266
AD	High Wind		5.2 a	38 a	37 a	8.7 a	8.7 a	6.9 a	26 a	5.4 a
BC	Low Wind		6.5 a	45 b	31 a	8.3 a	7.1 a	6.6 a	22 a	6.9 a
Wind F probability			0.230	<0.001	0.723	0.885	0.936	0.785	0.458	0.110
CD	High Thrips		6.7 b	44 b	32 a	8.0 a	7.6 a	6.6 a	23 a	6.5 a
AB	Low Thrips		4.7 a	37 a	37 a	9.0 a	8.7 a	6.9 a	26 a	5.4 a
Thrips F probability			0.022	<0.001	0.375	1.000	0.404	0.887	0.668	0.194

*1 Sampling: For weight of 5 plants: all blocks.
For other measurements: 5 plants in each of Blocks 1 and 4. Results for B in block 1 discarded because of herbicide damage.
*2 Means detransformed from logarithms. Letters indicate statistical separation (p = 0.050) Tukey's Unequal N HSD test

Table 3.17. The effect of the treatments on plant growth and development based on “in-field” assessment of two plants per plot on four occasions between Day 17 and Day 34

Treatment			Mean over four assessments *1			
Code	Wind Level	Thrips Level	Plant Height (cm)	# Racemes per plant	# Pods per plant	Average length (cm) of pods
Treatment Effects ANOVA						
A	High	Low	37.2 a	8.8	28.8 ab	5.7 a
B	Low	Low	43.9 b	6.9	24.1 a	5.9 ab
C	Low	High	49.9 c	9.0	30.6 b	7.4 c
D	High	High	39.4 a	8.7	27.5 ab	6.5 b
Treatment F probability			<0.001	n/a	0.027	<0.001
Sig. Bartlett's test			1.000	0.007	0.122	0.859
Factorial ANOVA (Wind by Thrips)						
Sig of Interaction *2			0.293	n/a	<0.001	0.183
AD	High Wind		38.3 a	8.8	28.1 a	6.1 a
BC	Low Wind		47.9 b	8.3	28.4 a	6.9 b
Wind F probability			<0.001	n/a	0.077	0.020
CD	High Thrips		44.6 a	8.8	29.0 b	6.9 b
AB	Low Thrips		39.5 a	8.2	27.2 a	5.8 a
Thrips F probability			0.156	n/a	0.012	<0.001

*1 Assessments on April, 3, 6, 9 and 20. There were no significant interactions between Time (assessment dates) and either Wind level, Thrips level or Block.
Treatment B in blocks 1 and 3 omitted because of herbicide damage.
Letters indicate statistical separation (p=0.050) Tukey’s Unequal N HSD test.

Table 3.18. The development of the bean plants between Day 17 and Day 34.

Assessment	Mean over all other factors *1			
	Plant Height (cm)	# Racemes per plant	# Pods per plant	Average length (cm) of pods
April 3	41.8 a	8.0	24.6 a	3.7 a
April 6	42.7 a	8.7	26.7 ab	4.6 b
April 9	42.5 a	8.8	30.4 b	7.3 c
April 20	42.9 a	8.7	31.5 b	10.4 d
Treatment F probability	0.600	n/a	0.003	<0.001
Sig. Bartlett's test	1.000	0.007	0.122	0.859

*1 The other factors were four treatments (2 Wind levels x 2 Thrips levels) and 2 or 4 blocks, depending on the treatment.
Letters indicate statistical separation (p=0.050) Tukey’s Unequal N HSD test.

Table 3.19. The effect of the treatments the proportion of Scorched pods.

Treatment *1 Code	Wind Level	Thrips Level	Mean % Scorched pods *2 on day # indicated "In field" assessments 17		20		23		34		Harvested pods 35	
Main Effects ANOVA												
A	High	Low	2.0	ab	6.3	b	12.5	b	20.8	b	53	b
B	Low	Low	4.3	ab	3.2	ab	2.4	a	3.8	a	7.3	a
C	Low	High	0.4	a	1.1	a	0.7	a	1.6	a	8.0	a
D	High	High	5.8	b	8.2	b	14.5	b	22.3	b	54.7	b
Treatment: Wald probability			0.035		0.004		<0.001		<0.001		<0.001	
Sig. Level of Bartlett's test			n/a									
Factorial ANOVA (Wind by Thrips)												
Interaction: Wald probability			0.005		0.09		0.118		0.154		0.794	
AD	High Wind		3.4	a	7.2	b	13.4	b	21.6	b	53.7	b
BC	Low Wind		1.4	a	1.9	a	1.3	a	2.5	a	7.3	a
Wind: F Wald probability			0.137		<0.001		<0.001		<0.001		<0.001	
CD	High Thrips		1.6	a	3.1	a	3.4	a	6.5	a	23.7	a
AB	Low Thrips		2.9	a	4.5	a	5.6	a	9.2	a	22.8	a
Thrips: F Wald probability			0.336		0.335		0.238		0.244		0.505	
Lowest # pods: per treatment | per plot			173|14		184|14		189|14		209|15		1308|206	
Highest # pods: per treatment | per plot			220|43		242|38		272|48		246|54		2366|673	

*1 Wind barriers erected on 26 February 2009.
Insecticides applied to reduce population in treatments A and B on 17/03, 23/03, 30/03 and 7/04.
*2 Predicted means ANOVA Binomial with Logit link.
Letters indicate statistical separation ($p \leq 0.05$) based on 95% CL or sig. of the Wald Statistic.

Table 3.20. The effect of the treatments on the condition of the pods of marketable length at harvest: by number

Treatment			Predicted mean *1 percentage (by number) of pods at Harvest: Day 32 to 35							
Code	Wind Level	Thrips Level	Scorched *3		Thrips Damaged		Scorched or Thrips Damaged or both		Diseased	
ANOVA										
A	High	Low	53.0	b	39.6	b	75.9	b	8.2	a
B	Low	Low	7.3	a	18.5	a	23.9	a	18.9	b
C	Low	High	8.0	a	20.2	a	25.9	a	16.2	b
D	High	High	54.7	b	52.8	c	81.8	b	10.1	a
Treatment: Wald statistic probability			<0.001		<0.001		<0.001		<0.001	
Factorial ANOVA (Wind by Thrips)										
Significance of Interaction *2			0.794		0.001		<0.001		0.057	
AD	High Wind		53.7	b	45.9	b	79.1	b	8.1	a
BC	Low Wind		7.3	a	18.9	a	24.6	a	16.0	b
Wind: Wald statistic probability			<0.001		<0.001		<0.001		<0.001	
CD	High Thrips		23.7	a	34.3	b	49.9	b	12.3	a
AB	Low Thrips		22.8	a	27.5	a	5.6	a	10.7	a
Thrips: Wald statistic probability			0.505		<0.001		<0.001		0.073	

*1 ANOVA: binomial distribution with logit link function.
*2 Interaction between Wind and Thrips levels.
*3 Repeated from Table 6 for completeness of this table.
Letters indicate statistical separation based on overlap of 95% confidence intervals.

Table 3.21. The effect of the treatments on the condition of the pods of marketable length at harvest: by weight.

Treatment Code	Wind Level	Thrips Level	Detransformed *1 mean percentage (by weight) of pods of marketable length at harvest, day 35: Scorched	Thrips Damaged	Scorched or Thrips Damaged or both	Diseased
ANOVA						
A	High	Low	53.8 b	42.4 b	77.4 b	8.4 a
B	Low	Low	8.0 a	23.6 a	28.0 a	14.8 a
C	Low	High	7.4 a	20.7 a	26.6 a	13.2 a
D	High	High	54.0 b	55.7 b	82.6 b	10.8 a
Treatment F probability			<0.001	<0.001	<0.001	0.189
Sig. level of Bartlett's test			0.383	0.144	0.089	0.949
Factorial ANOVA (Wind by Thrips)						
Interaction F probability			0.863	0.117	0.362	0.200
AD	High Wind		53.9 b	49.1 b	80.0 b	9.6 a
BC	Low Wind		7.7 a	22.1 a	27.3 a	14.0 b
Wind: F probability			<0.001	0.005	<0.001	0.039
CD	High Thrips		30.7 a	38.2 a	54.6 a	12.0 a
AB	Low Thrips		30.9 a	33.0 a	52.7 a	11.6 a
Thrips: F probability			0.938	0.258	0.592	0.754

Letters indicate statistical separation based on overlap of 95% confidence intervals.

Table 3.22. The effect of the treatments on yield of pods at harvest: by weight

Treatment *1*2			Mean weight (g) of harvested pods / plot *3							
Code	Wind Level	Thrips Level	All		Small		Marketable Length (Large)		Clean	
Treatment Effects ANOVA										
A	High	Low	1764	a	379	a	1385	a	321	a
B.	Low	Low	1953	ab	321	a	1632	ab	1312	b
C	Low	High	3065	b	329	a	2736	b	2014	c
D	High	High	2471	ab	343	a	2128	ab	375	a
Treatment F probability			0.006		0.498		0.004		<0.001	
Significance level of Bartlett's test			0.638		0.662		0.731		0.558	
Factorial ANOVA (Wind by Thrips)										
Interaction F probability			0.990		0.943		0.981		0.122	
AD	High Wind		2117	a	361	a	1757	a	348	a
BC	Low Wind		2694	a	326	a	2368	a	1780	b
Wind F probability			0.266		0.695		0.232		0.025	
CD	High Thrips		2768	a	336	a	2432	a	1195	a
AB	Low Thrips		1827	a	359	a	1467	a	651	a
Thrips F probability			0.230		0.473		0.196		0.102	

*1 Wind barriers erected on 26 February 2009.
Insecticides applied to kill thrips in treatments A and B on 17/03, 23/03, 30/03 and 7/04.
*2. Treatment B in blocks 1 and 3 omitted because of herbicide damage.
*3 The area harvested per plot was constant but unknown (lost record)
Letters indicate statistical separation ($p \leq 0.05$) Tukey's Unequal N HSD test

Table 3.23. The effect of the treatments on the number of pods of marketable length on day 35.

Treatment *1*2 Code	Wind Level	Thrips Level	Mean # of pods of marketable length / plot *3, day 35 Total		Clean		Mean Weight (g) per pod	
Treatment Effects ANOVA								
A	High	Low	376	a	92	a	3.64	a
B	Low	Low	410	ab	338	b	3.96	ab
C	Low	High	592	b	438	b	4.63	b
D	High	High	528	ab	99	a	4.02	a
Treatment F probability			0.016		<0.001		0.017	
Significance level of Bartlett's test			0.593		0.621		0.793	
Factorial ANOVA (Wind by Thrips)								
Interaction F probability			0.693		0.018		0.102	
AD	High Wind		452	a	95	a	3.8	a
BC	Low Wind		531	a	405	b	4.4	a
Wind F probability			0.371		0.002		0.058	
CD	High Thrips		560	a	268	b	4.3	b
AB	Low Thrips		387	a	174	a	3.7	a
Thrips F probability			0.375		0.015		0.037	

*1 Wind barriers erected on day -41.
Insecticides applied to kill thrips in treatments A and B on day 0, 7, 14 and 21.
*2 Treatment B in blocks 1 and 3 omitted because of herbicide damage.
*3 The area harvested per plot was constant but unknown (lost record)

Discussion

Where the population of *Thrips* spp. was reduced with applications of dimethoate the plants were significantly shorter and lighter than where dimethoate was not applied. Although the production of leaves, buds, flowers and racemes did not vary significantly with the population of *Thrips* spp. the "in-field" assessments showed there were significantly fewer pods on plants treated with dimethoate compared with plants not treated with dimethoate. This further supports the theory that Thrips spp do aid in pollination of green beans as discussed previously.

Wind again, was the main cause of the symptoms identified as wind scorch with a mean of 53.9% in the "High-Wind" treatments with the difference between the "High-Wind" and "Low-Wind" means being highly significant.

The incidence of pods with symptoms identified as "Thrips Damage" increased significantly with the level of wind and with the level of *Thrips* spp. The response to the level of wind was not expected and one explanation was that wind may increase the severity of "Thrips Damage" making it easier to detect.

Based on weight and numbers, the yield of pods of marketable length and free of blemish was significantly greater in plots protected from the wind than in plots exposed to the wind. Based on weight, yield appeared greater in plots where *Thrips* spp. were uncontrolled (no dimethoate) than in plots where they were controlled with dimethoate. This data again provides the support that some thrips are good for beans in that they aid pollination with more seeds per pod and subsequently longer pods. Further there appeared to be more of these pods on plants protected from the wind than on plants exposed to the wind.

Bean plants protected from the wind and where *Thrips* spp. were not controlled with dimethoate, produced significantly the greatest weight of pods and apparently the greatest number of marketable pods, compared with the other three treatments. Based on weight the proportions were 100% compared with from 65 to 16% and based on numbers they were 100% compared with from 77 to 21%.

The results show that the major cause of wind-scorch is wind and that the incidence of these symptoms may be reduced and the yield of marketable pods increased by installing wind-breaks. This may however increase the incidence of disease such as *Sclerotinia* or *Botrytis* pod rots and since there are many variables involved the severity of these diseases will be unpredictable.

Material and Methods

SITE 3

Location:	Forthside, north-west Tasmania. Chaplain Farms
Trial conducted by:	Crop Protection Research Pty Ltd
Participants:	Dale Griffin, David Hughes and Jodie Morriss
Crop (cultivar):	French beans (Montano)
Planting Method	Direct seeded in early January, 2011
Plant density:	50 mm in row 540 mm between rows
Soil:	Red ferrosol, Flat
Fertilizer:	Local good agricultural practice
Irrigation:	Travelling gun, as required

Layout

The trial was laid out as a randomized complete block experiment with four blocks each containing one plot of each of the four treatments. Each plot was 10 m long by 4 m wide (eight rows) and laterally adjacent plots were separated by two unsprayed rows. Each block was eight rows wide by four plots (40 m) long and the trial occupied 18 rows by 80 m. The planting rows ran north to south.

Treatments

There were four treatments, two levels of wind by two levels of *Thrips* spp.: their codes are designated in the table below:

	Low Thrips	High Thrips
Low Wind	A	B
High Wind	C	D

The low wind level was created by surrounding the central six rows by 8 m of the relevant plots with a 0.5 metre high windbreak of black synthetic weed-matting, held in place by Star-pickets and wooden stakes. Omitting the windbreak created the high wind level.

The windbreaks were installed on 3 March (day -1) and dismantled on 12 April (day 39).

The low level of *Thrips* spp. was created by spraying the relevant plots with an appropriate insecticide and omitting these sprays created the high level of *Thrips* spp.

The insecticides and the dates on which they were applied are tabulated below.

Application	Date in 2011. & Day #	Product(s)	Dose (mL/ha)	Adjuvant (mL/100L)
1	4 March Day 0	Spirotetramat plus Lambda-cyhalothrin	200 + 40	Agral 100
2	10 March. Day 6	Spirotetramat	200	Hasten 200
3	22 March Day 18	HGW-86	750	None

Application of the Insecticide Treatments

Equipment

A compressed gas powered sprayer fitted with a flat boom carrying four nozzles at 50 cm spacings.

Table 3.24 Settings and conditions

Calibration Date	4/03/2011	10/03/2011	22/03/2011
Day number:	0	6	18
Tips :	Hardi 1553-16 hollow cone		
Number of tips:	4	2	2
Pressure (kPa):	250	300	250
Mean Boom Discharge (mL/s):	68	40	36
Spray Quality:	Fine		
Application Date:	4/03/2011	10/03/2011	22/03/2011
Time:	08:05 – 09:45	12:10 – 14:30	08:30 – 09:20
Target Spray Vol. (L/ha):	300		
Plot Area Sprayed:	10 m x 4 m		
Av. Spraying Time / Plot (s):	18.8	31.3	34.3
Av Spray Volume(L/ha):	320	313	309
Temperature (0C):	12.5	22	17
Relative Humidity (%):	8.5	17	16
Wind speed in open(km/hr):	9.6	Still	8
Wind Bearing:	SW	N/A	Not recorded
Crop development:	early to mid-flowering	mid-flowering	late-flowering

Non-experimental treatments

Before the study began a standard program of fertiliser and pesticides other than insecticides were applied to the trial area. Once the trial began no non-experimental treatments were applied.

Weather

The crop was planted early January 2011 and harvested on 13 April, over the four calendar months the rainfall was about twice the long term average (359 mm compared with 189 mm) while daily maximum and minimum temperatures were about the long term average (Table 3.25). Daily rainfall and temperature records are in Appendix 6.

Table 3.25. Weather records for Devonport: January to April 2011

Measurement		January	February	March	April
Rainfall (mm)	Total	118.4	63.6	96.0	81.4
	LT-Av. Total	43.1	37.1	46.7	62.0
Maximum Daily Temperature (OC)	Mean	21.3	20.7	19.2	17.6
	LT-Mean	21.2	21.5	20.3	17.6
Minimum Daily Temperature (OC)	Mean	13.3	11.9	10.8	9.5
	LT-Mean	12.2	12.5	10.8	8.7

Records from Devonport airport about 5 km from the trial site

Assessments and Statistical Analysis

Day 0 was the 4 March 2011, the day that insecticides were first applied.

On day 6, 12, and 17, 25 to 30 whole flowers were picked from each plot. They were immediately placed into jars containing 70% methanol in water and transported to John Duff (QDPI) for species identification and counting. All species of adult thrips and total juvenile thrips were recorded.

In the "low wind" plots, flowers were picked from rows 3 and 6 i.e. one row away from a windbreak. In the "high wind" plots, flowers were picked from rows 5 and 6, i.e. at least six rows away from a windbreak on the long sides and at least 3 metres away on the ends.

On 13 April (day 40), 100 whole plants per plot were harvested into heavy-gauge plastic freezer-bags and placed into frozen storage (minus 18°C) within hours of harvest. Two months later, the plants were thawed and all the pods were stripped from them and sorted into six categories (Table 3.26). The criteria were disease, pod size, and damage caused by thrips and wind. The pods in categories "Diseased" and "Undersize" were unmarketable whereas the pods in the remaining four categories were marketable.

Table 3.26. Harvest assessment: categories of pods

Disease	Marketable Size	Damage	Category of Pods	Measurements Weight	Measurements Number
Y	Y or N	Unknown	"Diseased"	Y	N
N	N	Unknown	"Undersize"	Y	N
N	Y	None	"Good"	Y	Y
N	Y	Thrips damage	"Thrips"	Y	Y
N	Y	Wind damage (Scorch)	"Wind"	Y	Y
N	Y	Thrips & Wind damage	"Both"	Y	Y

Y = Yes. N = No.

Main effects and factorial ANOVA were calculated for the each set of counts and weights; transformed where necessary to comply with the requirement of homogeneity of variance, as indicated by Bartlett's test. Normal-probability plots were also viewed on screen to confirm the data were normally distributed. Fisher's protected ($p=0.050$) LSD test was calculated to compare treatment means.

Main effects and factorial repeated measures ANOVA were calculated for the total population data over the three assessments.

Friedman's two-way non-parametric ANOVA was calculated for data sets which violated the assumption of homogeneity of variance, irrespective of the transformation

To compare proportions derived from numbers of pods, ANOVA for binomial distributions with a logit link, were calculated.

The analyses were calculated using Statistica Release 8.

Results

Four thrips species from two genera were encountered *Thrips imaginis, T tabaci*, *T vulgatissimus* and *Pseudanaphothrips achaetus.*

At every assessment, the mean population of total thrips (larvae plus adults) was significantly ($p \leq 0.050$) less in plots treated with insecticides than in plots not treated with insecticides (Tables 3.27 to 3.29). This was also the case with total larvae in two of three assessments and with *T. tabaci* adults at one assessment. Additionally, although the differences were not statistically significant, the population of the remaining *Thrips* spp. appeared less in treated beans than in untreated beans.

Hence the program of selective applications of insecticide was successful in creating two distinctly different populations of thrips.

The population of *Thrips* spp. did not vary significantly with the level of wind at any assessment. However analysis of the counts over all assessments suggested there may have been more *Thrips* spp under "Low Wind" than under "High Wind" (p=0.080).

There was no significant interaction between the level of wind and the level of thrips with respect to the size of the population of thrips (Tables 3.27 to 3.29).

Wind and thrips level or combinations of both had no significant effect on the weight or numbers of any category of beans (Tables 3.30 and 3.31). Further, based on weight, there were no significant differences between the treatments with respect to the mean proportion of pods of any of the three marketable categories (Table 3.32). However, based on numbers, there was a significantly higher proportion of pods in the "Good" category under "Low Wind" than under "High Wind" (Table 3.33).

There was a significantly lower proportion of "Wind damaged" pods under "Low Wind" than under "High Wind" But, this was also the case with the proportion of "Thrips damaged" pods, which was inconsistent (indeed almost a contradiction) with the apparently higher population of thrips under "Low Wind" than under "High Wind". This strongly suggested that some wind damaged pods were identified as thrips damaged pods.

Table 3.27. The population of Thrips on 10 March (day 6)

Treatment Code	Treatment Description	Mean number per 100 flowers on day 6 *1 — Adults: *T. vulga.*	Adults: *T. tabaci*	Adults: *T. imaginis*	Larvae All spp.	Larvae + Adults
Treatment Effects ANOVA						
A	Low wind, Low Thrips	0.0 a	18.2 ab	0.0 a	9.4 a	29.5 a
B	Low wind, High Thrips	0.0 a	37.5 c	0.0 a	27.9 a	66.4 b
C	High wind, Low Thrips	0.0 a	13.9 a	0.0 a	15.1 a	29.4 a
D	High wind, High Thrips	1.9 a	24.6 b	2.7 b	31.6 a	63.2 b
ANOVA F probability: Treatments		0.104	0.007	0.010	0.215	0.028
Sig. level Bartlett's test		n/a	0.238	n/a	0.739	0.980
Transformation *1		None	LN	None	Sqrt.	Sqrt.
Factorial (Wind x Thrips) ANOVA						
ANOVA F probability: Interaction		0.184	0.624	0.184	0.916	1.000
AB	Low Wind	0.0 a	26.2 a	0.0 a	17.5 a	46.1 a
CD	High Wind	1.1 a	19.3 a	1.6 a	23.8 a	47.2 a
ANOVA F probability: Wind		0.422	0.274	0.134	0.763	0.752
AC	Low Thrips	0.0 a	15.9 a	0.0 a	12.1 a	29.4 a
BD	High Thrips	0.9 a	30.4 a	1.4 a	29.7 a	64.8 b
ANOVA F probability: Thrips		0.184	0.098	0.184	0.087	0.039

*1 All means are de-transformed, where relevant. LN: X = ln(x+0.5). Sqrt: X = Sqrt(x)

T vulga = T vulgatissimus

Letters indicate statistical separation (p=0.050), Fisher's protected LSD test

Table 3.28 The population of Thrips on 16 March (day 12)

Treatment Code	Treatment Description	Mean number per 100 flowers on day 12 *1 — Adults *2: *T. vulga.*	Adults: *T. tabaci*	Adults: *T. imaginis*	Adults: *Ps.*	Larvae All spp.	Larvae + Adults
Treatment Effects ANOVA							
A	Low wind, Low Thrips	2.1 a	20.2 a	3.6 a	0.0 a	19.0 ab	46.2 a
B	Low wind, High Thrips	1.3 a	26.1 a	18.0 bc	0.0 a	61.7 c	105.6 b
C	High wind, Low Thrips	2.3 a	23.8 a	6.7 ab	0.8 a	8.6 a	42.8 a
D	High wind, High Thrips	5.8 a	34.7 a	28.0 c	0.0 a	38.8 bc	108.8 b
ANOVA F probability: Treatments		0.457	0.424	0.032	0.436	0.012	0.004
Sig. level Bartlett's test		0.545	0.694	0.683	n/a	0.894	0.126
Transformation		Box-Cox	None	Angle	None	Angle	LN
Factorial (Wind x Thrips) ANOVA							
ANOVA F probability: Interaction		0.156	0.488	0.834	0.391	0.890	0.803
AB	Low Wind	1.7 a	23.2 a	9.5 a	0.0 a	37.7 a	69.9 a
CD	High Wind	3.8 a	29.3 a	15.6 a	0.4 a	21.2 a	68.3 a
ANOVA F probability: Wind		0.234	0.284	0.393	0.391	0.244	0.913
AC	Low Thrips	2.2 a	22.0 a	5.0 a	0.4 a	13.3 a	44.5 a
BD	High Thrips	3.1 a	30.4 a	22.7 a	0.0 a	49.7 b	107.2 b
ANOVA F probability: Thrips		0.379	0.170	0.062	0.391	0.049	0.020

*1 All means are de-transformed, where relevant. Angle: X = Asin(Sqrt(x/300)). LN: X =ln(x+0.5)
Box-Cox: X = (((x+(1.000))^(0.309182))-1)/(0.309182)

*2 Abbreviations: *vulga.* = *vulgatissimus. Ps* = *Pseudanaphothrips.*

Letters indicate statistical separation (p=0.050), Fisher's protected LSD test

Table 3.29. The population of Thrips on 21 March (day 17)

Treatment		Mean number per 100 flowers on 21 March *1						Total Thrips All *3 Asmnts.
Code	Description	Adults *2				Larvae All spp.	Larvae + Adults	
		T. vulga.	*T. tabaci*	*T. imag.*	*Ps*			
Treatment Effects ANOVA								
A	Low wind, Low Thrips	0.9 a	27.8 a	2.2 a	0.0 a	25.5 a	60.9 a	37.2 b
B	Low wind, High Thrips	0.0 a	52.7 b	11.1 a	0.0 a	107.0 b	182.0 c	89.8 d
C	High wind, Low Thrips	1.0 a	24.9 a	1.7 a	1.8 a	21.9 a	52.7 a	28.6 a
D	High wind, High Thrips	1.9 a	35.5 a	11.1 a	0.0 a	65.8 b	121.4 b	68.9 c
ANOVA F probability: Treatments		0.770	0.008	0.237	0.087	0.002	<0.001	<0.001
Sig. level Bartlett's test		1.000	0.550	0.944	n/a	0.204	0.560	*4
Transformation		None	LN	Angle	None	LN	LN	LN
Factorial (Wind x Thrips) ANOVA								
ANOVA F probability: Interaction		0.519	0.339	0.940	0.182	0.291	0.351	0.257
AB	Low Wind	0.4 a	38.3 a	5.8 a	0.0 a	52.4 a	105.4 a	57.8 a
CD	High Wind	1.4 a	29.8 a	5.4 a	0.9 a	38.0 a	80.0 a	47.3 a
ANOVA F probability: Wind		0.476	0.138	0.940	0.182	0.093	0.102	0.080
AC	Low Thrips	0.91 a	26.3 a	2.0 a	0.91 a	23.7 a	56.7 a	33.3 a
BD	High Thrips	0.93 a	43.3 b	11.1 a	0.00 a	83.9 b	148.7 b	78.6 b
ANOVA F probability: Thrips		0.991	0.029	0.151	0.182	0.002	0.004	0.005

*1 All means are de-transformed, where relevant. Angle: X = Asin(Sqrt(x/300)). LN: X =ln(x+0.5)
*2 Abbreviations: *vulga.* = *vulgatissimus*. *imag.* = *imaginis*. *Ps* = *Pseudanaphothrips*.
*3 Repeated Measures ANOVAs: three assessments viz. 10, 16 and 21 March
*4 The sig levels for Bartlett's test were 0.930, 0.126 and 0.560, respectively
Letters indicate statistical separation (p=0.050), Fisher's protected LSD test

Table 3.30. The effect of the treatments on the yield (weight) of pods.

Code	Treatment Description	All Pods	Un-marketable Undersize	Un-marketable Diseased	Marketable Total	Marketable Good (undamaged)	Marketable Thrips damaged	Marketable Wind damaged
		Mean weight (kg) of pods per plot sample *1						
Treatment Effects ANOVA								
A	Low wind, Low Thrips	3.81	0.82	0.20	2.74	1.98	0.55	0.26
B	Low wind, High Thrips	3.32	0.83	0.29	2.31	1.70	0.46	0.21
C	High wind, Low Thrips	3.70	0.87	0.17	2.63	1.72	0.72	0.29
D	High wind, High Thrips	3.74	0.95	0.22	2.55	1.66	0.64	0.35
ANOVA F probability: Treatments		0.825 *2	0.824	0.640	0.499	0.375	0.359	0.525
Significance level of Bartlett's test		0.026	0.823	0.262	0.178	0.742	0.236	0.422
Factorial (Wind x Thrips) ANOVA								
ANOVA F probability: Interaction		n/a	0.834	0.711	0.366	0.483	0.912	0.621
AB	Low Wind	3.56	0.83	0.24	2.52	1.84	0.51	0.23
CD	High Wind	3.72	0.91	0.20	2.59	1.69	0.68	0.32
ANOVA F probability: Wind		0.480 *2	0.504	0.432	0.692	0.349	0.185	0.454
AC	Low Thrips	3.75	0.84	0.19	2.68	1.85	0.63	0.27
BD	High Thrips	3.53	0.89	0.25	2.43	1.68	0.55	0.28
ANOVA F probability: Thrips		1.000 *2	0.716	0.277	0.230	0.292	0.464	0.956

*1 All means except those for "All pods" are detransformed from square roots
*2 Significance level of Friedman's ANOVA chi-square

Table 3.31. The effect of the treatments on the yield (number) of pods

Code	Treatment Description	Total	Good (undamaged)	Thrips damaged	Wind damaged
		Mean number of marketable pods per plot sample at harvest			
Treatment Effects ANOVA					
A	Low wind, Low Thrips	984	740	174	83
B	Low wind, High Thrips	861	652	157	67
C	High wind, Low Thrips	944	634	233	111
D	High wind, High Thrips	891	599	213	107
ANOVA F probability: Treatments		0.360	0.066	0.361	0.440
Significance level of Bartlett's test		0.102	0.457	0.295	0.521
Factorial (Wind x Thrips) ANOVA					
ANOVA F probability: Interaction		0.414	0.533	0.994	0.825
AB	Low Wind	922	695	165	75
CD	High Wind	917	617	223	109
ANOVA F probability: Wind		0.917	0.108	0.226	0.350
AC	Low Thrips	964	686	203	96
BD	High Thrips	876	625	184	86
ANOVA F probability: Thrips		0.098	0.178	0.652	0.758

Table 3.32. The effect of the treatments on the proportion of pods (by weight) damaged by Thrips and Wind.

Treatment		Mean % of marketable pods in category		
Code	Description	Good (undamaged)	Thrips Damaged	Wind Damaged
Treatment Effects ANOVA				
A	Low wind, Low Thrips	73	20	10
B	Low wind, High Thrips	74	21	9
C	High wind, Low Thrips	65	28	11
D	High wind, High Thrips	65	25	14
ANOVA F probability: Treatments		0.089	0.188	0.485
Significance level of Bartlett's test		0.792	0.673	0.895
Factorial (Wind x Thrips) ANOVA				
ANOVA F probability: Interaction		0.900	0.684	0.679
AB	Low Wind	73	20	10
CD	High Wind	65	26	13
ANOVA F probability: Wind		0.142	0.182	0.460
AC	Low Thrips	69	24	11
BD	High Thrips	69	23	12
ANOVA F probability: Thrips		0.968	0.797	0.752

Table 3.33. The effect of the treatments on the proportion of pods (by number) damaged by Thrips and Wind

Treatment		Predicted *1 mean % of marketable pods in category		
Code	Description	Good (undamaged)	Thrips Damaged	Wind Damaged
Treatment Effects ANOVA				
A	Low wind, Low Thrips	75 b	18 a	9 a
B	Low wind, High Thrips	76 b	18 a	8 a
C	High wind, Low Thrips	68 a	25 b	12 b
D	High wind, High Thrips	67 a	24 b	12 b
Sig. Wald statistic: Treatments		<0.001	<0.001	<0.001
Factorial (Wind x Thrips) ANOVA				
Sig. Wald statistic. Interaction		0.852	0.179	0.188
AB	Low Wind	75 b	18 a	8 a
CD	High Wind	67 a	24 b	12 b
Sig. Wald statistic: Wind		<0.001	<0.001	<0.001
AC	Low Thrips	72 a	21 a	10 a
BD	High Thrips	72 a	21 a	10 a
Sig. Wald statistic: Thrips		0.765	0.905	0.581

*1 Binomial ANOVA with Logit link
Letters indicate statistical separation p<0.050

Discussions

The program of insecticides significantly ($p \leq 0.050$) reduced the population of *Thrips* spp. by 58% compared with no insecticide. Averaged over days 6, 12, and 17, the total populations were 33 and 79 per 100 flowers, respectively. Assuming the windbreaks were effective, wind level had no significant effect on the population of *Thrips* spp. Nevertheless there was an indication ($p=0.080$) that Low Wind favoured *Thrips* spp. compared with High Wind. There was no significant interaction between insecticide (Thrips level) and windbreaks (Wind level) with respect to the population of *Thrips* spp.

Compared with the untreated control, none of the treatments had any significant effect on the weight of pods in any category or on the number of undamaged (Good), Thrips damaged and Wind damaged pods. Furthermore, there was no significant response to Thrips level or Wind level or any significant interaction between these variables. This was also the case with the proportions of the weight of pods damaged by thrips and wind.

Based on the number of pods, there was a significantly higher proportion of undamaged (Good) pods under Low Wind than under High Wind. Consistent with this, there was a significantly lower proportion of “Wind damaged” pods under “Low Wind” than under “High Wind”. However this was also the case with the proportion of thrips damaged pods and this was inconsistent with the apparently lower population of thrips under “Low Wind” than under “High Wind”. This strongly suggested that some wind damaged pods were identified as thrips damaged pods.

The absence of responses to the level of *Thrips* spp. was attributed to their low incidence at this time of the growing season

The trial confirmed that windbreaks reduce wind scorch (damage) in French beans.

Materials and Methods

SITE 4

Location:	Forthside, north-west Tasmania. Chaplain Farms
Trial conducted by:	Crop Protection Research Pty Ltd
Participants:	Dale Griffin, David Hughes and Jodie Morriss
Crop (cultivar):	French beans (Montano)
Planting Method	Direct seeded in early January, 2011
Plant density:	50 mm in row 540 mm between rows
Soil:	Red ferrosol, Flat
Fertilizer:	Local good agricultural practice
Irrigation:	Travelling gun, as required

Layout

The trial was laid out as a randomized complete block experiment with five blocks each containing one plot of each of the six insecticide treatments and three plots of the untreated control. Each plot was 20 m long by 1 m wide (~ 2 rows). Plots within the same planting row were positioned end-to-end without a buffer space; therefore, assessments were conducted in the central 18 metres of each plot. There was a buffer of at least one planting row between laterally-adjacent experimental plots.

Treatments

The seven treatments included in the study are tabulated below.

Code	Product	Active constituent (g/L)	Dose (mL/ha)	Adjuvant (mL/100L)	Number of applications
1, 2 and 6	None				
3	Karate with Zeon® Technology	lambda-cyhalothrin 250	40	Agral 100	1
4	Movento® 240 SC Insecticide	spirotetramat 240	200	Hasten 200	2
5	Nufarm Dimethoate Systemic Insecticide	dimethoate 400	800	Agral 100	1
7	HGW-86	Confidential	750	Hasten 200	2
8	Success™2 Naturalyte™ Insect Control	spinosad 240	400	None	1
9	GF-187	Confidential	100	None	1
Adjuvants	Agral = 600 g/L nonyl phenol ethylene oxide condensate				
	Hasten = 704 g/L ethyl and methyl esters of fatty acids from food grade canola oil				

Application of Insecticide Treatments

Equipment

A compressed gas powered sprayer fitted with a flat boom carrying two nozzles at 50 cm spacings was used to apply the various insecticide treatments.

Calibration Date	25/02/2011	10/03/2011
Day number:	-13	0
Tips :	Hardi 1553-16 with a grey swirl plate	
Pressure (kPa):	200	300
Mean Sprayer Discharge (mL/s)	34	40
Spray Quality:	Fine	
Application Date:	25/02/2011	10/03/2011
Treatments applied	4 and 7	3,4,5,7,8 and 9
Time:	15:45 – 16:15	12:10 – 14:30
Target Spray Volume (L/ha):	200	
Plot Area Sprayed:	20 m x 1 m	
Spraying time per plot (s):	11.6	10.4
Temperature (^{0}C):	21	22
Relative Humidity (%):	20.5	17
Wind speed in open (km/hr):	5.7	Still
Wind Bearing:	NW	N/A
Crop Condition:	Healthy, foliage dry	
Crop development:	early flowering	mid-flowering

Non-experimental treatments

Before the study began a standard program of fertiliser and pesticides, other than insecticides, was applied to the trial area. Once the trial began no non-experimental treatments were applied.

Weather

The crop was planted early January 2011 and harvested on 19 April, over the four calendar months the rainfall was about twice the long term average (359 mm compared with 189 mm) while daily maximum and minimum temperatures were about the long term average (Table 3.34). Daily rainfall and temperature records are in Appendix 7.

Table 3.34. Weather records for Devonport: January to April 2011

Measurement		January	February	March	April
Rainfall (mm)	Total	118.4	63.6	96.0	81.4
	LT-Av. Total	43.1	37.1	46.7	62.0
Maximum Daily Temperature (OC)	Mean	21.3	20.7	19.2	17.6
	LT-Mean	21.2	21.5	20.3	17.6
Minimum Daily Temperature (OC)	Mean	13.3	11.9	10.8	9.5
	LT-Mean	12.2	12.5	10.8	8.7

Assessments and Statistical Analysis

On days 0 (10 March 2011), 6, and 11, a sample of 25 to 30 whole flowers was picked from over the central18 m length of each plot and immediately placed into jars containing 70% methanol in water. These were sent to John Duff (QDPI) who identified and counted all species of adult thrips and total juvenile thrips.

On day 40, 100 whole plants in all treated plots and one untreated plot per block were harvested, put into heavy-gauge plastic freezer-bags and placed into frozen storage (minus 18°C) within a few hours of harvest, One month later, the plants were thawed and all the pods were stripped from them and sorted into six categories (Table 3.35). The criteria were disease, pod size, and damage caused by *Thrips* spp. and wind. The pods in categories “Diseased” and “Undersize” were unmarketable whereas the pods in the remaining four categories were marketable.

Table 3.35. Harvest assessment: categories of pods

Disease	Marketable Size	Damage	Category of Pods	Measurements	
				Weight	Number
Y	Y or N	Unknown	"Diseased"	Y	N
N	N	Unknown	"Undersize"	Y	N
N	Y	None	"Good"	Y	Y
N	Y	Thrips damage	"Thrips"	Y	Y
N	Y	Wind damage	"Wind"	Y	Y
N	Y	Thrips & Wind damage	"Both"	Y	Y

Y = Yes. N = No.

Main effects and factorial ANOVA were calculated for the each set of counts and weights; transformed where necessary to comply with the requirement of homogeneity of variance, as indicated by Bartlett’s test. Normal-probability plots were also viewed on screen to confirm the data were normally distributed. Fisher’s protected (p=0.050) LSD test was calculated to compare treatment means.

Main effects and factorial repeated measures ANOVA were calculated for the total population data over the three assessments.

Friedman’s two-way non-parametric ANOVA was calculated for data sets which violated the assumption of homogeneity of variance irrespective of the transformation

Gamma correlations were calculated to determine whether there were any significant relationships between the incidence of Thrips damaged pods and the population of Thrips and between the latter and marketable yield.

All statistical analyses were calculated using Statistical Release 8.

Results

Four species of thrips were encountered *Thrips tabaci, T imaginis, T vulgatissimus* and *Pseudanaphothrips achaetus*. *T. tabaci* were predominant, they comprised 89, 46 and 73% of the population of adults in untreated beans at day 0, 6 and 11: respectively. The proportions for *T. imaginis* were 7, 38 and 26%, respectively; while *T. vulgatissimus* comprised 4, 16 and 2%, respectively. *P. achaetus* were found on day 6 in extremely low numbers.

On day 0, there was no significant ($p \leq 0.050$) difference between the means of any of the seven treatments irrespective of whether they had been applied (Table 3.36). Thus the application of spirotetramat and HGW-86, 13 days earlier had no detectable effect on the population of thrips.

The counts on days 6 and 11 (Tables 3.37 and 3.38 and Figure 3.10) showed that only lambda-cyhalothrin, dimethoate and GF-187 significantly reduced the total population of thrips compared with the untreated control. This was clearly evident from the plot of the mean population of thrips from day 6 to 11, adjusted for the populations on day 0 (Figure 3.11). The significance level of the difference between lambda-cyhalothrin and dimethoate means was $p = 0.607$ while the significance level of the difference between the means of these two treatments and that of GF 187 was $p = 0.066$ and $p = 0.178$, respectively.

Compared with the untreated control, lambda-cyhalothrin, dimethoate and GF 187 had no significant effect on the population of adult *T. tabaci* whereas all significantly reduced the population of adult *T. imaginis*. While none of these insecticides had any significant effect on adult *T vulgatissimus*, this was probably because there were too few to detect any differences.

It is unknown whether the susceptibility of the larvae to the insecticides varied between species.

Compared with the untreated control, none of the treatments had any significant effect on the yield and quality of the pods (Tables 3.39 and 3.40). Indeed the incidence of thrips damaged pods was not significantly correlated with the population of thrips over the three assessments; further, there was no significant correlation between the weight and number of marketable pods and the population of thrips.

Table 3.36. The effect of the treatments on the population of Thrips on 10 March

Treatment *1	Mean number of Thrips per 100 flowers on day 0 Means detransformed from Angles *2				
	Larvae	Adults			
	All species	*T. tabaci*	*T. imaginis*	*T. vulgatissimus*	Total
1, 2 & 6 = Untreated	32	54	2.6	0.6	92
3 = Lambda-cyhalothrin	21	58	0.9	0.1	85
4 = Spirotetramat	23	61	0.6	0.1	86
5 = Dimethoate	26	53	2.5	0.6	85
7 = HGW-86	33	75	1.6	0.0	112
8 = Spinosad	28	46	2.1	1.6	82
9 = GF 187	35	64	0.3	0.8	103
Treatment F probability.	0.283	0.153	0.649	0.654	0.180
Sig. Bartlett's test	0.621	0.886	0.996	1.000	0.199
	% Reduction of the population compared with the UTC				
3 = Lambda-cyhalothrin	33	-9	66	75	8
4 = Spirotetramat	26	-13	79	76	6
5 = Dimethoate	19	2	6	9	8
7 = HGW-86	-5	-40	37	100	-22
8 = Spinosad	10	14	21	-163	10
9 = GF 187	-11	-19	89	-38	-12

*1 Treatments 4 and 7 applied on day -13 and 0, i.e. twice.
Treatments 3, 5, 6, 8 and 9 applied on day 0, i.e. once
*2 Transformation: X = Asin(Sqrt(x/10)); where x is the observed # of Thrips / flower.

Table 3.37. The effect of the treatments on the population of Thrips on 16 March

Treatment	Mean number of Thrips per 100 flowers on day 6 Means detransformed from Angles *1					
	Larvae	Adults				
	All species	*T. tabaci*	*T. imaginis*	*T. vulgatissimus.*	*Ps. achaetus.*	Total
1, 2 & 6 = Untreated	35 d	15 a	9.5 a	4.6 a	0.1 a	73 d
3 = Lambda-cyhalothrin	**3 a**	4 a	0.8 a	1.1 a	0.0 a	**15 a**
4 = Spirotetramat	24 cd	22 a	6.0 a	1.0 a	0.0 a	58 cd
5 = Dimethoate	**6 ab**	6 a	4.6 a	0.2 a	0.0 a	**25 ab**
7 = HGW-86	20 cd	7 a	14.6 a	1.5 a	0.0 a	49 bcd
8 = Spinosad	28 cd	15 a	6.4 a	0.2 a	0.2 a	57 cd
9 = GF 187	**17 bc**	14 a	1.1 a	0.2 a	0.0 a	**35 abc**
Treatment F prob.	<0.001	0.125	0.074	0.079	0.650	<0.001
Sig. Bartlett's test	0.654	0.756	0.182	0.893	1.000	0.730
	% Reduction of the population compared with the UTC					
3 = Lambda-cyhalothrin	91	71	92	75	100	80
4 = Spirotetramat	33	-46	37	78	100	20
5 = Dimethoate	84	59	52	96	100	66
7 = HGW-86	42	56	-53	66	100	32
8 = Spinosad	21	5	33	96	-135	22
9 = GF 187	53	10	88	96	100	52

*1 Transformation: X = Asin(Sqrt(x/10)); where x is the observed # of Thrips / flower.
Letters indicate statistical separation (p = 0.050), Fisher's protected LSD test
Means in **bold type** are significantly different from the UTC mean

Table 3.38. The effect of the treatments on the population of Thrips on 21 March

Treatment	Mean number of Thrips per 100 flowers on day 11 Means detransformed from Angles *1				
	Larvae	Adults			
	All species	*T. tabaci*	*T. imaginis*	*T. vulgatissimus.*	Total
1, 2 & 6 = Untreated	59 c	26 a	7.5 c	0.1 a	98 c
3 = Lambda-cyhalothrin	**18 a**	21 a	**0.7 a**	0.2 a	**46 a**
4 = Spirotetramat	55 c	22 a	6.8 bc	0.0 a	86 bc
5 = Dimethoate	**29 ab**	16 a	**0.5 a**	0.2 a	**49 a**
7 = HGW-86	48 bc	24 a	7.8 c	0.2 a	85 bc
8 = Spinosad	46 bc	25 a	7.5 c	0.2 a	80 bc
9 = GF 187	43 bc	22 a	**1.5 ab**	0.3 a	**70 ab**
Treatment F probability.	0.002	0.712	0.005	0.958	<0.001
Sig. Bartlett's test	0.645	0.447	0.527	1.000	0.978
	% Reduction of the population compared with the UTC				
3 = Lambda-cyhalothrin	70	19	91	-105	53
4 = Spirotetramat	8	16	10	100	12
5 = Dimethoate	52	38	93	-114	50
7 = HGW-86	20	6	-4	-136	13
8 = Spinosad	23	3	0	-114	18
9 = GF 187	28	13	80	-294	28

*1 Transformation: X = Asin(Sqrt(x/10)); where x is the observed # of Thrips / flower.
Letters indicate statistical separation (p = 0.050), Fisher's protected LSD test
Means in **bold type** are significantly different from the UTC mean

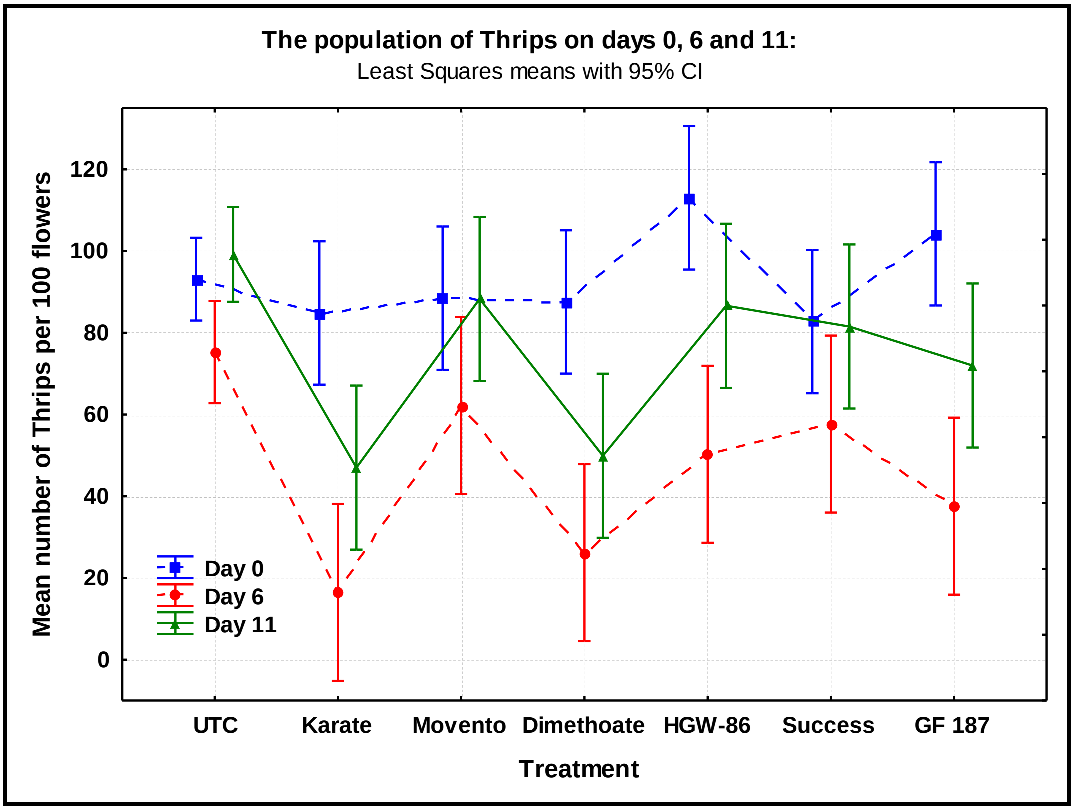


Figure 3.10

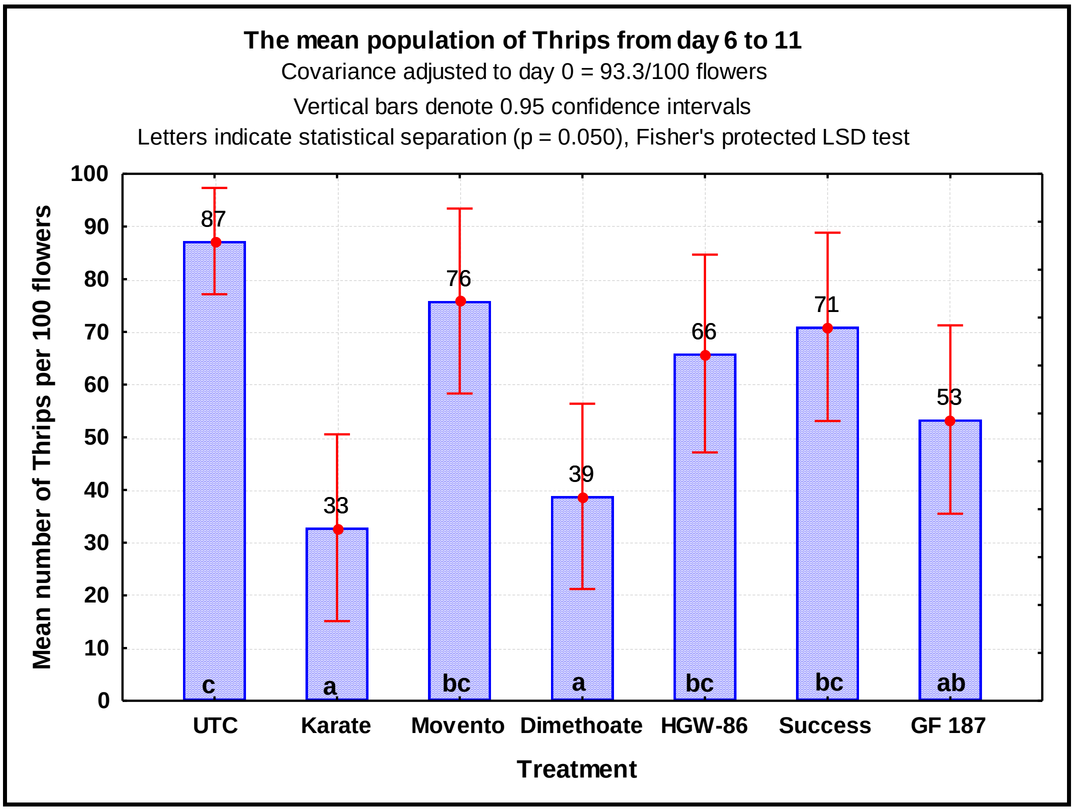


Figure 3.11.

Table 3.39. The effect of the treatments on the weight of pods at harvest

Treatment	Mean weight (kg) of Pods at harvest per 100 plants						
	All	Unmarketable pods		Marketable pods			
		“Undersize”	“Diseased”	Total *2	"Good"	“Thrips” *1 Damaged	“Wind” *1 Damaged
1 = Untreated	3.93	0.64	0.16	3.13	2.46	0.54	0.18
3 = Lambda-cyhalothrin	4.01	0.65	0.17	3.19	2.37	0.70	0.24
4 = Spirotetramat	4.16	0.65	0.13	3.38	2.57	0.61	0.27
5 = Dimethoate	4.00	0.63	0.13	3.23	2.47	0.66	0.16
7 = HGW-86	3.88	0.64	0.13	3.11	2.43	0.57	0.14
8 = Spinosad	4.36	0.65	0.16	3.55	2.72	0.70	0.19
9 = GF 187	4.27	0.64	0.14	3.49	2.53	0.82	0.22
Sig. Friedman's Chi-sqr.	0.581	0.913	0.355	0.731	0.822	0.969	0.820
Analysis in Appendix 3	19	20	21	22	23	24	25

*1 Pods with both Thrips and Wind damage allocated to both categories
*2 Total = Good + Thrips damaged only + Wind damaged only + Thrips and Wind damaged

Table 3.40. The effect of the treatments on the number of Marketable pods

Treatment	Mean number of Marketable Pods per 100 plants			
	Total *2	"Good"	Thrips *1 Damaged	Wind *1 Damaged
1 = Untreated	925	763	131	40
3 = Lambda-cyhalothrin	906	723	152	43
4 = Spirotetramat	889	718	145	35
5 = Dimethoate	896	703	164	44
7 = HGW-86	900	732	142	32
8 = Spinosad	964	761	170	41
9 = GF 187	969	727	163	92
Significance Friedman's Chi-square	0.957	0.840	0.944	0.508
Analysis in Appendix 3	26	27	28	29

*1 Pods with both Thrips and Wind damage allocated to both categories
*2 Total = Good + Thrips damaged only + Wind damaged only + Thrips and Wind damaged

Discussion

Thrips tabaci comprised 89, 46 and 73% of the population of adults in untreated beans at day 0, 6 and 11 respectively. The proportions for *T. imaginis* were 7, 38 and 26%, respectively and the proportions of *T. vulgatissimus* were 4, 16 and 2%, respectively. *Pseudanaphothrips achaetus* were only found on day 6 and in numbers too low to affect the results.

It is unknown whether the susceptibility of the larvae to the insecticides varied between species as these were not able to be accurately identified to species level.

Compared with the untreated control, spirotetramat at 200 mL/ha applied on day -13 and 0, had no significant effect on the population of any stage or grouping of *Thrips* spp. on days 0, 6 and 11. This was also the case with HGW-86 at 750 mL/ha applied on the same schedule as spirotetramat and with spinosad at 400 mL/ha applied, on day 0.

The total population of *Thrips* spp. in untreated plants was 92, 73 and 98 per 100 flowers on days 0, 6 and 11, respectively. Hence the failure of spirotetramat, HGW-86 and spinosad cannot be attributed to overwhelming pest pressure. Moreover, there was less than 0.5 mm of rain in the ten days following each application; so the spray deposits could not have been removed by rain. Consequently, at the doses and frequencies tested, it seems highly unlikely that any of these three insecticides will be suitable for the control of *Thrips* spp. in commercial crops of beans.

On days 6 and 11 lambda-cyhalothrin, dimethoate and GF-187 significantly reduced the total population of *Thrips* spp. compared with the UTC. Averaged over the two assessments these treatments reduced the total population of thrips by 62, 55 and 39%. Although this performance was superior to that of the other three insecticides it was insufficient for control of *Thrips* spp. in commercial crops of beans.

Under conditions of low pest incidence, compared with the untreated control, none of the treatments had any significant effect on the yield and quality of the pods. Moreover, there was no indication that any treatment damaged the plants in any other way or affected the finish of the pods. Thus, at the doses and frequencies tested, all insecticides appeared to be safe for use in commercial crops of French beans.

4. General Discussion

Queensland efficacy trials

Ten (10) insecticidal products were assessed for the control of thrips during flowering. Two products, dimethoate and methomyl are old products, are harsh on the environment and have been registered for use in beans for a long time. Dimethoate and methomyl are currently under review by the APVMA and my not be around for much longer limiting the availability of registered insecticides for managing thrips in green beans. Spinosad and spirotetramat are new generation products which are reportedly softer on the environment. The remaining products are not registered for use in green beans, although imidacloprid did have a permit for use against silver leaf white fly from 2003-2006.

The trial work carried out in Queensland showed clearly that there are very few effective insecticides that will control thrips to a level that limits damage to bean pods to below 10% of the harvested pods. This could be due to a number of factors; reinfestation, application, timing or simply ineffective insecticides. Depending on the time of year, the use of insecticides may not be necessary as the spring trial showed, but during the later part of the season in south east Queensland when bean blossom thrips is most prevalent, then no insecticides was outstanding in controlling this thrips or any other thrips. Spinosad and spirotetramat were very good at controlling larvae but were not as effective at managing the adult population. When dimethoate was added to spinosad, the adult population declined significantly during the 2010 autumn trial with less than 1 thrips per flower compared to the next best product spirotetramat with just under 3 thrips per flower. The unsprayed control had on average 3.5 thrips per flower during this time.

These trials also looked at the application techniques of the various insecticides as the neonicotinoids in particular are thought to perform better when applied to the soil allowing the plants to take up the product via the roots. None of these products, thiamethoxam, imidacloprid or clothianidin, performed well on thrips control, even when they were reapplied to the ground when the flower buds were present. The timing of such applications may be crucial in order to have sufficient product present in the flower for thrips control. Repeat applications will undoubtedly increase any residue levels within the crops and increase any resistance issues with thrips such as *F. occidentalis*. Marquini, Guedes et. al. (2002) found that imidacloprid sprays to the foliage gave up to 8 days control of *T. tabaci* on the foliage and so applying such products to the foliage just prior to flowering may result in a better control of thrips during this time.

The timing of all products known to control thrips may need revisiting, this includes those that can give a quick knockdown of the insects to the systemics that need to be inside the plant before the thrips become a problem. Spraying the flowers once they have opened is too late as the thrips are well protected within the flower where chemicals can't reach. As it is most likely that the thrips lay their eggs on the developing flower buds and closely related structures, chemical sprays may need to be targeted at the crop before the flowers start opening. This should aid in the control of larvae that are hatching and stop the adult thrips before they start to venture into the flowers where they are protected from the harmful insecticides. The literature has shown various thrips species to be susceptible to a wide range of insecticides (Marquini, Guedes et al. 2002; Thoeming, Borgemeister et al. 2003; Mo 2007; Nderitu, Wambua et al. 2007), it is just a matter of getting the chemicals to where the thrips are hiding.

With reviews in place for both dimethoate and methomyl and the likelihood of restrictions being imposed on their use, thrips control in green beans will become even more difficult. The reliance upon two products, spinosad and spirotetramat, both with variable results, does not bode well for the green bean industry. A closer look at the products tested in this project may result in alternative insecticides for thrips control. There is a need to conduct laboratory studies to test each product against the different species of thrips for their effectiveness, followed by more detailed studies looking at application methods and timing of the different products, either on their own or in combination. New products could be fast tracked this way instead of performing countless trials with very little return. The use of azadirachtin or Neem may even prove to be an effective alternative when applied to the soil as it has been shown to be taken up systemically by bean plants to control *F. occidentalis* and the leaf minor *Liriomyza huidobrensis* (Weintraub and Horowitz 1997; Thoeming, Borgemeister et al. 2003; Thoeming, Draeger et al. 2006).

As mentioned by Parrella and Lewis (1997) it is critical to understand the regional population dynamics of the pest thrips in the affected and surrounding crops and weeds. This project identified 11 thrips species from Queensland and 6 thrips species from Tasmania. Not all species of thrips can be found year round. One such thrips was *M. usitatus* which was most prevalent during the autumn months in Queensland and was not found in Tasmania during this project. Autumn is the time when temperatures were better suited to *M. usitatus*. This particular thrips is hindered in its development with temperatures over 29ºC, which cause the larvae to die during hatching and adult longevity to last only 11 days (Ekesi, Maniania et al. 1999). *F. occidentalis* on the other hand has a maximum population growth and reproduction rate at 30ºC but declines rapidly once temperatures exceeded 32.5ºC in conjunction with a low relative humidity (Chyzik and Ucko 2002) making this thrips more suited to spring plantings but not Queensland's intense summer heat. Collection of bean flowers throughout the growing season is the best way of finding the answers to when the full range of thrips are going to be present and potentially causing damage to the crop.

It must be remembered that not all thrips are going to damage the bean pod. Large numbers of thrips in spring, the majority of which was *F. occidentalis*, only resulted in 10% loss due to thrips damage at harvest. There was five other thrips species present during this time, one of which was *M. usitatus* but in very low numbers. What about the other thrips species found in the flowers? They may only be present to feed on pollen which is required to complete development and optimize egg production and without pollen, the larvae are unable to develop and adult females lay only a few eggs (Childers and Achor 1995). More work needs to be undertaken to look at what damage if any the different species of thrips do to bean pods. Growers are known to spray their crops when they find thrips in the flowers and if they know that *F. occidentalis* is one of these thrips then there is a clear need to apply a suitable insecticide, which is generally a spinosad spray. This is clearly a waste of time and money.

Tasmanian project work

The work in Tasmania centred around determining whether "wind scorch" was due primarily to the strong westerlies experienced each year across Tasmania known as the roaring 40's, thrips damage at flowering or a combination of both. To date the trial work conducted in Tasmania has shown that wind was clearly the main cause of the symptom identified as "wind scorch". With increased wind there were more damaged pods as you might expect. The incidence of pods with symptoms identified as "Thrips Damage" increased significantly with the level of wind and with the level of *Thrips* spp. The response to the level of wind was not expected and one explanation was that wind may increase the severity of "Thrips Damage" making it easier to detect.

How best to reduce wind damage on bean plants: intercrop with taller plantings such as sweet corn, maize or even sorghum, plant in locations away from direct westerly winds or plant wind breaks around the paddock. Wind barriers in the form of hessian walls in these trials did produce significantly taller plants but these plants did not produce any more leaves, buds, flowers or racemes or number of pods compared to the exposed plants. The use of hessian barriers did however increase the likelihood of diseases developing on the pods such a *Botrytis* and *Sclerotinia*, so care needs to be taken, with appropriate monitoring in place for diseases.

Thrips populations appear to be as dynamic in Tasmania as they are in Queensland with large populations early in the season, averaging 134 thrips per 25 flowers at the start of flowering on site 1, 14th January 2009, increasing to 388 thrips in 25 flowers 2 weeks later under the low wind and high thrips treatment. Whereas 2 months later the numbers of thrips found in 25 flowers on site 2 averaged 6.25 thrips on 24th March 2009 and 2.25 thrips per 25 flowers one week later under the low wind and high thrips treatment. The trials in 2011 were similarly low with thrips. Only two thrips were found harbouring within bean flowers during these initial trials, *Thrips imaginis* and *T. tabaci* with *T. tabaci* the more common of the two thrips. Subsequent trials in 2011 found two additional thrips in bean flowers, namely *T. vulgatissimus* and *Pseudanaphothrips achaetus* both in very low numbers.

The spray program of dimethoate achieved its objective of reducing the numbers of thrips allowing a low and high population interaction with the wind barriers. This was more prominent with the high population of thrips during the first trial at Site 1. However numbers were still high even in the low thrips treatments, on average 100 thrips per 25 flower or 4 thrips per flower, while during the second trial at Site 2, there were less than 1 thrips in 25 flowers when spraying with dimethoate and between 2-4 thrips when not using dimethoate.

The trial during 2011 used a mixture of lambda-cyhalothrin insecticide and spirotetramat followed by spirotetramat to manage the thrips populations. Although planted late, as at Site 2 in 2009, this trial also had low number of thrips, in most instances less than 1 thrips per flower but as high as 1.8 thrips per flower in the untreated plots. It is likely that lambda-cyhalothrin was the main cause for reducing the thrips population in the Low Thrips plots as spirotetramat is more effective against the larvae and takes some time for the insecticide to have an effect on the larvae. In a subsequent trial at site 4, lambda-cyhalothrin was shown to have a marked effect on the larval population as well as the adults. It would have been better to have used dimethoate as in the initial 2 trials during the 2008/09 season for consistency. However, this trial still confirmed that wind was the main contributor to the so called “wind scorch” and that thrips damage could be exacerbated by the effect of wind.

The second trial during the 2008/09 growing season showed that there were fewer pods on the plants treated with dimethoate. This was thought to be a phytotoxicity response to repeat applications of this product. Although, it is also possible that in the absence of thrips, the flowers failed to fully pollinate, indicating that some thrips may be necessary for pollination. The first trial had high numbers of thrips even after repeat applications of dimethoate (more than 14 thrips/flower), whereas the second trial had less than one thrips with repeat dimethoate applications. Thrips do require pollen for egg production and in the process of acquiring this pollen they would themselves be pollinating the flowers. Although not significant, the low wind and high thrips treatments resulted in more pods of marketable length compared with the low wind low thrips treatment, 353 compared to 296 pods for site 1 and 438 compared to 338 pods at site 2. This further strengthens the theory that thrips aid in pollination and that some thrips under Tasmanian conditions are actually beneficial to yield. This was not repeated in the subsequent trial of 2011. This could be explained by the way the insecticides were applied to the crop. The first application of the insecticides was applied early to mid flowering followed by a 2nd application mid-flowering, by which time a number of the flowers would have been pollinated. These insecticides should have been applied very early flowering (5%-10% flower) and again one week later with a 3rd application if required.

So, do beans need thrips to help with pollination and is there a fine balance between what is too many thrips resulting in significant pod damage and not enough thrips resulting in a reduced pod set. This would appear to be the case with these trials. This would not be the case for all thrips species, so making such assumptions can be fraught with danger. What thrips are beneficial for pollination and what are causing damage to the pods. Additional work would need to be undertaken to determine the pest status of these thrips and what threshold levels would be appropriate before a spray decision is required.

Clearly wind is the major cause of wind scorch in green beans during the times of high wind, with thrips contributing damage to the pods, particularly during periods of high pressure. Monitoring of flowers will help determine when thrips are present in high numbers which would warrant treatment by dimethoate or some other appropriate insecticide. What would be good to look at in future trial work would be whether one, two or three applications would increase the yield of the crop enough to warrant the cost of the pesticide treatment.

The last component of the Tasmanian work was looking at some alternative insecticides for use under Tasmanian growing conditions. Dimethoate and lambda-cyhalothrin gave the best control of thrips for between 6 and 11 days after the one application, while the majority of other insecticides were not that much different from the untreated control. What control would have resulted from two applications of these insecticides, as is most often the case? It is quite possible that the results would have been much improved. The two applications of spirotetramat were made too far apart to be of any use. The recommendations suggest two applications at least one week apart starting at the green bud stage and using between 300 and 400ml/ha instead of the 200ml/ha as was used in this trial. It is therefore difficult to get any meaningful information from this particular trial apart from the fact that there is potential for dimethoate and lambda-cyhalothrin to be used in green beans to control thrips in bean flowers. Dimethoate is still available for use in green beans but lambda-cyhalothrin is not. This synthetic pyrethroid was chosen due to its efficacy against *T. tabaci* in onions. There are other synthetic pyrethroids registered for use in green beans and they would need to be assessed for thrips control under similar conditions as to their efficacy.

With only a limited number of registered and partially effective insecticides available to growers, resistance building up to these insecticides is a real possibility. *F. occidentalis* already has built up resistance to a wide range of insecticides, organophosphates and synthetic pyrethroids alike. How long until the other thrips species found in green beans also build up resistance to the limited number of insecticides that grower have to rely upon. Rotation of insecticides in different chemical groupings is the only way to stave of resistance and ensure those insecticides currently available will remain so for a long time to come.

5. Thrips Training Report

Introduction

In order to gain a better understanding of the dynamics of thrips, the research officer based in Tasmania Odin Franssen undertook a basic course on thrips identification with a world renowned expert based with the CSIRO Canberra. This course would help in the identification of the various thrips collected from bean flowers during the life of the project and would help with analysis of the data in case there was some treatment effect on species found in green bean in Tasmania.

Name:	Odin Franssen
Project code:	VG07017
Date of Training:	April 2009
Course Name:	Thrips workshop
Supplier:	CSIRO – Laurence Mound
Duration:	4 days
Competencies:	Thrips identification (Major Australian pest species) Thrips Biology, anatomy Thrips taxonomy

Identification of thrips species involves detailed microscopic examination, and this requires careful specimen preparation and handling. The training emphasised the biological diversity of thrips, the differential diagnosis between pest and non-pest thrips species, as well as the techniques on which such studies are based. Instruction was given in the collection, preparation, preservation and curation of thrips specimens as well as the identification of thrips species with particular reference to worldwide pest species (and where appropriate the Australian fauna). The opportunity was also given, under expert guidance, to prepare and identify collections of thrips from the Tasmanian trials which were part of this project.

Much of the time was spent studying each major Australian pest thrips species' profile identifying a species using a key, noting the unique identifying characteristics of each. After identifying several specimens of each species, time was spent learning the host plants, the climatic regions they reside in, their seasonal habit, breeding and movement habits and general biology.

The following is a list of Thysanoptera studied:
Thrips tabaci
Thrips imaginis
Thrips australis
Thrips setipennis
Scirtothrips dorsalis
Haplothrips
Megalurothrips usitatus
Limothrips cerealium
Limothrips denticornis
Frankliniella occidentalis
Frankliniella schultzei
Pseudanaphothrips achaetus

This training provided me with the skills and experience necessary to be able to identify Australian thrips species to a level that could have many useful implications in the field of horticultural pest management. As well as this, the skills are very useful for further work for this particular project, whilst already having confirmed the identity of thrips populations in two Tasmanian bean crops used for 2008-2009 trials.

Location of workshop
Australian National Insect Collection - ACT
Clunies Ross Street
Black Mountain
ACTON ACT 2601
Australia
GPO Box 1700
Canberra ACT 2601
Australia

6. Technology Transfer

Growers have been informed about the research trials in Qld especially since they centred around the use of alternative insecticides for thrips control by way of a report:

A report was sent out to green bean growers on the work undertaken in Queensland entitled: "Thrips in green bean flowers and what insecticides are suitable for their control" (Appendix 8)

- highlighting the range of thrips found in green beans
- what insecticides have been trialled and the results

Article in the Vegetable Australia magazine Vol. 4.2 on thrips and the work that will happen in QLD and Tasmania. (Appendix 9)

A Thrips fact sheet is being produced along the lines of section 1.1 of the final report.

Grower talk on the range of thrips that can be found in green beans and vegetables in general
Young Growers meeting at Gatton Research Station 25th August 2011. (Appendix 10)

No field days were undertaken in Queensland due to the last field trial being overrun by broad mites and the lack of control of those insecticides trialled.

The field day that was supposed to be run in Tasmania also failed to eventuate due in part to the lateness of the trials in the growing season and staff changes.

7. Recommendations

- Life table studies for all the thrips species during the growing season needs to be undertaken to investigate when the different thrips species appear, peak and decline in numbers. Ideally this should be carried out in each major growing region to determine what thrips are present and causing the damage commonly seen on green beans. Where do they lay their eggs; stems, flower stalks, sepals, petals, where? This knowledge could help growers better target their limited insecticides to where the larvae are due to emerge from, if other than inside the flowers.

- Where do some of the thrips species come from, such as *Megalurothrips usitatus*? What crops or weeds do they reside on in the absence of green beans. Is lucerne a preferred host for this thrips and other thrips. Lucerne is grown as part of a rotation crop by many growers and is in the ground for a number of years making it an ideal host for a range of thrips species.

- Predator interaction of the thrips attacking thrips and thrips attacking mites. Whether potential predators can be mass reared and introduced into the crop to reduce the pest thrips population. Whether some thrips actually attack mites and what their potential as biocontrol agents may be.

- What thrips and combination of thrips are responsible for the damage that is seen on bean pods. Do adults and larvae cause damage to the pods and what is the magic number of thrips needed before a spray or control option is required. In other words what is the threshold for the pest thrips and does this vary during the season.

- Are some insecticidal products more efficient at controlling different thrips species. Laboratory work is required to look at topical applications of the various insecticides to determine efficacy against the different species. Can this then be replicated in pot trials and ultimately field trials.

- A closer look at application timing and whether applying the most efficacious product(s) before the flowers open is a better way to manage the developing thrips populations rather than during flowering. Thrips reportedly lay their eggs near and on the developing flower buds indicating the adults are still exposed and presumably a better target for insecticide control.

- Are there any other pesticides that could be trialled such as azadirachtin or newer products yet to be fully trialled by the chemical companies. Looking at their efficacy in the laboratory in the first instance would help to determine if there is potential for taking such products to the next level of pot and field trials.

- Varietal selection may have an influence on thrips numbers (Nderitu, Wambua et al. 2007). Whether this is due to some type of mechanical impediment to the thrips or a chemical factor that deters the thrips from attacking the plant and developing pods is unclear. Australia has a large range of varieties for a wide range of growing regions as well as pod shape and colour. No one has looked at the possibility of resistance to thrips.

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Appendix 1

Weather data for Autumn trial 2008 at the Gatton Research Station.

Date	Wind Dir	Wind Speed km/hr	Max Temp	Min Temp	Rain	RH 9am
01 Mar 2008	SE	15.1	28.0	14.5	0.0	63.4
02 Mar 2008	ESE	16.2	26.6	15.1	0.0	54.6
03 Mar 2008	SE	17.2	26.3	13.2	0.0	63.7
04 Mar 2008	ESE	3	27.2	12.9	0.0	65.4
05 Mar 2008	E	9.7	27.6	12.9	0.0	57.2
06 Mar 2008	SE	7	27.4	13.6	0.0	74.5
07 Mar 2008	SE	2.8	27.8	13.1	0.0	72.1
08 Mar 2008	SE	15.2	29.4	14.0	0.0	63.8
09 Mar 2008	SE	16.7	28.7	13.4	0.0	65.1
10 Mar 2008	E	14.7	28.2	18.5	0.8	67.8
11 Mar 2008	SSE	18.5	28.6	13.0	0.0	61.5
12 Mar 2008	SE	11.6	29.0	14.0	0.0	62.8
13 Mar 2008	E	7.2	28.6	12.8	0.0	63.5
14 Mar 2008	E	12.2	29.9	16.2	0.0	67.4
15 Mar 2008	ESE	14.4	29.3	15.0	0.0	70.0
16 Mar 2008	SE	6.9	29.1	16.5	0.0	73.1
17 Mar 2008	ESE	13.6	28.2	18.2	1.0	83.3
18 Mar 2008	ESE	9.9	24.6	18.3	7.6	77.7
19 Mar 2008	SE	5.7	26.9	17.4	1.0	95.6
20 Mar 2008	SE	1.7	25.3	18.0	0.0	87.1
21 Mar 2008	W	7.2	24.6	15.4	0.0	81.7
22 Mar 2008	E	14.5	30.3	15.8	0.0	71.4
23 Mar 2008	E	11.3	29.8	15.4	0.0	60.6
24 Mar 2008	SE	5.3	28.9	15.9	0.0	63.0
25 Mar 2008	SE	4.3	27.9	15.1	0.0	73.8
26 Mar 2008	NW	0.2	28.2	16.1	0.0	73.5
27 Mar 2008	W	1.8	31.0	18.6	24.8	92.7
28 Mar 2008	SE	5.5	23.1	18.1	10.0	84.7
29 Mar 2008	WSW	11.9	23.2	15.7	3.4	64.6
30 Mar 2008	SW	4.6	27.1	7.6	0.0	34.8
31 Mar 2008	W	1	28.0	7.5	0.0	55.7
01 Apr 2008	SWW	4.5	28.0	9.2	0.0	62.5
02 Apr 2008	WSW	0.2	27.4	13.6	0.0	68.6
03 Apr 2008	WSW	0.1	27.2	10.6	0.0	69.4
04 Apr 2008	WSW	2.6	28.5	11.0	0.0	48.1
05 Apr 2008	SSE	13.6	26.3	10.2	0.0	48.3
06 Apr 2008	SE	16.2	25.4	11.3	0.0	59.4
07 Apr 2008	SE	13.5	24.5	11.5	0.0	60.5
08 Apr 2008	NW	0.2	25.1	9.9	3.2	71.9
09 Apr 2008	NE	3	23.7	13.1	0.0	80.8
10 Apr 2008	W	1	22.1	10.3	0.0	72.5
11 Apr 2008	WSW	8.6	25.5	12.0	0.0	70.5
12 Apr 2008	WSW	2.1	27.9	11.7	0.0	75.9
13 Apr 2008	E	1.2	28.8	11.4	0.0	78.5
14 Apr 2008	SWW	3.4	28.8	14.1	0.0	78.5
15 Apr 2008	SE	7.8	30.7	12.3	0.0	63.1
16 Apr 2008	SE	11.7	26.1	10.4	0.0	62.1

17 Apr 2008	W	5.3	25.2	9.4	0.0	67.9
18 Apr 2008	SSE	14.8	25.5	16.8	0.0	61.1
19 Apr 2008	ESE	13.4	24.6	10.3	0.0	62.4
20 Apr 2008	SE	14	24.8	9.8	0.0	71.0
21 Apr 2008	WSW	7.2	24.7	9.4	0.0	75.3
22 Apr 2008	WSW	4.3	26.3	10.2	0.0	77.8
23 Apr 2008	SE	2.1	25.7	12.6	0.8	88.2
24 Apr 2008	W	0.8	23.7	10.2	0.0	79.5
25 Apr 2008	W	18.1	25.6	11.8	0.0	76.6
26 Apr 2008	WSW	6.8	24.7	12.4	0.0	75.5
27 Apr 2008	W	7.5	27.4	10.0	0.0	78.5
28 Apr 2008	WSW	25.5	30.2	14.0	0.2	42.9
29 Apr 2008	SSW	18.8	24.3	6.3	0.0	39.3
30 Apr 2008	W	4	21.7	3.3	0.0	58.6
01 May 2008	W	6.7	23.2	6.7	0.0	68.9
02 May 2008	W	1.9	24.8	8.2	0.0	76.6
03 May 2008	WSW	9.5	27.2	12.7	0.0	48.6
04 May 2008	WSW	3.7	26.8	7.2	0.0	78.2
05 May 2008	WSW	8.1	25.1	7.6	0.0	73.6
06 May 2008	WSW	2.9	25.1	7.6	0.0	77.4
07 May 2008	W	4.6	26.2	4.0	0.0	45.7
08 May 2008	SW	15.8	27.2	11.0	0.0	47.9
09 May 2008	W	4.7	26.3	6.8	0.0	68.5
10 May 2008	W	5.6	23.8	7.2	0.0	68.9
11 May 2008	W	8.8	25.8	7.2	0.0	78.3
12 May 2008	SW	7.1	25.8	10.4	0.4	84.4
13 May 2008	WSW	8.6	25.1	9.8	0.0	79.3

Crop was planted on the 4th March with foliar sprays commencing on the 16th April until the 26th April 2010 with harvest on the 12 May 2008.

Appendix 2

Weather data for Spring trial 2008 at the Gatton Research Station.

Date	Wind Dir	Wind Speed km/hr	Max Temp	Min Temp	Rain	RH 9am
01 Sep 2008	W	9.1	27.9	13.2	0.0	64.9
02 Sep 2008	W	1.3	24.9	10.4	0.0	76.7
03 Sep 2008	SE	11.3	24.1	11.4	0.0	62.5
04 Sep 2008	ESE	5.2	23.2	15.4	0.0	78.6
05 Sep 2008	NE	3.4	23.3	13.6	0.4	90.5
06 Sep 2008	W	12.1	23.8	13.2	21.2	74.4
07 Sep 2008	WSW	27.5	21.0	10.5	0.1	65.6
08 Sep 2008	W	4.1	23.4	7.2	0.0	64.8
09 Sep 2008	WSW	2.1	25.2	7.2	0.0	64.1
10 Sep 2008	W	3.2	22.7	8.6	0.0	71.3
11 Sep 2008	W	3	23.8	5.5	0.0	58.2
12 Sep 2008	NE	1.5	24.6	14.4	0.3	75.0
13 Sep 2008	WSW	0.8	27.0	10.6	2.0	82.2
14 Sep 2008	NNE	9.1	28.7	13.0	0.0	64.3
15 Sep 2008	NNE	2.4	26.2	13.0	2.4	87.0
16 Sep 2008	N	3.2	28.0	12.5	0.0	70.4
17 Sep 2008	SE	14.5	31.2	15.1	0.0	63.2
18 Sep 2008	ESE	7.2	23.0	15.3	0.0	66.9
19 Sep 2008	SE	7.5	20.0	16.8	0.0	86.4
20 Sep 2008	NNW	5.1	28.2	15.0	0.0	85.3
21 Sep 2008	NE	9.1	32.1	15.4	19.0	72.0
22 Sep 2008	NE	4	30.3	15.6	0.0	78.6
23 Sep 2008	SE	3.5	29.9	12.6	0.0	73.0
24 Sep 2008	SE	14.7	27.8	15.6	0.0	68.2
25 Sep 2008	SE	17.4	22.3	11.2	0.0	54.5
26 Sep 2008	SE	3.7	23.8	7.2	0.0	52.2
27 Sep 2008	W	2.3	24.6	9.4	0.0	72.8
28 Sep 2008	SW	3	28.3	9.0	0.0	69.0
29 Sep 2008	NE	10.6	32.3	10.5	0.0	44.5
30 Sep 2008	E	7.1	35.6	12.5	0.0	60.9
01 Oct 2008	NNE	6.5	26.8	12.5	0.0	64.4
02 Oct 2008	ENE	4.3	26.9	11.4	0.0	63.3
03 Oct 2008	NNE	1.6	25.7	12.7	0.0	64.8
04 Oct 2008	S	0.3	29.6	12.3	0.0	66.2
05 Oct 2008	N	1.2	31.0	13.1	0.0	54.7
06 Oct 2008	W	2.3	32.9	14.4	0.0	54.3
07 Oct 2008	W	9.8	35.2	15.7	0.0	27.8
08 Oct 2008	SW	6	29.0	9.2	0.0	39.7
09 Oct 2008	SE	11.6	28.7	15.7	0.0	54.7
10 Oct 2008	SE	4.8	26.9	16.2	8.6	96.1
11 Oct 2008	SW	1.6	17.4	15.1	16.0	87.7
12 Oct 2008	SE	1.2	19.8	15.1	3.9	88.9
13 Oct 2008	SE	2.4	23.2	14.4	0.2	77.3
14 Oct 2008	N	1.4	27.2	16.9	0.0	67.0
15 Oct 2008	W	0.2	28.8	16.5	0.0	73.3
16 Oct 2008	E	10	30.9	17.1	28.8	63.2
17 Oct 2008	E	10.6	22.1	13.0	6.0	62.8

18 Oct 2008	ENE	17.1	24.6	11.7	0.0	51.6
19 Oct 2008	ENE	18.2	25.7	9.4	0.0	58.9
20 Oct 2008	ENE	4.1	26.9	11.2	0.0	63.8
21 Oct 2008	N	6.2	28.2	11.0	0.0	61.0
22 Oct 2008	W	4.2	31.2	13.4	3.4	67.3
23 Oct 2008	W	21.7	29.0	9.3	0.0	37.9
24 Oct 2008	SE	2.8	25.6	6.7	0.0	41.6
25 Oct 2008	W	3.1	25.9	12.6	0.0	62.3
26 Oct 2008	NW	2.4	27.9	11.9	0.0	64.7
27 Oct 2008	N	7.5	28.3	12.4	0.0	58.3
28 Oct 2008	N	3.8	27.8	10.4	0.0	55.0
29 Oct 2008	NE	11	30.0	11.7	0.0	60.9
30 Oct 2008	NE	13.5	30.1	14.7	0.0	61.8
31 Oct 2008	SE	3.1	30.1	12.4	0.0	62.7
01 Nov 2008	NNE	10.2	33.3	16.0	0.0	50.7
02 Nov 2008	SE	1.1	34.4	17.8	3.6	77.1
03 Nov 2008	NE	1.8	26.1	19.0	0.0	70.5
04 Nov 2008	W	0.3	25.6	18.2	2.4	68.0
05 Nov 2008	E	13.2	34.4	19.4	0.0	75.4
06 Nov 2008	W	3.4	23.4	18.4	25.8	77.9
07 Nov 2008	E	0	31.6	16.4	0.0	70.7
08 Nov 2008	NE	4.6	33.7	21.6	4.2	79.2
09 Nov 2008	W	16.7	31.9	17.6	7.6	68.0
10 Nov 2008	E	10.2	24.6	14.9	0.0	53.1
11 Nov 2008	E	12.4	27.9	13.2	0.0	55.1
12 Nov 2008	SE	6.5	27.9	12.5	0.0	55.0
13 Nov 2008	SE	14.4	27.4	18.7	3.4	69.4
14 Nov 2008	NE	4.8	28.2	19.1	0.2	68.1
15 Nov 2008	NNE	8.8	30.4	18.5	0.0	69.7
16 Nov 2008	W	0.4	32.7	19.9	0.0	72.0
17 Nov 2008	SE	2.1	35.4	18.7	4.9	91.8
18 Nov 2008	E	5.7	20.5	15.5	26.2	96.1
19 Nov 2008	NE	1.2	21.9	16.7	33.0	88.1
20 Nov 2008	NE	0.4	29.8	17.4	164.6	80.8

Crop was planted on the 10th September with foliar sprays commencing on the 27th October until the 13th Novomber with harvest on the 19th November 2008.

Appendix 3

Weather data for Autumn trial 2010 at the Gatton Research Station.

Date	Wind Dir	Wind Speed	Max Temp	Min Temp	Rain	RH 9am
01 Feb 2010	SE	13.8	26.5	21.0	20.6	84.6
02 Feb 2010	E	12.5	26.6	20.0	2.0	66.9
03 Feb 2010	E	11.8	27.2	20.3	0.8	66.6
04 Feb 2010	E	3.3	30.2	20.0	0.0	65.4
05 Feb 2010	N	10.5	30.5	20.0	0.4	67.4
06 Feb 2010	ENE	9.9	31.9	22.5	0.0	71.9
07 Feb 2010	SE	8.3	32.9	21.4	25.0	90.7
08 Feb 2010	SE	10.9	25.1	21.3	3.4	83.2
09 Feb 2010	E	7.7	29.0	18.9	0.0	70.7
10 Feb 2010	SE	3.8	29.1	17.4	2.3	68.3
11 Feb 2010	E	1.2	30.0	19.0	0.0	73.5
12 Feb 2010	W	1.6	31.2	18.9	0.0	69.3
13 Feb 2010	N	2.7	32.1	19.5	0.0	70.0
14 Feb 2010	N	2	32.9	21.8	0.0	67.0
15 Feb 2010	S	1	33.2	24.1	0.0	67.1
16 Feb 2010	N	1	35.8	23.8	34.0	90.0
17 Feb 2010	NE	8.1	29.7	21.3	41.0	81.7
18 Feb 2010	SE	16.5	26.5	21.0	0.0	65.5
19 Feb 2010	SE	10.4	28.4	19.6	0.0	60.6
20 Feb 2010	SE	12.1	28.9	19.6	0.0	71.3
21 Feb 2010	SE	6.2	29.6	19.7	1.0	76.6
22 Feb 2010	SE	8.5	27.8	18.3	0.0	65.1
23 Feb 2010	W	7.4	31.5	21.8	0.0	72.7
24 Feb 2010	E	9.5	35.0	23.1	0.0	68.6
25 Feb 2010	SE	10.3	30.4	22.6	0.0	66.3
26 Feb 2010	SE	15.6	28.7	16.7	0.0	63.4
27 Feb 2010	SE	10.8	27.4	18.1	0.4	80.4
28 Feb 2010	E	6.4	27.3	21.2	4.8	78.0
01 Mar 2010	SE	4.8	29.3	22.0	9.4	92.5
02 Mar 2010	E	5.1	25.8	18.9	57.4	92.8
03 Mar 2010	E	3.3	23.5	19.0	30.2	78.5
04 Mar 2010	E	12.6	27.5	20.0	3.0	67.7
05 Mar 2010	SE	2.8	26.0	21.1	0.4	90.7
06 Mar 2010	SSE	11.9	26.4	21.7	17.2	94.9
07 Mar 2010	E	6.1	25.6	21.4	6.6	84.9
08 Mar 2010	-	0	26.0	20.8	4.2	89.9
09 Mar 2010	W	3.5	26.1	18.2	0.4	87.1
10 Mar 2010	W	0.1	30.2	18.4	0.1	60.6
11 Mar 2010	SE	14.2	32.5	20.6	0.8	62.5
12 Mar 2010	SE	20.4	29.4	20.1	0.0	93.5
13 Mar 2010	SE	21.3	27.2	17.8	0.0	52.3
14 Mar 2010	SE	8.7	28.4	18.1	1.4	68.5
15 Mar 2010	SE	14.7	25.3	16.6	0.5	60.7
16 Mar 2010	SE	16.2	26.8	14.9	0.0	60.6
17 Mar 2010	SE	14.8	28.5	14.8	0.0	63.6
18 Mar 2010	SE	18.6	27.8	16.8	0.0	55.0
19 Mar 2010	ESE	14.3	26.8	18.2	0.4	73.2
20 Mar 2010	SE	17.8	27.8	14.9	0.0	58.9

21 Mar 2010	SE	16.9	27.4	19.6	0.6	68.0
22 Mar 2010	WSW	6	28.3	19.0	0.0	82.6
23 Mar 2010	W	1.6	28.2	19.4	0.0	77.1
24 Mar 2010	E	1.1	29.2	18.6	4.4	72.8
25 Mar 2010	SE	2	29.7	15.5	0.0	66.4
26 Mar 2010	W	0.2	28.9	17.8	0.2	81.8
27 Mar 2010	N	4	29.4	15.4	0.0	71.1
28 Mar 2010	SE	1.2	29.4	17.2	0.0	75.2
29 Mar 2010	E	7.7	28.2	19.0	0.0	78.4
30 Mar 2010	S	6	27.2	16.6	0.2	80.7
31 Mar 2010	W	1.8	29.3	18.5	0.0	78.7
01 Apr 2010	-	0	28.2	19.5	53.6	86.6
02 Apr 2010	W	1	27.8	18.1	7.4	79.7
03 Apr 2010	SE	9.5	27.7	17.4	0.0	67.5
04 Apr 2010	S	13.4	27.0	18.3	0.0	69.2
05 Apr 2010	SE	2.1	26.0	14.7	0.0	71.1
06 Apr 2010	NE	0.6	27.2	15.8	0.0	69.3
07 Apr 2010	WSW	4.2	27.2	15.2	0.0	84.2
08 Apr 2010	WSW	3	26.7	16.0	0.0	74.3
09 Apr 2010	WSW	0.4	30.7	17.1	0.0	65.2
10 Apr 2010	NE	2.9	29.1	19.5	0.0	80.4

Crop was planted on the 4th February with foliar sprays commencing on the 15 March until the 31st March with harvest on the 6th april 2010.

Appendix 4

Table 1. Summary of wind speed recordings

Day #	Wind Speed km/h		
	Average	Maximum	Minimum
1	3.7	7.0	0.0
2	7.8	16.8	1.3
3	14.0	19.6	1.1
4	14.7	24.6	3.5
5	5.1	12.2	0.7
6	6.4	14.1	0.9
7	3.2	8.4	0.1
8	7.7	17.7	2.1
9	11.0	19.8	0.9
10	11.3	23.7	0.0
11	9.3	16.4	0.0
12	12.0	21.1	0.8
13	10.3	17.8	3.6
14	5.9	13.3	0.4
15	2.9	8.4	0.0
16	0.8	4.7	0.0
17	0.6	4.3	0.0
18	2.7	7.2	0.0
19	3.5	10.5	0.0
20	5.3	11.0	0.0
21	3.0	9.4	0.0
22	3.2	9.1	0.0
23	2.4	5.7	0.1
24	0.7	7.9	0.0
1 to 24	6.1	12.9	0.6

Wind speed in the open, measured and recorded every 5 minutes (data logger)

Table 2. Daily Rainfall and Temperature

Day #	Rain (mm)	Temperature (OC)	
		Maximum	Minimum
1	0	22.2	12.7
2	0	25.3	13.8
3	0	23.1	13.6
4	0	18.8	10.3
5	0	18.3	5.0
6	0	20.8	8.1
7	0	19.9	13.9
8	0	24.0	12.7
9	0	20.6	12.5
10	0	22.6	12.9
11	0.8	19.4	9.7
12	7.4	20.8	13.5
13	0.4	19.3	7.2
14	0	21.2	13.4
15	0	21.6	14.5
16	0	27.0	12.0
17	0	29.7	17.8
18	0	28.2	19.9
19	0	27.8	19.2
20	0	22.3	15.8
21	1.8	22.2	15.9
22	4.0	22.2	17.4
23	0	21.5	13.2
24	0	25.8	8.0
Average		22.7	13.0
Maximum		29.7	19.9
Minimum		18.3	5.0
Total	14.4		

Source: BOM station 091186,Forthside R/S

Appendix 5

Table 1. Summary of wind speed recordings

Day #	Wind Speed (km/h)		
	Average	Maximum	Minimum
1	7.71	13.80	0.00
2	7.23	20.90	0.00
3	3.77	11.30	0.00
4	3.25	9.60	0.00
5	3.63	8.80	0.00
6	3.75	10.90	0.00
7	3.61	10.40	0.00
8	3.65	7.90	0.00
9	2.84	10.00	0.00
10	10.77	24.60	0.00
11	8.34	16.70	1.70
12	11.03	22.10	2.50
13	5.78	16.30	0.00
14	8.22	14.20	0.00
15	9.70	14.60	3.80
16	7.96	14.20	2.90
17	6.22	13.40	0.00
18	5.43	17.50	0.00
19	8.64	15.90	0.00
20	12.96	28.40	1.70
21	10.45	21.70	1.70
22	7.76	15.00	0.00
23	2.94	7.90	0.00
24	4.17	12.10	0.00
25	5.97	15.40	0.00
26	3.15	7.50	0.00
27	5.41	12.50	0.00
28	6.22	15.40	0.00
29	5.66	13.80	0.40
30	3.42	27.10	0.00
31	stopped		
32	stopped		
33	3.19	11.30	0.00
34	3.46	8.30	0.00
35	1.86	7.50	0.00
1 to 35	6.00	14.45	0.45

Wind speed in the open, measured and recorded every 5 minutes (data logger)

Table 2. Daily Rainfall and Temperature

Day #	Rain (mm)	Temperature (OC)	
		Maximum	Minimum
1	0	21.6	10.5
2	0	19.1	8.8
3	0	20.1	11.2
4	0.2	20.4	12.3
5	0	20.5	11.8
6	0.2	25.3	15.5
7	0.4	22.2	16.0
8	0	20.0	15.2
9	0	19.6	16.4
10	1.8	20.7	10.4
11	0.4	19.1	9.0
12	0	18.8	13.2
13	0	20.5	6.0
14	0	20.2	11.4
15	0	19.6	13.6
16	0	22.4	14.3
17	0	22.5	16.6
18	0	20.6	15.9
19	8.4	18.6	8.3
20	4	17.8	12.2
21	0	15.9	4.0
22	0	20.8	10.0
23	0	18.4	6.3
24	0	18.3	12.1
25	0	18.8	12.3
26	0	17.9	8.3
27	0	20.0	8.4
28	0	18.7	12.3
29	0	20.2	10.3
30	13.5	15.3	9.4
31	5.6	15.5	5.4
32	0	18.7	9.8
33	0	22.8	9.8
34	0	19.1	10.8
35	0.2	15.4	10.7
Average		19.6	11.1
Maximum		25.3	16.6
Minimum		15.3	4.0
Total	34.7		

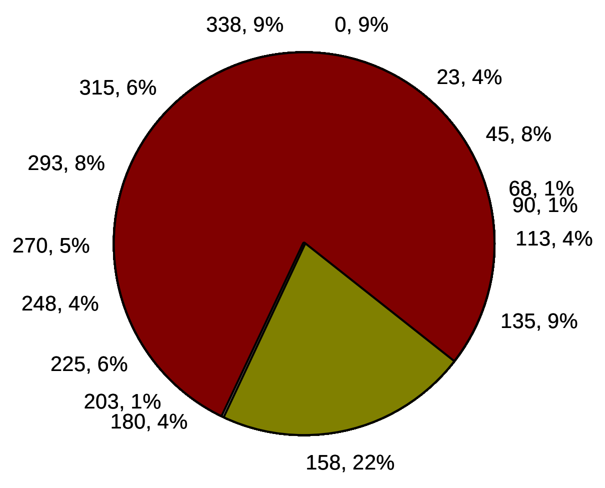
Source: BOM station 091186, Forthside.

Appendix 6

Daily rainfall and maximum and minimum temperature

Day Number	Rain (mm)	Temp. (^{O}C) Maximum	Temp. (^{O}C) Minimum	Day Number	Rain (mm)	Temp. (^{O}C) Maximum	Temp. (^{O}C) Minimum
0	0	16.4	8.5	21	9.4	21.4	11.1
1	0	15.8	3.3	22	0	17.3	10.0
2	0	18.5	7.8	23	0	18.6	9.3
3	0	21.0	11.9	24	0	18.6	7.4
4	0	19.3	14.9	25	0	17.6	10.8
5	14.2	20.1	14.9	26	0	17.9	14.2
6	0	22.5	12.7	27	0	17.5	4.4
7	0	20.1	13.7	28	0	17.3	8.6
8	0	20.8	12.0	29	0.8	15.8	9.1
9	0	21.0	16.0	30	0	18.5	10.2
10	0	19.1	7.4	31	0	19.0	6.7
11	0	19.4	10.0	32	0	18.2	8.7
12	0	19.6	7.5	33	0	18.2	9.1
13	0	19.6	6.9	34	0	19.3	8.7
14	0	18.4	6.8	35	0	19.9	11.1
15	0	20.4	10.9	36	0	21.1	12.6
16	0	20.4	11.0	37	22	16.3	11.9
17	0.2	24.0	13.6	38	9.8	14.8	12.1
18	2	19.4	17.8	39	11.2	14.5	11.3
19	5.2	20.4	14.7	40	30.6	16.2	8.9
20	65	17.8	15.1				

Study Reference: 08 -QDP-028: Site 2.
Wind direction from day 0 (4 March) to 40 (13 April), Devonport Airport Tasmania
Bearing in degrees, % observations (n = 82: 09:00 and 15:00 hrs each day)



Appendix 7

Table 1. Weather Records. Table 1 of 1

Day	Rain	Temperature (OC)		Day	Rain	Temperature (OC)	
Number	(mm)	Maximum	Minimum	Number	(mm)	Maximum	Minimum
-13	**0**	**20.5**	**11.2**	14	65	17.8	15.1
-12	0	19.5	13.2	15	9.4	21.4	11.1
-11	0.4	21.8	11.3	16	0	17.3	10.0
-10	0	19.1	14.7	17	0	18.6	9.3
-9	0	15.8	11.4	18	0	18.6	7.4
-8	0	18.7	7.8	19	0	17.6	10.8
-7	0	17.2	10.6	20	0	17.9	14.2
-6	0	16.4	8.5	21	0	17.5	4.4
-5	0	15.8	3.3	22	0	17.3	8.6
-4	0	18.5	7.8	23	0.8	15.8	9.1
-3	0	21.0	11.9	24	0	18.5	10.2
-2	0	19.3	14.9	25	0	19.0	6.7
-1	14.2	20.1	14.9	26	0	18.2	8.7
0	**0**	**22.5**	**12.7**	27	0	18.2	9.1
1	0	20.1	13.7	28	0	19.3	8.7
2	0	20.8	12.0	29	0	19.9	11.1
3	0	21.0	16.0	30	0	21.1	12.6
4	0	19.1	7.4	31	22	16.3	11.9
5	0	19.4	10.0	32	9.8	14.8	12.1
6	**0**	**19.6**	**7.5**	33	11.2	14.5	11.3
7	0	19.6	6.9	34	30.6	16.2	8.9
8	0	18.4	6.8	35	2	19.6	8.9
9	0	20.4	10.9	36	0	17.9	8.4
10	0	20.4	11.0	37	0	16.6	6.5
11	**0.2**	**24.0**	**13.6**	38	0	16.9	9.1
12	2	19.4	17.8	39	0	17.2	10.3
13	5.2	20.4	14.7	40	0	18.9	14.1

Records for Devonport Airport, (Station 091126) about 5 km from the trial site

Appendix 8

Thrips in green bean flowers and what insecticides are suitable for their control

by

John Duff

March 2009

The information contained within this report cannot be seen as a recommendation at this time as some of the pesticides used in the trials are not registered or permitted, and it is illegal to apply under the conditions used in these trials.

HAL

Know-how for Horticulture™

Queensland Government

Department of Primary Industries and Fisheries

Thrips in green beans

The majority of Australian beans are grown in Queensland and Tasmania. Queensland grows 40% for the fresh market while Tasmania grows 44% only for the processing industry (ABS data 2003). Thrips are a continuing pest problem and a difficult pest to control or manage due to the habit of this small insect, which can be found feeding on the developing pods with the flowers. Growers in Tasmania seem to be unaware of the full extent of this pest on their industry with limited research undertaken to date to understand the impact of this pest on the Tasmanian processing industry and the confusion of the damage caused by this pest and what is traditionally thought of as "wind scorch". Thrips are also a concern to local Queensland growers.

Queensland currently manages thrips by the use of traditional broad spectrum insecticides such as dimethoate and methomyl, which are very disruptive to an Integrated Pest Management program, where as Tasmanian growers currently don't use any insecticides for thrips control at flowering. Damage due to possible thrips in Tasmania can be as high as 10% scaring, which in Tasmania would result in the complete crop being rejected by the processor due to the increased cost associated with sorting at the processing plant. The ideal level of damage would be less than 4% damage whether it is due to thrips or wind scorch symptoms.

Thrips have been found to attack green beans from the moment they emerge from the ground right through until flowering, where they have greatest impact. Adult thrips are small cylindrical or cigar-shaped insects up to 2mm in length, ranging in colour from pale yellow to brown to nearly black. They have two pair of narrow wings, which are fringed with long hairs and rest along the length of their back. The young or nymphs are similar in shape, smaller and wingless and usually pale yellow to almost white. Trying to identify the types of thrips in the field is extremely difficult and can only be carried out with any degree of accuracy in the laboratory using diagnostic keys and a high powered microscope.

Thrips can be found on the underside of the cotyledons or leaves and even in the growing tips, where they leave a silvery-white scaring as a result of their feeding. Scaring can also be an issue where leaves touch one another. This is not considered a major problem as the plant grows quickly and tends to cope well with thrips on the leaves. Distorted new growth has not been a major problem with this group of insects, as can be the case with other crops.

The greatest damage caused by thrips is at flowering and pod set, when thrips are found within the flowers feeding on the developing pods. This action results in miss-shapen and distorted pods which are rejected at harvest. Not all thrips will attack developing pods, some will be there to feed on the pollen and nectar produced by the flower. One thrips, *Desmothrips tenuicornis,* can also be a predator of other thrips, which might be why it is found within flowers as well as scurrying on the leaves.

What Thrips are in Green Bean Flowers

To date there have been eleven thrips recorded from green bean flowers as shown below in Table 1, with a distinct difference in the type of thrips found within the green bean flowers from the spring and autumn plantings. As seen in Table 2, there was far more *Frankliniella occidentalis* or western flower thrips at the start of the season compared to late in the season, where the most common thrips was *Megalurothrips usitatus* or bean blossom thrips. The hairless flower thrips or *Pseudanaphothrips achaetus* was present in reasonable numbers during both assessment periods. The *Thrips* species was also present during both assessment but were present in greater number during the spring crop.

Table 1. Thrips found in green bean flowers.

Scientific name	Common name
Desmothrips tenuicornis	
Frankliniella occidentalis	Western flower thrips
Frankliniella schultzei	Tomato thrips
Haplothrips gowdeyi	Gold tipped tubular thrips
Limothrips cerealium	Grain thrips
Megalurothrips usitatus	Bean blossom thrips
Pseudanaphothrips achaetus	Hairless flower thrips
Thrips imaginis	Plague thrips 1
Thrips parvispinus	Taiwanese thrips
Thrips safrus	Plague thrips 2
Thrips tabaci	Onion thrips

Early season crops would also appear to harbour more thrips than latter crops as shown in Table 2. This could be due in part to the effect that natural predators might have on the thrips populations. Coming out of the cooler winter months there are fewer predators about compared to later in season. Also, certain thrips are far more prevalent during the cooler months and can therefore quickly colonise green bean flowers once they open. Western flower thrips and certain *Thrips* species can be found attacking a number of winter crops such as lettuce, brassicas and onions which could account for their higher numbers during the spring period of cropping.

Table 2. Distribution of adult thrips within untreated green bean flowers during the season. The numbers in brackets ( ) are the nymphs.

Type of adult Thrips	Autumn crop 6th May 08	Spring crop 3rd Nov 08
Pseudanaphothrips achaetus	6.75	12.25
Megalurothrips usitatus	8	0.25
***Thrips* species**	1.5	15.75
F. occidentalis	1.25	69
F. schultzei	0	3
Desmothrips tenuicornis	0	0.75
Tubeliferan	1	0
Unknowns	4.5	0.5
Total thrips in 25 flowers	23 (33.5)	101.5 (30)
Total thrips per flower	0.92 (1.34)	4.19 (1.20)
% *Pseudanaphothrips*	29.35	12.07
% *Megalurothrips*	34.78	0.25
% *Thrips*	6.52	15.52
% *F. occidentalis*	5.43	67.98
% *F. schultzei*	0	2.96
% others	23.91	1.23

The average number of thrips per flower was also much higher during the start of the season with over 5 thrips (both adults and nymphs) found in each flower. This number dropped off to just over 2 thrips (both adults and nymphs) per flower during autumn.

Insecticide Efficacy Trials

This project has been looking at the effectiveness of a number of alternative products to control thrips as well as looking at the wind scorch issues faced by Tasmanian green bean growers.

Six alternative products in two efficacy trials have so far been trialled, and have included both foliar applied insecticides as well as soil applied insecticides.

Thrips trial Autumn 2008

1. Control
2. DPX-HGW86 15ml/100m row
3. DPX-HGW86 30ml/100m row
4. Confidor Guard 14ml/100m row
5. Biocontrol fungus
6. Movento 300ml/ha
7. Movento 400ml/ha
8. Success2 400ml/ha

Thrips trial Spring 2008.

1. Control
2. Samurai 25ml/100m row
3. Actara 10g/100m row
4. Success2 400ml/ha
5. Dimethoate/Lannate
6. DPX-HGW86 750ml/ha
7. DPX-HGW86 1000ml/ha

Three neo-nicotinoids, Confidor, Actara and Samurai, were applied to the furrow at planting, as was DPX-HGW86 at 2 different rates. DPX-HGW86 was subsequently trialled as a foliar treatment due to its poor performance as a soil application. A biocontrol fungus was also assessed with poor results.

To date only one product seems to have potential as an effective substitute to the currently available insecticides used to manage thrips at flowering, such as dimethoate, methomyl and spinosad. This new product is Movento, which is being trialled by Bayer Crop Sciences. This product appears to have a very good effect on reducing the immature populations with a perceived reduction in the adults as seen in Figure 1. There was no significant difference between this product and spinosad, which could be a useful alternative product that growers could rely upon in a rotation program and as part of a resistance management program.

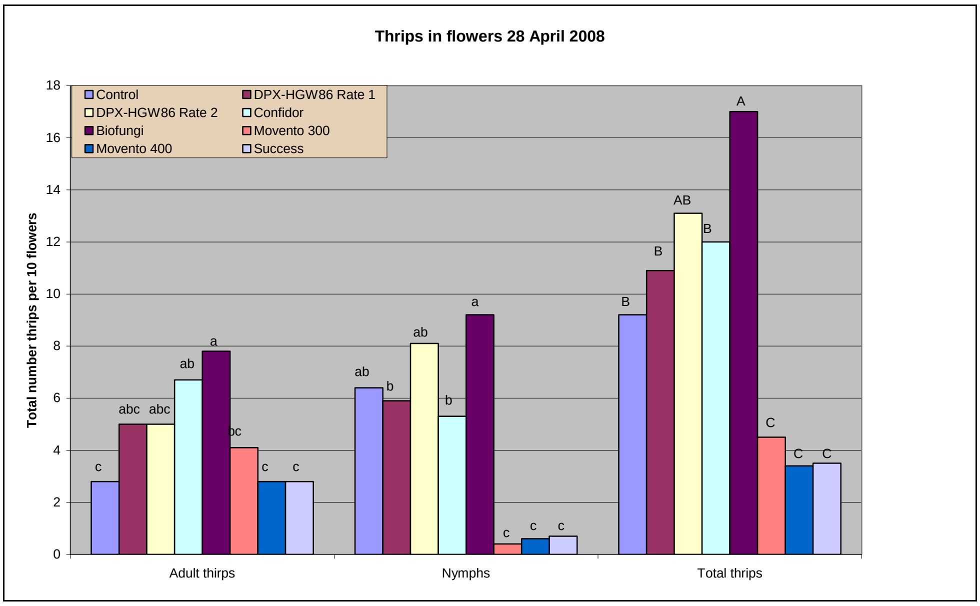


Figure 1. Autumn planted crop. Results were after 2 applications of the various treatments.

Movento was not looked at during the spring planting, where there was a different thrips spectrum, to determine how effective this product would perform against western flower thrips and a higher number of thrips in general.

Thrips counts after 2 applications of the various foliar insecticides in spring showed little difference between treatments with the unsprayed control having just as many thrips in the flowers as a number of insecticide treatments as seen in Figure 2 below. The dimethoate and methomyl treatment was the worst performer, highlighting the need for alternative products to try and manage this insect pest at flowering. Even after a third application there was no significant differences between treatments.

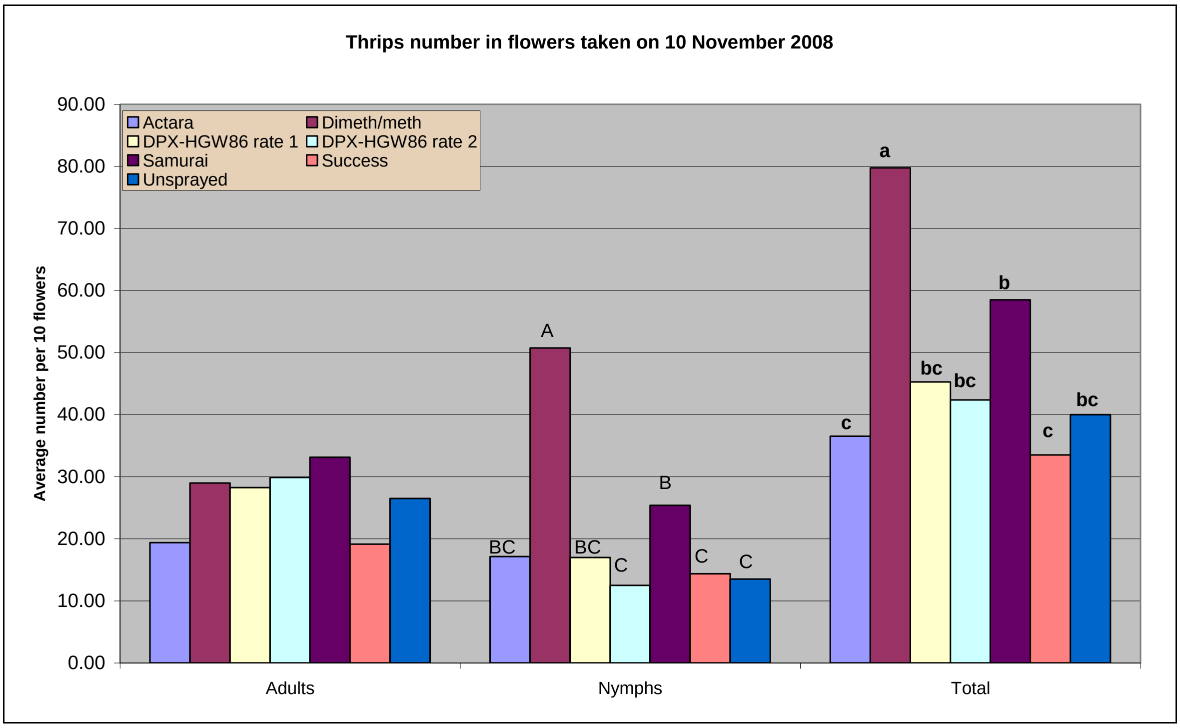


Figure 2. Spring planted crop. Results were after 2 applications of the various treatments.

These two trials have only come up with one suitable replacement to those insecticides currently available to green bean growers, and that is Movento. This is a Bayer Crop Science product and it is hoped that this product should be registered for use with 12 months, depending on its speed of passage through the APVMA. Additional trials are still needed to check out combinations of insecticides, both soil applied followed by foliar applied insecticides. Some of the neo-nicotinoids showed some reduction in thrips numbers over the standard dimethoate and methomyl mix, as seen in Figure 2. If another product were then applied at the first signs of flowering, or even the same product, thrips may be managed to a more acceptable level resulting in less pod damage and a greater yield.

Harvest Assessment

The autumn planted crop of green beans suffered from poor growth, stunting and leaf scorching as a result of poor quality irrigation water, which had a very high salt content. As a result of this, it was only possible to harvest the equivalent of one replication of all the treatments. The results therefore are not all that conclusive but do show some interesting trends with regards pod damage. Over 50% of the pods could still be considered as marketable even in the control plot, whereas the best performer was Success2 with just over 80% of the pods being marketable. Movento gave mixed results, even though this product did reduce the number of thrips in the flowers. It must also be remembered that the number of thrips per flower in the unsprayed control plots averaged just over two thrips, including both adults and nymphs. Although Movento had the least number of thrips per flower, the damage caused to the pods was similar to that of the unsprayed control. This product needs to be looked at in more detail and will be a part of another trial during the spring of 2009. It could be assumed from Figure 3 and Table 3 below, that even one thrips per flower is sufficient to cause over 60% of damage to pods as shown with Movento in Figure 3 below.

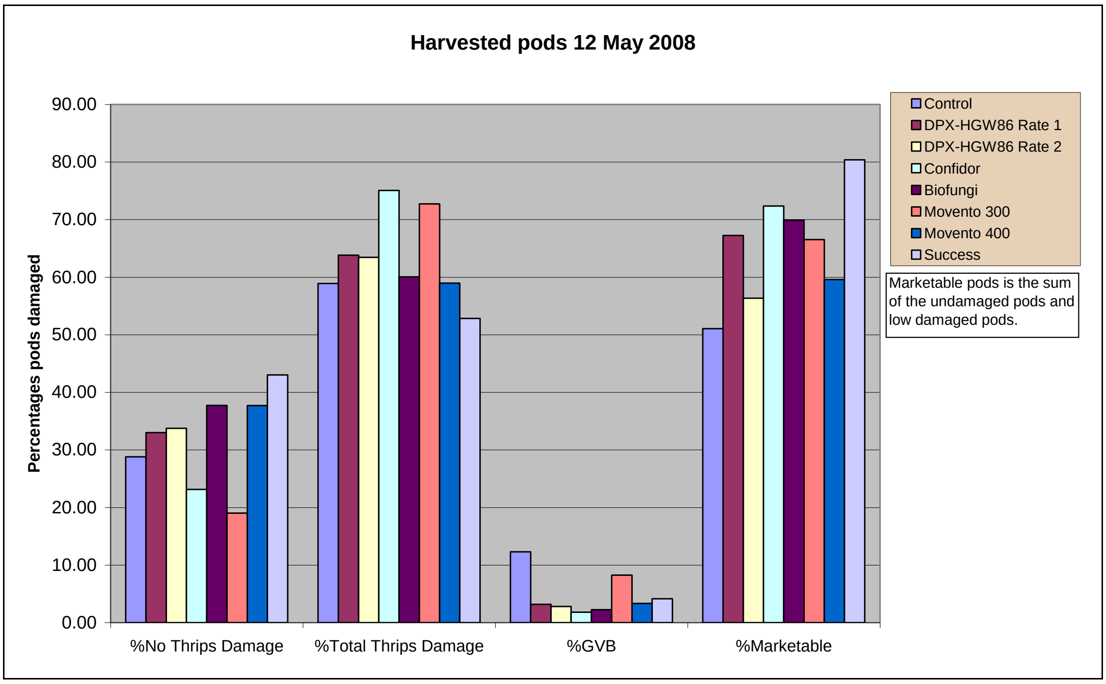


Figure 3. Harvest results from only one replicate taken on the 12th May 2008.

Table 3. Average number of thrips per flower, collected on the 6th May 2008.

Treatment!	Adult thrips	Nymphs	Total thrips
Control	0.92	1.34	2.26
DPX-HGW86 Rate 1	0.96	2.64	3.6
DPX-HGW86 Rate 2	1.35	2.76	4.11
Confidor	1.15	1.33	2.48
Biofungi	0.69	1.82	2.51
Movento 300	0.72	0.13	0.85
Movento 400	0.65	0.05	0.7
Success2	0.99	0.77	1.76

Thrips numbers during autumn were low in comparison to the spring crop, which had more than a 4 fold increase in numbers, and were predominantly western flower thrips. Such an increase in numbers might see an increase in damage to pods. This however, was not the case as is shown in

Figure 4 below with only 16% of pods damaged due to thrips as seen in the unsprayed treatment, with no significant difference between treatments. All treatments were similar in damage levels and marketable pods, even with such high numbers of thrips as shown in Table 4. Thrips numbers started off between 5 and 7 thrips per flower, but dropped off by the end of the trial to below 1 thrips per flower. This included the untreated plots, which would indicate something other than a chemical induced reduction in populations.

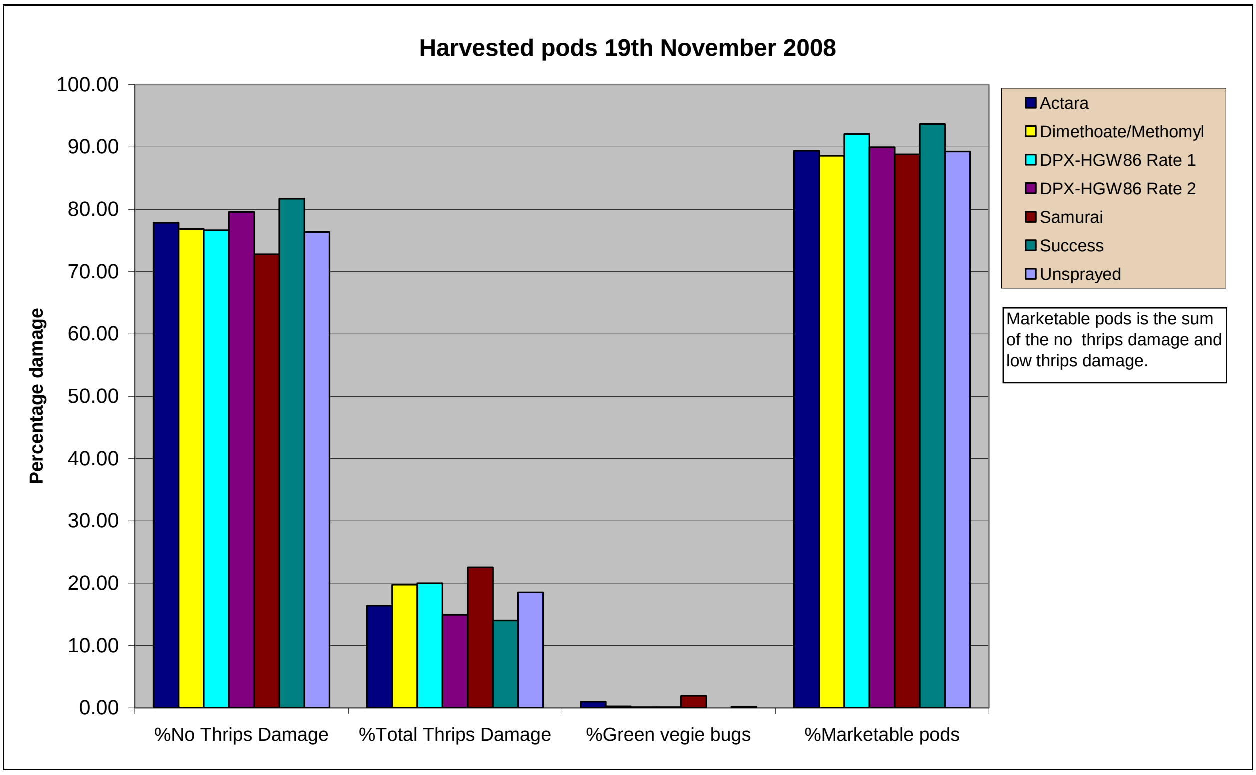
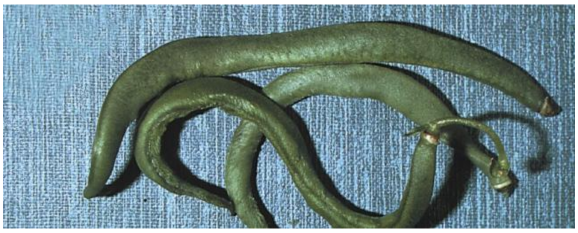


Figure 4. Harvest results from spring 2008 planting from 4 replications.

Table 4. Average number of thrips per flower during November 2008.

Treatment	3rd Nov	10th Nov	17th Nov
Actara	6.22	3.65	0.79
Dimethoate/methomyl	7.14	7.98	0.99
DPX-HGW86 Rate 1	6.67	4.53	0.80
DPX-HGW86 Rate 2	6.37	4.24	0.60
Samurai	6.87	5.85	0.84
Success2	6.88	3.35	0.35
Unsprayed	5.39	4.00	0.53

With such high numbers in the flowers at the start of flowering, growers could easily assume there would be a corresponding increase in damage, when considering the results from the autumn trial. This however was not the case and poses more questions than it answers.

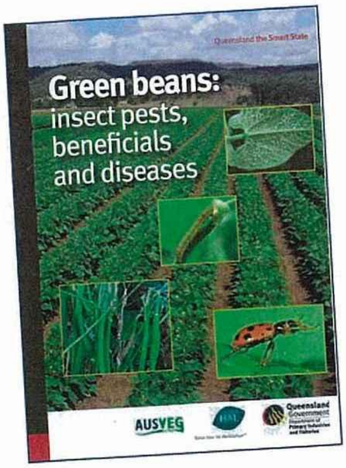


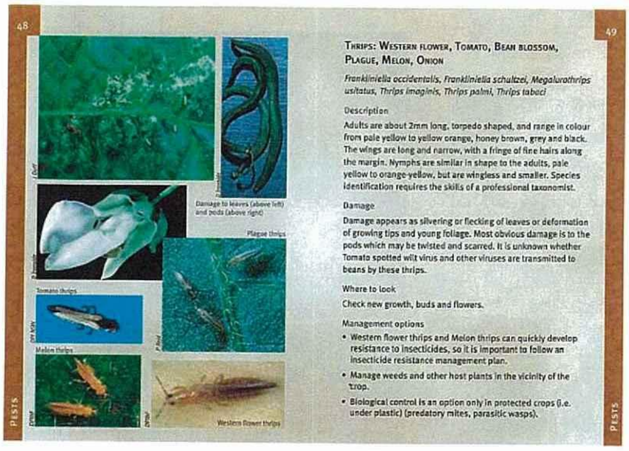
Conclusions

This project is asking more questions than can be answered in the time remaining in the project. Is it necessary to apply any insecticides during the spring crop to manage high numbers of thrips found in the flowers? With the change in thrips species from autumn to spring, which thrips are actually causing the damage to the pods, western flower thrips, bean blossom thrips, hairless flower thrips or the various *Thrips* species. There were far more undamaged pods during spring when western flower thrips were in very large numbers, while in autumn western flower thrips were almost absent from the flowers, whereas the bean blossom thrips were readily found during this time when damage was much higher. What about the other thrips such as the hairless flower thrips and the various *Thrips* spp., which were present during both spring and autumn? Do they actually contribute to pod damage and by how much. Do more than one species of thrips need to be present to cause damage to the pods?

Clearly a better understanding of the thrips types present during the growing season is needed to determine just when the various types are most prevalent. Of the 10 or more thrips found in the flowers, at least five are commonly found throughout the growing season. Additional work should then centre on looking at the response of each type of thrips at flowering to determine just which thrips, and/or combination of thrips, are causing the damage to the green bean pods and the number required to cause significant damage to the pods and before a spray is necessary.

Appendix 9





THRIPS: WESTERN FLOWER, TOMATO, BEAN BLOSSOM, PLAGUE, MELON, ONION

Frankliniella occidentalis, Frankliniella schultzei, Megalurothrips usitatus, Thrips imaginis, Thrips palmi, Thrips tabaci

Description

Adults are about 2mm long, torpedo shaped, and range in colour from pale yellow to yellow orange, honey brown, grey and black. The wings are long and narrow, with a fringe of fine hairs along the margin. Nymphs are similar in shape to the adults, pale yellow to orange-yellow, but are wingless and smaller. Species identification requires the skills of a professional taxonomist.

Damage

Damage appears as silvering or flecking of leaves or deformation of growing tips and young foliage. Most obvious damage is to the pods which may be twisted and scarred. It is unknown whether Tomato spotted wilt virus and other viruses are transmitted to beans by these thrips.

Where to look

Check new growth, buds and flowers.

Management options

- Western flower thrips and Melon thrips can quickly develop resistance to insecticides, so it is important to follow an insecticide resistance management plan.
- Manage weeds and other host plants in the vicinity of the crop.
- Biological control is an option only in protected crops (i.e. under plastic) (predatory mites, parasitic wasps).

You-beaut ute guide: the bible for green bean growers

With their new ute guide in hand, green bean growers can identify pests attacking their crops and respond in an economical and environmental fashion, writes Angela Brennan.

There is potential for more pests and diseases to affect green bean crops than any other vegetable commodity in Australia. However, growers' pains may be eased with the recent publication of a ute guide, which assists in the prompt identification of pests, diseases and beneficials, and advises a course of action, where appropriate.

The guide, *Green beans: insect pests, beneficials and diseases,* is being sent to growers, and has the potential to become their new bible. It contains more than 200 images, and information about pests, beneficials and diseases. It also includes a simple key to disorders of seedlings, roots, stems, leaves, flowers and pods, and where to find the likely cause of these disorders.

The guide provides a definition of integrated pest management (IPM) and advises growers about crop monitoring—the cornerstone to any IPM system. Information about pathogens responsible for causing plant diseases is included, as is general information about disease and insect life cycles.

Extensive research

The national green bean industry is worth about $65 million annually. Queensland and Tasmania dominate the market with around 40 per cent each in the fresh market produce and process industry, respectively. The fresh market produce and process industry. However, growers lose hundreds of thousands of dollars each year in unsaleable crops due to losses from pests and diseases.

Research into IPM against the myriad invaders attacking green beans has been conducted for a number of years (see *Vegetables Australia* 1.6, page 20). This earlier project centred on developing an IPM system suitable for the green bean industry in the face of increasing insecticide resistance and access to only a small range of effective insecticides, which limited the level of insect pest control achieved by growers.

On the strength of this project an extension was granted. This enabled the team to complete its work with the production of the ute guide and further research into the complex problem of thrip management.

"Traditionally, growers have relied on heavy insecticide use to control the most common pests," said John Duff, Senior Plant Protectionist at the Queensland Department of Primary Industries and Fisheries, who compiled the ute guide with a team of researchers.

"However, very few insecticides are registered for green beans, so our original research focused on alternative approaches. We did on-farm and research-station trial work to compare conventional pest management systems with

Best Management Options (BMO)."

These options included modified cultural practices, soft option insecticides, insect monitoring, augmentation of beneficial insects where possible, and modified pesticide application techniques.

John described the results as variable, but said they demonstrated that growers don't need to spray just because they see an insect flying within their crop.

"We found we were able to

> "We were able to halve the use of some insecticides, which has the benefit of cutting costs and improving yields."

ıalve the use of some insecticides ı certain situations, which has he benefit of cutting costs and ıproving yields," he said.

"I cannot see a time when we ɹon't use insecticides, but if we an minimise the old 'kill everyıing in the paddock' approach, and select soft option or biological insecticides as a first option, then beneficial insects will build up, helping growers manage their insect pest problems with much less cost in the long-term."

Elusive thrips

Although the guide covers an extensive range of pests, some, such as flower thrips, continue to slip through the net. "We're not out of the woods yet," said John.

"Thrips are a particularly difficult pest to manage. It is a big issue for growers, with very few insecticides fully effective against the suite of species that can be found in bean flowers."

Up to 10 different thrips have been identified in green bean flowers, including bean blossom thrips, western flower thrips, tomato thrips and plaque thrips.

"Part of the problem, particularly in Tasmania, is confusion about whether damage is caused by 'wind scorch' or thrips, both of which can have a very adverse impact on Tasmania's processing industry," he said.

John's team is conducting insecticide efficacy trials in both Tasmania (with Agronico Research) and Queensland, comparing new sap-sucking insecticides with the traditionally used products.

"We hope that alternative products show some promise. In Queensland, growers tend to use traditional broad-spectrum insecticides, which are very disruptive to an IPM program," he said.

"In Tasmania, growers currently don't use any insecticides for thrip control at flowering, which can potentially lead to the entire crop being rejected by the processor."

John added that if alternative products are found that help in the management of thrips, most growers would consider using these new products when they are registered for green beans use.

THE BOTTOM LINE

- A ute guide has been produced for growers in involved in the green bean industry.
- The guide will help growers identify pests, diseases and beneficials, and advise on a course of action, where appropriate.
- Thrip control in the green been industry is a more complex issue, and trials are being conducted in Queensland and Tasmania to find efficient ways of dealing with this pest.

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Project numbers: VG02030, VG06016
Keywords: Green bean industry