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Evaluation of tea tree oil as an insecticide in vegetables

(Three trials in North Queensland - 2002)

A report for the Rural Industries Research and Development Corporation

by Keith Lewis and Michael Gorton

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Foreword

The possibility that tea tree oil might be used as an insecticide would have significant beneficial consequences for this industry, which has experienced a major decline in production over the past four years. Much anecdotal evidence has been cited to support the belief that tea tree oil possesses insecticidal properties, but evidence in the form of documented trial results has not been generated. In an effort to prove the reality or otherwise of the insecticidal properties of tea tree oil, three replicated small plot trials conducted in North Queensland in 2002 aimed to evaluate the insecticidal effects of tea tree oil for the control of foliar pests in potatoes and cabbages.

This project was funded from industry revenue which is matched by funds provided by the Australian Government.

This report is an addition to RIRDC's diverse range of over 1000 research publications, forms part of our tea tree oil R&D program, which aims to support the development of an environmentally sustainable and profitable Australian tea tree oil industry.

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Simon Hearn
Managing Director
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Executive Summary

At Atherton, in 2002, three replicated field trials were conducted to evaluate the insecticidal properties of tea tree oil. The target pests were heliothis (*Helicoverpa* spp.) infesting Sebago potatoes, and common foliar pests of cabbages (cv Green Giant). The cabbage pests assessed were cabbage white butterfly (*Pieris rapae*), diamond back moth (*Plutella xylostella*), heliothis (*Helicoverpa* spp.), cabbage centre grub (*Hellula hydralis*) and cluster caterpillar (*Spodoptera litura*).

Two trials were conducted in potatoes and a single trial was carried out in cabbages. All the trials were designed as replicated complete blocks with four replications. The active constituent, raw tea tree oil, was applied at 1.0, 2.0, 3.0 and 4.0 L/ha to potatoes, and at 100, 200, 300 and 400 mL/100L in the cabbage trial.

In two potato trials there was no control of heliothis after two spray applications at a five day spray interval. In both cases, the larvae were small at application, and would be considered to be sensitive to conventional insecticides. The larval population developed unchecked, with progressively fewer small larvae and increasing numbers of larger larvae being observed in all treatments.

In cabbages, the results were similarly poor, and no treatment effects on pest numbers, feeding behaviour or development were observed.

It was concluded that tea tree oil was not suitable as an insecticide for the control of leaf eating caterpillars in potatoes or cabbages.

Introduction

There is much anecdotal evidence to support the view that tea tree oil has significant insecticidal properties. Such evidence originated mainly through growers' efforts in experimenting with the product to discover for themselves whether tea tree oil might be an effective insecticide. Should this be the case, it might then be possible for them to grow their own insecticide; an attractive proposition. Some instances, which appeared to support the case for tea tree oil as an insecticide, are provided in the following accounts:

1. Department of Primary Industries (Mareeba). Heliothis larvae were topically treated with dilute tea tree oil. There was approximately 40% mortality after 1 day and approximately 80% mortality after 5 days. (ref: P. Tonnello, DPI Mareeba).
2. At Skybury Coffee Plantation (Mareeba), dilute tea tree oil was applied to paw paw to observe what effect it might have on two spotted mite. The treatments appeared to prevent mite establishment in the trees. (ref: Brian Dunnigan).
3. At the property of Tom Maisel in Mareeba, dilute tea tree oil was applied to non commercial mango trees in an attempt to control scale insects. Although no thorough assessments were carried out, the treatment appeared to reduce scale numbers.
4 At the property of Les Fluerty in Emerald, two applications of tea tree oil applied at 2.4 L/ha with 2.4 L/ha of emulsifying vegetable oil were made to cotton. It was observed that heliothis failed to establish in the tea tree oil treated area whilst the pest readily established in an adjacent block of endosulfan treated crop. (ref: Rick Castino – Tolga).
5. Serve Ag BFS conducted an unreplicated small plot trial (1996) in which 2.5 L/ha and 5.0 L/ha of tea tree oil emulsified with Codacide vegetable oil achieved approximately 80% mortality of heliothis infesting potatoes. Dead larvae were found on the treated crop at 1 day after application. (ref: Keith Lewis – Serve Ag BFS).
6. A mobile tea tree oil distillery operator reported that old mango trees heavily infested with scale became free of the pest only on the side of the tree exposed to vapours emanating from the still. (ref: Brian Dunnigan).
7. There are a number of cases in which individuals have reported control of animal pests with tea tree oil including buffalo fly on cattle and ticks on dogs. In the latter case, a specific instance was reported in which a single drop of tea tree oil with a similar quantity of emulsifying vegetable oil was added to 20 L of warm water. After shaking, a quantity of the mixture was applied to the neck and ruff of a dog heavily infested with ticks. The mixture apparently had a strong expellant effect and 70 ticks were recovered after detaching from the host.
8. A mixture of 50 mL of tea tree oil with 50 mL of emulsifying vegetable oil is said to repel buffalo fly on cattle.

These and other reports suggested that it would be worthwhile to further investigate the possible insecticidal properties of tea tree oil. The work reported in this project was not intended to fall into the category of "innovative" research but rather to provide a low cost answer to the question of whether or not tea tree oil has potential as an insecticide. Should this be the case, the tea tree industry would benefit substantially in that an important new use for this product would be available.

Three trials were conducted in North Queensland to investigate the alleged insecticidal effect of tea tree oil by applying four rates of the product to foliar pests infesting potatoes and cabbages.

Objectives

- To evaluate four rates of tea tree oil as an insecticide in potatoes.
- To evaluate four rates of tea tree oil as an insecticide in cabbages.
- To compare four rates of tea tree oil emulsified with Agral non ionic surfactant or Spraytech oil®, to Agral® and Spraytech oil® applied alone.

Methodology

All trials were in randomised complete block design with four replications. Treatments were applied on a per hectare basis using a spray volume of 279 L/ha in the case of potatoes, and as a high volume spray using a rate per 100L in the case of cabbages. The active constituent, raw, unrefined tea tree oil, was applied at 1.0, 2.0, 3.0 and 4.0 L/ha to potatoes, and at 100, 200, 300 and 400 mL/100L in the cabbage trial. Agral® non ionic surfactant at 0.3% v/v of the final spray mixture was used to emulsify the tea tree oil in most cases, but Spraytech oil® was used as an emulsifier at 1.5 L/ha in a single treatment in potatoes, and at 150 mL/100L in one of the cabbage trial treatments. Treatments applied included Agral® and Spraytech oil® applied alone at the equivalent rates to those used in mixture with the tea tree oil.

Treatments were applied using a motorised Komatsu back pack sprayer. Potatoes were sprayed with a hand held boom configured to spray over the top and to each side of the crop row using three Spraying Systems TX6 hollow cone nozzles per row. A spray volume of 279 L/ha was applied at a pressure of 480 kPa.

Cabbages were sprayed by means of a two Spraying Systems TX4 hollow cone nozzles mounted side by side on a single lance. Spray mixture was applied at a pressure of 500 kPa to thoroughly wet the cabbage foliage and heart.

Prior to application, the trial sites were monitored for pest activity, and spraying commenced when sufficient pest pressure was present. At both potato trial sites, two metres of row, at six randomly selected and widely separated locations within the trial area, were thoroughly searched before spraying in order to assess the uniformity and composition of the pest population. Assessments of treatment efficacy were conducted at one and four days after the first application. Both trials received a second spray application five days after the first, and further assessments were carried out at three and seven days after these. At each assessment, two 1m sections of row from the central area of each plot were threshed onto a plastic sheet to obtain all heliothis larvae, and the numbers and size class of these were recorded.

Larvae were classified into four size classes where:

Very small = 0 - 3 mm in length. (1st instar)
Small = 3 - 7 mm in length. (2nd instar)
Medium = 7 - 23 mm in length. (3rd & 4th instars)
Large = > 23 mm in length. (5th & 6th instars)

Treatment mean counts were processed using a general linear model analysis of variance, and the LSD test at the 95% confidence level.

In cabbages, a pre spray assessment of the pest population was conducted by thoroughly searching 5m of crop row at eight widely separated locations within the trial area. All pest species found were recorded. Assessments of treatment efficacy were conducted at one, three and five days after application. All assessments comprised of an active search of five metres of row and recording the number and species of all larvae found.

Mixing of tea tree oil

The required volume of tea tree oil and emulsifying agent (Agral® or Spraytech oil®) were thoroughly mixed in a glass beaker. Water was slowly added whilst stirring. The emulsified concentrate was added to the final volume of water in the spray tank, and stirring was continued. During application, constant agitation of the spray mix was maintained by circulation of the mixture through the by-pass pipe of the spraying machine.

Detailed Results

Trial 1 - Evaluation of tea tree oil in potatoes (1)

Treatments Applied

Trt No.	Product	Product rate (L/ha)
1.	Untreated	Nil
2.	Agral	0.3%
3.	Spraytech Oil	1.5
4.	Tea tree oil + Agral	1.0 + 0.3%
5.	Tea tree oil + Agral	2.0 + 0.3%
6.	Tea tree oil + Spraytech oil	2.0 + 1.5
7.	Tea tree oil + Agral	3.0 + 0.3%
8.	Tea tree oil + Agral	4.0 + 0.3%

Trial Details

Location	Tolga - North Queensland
Grower	A. Pogiolli
Crop	Potatoes
Variety	Sebago
Planting Date	16/07/02
Row Spacing (m)	0.90
Plant Spacing (m)	0.15
Trial Design	Randomised Complete Block
Replications	4
Plot Size	4 rows X 8 m

Application Details

Date	29/08/02	03/09/02
Crop Stage	Flower buds	Early flowers
Time (h)	1130	1130
Temperature (°C)	25	25
Rel. Humidity (%)	76	74
Cloud Cover	7/8	1/8
Wind Velocity (kph)	5 SE	7 SE
Equipment & Method	Komatsu motorised knapsack sprayer - 3 nozzles per row	Komatsu motorised knapsack sprayer - 3 nozzles per row
Nozzle Type/Size	Spraying Systems cone jet TX 6	Spraying Systems cone jet TX 6
Swath (m)	0.86	0.86
Spray Volume (L/ha)	279	279
Pressure (kPa)	480	480

Weather Conditions

Weather conditions over the period were mild. Average maximum and minimum temperatures were 25^0C and 11^0C respectively, and no rain fell over the period. Overhead irrigation was applied at three days after application one, and again at three days after the second spray application. At each watering, 25 mm of irrigation was applied.

Results

Table 1 - Mean number of heliothis larvae in two metres of row - preliminary assessment

Plot	Preliminary assessment - 29/08/02				
	Very small	Small	Medium	Large	Total
1.	3	5	12	0	20
2.	4	12	9	0	25
3.	1	7	8	1	17
4.	6	5	8	0	19
5.	9	12	12	1	34
6.	12	6	8	0	26
Mean	5.8	7.8	9.5	0.3	23.5

The preliminary assessment indicated a heavy infestation of heliothis larvae, mainly in the small to medium size classes.

Table 2 - Mean number of heliothis larvae in 2 metres of row - 1 day after application one (DAA1)

Treatment	Product Rate (L/ha)	1 DAA1 - 30/08/2002				
		V.Small	Small	Medium	Large	Total
1. Untreated	Nil	4.5	10.3	13.3	1.3	29.3
2. Agral	0.3%	4.5	9.3	16.5	1.0	31.3
3. Spraytech oil	1.5	4.0	8.8	14.0	0.3	27.0
4. Tea tree oil + Agral	1.0 + 0.3%	5.0	8.8	12.3	0.8	26.8
5. Tea tree oil + Agral	2.0 + 0.3%	5.3	7.0	12.5	0.3	25.0
6. Tea tree oil + Spraytech oil	2.0 + 1.5	3.5	6.5	13.5	1.3	24.8
7. Tea tree oil + Agral	3.0 + 0.3%	5.0	7.8	10.8	0.8	24.3
8. Tea tree oil + Agral	4.0 + 0.3%	8.5	8.8	11.0	0.3	28.5
p Value (F-test)		*0.40*	*0.27*	*0.60*	*0.57*	*0.25*
LSD (Pr=0.05)		*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

At one day after application 1, there were no significant treatment related effects on total heliothis larvae numbers, or within any of the individual size classes recorded.

Table 3 - Mean number of heliothis larvae in 2 metres of row - 4 days after application one (DAA1)

Treatment	Product Rate (L/ha)	4 DAA1 - 02/09/2002				
		V.Small	Small	Medium	Large	Total
1. Untreated	Nil	2.0	4.8	9.8	0.3	16.8
2. Agral	0.3%	1.5	6.0	14.8	0.8	23.0
3. Spraytech oil	1.5	1.0	2.3	11.8	0.5	15.5
4. Tea tree oil + Agral	1.0 + 0.3%	2.0	3.3	6.5	0.3	12.0
5. Tea tree oil + Agral	2.0 + 0.3%	3.5	6.0	13.0	0.5	23.0
6. Tea tree oil + Spraytech oil	2.0 + 1.5	3.0	4.5	11.3	0.3	19.0
7. Tea tree oil + Agral	3.0 + 0.3%	0.0	3.0	9.5	0.0	12.5
8. Tea tree oil + Agral	4.0 + 0.3%	1.0	6.3	16.3	0.0	23.5
p Value (F-test)		*0.20*	*0.23*	*0.82*	*	*0.65*
LSD (Pr=0.05)		*N/A*	*N/A*	*N/A*	*	*N/A*

* Not Analysed

At four days after application 1, there were no significant treatment related effects on total heliothis larvae numbers, or within any individual size class.

Table 4 - Mean number of heliothis larvae in 2 metres of row - 3 days after application two (DAA2)

Treatment	Product Rate (L/ha)	3 DAA2 - 06/09/02				
		V.Small	Small	Medium	Large	Total
1. Untreated	Nil	0.5	1.3	5.0	0.3	7.0
2. Agral	0.3%	0.0	1.5	7.0	0.3	8.8
3. Spraytech oil	1.5	0.5	2.0	5.5	0.3	8.3
4. Tea tree oil + Agral	1.0 + 0.3%	1.5	0.8	3.5	0.0	5.8
5. Tea tree oil + Agral	2.0 + 0.3%	1.3	1.5	4.0	0.0	6.8
6. Tea tree oil + Spraytech oil	2.0 + 1.5	0.5	1.5	2.8	0.8	5.5
7. Tea tree oil + Agral	3.0 + 0.3%	1.3	1.0	2.8	0.0	5.0
8. Tea tree oil + Agral	4.0 + 0.3%	0.8	1.0	6.3	0.3	8.3
p Value (F-test)		*0.48*	*0.60*	*0.41*	*0.33*	*0.83*
LSD (Pr=0.05)		*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

At three days after application 2, there were no significant treatment related effects on total larvae numbers, or within any individual size class.

Table 5 - Mean number of heliothis larvae in 2 metres of row - 7 days after application two (DAA2)

Treatment	Product Rate (L/ha)	7 DAA2 - 10/09/02				
		V.Small	Small	Medium	Large	Total
1. Untreated	Nil	0.0	3.0	3.0	1.3	7.3
2. Agral	0.3%	0.0	4.8	4.8	1.5	11.0
3. Spraytech oil	1.5	0.0	2.3	2.8	0.0	5.0
4. Tea tree oil + Agral	1.0 + 0.3%	0.0	4.0	4.0	0.5	8.5
5. Tea tree oil + Agral	2.0 + 0.3%	0.0	3.3	3.3	0.8	7.3
6. Tea tree oil + Spraytech oil	2.0 + 1.5	0.0	4.0	2.5	0.5	7.0
7. Tea tree oil + Agral	3.0 + 0.3%	0.0	3.8	3.0	0.0	6.8
8. Tea tree oil + Agral	4.0 + 0.3%	0.0.	4.0	5.8	0.8	10.5
p Value (F-test)		*N/A*	*0.58*	*0.60*	*0.15*	*0.47*
LSD (Pr=0.05)			*N/A*	*N/A*	*N/A*	*N/A*

At seven days after application 2, there were no significant treatment related effects on total larvae numbers or within any individual size class.

Trial 2 - Evaluation of tea tree oil in potatoes (2)

Treatments Applied

Trt No.	Product	Product rate (L/ha)
1.	Untreated	Nil
2.	Agral	0.3%
3.	Spraytech oil	1.5
4.	Tea tree oil + Agral	1.0 + 0.3%
5.	Tea tree oil + Agral	2.0 + 0.3%
6.	Tea tree oil + Spraytech oil	2.0 + 1.5
7.	Tea tree oil + Agral	3.0 + 0.3%
8.	Tea tree oil + Agral	4.0 + 0.3%

Trial Details

Location	Tolga - North Queensland
Grower	D. Isabella
Crop	Potatoes
Variety	Sebago
Planting Date	29/07/02
Row Spacing (m)	0.90
Plant Spacing (m)	0.15
Trial Design	Randomised Complete Block
Replications	4
Plot Size	4 rows X 8 m

Application Details

Date	02/09/02	07/09/02
Crop Stage	Early flowers	Early flowers
Time (h)	1230	0930
Temperature (°C)	28	27
Humidity (%)	85	74
Cloud Cover	7/8	0/8
Wind Velocity (kph)	10 SE	3 SE
Equipment & Method	Komatsu motorised knapsack sprayer - 3 nozzles per row	Komatsu motorised knapsack sprayer - 3 nozzles per row
Nozzle Type/Size	Spraying Systems cone jet TX 6	Spraying Systems cone jet TX 6
Swath (m)	0.86	0.86
Spray Volume (L/ha)	279	279
Pressure (bar)	4.5	4.5

Weather Conditions

Weather conditions over the period were mild. Average maximum and minimum temperatures were 26^0C and 12^0C respectively, and no rain fell over the period. Overhead irrigation was applied at two days after application 1, and again at three days after the second spray application. At each watering, approximately 25 mm of irrigation was applied.

Results

Table 6 - Mean number of heliothis larvae in two metres of row - preliminary assessment

Plot	Preliminary assessment - 02/09/02				
	Very small	Small	Medium	Large	Total
1.	12	3	0	0	15
2.	15	2	0	0	17
3.	3	3	2	0	8
4.	9	6	0	0	15
5.	12	5	5	0	22
6.	10	1	14	0	25
Mean	10.2	3.3	3.5	0	17.0

The preliminary assessment indicated large numbers of very small and small larvae. There was little variability in larval numbers across the trial site.

Table 7 - Mean number of heliothis larvae in 2 metres of row - 1 day after application one (DAA1)

Treatment	Product Rate (L/ha)	1 DAA1 - 3/9/02				
		V.Small	Small	Medium	Large	Total
1. Untreated	Nil	7.5	3.3	1.0	0.0	11.8
2. Agral	0.3%	6.8	3.5	1.3	0.0	11.5
3. Spraytech oil	1.5	7.0	5.5	2.8	0.0	15.3
4. Tea tree oil + Agral	1.0 + 0.3%	6.3	5.0	3.5	0.0	14.8
5. Tea tree oil + Agral	2.0 + 0.3%	5.0	3.5	2.8	0.0	11.3
6. Tea tree oil + Spraytech oil	2.0 + 1.5	9.3	4.5	1.0	0.0	14.8
7. Tea tree oil + Agral	3.0 + 0.3%	8.3	3.5	1.0	0.0	12.8
8. Tea tree oil + Agral	4.0 + 0.3%	3.5	5.0	4.0	0.0	12.5
p Value (F-test)		*0.26*	*0.74*	*0.17*	*N/A*	*0.48*
LSD (Pr=0.05)		N/A	*N/A*	*N/A*	*N/A*	*N/A*

At one day after application 1, there were no significant treatment related effects on total larval numbers, or within any individual size class.

Table 8 - Mean number of heliothis larvae in 2 metres of row - 4 days after application one (DAA1)

Treatment	Product Rate (L/ha)	4 DAA1 - 6/9/02				
		V.Small	Small	Medium	Large	Total
1. Untreated	Nil	1.5	4.8	8.0	1.0	15.3
2. Agral	0.3%	1.3	3.0	3.8	0.0	8.0
3. Spraytech oil	1.5	2.3	2.8	5.8	0.3	11.0
4. Tea tree oil + Agral	1.0 + 0.3%	1.8	1.8	5.5	0.3	9.3
5. Tea tree oil + Agral	2.0 + 0.3%	2.8	3.5	6.3	0.8	13.3
6. Tea tree oil + Spraytech oil	2.0 + 1.5	1.8	5.3	7.3	0.8	15.0
7. Tea tree oil + Agral	3.0 + 0.3%	2.5	2.5	2.5	0.0	7.5
8. Tea tree oil + Agral	4.0 + 0.3%	2.3	3.3	4.5	0.3	10.3
p Value (F-test)		0.92	0.21	0.46	0.30	0.34
LSD (Pr=0.05)		*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

At four days after application 1, there were no significant treatment related effects on total larval numbers, or within any individual size class.

Table 9 - Mean number of heliothis larvae in 2 metres of row - 3 days after application two (DAA2)

Treatment	Product Rate (L/ha)	3 DAA2 - 10/9/02				
		V.Small	Small	Medium	Large	Total
1. Untreated	Nil	0.3	2.3	6.0	2.3	10.8
2. Agral	0.3%	0.0	1.5	8.0	0.5	10.0
3. Spraytech oil	1.5	0.8	1.8	5.5	0.8	8.8
4. Tea tree oil + Agral	1.0 + 0.3%	0.8	1.5	8.3	1.3	11.8
5. Tea tree oil + Agral	2.0 + 0.3%	0.3	2.0	5.5	2.0	9.8
6. Tea tree oil + Spraytech oil	2.0 + 1.5	1.0	2.5	14.8	0.8	19.0
7. Tea tree oil + Agral	3.0 + 0.3%	0.3	1.0	5.5	1.0	7.8
8. Tea tree oil + Agral	4.0 + 0.3%	0.8	1.0	7.8	0.3	9.8
p Value (F-test)		*0.80*	*0.73*	*0.14*	*0.23*	*0.25*
LSD (Pr=0.05)		*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

At three days after application 2, there were no significant related effects on total larval numbers, or within any individual size class.

Table 10 - Mean number of heliothis larvae in 2 metres of row -7 days after application two (DAA2)

Treatment	Product Rate (L/ha)	7 DAA2 - 14/9/02				
		V.Small	Small	Medium	Large	Total
1. Untreated	Nil	0.0	3.8	4.0	1.0	8.8
2. Agral	0.3%	0.0	2.5	2.3	0.3	5.0
3. Spraytech oil	1.5	0.0	3.8	2.0	0.8	6.5
4. Tea tree oil + Agral	1.0 + 0.3%	0.0	3.0	4.3	0.8	8.0
5. Tea tree oil + Agral	2.0 + 0.3%	0.0	4.8	5.3	1.8	11.8
6. Tea tree oil + Spraytech oil	2.0 + 1.5	0.0	1.8	4.5	2.0	8.3
7. Tea tree oil + Agral	3.0 + 0.3%	0.0	2.8	2.5	0.8	6.0
8. Tea tree oil + Agral	4.0 + 0.3%	0.0	1.8	3.8	1.5	7.0
p Value (F-test)		*N/A*	*0.52*	*0.14*	*0.21*	*0.29*
LSD (Pr=0.05)			*N/A*	*N/A*	*N/A*	*N/A*

At seven days after application 2, there were no significant treatment related effects on total larval numbers, or within any individual size class.

Trial 3 - Evaluation of tea tree oil in cabbages

Treatments Applied

Trt No.	Product	Product rate (mL/100L)
1.	Untreated	Nil
2.	Agral	300
3.	Spraytech oil	150
4.	Tea tree oil + Agral	100 + 300
5.	Tea tree oil + Agral	200 + 300
6.	Tea tree oil + Spraytech oil	200 + 150
7.	Tea tree oil + Agral	300 + 300
8.	Tea tree oil + Agral	400 + 300

Trial Details

Location	Kairi - North Queensland
Grower	N. Folino-Gallo
Crop	Cabbages
Variety	Green major
Planting Date	21/10/02
Row Spacing (m)	0.9
Plant Spacing (m)	0.3
Trial Design	Randomised Complete Block
Replications	4
Plot Size	1 row x 8 m

Application Details

Date	04/11/02
Crop Stage	Majority newly formed heart stage
Time (h)	1500
Temperature (°C)	30
Humidity (%)	74
Cloud Cover	3/8
Wind Velocity (kph)	5 -10 SE
Equipment & Method	Komatsu motorised knapsack sprayer & lance. Spray to point of runoff.
Nozzle Type/Size	2 x Spraying Systems cone jet TX 4
Pressure (kPa)	500

Weather Conditions

Weather conditions were fine and dry throughout the trial period. The average maximum temperature was 30^0C and average minimum temperature was 16^0 C. A single application of 15mm of overhead irrigation was applied three days after application 1.

Results

Table 11 - Mean number of lepidopteran larvae per five metres of row - preliminary assessment

Treatment	Preliminary Assessment - 04/11/02				
	Pieris rapae	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*
1.	2.0	8.8	7.8	2.0	0.8
2.	1.3	9.0	7.8	0.5	0.5
3.	2.3	9.5	6.3	2.0	0.8
4.	0.5	6.8	8.3	1.5	1.3
5.	2.0	21.8	8.5	2.0	2.3
6.	2.8	12.0	5.0	2.5	2.5
7.	1.5	10.0	6.0	3.0	0.0
8.	1.0	9.0	7.5	2.0	0.5
Mean	1.7	10.9	7.2	1.9	1.1

The preliminary assessment showed that five pest species were present at the site. *Helicoverpa* spp. larvae were present in fairly high numbers, and were evenly distributed throughout the assessed area. *Plutella xylostella* were also very common, but their distribution was somewhat variable. *Pieris rapae*, *Hellula hydralis* and *Spodoptera litura* occurred in moderate numbers and with little variability in distribution.

Table 12 - Mean numbers of larvae in 5 metres of row - 1 day after application (1 DAA)

Treatment	Product Rate (mL/100L)	1 DAA - 05/11/02					
		P. rapae	*P. xylostella*	*Helicoverpa* spp.	*H. hydralis*	*S. litura*	*Total*
1. Untreated	Nil	1.0	8.5	5.8	1.8	2.5	20
2. Agral	300	1.8	8.5	7.0	0.5	1.5	19
3. Spraytech oil	150	1.0	10.0	3.5	2.8	5.3	23
4. Tea tree oil + Agral	100 + 300	1.3	10.0	4.3	1.3	1.5	18
5. Tea tree oil + Agral	200 + 300	1.0	17.3	5.8	0.5	3.8	28
6. Tea tree oil + Spraytech oil	200 + 150	1.8	8.8	9.3	2.8	1.5	24
7. Tea tree oil + Agral	300 + 300	0.8	11.3	5.0	1.5	2.3	21
8. Tea tree oil + Agral	400 + 400	2.0	10.3	4.8	1.5	1.8	20
p Value (F-test)		*0.70*	*0.38*	*0.15*	*0.27*	*0.62*	*0.49*
LSD (Pr=0.05)		*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

At one day after application, there were no significant treatment effects on the numbers of any of the species assessed.

Table 13 - Mean numbers of larvae in 5 metres of row - 3 days after application (3 DAA)

Treatment	Product Rate (mL/100L)	3 DAA - 07/11/02					
		P. rapae	*P. xylostella*	*Helicoverpa* spp.	*H. hydralis*	*S. litura*	*Total*
1. Untreated	Nil	2.0	6.8	5.5	3.3	3.0	21
2. Agral	300	2.8	14.5	5.0	4.3	1.0	28
3. Spraytech oil	150	2.5	14.3	5.5	4.0	4.3	31
4. Tea tree oil + Agral	100 + 300	1.8	10.5	5.0	4.3	2.0	24
5. Tea tree oil + Agral	200 + 300	4.3	16.5	3.5	3.8	8.5	37
6. Tea tree oil + Spraytech oil	200 + 150	4.5	13.0	6.0	7.0	4.3	35
7. Tea tree oil + Agral	300 + 300	3.0	9.0	3.8	5.8	2.8	24
8. Tea tree oil + Agral	400 + 400	2.5	9.8	3.3	3.5	1.3	20
p Value (F-test)		*0.56*	*0.13*	*0.31*	*0.42*	*0.57*	*0.15*
LSD (Pr=0.05)		*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

At three days after application, there were no significant treatment effects on the numbers of any of the species assessed.

Table 14 - Mean numbers of larvae in 5 metres of row - 5 days after application (5 DAA)

Treatment	Product Rate (mL/100L)	5 DAA - 09/11/02					
		P. rapae	*P. xylostella*	*Helicoverpa* spp.	*H. hydralis*	*S. litura*	*Total*
1. Untreated	Nil	5.3	12.8	6.8	11.0	4.5	40
2. Agral	300	8.3	18.8	3.5	8.8	2.0	41
3. Spraytech oil	150	5.0	16.0	5.3	11.5	7.0	45
4. Tea tree oil + Agral	100 + 300	6.8	13.3	4.5	14.8	2.0	41
5. Tea tree oil + Agral	200 + 300	4.8	19.5	5.3	3.8	12.8	46
6. Tea tree oil + Spraytech oil	200 + 150	7.0	18.0	5.0	14.0	3.8	48
7. Tea tree oil + Agral	300 + 300	5.0	16.5	3.5	10.8	3.0	39
8. Tea tree oil + Agral	400 + 400	5.8	16.5	4.0	7.0	2.0	35
p Value (F-test)		*0.72*	*0.79*	*0.60*	*0.12*	*0.12*	*0.94*
LSD (Pr=0.05)		*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

At five days after application, there were no significant treatment effects on the numbers of any of the species assessed.

Discussion of Results

There did not appear to be any treatment effects on the target pests in any of the trials conducted. In both potato trials, heliothis larvae were mostly small, and might be considered to be rather susceptible to potentially toxic substances. However, despite two applications, the larvae population in both trials developed unchecked, with progressively fewer small larvae and increasing numbers of larger larvae being observed in all treatments. Spray coverage was believed to be perfectly adequate, particularly as larvae were feeding at very exposed terminals. The larvae displayed vigorous avoidance behaviour whilst being actively sprayed but soon reverted to apparently normal behaviour after spraying was complete. There was no noticeable effect on feeding, and all larvae fed and developed normally. Spray application was timed to avoid irrigation that might have washed treatments from the foliage, so that irrigation would not have affected efficacy of the product.

In cabbages, the results were similarly poor and there were no treatment effects on pest numbers, feeding behaviour or development observed. In this trial, there was a general increase in pest numbers observed over the assessment period.

The rates of tea tree oil applied were selected on the basis of both the anecdotal evidence previously mentioned, and with regard to economic considerations. In practical terms, it is unlikely that a tea tree oil product could be economically applied at rates over 2.0 L/ha at current prices. Thus the range of rates selected was believed to be suitable to provide information on the efficacy of tea tree oil at rates which could be commercially adopted.

In a similar way, the assessment intervals were designed to provide information on both knockdown and longer term toxic effects of tea tree oil. In at least two instances, (DPI Mareeba and Serve-Ag BFS) previously mentioned, there appeared to be mortality after 1 day increasing up to 5 days after application. As rapid knockdown of the pest is essential where normal feeding activity continues after application, the assessment intervals were believed to be sufficient to demonstrate the practical possibilities of the product.

Prior to spray application, a number of mixtures were tested in the laboratory to ensure that adequate emulsification of the tea tree oil was achieved. Both emulsifying vegetable oil (Spraytech Oil®) and the commonly used commercially available surfactant Agral® were suitable in this regard. Spraytech oil required that the mixture be frequently agitated to maintain a suitable degree of emulsification. The mixtures used in the trial were then field tested to confirm that they provided a good spray deposit on the plant surface, particularly on cabbages, which are difficult to wet. It was observed that the mixtures used in the trials were very suitable for field application.

It was somewhat surprising that the trials showed no efficacy at all, particularly in light of the anecdotal evidence available. There are numerous factors which might account for the failure of tea tree oil to control the target pests in the trials reported. In particular, it is possible that the type of emulsifying agent used might affect the properties of the tea tree oil, as well as numerous other chemical and physical factors which could only be investigated in the laboratory.

The purpose of this project was to demonstrate, in an economical way, the capacity or otherwise of tea tree oil to control some commonly occurring agricultural pests, and was not intended to enter into detailed research into the insecticidal properties of tea tree oil. Such an undertaking would require significant resourcing of a scale well beyond that required to conduct work of the type reported in this project

Implications

The implications of this work are that there is little potential for tea tree oil to be used as a foliar insecticide, at least in the case of lepidopteran larvae.

It might be considered financially imprudent to consider further investment of funds in this pursuit.

Recommendations

It is recommended that no further work to evaluate the potential of tea tree oil as an insecticide for the control of lepidopterous pests be considered.

Appendix 1

Complete Data - Trial 1 (Potato 1)

Assessment - One day after application one					
Treatment 1: Untreated					
Rep	Very small	Small	Medium	Large	Total
1	4	10	12	0	26
2	7	13	14	1	35
3	3	10	13	2	28
4	4	8	14	2	28
Means	4.5	10.3	13.3	1.3	29.3
Treatment 2: Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	6	10	15	1	32
2	6	16	14	1	37
3	2	4	18	2	26
4	4	7	19	0	30
Means	4.5	9.3	16.5	1	31.3
Treatment 3: Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	4	8	19	1	32
2	4	10	11	0	25
3	3	10	13	0	26
4	5	7	13	0	25
Means	4	8.8	14	0.3	27
Treatment 4: Tea tree oil 1.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	5	8	18	0	31
2	7	13	14	0	34
3	5	7	7	0	19
4	3	7	10	3	23
Means	5	8.8	12.3	0.8	26.8
Treatment 5: Tea tree oil 2.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	2	5	18	0	25
2	9	11	7	1	28
3	6	7	7	0	20
4	4	5	18	0	27
Means	5.3	7	12.5	0.3	25
Treatment 6: Tea tree oil 2.0 L/ha + Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	1	6	15	2	24
2	3	6	15	2	26
3	5	8	11	0	24
4	5	6	13	1	25
Means	3.5	6.5	13.5	1.3	24.8
Treatment 7: Tea tree oil 3.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	5	5	5	0	15
2	7	10	13	2	32
3	3	9	16	1	29
4	5	7	9	0	21
Means	5	7.8	10.8	0.8	24.3
Treatment 8: Tea tree oil 4.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	11	6	8	0	25
2	12	15	7	0	34
3	5	8	15	1	29
4	6	6	14	0	26
Means	8.5	8.8	11	0.3	28.5

Assessment - Four days after application one					
Treatment 1: Untreated					
Rep	Very small	Small	Medium	Large	Total
1	1	4	1	0	6
2	1	3	7	0	11
3	0	3	4	0	7
4	6	9	27	1	43
Means	2	4.8	9.8	0.3	16.8
Treatment 2: Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	3	3	1	0	7
2	0	3	15	1	19
3	0	11	29	1	41
4	3	7	14	1	25
Means	1.5	6	14.8	0.8	23
Treatment 3: Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	2	1	2	0	5
2	1	3	9	0	13
3	1	3	20	0	24
4	0	2	16	2	20
Means	1	2.3	11.8	0.5	15.5
Treatment 4: Tea tree oil 1.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	3	5	4	1	13
2	4	0	3	0	7
3	0	5	11	0	16
4	1	3	8	0	12
Means	2	3.3	6.5	0.3	12
Treatment 5: Tea tree oil 2.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	3	3	2	0	8
2	2	6	33	2	43
3	3	6	13	0	22
4	6	9	4	0	19
Means	3.5	6	13	0.5	23
Treatment 6: Tea tree oil 2.0 L/ha + Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	1	2	2	0	5
2	2	5	12	0	19
3	1	5	20	0	26
4	8	6	11	1	26
Means	3	4.5	11.3	0.3	19
Treatment 7: Tea tree oil 3.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	2	2	0	4
2	0	4	10	0	14
3	0	1	2	0	3
4	0	5	24	0	29
Means	0	3	9.5	0	12.5
Treatment 8: Tea tree oil 4.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	1	9	16	0	26
2	3	7	20	0	30
3	0	7	22	0	29
4	0	2	7	0	9
Means	1	6.3	16.3	0	23.5

Assessment - Three days after application two					
Treatment 1: Untreated					
Rep	Very small	Small	Medium	Large	Total
1	0	0	0	0	0
2	0	1	3	0	4
3	1	3	5	0	9
4	1	1	12	1	15
Means	0.5	1.3	5	0.3	7
Treatment 2: Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	1	1	0	2
2	0	2	10	0	12
3	0	1	12	1	14
4	0	2	5	0	7
Means	0	1.5	7	0.3	8.8
Treatment 3: Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	0	1	1	0	2
2	1	4	9	0	14
3	1	2	6	0	9
4	0	1	6	1	8
Means	0.5	2	5.5	0.3	8.3
Treatment 4: Tea tree oil 1.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	1	1	1	0	3
2	0	1	3	0	4
3	5	1	8	0	14
4	0	0	2	0	2
Means	1.5	0.8	3.5	0	5.8
Treatment 5: Tea tree oil 2.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	1	0	0	1
2	1	2	8	0	11
3	2	2	5	0	9
4	2	1	3	0	6
Means	1.3	1.5	4	0	6.8
Treatment 6: Tea tree oil 2.0 L/ha + Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	1	1	0	0	2
2	0	2	0	0	2
3	1	2	4	1	8
4	0	1	7	2	10
Means	0.5	1.5	2.8	0.8	5.5
Treatment 7: Tea tree oil 3.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	1	1	0	0	2
2	0	0	5	0	5
3	3	1	1	0	5
4	1	2	5	0	8
Means	1.3	1	2.8	0	5
Treatment 8: Tea tree oil 4.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	2	2	8	0	12
2	1	0	5	0	6
3	0	1	5	1	7
4	0	1	7	0	8
Means	0.8	1	6.3	0.3	8.3

Assessment - Seven days after application two					
Treatment 1: Untreated					
Rep	Very small	Small	Medium	Large	Total
1	0	5	4	1	10
2	0	1	0	3	4
3	0	2	4	0	6
4	0	4	4	1	9
Means	0	3	3	1.3	7.3
Treatment 2: Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	3	3	1	7
2	0	3	6	0	9
3	0	8	6	4	18
4	0	5	4	1	10
Means	0	4.8	4.8	1.5	11
Treatment 3: Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	0	2	1	0	3
2	0	2	5	0	7
3	0	4	3	0	7
4	0	1	2	0	3
Means	0	2.3	2.8	0	5
Treatment 4: Tea tree oil 1.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	4	3	0	7
2	0	3	6	0	9
3	0	6	4	1	11
4	0	3	3	1	7
Means	0	4	4	0.5	8.5
Treatment 5: Tea tree oil 2.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	3	6	1	10
2	0	4	0	0	4
3	0	3	5	1	9
4	0	3	2	1	6
Means	0	3.3	3.3	0.8	7.3
Treatment 6: Tea tree oil 2.0 L/ha + Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	0	2	1	0	3
2	0	2	2	0	4
3	0	5	3	0	8
4	0	7	4	2	13
Means	0	4	2.5	0.5	7
Treatment 7: Tea tree oil 3.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	3	1	0	4
2	0	4	3	0	7
3	0	4	3	0	7
4	0	4	5	0	9
Means	0	3.8	3	0	6.8
Treatment 8: Tea tree oil 4.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	5	7	1	13
2	0	6	12	1	19
3	0	3	2	0	5
4	0	2	2	1	5
Means	0	4	5.8	0.8	10.5

Complete Data - Trial 2 (Potato 2)

Assessment - One day after application one					
Treatment 1: Untreated					
Rep	Very small	Small	Medium	Large	Total
1	7	5	3	0	15
2	10	5	0	0	15
3	5	2	1	0	8
4	8	1	0	0	9
Means	7.5	3.3	1	0	11.8
Treatment 2: Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	3	4	3	0	10
2	9	1	1	0	11
3	4	3	1	0	8
4	11	6	0	0	17
Means	6.8	3.5	1.3	0	11.5
Treatment 3: Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	5	9	3	0	17
2	5	7	5	0	17
3	10	2	2	0	14
4	8	4	1	0	13
Means	7	5.5	2.8	0	15.3
Treatment 4: Tea tree oil 1.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	10	7	1	0	18
2	5	4	10	0	19
3	4	6	2	0	12
4	6	3	1	0	10
Means	6.3	5	3.5	0	14.8
Treatment 5: Tea tree oil 2.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	1	2	3	0	6
2	9	0	5	0	14
3	3	7	0	0	10
4	7	5	3	0	15
Means	5	3.5	2.8	0	11.3
Treatment 6: Tea tree oil 2.0 L/ha + Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	6	8	2	0	16
2	15	1	0	0	16
3	6	3	0	0	9
4	10	6	2	0	18
Means	9.3	4.5	1	0	14.8
Treatment 7: Tea tree oil 3.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	3	6	0	0	9
2	12	4	3	0	19
3	4	2	1	0	7
4	14	2	0	0	16
Means	8.3	3.5	1	0	12.8
Treatment 8: Tea tree oil 4.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	4	6	4	0	14
2	2	5	7	0	14
3	5	5	1	0	11
4	3	4	4	0	11
Means	3.5	5	4	0	12.5

Assessment - Four days after application one					
Treatment 1: Untreated					
Rep	Very small	Small	Medium	Large	Total
1	0	3	5	0	8
2	3	3	0	0	6
3	0	5	8	2	15
4	3	8	19	2	32
Means	1.5	4.8	8	1	15.3
Treatment 2: Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	2	3	0	5
2	3	3	6	0	12
3	1	4	5	0	10
4	1	3	1	0	5
Means	1.3	3	3.8	0	8
Treatment 3: Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	0	2	2	1	5
2	2	1	6	0	9
3	2	3	8	0	13
4	5	5	7	0	17
Means	2.3	2.8	5.8	0.3	11
Treatment 4: Tea tree oil 1.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	1	1	0	0	2
2	2	3	7	0	12
3	2	2	10	0	14
4	2	1	5	1	9
Means	1.8	1.8	5.5	0.3	9.3
Treatment 5: Tea tree oil 2.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	5	1	0	6
2	2	4	7	1	14
3	2	2	6	2	12
4	7	3	11	0	21
Means	2.8	3.5	6.3	0.8	13.3
Treatment 6: Tea tree oil 2.0 L/ha + Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	5	8	4	0	17
2	1	3	4	0	8
3	0	6	11	2	19
4	1	4	10	1	16
Means	1.8	5.3	7.3	0.8	15
Treatment 7: Tea tree oil 3.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	4	1	0	0	5
2	1	3	0	0	4
3	2	1	0	0	3
4	3	5	10	0	18
Means	2.5	2.5	2.5	0	7.5
Treatment 8: Tea tree oil 4.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	3	2	1	0	6
2	1	2	5	0	8
3	1	1	3	0	5
4	4	8	9	1	22
Means	2.3	3.3	4.5	0.3	10.3

Assessment - Three days after application two					
Treatment 1: Untreated					
Rep	Very small	Small	Medium	Large	Total
1	0	1	7	1	9
2	0	0	4	0	4
3	0	5	4	5	14
4	1	3	9	3	16
Means	0.3	2.3	6	2.3	10.8
Treatment 2: Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	2	6	0	8
2	0	3	11	0	14
3	0	1	10	2	13
4	0	0	5	0	5
Means	0	1.5	8	0.5	10
Treatment 3: Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	0	0	5	0	5
2	3	2	6	2	13
3	0	2	4	1	7
4	0	3	7	0	10
Means	0.8	1.8	5.5	0.8	8.8
Treatment 4: Tea tree oil 1.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	0	3	0	3
2	0	2	14	2	18
3	0	2	14	2	18
4	3	2	2	1	8
Means	0.8	1.5	8.3	1.3	11.8
Treatment 5: Tea tree oil 2.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	1	2	2	0	5
2	0	4	7	2	13
3	0	1	9	4	14
4	0	1	4	2	7
Means	0.3	2	5.5	2	9.8
Treatment 6: Tea tree oil 2..0 L/ha + Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	2	4	27	0	33
2	0	3	10	1	14
3	1	2	14	2	19
4	1	1	8	0	10
Means	1	2.5	14.8	0.8	19
Treatment 7: Tea tree oil 3.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	1	1	1	3
2	0	1	11	0	12
3	1	0	4	0	5
4	0	2	6	3	11
Means	0.3	1	5.5	1	7.8
Treatment 8: Tea tree oil 4.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	2	1	5	0	8
2	1	2	10	1	14
3	0	0	8	0	8
4	0	1	8	0	9
Means	0.8	1	7.8	0.3	9.8

Assessment - Seven days after application two					
Treatment 1: Untreated					
Rep	Very small	Small	Medium	Large	Total
1	0	5	6	0	11
2	0	2	3	1	6
3	0	5	3	2	10
4	0	3	4	1	8
Means	0	3.8	4	1	8.8
Treatment 2: Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	2	1	0	3
2	0	2	3	1	6
3	0	2	4	0	6
4	0	4	1	0	5
Means	0	2.5	2.3	0.3	5.0
Treatment 3: Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	0	4	3	1	8
2	0	7	3	0	10
3	0	1	0	1	2
4	0	3	2	1	6
Means	0	3.8	2	0.8	6.5
Treatment 4: Tea tree oil 1.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	1	2	0	3
2	0	4	7	2	13
3	0	1	6	0	7
4	0	6	2	1	9
Means	0	3	4.3	0.8	8
Treatment 5: Tea tree oil 2.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	5	8	2	15
2	0	3	5	2	10
3	0	1	3	1	5
4	0	10	5	2	17
Means	0	4.8	5.3	1.8	11.8
Treatment 6: Tea tree oil 2..0 L/ha + Spraytech oil 1.5 L/ha					
Rep	Very small	Small	Medium	Large	Total
1	0	4	7	3	14
2	0	0	3	2	5
3	0	1	4	2	7
4	0	2	4	1	7
Means	0	1.8	4.5	2	8.3
Treatment 7: Tea tree oil 3.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	0	2	1	3
2	0	3	2	0	5
3	0	3	3	0	6
4	0	5	3	2	10
Means	0	2.8	2.5	0.8	6
Treatment 8: Tea tree oil 4.0 L/ha + Agral 0.3%					
Rep	Very small	Small	Medium	Large	Total
1	0	1	2	4	7
2	0	1	5	1	7
3	0	4	5	1	10
4	0	1	3	0	4
Means	0	1.8	3.8	1.5	7

Complete Data - Trial 3 (Cabbage)

Assessment - One day after application						
		Treatment 1: Untreated				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	0	4	6	6	6	22
2	2	6	6	0	0	14
3	2	13	3	1	2	21
4	0	11	8	0	2	21
Means	1	8.5	5.8	1.8	2.5	19.5
		Treatment 2: Agral 300 mL/100L				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	2	11	9	1	0	23
2	4	3	13	1	0	21
3	0	14	2	0	3	19
4	1	6	4	0	3	14
Means	1.8	8.5	7	0.5	1.5	19.3
		Treatment 3: Spraytech oil 150 mL/100L				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	1	14	6	3	13	37
2	2	5	1	1	1	10
3	1	10	3	3	5	22
4	0	11	4	4	2	21
Means	1	10	3.5	2.8	5.3	22.5
		Treatment 4: Tea tree oil 100 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	1	21	1	0	0	23
2	1	11	3	5	5	25
3	1	5	8	0	1	15
4	2	3	5	0	0	10
Means	1.3	10	4.3	1.3	1.5	18.3
		Treatment 5: Tea tree oil 200 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	0	9	5	1	2	17
2	0	25	4	1	6	36
3	2	25	5	0	7	39
4	2	10	9	0	0	21
Means	1	17.3	5.8	0.5	3.8	28.3
		Treatment 6: Tea tree oil 200 mL/100L + Spraytech oil				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	2	9	7	4	1	23
2	2	5	10	3	0	20
3	2	11	11	2	3	29
4	1	10	9	2	2	24
Means	1.8	8.8	9.3	2.8	1.5	24.0
		Treatment 7: Tea tree oil 300 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	2	13	5	2	1	22
2	1	5	3	2	3	14
3	0	16	6	1	0	23
4	0	11	6	1	5	23
Means	0.8	11.3	5	1.5	2.3	20.5
		Treatment 8: Tea tree oil 400 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	4	16	5	2	0	27
2	1	9	4	3	0	17
3	2	11	5	0	2	20
4	1	5	5	1	5	17
Means	2	10.3	4.8	1.5	1.8	20.3

Assessment - Three days after application						
		Treatment 1: Untreated				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	1	9	6	7	4	27
2	1	4	6	2	0	13
3	3	7	4	1	6	21
4	3	7	6	3	2	21
Means	2	6.8	5.5	3.3	3	20.5
		Treatment 2: Agral 300 mL/100L				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	4	14	5	5	0	28
2	2	8	5	5	0	20
3	1	17	5	3	3	29
4	4	19	5	4	1	33
Means	2.8	14.5	5	4.3	1	27.5
		Treatment 3: Spraytech oil 150 mL/100L				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	2	20	8	5	15	50
2	3	13	3	2	0	21
3	1	12	7	2	2	24
4	4	12	4	7	0	27
Means	2.5	14.3	5.5	4	4.3	30.5
		Treatment 4: Tea tree oil 100 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	3	15	4	3	0	25
2	3	16	3	6	2	30
3	0	9	5	3	4	21
4	1	2	8	5	2	18
Means	1.8	10.5	5	4.3	2	23.5
		Treatment 5: Tea tree oil 200 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	0	13	1	6	0	20
2	4	18	2	3	10	37
3	3	18	4	3	24	52
4	10	17	7	3	0	37
Means	4.3	16.5	3.5	3.8	8.5	36.5
		Treatment 6: Tea tree oil 200 mL/100L + Spraytech oil				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	1	17	4	7	1	30
2	2	12	7	2	0	23
3	6	10	6	10	14	46
4	9	13	7	9	2	40
Means	4.5	13	6	7	4.3	34.8
		Treatment 7: Tea tree oil 300 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	2	17	4	9	6	38
2	2	7	1	6	1	17
3	4	9	5	5	1	24
4	4	3	5	3	3	18
Means	3	9	3.8	5.8	2.8	24.3
		Treatment 8: Tea tree oil 400 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	4	7	0	1	0	12
2	2	9	1	8	2	22
3	3	21	5	2	1	32
4	1	2	7	3	2	15
Means	2.5	9.8	3.3	3.5	1.3	20.3

Assessment - Five days after application						
		Treatment 1: Untreated				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	3	20	6	21	4	54
2	8	9	8	9	0	34
3	4	12	3	6	10	35
4	6	10	10	8	4	38
Means	5.3	12.8	6.8	11	4.5	40.3
		Treatment 2: Agral 300 mL/100L				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	10	20	7	5	3	45
2	6	12	2	20	0	40
3	6	15	2	7	2	32
4	11	28	3	3	3	48
Means	8.3	18.8	3.5	8.8	2	41.3
		Treatment 3: Spraytech oil 150 mL/100L				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	6	20	7	14	22	69
2	2	7	2	7	1	19
3	6	25	3	8	4	46
4	6	12	9	17	1	45
Means	5	16	5.3	11.5	7	44.8
		Treatment 4: Tea tree oil 100 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	10	9	5	7	1	32
2	9	19	4	22	2	56
3	6	19	4	18	2	49
4	2	6	5	12	3	28
Means	6.8	13.3	4.5	14.8	2	41.3
		Treatment 5: Tea tree oil 200 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	0	11	3	5	3	22
2	5	21	3	3	5	37
3	6	23	6	4	23	62
4	8	23	9	3	20	63
Means	4.8	19.5	5.3	3.8	12.8	46.0
		Treatment 6: Tea tree oil 200 mL/100L + Spraytech oil				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	4	12	5	12	2	35
2	4	21	1	17	0	43
3	5	15	2	9	7	38
4	15	24	12	18	6	75
Means	7	18	5	14	3.8	47.8
		Treatment 7: Tea tree oil 300 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	4	16	2	10	5	37
2	2	10	1	17	0	31
3	8	19	5	10	6	48
4	6	21	6	6	1	40
Means	5	16.5	3.5	10.8	3	39.0
		Treatment 8: Tea tree oil 400 mL/100L + Agral				
Rep	*Pieris rapae*	*Plutella xylostella*	*Helicoverpa* spp.	*Hellula hydralis*	*Spodoptera litura*	*Total*
1	6	12	0	7	3	28
2	4	20	2	15	2	43
3	7	26	6	1	2	42
4	6	8	8	5	1	28
Means	5.8	16.5	4	7	2	35.3

Appendix 2

Statistical analysis - Trial 1 (Potato 1)

Analyses of larva abundance one day after application one

ANALYSIS OF VARIANCE TABLE FOR VERY SMALL LARVAE 1 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	19.5000	2.78571	1.11	0.3908
R (B)	3	34.0000	11.3333	4.53	0.0133
A*B	21	52.5000	2.50000		
TOTAL	31	106.000			

ANALYSIS OF VARIANCE TABLE FOR SMALL LARVAE 1 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	42.0000	6.00000	1.37	0.2675
R (B)	3	127.750	42.5833	9.75	0.0003
A*B	21	91.7500	4.36905		
TOTAL	31	261.500			

ANALYSIS OF VARIANCE TABLE FOR MEDIUM LARVAE 1 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	93.7187	13.3884	0.79	0.6008
R (B)	3	21.0938	7.03125	0.42	0.7427
A*B	21	354.156	16.8646		
TOTAL	31	468.969			

ANALYSIS OF VARIANCE TABLE FOR LARGE LARVAE 1 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	5.21875	0.74554	0.84	0.5676
R (B)	3	0.59375	0.19792	0.22	0.8795
A*B	21	18.6563	0.88839		
TOTAL	31	24.4688			

ANALYSIS OF VARIANCE TABLE FOR TOTAL LARVAE 1 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	167.969	23.9955	1.41	0.2514
R (B)	3	200.594	66.8646	3.94	0.0224
A*B	21	356.156	16.9598		
TOTAL	31	724.719			

Analyses of larva abundance four days after application one

ANALYSIS OF VARIANCE TABLE FOR VERY SMALL LARVAE 4 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	36.0000	5.14286	1.56	0.2021
R (B)	3	22.7500	7.58333	2.30	0.1068
A*B	21	69.2500	3.29762		
TOTAL	31	128.000			

ANALYSIS OF VARIANCE TABLE FOR SMALL LARVAE 4 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	66.0000	9.42857	1.48	0.2269
R (B)	3	18.5000	6.16667	0.97	0.4254
A*B	21	133.500	6.35714		
TOTAL	31	218.000			

ANALYSIS OF VARIANCE TABLE FOR MEDIUM LARVAE 4 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	269.969	38.5670	0.51	0.8174
R (B)	3	666.594	222.198	2.93	0.0572
A*B	21	1591.16	75.7693		
TOTAL	31	2527.72			

ANALYSIS OF VARIANCE TABLE FOR TOTAL LARVAE 4 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	620.469	88.6384	0.73	0.6498
R (B)	3	891.844	297.281	2.44	0.0923
A*B	21	2553.91	121.615		
TOTAL	31	4066.22			

Analyses of larva abundance three days after application two

ANALYSIS OF VARIANCE TABLE FOR LOG VERY SMALL LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	7.21875	1.03125	0.97	0.4800
R (B)	3	7.84375	2.61458	2.45	0.0918
A*B	21	22.4062	1.06696		
TOTAL	31	37.4687			

ANALYSIS OF VARIANCE TABLE FOR SMALL LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	4.37500	0.62500	0.80	0.5951
R (B)	3	2.12500	0.70833	0.91	0.4537
A*B	21	16.3750	0.77976		
TOTAL	31	22.8750			

ANALYSIS OF VARIANCE TABLE FOR MEDIUM LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	71.4687	10.2098	1.08	0.4106
R (B)	3	111.594	37.1979	3.93	0.0226
A*B	21	198.656	9.45982		
TOTAL	31	381.719			

ANALYSIS OF VARIANCE TABLE FOR LARGE LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	1.71875	0.24554	1.24	0.3255
R (B)	3	1.59375	0.53125	2.68	0.0728
A*B	21	4.15625	0.19792		
TOTAL	31	7.46875			

ANALYSIS OF VARIANCE TABLE FOR TOTAL LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	55.9687	7.99554	0.49	0.8319
R (B)	3	181.344	60.4479	3.70	0.0279
A*B	21	343.406	16.3527		
TOTAL	31	580.719			

Analyses of larva abundance seven days after application two

ANALYSIS OF VARIANCE TABLE FOR SMALL LARVAE 7 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	16.5000	2.35714	0.83	0.5779
R (B)	3	7.00000	2.33333	0.82	0.4991
A*B	21	60.0000	2.85714		
TOTAL	31	83.5000			

ANALYSIS OF VARIANCE TABLE FOR MEDIUM LARVAE 7 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	35.5000	5.07143	0.80	0.5934
R (B)	3	5.50000	1.83333	0.29	0.8317
A*B	21	132.500	6.30952		
TOTAL	31	173.500			

ANALYSIS OF VARIANCE TABLE FOR LOG LARGE LARVAE 7 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	0.43291	0.06184	1.74	0.1542
R (B)	3	0.07789	0.02596	0.73	0.5458
A*B	21	0.74725	0.03558		
TOTAL	31	1.25806			

ANALYSIS OF VARIANCE TABLE FOR TOTAL LARVAE 7 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	112.469	16.0670	0.98	0.4701
R (B)	3	12.5937	4.19792	0.26	0.8558
A*B	21	343.656	16.3646		

Statistical analysis - Trial 2 (Potato 2)

Analyses of larva abundance one day after application one

ANALYSIS OF VARIANCE FOR VERY SMALL LARVAE BY TREATMENT 1 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	91.8750	13.1250	1.39	0.2591
R (B)	3	91.3750	30.4583	3.24	0.0428
A*B	21	197.625	9.41071		
TOTAL	31	380.875			

ANALYSIS OF VARIANCE FOR SMALL LARVAE BY TREATMENT 1 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	21.7187	3.10268	0.62	0.7351
R (B)	3	30.3437	10.1146	2.02	0.1426
A*B	21	105.406	5.01935		
TOTAL	31	157.469			

ANALYSIS OF VARIANCE FOR MEDIUM LARVAE BY TREATMENT 1 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	42.9688	6.13839	1.66	0.1736
R (B)	3	39.5938	13.1979	3.57	0.0314
A*B	21	77.6563	3.69792		
TOTAL	31	160.219			

ANALYSIS OF VARIANCE FOR TOTAL LARVAE BY TREATMENT 1 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	73.3750	10.4821	0.97	0.4755
R (B)	3	136.375	45.4583	4.22	0.0175
A*B	21	226.125	10.7679		
TOTAL	31	435.875			

Analyses of larva abundance three days after application one

ANALYSIS OF VARIANCE TABLE FOR VERY SMALL LARVAE 3 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	7.50000	1.07143	0.36	0.9145
R (B)	3	18.2500	6.08333	2.05	0.1373
A*B	21	62.2500	2.96429		
TOTAL	31	88.0000			

ANALYSIS OF VARIANCE TABLE FOR SMALL LARVAE 3 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	37.4688	5.35268	1.52	0.2143
R (B)	3	17.8438	5.94792	1.69	0.1997
A*B	21	73.9063	3.51935		
TOTAL	31	129.219			

ANALYSIS OF VARIANCE TABLE FOR MEDIUM LARVAE 3 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	91.8750	13.1250	1.01	0.4546
R (B)	3	212.125	70.7083	5.42	0.0064
A*B	21	273.875	13.0417		
TOTAL	31	577.875			

ANALYSIS OF VARIANCE TABLE FOR LARGE LARVAE 3 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	3.96875	0.56696	1.30	0.2981
R (B)	3	2.59375	0.86458	1.98	0.1474
A*B	21	9.15625	0.43601		
TOTAL	31	15.7188			

ANALYSIS OF VARIANCE TABLE FOR TOTAL LARVAE 3 DAA ONE

SOURCE	DF	SS	MS	F	P
T (A)	7	254.875	36.4107	1.21	0.3399
R (B)	3	510.625	170.208	5.66	0.0053
A*B	21	631.375	30.0655		
TOTAL	31	1396.88			

Analyses of larva abundance three days after application two

ANALYSIS OF VARIANCE TABLE FOR SMALL LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	8.37500	1.19643	0.63	0.7289
R (B)	3	2.37500	0.79167	0.41	0.7445
A*B	21	40.1250	1.91071		
TOTAL	31	50.8750			

ANALYSIS OF VARIANCE TABLE FOR MEDIUM LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	269.969	38.5670	1.79	0.1418
R (B)	3	43.5937	14.5312	0.68	0.5766
A*B	21	451.656	21.5074		
TOTAL	31	765.219			

ANALYSIS OF VARIANCE TABLE FOR LARGE LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	13.9688	1.99554	1.48	0.2296
R (B)	3	12.3437	4.11458	3.04	0.0515
A*B	21	28.4062	1.35268		
TOTAL	31	54.7187			

ANALYSIS OF VARIANCE TABLE FOR TOTAL LARVAE 3 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	337.375	48.1964	1.42	0.2482
R (B)	3	79.3750	26.4583	0.78	0.5176
A*B	21	711.125	33.8631		
TOTAL	31	1127.87			

Analyses of larva abundance seven days after application two

ANALYSIS OF VARIANCE TABLE FOR SMALL LARVAE 7 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	30.5000	4.35714	0.90	0.5236
R (B)	3	18.0000	6.00000	1.24	0.3198
A*B	21	101.500	4.83333		
TOTAL	31	150.000			

ANALYSIS OF VARIANCE TABLE FOR MEDIUM LARVAE 7 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	38.8750	5.55357	1.80	0.1408
R (B)	3	4.12500	1.37500	0.45	0.7233
A*B	21	64.8750	3.08929		
TOTAL	31	107.875			

ANALYSIS OF VARIANCE TABLE FOR LARGE LARVAE 7 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	9.96875	1.42411	1.52	0.2141
R (B)	3	1.09375	0.36458	0.39	0.7617
A*B	21	19.6563	0.93601		
TOTAL	31	30.7188			

ANALYSIS OF VARIANCE TABLE FOR TOTAL LARVAE 7 DAA TWO

SOURCE	DF	SS	MS	F	P
T (A)	7	119.969	17.1384	1.32	0.2901
R (B)	3	12.3438	4.11458	0.32	0.8132
A*B	21	272.906	12.9955		
TOTAL	31	405.219			

Statistical analysis - Trial 3 (Cabbage)
Analyses of larva abundance one day after application

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF PIERIS RAPAE LARVAE 1 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	5.87500	0.83929	0.67	0.6964
R (B)	3	2.62500	0.87500	0.70	0.5644
A*B	21	26.3750	1.25595		
TOTAL	31	34.8750			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF PLUTELLA XYLOSTELLA LARVAE 1 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	230.875	32.9821	1.13	0.3818
R (B)	3	140.375	46.7917	1.60	0.2184
A*B	21	612.625	29.1726		

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF HELICOVERPA SPP. *LARVAE 1 DAA*

SOURCE	DF	SS	MS	F	P
T (A)	7	90.4688	12.9241	1.77	0.1457
R (B)	3	3.84375	1.28125	0.18	0.9115
A*B	21	152.906	7.28125		

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF HELLULA HYDRALIS LARVAE 1 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	20.8750	2.98214	1.37	0.2708
R (B)	3	13.1250	4.37500	2.00	0.1445
A*B	21	45.8750	2.18452		
TOTAL	31	79.8750			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF SPODOPTERA LITURA LARVAE 1 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	51.0000	7.28571	0.77	0.6151
R (B)	3	5.50000	1.83333	0.19	0.8987
A*B	21	197.500	9.40476		

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF TOTAL LARVAE

SOURCE	DF	SS	MS	F	P
T (A)	7	299.875	42.8393	0.95	0.4905
R (B)	3	175.625	58.5417	1.30	0.3010
A*B	21	946.375	45.0655		
TOTAL	31	1421.87			

Analyses of larva abundance three days after application

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF PIERIS RAPAE LARVAE 3 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	27.4688	3.92411	0.85	0.5611
R (B)	3	28.0938	9.36458	2.02	0.1413
A*B	21	97.1563	4.62649		
TOTAL	31	152.719			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF PLUTELLA XYLOSTELLA LARVAE 3 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	304.219	43.4598	1.86	0.1286
R (B)	3	101.844	33.9479	1.45	0.2565
A*B	21	491.406	23.4003		
TOTAL	31	897.469			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF HELICOVERPA SPP. *LARVAE 3 DAA*

SOURCE	DF	SS	MS	F	P
T (A)	7	30.3750	4.33929	1.28	0.3087
R (B)	3	33.1250	11.0417	3.25	0.0423
A*B	21	71.3750	3.39881		
TOTAL	31	134.875			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF HELLULA HYDRALIS LARVAE 3 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	45.2188	6.45982	1.06	0.4216
R (B)	3	12.8438	4.28125	0.70	0.5609
A*B	21	127.906	6.09077		
TOTAL	31	185.969			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF SPODOPTERA LITURA LARVAE 3 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	161.500	23.0714	0.83	0.5722
R (B)	3	144.250	48.0833	1.74	0.1904
A*B	21	581.750	27.7024		
TOTAL	31	887.500			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF TOTAL LARVAE

SOURCE	DF	SS	MS	F	P
T (A)	7	1080.22	154.317	1.76	0.1484
R (B)	3	301.344	100.448	1.15	0.3530
A*B	21	1837.91	87.5193		
TOTAL	31	3219.47			

Analyses of larva abundance five days after application

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF PIERIS RAPAE LARVAE 5 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	43.2188	6.17411	0.64	0.7184
R (B)	3	29.0937	9.69792	1.00	0.4102
A*B	21	202.656	9.65030		
TOTAL	31	274.969			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF PLUTELLA XYLOSTELLA LARVAE 5 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	164.469	23.4955	0.54	0.7911
R (B)	3	99.3437	33.1146	0.77	0.5249
A*B	21	905.906	43.1384		
TOTAL	31	1169.72			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF HELICOVERPA SPP. *LARVAE 5 DAA*

SOURCE	DF	SS	MS	F	P
T (A)	7	33.2188	4.74554	0.79	0.6025
R (B)	3	107.344	35.7813	5.97	0.0042
A*B	21	125.906	5.99554		
TOTAL	31	266.469			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF HELLULA HYDRALIS LARVAE 5 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	366.875	52.4107	1.89	0.1224
R (B)	3	155.625	51.8750	1.87	0.1655
A*B	21	582.375	27.7321		
TOTAL	31	1104.88			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBER OF SPODOPTERA LITURA LARVAE 5 DAA

SOURCE	DF	SS	MS	F	P
T (A)	7	383.000	54.7143	1.92	0.1163
R (B)	3	141.250	47.0833	1.66	0.2070
A*B	21	597.250	28.4405		
TOTAL	31	1121.50			

ANALYSIS OF VARIANCE TABLE FOR MEAN NUMBEROF TOTAL LARVAE

SOURCE	DF	SS	MS	F	P
T (A)	7	461.375	65.9107	0.31	0.9420
R (B)	3	297.625	99.2083	0.46	0.7102
A*B	21	4486.88	213.661		
TOTAL	31	5245.88			