Contract report

No. SF15a

Strawberries -control of vine-weevil

with suSCon Green, insect-parasitic nematodes and insect-pathogenic fungi

Undertaken for the HDC and Incitec Ltd.

FINAL REPORT

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PRACTICAL SECTION FOR GROWERS

Vine weevil

Vine weevil feed on the roots and crowns of strawberry plants through the winter causing increasing amounts of damage through the life of the crop. The adult weevils are wingless, so spread slowly into crops from adjoining fields containing host crops and from hedgerows and shelter belts. The pest therefore causes the greatest problems on intensive fruit farms where rotations with non-host crops to reduce carry-over and migration of weevils is not possible.

Control

Current control relies on a laborious annual drenching with chlorpyrifos or the use of carbofuran granules once in the crop's life. Neither treatment method is popular with growers as they are expensive and difficult to apply, and have been found to give variable results in practice. Various alternative treatments have been developed for use on hardy ornamental nursery stock, and this experiment was set up to test the possible application of these treatments for strawberries grown in conventional matted rows in the field. A companion MAFF funded experiment for container raised plants has been done at HRI Efford.

It was found the a preparation of *Metarhizium* insect-pathogenic fungus. suSCon Green granules and *Heterorhabditis* nematodes were ineffective as applied in the experiment. The standard chlorpyrifos drench treatment used gave good control in the second year after planting, but was ineffective in the following winter. It was concluded that by this time the crop had out-grown the treatment's ability to cover all of the root area.

It was concluded that protracted control of vine weevil infestations was not possible using the treatments under test. The grower would be best advised on concentrating control efforts on cleaning up invading infestations in the first year after planting, thereby gaining a further productive cropping year than would have been possible without vine weevil control. Subsequent control measures are unlikely to be effective and provide a worthwhile return for the cost and effort involved

OBJECTIVE

The objective of this experiment is to evaluate the efficacy of SuSCon Green slow release chlorpyrifos granules, Fightagrub *Heterorhabditis* nematodes and *Metarhizium* insect-pathogenic fungus compared to a standard chlorpyrifos drench treatment for the control of vine weevil in a strawberry crop through a three year cropping cycle.

INTRODUCTION

Vine weevil remains a major pest of field grown strawberry crops grown on fruit farms practising an intensive rotation. The existing control measures are regarded as expensive and difficult to apply, and have been found to give variable control under field conditions. A range of potential alternative treatments have been shown to give a worthwhile control of vine weevil infestations in nursery stock containers, but their efficacy has not been directly compared on a field grown strawberry crop through a full cropping cycle. In this experiment each treatment was used as recommended from on-going research programmes at the most appropriate rates according to current knowledge. Programmes were compared using treatments applied at planting only, or applied annually, at a timing to coincide with the first hatch of vine weevil larvae.

MATERIALS AND METHODS

The experiment was sited in a field previous cropped with strawberries suffering a serious vine weevil infestation so as to maximise the challenge to the crop. Cambridge Favourite strawberries were planted on 7 October 1991. All treatments but treatment 6 were treated with a chlorpyrifos drench as in treatment 4 on 22 November 1991, so as to prevent direct carry over of larvae in the soil from the previous crop.

Design

Three separate experiments were established, each containing three replicates of the eight treatments arranged in a randomised block design. Each experiment was to be destructively samples in separate years from 1992 to 1994. All treatments on the different year's experiments received the same treatments until they were destructively sampled.

Treatments

1. SuSCon Green 10% chlorpyrifos granules at 40 Kg/ha on 4 October 1991.
2. SuSCon Green 10% chlorpyrifos granules at 60 Kg/ha on 4 October 1991.
3. SuSCon Green 10% chlorpyrifos granules at 80 Kg/ha on 4 October 1991.
4. Chlorpyrifos (Dursban 4) 48% ec at 430 mls/plant of a solution of 2 L/ 1000 L water. Applied 1 September 1992 and 6 September 1993.
5. Fightagrub *Heterorhabditis* nematodes applied at one pack of 10 million nematodes in 9 L water per 15 m^2 followed by a further 9 L water to wash off foliage on 24 September 1992 and 6 September 1993.
6. *Metarhizium* insect-pathogenic fungus applied at 3g of product (7.5×10^9 spores) per plant on 7 October 1991 before planting.

7. *Metarhizium* insect-pathogenic fungus applied at 3g of product (7.5×10^9 spores) per plant on 7 October 1991 before planting, 20g (5×10^{10} spores) per 10 m of row on 15 July 1992 and 27 September 1993.

8. Untreated.

Assessments

Growth vigour scores were made on 3 June and 17 November 1992 on the first year's experiment. As differences were relatively small the plots were scored on a 1 - 4 scale. The second year experimental plots were scored on a 1 - 10 scale on 9 June 1993.

Plant and soil samples were taken from the first year experiment on 3 February 1993 and the second year experiment on 18 January 1994. 245 mm diameter soil cores were removed centred on marked positions of 10 of the originally planted crowns. Vine weevil larvae were extracted by wet sieving and floatation in saturated magnesium sulphate solution. In 1993 the roots and leaves were removed from the crowns, which were then weighed.

Fruit was harvested from the second year experiment on 23 and 28 June 1994, all ripe fruit were picked from 10 plants per plot and weighed in the field.

RESULTS

The first year experiment plots were scored for relative vigour on 3 June and 17 November 1992. No significant differences in vigour between treatments were recorded (Table 1).

Table 1. Growth scores on first year experiment

Treatment	3 June	13 November
1. SuScon Green @ 40 kg/ha pre-planting	3.0	3.2
2. SuSCon Green @ 60 kg/ha pre-planting	3.0	3.1
3. SuSCon Green @ 80 kg/ha pre-planting	3.3	3.3
4. Dursban 4 drench annually	2.3	2.7
5. Fightagrub annually	2.3	2.7
6. Metarhizium pre-planting	2.9	3.2
7. Metarhizium annually	2.8	2.8
8. Untreated	3.0	3.1

Ten plants per plot from the first year experiment were lifted on 3 February 1993 and larvae extracted (Table 2). The Dursban 4 drench treatment had reduced numbers of vine weevil larvae (P <0.05) compared to the untreated plots. No significant differences were detected in the numbers of larvae recovered following other treatments. The larvae recovered from the Fightagrub treated plots appeared healthy and active, but on warming to room temperature died within a day. Small numbers of nematodes were found in the dead larvae. No significant differences in crown weight were detected.

Table 2. Numbers of vine weevil per 10 plants and average crown weights in February 1993.

Treatment	larvae/10 plants ($\log_{10}$ + 1 transformation)	crown weight g
1. SuScon Green @ 40 kg/ha pre-planting	11 (1.06)	33.6
2. SuSCon Green @ 60 kg/ha pre-planting	5 (0.75)	34.5
3. SuSCon Green @ 80 kg/ha pre-planting	9 (0.94)	36.3
4. Dursban 4 drench annually	1 (0.26)	35.0
5. Fightagrub annually	15 (1.12)	42.8
6. Metarhizium pre-planting	13 (1.10)	34.5
7. Metarhizium annually	5 (0.72)	31.5
8. Untreated	13 (0.98)	34.4
SED (14 df)	(0.1926)	2.903
CV%	(27.0)	10.1

The second year experiment plots were scored for relative vigour on 9 June 1993. No significant differences in vigour between treatments were recorded (Table 3).

Table 3. Growth score on second year experiment

Treatment	9 June
1. SuScon Green @ 40 kg/ha pre-planting	9.0
2. SuSCon Green @ 60 kg/ha pre-planting	7.3
3. SuSCon Green @ 80 kg/ha pre-planting	8.0
4. Dursban 4 drench annually	7.3
5. Fightagrub annually	7.7
6. Metarhizium pre-planting	9.0
7. Metarhizium annually	7.3
8. Untreated	7.0
SED (14 df)	1.45
CV%	18.6

All the ripe fruit was picked on two occasions from the second year experiment in 1993. No significant differences were found between the weight of fruit picked on either occasion, or the combined weight over both harvests (Table 4).

Table 4. Yield (kg) of ripe fruit from 10 plants on 23 and 28 June 1993

Treatment	23 June	28 June	Total
1. SuScon Green @ 40 kg/ha pre-planting	0.39	1.73	2.12
2. SuSCon Green @ 60 kg/ha pre-planting	0.43	1.32	1.75
3. SuSCon Green @ 80 kg/ha pre-planting	0.46	1.50	1.97
4. Dursban 4 drench annually	0.29	1.45	1.74
5. Fightagrub annually	0.48	1.24	1.72
6. Metarhizium pre-planting	0.35	1.27	1.62
7. Metarhizium annually	0.52	1.29	1.80
8. Untreated	0.36	1.69	2.05
SED (14df)	0.124	0.499	0.529
CV%	37.0	42.5	35.1

Ten plants per plot from the first year experiment were lifted on 18 January 1994 and larvae extracted (Table 2). No significant differences were detected between any of the treatments.

Table 5. Numbers of larvae per 10 plants in January 1994

Treatment	larvae (log_{10} n + 1 transformation)
1. SuScon Green @ 40 kg/ha pre-planting	50 (1.71)
2. SuSCon Green @ 60 kg/ha pre-planting	42 (1.63)
3. SuSCon Green @ 80 kg/ha pre-planting	26 (1.42)
4. Dursban 4 drench annually	36 (1.56)
5. Fightagrub annually	30 (1.43)
6. Metarhizium pre-planting	23 (1.37)
7. Metarhizium annually	27 (1.43)
8. Untreated	27 (1.43)
SED (14 df)	(0.192)
CV%	(15.6)

DISCUSSION

Dursban 4 drenches were applied to all main treatments, but the planting treatment of Metarhizium, when the experiment was planted to control vine weevil larvae surviving from the previous crop, which could have prevented establishment of the runners. As this initial treatment could have prejudiced the efficacy of a once only fungal treatment, by killing larvae which could have acted as initial hosts and improved persistence, this treatment was left undrenched. Four additional plots of the high rate SuSCon Green treatment were also left undrenched as a check against unexpected effects from this overall drench on growth, none were observed.

Three rates of SuScon Green application were used to test the dose response curve through time. This product releases chlorpyrifos over a 3 year period, but the rate of release is greatest in the first year (May, 1991), so the dose required will depend on the length of effective control desired. The control in the second autumn after application was poorer than previously recorded in other experiments, with some suggestion of reduced efficacy at the lowest dose, but due to the variability in larval numbers between plots this was not fully proven. The price announced for SuSCon Green of £11.50/kg means that the rates tested would cost between £460 and £920/ha, compared to an annual cost of £250/ha plus application for a Dursban 4 drench. A parallel MAFF funded experiment at HRI Efford is examining the possibility of incorporating SuSCon Green in modules. This alternative approach has given good control in the planting season.

The Metarhizium treatment applied at planting in 1991 gave no control in the autumn of 1992. The 1992 drench may have had some effect, reducing numbers by around 60%, but again due to the variability in larval numbers between plots this was not fully proven. A lack of persistence in the soil from the previous season may have been due to a shortage of host larvae in the plots. As yet no commercial formulation is available in the UK.

Fightagrub nematodes successfully invaded larvae, but had not killed them by February. Higher temperatures are required for the nematodes to release bacteria into the larva and kill it. This critical temperature ranges between 10 and 14°C for the strains of nematode in current use (Griffin & Downes 1991). The rate used would cost £2500/ha at current prices. Development of nematode based control for vine weevil on strawberries will depend on the introduction of cold adapted strains at significantly lower prices.

The September 1992 Dursban 4 drench treatment gave a superior control of vine weevil to all the other treatments tested. An annual chlorpyrifos drench seems likely to remain the standard treatment until further development work is completed to improve the efficacy and economics of the other methods tested under field conditions.

The small plots used in a replicated experiment put a greater pressure on the treatments under test than would occur in most fields crops where the whole crop received the same treatment. Adult weevils coming from plots receiving ineffective treatments will redistribute themselves across the whole experimental area, so that no roll-over effect of treatment reducing following populations occurs. This situation was deliberately built into this experiment so as to put treatments under the level of challenge that would occur in small crop areas on intensive fruit farms. Generally growers can anticipate a better effective persistence of treatments when applied on a field scale , so that control of the initial invasion of weevils in the year after planting can be expected to also reduce attack in the following year, and give the crop an addition year's productive life. This experiment suggests that attempts to prolong the crop's life into a third cropping year, if desired, on farms with a close cropping sequence will be futile, as the extended root system which will have developed by then can not be adequately protected by existing or potential treatments.

ACKNOWLEDGEMENTS

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APPENDIX I.

Management of the experimental site

Previous cropping:	strawberries 1988-91
Crop planted:	7 October 1991
Weed control:	Hand weeded 30 October 1991
	Dacathal W75 (9 kg/ha) + Propachlor (9 l/ha) 30 October 1991
	Devrinol (7 l/ha) 29 January 1992
	Propachlor (9 l/ha) 23 April 1992
	Betanal E (10 l/ha) 30 April 1992
	Hand weeded 2-5 June 1992
	Dacathal W75 (9 kg/ha) 5 June 1992
	Gramoxone 100 (5 l/ha) between rows 8 June 1992
	Hand weeded 14 July 1992
	Gramoxone 100 (5 l/ha) between rows 3 February 1993
	Dacathal W75 (9 kg/ha) 15 April 1993
	Hand weeded 27 October 1993
Fungicides:	Elvaron (4.5 kg/ha) 1 May 1992
	Elvaron (4.5 kg/ha) 15 May 1992
	Elvaron (4.5 kg/ha) 1 June 1992
Insecticides:	Dursban 4 drench (to all but treatments 6 & 9) 25 October 1991
	Experimental treatments as listed