Project Title:	Evaluation of reduced rates of SuSCon Green and Intercept 5GR when potting on treated liners
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A. PRACTICAL SECTION FOR GROWERS

Objectives and background

Extensive trials work by ADAS entomologists over several years has shown that the most reliable control of vine weevil larvae was always given by compost incorporated insecticides. However, the cost of these treatments increased as the pot volume (i.e. the amount of compost) increases; so many growers, while routinely using incorporated insecticides such as SuSCon Green for vine weevil control, tend only to use it in the liner stage, normally one litre pots. For potting-on into 2 or 3 litre pots, many growers only use SuSCon Green on so-called "susceptible" subjects, in order to reduce costs.

The problem with this approach is that vine weevil, although it does have "favourite" plant subjects, can attack or oviposit on almost any plant species, and so an infestation can develop if only susceptible subjects are treated at the final potting stage.

If the cost of treating the larger pot volumes could be reduced, growers would be more likely to treat all their subjects, thus giving improved overall, more reliable control.

The objective of this work was to determine whether, where the liner has had full rate of compost incorporated insecticide, reduced rates could be used in the final potting and still achieve acceptable levels of control.

A range of rates of compost incorporated insecticide (either SuSCon Green or Intercept 5GR) were used in the final potting mix and the liners were treated with either full rate of insecticide, or none, so a true comparison could be made. Treated pots were kept for up to two years, and then vine weevil eggs were artificially inoculated onto each test plant, incubated for several months, and the number of surviving larvae counted in order to determine treatment effects.

Summary of results

Two types of plant were used in the trial, a "susceptible" plant (Euonymus) and a "less susceptible" plant (Cotoneaster). When the liner and the potting-on mix were both untreated, out of 30 eggs placed on each pot, a mean of 14 larvae per pot were recovered in Year 1, and 24 larvae per pot in Year 2.

The numbers of vine weevil larvae recovered and the root damage observed in Cotoneaster and Euonymus were contrary to the perceived susceptibilities of these two species.

If the liner was treated with full rate SuSCon Green (1,000 gm/m^3), but the potting on mix was not treated, survival of weevil larvae was still high, showing that they could survive and feed, in the untreated compost around the liner core. The same effect was seen when the liner was treated with full rate Intercept 5GR, but potting on mix was untreated.

These results confirm that unless both liner and potting on mix are treated, control will be commercially unacceptable. The most interesting results, however, for growers were the treatments with reduced rates of insecticide in the potting on mix.

In Year 1, rates of 250 g/m^3 to 1,000 g/m^3 SuSCon in the potting on mix gave good control of vine weevil, and there was little difference between any of the rates used, providing the liner had been treated with the full recommended rate of SuSCon Green.

With Intercept 5GR only the full rate (280 g/m^3) and half rate (140 g /m^3) were tested. Results indicated that the rate of Intercept may be more critical, as there was a rise in vine weevil numbers when half rate was used in the potting on mix.

By Year 2, when the residues of insecticide had aged (all pots were maintained outside in natural conditions), the results were somewhat different. The lower rates of SuSCon Green (250 g/m^3 and 500 g/m^3 in the potting-on mix) had significant numbers of larvae present; commercially this level of survival would not be acceptable. Similarly, with Intercept 5GR in Year 2, larval survival was increased when the rate in the potting-on mix was half label rate (140 g/m^3).

In Year 2, control of vine weevil in *Cotoneaster* plants by any of the rates of Intercept 5GR was poor, but in the susceptible Euonymus plants, control was much better. The dramatic effect that vine weevil infestation can have on root weights was shown in *Cotoneaster* in Year 2, when the roots in SuSCon Green treated pots (at recommended rates) were approximately 350% heavier than untreated pots.

Action points for growers

- These results are potentially very important for growers. They indicate that providing the central core of compost (the liner) is treated with full rate of insecticide, then when potting the plants on, a reduced rate of either SuSCon Green or Intercept can be used (thus saving money) which still achieves good vine weevil control, though for one season only.

- By the second season, when the residues of insecticide have decreased naturally, control from reduced rates of SuSCon Green in the potting on mix is not as reliable. With Intercept 5GR, especially when *Cotoneaster* was the test plant, all rates, including the full label rate, gave poor control.

- It should be borne in mind that these trials represent a very severe test of the insecticides, as large numbers of weevil eggs were put into each pot. On a commercial nursery, it is very unlikely that such a heavy infestation of vine weevil would be present; so growers should interpret the results of the trials in this light.

- Note: The use of rates lower than those recommended by the manufacturers are at growers own risk.

B. EXPERIMENTAL SECTION

Introduction

Growers have been using SuSCon Green as a compost incorporated treatment for vine weevil control for six years now, and its use has become routine. The label states that 750 g/m^3 should be used, or 1,000 g/m^3 when the compost contains 25% or more bark. Generally, control of the pest has been excellent, as was expected from the many detailed trials that have been carried out, both by HDC and by Crop Care Limited.

For the last three years, another insecticide, Intercept 5GR, has also been available as a compost incorporated treatment for vine weevil. This product is only available ready mixed in Scotts compost, but the label rate is 280 g/m^3 compost.

Obviously, the cost of a compost incorporated insecticide increases as the pot volume increases, and although most liners (1 litre pots) are treated, some growers only treat the final pot (2 or 3 litres) if the plant subject is considered susceptible to vine weevil (e.g. Azalea, Rhododendron, Euonymus, etc.) However, it is very difficult to state what plants are not susceptible to the pest; indeed there are no lists available currently that rank nursery stock subjects according to their susceptibility, either to larval infestation on the roots, or adult feeding on the leaves.

Therefore, to save money, sometimes not all plants are treated in the final pot; this can allow the pest to survive even if the liner was treated, and thus an infestation can build up on a nursery.

The aim of these trials was to evaluate four rates of SuSCon Green and two rates of Intercept SG in the final potting on mix, and to determine the effect on levels of vine weevil control, when the initial liners all received full rate of either product.

Previous work

YEAR 1

In October and December 1996 treated liners of *Euonymus fortunei* 'Emerald Gaiety' and *Cotoneaster salcifolius repens* were potted in 3 l pots using compost containing a range of rates of either SuSCon Green or Intercept. Four rates of SuSCon Green (250, 500, 750 and 1000 g/m^3 compost), and two of Intercept, (140 and 280 g/m^3) and untreated compost were compared. In both cases untreated liners potted on into untreated compost were used as a control treatment. The SuSCon Green experiment therefore compared six treatments and the Intercept experiment compared four treatments. Each pot was inoculated with 30 vine weevil (*Otiorynchus sulcatus*) eggs in July 1997. Subsequently in February and March 1998 all pots were assessed for root damage, the presence of vine weevil larvae and root dry weight. Both SuSCon Green and Intercept gave excellent control of vine weevil larvae independent of rate. Generally more larvae were found in pots of Cotoneaster than of Euonymus.

YEAR 2

Further sets of plants potted in October and December 1996, as described above, were inoculated (40 vine weevil eggs/pot) in July 1998. Subsequently in February and March 1999 all pots were assessed for root damage, the presence of vine weevil larvae and root dry weight. In general, SuSCon Green was more effective than Intercept for control of vine weevil larvae, particularly in Cotoneasters. Root dry weight was a good indicator of insecticide efficacy in contrast to visual assessment of root damage. More larvae were found in pots of Cotoneaster than of Euonymus

Materials and Methods

In October 1996 144, 11 cm liners of *Euonymus fortunei* 'Emerald Gaiety' and *Cotoneaster salcifolius repens* with 1000 g SuSCon Green/m^3 were potted up in 3 l pots. The compost consisted of 100% sphagnum peat, 5% lime free coarse grit, 2.5 kg/m^3 of magnesian limestone and 5.0 kg/m^3 of Osmocote Plus 12-14 month autumn potting. SuSCon Green (10.3% chlorpyrifos) was also incorporated into the compost at 0, 250, 500, 750 or 1000 g/m^3. An untreated control was created by washing all the compost from around the roots of treated liners and repotting in untreated compost. Therefore in total there were six experimental treatments as given below:

a. Treated liner in untreated compost
b. Treated liner + 250 g/m^3 SuSCon Green
c. Treated liner + 500 g/m^3 SuSCon Green
d. Treated liner + 750 g/m^3 SuSCon Green
e. Treated liner + 1000 g/m^3 SuSCon Green
f. Untreated liner in untreated compost

All composts were mixed in an industrial cement mixer and there were 24 replicates of each treatment for both the Euonymus and Cotoneaster giving 288 pots in total. Liners were planted according to standard commercial practice with the top of the compost one cm above the liner compost. Pots were then maintained in a secure insectary with irrigation via an overhead sprinkler system. Each pot was treated with Nemasys H on 20 October 1996 to control any vine weevil larvae carried over from the treated liners.

In December 1996 80 extra untreated 11 cm liners of each of the same variety of Euonymus and Cotoneaster had their roots washed clean of compost. These were then repotted into the same liners with 60 of each species having Intercept (5% imidacloprid) incorporated at 280 g/m^3 of compost. The remaining 20 plants were untreated. The same compost mix was used as described previously. The liners were maintained in a constant temperature chamber at 16°C with 12 hour artificial lighting until they showed signs of new growth. They were then transferred to the insectary.

In March 1997 the liners were potted on into 3 l pots to create 20 replicates of each of the experimental treatments listed below:

a. Untreated liner in untreated compost
b. Treated liner in untreated compost
c. Treated liner + 280 g/m^3 Intercept
d. Treated liner + 140 g/m^3 Intercept

These pots were then maintained in the insectary together with those from the SuSCon Green experiment. Both groups of plants were arranged in a randomised block design.

In July 1997, 12 replicates of each of the SuSCon Green treatments (72 pot) and 10 replicates of the Imidacloprid treatments (40 pots) for both Euonymus and Cotoneaster were inoculated with 30 vine weevil eggs collected from a laboratory culture. Only brown sclerotised eggs were used. Inoculation was done by making a (0.5 cm deep) depression in the compost as an arc at a radius of approximately four centimetres from the stem of the plant. Eggs were placed in the depression and then covered with compost. Ten batches of 30 spare eggs were placed on damp black filter paper in Petri dishes. These were maintained at room temperature and observed daily to determine the proportion that hatched.

In February and March 1998 all plants were assessed for the presence of vine weevil larvae by tipping the compost from each pot, and washing that from around the roots, into a 250 μm sieve. This was then immersed in saturated magnesium sulphate and any larvae which floated to the surface were picked off. Feeding damage by vine weevil larvae was also assessed according to the following scale.

0	=	No larval feeding
1	=	Slight, few small areas of damage to the main stem, no obvious reduction in lateral root system
2	=	Moderate, discrete areas of damage on main stem, no obvious reduction in size of lateral root system
3	=	Severe, extensive feeding damage girdling the main stem and a significant reduction in the lateral root system

Root dry weights of plants were measured according to ADAS standard Operating Procedure HONS/001. This involved oven drying at 102°C for 16 hours.

During 1997, 12 replicates of each of the SuSCon Green treatments and 10 replicates of the Intercept treatments remained uninoculated. All pots were maintained in a secure, mesh covered insectary which was open to the elements with additional irrigation via an overhead sprinkler system. The pots remained in these conditions until the next year, to allow the insecticide residues to age naturally. In April 1998 the remaining uninoculated pots were all pruned and in May 1998 all received a top dressing of Osmocote at 12g/pot. From 9-10 July all pots from both the SuSCon Green and Intercept experiments were inoculated with 30 vine weevil eggs collected from a laboratory culture, using the same techniques as in Year 1. Plants were then maintained in the insectary and both experiments were arranged in randomised complete block designs.

Eight batches of 30-32 spare eggs were placed on damp black filter paper in Petri dishes. These were maintained at room temperature and observed daily to determine the proportion that hatched Hatch ranged from 40-90% (see results) and because of this variability it was decided to inoculate 10 more eggs per pot on 28 July. The viability of these eggs was also assessed on five batches of spare eggs (10-14 eggs/batch) as previously described. Therefore, in total, all pots were inoculated with 40 vine weevil eggs.

In February and March 1999 all plants were assessed for the presence of vine weevil larvae by tipping the compost from each pot, and washing that from around the roots, into a 250 µm sieve. This was then immersed in saturated magnesium sulphate and any larvae which floated to the surface were picked off. Larvae were classified as small (<5 mm long) medium (5-10 mm long) or large (>10 mm long). Feeding damage by vine weevil larvae was also assessed according to the scale as shown in Year 1.

RESULTS

YEAR 1

Egg viability

A total of 10 batches of eggs were monitored for their viability. Petri dishes were maintained in the laboratory at temperatures ranging from 17-22°C. The proportion of eggs hatching ranged between batches from 87-100% (Table 2) with a mean of 94.5% +/- 1.56%. Most larvae (90.8%) hatched 11 days after viability tests were set up.

Table 1. Egg viability

	Egg Batch											SEM
	1	2	3	4	5	6	7	8	9	10	Mean	(9DF)
Number of eggs hatched	26	29	26	27	29	29	30	30	28	29		
% of eggs hatched	87	97	87	90	97	97	100	100	93	97	94.5	1.56

Evaluation of reduced rate SuSCon Green

Larval numbers

Very few vine weevil larvae were found in treatments b, c, d or e where SuSCon Green was incorporated into the compost at potting on of both Cotoneaster and Euonymus. Where the insecticide was omitted at potting on (treatments a and f), larvae were much more numerous (Table 2). These data were not subjected to statistical analysis in view of the large differences between treatments. Most larvae were found where an untreated liner was potted on into untreated compost and least where a treated liner was potted on with 1000 g/m^3 SuSCon Green.

Table 2. Mean number of vine weevil larvae (+/- SE) recovered from pots of Cotoneaster and Euonymus

Treatment	Mean numbers of larvae Cotoneaster	Euonymus
a. Treated liner in untreated compost	9.9 +/- 1.55	2.1 +/- 0.80
b. Treated liner + 250 g/m^3 SuSCon Green	0.1 +/- 0.08	0.5 +/- 0.26
c. Treated liner + 500 g/m^3 SuSCon Green	0.7 +/- 0.58	0.4 +/- 0.22
d. Treated liner + 750 g/m^3 SuSCon Green	0.2 +/- 0.11	0.8 +/- 0.43
e. Treated liner + 1000 g/m^3 SuSCon Green	0 -	0.1 +/- 0.08
f. Untreated liner in untreated compost	14.2 +/- 2.51	9.1 +/- 1.47

Root damage assessment

Root damage assessment produced a non-continuous data set which could not be subjected to the analysis of variance. Therefore these data are summarised in Table 3.

Table 3. Number of roots within each damage category

Treatment	Number of roots in each damage category (3 = severe)							
	Cotoneaster				Euonymus			
	0	1	2	3	0	1	2	3
a. Treated liner in untreated compost	4	4	3	1	4	4	3	1
b. Treated liner + 250 g/m^3 SuSCon Green	2	9	1	0	5	6	1	0
c. Treated liner + 500 g/m^3 SuSCon Green	1	7	3	1	5	7	0	0
d. Treated liner + 750 g/m^3 SuSCon Green	3	9	0	0	4	7	1	0
e. Treated liner + 1000 g/m^3 SuSCon Green	2	6	4	0	2	7	3	0
f. Untreated liner in untreated compost	2	6	2	2	0	2	2	8

All Euonymus grown in untreated liners and potted on into untreated compost showed some root damage and eight out of 12 plants were in the highest root damage category. Otherwise there were few clear and consistent differences in root damage between treatments.

Root dry weight

Root dry weight data were subjected to the analysis of variance. Root dry weight differed significantly between treatments ($P < 0.05$) for both Cotoneaster and Euonymus (Table 4). Euonymus grown in untreated liners and potted on into untreated compost had a significantly lower root dry weight than all other treatments ($P < 0.05$). Cotoneaster growing in the same treatment had a significantly lower root weight than all other treatments except where plants raised in a treated liner were potted on into untreated compost ($P < 0.05$). Plants from a treated liner potted on into compost containing 750 g/m^3 SuSCon Green also had a significantly higher root dry weight than those from treated liners in untreated compost ($P < 0.05$).

Table 4. Mean root dry weight (g)

Treatment	Root dry weight Cotoneaster	Euonymus
a. Treated liner in untreated compost	16.91 ab	11.48 b
b. Treated liner + 250 g/m^3 SuSCon Green	23.62 bc	12.42 b
c. Treated liner + 500 g/m^3 SuSCon Green	23.74 bc	14.07 b
d. Treated liner + 750 g/m^3 SuSCon Green	31.37 c	12.69 b
e. Treated liner + 1000 g/m^3 SuSCon Green	24.58 bc	13.71 b
f. Untreated liner in untreated compost	11.88 a	5.98 a
SED (55 DF)	4.212	1.726

a, b and c are Duncan's Multiple Range Test indices, values followed by a common letter are not significantly different ($P < 0.05$).

Evaluation of reduced rate Intercept

Larval numbers

Similar trends between treatments were recorded as with SuSCon Green. Larval numbers were much higher where no Intercept was added to the compost at potting on than where it was incorporated (Table 5). Therefore, these data were not subjected to statistical analysis. Most larvae were recovered from plants raised in an untreated liner and potted on in untreated compost and least where the treated liner was potted on with 280 g/m^3 Intercept.

Table 5. Mean number of vine weevil larvae (+/- SE) recovered from pots of Cotoneaster and Euonymus

Treatment	Mean numbers of larvae Cotoneaster	Euonymus
a. Untreated liner in untreated compost	13.2 +/- 2.08	8.5 +/- 1.50
b. Treated liner in untreated compost	8.5 +/- 1.27	3.8 +/- 1.02
c. Treated liner + 280 g/m^3 Intercept	0 -	0.7 +/- 0.37
d. Treated liner + 140 g/m^3 Intercept	1.2 +/- 0.44	1.5 +/- 0.73

Root damage assessment

All roots from Cotoneaster grown in untreated liners and untreated compost showed some vine weevil damage but there was little difference between the other treatments (Table 6). Where Euonymus were grown in untreated liners and untreated compost half of the roots were in the highest damage category. Where treated liners were potted on into untreated compost there was also a high proportion of roots showing damage. In contrast, incorporation of Intercept at either rate minimised larval attack and over eight out of ten plants showed little or no sign of root damage.

Table 6. Number of roots within each damage category

Treatment	Number of roots in each damage category (3 = severe)							
	Cotoneaster				Euonymus			
	0	1	2	3	0	1	2	3
a. Untreated liner in untreated compost	0	4	5	1	1	4	0	5
b. Treated liner in untreated compost	3	4	3	0	2	5	1	2
c. Treated liner + 280 g/m^3 Intercept	2	5	3	0	6	2	1	1
d. Treated liner + 140 g/m^3 Intercept	3	5	2	0	6	2	1	1

Root dry weight

Root dry weight differed significantly between treatments for Cotoneasters ($P <0.05$) but not for Euonymus (Table 7). Cotoneasters from untreated liners and untreated compost had a significantly lower root dry weight than all other treatments ($P <0.05$) except where treated liners were potted on into compost containing 280 g/m^3 Intercept.

Table 7. Mean root dry weight (g)

Treatment	Mean root dry weight (gm) Cotoneaster	Euonymus
a. Untreated liner in untreated compost	15.73 a	15.55
b. Treated liner in untreated compost	27.97 b	14.91
c. Treated liner + 280 g/m^3 Intercept	19.89 ab	17.40
d. Treated liner + 140 g/m^3 Intercept	24.79 b	16.43
SED (27 DF)	4.064	2.325NS

a and b are Duncan's Multiple Range Test indices, values followed by a common letter are not significantly different ($P<0.05$).

Egg viability

YEAR 2

A total of eight batches of eggs inoculated on 9-10 July 1998 were monitored for their viability. Petri dishes were maintained in the laboratory at temperatures ranging from 17-22°C. The proportion of eggs hatched ranged between batches from 40-90% (Table 8) with a mean of 71.8% +/- 6.37%. Most larvae (97%) hatched 17 days after viability tests were set up.

Table 8. Viability of eggs inoculated 9-10 July, 1998

	Egg Batch									SEM
	1	2	3	4	5	6	7	8	Mean	(9 DF)
Number of eggs	31	30	30	30	30	30	32	30		
Number of eggs hatched	24	27	23	24	24	25	15	12		
% of eggs hatched	77	90	77	80	80	83	47	40	71.8	6.37

The level of hatch was lower than in previous experiments with this pest (94.5% of eggs hatched in the 1997 experiment) and so it was decided to inoculate an extra 10 eggs per pot as previously discussed. The viability of these eggs is shown in Table 9.

Table 9. Viability of eggs inoculated on 28 July 1998

	Egg batch						SEM
	1	2	3	4	5	Mean	(4 DF)
Number of eggs	10	15	11	10	11		
Number of eggs hatched	8	13	10	7	10		
% of eggs hatched	80	93	91	70	91	85.0	4.39

The proportion of eggs hatched ranged from 70-91% which was less variable than eggs inoculated on 9-10 July. All eggs hatched within 14 days of establishing the viability tests.

Evaluation of reduced rate SuSCon Green

Larval numbers

The mean numbers of vine weevil larvae (+/-SE) in each treatment and size category are summarised in Table 10.

Table 10. Mean numbers of vine weevil larvae (+/-SE) in each of the three size categories recovered in each treatment

	Treatments	Cotoneaster				Euonymus			
		Small	Medium	Large	Total	Small	Medium	Large	Total
a.	Treated liner in untreated compost	1.3+/-0.68	1.4+/-0.67	20.0+/-2.47	22.7+/-2.47	0.2+/-0.2	0.2+/-0.11	0.6+/-0.29	0.9+/-0.38
b.	Treated liner +250 g/m^3 SuSCon Green	0.5+/-0.26	0.6+/-0.29	5.5+/-1.10	6.6+/-1.40	0	0.5+/-0.23	0.6+/-0.19	1.1+/-0.29
c.	Treated liner + 500 g/m^3 SuSCon Green	0	0.3+/-0.19	3.5+/-0.9	3.8+/-0.94	0	1.6+/-0.66	1.8+/-0.81	3.5+/-1.25
d.	Treated liner + 750 g/m^3 SuSCon Green	0	0.2+/-0.20	2.6+/-0.86	2.8+/-0.90	0	0.7+/-0.28	0.5+/-0.23	1.2+/-0.41
e.	Treated liner + 1000 g/m^3 SuSCon Green	0	0.3+/-0.13	0.7+/-0.36	0.9+/-0.36	0	0.1+/-0.08	0.2+/-0.11	0.3+/-0.13
f.	Untreated liner in untreated compost	1.2+/-0.52	2.1+/-0.92	20.8+/-3.05	23.8+/-3.20	0.1+/-0.1	1.8+/-0.59	3.4+/-1.43	5.3+/-1.60

In general, most larvae were within the large size category. There was no clear consistent effect of treatment on the size of vine weevil larvae. Total numbers of larvae were subjected to the analysis of variance following transformation to $\log_{10}(x + 1)$ values. Numbers recovered from Cotoneasters differed significantly between treatments ($P<0.05$, Table 11). In general, larval numbers decreased with increasing rate of incorporation of SuSCon Green. Where no SuSCon Green was incorporated at potting on, larval numbers were markedly higher than where even the lowest rate of the insecticide (250 g/m^3) was used.

Numbers of larvae recovered from Euonymus also differed significantly between treatments ($P<0.05$). Most larvae were found where an untreated liner was potted on in untreated compost and least where a treated liner was potted on in compost containing 1000 g/m3 SuSCon Green. Duncan's Multiple Range Test indices are provided for individual treatment comparisons for both the Cotoneaster and Euonymus data.

Table 11 Mean number of vine weevil larvae ($\log_{10}(x+1)$ values) recovered from pots of Cotoneaster and Euonymus treated with a range of rates of compost incorporated SuSCon Green (figures in brackets are back transformed values)

Treatment	Larval numbers	
	Cotoneaster	Euonymus
a. Treated liner in untreated compost	1.32d (19.9)	0.21ab (0.6)
b. Treated liner + 250 g/m^3 SuSCon Green	0.79c (5.2)	0.27ab (0.9)
c. Treated liner + 500 g/m^3 SuSCon Green	0.57bc (2.7)	0.46bc (1.9)
d. Treated liner + 750 g/m^3 SuSCon Green	0.46b (1.9)	0.27ab (0.9)
e. Treated liner + 1000 g/m^3 SuSCon Green	0.21a (0.6)	0.08a (0.2)
f. Untreated liner in untreated compost	1.32d (19.9)	0.64c (3.4)
SED (55DF)	0.118	0.123

a, b, c and d are Duncan's Multiple Range Test indices, values followed by a common letter are not significantly different ($P<0.05$).

Root damage assessment

It was not possible to distinguish any clear signs of root feeding on either the Euonymus or Cotoneaster. In the first year of the experiment the primary root had been damaged just below the surface of the compost. This was not the case in 1998/99 possibly because larvae preferred to feed on the mass of lateral roots which had developed. (However, no obvious vine weevil feeding on lateral root was observed)?

Root dry weight

Despite little visible evidence of root damage there were clear differences in the mass of root material between treatments. Root dry weight differed significantly between treatments for both Cotoneaster and Euonymus (Table 12). Root dry weight of Cotoneasters followed a similar but inverse pattern to the larval numbers data and tended to increase with increasing rate of SuSCon Green incorporation. Incorporation of SuSCon Green at least doubled root dry weight in comparison with the controls.

Root dry weight of Euonymus was also lowest where no SuSCon Green was incorporated. However, there was no obvious relationship between rate of SuSCon Green incorporation and root dry weight. Duncan's Multiple Test indices are given to allow individual treatment comparisons.

Table 12. Mean root dry weight (g) of cotoneasters and euonymus treated with a range of rates of compost incorporated SuSCon Green

Treatment	Root dry weight	
	Cotoneaster	Euonymus
a. Treated liner in untreated compost	9.82a	8.12ab
b. Treated liner + 250 g/m^3 SuSCon Green	22.37b	13.68cd
c. Treated liner + 500 g/m^3 SuSCon Green	27.82bc	16.18d
d. Treated liner + 750 g/m^3 SuSCon Green	31.88c	12.06bcd
e. Treated liner + 1000 g/m^3 SuSCon Green	32.16c	11.47abc
f. Untreated liner in untreated compost	8.58a	7.70a
SED (55 DF)	4.208	1.965

a, b, c and d are Duncan's Multiple Range Test indices, values followed by the same letter are not significantly different. ($P<0.05$).

Evaluation of reduced rate Intercept

Larval numbers

The mean numbers of vine weevil larvae *(*+/-SE) in each treatment and size category are summarised in Table 13.

Table 13. Mean numbers of vine weevil larvae (+/-SE) in each of the three size categories recovered in each treatment.

Treatment	Cotoneaster				Euonymus			
	Small	Medium	Large	Total	Small	Medium	Large	Total
a. Untreated liner in untreated compost	0.60+/-0.34	2.20+/-1.36	38.00+/-3.04	40.80+/-3.88	2.20+/-1.12	4.50+/-0.97	15.60+/-3.37	22.30+/-2.89
b Treated liner in untreated compost	0.5+/-0.27	2.50+/-0.83	33.10+/-2.86	36.10+/-3.37	0	1.90+/-0.67	3.7+/-1.33	5.60+/-1.51
c. Treated liner + 280 g/m^3 Intercept	1.60+/-0.58	3.20+/-0.42	19.70+/-2.77	24.50+/-2.68	1.50+/-0.70	0.30+/-0.15	1.7+/-0.63	3.50+/-0.87
d Treated liner + 140 g/m^3 Intercept	2.10+/-1.11	4.70+/-0.92	16.90+/-2.02	23.70+/-2.61	0.20+/-0.13	0.40+/-0.22	1.80+/-0.53	2.40+/-0.58

Most larvae were in the large size category. Numbers were also generally greater where plants were potted on in untreated compost than where Intercept was incorporated. However, data for Cotoneasters showed that numbers of small and medium sized larvae were greater where Intercept was incorporated than where it was omitted.

Total numbers of larvae per pot were transformed to $\log_{10}(x+1)$ values and subjected to the analysis of variance. Numbers recovered from Cotoneasters differed significantly between treatments (P<0.01, Table 14).

Table 14. Mean number of vine weevil larvae ($\log_{10}(x+1)$values) recovered from pots of Cotoneaster and Euonymus treated with compost incorporated Intercept. (Figures in brackets are back transformed values).

Treatment		Mean numbers of larvae	
		Cotoneaster	Euonymus
a.	Untreated liner in untreated compost	1.60b (38.8)	1.33b (20.4)
b.	Treated liner in untreated compost	1.55b (34.5)	0.71a (4.1)
c.	Treated liner + 280 g/m^3 Intercept	1.39a (23.5)	0.56a (2.6)
d.	Treated liner + 140 g/m^3 Intercept	1.36a (21.9)	0.46a (1.9)
SED (27 DF)		0.068	0.143

a and b are Duncan's Multiple Range Test indices, values followed by a common letter are not significantly different (P<0.01).

Most larvae were found where plants were potted on in untreated compost. With Cotoneaster plants, there was little difference in larval numbers between either full or low rate Intercept. However, even in the presence of Intercept, large numbers of larvae (up to 24 per pot) were recorded. Fewer larvae were recovered from Euonymus than Cotoneaster but numbers still differed significantly between treatments (P<0.01). The use of a treated liner with Euonymus greatly reduced larval numbers. Numbers were also lower where the treated liner received additional Intercept at potting-on in comparison with the treated liner in untreated compost. However, these differences were not statistically significant. Duncan's Multiple Range Test indices are provided for individual treatment comparisons of both Cotoneaster and Euonymus data.

Root damage assessment

Root damage was not assessed on either plant species for reasons already discussed.

Root dry weight

Root dry weight of Cotoneasters differed significantly between treatments ($P<0.05$, Table 15) and was markedly greater where plants were potted-on in Intercept treated compost than where the insecticide was omitted. There was no significant difference in the root dry weight of Euonymus. The lowest weight was recorded where the treated liner was potted on in untreated compost and the highest where 280 g/m^3 Intercept was incorporated.

Table 15. Mean root dry weight (g) of Cotoneasters and Euonymus treated with compost incorporated Intercept.

Treatment	Root dry weight (gm) Cotoneaster	Euonymus
a. Untreated liner in untreated compost	6.23 a	13.65
b. Treated liner in untreated compost	10.09 a	10.00
c. Treated liner + 280 g/m^3 Intercept	28.00 b	14.76
d. Treated liner + 140 g/m^3 Intercept	35.51 b	13.88
SED (27 DF)	4.358	1.860 NS

a and b are Duncan's Multiple Range Test indices, values followed by a common letter are not significantly different ($P<0.05$).

DISCUSSION

These detailed trials have shown differences in the levels of control given by a range of rates of SuSCon Green and Intercept 5GR when tested one and two years after incorporation into compost.

In the first year of the trials, all rates of SuSCon Green in the final potting on mix, (from 250 gm to 1,000 g/m^3) were equally effective in controlling the pest, and this gave rise to optimism that lower rates could be used, thus saving money.

However, by the second year, when insecticide residues had aged, this trend was not so marked. Potting-on treated liners into compost which had SuSCon Green incorporated still gave good control of vine weevil larvae. However, there were clear differences in the efficacy of different rates. This was most marked with the data for Cotoneasters. Larval numbers tended to decrease with increasing rate of SuSCon Green and only where 1,000 g/m^3 compost was incorporated was there less than one larva per plant. This suggests that only low rates of SuSCon Green are required to provide control for one year after treatment of the liner, a higher rate of incorporation is necessary at potting-on to give acceptable control of larvae for two years.

Intercept was very effective for control of vine weevil larvae in both Euonymus and Cotoneaster in year 1. However, it was markedly less effective than SuSCon Green for control of vine weevil larvae in Cotoneasters in the second year of study. Numbers of larvae were reduced by incorporating the insecticide at potting-on but were still unacceptably high, with a mean of 23.5 per pot in pots treated with full label rate. The reasons for this are not known.

In Euonymus, Intercept was more effective than in Cotoneasters. Larval numbers were reduced from approximately 20 per pot where the untreated liner was potted-on in untreated compost to approximately 2-3 per pot where Intercept was incorporated. However, this level of infestation is still unacceptable on a commercial nursery where total control of the pest would be the aim. In general, results suggest that SuSCon Green is more persistent than Intercept over two years although there was little to choose between them after one year.

Root dry weight data generally reflected the effectiveness of larval control. This relationship was most evident with Cotoneasters and SuSCon Green where root dry weight increased with increasing rate of insecticide incorporation. In contrast, a visual assessment of root damage was a poor indicator of insecticide efficacy. In year one, the relationship between root damage and larval numbers was poor. In year two, very little root damage was seen. This is probably because larvae fed on the well developed lateral roots which showed little sign of attack although root dry weight data clearly demonstrated that root feeding had taken place.

Egg viability varied between 40 and 93% so it was surprising that approximately 39 larvae were recovered from Cotoneasters in the Intercept study, where only 40 eggs were inoculated (97.5% viability). This suggests that there was some egg laying by wild weevils and some adults were found sheltering under the pots during the summer. Therefore it should be assumed that the total number of eggs in each pot was greater than the 40 inoculated from laboratory culture. This is a very high level of pest pressure and may be in part responsible for no treatment being able to achieve 100% control of all larvae.

As in the first year of study much higher numbers of larvae were recovered from Cotoneasters than Euonymus. This may be related to the greater volume of root generally associated with Cotoneasters than euonymus, and also possibly differences in the susceptibility of both plants to the pest.

These results must be considered in the context of the situation on a commercial nursery, however, where it is unlikely that the pest pressure would be so high. On most nurseries, these results suggest it is possible that a reduction in rate of SuSCon Green in the final pot of approximately 25% (to 500 g/m^3 or 750 g/m^3 instead of 750 or 1000 g/m^3 in peat or peat/bark composts, respectively) would give acceptable results, especially if the plants were only being grown for one season after potting.

It would be worthwhile repeating these trials, on a smaller scale, but on a site free from "wild" weevil infestation, and only inoculating 15-20 eggs per pot, to determine the levels of control.

The results of the present work confirm how serious the damage from vine weevil larvae can be: even on a vigorous subject such as Cotoneaster, the root weight was increased by up to 350% by SuSCon Green treatment, compared with untreated pots.

CONCLUSIONS

1. Root damage indices are an unreliable indicator of vine weevil feeding. Dry root weights are much more accurate and are to be preferred.

2. Assessments of larval size are not really relevant in trials of compost-incorporated insecticides, where control of vine weevil occurs at a very young larval stage. However, in trials of drench treatments, where different age larvae may be present at the time of treatment, size assessments would be worthwhile.

3. These results have shown that there is scope for reducing the amount of SuSCon Green in the final potting by about 25% without significant loss of control (providing the liner was treated with full rate), but only where pots are to be kept for one season after final potting. If pots are kept on the nursery for a second year, full rates may be needed.

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