PROJECT REPORT No. OS57

THE FURTHER DEVELOPMENT OF SEED TREATMENTS TO CONTROL CABBAGE STEM FLEA BEETLE AND OTHER PESTS ON WINTER OILSEED RAPE

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by

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This is the final report of a fifteen-month research project which started in August 2001. The work was funded by a grant of £16,990 from HGCA (project no. 2364).

Contents:

Abstract

- The first year pilot study (Project Report OS43) identified three potential replacements for gamma-HCH. Imidacloprid + beta-cyfluthrin (as UK 805 from Bayer plc) provided similar or improved reductions in cabbage stem flea beetle adult damage compared with the previous industry-standard gamma-HCH. A 90% reduction in the percentage of plants infested by aphids was obtained at one site where a significant infestation developed. Indications were obtained from the manufacturer that UK 805 may also provide useful suppression of the incidence of slug damage.

- In this project, the second year of the study, UK 805 was tested against other coded products, and methiocarb and carbosulfan which were available as commercial treatments in mainland Europe. Bayer UK 894, containing a lower rate of imidacloprid than available in UK 805, was also included as this product seemed the most likely candidate for approval to be obtained for use in the UK.

- Imidacloprid + beta-cyfluthrin at the rate used in the first year's trials reduced cabbage stem flea beetle larval damage by 45%, a similar mean reduction to that obtained in year 1. UK 894 provided a similar mean reduction in damage of 52%. Fipronil treatments reduced the attack by a mean of 58%, carbosulfan by 65%, bifenthrin by 81% and methiocarb by 11%. A pyrethroid spray of lambda-cyhalothrin at early larval invasion in the autumn reduced larval numbers by 78%. UK 894 followed by the spray gave a marginal improvement compared with the spray alone and reduced numbers by 86%.

- As in the first year, significant reductions in mean percentage of plants infested with aphids, predominantly peach-potato aphid, were obtained at one site. Results from UK 805 and UK 894 were similar to those from an autumn-applied pyrethroid spray.

- Imidacloprid + beta-cyfluthrin and methiocarb seed treatment provided significant reductions of 53-55% of plants damaged by slugs at site 1 where a moderate level of slug activity was recorded.

- In summer 2001, an HGCA Topic Sheet (No. 48) was prepared and distributed within the industry. This provided a summary of the key action points for growers.

- The seed treatment UK894 based on imidacloprid (100 g/litre) + beta-cyfluthrin (100 g/litre) has now received approval from the Pesticides Safety Directorate for use in the UK as 'Chinook'.

- The registration for UK 894 as Chinook is for use as a seed treatment for autumn-sown crops of oilseed rape to reduce the damage to seedlings caused by early attacks of cabbage stem flea beetle with the objective of improving crop establishment. Chinook is recommended for use as a seed treatment for winter oilseed rape at 2.0 litres of product per 100 kg seed. The seed must be drilled and not broadcast to minimise wildlife risks.

Summary:

This was the second project funded by HGCA on this subject. The first was reported as Project Report OS43. The overall aim was to further investigate insecticidal seed treatments for control of cabbage stem flea beetle (*Psylliodes chrysocephala)* on winter oilseed rape. Observations were also made on aphid infestation levels and severity of slug damage. Trials were established at three sites with a history of appropriate pest attack in Staffordshire, Hampshire and Warwickshire (sites 1, 2 and 3 respectively).

Commercially-available winter oilseed rape cv Pronto was treated with iprodione + thiram (Rovral + Thiram) and overtreated with the test insecticidal seed treatments. Selected active ingredients were imidacloprid (at 2.0 or 10.0 g ai/kg seed) + beta-cyfluthrin; fipronil at two rates selected by the manufacturer, carbosulfan, methiocarb and bifenthrin. A spray treatment of lambda-cyhalothrin applied at early cabbage stem flea beetle larval invasion was also included as a test standard. All treatments were compared with untreated means.

The trials in Staffordshire and Hampshire were drilled on 25 and 29 August 2000 respectively; the Warwickshire trial was drilled deliberately later on 13 September 2000 at a site selected primarily on the basis of slug risk. All trials were drilled at a seed rate of 4.5 kg/ha with the objective of providing 50-55 established plants/m^2. Crops emerged quickly within seven days in the two August-sown trials and within 16 days from the later drilling at the Warwickshire site, where heavy rain soon after drilling resulted in waterlogged conditions and adversely-affected establishment.

Cabbage stem flea beetle adult activity was assessed using four ground-placed, yellow water traps per site. Catches were lower than in the first year of the experiment but with a similar timing for peak catches in early to mid-September. Crop vigour was assessed visually at early crop emergence; plant populations were counted at early and full crop emergence at all sites and again in late winter at the August-sown sites. A sample of 50 plants was removed from each plot at the one-two expanded leaf stage (GS 1.1, 1.2) to assess percentages of plants damaged by slugs and adult cabbage stem flea beetles. In December, samples of 10 plants per plot were taken to assess percentages of plants infested with aphids, slug damage and numbers of cabbage stem flea beetle larvae present in petioles. The trials were yielded at the two trials in Staffordshire and Hampshire.

Significant increases in mean plant populations were obtained from all seed treatments except methiocarb at site 1 (Brewood) with differences compared with the untreated means persisting until late-winter (Table 2a; Figure 3). Effects at the other two sites were less consistent. Significant reductions in mean percentages of plants damaged by slugs were obtained from imidacloprid (as UK 894 or UK 805) + beta-cyfluthrin and methiocarb seed treatments at site 1 compared with the untreated mean 30.0% (Table 4a). Reductions in percentage area of cotyledons damaged by slugs were also obtained from UK 894, UK 805, carbosulfan and methiocarb compared with the untreated mean (Table 8a). Significant reductions in the mean percentage of plants infested with aphids compared with the untreated mean 15.0% were obtained from UK 894 or UK 805 and by the lambda-cyhalothrin spray treatment at site 1.

Percentages of plants damaged by cabbage stem flea beetle adults varied from 11.5% at site 1 (Table 4a) to 94.4% at site 2 (Table 4b) where a small but significant reduction in damage was obtained from UK 805. The incidence of adult feeding damage on cotyledons and first true leaves was too slight at site 1 for significant differences to be obtained between treatments. At site 2, there was a tendency for damage to be reduced compared with the untreated mean but differences were not significant at p=0.05. Significant reductions in numbers of cabbage stem flea beetle larvae in petioles were obtained at site 1 where a slight attack was reduced by all treatments except methiocarb (Table 9a). Differences at other sites were not significant.

Yields were not significantly improved by treatments at either of the two sites harvested (Table 10).

Introduction:

The revocation of approvals for the use of lindane (gamma-HCH) as a UK-applied seed treatment in August 1999 removed the only approved seed treatment available to oilseed rape growers. The Pesticide Usage Surveys report for 1998 showed that more than 80% of the oilseed rape crop in Great Britain received a seed treatment including gamma-HCH, illustrating its importance to manufacturers and oilseed rape growers.

The first year pilot study, in harvest year 2000, was conducted at three sites and identified three potential replacement seed-applied treatments to gamma-HCH. Imidacloprid plus beta-cyfluthrin (as UK 805) from Bayer plc provided similar or improved reductions in cabbage stem flea beetle adult or larval damage compared with the gamma-HCH test standard. An effective reduction (90%) in the percentage of plants infested with aphids was also obtained at one site. Indications were obtained from the manufacturer that UK 805 may also provide useful reductions in slug damage.

Oilseed rape is attacked by a complex of pests. In recent years, cabbage stem flea beetle (*Psylliodes chrysocephala*) has become one of the most important insect pests during establishment of autumn-sown crops (Winfield, 1992; Evans & Scarisbrick, 1994). The distribution range has continued to increase, particularly northwards and into Scotland (Walters *et. al.*, 2001). Adult *P. chrysocephala* emerge from aestivation from mid to late-August onwards (Alford, 1979) and lay eggs in the soil after a period of feeding on the cotyledons and leaves of newly-emerged crops. The resulting larvae burrow into the plants and feed within the leaf petioles or stems during the autumn and winter period (Alford *et. al.*, 1991).

The larvae of cabbage stem flea beetle are normally considered to be more damaging than the adults. The published threshold for control of cabbage stem flea beetle larvae in the UK is an average of five larvae per plant. Generally, treatment with a pyrethroid insecticide, if well-timed to coincide with the early stages of larval invasion, provides control of 70-80% or more. Delaying treatment until late winter reduced numbers by about 50% (Lane & Cooper, 1989; Purvis, 1986). At an infestation level of five larvae per plant, a yield response averaging 0.34 t/ha can be expected from an autumn-applied spray (Purvis, 1986). A lower threshold of under one larva per plant was proposed in Sweden (Nilsson, 1990) for a spray treatment and under 0.5 larva per plant for an insecticidal seed treatment. The latter halved the numbers of larvae in trials and increased yield by an average of 0.1 t/ha. In the pilot, HGCA-funded study in harvest year 2000, reductions in larval numbers averaged 23% from the then, industry-standard lindane and 42% from imidacloprid seed treatment.

Oilseed rape is susceptible to a number of viruses including Beet Western Yellows Virus which is introduced to and spread within crops in the autumn mainly by peach-potato aphid (*Myzus persicae*). Studies by Smith & Hinckes (1985) showed that 78 of 80 crops of oilseed rape were infected with BWYV. A number of pyrethroid insecticides are approved for aphid control in oilseed rape in the autumn. In the first year of this study, seed treatments were shown at one site to have some effect against aphids with imidacloprid providing the most effective control. This treatment was therefore expected to provide a potentially useful benefit to growers. Imidacloprid-based seed treatment is already used to good effect on sugar beet for aphid vector suppression on around 70% of crop area in the UK and on winter cereals for reductions of aphid vectors of Barley Yellow Dwarf Virus.

Slug attack at early crop emergence can result in irreversible damage if the stems of oilseed rape plants are severed and immediate action to control slugs and protect the remaining plants may be necessary. In severe cases, feeding damage can result in crop destruction and the need for redrilling. Many ADAS studies have shown that slugs can seriously affect oilseed rape establishment in the autumn. In the TALISMAN studies, slugs were the most troublesome and damaging invertebrate pest experienced in the six year study and responsible for complete crop failures in two winter oilseed rape crops (Young *et.al.,* 2001). The slug problems encountered were a reflection of the difficulties of both reliably forecasting the severity of slug damage and of obtaining effective control of slugs once attacks are underway.

The Pesticide Usage Survey Report for arable crops 1998 (Garthwaite & Thomas, 1998) showed that 20.9% of oilseed rape crops in Great Britain were treated with molluscicide. The proportion of oilseed rape crops treated with slug pellets was nearly three times greater than the meaned average for all arable crops of 7.7% of crop area. Costs of crop failure are substantial. Studies by the Home-Grown Cereals Authority estimated that around 50% of the costs of growing oilseed rape were associated with the establishment period with critical timings relating to high germination percentages for seed and the impact of pest attack including slugs and cabbage stem flea beetle.

The benefits from reductions in incidence of slug damage have not been investigated in the UK as thoroughly in oilseed rape as for winter cereals. Seed treatment based on methiocarb that would be expected to provide some reduction in the severity of slug damage and is commercially available in mainland Europe. Imidacloprid, when used as a seed treatment on winter wheat has been shown by Bayer plc to provide reductions in grain hollowing on winter wheat averaging 66%. Given the importance of slugs during the establishment of winter oilseed rape, the effects of seed treatments against slugs and benefits from reductions in slug damage were also investigated in the three trials conducted in harvest year 2001.

Imidacloprid, available as Secur for use as a seed treatment on cereals, is known (pers. comm., Bayer plc) to provide an additional benefit to that obtained from reduction in aphid-vected BYDV and to provide useful incidental reduction in the incidence of slug damage in autumn-drilled crops. The opportunity was taken in year two of this study to investigate the potential of imidacloprid and other seed treatments, including methiocarb, to reduce the severity of slug damage on winter oilseed rape. Site 3 (Drayton) was specifically selected on the basis of slug risk and was intentionally drilled later (mid September) than is normally considered optimal for winter oilseed rape.

Objectives:

To screen candidate seed treatments for the control of cabbage stem flea beetle (*Psylliodes chrysocephala*) on winter oilseed rape as a replacement for gamma-HCH and to assess the impact of these treatments on aphids and slugs at two sites in the Midlands and one in the south of England.

- To evaluate materials for their impact on plant populations and adult flea beetle damage.
- To test seed treatments for their impact on cabbage stem flea beetle larval numbers, plant survival through the winter and yield.
- To assess the efficacy of seed treatments against aphid virus vectors.
- To assess the efficacy of seed treatments on the severity of slug damage.
- To assess yield effects as a result of seed treatment applications.

Sites:

1. Mr P Sands, J B Sands Ltd., Horsebrook Lane, Brewood, Staffordshire, ST19 9LT.
2. ADAS Bridgets, Martyr Worthy, Hampshire, SO21 1AP.
3. ADAS Drayton, Alcester Road, Stratford upon Avon, Warwickshire, CV37 9RQ.

Site details:

Site	WOSR variety	Soil type	Drilling dates	Seed rate kg/ha	Reps.	Plot size (m)
1. Brewood	Pronto	Sandy loam	25.08.00	4.5	4	12 x 2.0
2. Bridgets	Pronto	Chalky clay	29.08.00	4.5	4	24 x 2.0
3. Drayton	Pronto	Clay	13.09.00	4.5	4	24 x 2.0

Treatments:

	Active ingredients	Product	Rate g ai/kg
1	iprodione + thiram	Rovral + Thiram	2.5, 3.0
2	iprodione + thiram + imidacloprid + beta-cyfluthrin	Rovral + Thiram + UK 894	2.5, 3.0, 2.0, 2.0
3	iprodione + thiram + imidacloprid + beta-cyfluthrin	Rovral + Thiram + UK 805	2.5, 3.0, 10.0, 2.0
4	iprodione + thiram + fipronil low rate	Rovral + Thiram + experimental	2.5, 3.0, ?
5	iprodione + thiram + fipronil high rate	Rovral + Thiram + experimental	2.5, 3.0, ?
6	thiram + carbosulfan	TMTD 98% Satec® + Combicoat® CBS	4.0, 15 ml product/kg
7	iprodione + thiram + methiocarb	Pomarsol + Mesurol	3.0 g + 30 ml products/kg
8	iprodione + thiram + lambda-cyhalothrin spray at larval invasion	Rovral + Thiram + Hallmark	2.5, 3.0, 5.0
9	iprodione + thiram + imidacloprid (2g) + beta-cyfluthrin + lambda-cyhalothrin spray at larval invasion	Rovral + Thiram + UK 894 + Hallmark	2.5, 3.0, 2.0, 2.0, 5.0
10	iprodione + thiram + bifenthrin	Rovral + TMTD + I1 - 2000	2.5, 3.0, 2.7

Treatments 4, 5 and 10 were subject to crop disposal requirements.

Product information:
Treatment 6 was obtained as a commercially-available treatment from SATEC, Elmshorn. Carbosulfan is registered for use against cabbage stem flea beetle in Denmark, France, Germany, Germany and Sweden.
Treatment 7 methiocarb, as Mesurol, is registered for use in France.

Lambda-cyhalothrin is approved in the UK for the control of cabbage stem flea beetle. Applied as Hallmark (lambda-cyhalothrin 50 g/l) at rate of 100 ml/ha product + approved wetter.

Spray dates:
Lambda-cyhalothrin was applied at site 1 at GS 1.6 on 30.11.00 and at site 2 at GS 1.8 on 17.11.00. The spray treatments were made with CO_2 or Oxford precision sprayers at 2 bar pressure in a water volume of 200 l/ha. Approved non-ionic wetters wetters were included as recommended: Enhance at site 1, Agral at site 2.

Methods:

Design of trials

Randomised complete block designs; 4 replicates of 10 treatments. Plot width 2.0m, plot length 12 m in Staffordshire; 1.68 x 24 m at ADAS Bridgets; 2.0 x 24m at ADAS Drayton, Warwickshire. Ref: EPPO PP 1/73(3) Guidelines for the efficacy evaluation of insecticides (*Psylliodes chrysocephala).*

Assessments

1. Soil analysis prior to planting. A representative soil sample was taken at each site to cultivation depth from the trial area for pH, P, K, Mg determination. Soil type was recorded.

2. Pre-drilling 1000 seed weight (CPB Twyford Limited) 7.2 g. Germination 91%.

3. Four yellow water traps (16 cm diameter) to identify species of flea beetles were placed on the ground at the trial corners at sowing and changed weekly until the first week of November. Catches were removed for identification. Weekly numbers of cabbage stem flea beetle and individual species of *Phyllotreta* spp. and other flea beetles were recorded separately.

4a. Plant counts were made at early cotyledon stage (GS 1.0 when most plants were at this stage). Plants were counted on 5 x 1 metre paired rows per plot at random marked positions. Row width was recorded; plant counts were expressed as numbers/m².

4b. Vigour was assessed visually at early cotyledon stage**.** Vigour was recorded on a 0 - 10 scale (0 = not emerged, 10 = even emergence, target plant population achieved, no stunting or phytotoxic effects e.g. cupping, marginal scorch). Because of the variable plant population at site 3, it was not possible to assess vigour in this manner.

5a. At the early second true leaf stage (GS 1.1 - 1.2 when most plants had reached this stage), plants were counted on 5 x 1 metre paired rows or where rows were not well defined using 10 x 0.5m x 0.5m quadrats per plot at random marked positions (see 4a above). Plant counts were expressed as numbers/m².

5b. Cabbage stem flea beetle and slug damage assessments were made on cotyledons and first true leaves from 10 plants from each of the five marked 1.0 metre rows or quadrat positions (50 plants per plot) at early second true leaf stage (GS 1.1 - 1.2) to record:

- percentage of plants attacked by cabbage stem flea flea beetles and slugs.
- percentage of cotyledon leaf area holed, notched or windowed by flea beetles.
- percentage of first true leaf area holed, notched or windowed by flea beetles.

6. In December, 10 plants per plot comprising two plants from each of the five marked lengths of row per plot were sampled (Ref: EPPO guideline PP 1/73(2)), to record the following for each plant:

a. Number of leaves > 2 cm
b. Number of petioles with scarring due to cabbage stem flea beetle larval attack.
c. Dissection of petioles to record numbers and size range of cabbage stem flea beetle larvae recovered. Small <2mm; medium 2-4 mm; large > 4 mm and total number of larvae recovered from each plant.
d. Plants infested with aphids.
e. Number of aphids on each plant.
f. Plants damaged by slugs.
g. Other pests including rape winter stem weevil (*Ceutorhynchus picitarsis)* larvae and numbers per plant if present; leaf miners *Phytomyza* spp., *Scaptomyza* spp.

7. Post winter plant count at start of stem elongation (sites 1 and 2 only).

8. Yield (sites 1 and 2 only) using small-plot combine with result expressed at 91% dry matter.

Statistical analysis

Using Minitab, data were subjected to Analysis of Variance in order to obtain the standard error of difference (SED) used to assess the significance of differences. Least significant differences (LSD) were calculated from t values for the appropriate degrees of freedom (n=27). Ref: EPPO Guideline on design and analysis of efficacy evaluation trials EPPO PP 1/152(2). Data for percentage values were transformed as required using angular transformation which were also subjected to an Analysis of Variance.

Results:

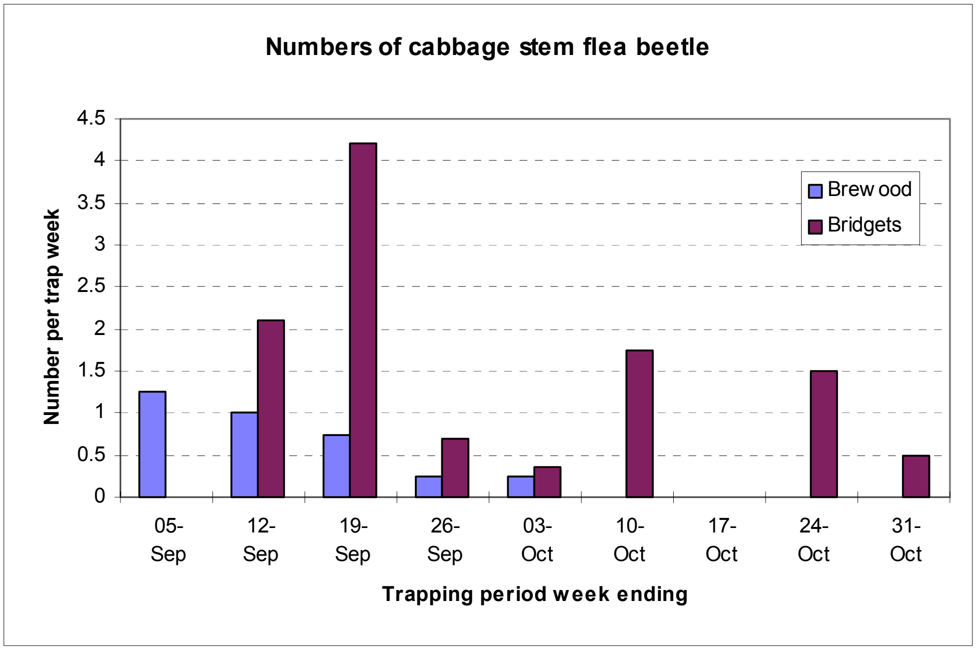
Table 1a. Mean numbers of cabbage stem flea beetles per water trap in autumn 2000 compared with nearest equivalent period in autumn 1999.

Site 1 Brewood, Staffordshire.

Date	Mean number per trap per week (autumn 2000)	Mean number per trap per week (autumn 1999)
04.09.00	1.25	5.0
11.09.00	1.0	7.75
18.09.00	0.75	4.0
25.09.00	0.25	3.75
02.10.00	0.25	1.25
10.10.00	0	1.0
16.10.00	0	2.5
23.10.00	0	0.5
30.10.00	0	1.0
06.11.00	0	1.0

Although the first adult cabbage stem flea beetles were trapped during the early stages of crop emergence in autumn 2000, total numbers were small and smaller than the catches for the equivalent periods in the previous autumn on the same farm. The period of adult activity was shorter in autumn 2000 compared with autumn 1999. The incidence of damage was less severe in 2000 than in the previous season on the same farm. No flea beetles (*Phyllotreta* spp.) were recovered from the traps.

Figure 1. Numbers of cabbage stem flea beetles caught in water traps in autumn 2000 at sites 1 and 2.



At sites 1 and 2, the first catches of cabbage stem flea beetle adults were made at early crop emergence although total catches for each site were lower than those made in the previous autumn. Peak activity was in early-mid September at site 1 (Brewood); earlier than the mid-September peak catches in water traps at site 2 (Bridgets).

Data are not presented for the later-drilled site 3 (Drayton) where the trial plots were emerging in late September/early October at a time of declining cabbage stem flea beetle activity. Ground-placed water traps caught only a single cabbage stem flea beetle adult during the autumn.

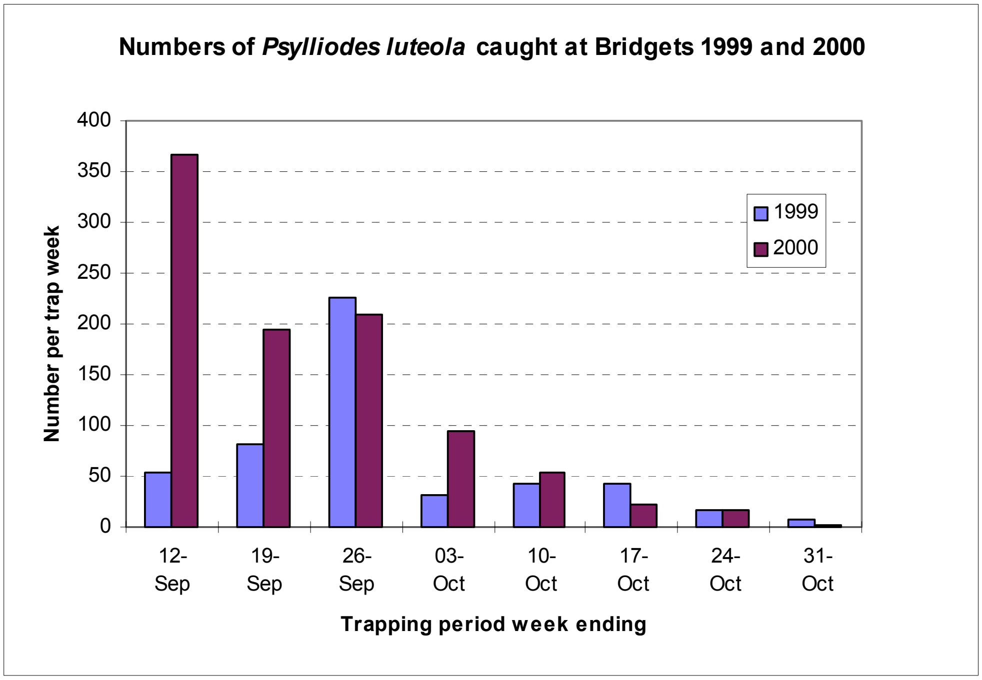
Table 1b. Mean numbers of cabbage stem flea beetles *Psylliodes chrysocephala* and *Psylliodes luteola* per trap per week in autumn 2000 and nearest equivalent period in the previous year.

Site 2 Bridgets, Hampshire.

Date w/e	Mean catch per trap per week (autumn 2000) *Psylliodes chrysocephala*	Mean catch per trap per week (autumn 1999) *Psylliodes chrysocephala*	Mean catch per trap per week (autumn 2000) *Psylliodes luteola*	Mean catch per trap per week (autumn 1999) *Psylliodes luteola*
12.09.00	2.1	19.0	367.5	83.5
19.09.00	4.2	5.5	195.3	229.0
26.09.00	0.7	1.0	208.6	32.5
03.10.00	0.35	1.0	93.8	42.0
10.10.00	1.75	1.5	54.6	41.0
17.10.00	0	6.0	21.7	15.0
24.10.00	1.5	0	17.5	0
31.10.00	0.5	0	2.1	-

Mean weekly catches of cabbage stem flea beetle at site 2 were lower than in the previous autumn although the timing for peak activity was similar.

Figure 2. Numbers of *Psylliodes luteola* caught in water traps at ADAS Bridgets and the nearest equivalent period in the previous season.



As in the previous season, high catches of the 'Weesex flea beetle' (*Psylliodes luteola*) were taken in the water traps. Peak activity in autumn 2000 coincided with early crop emergence, followed by a gradual decrease in numbers until late-October. *P. luteola* is described as a diverse feeder with the potential to damage oilseed rape. Previous damage on oilseed rape and herbage seed crops has been recorded in Wiltshire and Hampshire.

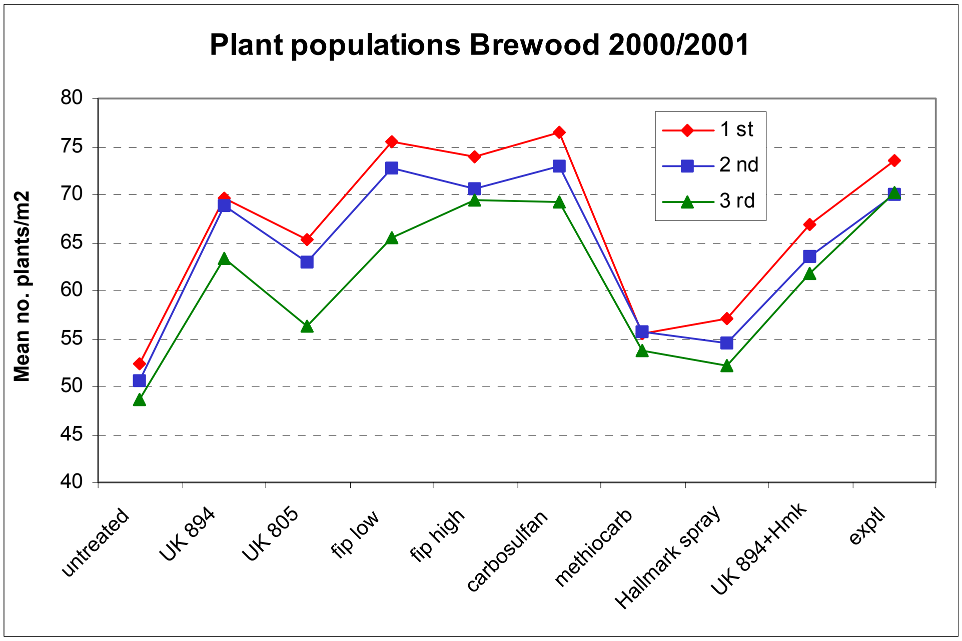
Table 2a. Mean numbers of plants/m² on 8.09.00, 22.09.00 and 21.02.01. Site 1 Brewood, Staffordshire.

Treatment	Mean number of plants/m² GS 1.0 08.09.2000	Mean number of plants/m² GS 1.1-1.2 22.09.2000	Mean number of plants/m² GS 1.12-1.14 21.02.2001
1. iprodione+thiram	52.4	50.6	48.6
2. iprodione+thiram + UK 894	69.6 **	68.8 **	63.4 **
3. iprodione+thiram + UK 805	65.2 *	63.0 *	56.2
4. iprodione+thiram + exptl. low rate	75.4 ***	72.8 ***	65.4 **
5. iprodione+thiram + exptl. high rate	74.0 ***	70.6 ***	69.4 ***
6. thiram + carbosulfan	76.4 ***	73.0 ***	69.2 ***
7. iprodione+thiram + methiocarb	55.4	55.6	53.8
8. iprodione+thiram + Hallmark	57.0	54.6	52.2
9. iprodione+thiram + UK894 + Hallmark	66.8 **	63.6 *	61.8 *
10. iprodione+thiram + exptl.	73.6 ***	70.0 ***	70.2 ***
df 27			
SED	5.18	5.20	5.08
LSD p = 0.05	10.64	10.67	10.42
CV %	11.0	8.1	11.8
F value treatment	5.85	4.93	4.77
F probability treatment	<0.001	0.001	0.001
F value block	3.35	2.30	0.91
F probability block	0.034	0.100	0.447

At the autumn assessments, all seed treatments with the exception of methiocarb significantly increased mean plant populations compared with the untreated means 52.4/m² and 50.6/m² on 8 and 22 September respectively. Plant populations fell slightly between the assessments on all treatments as shown also in Figure 3.

Where significant increases in mean plant numbers were obtained at the emergence and two-leaf stage assessments, percentage increases were in the range 24-46% and 25-44% respectively. Overall mean plant populations at the first, second and third counts were 66.6, 63.5 and 61.0/m² respectively. Similar small reductions in plant numbers overwinter between the assessment dates were obtained irrespective of the seed treatment applied. Significant regressions were obtained between the first and second counts ($p < 0.001$; r^2 92.1%) and the second and third counts ($p < 0.001$; r^2 33.3%). Appendix 4 shows the regression plot for the first and second plant counts. The significant relationship indicates that pest-related effects on plant population were most severe at early establishment and any subsequent attack had a negligible effect on plant numbers.

Figure 3. Plot of mean number of plants/m² for each of three assessment dates at site 1, Brewood.



Significant regressions (p<0.001) were obtained for the first versus the second plant counts (variance explained 92.1%) indicative of rapid and even plant establishment and pest activity during the establishment stage that was sufficiently severe to adversely affect plant numbers on untreated plots.

Mean plant populations at the second compared with the third assessment were also significantly (p<0.001) correlated with 33.3% of the variance explained.

The above plot shows a consistency of effect with the lowest plant populations on the untreated, methiocarb and lambda-cyhalothrin spray treatment. The effects from treatment UK 894 followed by the lambda-cyhalothrin spray was similar to UK 894 alone indicating that the main benefit from treatment was obtained during the early stages of crop establishment. There was a tendency for plant numbers to be slightly lower for UK 805 compared with UK 894.

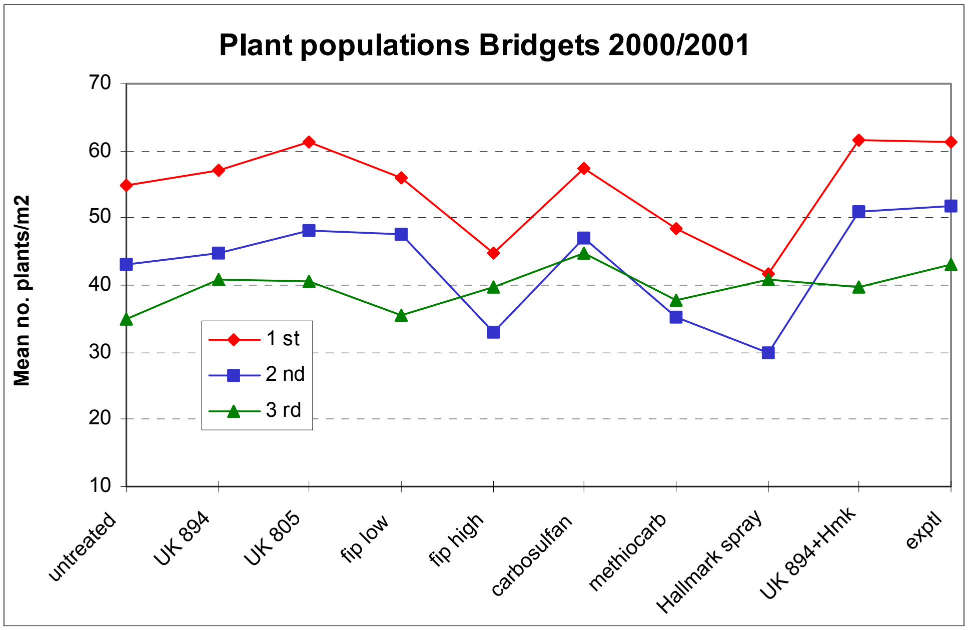
No phytotoxic effects of seed treatment compared with the untreated were observed.

Table 2b. Mean numbers of plants/m² on 12.09.00, 28.09.00 and 16.02.01. Site 2 Bridgets, Hampshire.

Treatment	Mean number of plants/m² 12.09.2000	Mean number of plants/m² 28.09.2000	Mean number of plants/m² 16.02.2001
1. iprodione+thiram	55.0	43.0	35.0
2. iprodione+thiram + UK 894	57.0	44.8	40.8
3. iprodione+thiram + UK 805	61.3	48.0	40.5
4. iprodione+thiram + exptl. low rate	56.0	47.5	35.5
5. iprodione+thiram + exptl. high rate	44.8	33.0	39.8
6. thiram + carbosulfan	57.3	47.0	44.8 *
7. iprodione+thiram + methiocarb	48.5	35.3	37.8
8. iprodione+thiram + Hallmark	41.7	30.0	40.8
9. iprodione+thiram + UK894 + Hallmark	61.5	50.8	39.8
10. iprodione+thiram + exptl.	61.3	51.8	43.0
df 27			
SED	7.25	6.72	4.70
LSD p = 0.05	14.87	13.79	9.64
CV %	18.8	22.1	16.7
F value treatment	1.90	2.61	0.83
F probability treatment	0.095	0.026	0.593
F value block	5.38	3.59	1.05
F probability block	0.005	0.026	0.385

At the establishment count made on 12 September, no significant differences were recorded for mean numbers of plants/m² compared with the untreated mean. The overall mean plant population declined from 54.4/m² to 43.1/m² (reduction of 27%) between the first and second assessments and followed by a further small reduction between the second and third assessments (overall mean 39.7 plants/m² at the latter) as shown graphically in Figure 4. An inconsistent treatment effect was noted at the second plant count. A significant regression was obtained for mean plant population at the first and second assessments (p =0.007; r^2 17.7%). Appendix 5 shows the regression plot for the first and second plant counts.

Figure 4. Plot of mean number of plants/m² for each of three assessment dates. Site 2 Bridgets.



Although the overall mean plant population decreased between the first and second counts, a significant (p=0.007) regression was obtained. The slightly higher plant populations noted at the first assessment were maintained on the imidacloprid UK 894 and UK 805 treatments; carbosulfan and by the experimental bifenthrin treatment 10. At the third assessment, the plant population was reasonably even across the trial with no treatment-related effects apparent.

The above figure shows a different effect of the treatments compared with site 1. At both sites, UK 894, carbosulfan and treatment 10 enhanced plant populations compared with untreated means. In contrast with results obtained at site 1, there was no indication of a lower plant population from UK 805 treatment compared with UK 894 at either the first or second assessment.

Table 2c. Mean numbers of plants/m² on 23.10.00 and 21.11.00.
Site 3 Drayton, Warwickshire.

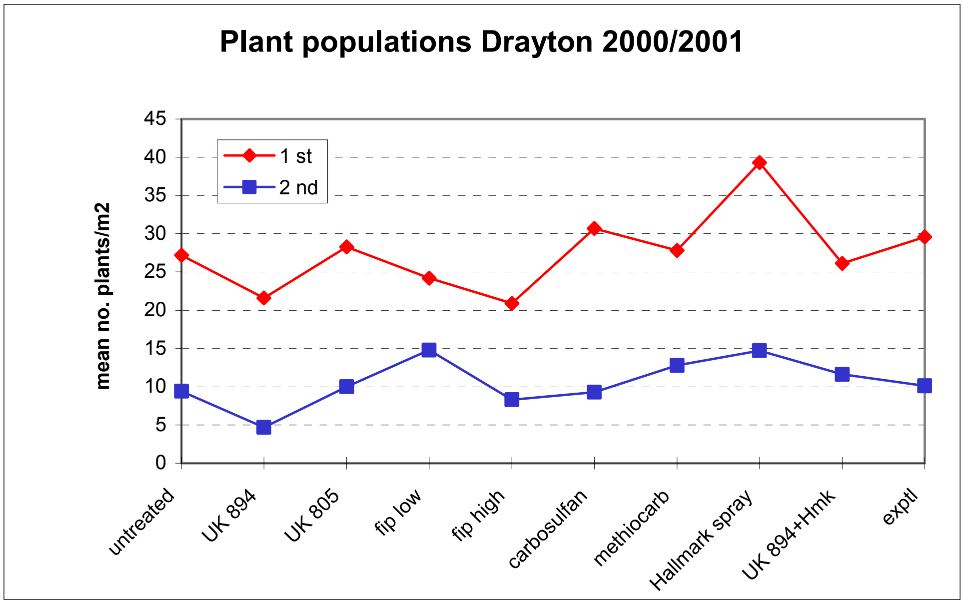
Treatment	Mean number of plants/m² 23.10.2000	Mean number of plants/m² 21.11.2000
1. iprodione+thiram	27.2	9.4
2. iprodione+thiram + UK 894	21.6	4.7
3. iprodione+thiram + UK 805	28.3	10.0
4. iprodione+thiram + exptl. low rate	24.2	14.8
5. iprodione+thiram + exptl. high rate	20.9	8.3
6. thiram + carbosulfan	30.7	9.3
7. iprodione+thiram + methiocarb	27.8	12.8
8. iprodione+thiram + Hallmark	39.3	14.7
9. iprodione+thiram + UK894 + Hallmark	26.1	11.6
10. iprodione+thiram + exptl.	29.6	10.1
df 27		
SED	9.89	3.65
LSD p = 0.05	20.28	7.48
CV %	50.7	48.8
F value treatment	0.56	1.41
F probability treatment	0.818	0.235
F value block	1.43	10.04
F probability block	0.256	<0.001

Crop emergence, first recorded on 29 September (16 days after drilling), was variable and not complete until the timing for the first plant count on 23 October. Mean plant populations were below the target of 50-60 plants/m² due to adverse seedbed conditions post drilling and the severity of slug damage. Drilling on 13 September was followed by 36 mm rain on 14 September with a total of more than 90 mm rain in the 12 day period post drilling. Met. data for the appropriate MORECs square indicates a total of 306 mm rain for the period September to November 2000; 185% of normal value.

At the second plant count made on 21 November, plants were unevenly distributed over the trial area and with many plants at cotyledon or first true leaf stages. Plant populations were under 5/m² on ten plots where the slug attack was most severe as indicated by refuge trapping using bran-baited traps. The decision was taken to abort the trial after completion of the appropriate damage assessments.

No treatment-related effects were discernible at either assessment. Weak relationships were obtained between mean plant populations on 23 October and 21 November and total catch of slugs in refuge traps (Appendices 7 and 8).

Figure 5. Plot of mean number of plants/m² for each of three assessment dates at site 3, Drayton.



The overall mean plant populations fell from 27.6/m² at the first assessment to 10.6/m² at the second when the plant population across the trial was very variable and unacceptably low (range for individual plots was 0-23.6 plants/m²). Despite this, a significant correlation ($p < 0.001$, r^2 28.2%) was obtained between the first and second counts. Appendix 6 shows the regression plot for the first and second plant counts.

Three bran-baited slug refuge traps per plot were set out on 27 November with the objective of assessing slug activity on two occasions on 6 and 13 December. Although no significant differences in total slug numbers were recorded, a weak non significant regression plot (Appendix 7) was obtained between plant population at the first assessment and total slug numbers in refuge traps. A significant regression plot (Appendix 8) was obtained between the mean plant population at the second assessment on 21 November and slug catches made on 6 December ($p=0.009$ with 16.6% of variance explained). Percentages of slugs damaged by slugs were also significantly correlated ($p=0.047$) with total number of slugs in refuge traps on 6 December (Appendix 9). Such regression calculations indicate that, in part, plant populations were determined by the high incidence of slug damage which was sufficiently severe to overwhelm the benefits obtained from seed treatment applications.

Table 3a. Mean scores for crop vigour on 8.09.00. 22.09.00 and 21.02.01. Site 1 Brewood.

Treatment	Mean vigour 8.09.00	Mean vigour 22.09.00	Mean vigour 21.02.01
1. iprodione+thiram	8.3	6.8	8.3
2. iprodione+thiram + UK 894	9.0	7.8 *	8.0
3. iprodione+thiram + UK 805	8.3	7.0	8.0
4. iprodione+thiram + exptl. low rate	8.8	7.8 *	8.5
5. iprodione+thiram + exptl. high rate	8.8	7.5	8.0
6. thiram + carbosulfan	9.3 *	7.5	8.0
7. iprodione+thiram + methiocarb	7.5	7.3	8.0
8. iprodione+thiram + Hallmark	8.0	6.8	8.0
9. iprodione+thiram + UK894 + Hallmark	8.5	7.3	8.0
10. iprodione+thiram + exptl.	8.3	7.5	8.0
df 27			
SED	0.41	0.41	0.17
LSD p = 0.05	0.85	0.83	0.34
CV %	6.9	7.9	2.9
F value treatment	3.07	1.65	2.08
F probability treatment	0.012	0.151	0.068
F value block	9.10	2.63	1.68
F probability block	0.000	0.071	0.195

Plots established evenly and only small differences in mean crop vigour scores were apparent at early crop emergence (see also Figure 6). Although only weak relationships were established between mean vigour scores for each assessment date, a significant regression plot was obtained between mean plant populations and vigour scores at the second assessment made at GS 1.1-1.2 on 22 September (Figure 7).

Figure 6. Plot for mean vigour scores for the three assessments at site 1, Brewood.

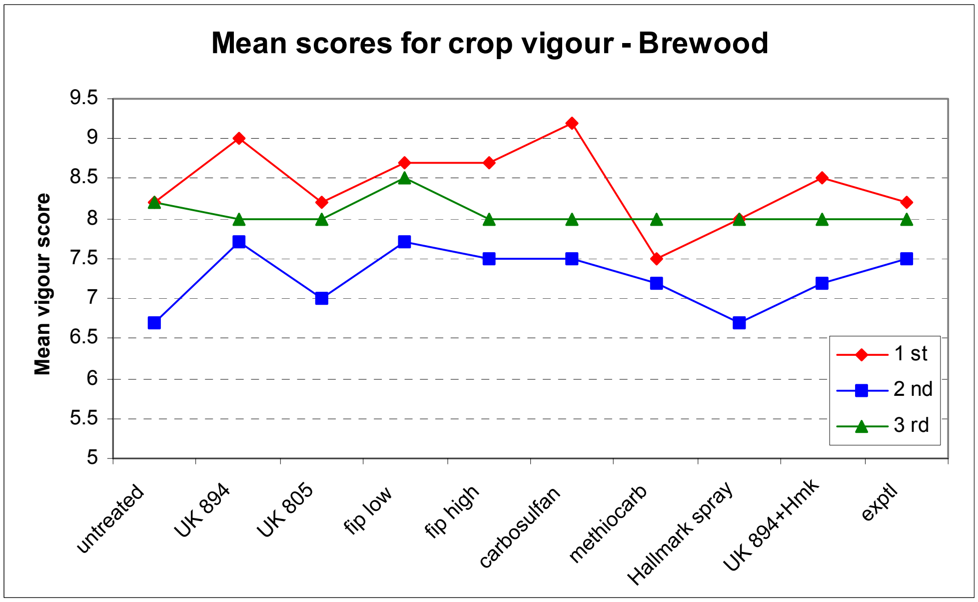
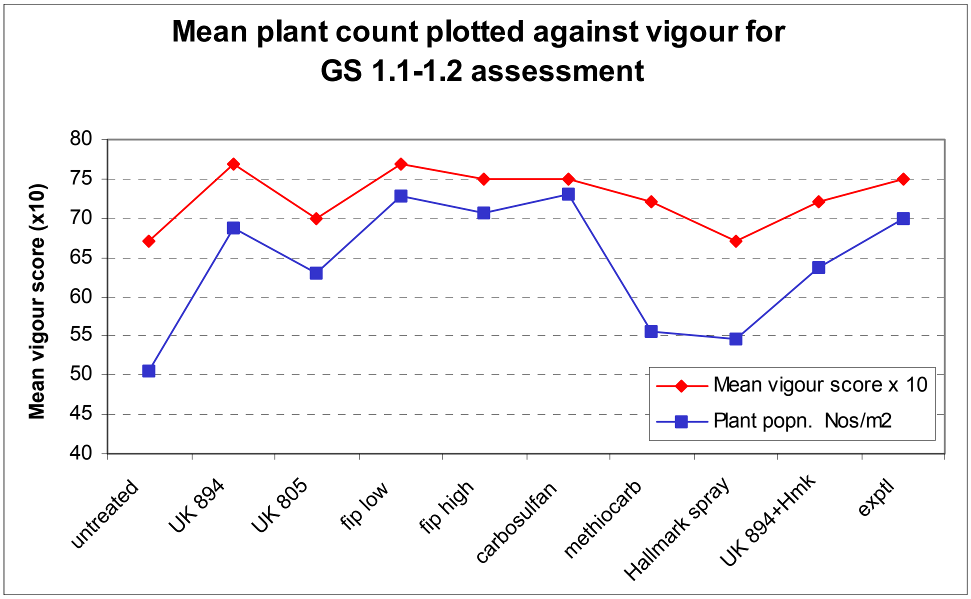


Figure 7. Plot for mean numbers of plants/m² against mean vigour score (n x10) for the GS 1.1-1.2 assessment at site 1, Brewood.



At the second assessment made at GS 1.1-1.2, mean crop vigour scores were significantly ($p<0.001$; r^2 33.7%) correlated with mean plant populations. The above plot is shown with data for vigour scores x10 for clarity.

Table 3b. Mean scores for crop vigour on 12.09.00 and 16.02.01. Site 2 Bridgets.

Treatment	Mean vigour 12.09.00	Mean vigour 16.02.01
1. iprodione+thiram	5.5	3.5
2. iprodione+thiram + UK 894	6.3	4.0
3. iprodione+thiram + UK 805	4.8	3.5
4. iprodione+thiram + exptl. low rate	4.8	3.5
5. iprodione+thiram + exptl. high rate	4.8	3.8
6. thiram + carbosulfan	5.3	3.8
7. iprodione+thiram + methiocarb	5.5	3.8
8. iprodione+thiram + Hallmark	6.3	3.5
9. iprodione+thiram + UK894 + Hallmark	6.0	4.0
10. iprodione+thiram + exptl.	6.5	4.0
df 27		
SED	0.60	0.33
LSD p = 0.05	1.24	0.67
CV %	15.3	12.4
F value treatment	2.51	0.90
F probability treatment	0.031	0.542
F value block	0.87	3.86
F probability block	0.468	0.020

Small but inconsistent non significant differences in crop vigour were recorded at the first assessment.

Table 4a. Mean % plants attacked by slugs and cabbage stem flea beetle adults at GS 1.1-1.2 on 22.09.00.
Site 1 Brewood.

Treatment	Mean % plants damaged by slugs	Ang. trans. Mean % pl. dam by slugs	Mean % plants damaged by csfb adults	Ang. trans. Mean % pl. dam by csfb
1. iprodione+thiram	30.0	32.8	11.5	19.3
2. iprodione+thiram + UK 894	14.0 **	21.8 *	10.0	18.0
3. iprodione+thiram + UK 805	13.5 **	18.4 **	8.0	15.7
4. iprodione+thiram + exptl. low rate	20.0	26.3	6.5	14.6
5. iprodione+thiram + exptl. high rate	25.0	29.9	8.5	14.3
6. thiram + carbosulfan	18.5	25.0	7.5	15.7
7. iprodione+thiram + methiocarb	13.5 **	21.5 *	13.5	21.2
8. iprodione+thiram + Hallmark	34.0	35.2	15.5	22.1
9. iprodione+thiram + UK894 + Hallmark	13.5 **	21.4 *	13.0	20.6
10. iprodione+thiram + exptl.	19.5	26.0	8.0	15.0
df 27				
SED	5.66	4.55	3.73	3.77
LSD p = 0.05	11.61	9.34	7.66	7.74
CV %	39.7	24.9	51.8	30.2
F value treatment	3.37	2.83	1.31	1.23
F probability treatment	0.007	0.018	0.278	0.320
F value block	3.60	2.68	8.01	6.96
F probability block	0.026	0.067	0.001	0.001

Mean percentage of plants damaged by slugs was significantly (p = 0.01) reduced by UK 894, UK 805 and methiocarb treatments compared with the untreated untransformed or transformed mean damage of 30.0% or 32.8% respectively, but with no significant differences between these treatments. The incidence of slug attack was reduced by 53-55% compared with the untreated mean 30.0% attack for those treatments that provided significant reductions in plant damage (see also Figure 8).

A low incidence of cabbage stem flea beetle adult feeding damage was not significantly reduced by any treatment compared with the untreated mean 11.5% damage. This result contrasts with that obtained in the first year of the experiment at this site, when a mean of 100% of plants on the untreated were damaged by cabbage stem flea beetle adults.

Figure 8. Plot showing mean percentage of plants damaged by slugs at site 1, Brewood at GS 1.1-1.2.

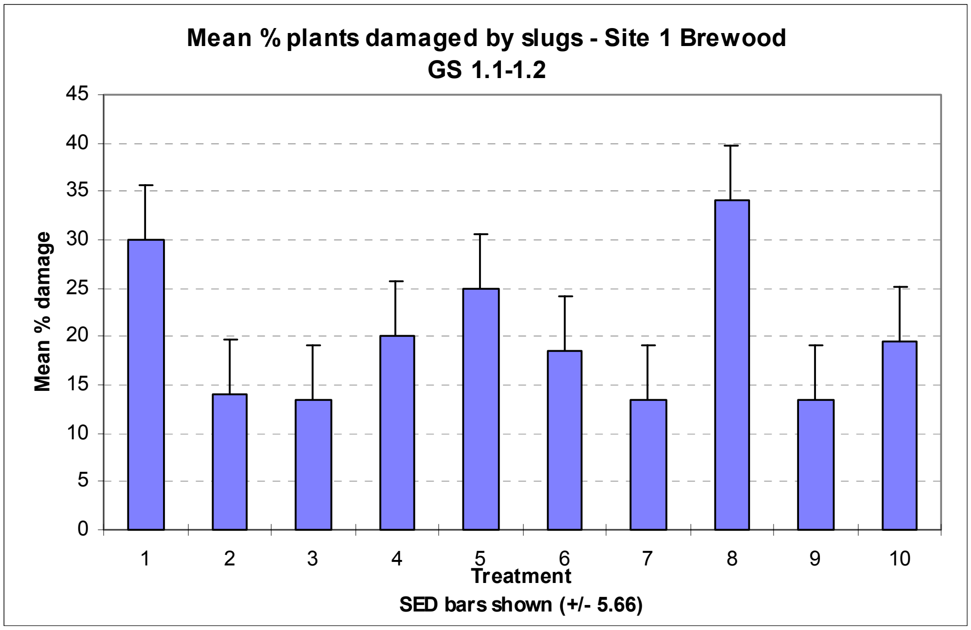


Table 4b. Mean % plants attacked by slugs and cabbage stem flea beetle adults at GS 1.2 on 28.09.00.
Site 2 Bridgets.

Treatment	Mean % plants damaged by slugs	Ang. trans. Mean % pl. dam by slugs	Mean % plants damaged by csfb adults	Ang. trans. Mean % pl. dam by csfb
1. iprodione+thiram	95.0	78.0	94.4	78.7
2. iprodione+thiram + UK 894	94.5	77.2	100.0	90.0 *
3. iprodione+thiram + UK 805	91.5	75.3	87.0 *	71.6
4. iprodione+thiram + exptl. low rate	91.5	73.8	97.2	83.2
5. iprodione+thiram + exptl. high rate	96.0	78.9	95.3	79.6
6. thiram + carbosulfan	91.9	75.8	93.2	77.8
7. iprodione+thiram + methiocarb	99.0	85.9	93.0	79.2
8. iprodione+thiram + Hallmark	95.5	79.8	98.3	84.8
9. iprodione+thiram + UK894 + Hallmark	96.0	80.3	96.5	82.9
10. iprodione+thiram + exptl.	94.4	76.8	94.1	78.2
df 27				
SED	3.11	4.83	2.82	4.21
LSD p = 0.05	6.39	9.90	5.78	8.64
CV %	4.7	8.7	4.2	7.4
F value treatment	1.17	1.00	3.21	2.73
F probability treatment	0.354	0.465	0.009	0.021
F value block	1.28	1.15	13.66	15.17
F probability block	0.300	0.346	<0.001	<0.001

A high and evenly-distributed incidence of slug damage was not significantly affected by any of the test treatments compared with the untreated mean.

A small but significant (p=0.05) reduction in cabbage stem flea beetle adult damage was obtained from UK 805 compared with the untreated mean.

Table 4c. Mean % plants attacked by slugs and cabbage stem flea beetle adults 23.10.00.
Site 3 Drayton

Treatment	Mean % plants damaged by slugs	Ang. trans. Mean % plants. damaged by slugs	Mean % plants damaged by csfb adults
1. iprodione+thiram	33.6	37.2	0
2. iprodione+thiram + UK 894	15.0	22.3	0
3. iprodione+thiram + UK 805	14.3	19.2	0
4. iprodione+thiram + exptl. low rate	23.6	27.6	0
5. iprodione+thiram + exptl. high rate	27.5	31.1	0
6. thiram + carbosulfan	24.8	29.8	0
7. iprodione+thiram + methiocarb	10.9	19.2	0
8. iprodione+thiram + Hallmark	12.1	20.0	0
9. iprodione+thiram + UK894 + Hallmark	12.9	20.3	0
10. iprodione+thiram + exptl.	12.9	20.4	0
df 27			
SED	19.08	9.84	-
LSD p = 0.05	39.15	20.20	-
CV %	39.2	24.2	-
F value treatment	0.39	0.82	-
F probability treatment	0.929	0.601	-
F value block	5.26	0.35	-
F probability block	0.005	0.790	-

Although there appeared to be a tendency for some treatments to provide reductions in the severity of slug attack, effects were inconsistent and not significant compared with the untreated mean.

Table 5a. Mean % plants infested with aphids and mean number of aphids per plant 13.12.00.
Site 1 Brewood

Treatment	Mean % plants infested with aphids	Ang % plants infested with aphids	Mean number of aphids per plant
1. iprodione+thiram	15.0	22.13	0.25
2. iprodione+thiram + UK 894	2.5 *	4.61 **	0.02
3. iprodione+thiram + UK 805	0 *	0 ***	0
4. iprodione+thiram + exptl. low rate	5.0	9.22 **	0.07
5. iprodione+thiram + exptl. high rate	7.5	11.25 **	0.72
6. thiram + carbosulfan	12.5	17.89	0.15
7. iprodione+thiram + methiocarb	12.5	17.89	0.12
8. iprodione+thiram + Hallmark	0 *	0 ***	0
9. iprodione+thiram + UK894 + Hallmark	0 *	0 ***	0
10. iprodione+thiram + exptl.	17.5	21.06	0.52
df 27			
SED	5.421	3.833	0.179
LSD p = 0.05	11.12	7.86	0.368
CV %	105.8	87.5	135.1
F value treatment	3.07	3.88	0.98
F probability treatment	0.012	0.003	0.481
F value block	3.33	3.26	1.26
F probability block	0.034	0.037	0.309

Effective and significant ($p<0.05$) reductions in mean percentages of plants infested with aphids were obtained from the imidacloprid (UK 894 and UK 805) treatments and by the lambda-cyhalothrin spray. The aphid infestation comprised peach-potato aphid (*Myzus persicae*) and mealy-cabbage aphid (*Brevicoryne brassicae*) forming 63% and 37% respectively of the total number of aphids recorded. The higher aphid population on treatment 5 was accounted for by a single colony of 27 mealy-cabbage aphids on one plant.

Aphid numbers were significantly ($p=0.001$) correlated with percentages of plants infested with aphids (r^2 27.1%). The calculated equation $y=5.35+10.1x$ where y = percentage of plants infested and x = number of aphids per plant, showed that an infestation of one aphid per plant would result in 15.4% plants infested.

Treatment with UK 894 reduced the aphid infestation by 83%; a similar reduction to the 90% reduction of a mean of 29.0% plant infestation obtained with this treatment in autumn 1999.

Figure 9. Plot showing mean percentage of plants infested with aphids at site 1, Brewood on 13 December 2000.

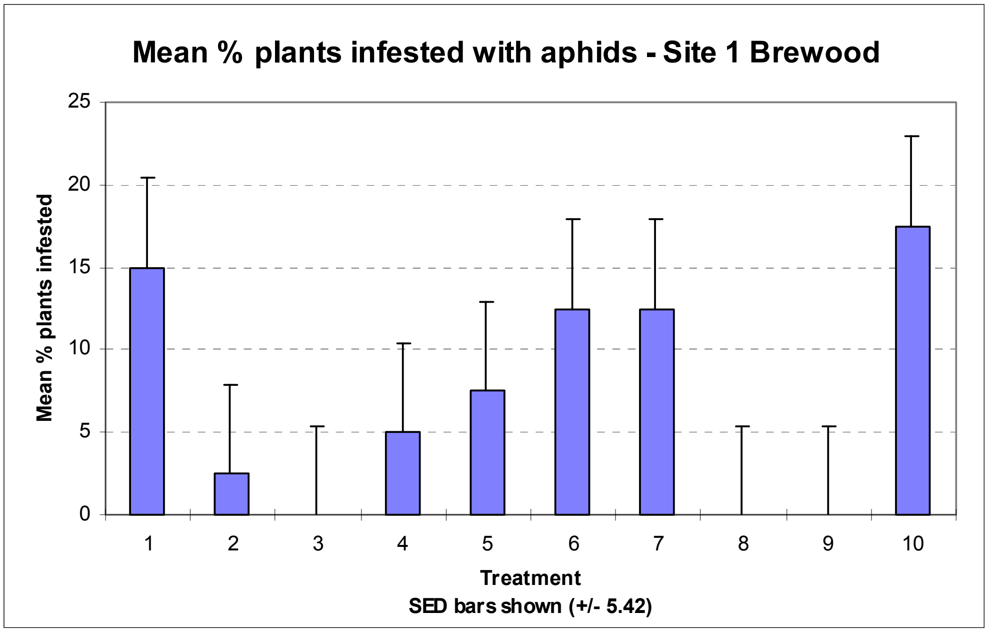


Table 5b. Mean % plants infested with aphids and mean number of aphids per plant 20.12.00.
Site 2 Bridgets

Treatment	Mean % plants infested with aphids	Ang % plants infested with aphids	Mean number of aphids per 10 plants
1. iprodione+thiram	5.0	6.64	1.50
2. iprodione+thiram + UK 894	2.5	4.61	0.25
3. iprodione+thiram + UK 805	2.5	4.61	0.25
4. iprodione+thiram + exptl. low rate	5.0	9.22	1.25
5. iprodione+thiram + exptl. high rate	7.5	11.25	0.75
6. thiram + carbosulfan	7.5	11.00	0.75
7. iprodione+thiram + methiocarb	7.5	11.25	0.75
8. iprodione+thiram + Hallmark	0	0	0
9. iprodione+thiram + UK894 + Hallmark	0	0	0
10. iprodione+thiram + exptl.	0	0	0
df 27			
SED	4.77	6.99	0.852
LSD p = 0.05	9.78	14.35	1.748
CV %	179.8	168.8	219.1
F value treatment	0.89	0.92	0.80
F probability treatment	0.550	0.523	0.623
F value block	1.08	1.11	1.91
F probability block	0.374	0.361	0.153

Although the imidacloprid UK 894 and UK 805 treatments, lambda-cyhalothrin spray and bifenthrin treatment 10 provided reductions in the mean percentage of plants infested with aphids, differences were not significant compared with the untreated mean 5.0%

Percentages of plants infested with aphids were significantly ($p<0.001$) correlated with number of aphids per plant which explained 65.9% of the variance. Substituting into the equation $y = 1.30 + 4.45 x$ where y = percentage plants infested and x = aphid number, indicates a 5.8% plant infestation from a mean of one aphid per 10 plants.

Table 6a. Mean % plants damaged by slugs at GS 1.8 on 13.12.00. Site 1 Brewood

Treatment	Mean % plants damaged by slugs 13.12.00	Ang mean % plants damaged by slugs 13.12.00
1. iprodione+thiram	40.0	39.1
2. iprodione+thiram + UK 894	30.0	32.9
3. iprodione+thiram + UK 805	35.0	35.4
4. iprodione+thiram + exptl. low rate	40.0	38.3
5. iprodione+thiram + exptl. high rate	35.0	32.3
6. thiram + carbosulfan	35.0	35.8
7. iprodione+thiram + methiocarb	47.5	43.5
8. iprodione+thiram + Hallmark	52.5	46.5
9. iprodione+thiram + UK894 + Hallmark	45.0	41.9
10. iprodione+thiram + exptl.	55.0	48.7
df 27		
SED	11.67	7.85
LSD p = 0.05	23.95	16.10
CV %	39.8	28.1
F value treatment	1.00	1.02
F probability treatment	0.462	0.450
F value block	7.20	6.89
F probability block	0.001	0.001

No significant differences in the mean percentage of plants damaged by slugs were obtained compared with the untreated mean 40.0% plant attack. This result contrasts with the significant reduction in slug damage obtained at the earlier assessment made at GS 1.1-1.2 (Table 4a).

Table 6b. Mean % plants damaged by slugs at GS 1.6-1.7 on 20.12.00. Site 2 Bridgets

Treatment	Mean % plants damaged by slugs 20.12.00	Ang mean % plants damaged by slugs 20.12.00
1. iprodione+thiram	85.0	70.5
2. iprodione+thiram + UK 894	97.5	85.4
3. iprodione+thiram + UK 805	97.5	85.4
4. iprodione+thiram + exptl. low rate	92.5	78.8
5. iprodione+thiram + exptl. high rate	100.0	90.0
6. thiram + carbosulfan	97.5	85.4
7. iprodione+thiram + methiocarb	90.0	77.1
8. iprodione+thiram + Hallmark	95.0	80.8
9. iprodione+thiram + UK894 + Hallmark	92.5	78.8
10. iprodione+thiram + exptl.	100.0	90.0
df 27		
SED	5.85	7.93
LSD p = 0.05	12.00	16.27
CV %	8.73	13.6
F value treatment	1.34	1.21
F probability treatment	0.265	0.330
F value block	0.62	0.48
F probability block	0.607	0.701

A similarly high incidence of slug damage was recorded to that at the earlier GS 1.2 assessment (Table 4b). No significant differences were obtained compared with the untreated mean.

Table 6c. Mean % plants damaged by slugs and second laboratory assessemnt of % plants damaged by cabbage stem flea beetle adults 21.11.00.
Site 3 Drayton

Treatment	Mean % plants damaged by slugs 21.11.00	Mean % plants damaged by csfb adults 21.11.00
1. iprodione+thiram	78.8	2.1
2. iprodione+thiram + UK 894	82.3	1.5
3. iprodione+thiram + UK 805	74.6	0.5
4. iprodione+thiram + exptl. low rate	90.4	3.1
5. iprodione+thiram + exptl. high rate	89.0	2.0
6. thiram + carbosulfan	86.4	0.8
7. iprodione+thiram + methiocarb	74.9	2.1
8. iprodione+thiram + Hallmark	67.0	10.3
9. iprodione+thiram + UK894 + Hallmark	81.8	2.6
10. iprodione+thiram + exptl.	79.4	2.3
df 27		
SED	8.44	2.77
LSD p = 0.05	17.33	5.69
CV %	14.9	144.8
F value treatment	1.44	1.97
F probability treatment	0.220	0.083
F value block	5.30	1.07
F probability block	0.005	0.083

No significant reductions were obtained for the severity of slug or cabbage stem flea beetle damage compared with the untreated means. Treatment 8 (Hallmark spray) had not been applied at the time of assessment. The apparently higher percentage plant damage on this treatment was explained by comparatively small numbers of plants (2 from a total of 8) showing slight damage to cotyledons of first true leaves on one plot (22) on which a low plant population of 5.6/m² was recorded.

Incidence of slug damage was variable with no significant treatment-related effects. A weak correlation, plotted in Appendix 9, was identified between mean percentage of plants damaged by slugs and the total number of slugs in refuge traps ($p=0.047$, r^2 10.0%).

Table 7a. Mean % area of cotyledons and first true leaf damaged by cabbage stem flea beetle adults 22.09.00.
Site 1. Brewood

Treatment	Mean % cotyledon area damaged by csfb adults 22.09.00	Mean % leaf 1 area damaged by csfb adults 22.09.00
1. iprodione+thiram	0.06	0.01
2. iprodione+thiram + UK 894	0.03	0.05
3. iprodione+thiram + UK 805	0.07	0.01
4. iprodione+thiram + exptl. low rate	0.06	0
5. iprodione+thiram + exptl. high rate	0.08	0
6. thiram + carbosulfan	0.04	0.01
7. iprodione+thiram + methiocarb	0.08	0.01
8. iprodione+thiram + Hallmark	0.09	0.06
9. iprodione+thiram + UK894 + Hallmark	0.08	0.01
10. iprodione+thiram + exptl.	0.07	0.01
df 27		
SED	0.033	0.029
LSD p = 0.05	0.068	0.059
CV %	67.1	205.0
F value treatment	0.72	1.11
F probability treatment	0.688	0.389
F value block	1.09	2.51
F probability block	0.371	0.080

Following the low incidence of cabbage stem flea beetle activity in autumn 2000, subsequent damage to cotyledons and the first true leaf was slight and too low to discern significant treatment-related effects. The 2000 data contrast with those obtained in 1999 when a higher incidence of damage to cotyledons and leaf one (untreated means 4.3% and 11.8% respectively) were obtained.

Table 7b. Mean % area of cotyledons and first true leaf damaged by cabbage stem flea beetle adults 28.09.00.
Site 2. Bridgets

Treatment	Mean % cotyledon area damaged by csfb adults 28.09.00	Mean % leaf 1 area damaged by csfb adults 28.09.00
1. iprodione+thiram	5.0	6.9
2. iprodione+thiram + UK 894	3.3	4.9
3. iprodione+thiram + UK 805	2.4	4.4
4. iprodione+thiram + exptl. low rate	2.9	5.3
5. iprodione+thiram + exptl. high rate	4.1	4.4
6. thiram + carbosulfan	5.4	6.5
7. iprodione+thiram + methiocarb	4.0	6.0
8. iprodione+thiram + Hallmark	4.5	5.3
9. iprodione+thiram + UK894 + Hallmark	3.3	5.6
10. iprodione+thiram + exptl.	3.2	4.9
df 27		
SED	1.11	3.53
LSD p = 0.05	2.28	7.25
CV %	41.2	18.2
F value treatment	1.47	0.98
F probability treatment	0.211	0.477
F value block	13.12	95.55
F probability block	<0.001	<0.001

The incidence of damage to cotyledons and leaf one was greater than at site 1. No significant differences were recorded compared with untreated means for either cotyledons or first true leaf, although an indication of a reduction in severity of damage to cotyledons of 30-50% was obtained from the most effective seed treatments.

Table 8a. Mean % area of cotyledons and first true leaf damaged by slugs 22.09.00.
Site 1 Brewood

Treatment	Mean % cotyledon area damaged by slugs 22.09.00	Mean % leaf 1 area damaged by slugs 22.09.00
1. iprodione+thiram	1.74	0.70
2. iprodione+thiram + UK 894	0.67 *	0.09
3. iprodione+thiram + UK 805	0.29 **	0.19
4. iprodione+thiram + exptl. low rate	1.37	0.40
5. iprodione+thiram + exptl. high rate	1.20	0.18
6. thiram + carbosulfan	0.66 *	0.14
7. iprodione+thiram + methiocarb	0.87 *	0.35
8. iprodione+thiram + Hallmark	1.87	0.34
9. iprodione+thiram + UK894 + Hallmark	0.66 *	0.42
10. iprodione+thiram + exptl.	1.05	0.36
df 27		
SED	0.434	0.302
LSD p = 0.05	0.870	0.620
CV %	57.7	131.2
F value treatment	2.85	0.69
F probability treatment	0.017	0.710
F value block	1.20	4.59
F probability block	0.329	0.010

Although damage was slight, significant reductions in mean percentage damage to cotyledons were obtained from the imidacloprid + beta-cyfluthrin (UK 894 and UK 805), carbosulfan and methiocarb treatments, compared with the untreated mean 1.74% damage.

Table 8b. Mean % area of cotyledons and first true leaf damaged by slugs 28.09.00.
Site 2 Bridgets

Treatment	Mean % cotyledon area damaged by slugs 28.09.00	Mean % leaf 1 area damaged by slugs 28.09.00
1. iprodione+thiram	28.4	28.1
2. iprodione+thiram + UK 894	26.1	27.0
3. iprodione+thiram + UK 805	34.8	24.5
4. iprodione+thiram + exptl. low rate	33.8	27.0
5. iprodione+thiram + exptl. high rate	29.1	29.4
6. thiram + carbosulfan	25.3	28.9
7. iprodione+thiram + methiocarb	33.0	30.6
8. iprodione+thiram + Hallmark	32.3	23.0
9. iprodione+thiram + UK894 + Hallmark	26.8	25.8
10. iprodione+thiram + exptl.	22.6	30.2
df 27		
SED	7.72	3.53
LSD p = 0.05	15.83	7.25
CV %	37.4	18.2
F value treatment	0.56	0.98
F probability treatment	0.814	0.477
F value block	16.99	95.55
F probability block	<0.001	<0.001

No significant treatment-related effects were observed.

Table 8c. Mean % area of cotyledons and first true leaf damaged by slugs on 21.11.00.
Site 3 Drayton

Treatment	Mean % cotyledon area damaged by slugs 21.11.00	Mean % leaf 1 area damaged by slugs 21.11.00
1. iprodione+thiram	51.9	42.5
2. iprodione+thiram + UK 894	48.4	11.9
3. iprodione+thiram + UK 805	51.3	21.9
4. iprodione+thiram + exptl. low rate	61.4	23.2
5. iprodione+thiram + exptl. high rate	60.6	23.4
6. thiram + carbosulfan	52.3	17.4
7. iprodione+thiram + methiocarb	47.2	16.4
8. iprodione+thiram + Hallmark	31.1	15.5
9. iprodione+thiram + UK894 + Hallmark	50.4	18.9
10. iprodione+thiram + exptl.	46.7	21.9
df 27		
SED	13.58	10.96
LSD p = 0.05	27.87	22.48
CV %	38.3	72.7
F value treatment	0.76	1.16
F probability treatment	0.652	0.360
F value block	0.58	1.46
F probability block	0.633	0.248

A severe slug attack developed at this site which resulted in complete destruction of cotyledons and the first true leaf on many plants. None of the treatments provided significant reductions in damage compared with untreated means.

Table 9a. Mean number of cabbage stem flea beetle larvae per plant and mean number of leaves scarred 13.12.00.
Site 1 Brewood

Treatment	Mean number of cabbage stem flea beetle larvae per plant 13.12.00	Mean number of csfb scarred leaves per plant 13.12.00
1. iprodione+thiram	0.12	0.15
2. iprodione+thiram + UK 894	0.02	0.02
3. iprodione+thiram + UK 805	0.02	0.12
4. iprodione+thiram + exptl. low rate	0 *	0.07
5. iprodione+thiram + exptl. high rate	0 *	0.02
6. thiram + carbosulfan	0 *	0.02
7. iprodione+thiram + methiocarb	0.15	0.15
8. iprodione+thiram + Hallmark	0 *	0.02
9. iprodione+thiram + UK894 + Hallmark	0 *	0.02
10. iprodione+thiram + exptl.	0 *	0
df 27		
SED	0.052	0.089
LSD p = 0.05	0.107	0.182
CV %	224.6	201.0
F value treatment	2.37	0.85
F probability treatment	0.040	0.575
F value block	0.42	0.57
F probability block	0.742	0.642

Following the low incidence of adult cabbage stem flea beetle activity, the larval infestation was slight and resulted in little leaf scarring damage. There was an indication that damage was reduced by all seed treatments with the exception of methiocarb and by the lambda-cyhalothrin spray. Reductions in larval numbers were in the range 83-100%.

There was tendency for the incidence of leaf scarring to be reduced from the treatments that provided reductions in larval numbers.

Table 9b. Mean number of cabbage stem flea beetle larvae per plant and mean number of leaves scarred 20.12.00.
Site 2 Bridgets

Treatment	Mean number of cabbage stem flea beetle larvae per plant 20.12.00	Mean number of csfb scarred leaves per plant 20.12.00
1. iprodione+thiram	2.18	2.73
2. iprodione+thiram + UK 894	1.70	3.30
3. iprodione+thiram + UK 805	2.03	3.08
4. iprodione+thiram + exptl. low rate	1.25	2.13
5. iprodione+thiram + exptl. high rate	2.38	3.28
6. thiram + carbosulfan	1.50	2.95
7. iprodione+thiram + methiocarb	1.13 *	2.53
8. iprodione+thiram + Hallmark	0.95 *	2.10
9. iprodione+thiram + UK894 + Hallmark	0.60 **	2.13
10. iprodione+thiram + exptl.	0.83 **	2.28
df 27		
SED	0.478	0.461
LSD p = 0.05	0.981	0.945
CV %	46.6	24.6
F value treatment	3.19	2.20
F probability treatment	0.009	0.055
F value block	0.95	4.45
F probability block	0.429	0.012

Methiocarb and bifenthrin (treatment 10) provided significant reductions in larval damage compared with the untreated mean 2.18 larvae per plant. Reductions in damage were similar to those obtained from the lambda-cyhalothrin spray.

Only small and non significant reductions were obtained from UK 805 and UK 894 treatments.

Table 10. Mean yield t/ha @ 91% dry matter.
Sites 1 and 2

Harvest dates:
Site 1 Brewood 29 July 2001
Site 2 Bridgets 26 July 2001

Treatment	Mean yield t/ha @ 91% dm	Mean yield t/ha @ 91% dm
1. iprodione+thiram	3.46	5.29
2. iprodione+thiram + UK 894	2.98	5.48
3. iprodione+thiram + UK 805	3.33	5.50
4. iprodione+thiram + exptl. low rate	3.42	5.39
5. iprodione+thiram + exptl. high rate	3.29	4.85
6. thiram + carbosulfan	3.12	5.28
7. iprodione+thiram + methiocarb	3.24	4.69
8. iprodione+thiram + Hallmark	3.10	5.35
9. iprodione+thiram + UK894 + Hallmark	3.02	5.13
10. iprodione+thiram + exptl.	3.10	5.25
df 27		
SED	0.168	0.328
LSD p = 0.05	0.344	0.674
CV %	7.4	8.9
F value treatment	2.00	1.29
F probability treatment	0.079	0.288
F value block	36.72	4.55
F probability block	<0.001	0.010

Mean yield was not significantly increased at either of the two sites taken through to yield. This was an interesting result, particularly at site 1 (Brewood) where most treatments led to significant increases in plant population (Table 2a). These data contrast with the previous year when a tendency towards increased yield was recorded at this site following a heavier attack from cabbage stem flea beetle larvae.

Discussion:

Plant populations:
At site 1 (Brewood), plant numbers were significantly increased from all seed treatments with the exception of methiocarb. Where significant increases from treatments were obtained for plant numbers at the crop emergence and GS 1.2 assessments, increases were in the range 24-46%. However, the increased mean plant populations were not subsequently translated into a yield benefit. Effects at the other sites were inconsistent, as noted also in the first year of this study.

Cabbage stem flea beetle monitoring:
As in the first year of the experiment, the first catches of adult cabbage stem flea beetles were recorded in water traps in the two August-drilled trials during the early stages of crop emergence. The traps provided a good indication of the timing of first migration into the crops. Catches were smaller than in the previous year. In autumn 2000, the highest weekly totals in traps were recorded in early to mid September comprising 1.25 and 4.2 per week at sites 1 and 2 respectively, equivalent to only 16% and 22% of the maximum weekly catch in the previous autumn in trials located on the same farms. DEFRA-funded surveys of pest incidence in winter oilseed rape also indicated smaller mean numbers of cabbage stem flea beetle larvae of 0.37 per plant in 2001 compared with 0.48 per plant in the previous year.

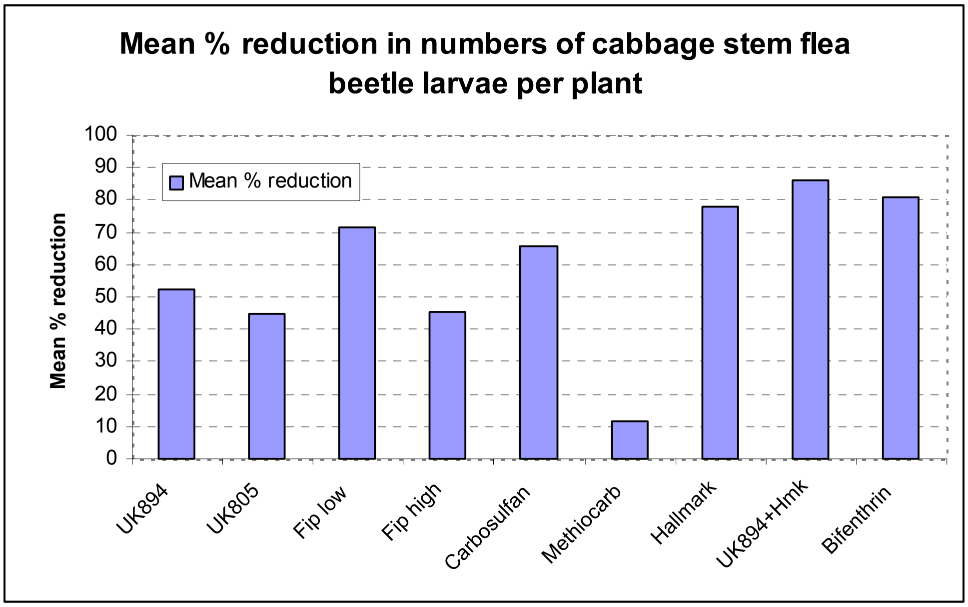
Cabbage stem flea beetle adult damage:
At site 1, a low incidence of cabbage stem flea beetle adult damage was recorded with a mean 11.5% plant attack at the one-two leaf stage. Following the higher incidence of adult activity at site 2, the plant attack was also greater with a mean of 94.4% plants damaged at the two leaf stage. A small but significant reduction in the severity of plant damage was obtained at site 2.

Cabbage stem flea beetle larval damage:
In the first year of the study, numbers of cabbage stem flea beetle larvae were significantly reduced at one site by gamma-HCH, fipronil and imidacloprid + beta-cyfluthrin with reductions in the range 30-44% compared with the untreated mean 5.8 larvae per plant. Treatments were shown to significantly reduce numbers of medium sized (2-4 mm) and large (>4 mm in length) larvae but to have no effects against later-autumn invading small (<2 mm) larvae. This indicates that benefits from reductions in larval numbers would depend on the timing of plant invasion by larvae hatching from eggs laid in the soil. Across the three trials in the series in year 1, mean percentage reductions in larval numbers were 42% from imidacloprid + beta-cyfluthrin (UK 805), 23% from gamma-HCH and 36-40% from fipronil.

In the second year at one site, a low incidence of larval damage (mean 0.12 larvae per plant on the untreated) was reduced by all seed treatments except methiocarb and by the lambda-cyhalothrin spray. Reductions were in the range 83-100% contrasting with the much smaller percentage reductions in damage at site 2. No damage was recorded at the third, later-drilled site. Across the two trials where larval infestations were assessed, imidacloprid + beta-cyfluthrin as UK 894 reduced larval numbers by a mean of 52%; UK 805 containing the higher-rate of imidacloprid reduced numbers by 45%. Reductions in larval numbers for other products were in the range 11.5%

(methiocarb) to 86.0% (UK 894 followed by the autumn pyrethroid spray) as summarised in Figure 10.

Figure 10. Mean percentage reduction in mean numbers of cabbage stem flea beetle larvae per plant across two sites in harvest year 2001.



Similar reductions in damage were obtained from the lambda-cyhalothrin spray irrespective of whether an earlier seed treatment had been applied.

Slug damage:

A moderate incidence in slug damage was recorded at site 1 (Brewood) at which significant reductions in slug damage were obtained and where useful and consistent data on reductions in slug damage from seed treatment usage were obtained. Reductions in the mean percentage of plants damaged by slugs were obtained from imidacloprid (applied at 2.0 or 10.0 g a.i. per kg seed in UK894 or UK805 respectively) and methiocarb seed treatments. These treatments reduced the incidence of slug damage by 53-55% compared with the untreated mean 30.0% plant damage (see Table 4a and summary Figure 8).

At site 2 (Bridgets), slug damage was recorded by late September at GS 1.02 on a mean of 95.0% of plants on the untreated. The incidence of slug damage was not significantly reduced by any treatment indicating that the main benefits from seed treatment usage are likely to be obtained at sites with a more marginal incidence of slug attack such as that recorded at site 1 (Brewood). At this site, significant reductions in the mean percentage of cotyledon area damaged by slugs at GS 1.1-1.2 were obtained from UK 894, UK 805, carbosulfan and methiocarb seed treatments (Table 8a).

At site 3 (Drayton), on a clay soil on which crops can be prone to slug damage, a severe attack developed on a later-drilled site that adversely affected crop establishment. Plant stand, although not significantly influenced by the seed treatment applied, was significantly correlated with numbers of slugs in refuge traps introduced to the site to monitor slug activity during the wet autumn conditions. At this site, the importance of slug damage to establishing winter oilseed rape was also conclusively demonstrated in TALISMAN studies (funded by MAFF). Slug damage in two winter oilseed rape crops (one at Drayton) on clay soils, from a total of six oilseed rape crops drilled, had been sufficiently severe to result in crop destruction that required re-drilling.

Aphids:
The incidence of aphid infestation was lower in autumn 2000 than in the previous year with means of 15.0% and 5.0% of plants infested at Brewood and Bridgets respectively compared with 29% of plants infested on the untreated at Brewood in autumn 1999. At both sites in harvest year 2001, the aphid infestation predominantly comprised peach-potato aphid (*Myzus persicae*). A lower aphid incidence on winter oilseed rape was also noted in autumn 2000 in a MAFF-funded survey in which *M. persicae* was recorded in 14% of surveyed fields compared with 26% in autumn 1999. Equivalent data for mealy-cabbage aphid (*Brevicoryne brassicae*) were 8% and 34% of sites in autumn 2000 and 1999 respectively.

In 2001, the level of aphid infestation at site 1 was significantly reduced by the two seed treatments containing imidacloprid (UK 805 and UK 894) and by the lambda-cyhalothrin spray (see Table 5a and summary Figure 9). The reduction in percentage of plants infested with aphids from imidacloprid seed treatment was similar to the reduction obtained at one site in the pilot study. Reductions in aphid numbers would also be expected to provide benefits from lower infection from aphid-vected Beet Western Yellow Virus. Imidacloprid is known to provide effective suppression of aphids in cereal crops and of peach-potato aphid in sugar beet.

Yields:
Significant increases in plant populations were recorded at site 1 in the autumn and late-winter and some significant reductions in the incidence of slug damage, cabbage stem flea beetles and aphids were also obtained. Despite this, yield was not improved by any of the treatments compared with the untreated mean 3.46 t/ha (Table 10). This result contrasts with those obtained in year one of the study, when a trend towards improved yield was obtained from treatments that provided significant reductions in cabbage stem flea beetle larval numbers. Yield responses to treatment were not obtained at site 2 compared with the untreated mean 5.29 t/ha.

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Appendix 1. Site details and crop husbandry.
Site 1. Brewood.

Site	Farm	Oakley Farm, Brewood, Staffordshire
	Field	Oakley
	Grid ref:	SJ 863089
Previous cropping	1999/2000	Winter barley
Soil analysis:	pH	7.4
(2000)	Phosphorous	41 mg/1 (Index 3)
	Potassium	114 mg/l (Index 1)
	Magnesium	64 mg/1 (Index 2)
Cultivations:	Sub soiled	
	Cultivated	August 2000
	Drilled – trial (Wintersteiger)	25 August 2000
Soil conditions at drilling:	Firm and dry followed by showery rain on 26-28 August	
Emergence:	Chitting	28 August 2000
	Full emergence on all plots	By 4 September 2000
Harvest	Sampo plot harvester	29 July 2001
Pesticide applications:		
Herbicides	Butisan S 1.0 l/ha	Pre emergence
	Fusilade 0.75 l/ha	October
Fungicides	Compass 2.0 l/ha	mid-May
Insecticide	None to trial area other than experimental treatments	
	Metaldehyde (Mini Slug Pellets)	In seedbed of field crop
Molluscicide	6.0 kg/ha	
Desiccant	Reglone	16 July 2001
Fertiliser:	N 100 kg/ha	mid March
	100 kg/ha	late March
	P none	
	K 75 kg/ha	January

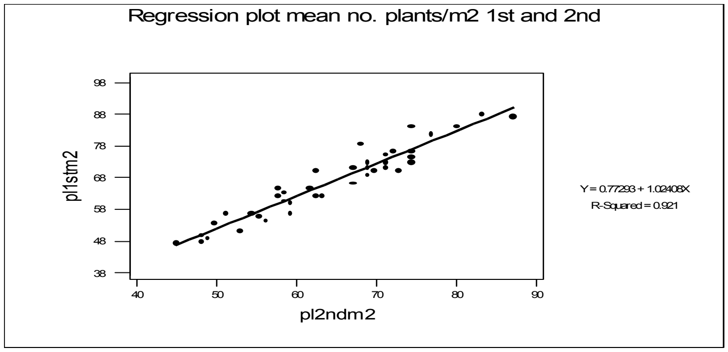
Appendix 2. Site details and crop husbandry.
Site 2. Bridgets.

Site:	Farm	ADAS Bridgets, Martyr Worthy, Hampshire
	Field	Oklahoma
Previous cropping	1999/2000	Winter barley
Soil analysis:	pH	7.8
(2000)	Phosphorous	39 mg/1
	Potassium	122 mg/l
	Magnesium	57 mg/1
Cultivations:	Plough/press	19.08.00
	Drilled – trial (Combi drill)	29.08.00
	Cambridge roll	30.08.00
Soil conditions at drilling:	Fine/firm/moist	
Harvest		26 July 2001
Pesticide applications:		
Herbicides	Katamaran 2.1 l/ha	31.08.00
	Fortrol 0.95 l/ha	20.01.01
Fungicides	Punch 2 x0.3l/ha	23.10.00, 14.02.01
Insecticide	None to trial area other than experimental treatments	
	Metaldehyde (Metarex Green)	13.09.00
Molluscicide	7.4 kg/ha	
Desiccant	Glyphosate 2.0 l/ha + Kandu (adjuvant)	15.07.01
Fertiliser:	N 34.5% 125 kg/ha	13.10.00
	N:P:K 0:20:30 217 kg/ha	13.01.01
	Sulphan	26.02.01, 03.04.01

Appendix 3. Site details and crop husbandry.
Site 3. Drayton.

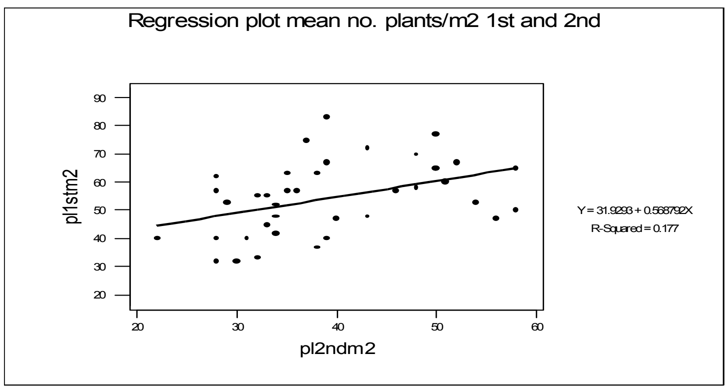
Site:	Farm	ADAS Drayton, Warwickshire
	Field	Field 37
	Grid ref:	SP 165555
Previous cropping	1999/2000	Winter wheat
Soil type	Clay	
Soil analysis:	pH	7.7
(2000)	Phosphorous	21 mg/1
	Potassium	429 mg/l
	Magnesium	253 mg/1
Cultivations:	Plough	10.09.00
	Power harrow x 3 times	11.09.00
	Power harrow x1	12.09.00
	Drilled – trial (Wintersteiger) drill)	13.09.00
	Flat roll	13.09.00
Soil conditions at drilling:	Slightly cloddy, dry followed by heavy rain	
Pesticide applications:		
Insecticide	None to trial area other than experimental treatments	
Molluscicide	Methiocarb (Draza) 5.5 kg/ha	03.10.00
Fertiliser:	None applied.	

Appendix 4. Regression plot for mean number of plants/m² at first and second assessments for site 1 Brewood.



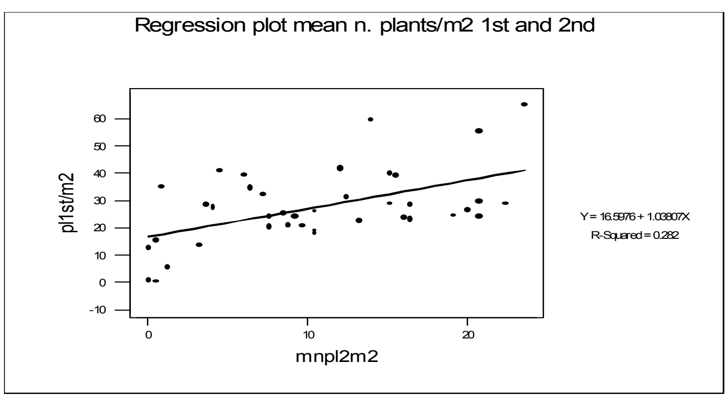
P = < 0.001 r² 92.1%

Appendix 5. Regression plot for mean number of plants/m² at first and second assessments for site 2 Bridgets.



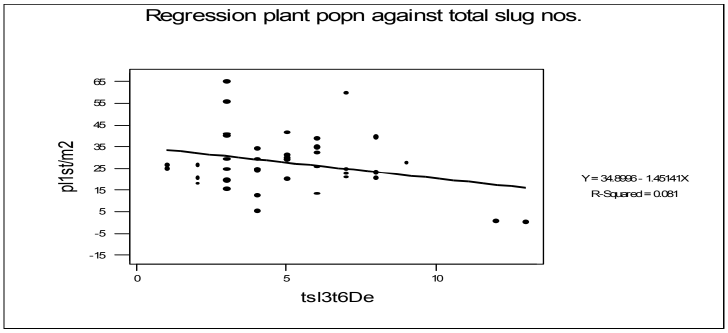
p = 0.007; r² 17.7%

Appendix 6. Regression plot for mean number of plants/m² at first and second assessments for site 3 Drayton.



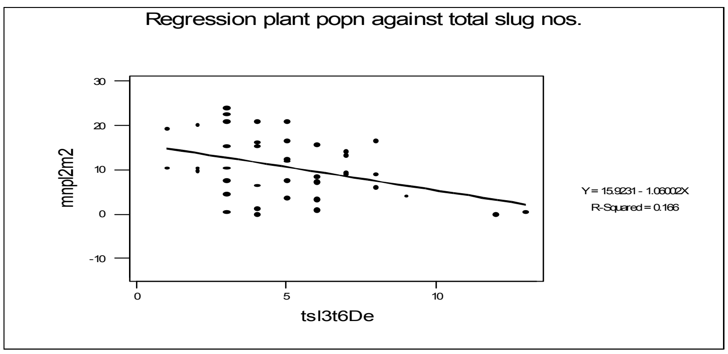
p = <0.001; r² 28.2%

Appendix 7. Regression plot for first plant count on 23.10.00 and total number of slugs in refuge traps at site 3 Drayton.



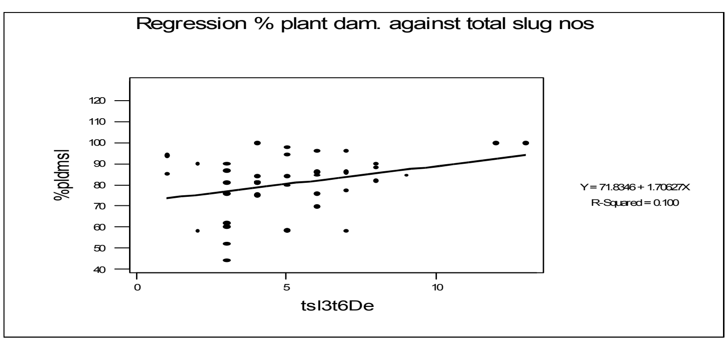
p=0.075; r^2= 8.1%

Appendix 8. Regression plot for second plant count on 21.11.00 and total number of slugs in refuge traps at site 3 Drayton.



p=0.009; r^2 =16.6%

Appendix 9. Regression plot for mean % plants damaged by slugs on 21.11.00 and total number of slugs in refuge traps at site 3 Drayton on 6.12.00.



p=0.047; r^2 =10.0%