HDC Project FV 208a

FINAL REPORT

Brassicas: Effectiveness of new compounds on aphid control in transplanted crops and compatibility of seed treatments for aphid and cabbage root fly control.

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SCOPE AND OBJECTIVE

As a result of the MAFF review of anticholinesterase compounds, it is likely that the use of some OP and carbamate insecticides will be revoked within the next few years. Effective alternatives will be required for brassica pest control. Triazamate and imidacloprid have shown considerable potential as aphicides. The aim of the project is to:

1. Evaluate the effectiveness and persistence of imidacloprid seed treatments and foliar sprays of triazamate, as part of a programme of aphid control on Brussels sprouts.

2. Evaluate the effectiveness and persistence of imidacloprid seed treatments and foliar sprays of triazamate, as part of a programme of aphid control on cauliflower planted at different times during the year.

3. Determine whether seed treatments applied to cauliflower seed for control of aphids (imidacloprid) and cabbage root fly (chlorpyrifos/fipronil/tefluthrin/carbofuran) are compatible or phytotoxic.

4. Determine how long cauliflower seed treated with imidacloprid remains viable.

SUMMARY

The insecticides imidacloprid and triazamate were evaluated for aphid control in field and laboratory trials at HRI Kirton and HRI Stockbridge House. Imidacloprid was used as a seed treatment and applied at a rate of 1.5 mg a.i./seed. Triazamate was applied as a foliar spray (56 g a.i./ha + 500 ml/ha Swirl adjuvant).

There were three field trials, one on Brussels sprouts at HRI Stockbridge House and two on cauliflower (planted on 15 June and 15 July) at HRI Kirton. In addition to the imidacloprid and triazamate treatments, there was an insecticide-free control treatment and a treatment where foliar sprays of Approved insecticides were applied (‘commercial standard’ – using pirimicarb, dimethoate and lambda-cyhalothrin + pirimicarb). Treatments were applied as necessary, according to pre-determined threshold levels based on the percentage of plants infested with wingless cabbage aphids. Infestation levels were determined by crop monitoring at fortnightly intervals.

Plots treated with ‘commercial standard’ insecticides required sprays every two weeks. Treatment with either triazamate or imidacloprid reduced the numbers of sprays required to suppress aphid infestations to a level similar to the ‘commercial standard’ treatment. Over the five trials done within projects FV 208 and FV 208a during 1998 and 1999, seed treatment with imidacloprid reduced the numbers of sprays required subsequently by an average of 3.8. Plots treated with triazamate

required an average of 3 fewer sprays to maintain similar levels of control to the 'commercial standard' treatment.

Propagation trials were done to determine the effects of different combinations of insecticides applied as seed treatments both on the germination of cauliflower seed and on seedling development. Imidacloprid was combined with fipronil, tefluthrin, chlorpyrifos and carbofuran, all possible insecticides for cabbage root fly control. Germination was delayed by 1-2 days and reduced by up to 6% in seeds that had been film-coated with insecticide. However, insecticide treatment had no effect on subsequent plant vigour.

Cauliflower seed film-coated with imidacloprid (1.5 mg a.i./seed) and similar batches of insecticide-free seed were stored in a refrigerator for up to 18 months. Sub-samples of the seed were sown at two monthly intervals throughout that period. Insecticide treatment delayed seedling emergence by an average of 1-3 days and reduced emergence by up to 5%. However, there were no treatment effects on subsequent plant vigour. As yet there is no evidence that storage of imidacloprid-treated seed (for up to 18 months) causes it to deteriorate.

ACTION POINTS FOR GROWERS

Both imidacloprid and triazamate show considerable potential as aphicides in brassica crops.

Imidacloprid (Gaucho)

- Using brassica plants grown from seed film-coated with imidacloprid (1.5 mg a.i./seed) reduced the numbers of sprays required to suppress aphid infestations to a level similar to the 'commercial standard' treatment. Over the five trials done within projects FV 208 and FV 208a during 1998 and 1999, seed treatment with imidacloprid reduced the numbers of sprays required subsequently by an average of 3.8.

- Cauliflower seed film-coated with imidacloprid (1.5 mg a.i./seed) and similar batches of insecticide-free seed were stored in a refrigerator for up to 18 months. Sub-samples of the seed were sown at two monthly intervals throughout that period. Insecticide treatment delayed seedling emergence by an average of 1-3 days and reduced emergence by up to 5%. However, there were no effects on subsequent plant vigour. As yet there is no evidence that storage of imidacloprid-treated seed (for up to 18 months) causes it to deteriorate.

- Propagation trials were done to determine the effects of different combinations of insecticides applied as seed treatments both on the germination of cauliflower seed and on subsequent seedling development. Imidacloprid was combined with fipronil, tefluthrin, chlorpyrifos and carbofuran, which are all possible insecticides for cabbage root fly control. Germination was delayed by 1-2 days and seedling emergence was reduced by up to 6% in seeds that had been film-coated with insecticide. However, insecticide treatment had no effect on subsequent plant vigour.

- A SOLA has been granted for the use of Gaucho seed treatment (imidacloprid) to control peach-potato aphids (*Myzus persicae*) on field brassica crops. The new SOLA approves the use of Gaucho seed treatment for the control of peach-potato aphids on cabbage, Brussels sprout, cauliflower, calabrese and broccoli. Applications must be via specialist seed treatment equipment at a maximum rate of 200g product/100,000 seeds (equivalent to 1.4 mg a.i./seed). Only one treated crop per field area per year is permitted.

- This treatment is likely to control aphids for several weeks after planting. The persistence of Gaucho seed treatment in each crop will depend on the size of the aphid infestation. If the aphid infestation is large, the treatment will 'fail' earlier than if it is small.

Triazamate (Aztec)

- Treatment with foliar sprays of triazamate reduced the numbers of sprays required to suppress aphid infestations to a level similar to the 'commercial standard' treatment. Over the five trials done within projects FV 208 and FV 208a during 1998 and 1999, plots treated with triazamate required an average of 3 fewer sprays to maintain similar levels of control to the 'commercial standard' treatment.

- There is Approval for the use of triazamate (Aztec) on Brussels sprouts and cabbage (excluding Savoy cabbage). A maximum of 3 sprays (maximum rate 0.4 l/ha/spray) may be applied to each crop and the harvest interval is 28 days.

BENEFITS

- There is a nil tolerance for aphid presence or damage at harvest.
- A wider choice of effective compounds would be of great benefit for the control of cabbage aphid and would help also in the development of a resistance-management strategy for peach-potato aphid, which is considered to be an increasing threat to brassica crops.
- Growers will require information on how to use new active ingredients judiciously, so that they avoid potential problems such as the development of insecticide resistance.
- If several effective OP compounds are withdrawn from use then the need for alternative aphicides will become even more pressing.
- Effective cabbage root fly control is also vital and it is important that seed treatments for cabbage root fly and aphids are compatible.

Leafy brassicas are worth more than £160M annually (MAFF Basic Horticultural Statistics for the UK, 1986-96). In 1995 (Pesticide Usage Survey Report for 1995), OP's were applied to 47% of the area treated with insecticides and carbamates to 9%. Thus the withdrawal of key OP and/or carbamate insecticides, without the provision of effective substitutes, would have a considerable impact on pest control. If for example, there were a 10% loss of crop due to pest damage, this would be worth £16M annually.

SCIENCE SECTION

INTRODUCTION

Almost all of the 41,000 ha (MAFF Basic Horticultural Statistics) of horticultural brassicas grown in the UK receive applications of insecticides for foliar aphids and for cabbage root fly. For more than 20 years, organophosphorus (OP) and carbamate insecticides have dominated control of these pests. However, as a result of the MAFF review of anticholinesterase compounds, it is likely that the use of some OP and carbamate insecticides will be revoked within the next few years. In anticipation of this, some insecticides are being withdrawn by the manufacturers because of the large costs that would be incurred in obtaining additional data to maintain approval. For example, one of the more effective aphicides, demeton-s-methyl, cannot be used after 31 October 2000. It is likely that withdrawal of this and other OP and carbamate insecticides will lead to a lack of effective compounds for controlling brassica pests.

The cabbage aphid (*Brevicoryne brassicae*) is the major aphid pest of brassicas. However, during 1996, large infestations of the peach-potato aphid (*Myzus persicae*) were found in many crops, and following biochemical tests by IACR Rothamsted, a considerable proportion of the aphids were found to be resistant to insecticides. Three new compounds (imidacloprid (*Bayer)*, triazamate (*BASF plc)* and pymetrozine (*Syngenta)*) might provide effective alternatives for the control of aphids in field brassica crops. Apart from the possibility of finding at least one effective treatment for cabbage aphid control, a wider choice of compounds would be useful in a resistance management strategy for peach-potato aphid.

Imidacloprid, triazamate and pymetrozine were evaluated for aphid control on summer cauliflower (1997) and Brussels sprouts (1998) in HDC funded field trials at HRI Kirton and HRI Stockbridge House (FV 208). Imidacloprid was incorporated either into module compost (1997 & 1998), applied as a pre-planting drench (1997), or as a seed treatment (1998). Triazamate and pymetrozine were applied as foliar sprays. The performance of these treatments was compared with commercial standards (foliar sprays of demeton-s-methyl, pirimicarb, heptenophos). The foliar spray treatments were evaluated also in an additional trial on Brussels sprouts at HRI Wellesbourne in 1997. The results of these trials showed that of the three insecticides tested, imidacloprid and triazamate show considerable potential as aphicides in brassica crops.

It is possible that the MAFF review of anticholinesterase compounds will reduce also the number of insecticides available for cabbage root fly control. One possible outcome is that in future, growers may wish to treat seed for both cabbage root fly and aphid control. Although still using an OP, chlorpyrifos seed treatment (Gigant) is a method of applying very small amounts of insecticide, and the combination of insecticide seed treatments that is most likely to become available to growers in the short term is chlorpyrifos and imidacloprid. Other possible combinations for the future are fipronil/imidacloprid, tefluthrin/imidacloprid or carbofuran/imidacloprid, although, as a carbamate, carbofuran is subject also to the MAFF review. Nothing is known about the performance of these insecticide combinations when applied as seed treatments, either in terms of pest control or phytotoxicity.

Alternatives to OP's for cabbage root fly control on radish have been evaluated at HRI Wellesbourne in HDC Project FV 159a and are being evaluated on swedes and leafy brassicas in FV 223. In 1998, the performance of cauliflower plants grown from Gigant treated seed was compared with those treated using a standard programme of cabbage root fly control, in this case a Dursban drench (FV 217). Treated plants were exposed to first generation cabbage root fly attack at HRI Kirton. There were no statistically significant differences in cabbage root fly damage or yield and quality at harvest between Gigant-treated plants and those that had been treated with a pre-planting Dursban drench. However, cabbage root fly damage at HRI Kirton was not as high as it is in some areas, particularly those where oil seed rape is grown extensively.

The aim of this project is to:

1. Evaluate the effectiveness and persistence of imidacloprid seed treatments and foliar sprays of triazamate, as part of a programme of aphid control on Brussels sprouts.

2. Evaluate the effectiveness and persistence of imidacloprid seed treatments and foliar sprays of triazamate, as part of a programme of aphid control on cauliflower planted at different times during the year.

3. Determine whether seed treatments applied to cauliflower seed for control of aphids (imidacloprid) and cabbage root fly (chlorpyrifos/fipronil/tefluthrin/carbofuran) are compatible or phytotoxic.

4. Determine how long cauliflower seed treated with imidacloprid remains viable.

EXPERIMENTAL

1. Evaluate the effectiveness and persistence of imidacloprid seed treatments and foliar sprays of triazamate, as part of a programme of aphid control on Brussels sprouts.

Crop

Brussels sprout seed (cv Diablo) was sown in Hassy 308 trays on 1 April 1999 at HRI Stockbridge House. One batch of seed was film-coated with imidacloprid (Gaucho) at a rate of 1.5 mg a.i./seed. The other batch was insecticide-free. Both batches of seed received standard fungicide treatments. The seed was supplied and treated by Elsoms.

The plants were transplanted on 20 May into field plots at HRI Stockbridge House. A drench of chlorpyrifos (Dursban) was applied to all trays before planting, to control cabbage root fly.

Seedling emergence counts

Seedling emergence counts were made on six trays sown from treated seed and six trays sown from insecticide-free seed. Vigour was assessed by scoring individual plants on a scale of 1-10 (1 = weak, 10 = strong).

Experimental design
The plots were 4 x 25 plants in size. Each of the 4 treatments was replicated five times and the trial was arranged in a row and column design.

Treatments

A	Control - no aphicides.
B	Seed treated with imidacloprid (Gaucho) at 1.5 mg a.i./seed.
C	Triazamate (Aztec) spray at 56 g a.i./ha + 500 ml/ha Swirl.
D	Control - commercial standard (aphicides approved currently [dimethoate, pirimicarb, lambda-cyhalothrin + pirimicarb] applied at recommended rates).

Assessments
Every two weeks 10 randomly selected plants in each plot were examined to determine the numbers of plants infested with wingless cabbage aphids. The results from the five replicate plots of each treatment were combined. Decisions to treat plots with insecticide sprays were based on the numbers of plants (out of a total of 50) infested with aphids.

Treatment thresholds evaluated in HDC Project FV 194 were used throughout the trial to determine when foliar sprays should be applied to each treatment. The thresholds were 20%, 10% and 5% plants infested and they were used during weeks 0-10, 11-15 and 16 onwards from planting. The numbers of plants used to make each 'spray' decision are shown below:

Decision ranges – numbers of plants infested to make each 'spray' decision

Threshold	*'No spray'*	*'Spray'*
20%	0 – 6	7 – 50
10%	0 – 3	4 – 50
5%	0 - 1	2 – 50

N.B.

Maximum probability of making an incorrect spray decision (alpha) = 0.75

Maximum probability of making an incorrect no spray decision (beta) = 0.05

For all thresholds, the maximum probabilities of making incorrect decisions are at the threshold minus 20% of the threshold (incorrect spray decision) and plus 20% of the threshold (incorrect no spray decision).

Determining the persistence of imidacloprid

The same treatment thresholds were used to determine when the imidacloprid treatments had ceased to be effective. The intention was to be 95% certain that the infestation level had exceeded the threshold on two sampling occasions. For this to be so, 16 or more plants (out of 50) had to be infested at the 20% threshold, 11 or more plants had to be infested at the 10% threshold and 6 or more plants at the 5% threshold.

Once the numbers of infested plants in the plots grown from seed treated with imidacloprid had exceeded these criteria on two occasions, the plots were sprayed with a 'commercial standard' programme of sprays according to the thresholds used for foliar sprays.

Detailed plant assessments

On three occasions during the summer, detailed assessments were made on a random sample of 20 plants/plot to determine the size of the aphid infestation, rather than whether aphids were merely present or absent. Records were made of the number of winged aphids, single wingless aphids, the number of colonies and the estimated diameter of each colony. This information was used to estimate the numbers of aphids on each plant using a 'colony diameter calibration' equation determined previously.

The data were analysed using Analysis of Variance. The variates analysed were:

- Mean number of winged aphids/plant
- Mean number of colonies/plant
- Mean number of aphids/plant (calculated using 'colony diameter calibration' equation).

These variates were subject to square root transformation prior to analysis to stabilise the variance.

The percentages of plants infested with aphids were analysed also. These data were subject to angle transformation prior to analysis, to stabilise the variance.

Harvest assessments

The plots were harvested on 27 November 1999. Twenty randomly selected plants were harvested from each plot. The stems were divided in half (top and bottom) and all the buttons from each half of the stem were assessed for aphid and other pest and non-pest damage. The buttons in each category were weighed and counted.

The data were analysed using Analysis of Variance (ANOVA). Variates analysed included:

- Percentages by both number and weight of aphid damaged buttons on the top and bottom parts of the stem, and also overall

- Percentages by both number and weight of undamaged buttons on the top and bottom parts of the stem, and also overall
- Total numbers and weights of buttons on the top and bottom parts of the stem, and also overall.

Diagnostic plots for all the variates that were analysed did not suggest any need for transformation of the percentage data. The total numbers were also reasonably variable, which removed any justification for using an angular transformation.

Results

Seedling emergence and plant vigour
On 6 April, 5 days after sowing, 83% of insecticide-free seeds had emerged compared with only 17% of those film-coated with imidacloprid. However, by 19 April, emergence was 90 and 83% for the two treatments respectively. The seedlings from the seed film-coated with imidacloprid were less vigorous than those from the insecticide-free seed (mean vigour scores of 4.5 and 6.6 respectively).

Aphid infestation
Aphid numbers increased from planting and by 16 July, 100% plants examined in the insecticide-free plots were infested with aphids. Aphid numbers remained relatively high throughout the life of the crop (Figure 1).

Spray applications
The dates when decisions were made to apply the first spray, and the numbers of sprays applied to each treatment are shown in Table 1. Figure 1 shows the numbers of plants (out of the 50 sampled) infested with aphids at each assessment.

The 'commercial standard' treatment [D] required a spray following every assessment and as a result, 11 sprays were applied at two-week intervals from planting until harvest. The 'triazamate' treatment [C] received five sprays between 17 June and 7 September, when the last spray was applied. Sprays to the 'imidacloprid' treatment [B] were delayed by 6 weeks compared with the 'commercial standard' and the first spray (of eight) was applied on 28 July. The plots then required spraying at two-week intervals until harvest.

Detailed plant assessments
Detailed plant assessments were made on 15 July, 22 September and 19 October. The results of the statistical analyses are shown in Tables 2-3 and Figure 2. On each occasion, plants from the insecticide-free plots were the most heavily infested and plants sprayed with triazamate were the least infested. Aphid numbers were generally greater on the plots grown from insecticide-free seed and sprayed subsequently with 'commercial standard' insecticides than those grown from seed film-coated with imidacloprid. The percentages of infested plants showed similar trends. The relationship between the percentage of plants infested and the numbers of aphids/20 plants is shown in Figure 3. In general, there was good correlation between the mean number of aphids/20 plants and the percentage of infested plants on each sampling occasion, but the relationship changed between occasions.

Harvest assessments

Analysis of the harvest data is summarised in Table 4. Figure 4 shows the percentage of aphid damaged buttons (by number) harvested from each treatment. The results for the upper and lower parts of the stem are presented separately.

Insecticide treatment had no effect on final yield (total number and weight of buttons). However, there was a statistically significant treatment effect on the percentage of buttons damaged by aphids (by weight and number).

The percentages (by number and weight) of aphid-damaged buttons from the insecticide-free control (39-47%) were statistically significantly different from the other treatments (4-9%) ($p<0.001$). However, there was no difference between insecticide treatments. Buttons on the lower part of the stem were considerably more damaged than those on the upper part of the stem (Figure 4). The ratios of percentage of damaged buttons on the lower stem vs the upper stem ranged from approximately 3 (insecticide-free control and triazamate treatments) to approximately 15 (imidacloprid and commercial standard treatments).

2. Evaluate the effectiveness and persistence of imidacloprid seed treatments and foliar sprays of triazamate, as part of a programme of aphid control on cauliflower planted at different times during the year.

Crop

Cauliflower seed (cv Lateman) was sown in Hassy 308 trays on 30 April and 3 June 1999 at HRI Kirton. One batch of seed was film-coated with imidacloprid (Gaucho) at a rate of 1.5 mg a.i./seed. The other batch was insecticide-free. Both batches received standard fungicide treatments. The seed was supplied by Elsoms and treated by Germains.

The plants were transplanted on 15 June and 15 July respectively into field plots at HRI Kirton. A drench of chlorpyrifos (Dursban) was applied to all trays before planting, to control cabbage root fly.

Seedling emergence counts

Seedling emergence counts were made on two trays sown from each treatment (100 marked plants in each tray).

Experimental design

The plots were 4 x 25 plants in size. Each of the 4 treatments was replicated five times and the trial was arranged in a row and column design.

<u>Treatments</u>

A	Control - no aphicides.
B	Seed treated with imidacloprid (Gaucho) at 1.5 mg a.i./seed.
C	Triazamate (Aztec) spray at 56 g a.i./ha + 500 ml/ha Swirl.
D	Control - commercial standard (aphicides approved currently [dimethoate, pirimicarb] applied at recommended rates).

Assessments

Every two weeks 10 randomly selected plants in each plot were examined to determine the numbers of plants infested with wingless cabbage aphids. The results from the five replicate plots of each treatment were combined. Decisions to treat plots with insecticide sprays were based on the numbers of plants (out of a total of 50) infested with aphids.

A 5% treatment threshold was used throughout the trial to determine when foliar sprays should be applied to each treatment. Plots were sprayed when 2 or more plants out of 50 were infested with wingless cabbage aphids (see Experiment 1).

<u>Determining the persistence of imidacloprid</u>

The same treatment threshold was used to determine when the imidacloprid seed treatments had ceased to be effective. The intention was to be 95% certain that the infestation level had exceeded the threshold on two sampling occasions. For this to be so, 6 or more plants (out of 50) had to be infested.

Once the numbers of infested plants in the plots grown from seed film-coated with imidacloprid had exceeded this criterion on two occasions, the plots were sprayed with a programme of ‘commercial standard’ sprays according to the thresholds used for foliar sprays.

<u>Detailed plant assessments</u>

One detailed assessment was made on each planting (3 August and 7 September respectively) on a random sample of 20 plants/plot to determine the size of the aphid infestation, rather than whether aphids were merely present or absent. Records were made of the number of winged aphids, single wingless aphids, the number of colonies and the estimated diameter of each colony. This information was used to estimate the numbers of aphids on each plant using a ‘colony diameter calibration’ equation determined previously.

The data were analysed using Analysis of Variance. The variates analysed were:

- Mean number of winged aphids/plant

- Mean number of colonies/plant
- Mean number of aphids/plant (calculated using 'colony diameter calibration' equation).

These variates were subject to square root transformation prior to analysis, to stabilise the variance. The percentages of plants infested with aphids were also analysed. These data were subject to angle transformation prior to analysis.

Harvest assessments
The plots were harvested over a period of several days and the heads were cut as they matured. Forty plants were harvested from each plot. Each head was weighed and scored, and the numbers of aphids found on the leaves and curd were recorded.

The data were analysed using Analysis of Variance (ANOVA). Variates analysed included:

- Times to 10, 50 and 90% maturity (cut) in each plot.
- Mean date of maturity (cut).
- Length of cutting period.
- Yield of Class 1 heads.
- Total marketable yield.
- Mean head weight.
- Numbers of aphids on the leaves or curd and the total numbers of aphids.
- Percentage of plants infested.

Results

Seedling emergence and plant vigour
Although emergence of the seed film-coated with imidacloprid was delayed (see Experiment 4 below), 94.7 and 96% seedlings emerged from the insecticide-free and imidacloprid-treated seed respectively in Experiment 2a and 94.7 and 95.5% in Experiment 2b.

Aphid infestation
Aphid numbers increased from planting. From 4-6 weeks after planting, until harvest, 80 - 100% plants examined in the insecticide-free plots were infested with aphids (Figures 5-6).

Spray applications
The dates when decisions were made to apply the first spray, and the numbers of sprays applied to each treatment are shown in Tables 5-6. The timings of assessments for the different treatments were out of phase at the end of both trials because bad weather delayed spraying; plots were always assessed two weeks after spraying.

Experiment 2a
The 'commercial standard' treatment [D] required a spray following every assessment and as a result, 5 sprays were applied at two-week intervals from planting until harvest. The 'triazamate' treatment [C] received 4 sprays between 29 June and 17 August, when the last spray was applied. Sprays to the 'imidacloprid' treatment [B]

were delayed by 6 weeks compared with the 'commercial standard' and the first and only spray was applied on 10 August.

Experiment 2b

The 'commercial standard' treatment [D] required a spray following every assessment and as a result, 4 sprays were applied at two-week intervals from planting. The 'triazamate' treatment [C] received 3 sprays. A decision to spray the 'imidacloprid' treatment [B] was triggered on 24 September. However, spray application was delayed and since the plots were then ready for cutting, this spray was not applied.

Detailed plant assessments

Detailed plant assessments were made on 3 August and 7 September in Experiments 2a and 2b respectively. The results are presented in Table 7.

In both experiments, treatment had a statistically significant effect on the numbers of aphids found on the 20 plants sampled in each plot. More aphids were found on plants in the insecticide-free plots than those treated with insecticide (p=0.001 to<0.001) and more plants were infested with aphids (p=0.002 to <0.001). However, there were few statistically significant differences between insecticide treatments. In Experiment 2a fewer plants were infested with aphids following treatment with triazamate, than those treated with sprays of 'commercial standard' insecticides (with or without imidacloprid seed treatment).

Harvest assessments

The results are presented in Tables 8-9. Figure 7 shows the mean numbers of aphids found on 40 cauliflower plants at harvest.

Insecticide treatment had no effect on the time of maturity or the length of the cutting period. Similarly, the numbers of Class 1 heads and total marketable yield were unaffected. Treatment did have a statistically significant effect on the mean head weight (p=0.008) in Experiment 2a. Heads from plots treated with imidacloprid or triazamate were heavier than heads from the two 'control' treatments.

Insecticide treatment had a statistically significant effect on aphid numbers. Aphid numbers and the percentage of plants infested with aphids were larger in the insecticide-free plots than in those treated with insecticide (p=0.013 to <0.001). There was only one difference between insecticide treatments (the total number of aphids in Experiment 2a.). However, none of the insecticide treatments provided complete aphid control. There was good correlation between the mean number of aphids/40 plants and the percentage of infested plants.

3. Determine whether seed treatments applied to cauliflower seed for control of aphids (imidacloprid) and cabbage root fly are compatible or phytotoxic.

Cauliflower seed (cv Lateman) was film-coated at HRI Wellesbourne with several combinations of insecticides that might be used in the future for aphid and cabbage root fly control. Standard fungicide treated cauliflower seed was used throughout.

Although target rates were specified at the start of the project, it was not possible to achieve these loadings with some of the combinations.

Treatments

	Insecticide	Dose applied (mg a.i./seed)	% of target dose
A	Imidacloprid	1.04	104
B	Imidacloprid	1.39	92.7
C	Imidacloprid	0.81	81
	Fipronil	0.97	64.7
D	Imidacloprid	0.9	60
	Fipronil	0.82	54.7
E	Imidacloprid	0.43	43
	Carbofuran	0.147	43.3
F	Imidacloprid	0.65	58.8
	Carbofuran	0.124	49.6
G	Imidacloprid	0.69	69
	Tefluthrin	0.162	64.8
H	Imidacloprid	0.92	61.3
	Tefluthrin	0.168	67.2
I	Imidacloprid	1.14	114.0
	Chlorpyrifos	0.089	92.7
J	Imidacloprid	1.67	111.3
	Chlorpyrifos	0.091	94.8
K	Chlorpyrifos	0.086	89.6
L	Control – no insecticides		

The seed was sown on 20 August 1999 and assessments were made of seedling emergence (times for 50, 80 and 90% emergence) and plant vigour (on 4 October). Plants were scored for vigour on a scale of 1-5 (1 = very small and weak, 5 = most vigorous). Fresh weights were also recorded on 4 October, on a 20-plant sample from each tray. The plants were snipped off at ground level and weighed together. The plants were then discarded.

Results

Seed treatment had statistically significant effects on the times to 50% and 80% emergence, but not on the time to 90% emergence (Table 10). Insecticide-free seed [L] germinated most rapidly, followed by seed treated with chlorpyrifos only [K]. Seed treated with imidacloprid + chlorpyrifos [I & J] germinated least rapidly. Times to 80% emergence ranged from 4.2 to 5.3 days (Figure 8).

Final percentage emergence (assessed 13 days after sowing) ranged from 93-99% (Figure 9) and there was a statistically significant treatment effect (Table 10). Emergence of insecticide-free seed [L] was the most successful. Emergence of seed treated with imidacloprid + carbofuran [F] was the least successful (Figure 9). Although germination of almost all the insecticide treated seed was slower and less successful than insecticide-free seed, there were no statistically significant effects on plant vigour or fresh weight six weeks after sowing (Table 10).

4. Determine how long cauliflower seed treated with imidacloprid remains viable.

Cauliflower seed (cv Lateman) was supplied by Elsoms. One batch of seed was film-coated by Germains with imidacloprid (Gaucho) at a rate of 1.5 mg a.i./seed on 30 March 1999. The other batch was insecticide-free. Both batches received standard fungicide treatments.

The seed was stored in a refrigerator at a temperature of 3-5^{o}C (to simulate standard treatment by propagators) and batches of seed were sown in Hassy 308 trays (four trays/treatment) at two monthly intervals until 12 October 2000. Once the seed had been sown, all the trays were placed in a germination room at 20-21^{o}C for 48 hours before going into ambient glass, except the first sowing, which went into ambient glass straight away. Seedling emergence and plant vigour were recorded in 100 marked cells in each tray. Plant vigour was scored when the plants had reached a size suitable for planting and was scored on a scale of 1-4 (1= very small and weak, 4 = most vigorous).

Sowing date and seed treatment had statistically significant effects on the times to 50, 80 and 90% seedling emergence (Table 11). There was an interaction between sowing date and seed treatment for the times to 50 and 80% emergence. The mean times to 80% emergence of insecticide treated and insecticide-free seed are shown for each sowing date in Figure 10. Overall, film-coating seed with imidacloprid delayed 50% emergence by a mean of 1.1 days, 80% emergence by 1.5 days and 90% emergence by 2.4 days.

Final percentage emergence was affected also by seed treatment, but not by sowing date (Table 12; Figure 11). Overall, seedlings emerged from 97% insecticide-free seed and from 96% seed film-coated with imidacloprid.

Sowing date affected plant vigour, but seed treatment had no effect (Table 12). There was no evidence that the seed treated with imidacloprid had deteriorated after 18 months of storage.

DISCUSSION

During 1998 and 1999, imidacloprid seed treatment (1.5 mg a.i./seed) was evaluated in five trials (three on Brusssels sprouts, two on cauliflower) at HRI Kirton and HRI Stockbridge House. In each trial there was also a ‘commercial standard’ treatment (sprayed with Approved insecticides) and an insecticide-free control.

The plants in each plot were assessed at two-weekly intervals after planting and sprays of Approved insecticides were applied as necessary using treatment thresholds based on the percentage of plants infested with cabbage aphids (*B. brassicae*). In all cases, when compared with the 'commercial standard', the use of seed film-coated with imidacloprid reduced the numbers of sprays required to achieve similar levels of aphid control at harvest (Table 13). On average, 3.8 more sprays were applied to plants grown from insecticide-free seed.

Similarly, a programme of foliar sprays of triazamate was more effective than the 'commercial standard' treatment and on average, 3 fewer sprays were required to achieve similar levels of control at harvest (Table 14).

A SOLA has been granted for the use of Gaucho seed treatment (imidacloprid) to control peach-potato aphids (*M. persicae*) on field brassica crops. The new SOLA approves the use of Gaucho seed treatment for the control of peach-potato aphids on cabbage, Brussels sprout, cauliflower, calabrese and broccoli. Applications must be via specialist seed treatment equipment at a maximum rate of 200g product/100,000 seeds (equivalent to 1.4 mg a.i./seed). This is slightly lower than the rate used in this project, but the small reduction is unlikely to reduce aphid control substantially. Because it is used in a seed treatment, imidacloprid can be deployed only during the early life of the crop. Apart from reducing the overall numbers of sprays required subsequently, imidacloprid may have an important role in the control of virus transmission, since viruses have greater impact if they are transmitted early in the life of the crop. Populations of peach-potato aphids resistant to all Approved insecticides (apart from nicotine) have been identified in the UK (Anon., 2000). In addition, some individuals have extreme resistance to triazamate. Thus imidacloprid could play a key role in an overall strategy for aphid control in field brassica crops.

There is Approval for the use of triazamate (Aztec) on Brussels sprouts and cabbage (excluding Savoy cabbage). Triazamate will have a role later in the season, particularly on Brussels sprouts where it can reduce the cabbage aphid 'load' substantially. Although the number of applications is restricted (3/crop) and there is a relatively long harvest interval (28 days), it will still be an extremely useful insecticide.

Seed companies, propagators and growers have been concerned about the possible impact of imidacloprid seed treatment on germination and plant vigour. The results of this study show that film-coating seed with imidacloprid at a rate of 1.5 mg a.i./seed can delay and reduce germination by detectable amounts. However, the delay in germination is only 1-3 days on average and final emergence is reduced by a few percent. In addition, there is no evidence that seed treatment affects subsequent plant vigour or yield at harvest. There is also no evidence that storage of imidacloprid-treated seed for up to 18 months causes it to deteriorate.

In future, growers may use to wish seed treated with combinations of insecticides for the simultaneous control of aphids and cabbage root fly. The results of the preliminary study made in this project shown that although seed treatment with combinations of insecticides delayed and reduced seedling emergence, there were no major effects and subsequent plant vigour did not appear to be affected adversely.

CONCLUSIONS

1. Treatment with either triazamate or imidacloprid reduced the numbers of sprays required to suppress aphid infestations to a level similar to the 'commercial standard' treatment. Over the five trials done within projects FV 208 and FV 208a during 1998 and 1999, seed treatment with imidacloprid reduced the numbers of sprays required subsequently by an average of 3.8. Plots treated with triazamate required an average of 3 fewer sprays to maintain similar levels of control to the 'commercial standard' treatment.

2. Cauliflower seed film-coated with imidacloprid (1.5 mg a.i./seed) and similar batches of insecticide-free seed were stored in a refrigerator for up to 18 months. Sub-samples of the seed were sown at two monthly intervals throughout that period. Insecticide treatment delayed seedling emergence by an average of 1-3 days and reduced emergence by up to 5%. However, there were no effects on subsequent plant vigour. As yet there is also no evidence that storage of imidacoprid-treated seed for up to 18 months causes it to deteriorate.

3. Propagation trials were done to determine the effects of different combinations of insecticides applied as seed treatments on the germination of cauliflower seed and on subsequent seedling development. Imidacloprid was combined with fipronil, tefluthrin, chlorpyrifos and carbofuran. Germination was delayed by 1-2 days and reduced by up to 5% in seeds that had been film-coated with insecticide. However, insecticide treatment had no effect on subsequent plant vigour.

ACKNOWLEDGEMENTS

We would like to thank Elsoms for providing the cauliflower and Brussels sprout seed and Elsoms, Germains and Andy Jukes for film-coating samples of seed with insecticides. Julian Davies and Carole Rockliffe managed Experiment 1, which was done at HRI Stockbridge House. Andrew Mead provided the experimental designs and statistical analyses of the data. We are grateful to the Horticultural Development Council for supporting this project.

REFERENCES

Anon. (2000). Guidelines for preventing and managing insecticide resistance in the peach-potato aphid, *Myzus persicae*. Insecticide Resistance Action Group, UK.

Figure 1. The numbers of plants infested with aphids at each assessment during Experiment 1 (Brussels sprouts at HRI Stockbridge House). Ten plants were sampled in each of the 5 replicate plots/treatment on each occasion. Decisions to spray are indicated by solid circles (●). Treatment thresholds are indicated by horizontal dashed lines.

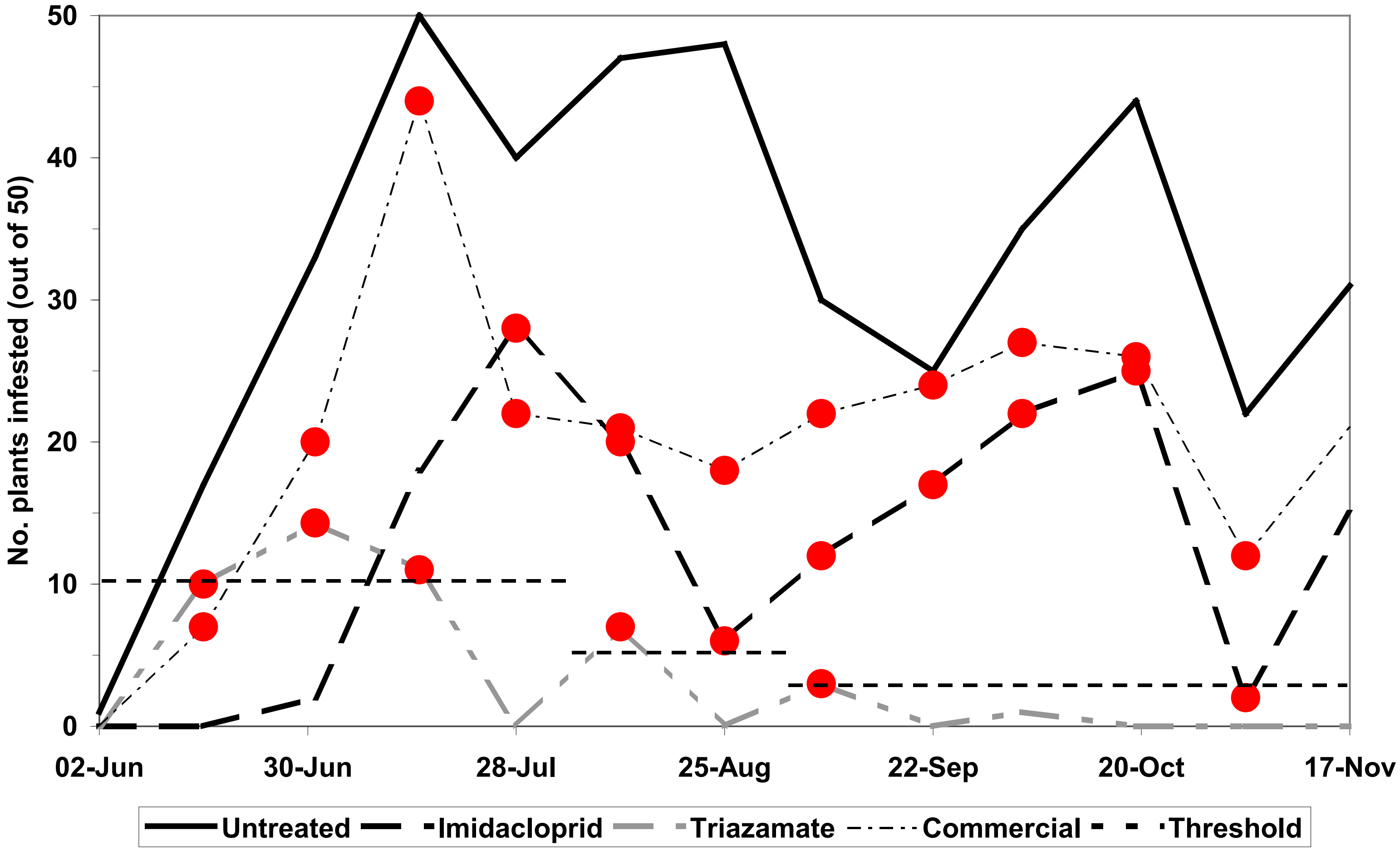


Figure 2. The mean numbers of aphids/20 plants from each detailed assessment made during Experiment 1 (Brussels sprouts at HRI Stockbridge House). Assessments were made on 15 July, 22 September and 19 October. Twenty plants were sampled in each of the 5 replicate plots/treatment on each occasion. Statistical analyses including LSD's are shown in Table 2.

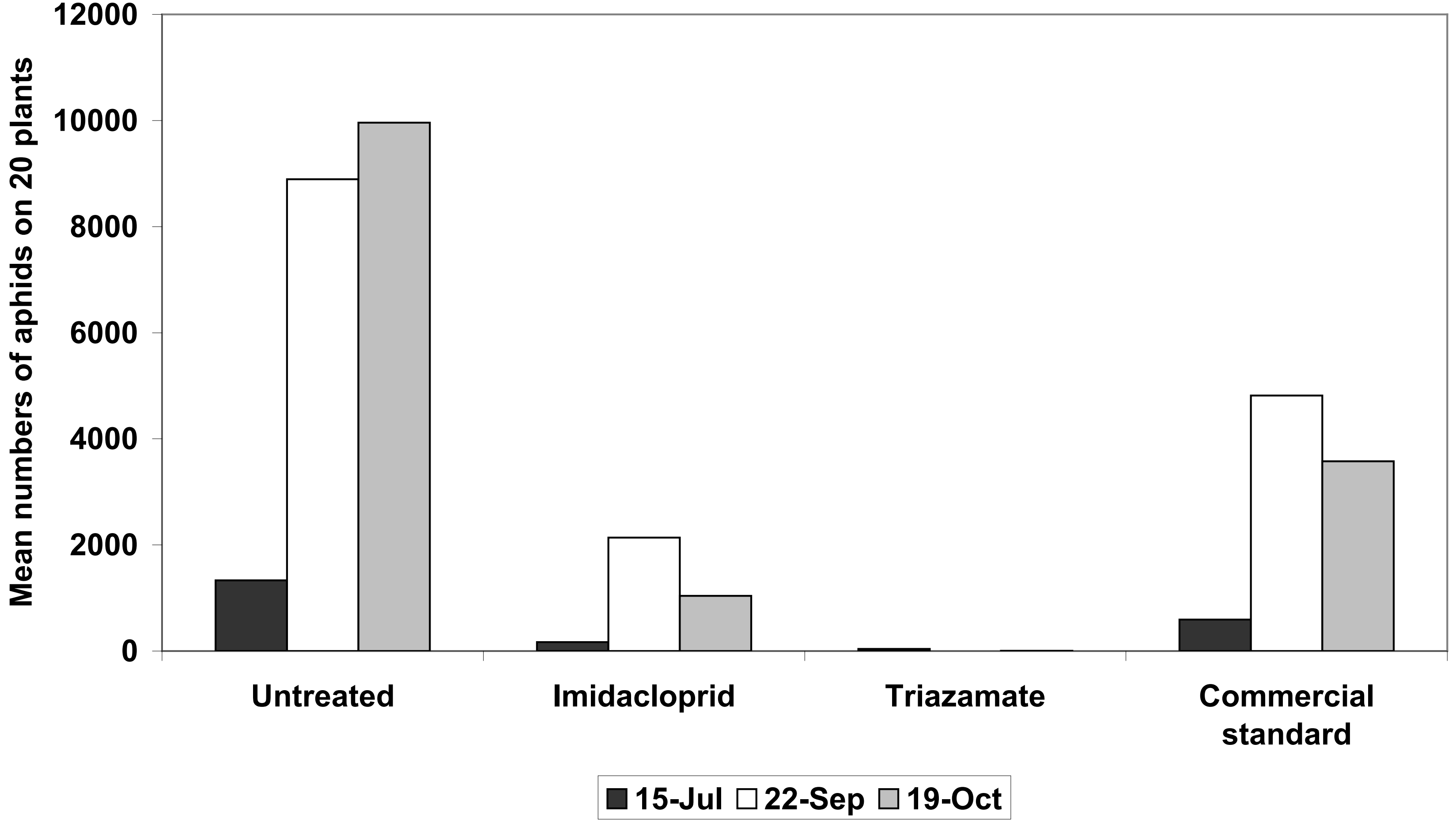


Figure 3. The relationship between the numbers of aphids/20 plants and the percentage of plants infested with aphids on each of the three detailed assessment occasions in Experiment 1. Statistical analyses including LSD's are shown in Tables 2-3.

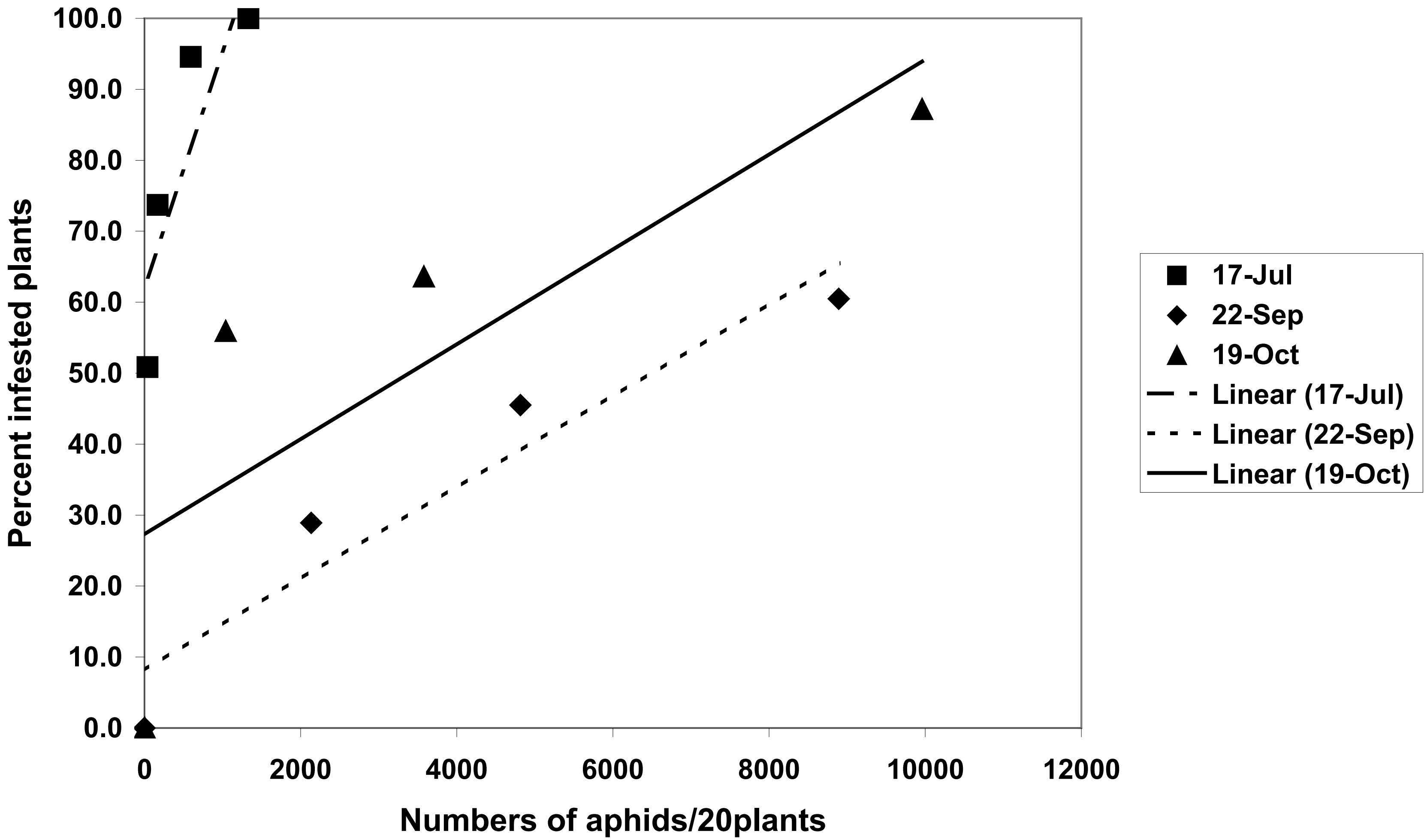


Figure 4. The percentage (by number) of Brussels sprout buttons damaged by aphids at harvest (Experiment 1 – HRI Stockbridge House). Statistical analyses including LSD's are shown in Table 4.

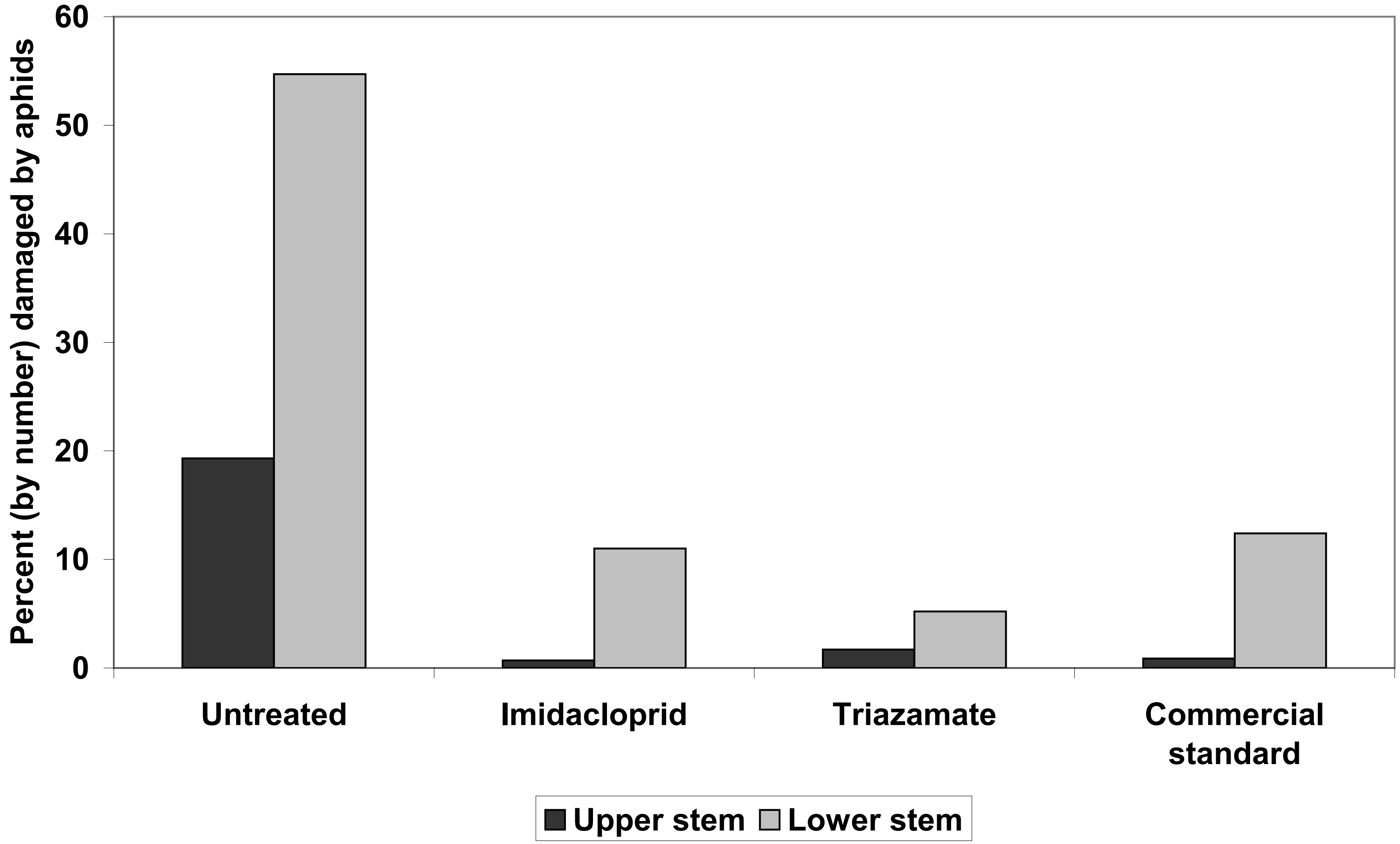


Figure 5. The numbers of plants infested with aphids at each assessment during Experiment 2 – Planting 1 (cauliflower at HRI Kirton). Ten plants were sampled in each of the 5 replicate plots/treatment on each occasion. Decisions to spray are indicated by solid circles (●). Treatment thresholds are indicated by horizontal dashed lines.

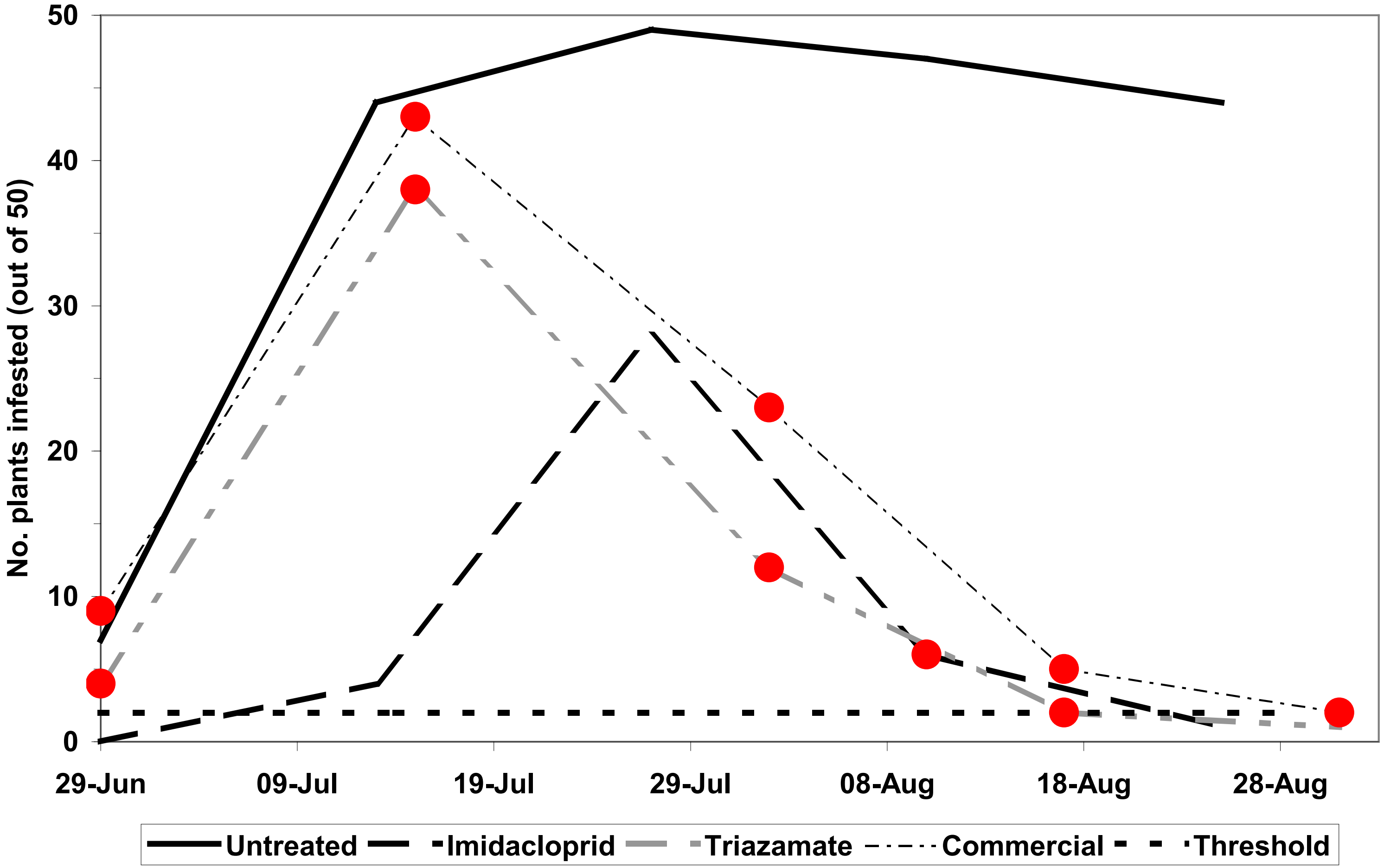


Figure 6. The numbers of plants infested with aphids at each assessment during Experiment 2 – Planting 2 (cauliflower at HRI Kirton). Ten plants were sampled in each of the 5 replicate plots/treatment on each occasion. Decisions to spray are indicated by solid circles (●). Treatment thresholds are indicated by horizontal dashed lines.

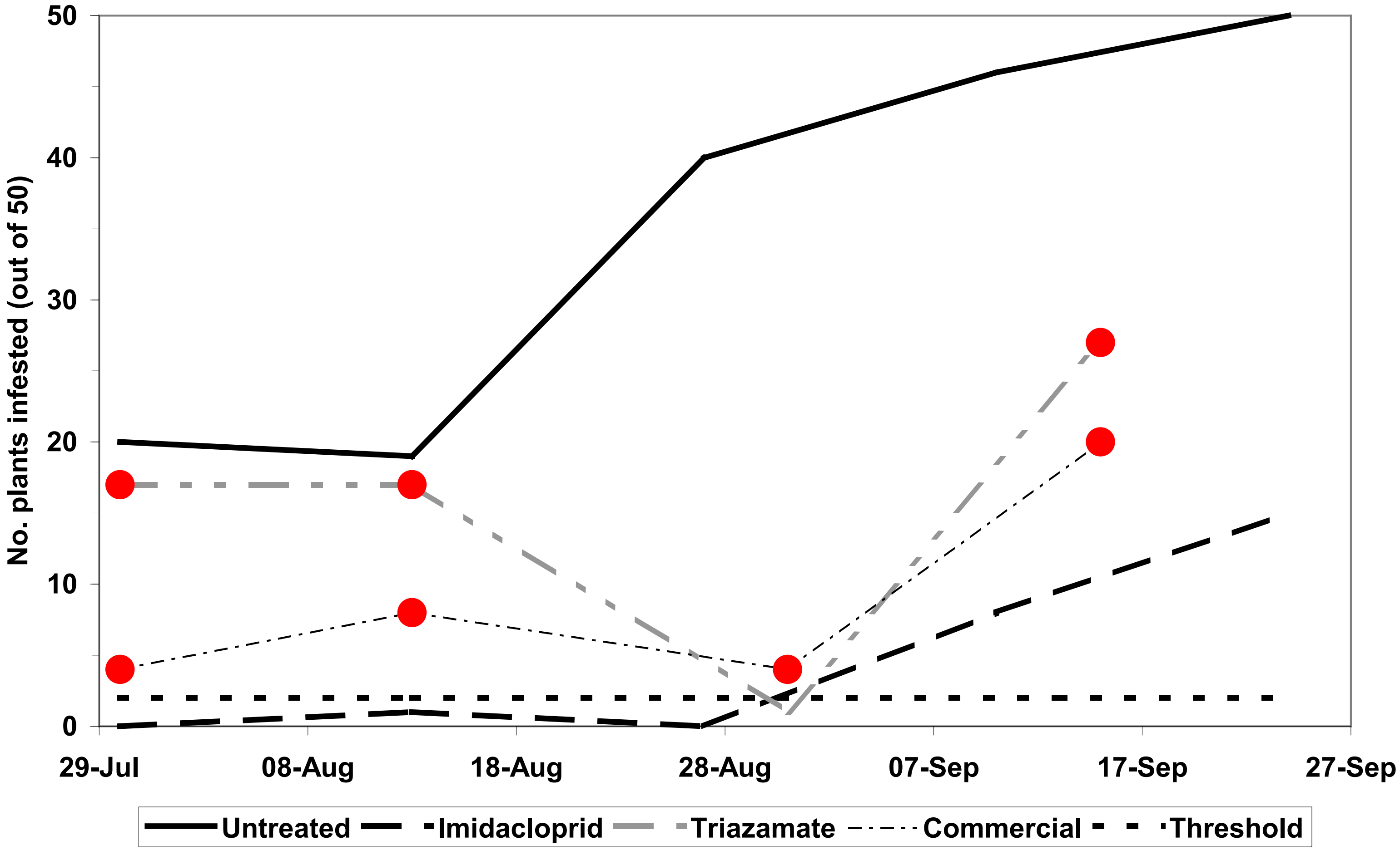


Figure 7. The numbers of aphids on 40 cauliflower plants at harvest (Experiments 2a and 2b). Statistical analyses including LSD's are shown in Table 9.

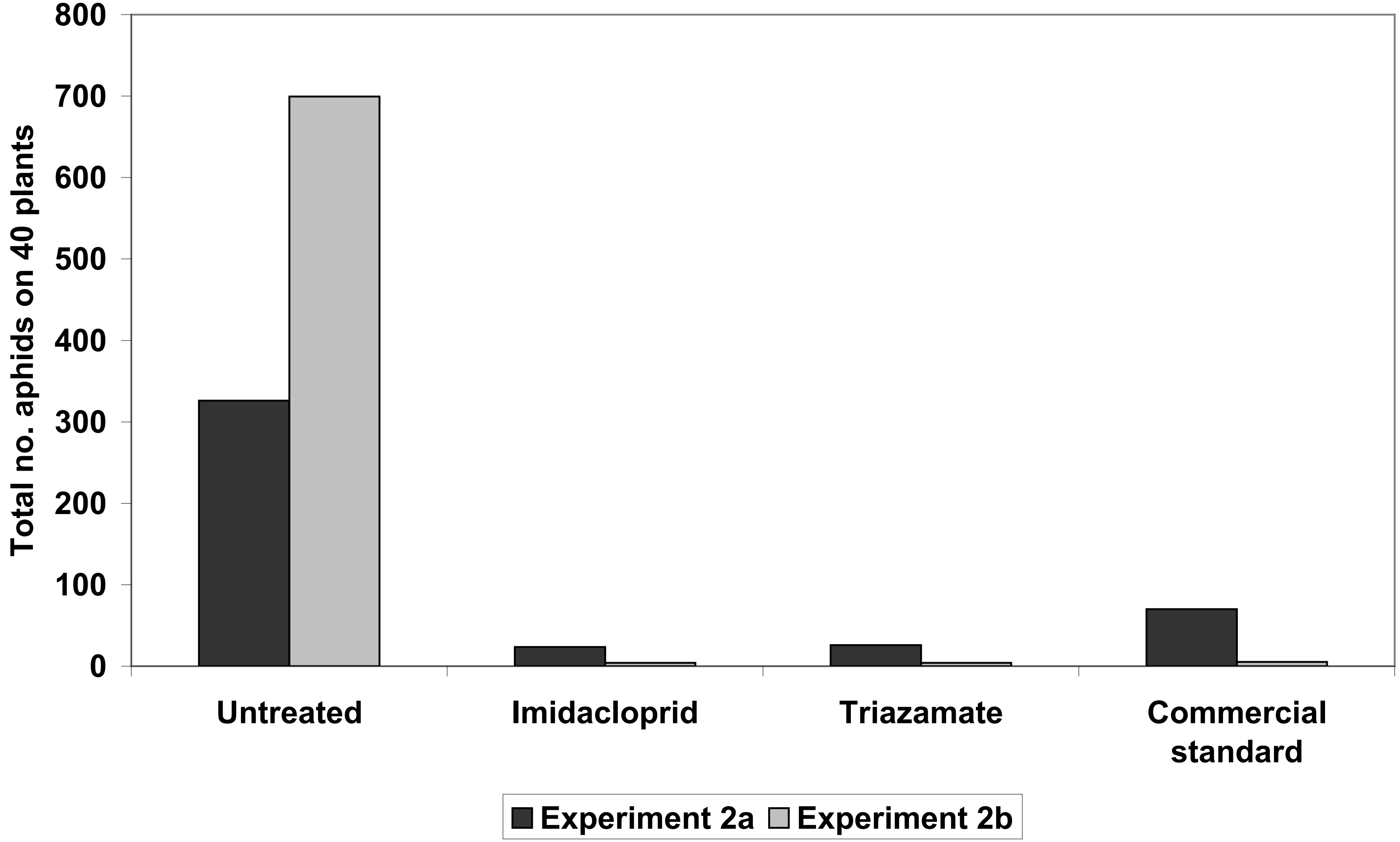


Figure 8 . The time in days from sowing to 80% seedling emergence (Experiment 3). Statistical analyses including LSD's are shown in Table 10.

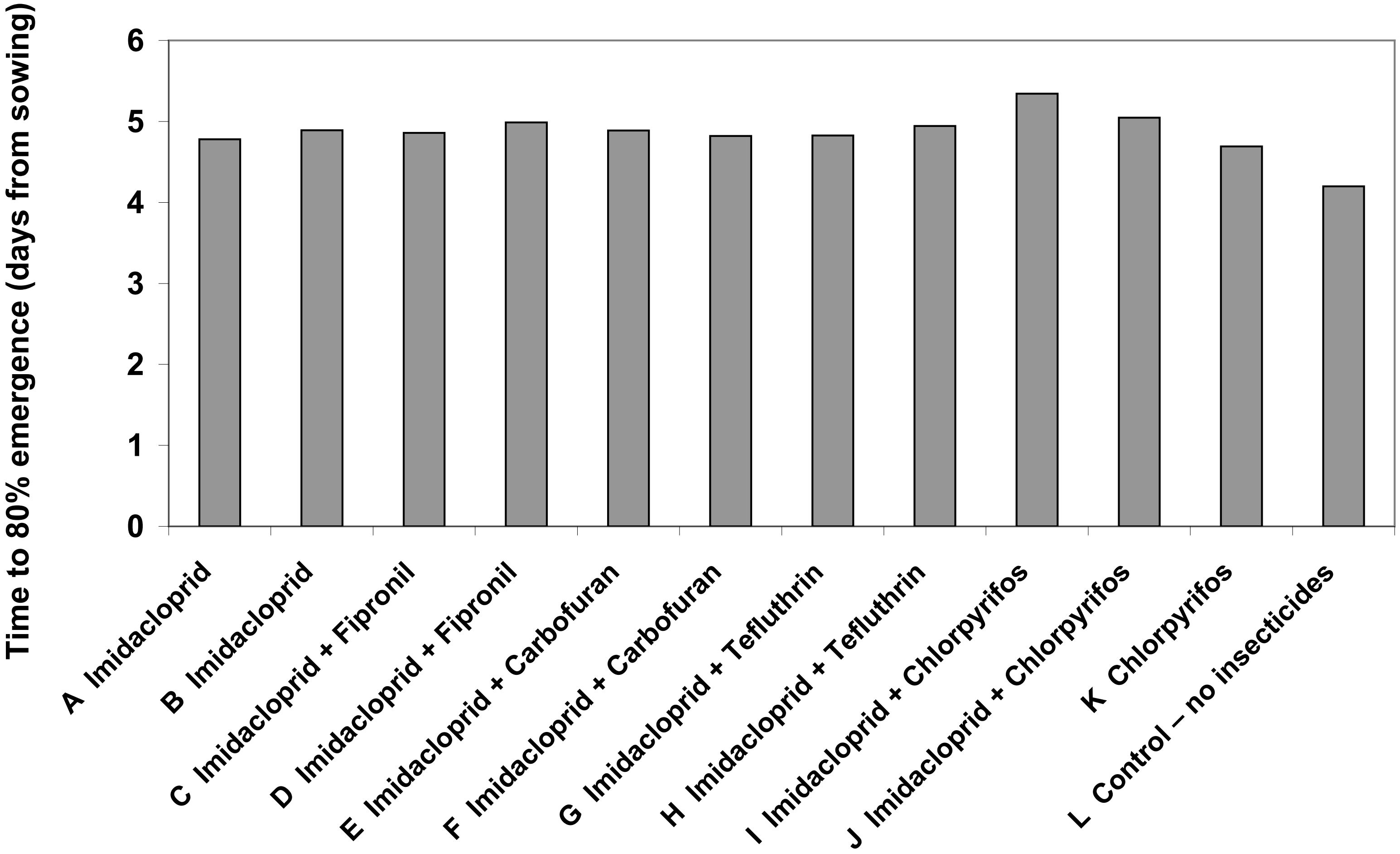


Figure 9. Final percentage seedling emergence (Experiment 3). Statistical analyses including LSD's are shown in Table 10.

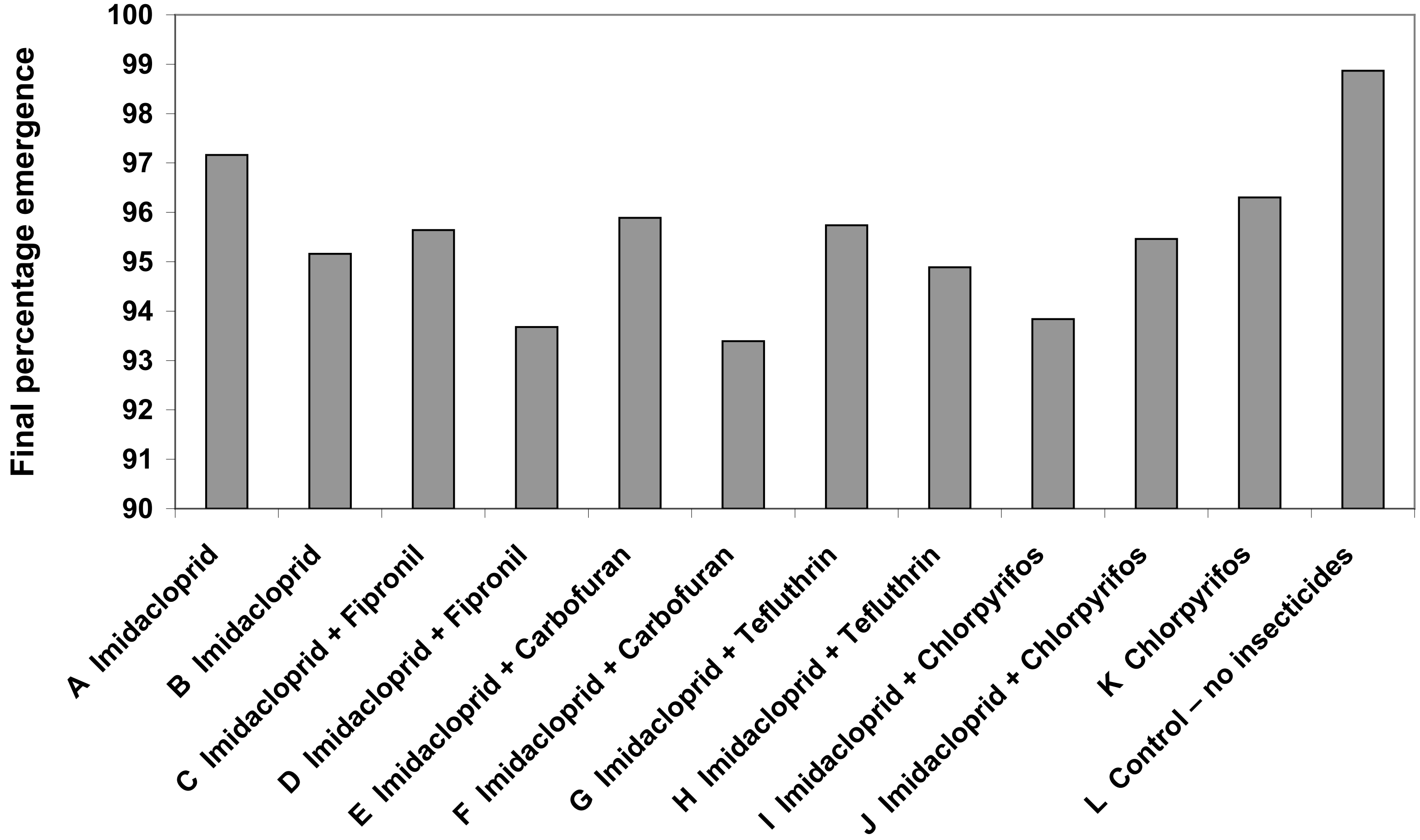


Figure 10. Mean time to 80% emergence in days from sowing (Experiment 4). Statistical analyses including LSD's are shown in Table 11.

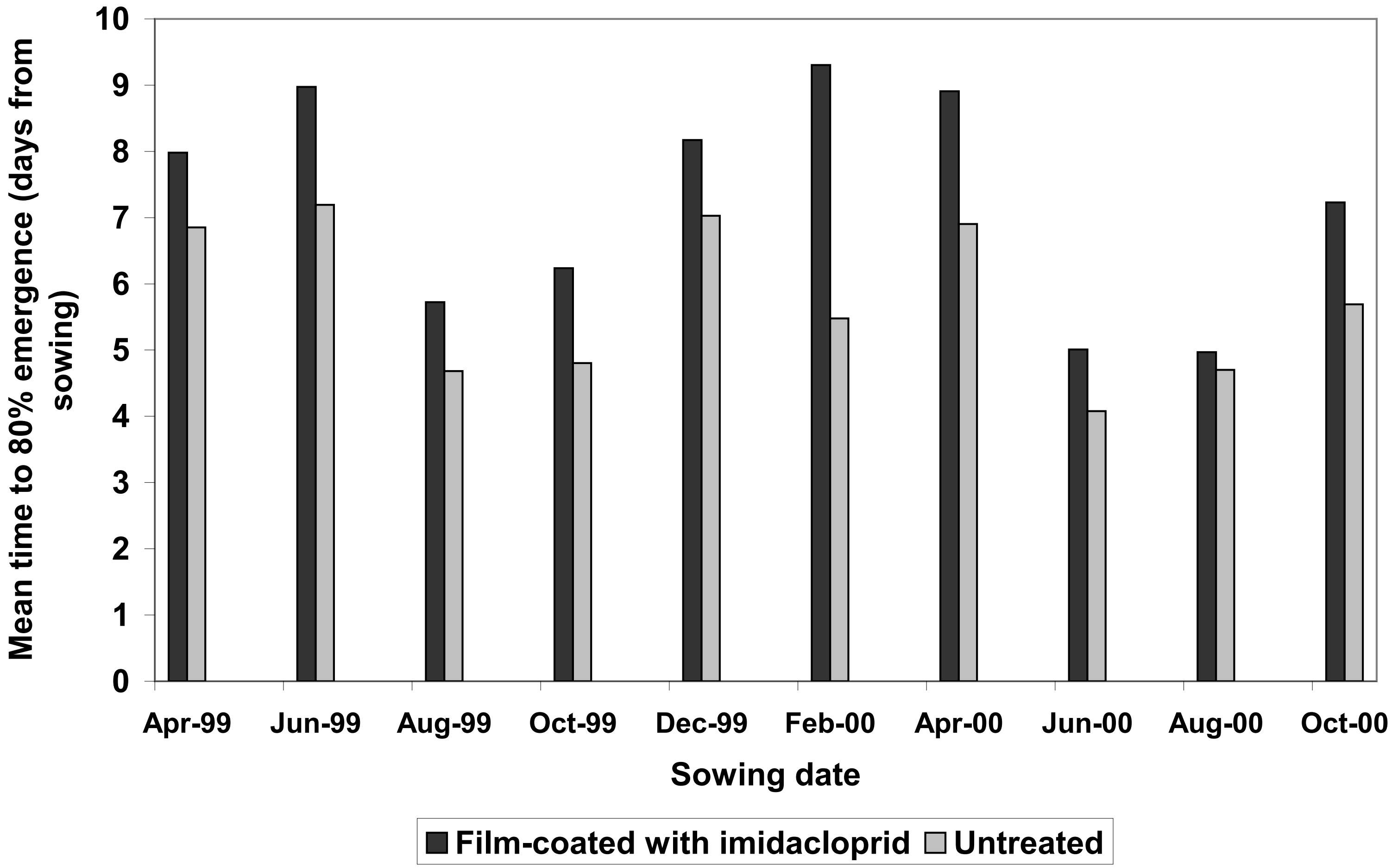
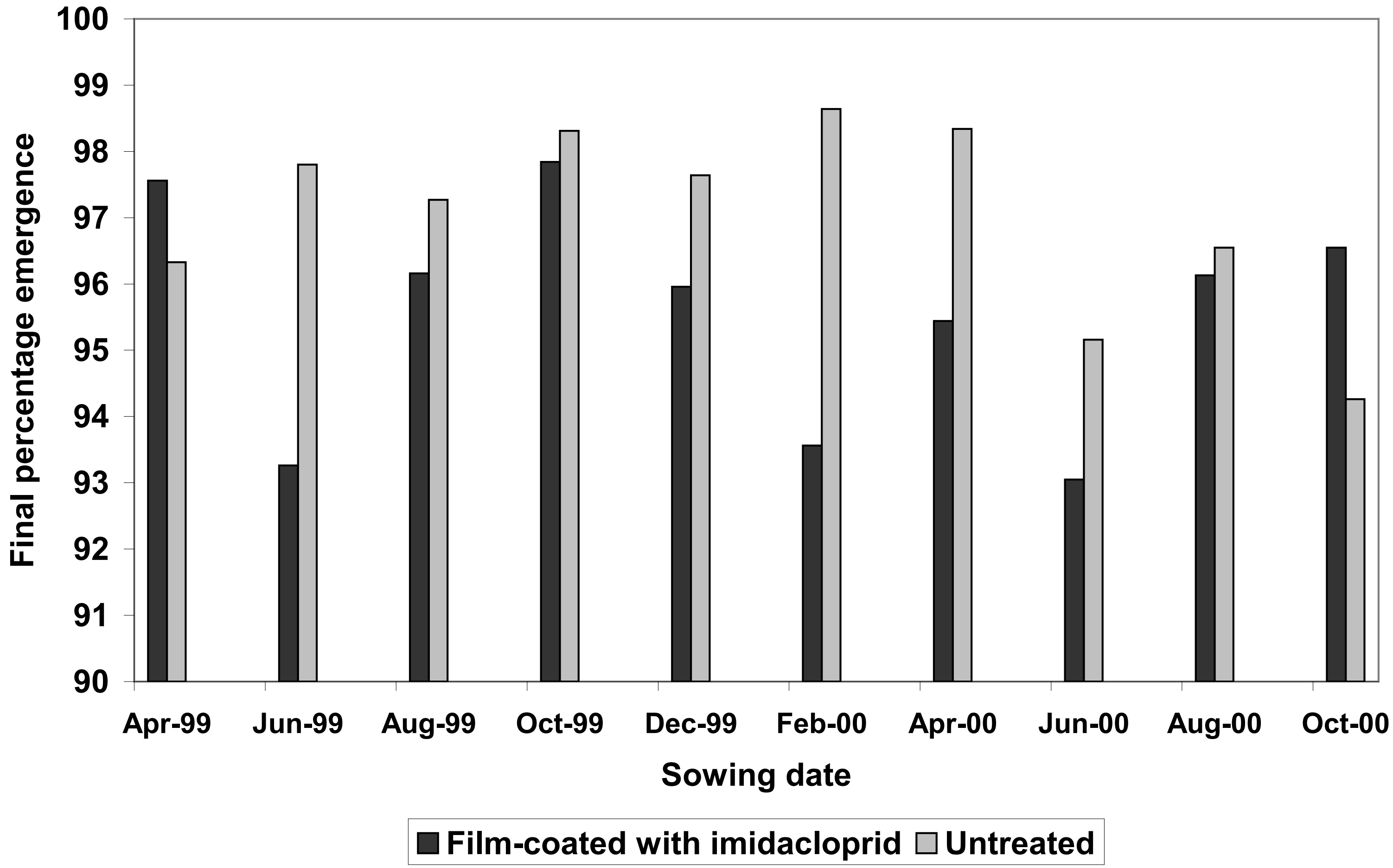


Figure 11. Final percentage seedling emergence (Experiment 4). Statistical analyses including LSD's are shown in Table 12.



Appendix 1. Insecticides applied in Experiment 1.

Date	B-imidacloprid	C-triazamate	D-commercial standard
18-Jun		T	P
02-Jul		T	P
19-Jul		T	P
29-Jul	P		P
13-Aug	P	T	P
25-Aug	P		P
09-Sep	D	T	D
27-Sep	D		D
07-Oct	DO		DO
22-Oct	D		D
04-Nov	D		D

P = Pirimicarb (420g/ha) + Agral (150 ml/ha)
D = Dimethoate (Danadim) (1.05 l/ha)
DO = Lambda-cyhalothrin + pirimicarb (Dovetail) (2.0 l/ha) + Agral (180 ml/ha)
T = Triazamate (Aztec) (400 ml/ha) + Swirl (500 ml/ha)

Appendix 2. Insecticides applied in Experiment 2.

Expt 2a		Expt 2b	
B - imidacloprid		**B - imidacloprid**	
11-Aug	P		
C - triazamate		**C - triazamate**	
02-Jul	T	30-Jul	T
19-Jul	T	16-Aug	T
03-Aug	T	21-Sep	T
18-Aug	T		
D – commercial standard		**D – commercial standard**	
02-Jul	P*	30-Jul	P
19-Jul	P	16-Aug	P
03-Aug	P	01-Sep	P
18-Aug	P	21-Sep	D
01-Sep	P		

T = Triazamate (Aztec) (400 ml/ha) + Swirl (500 ml/ha)
P = Pirimicarb (420 g/ha) + Activator 90 (150 ml/ha)
P* = Pirimicarb (420 g/ha) (no adjuvant added)
D = Dimethoate (1.05 l/ha) + Activator 90 (150 ml/ha)