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Signed on behalf of: **Warwick HRI**

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GROWER SUMMARY

Headline

- Four seed treatments (including imidacloprid and thiamethoxam) were evaluated for control of *Nasonovia ribisnigri* on lettuce and all appeared to be providing aphid control 6 weeks after sowing. One of the treatments (thiamethoxam) still appeared to be particularly effective 9 weeks after sowing, but had failed after 12 weeks.
- Two non-approved foliar spray treatments (Actara and Exp U) applied to control *Nasonovia ribisnigri* on lettuce were consistently more effective than the approved treatments applied at the same time, probably because they both have systemic activity.

Background and expected deliverables

Several aphid species infest the foliage of lettuce, of which currant–lettuce aphid (*Nasonovia ribisnigri*), peach-potato aphid (*Myzus persicae*) and potato aphid (*Macrosiphum euphorbiae*) are the most important. *Nasonovia ribisnigri* is particularly difficult to control, as it infests the heart of the plant and is therefore inaccessible to foliar sprays of insecticide.

In addition, insecticide resistance to pirimicarb (Aphox) in *N. ribisnigri* is present in the UK, but levels vary. Between 1999 and 2001 the levels of resistance to pyrethroids appeared to have increased in some strains of *N. ribisnigri* in the UK and resistant aphids commonly show cross-resistance to a range of pyrethroid compounds. However, monitoring between 2004 and 2006 found no strong evidence that populations of *N. ribisnigri* had high levels of resistance to any of the insecticides tested (Defra project HH3117TFV). There is no evidence of resistance to imidacloprid (Gaucho) or pymetrozine (Plenum) in *N. ribisnigri*. Some populations of peach-potato aphid are also resistant to insecticides, particularly pirimicarb and pyrethroids. Again there is no evidence of pronounced resistance to imidacloprid or pymetrozine in peach-potato aphid.

The difficulties of controlling lettuce aphids and the occurrence of insecticide resistance in *N. ribisnigri* and *M. persicae* mean that there is a need to find alternative and effective methods of control. The aim of this project is to evaluate novel insecticides for the control of aphids, particularly *N. ribisnigri*, on lettuce crops

The benefits of this project will be an assessment of new treatments for control of aphids on lettuce and an indication of those that should be taken forward for Full or Specific Off-Label Approval.

The expected deliverables from this work include:

- An evaluation of novel seed treatments for the control of aphids on lettuce
- An evaluation of novel insecticide sprays for the control of aphids on lettuce

Summary of the project and main conclusions

Three experiments were done in 2008 at Warwick HRI, Wellesbourne using 11 insecticidal treatments Aphox (pirimicarb), Plenum (pymetrozine), Biscaya (thiacloprid), Sanokote (imidacloprid), Sanokote (thiamethoxam), Actara (thiamethoxam) and five experimental treatments (Exp A, Exp B, Exp U, Exp X1, Exp X2). Experiments were done to answer the following questions:

1. Are there novel seed treatments to control aphids on lettuce? (Field Experiment 1)
2. Are there novel spray treatments to control aphids on lettuce? (Field Experiments 2a and 2b)

Experiment 1: Novel seed treatments to control aphids on lettuce

Lettuce seeds were sown in peat blocks on 24 July 2008 and kept in a glasshouse. There were four treatments using cv Saladin. These were: insecticide-free seed, imidacloprid (applied to dead seed which was sown with the live seed – Sanokote treatment), thiamethoxam (Sanokote) and Exp B (experimental seed treatment applied at Warwick HRI). In addition there were two treatments using cv Ixita, which were: insecticide-free seed and Exp A (experimental seed treatment applied commercially). The plants were transplanted on 22 August. The experiment was laid out as a randomised block design and there were 4 replicates of the 6 treatments. Because natural aphid numbers were very low, a fixed number of plants in each plot were infested with *N. ribisnigri* (wingless adults) by placing 5 aphids into a clip cage which was then secured onto a leaf, so that the aphids could not escape but had access to the leaf surface. Clip cages were applied on 4 September, 24 September and 16 October which was 6, 9 and 12 weeks after sowing respectively. The clip cages were removed after 11-14 days and the numbers of wingless and winged aphids were counted.

The first set of aphids (clip cages applied 4 September – 6 weeks after sowing) were exposed to a very heavy rain storm and a number of the cages fell off the plants. This was particularly true for cv Ixita, as this lettuce variety had small crinkled leaves and was unsuitable for clip cage tests. Because of the missing data and a large number of zero counts on the plots where data were available, no formal analysis was carried out for the first inoculation. Very few aphids were recovered, with the exception of the untreated control plots cv Saladin, suggesting that all the seed treatments were effective at this stage.

The second set of aphids (clip cages applied 24 September – 9 weeks after sowing) was again applied to all treatments. Fewer aphids were recovered from the 'thiamethoxam (Saladin)' treatment than from the Saladin plants grown from insecticide-free seed (Figure 1). This treatment reduced aphid numbers by 79%. The 'imidacloprid (Saladin)' treatment reduced aphid numbers by 66% but this was not a statistically-significant effect. Overall, aphid numbers were lower on cv Ixita and there was no statistically significant effect of Treatment A, even though it reduced aphid numbers compared with the insecticide-free cv Ixita.

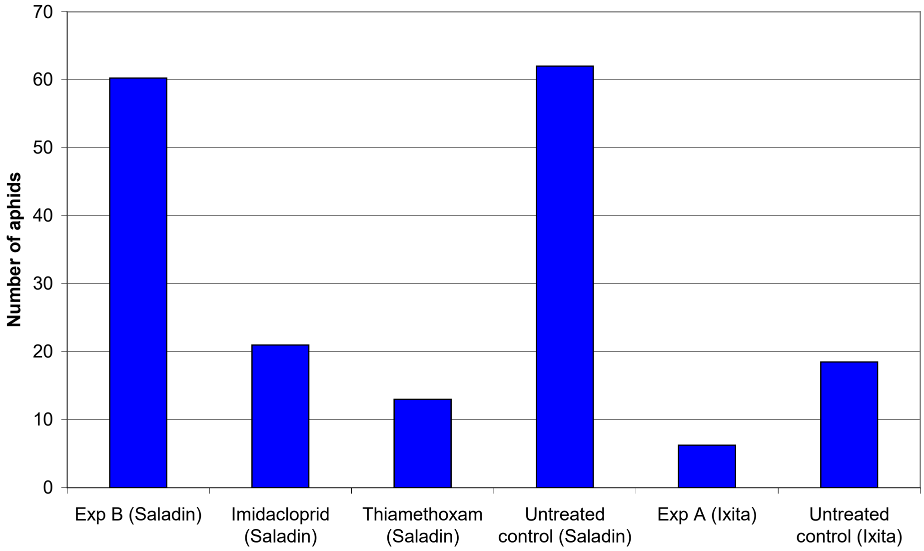

Figure 1: Insecticide seed treatments – second inoculation (9 weeks after sowing) - number of aphids per plot

The cv Ixita treatments were excluded from the final inoculations (12 weeks from sowing) and so the analysis was based only on the cv Saladin treatments. The effect of treatment was not statistically significant at this stage.

Experiment 2: Novel spray treatments to control aphids on lettuce

There were two experiments (2a and 2b). Lettuce seeds (cv Saladin) were sown in peat blocks on 20 May (2a) and 4 August (2b) and kept in a glasshouse. One to two weeks before transplanting, the plants were infested with *N. ribisnigri* (by introduction of laboratory-reared aphids on lettuce leaves). The plants were transplanted into field plots on 20 June (2a) and 12 September (2b) respectively and the plots were covered with fine mesh netting (supported on polythene pipe hoops to give a height of approximately 0.5 m) to aid the establishment of the aphids. The experiment was laid out as a randomised block design and there were 4 replicates of 8 treatments (untreated control, Actara (thiamethoxam), Biscaya (Thiacloprid), Aphox (pirimicarb), Plenum (pymetrozine), Exp U, Exp X1, Exp X2).

In each experiment, aphid numbers on the plots were monitored after transplanting and when an infestation had developed, the numbers of aphids on 6 plants/plot were recorded. The first foliar spray was applied soon after this count. The plots were then assessed a second time, approximately a week later. Then a second spray was applied and the plots were assessed for a third and final time approximately a week later. Foliar spray treatments were applied to Experiment 2a on 15 and 23 July and to Experiment 2b on 3 and 10 October. A spray rate of 300 l water/ha was used for all treatments. In October, the plots were re-covered with the fine mesh netting after spraying.

Experiment 2a

After the first spray application, the Actara and Exp U treatments reduced aphid numbers by 75 and 83% respectively compared with the untreated control (Figure 2). No other treatment effects were statistically significant. Aphid numbers were much lower after the second spray, even on the untreated control plots and none of the treatments reduced aphid numbers significantly compared with the insecticide-free control. Aphid numbers were actually higher on some of the insecticide-treated plots.

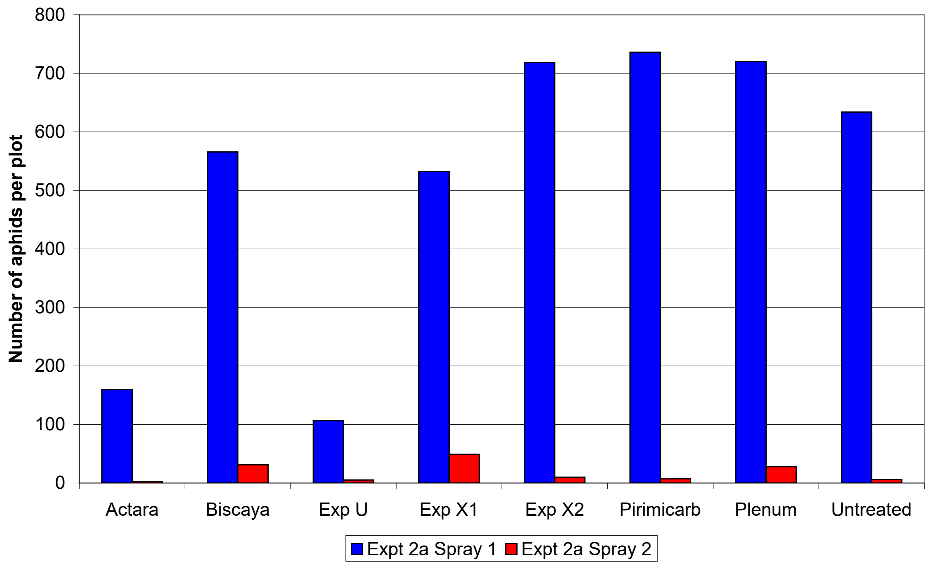

Figure 2: Experiment 2a - insecticide spray treatments –- number of aphids per plot

Experiment 2b

The first Actara, Biscaya and Plenum treatments reduced aphid numbers by 68, 61 and 66% respectively compared with the insecticide-free control plots (Figure 3). All of the second spray treatments, apart from the Exp X1 treatment, reduced aphid numbers compared with the insecticide-free control.

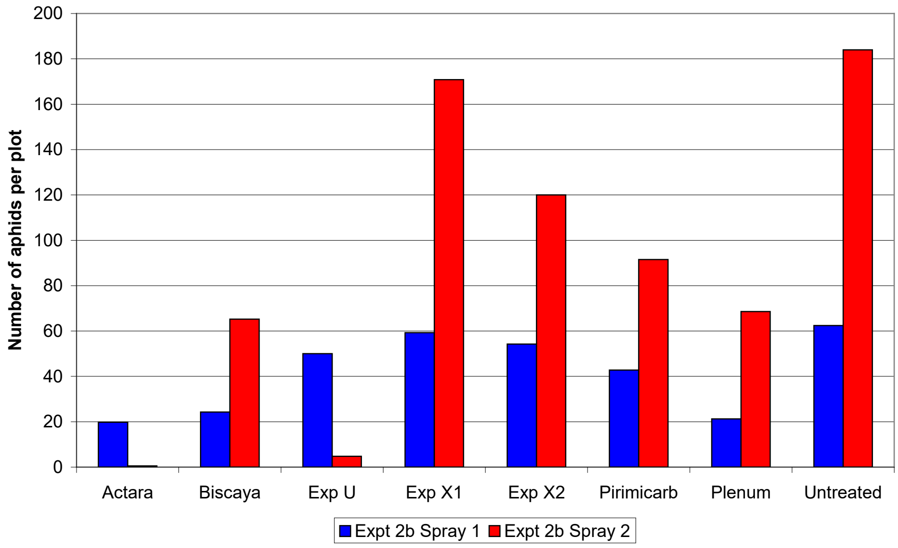

Figure 3: Experiment 2b - insecticide spray treatments –- number of aphids per plot

Summary

According to Met Office summaries, the summer of 2008 (June-August) was the third wettest in the last 40 years; the summer of 2007 receiving the most rainfall. Such conditions are unfavourable for the survival of several vegetable pests, including aphids. Consequently, all of the experiments were infested artificially with aphids (*Nasonovia ribisnigri*) from the culture maintained at Warwick HRI.

The wet weather also affected the first inoculation of the seed treatment experiment adversely. However, the information that was obtained suggested that the seed treatments were all performing well at this stage (6 weeks after sowing). One of the seed treatments still appeared to be particularly effective 9 weeks after sowing, but had failed after 12 weeks (crops of this age are unlikely to occur in commercial practice).

There were two insecticide spray experiments and sprays were applied on two occasions to each experiment. In general, the sprays were pitched against relatively high numbers of aphids. The exception to this was the second spray in the first experiment where there appeared to have been a natural population crash, since aphid numbers on the untreated plots were also very low. In general, Actara and Exp U were the most effective insecticides applied as foliar sprays and this is logical since they both have a degree of systemic activity and so may reach aphids that would be inaccessible to insecticides that are only effective through contact action.

Financial benefits

- The farm gate value of the approximately 6000 ha of field lettuce grown in the UK is around £75 million. The retail value of the UK market for bagged salads and whole-head lettuce is approximately £478 million. However, bagged salads would include spinach, watercress, babyleaf Brassica etc.
- The presence of aphids can lead to the rejection of a whole consignment of lettuce, be it whole-head or destined for processing in bagged salads. Around 70% of the crop is at risk from aphid losses.
- Despite the availability of cultivars of lettuce resistant to *N. ribisnigri*, many growers prefer to grow susceptible varieties, so insecticidal control methods will be relied on for some years to come. In addition, there is some evidence that, in 2007, some populations of *N.ribisnigri* in mainland Europe have been able to develop on resistant varieties.
- With reports of *N. ribisnigri* having reduced sensitivity to pirimicarb and pyrethroid insecticides and with some populations of *M. persicae* already having resistance to these chemicals, the new chemistries that are becoming available to growers give them the opportunity to develop effective control programmes and reduce the incidence of crop losses due to aphid infestation.

Action points for growers

- Four seed treatments (including imidacloprid and thiamethoxam) were evaluated for control of *Nasonovia ribisnigri* on lettuce and all appeared to be providing control 6 weeks after sowing. One of the seed treatments (thiamethoxam) still appeared to be particularly effective 9 weeks after sowing, but had failed after 12 weeks.
- Two non-approved foliar spray treatments (Actara and Exp U) applied to control *Nasonovia ribisnigri* on lettuce were consistently more effective than the approved treatments applied at the same time, probably because they both have systemic activity.
- The availability of Plenum, Biscaya and other new insecticides with different modes of action to pirimicarb and pyrethroids provides the opportunity to develop insecticide spray programmes which alternate insecticide products with different modes of action, to minimise the risk of developing insecticide-resistant aphid populations.
- However, it is important to avoid using insecticides with a similar mode of action in succession, so, for example, a neonicotinoid should not be used as the first spray treatment on crops that have been grown from seed treated with imidacloprid .

SCIENCE SECTION

Introduction

Several aphid species infest the foliage of lettuce, of which currant–lettuce aphid (*Nasonovia ribisnigri*), peach-potato aphid (*Myzus persicae*) and potato aphid (*Macrosiphum euphorbiae*) are the most important. *Nasonovia ribisnigri* is particularly difficult to control, as it infests the heart of the plant and is therefore inaccessible to foliar sprays of insecticide. In addition, insecticide resistance to pirimicarb (Aphox) in *N. ribisnigri* is now present in the UK, but levels vary. Between 1999 and 2001 the levels of resistance to pyrethroids appeared to have increased in some strains of *N. ribisnigri* in the UK and resistant aphids commonly show cross-resistance to a range of pyrethroid compounds. However, monitoring between 2004 and 2006 found no strong evidence that populations of *N. ribisnigri* had high levels of resistance to any of the insecticides tested (Defra project HH3117TFV). There is no evidence of resistance to imidacloprid (Gaucho/Sanokote) or pymetrozine (Plenum) in *N. ribisnigri*. Some populations of peach-potato aphid are also resistant to insecticides, particularly pirimicarb and pyrethroids. Again there is no evidence of pronounced resistance to imidacloprid or pymetrozine in peach-potato aphid.

The difficulties of controlling lettuce aphids and the occurrence of insecticide resistance in *N. ribisnigri* and *M. persicae* mean that there is a need to find alternative and effective methods of control. The aim of this project is to evaluate novel insecticides for the control of aphids, particularly *N. ribisnigri*, on lettuce crops

Experiments were done to answer the following four questions:

1. Are there novel seed treatments to control aphids on lettuce? (Field Experiment 1)
2. Are there novel spray treatments to control aphids on lettuce? (Field experiments 2a & 2b)

The test chemicals are shown as the products (with the active substances used in parentheses) as certain chemicals are available under a range of different product names. These were: Aphox (pirimicarb), Plenum (pymetrozine), Biscaya (thiacloprid), Sanokote (imidacloprid; thiamethoxam), Actara (thiamethoxam) and five experimental treatments (Exp A, Exp B, Exp U, Exp X1, Exp X2).

Experiment 1 - Novel seed treatments to control aphids on lettuce

Materials and methods

The experiment was done within the field known as Big Cherry at Warwick HRI, Wellesbourne. The treatments are listed in Table 1.

Lettuce seeds (two cultivars, see Table 1) were sown in peat blocks on 24 July 2008 and kept in a glasshouse. The plants were transplanted on 22 August. The experiment was laid out as a randomised block design and there were 4 replicates of 6 treatments. Plots were 2 m x 1 bed (1.83 m) in size and there were 4 rows of 5 plants (20 plants). Plants were planted at 35 cm spacing within rows and 38 cm between rows.

Because natural aphid numbers proved to be very low, a 'clip cage' experiment was instigated. A fixed number of plants in each plot were infested with *N. ribisnigri* (wingless adults) by placing 5 wingless aphids into a clip cage which was then secured onto a leaf, so that the aphids could not escape but had access to the leaf surface. Clip cages were applied on 4 September, 24 September and 16 October, 6, 9 and 12 weeks respectively after sowing. In particular, this provided a test of the persistence of the different insecticide treatments. The clip cages were removed on 18 September, 8 October and 27 October respectively and the numbers of wingless and winged aphids were counted. The treatment and assessment timetable is shown in Table 2.

Table 1: Seed treatments to control aphids on lettuce

Treatment	Variety	Active ingredient	Rate
Exp A treated seed	Ixita	Exp A	Not provided
Exp A untreated control	Ixita		
Exp B treated seed	Saladin	Exp B	142.7 g product/unit
imidacloprid Sanokote	Saladin	imidacloprid	120 g a.i./unit
thiamethoxam Sanokote	Saladin	thiamethoxam	80 g a.i./unit
Untreated control	Saladin		

1 unit = 100,000 seeds

Table 2: Treatment and assessment timetable

24 Jul	Sown
11 Aug	Seedling assessment
22 Aug	Transplanted
4 Sep	Clip cages put on plants (6 weeks after sowing)
18 Sep	Clip cages removed from plants and aphids counted
24 Sep	Clip cages put on plants (9 weeks after sowing)
8 Oct	Clip cages removed from plants and aphids counted
16 Oct	Clip cages put on plants (12 weeks after sowing)
27 Oct	Clip cages removed from plants and aphids counted

Data analysis

Analysis was carried out using a Log-Linear model and undertaken assuming a randomised complete block design.

Results

The first set of aphids (clip cages applied 4 September – 6 weeks after sowing) were exposed to a very heavy rain storm and a number of the cages fell off the plants. This was particularly true for cv Ixita as this lettuce variety had small crinkled leaves and was unsuitable for clip cage tests.

Because of the missing data and a large number of zero counts on the treated plots where data were available, no formal analyses were carried out for the first inoculation. Figure 4 summarises the mean numbers of aphids recovered. There was a relatively large number of aphids on the untreated control plots cv Saladin.

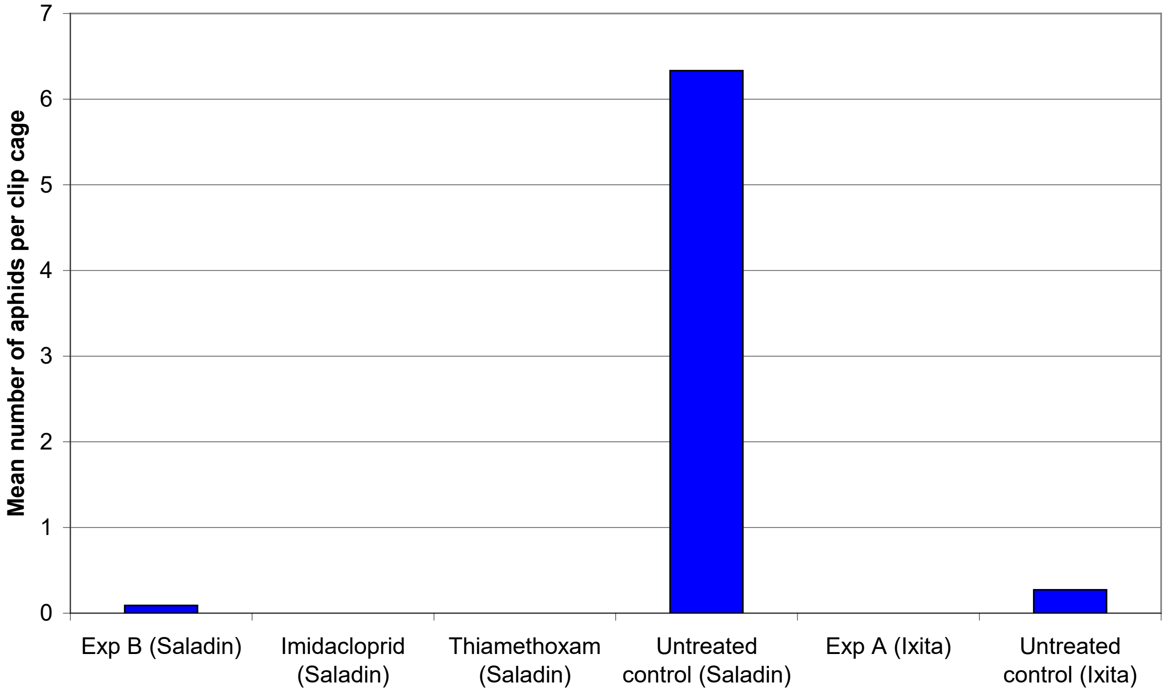

Figure 4: The mean numbers of aphids per clip cage in cages applied on 4 September (6 weeks after sowing)

The second set of aphids (clip cages applied 24 September – 9 weeks after sowing) was again applied to all treatments. Analysis showed that the effect of treatment was statistically significant (p=0.028). Table 3 summarises the effects of each treatment relative to the untreated control. Here significantly lower numbers of aphids were observed on the 'thiamethoxam (Saladin)' and the 'Exp A (Ixita)' treatments. The responses of each treatment are also presented as a proportion of the response of the untreated control treatments. The additional effect of the 'Exp A (Ixita)' treatment relative to the 'untreated (Ixita)' treatment is illustrated in the lower section of the table. The effect was not statistically significant. The total numbers of aphids per plot are shown in Figure 5.

Table 3: Second clip cage inoculation (24 September, 9 weeks after sowing) - the effect of treatments relative to the untreated control treatment.

The significance of the effects was determined using a t probability value on 15 degrees of freedom and the terms significant at a 5% level are shown in bold. The additional effect of the 'Exp A (Ixita)' treatment relative to the 'untreated (Ixita)' treatment is illustrated in the lower section of the table

Treatments	Additional Effect	Standard Error	P value	Pr(>T)	Proportion of Control
Exp B (Saladin)	-0.029	0.430	-0.160	0.948	0.972
imidacloprid (Saladin)	-1.083	0.600	-0.070	0.091	0.339
thiamethoxam (Saladin)	**-1.562**	**0.725**	**-1.800**	**0.048**	**0.210**
Exp A (Ixita) treated	**-2.295**	**0.997**	**-2.150**	**0.036**	**0.101**
Untreated control (Ixita)	-1.209	0.629	-1.920	0.074	0.298

Treatments	Additional Effect	Standard Error	P value	Pr(>T)	Proportion of Control
Exp A (Ixita) treated	-1.09	1.1	-0.99	0.339	0.338

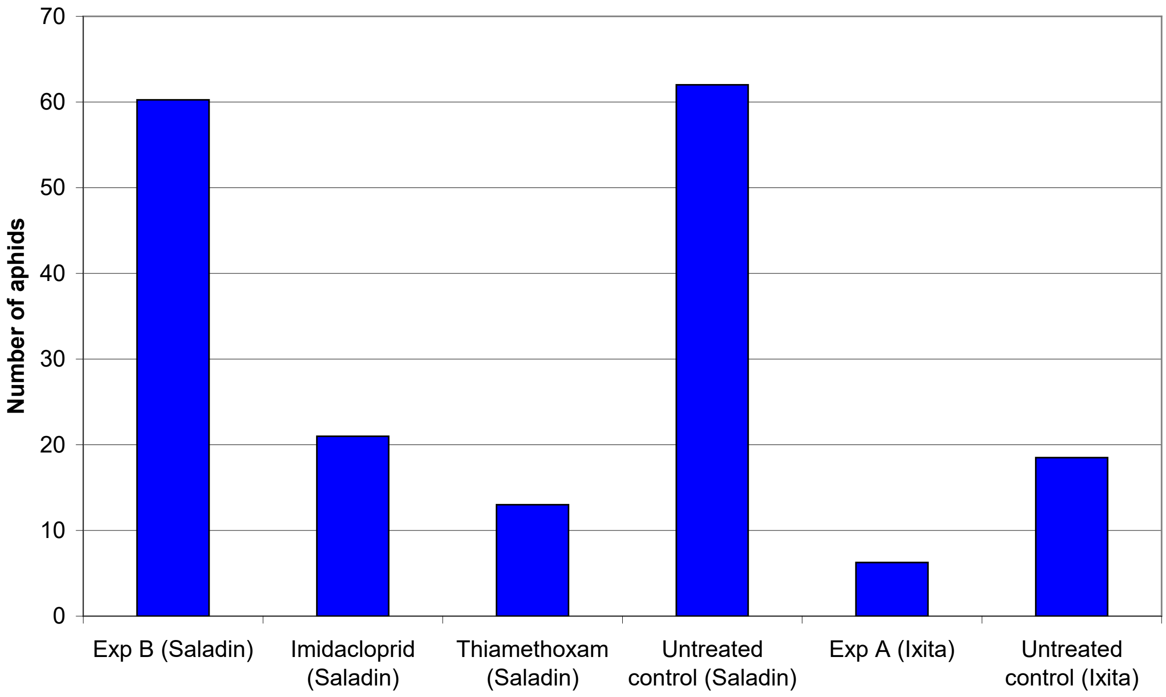

Figure 5: Insecticide seed treatments – second inoculation (9 weeks after sowing) - number of aphids per plot

The cv Ixita treatments were excluded from the final inoculations and so the analysis is based only on the Saladin treatments. Analysis showed that the effect of treatment was not statistically significant (p=0.514). Table 4 summarises the effects of each treatment relative to the untreated control. None of the effects were significant. Figure 6 shows the numbers of aphids per plot.

Table 4: Third clip cage inoculation – 16 October (12 weeks after sowing) - the effect of treatments relative to the untreated control treatment. The significance of the effects was determined using a t probability value on 9 degrees of freedom and the terms significant at a 5% level are shown in bold

Treatments	Additional Effect	Standard Error	P value	Pr(>T)	Proportion of Control
Exp B (Saladin)	0.034	0.577	0.060	0.954	1.034
imidacloprid (Saladin)	-0.477	0.665	-0.720	0.491	0.621
thiamethoxam (Saladin)	0.439	0.528	0.830	0.426	1.552

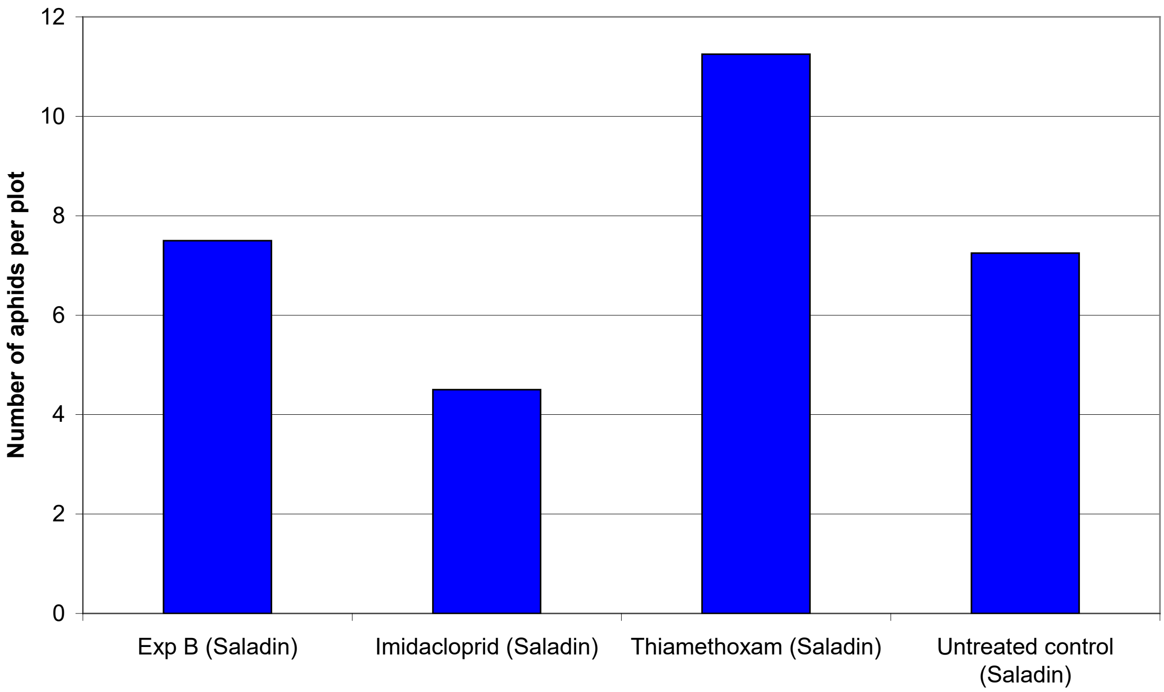

Figure 6: Insecticide seed treatments – third inoculation (12 weeks after sowing) - number of aphids per plot

Experiment 2 - Novel spray treatments to control aphids on lettuce

Materials and methods

There were two experiments (2a & 2b) and both experiments were done within the field known as Big Cherry at Warwick HRI, Wellesbourne. The treatments are listed in Table 7. Lettuce seeds were sown in peat blocks on 20 May (2a) and 4 August (2b) and kept in a glasshouse.

One to two weeks before transplanting, the plants were infested with *N. ribisnigri* (by introduction of laboratory-reared aphids on lettuce leaves). The plants were transplanted into field plots on 20 June (2a) and 12 September (2b) respectively and the plots were covered with fine mesh netting (supported on polythene pipe hoops to give a height of approximately 0.5 m) to aid the establishment of the aphids. The experiment was laid out as a randomised block design and there were 4 replicates of 8 treatments. Plots were 3 m x 1 bed (1.83 m) in size and there were 4 rows of 9 plants (36 plants). Plants were planted at 35 cm spacing within, and 38 cm between, rows.

In each experiment, aphid numbers on the plots were monitored after transplanting and when an infestation had developed the numbers of aphids on 6 plants/plot were recorded. The first foliar spray was applied soon after this count. The plots were then assessed a second time, approximately a week later. Then a second spray was applied and the plots were then assessed for a third and final time approximately a week later. Foliar spray treatments were applied to Experiment 2a on 15 and 23 July and to Experiment 2b on 3 and 10 October. A spray rate of 300 l water/ha was used for all treatments. In October, the plots were re-covered with the fine mesh netting after spraying.

Table 5: Foliar treatments applied to lettuce to control aphids

Treatment	Active ingredient	Rate (product/ha)
Actara	thiamethoxam	400 g
Aphox	pirimicarb	150 g
Biscaya	Thiacloprid	400 ml
Exp U		480 ml
Exp X1		1500 ml
Exp X2		175 ml
Plenum	pymetrozine	400 g

Untreated		

Table 6: Treatment and assessment timetable

20-May	Trial 1	Sown
20-Jun	Trial 1	Transplanted
14-Jul	Trial 1	Assessed
15-Jul	Trial 1	Sprayed
22-Jul	Trial 1	Assessed
23-Jul	Trial 1	Sprayed
30-Jul	Trial 1	Assessed
4-Aug	Trial 2	Sown
12-Sep	Trial 2	Planted
3-Oct	Trial 2	Assessed
3-Oct	Trial 2	Sprayed and re-covered with netting
9-Oct	Trial 2	Assessed
10-Oct	Trial 2	Sprayed
22-Oct	Trial 2	Assessed

Data analysis

The trials were designed using a Trojan square (row and column) design. After initial investigations of the block sources of variability using Analysis of Variance (ANOVA), the decision was taken to analyse the trials assuming a randomised complete block design (blocks = columns). An advantage of this was that it allowed analysis using a Log-Linear model of the counts to be performed. Each trial was analysed separately. Analysis was carried out using the post application counts as the response variable. On each occasion, the counts taken prior to each treatment application were used as covariates within the analysis.

There were too many zeros in the data to justify analysis of the numbers of other aphid species on the plots.

Results

Experiment 2a – first spray

The effect of some of the treatments was statistically significant ($p<0.001$). Table 7 summarises the effect of each treatment relative to the untreated control. The effects of the Actara and Exp U sprays were significantly negative, showing that these plots had aphid counts that were significantly smaller than the untreated control. No other treatment effects were significant. Counts for each treatment as a proportion of the untreated control are also shown in Table 7. Here the lowest proportion is observed for the Exp U treatment (0.168).

Table 7: Experiment 2a, spray 1 – the effect of treatments relative to the untreated control treatment.

The significance of the effects was determined using a t probability value on 20 degrees of freedom and those terms significant at a 5% level are shown in bold

Treatments	Additional Effect	Standard Error	P value	Pr(>T)	Proportion of Control
Actara	**-1.378**	**0.421**	**-3.280**	**0.004**	**0.252**
Biscaya	-0.114	0.264	-0.430	0.671	0.893
Exp U	**-1.784**	**0.498**	**-3.580**	**0.002**	**0.168**
Exp X1	-0.175	0.221	-0.790	0.438	0.840
Exp X2	0.125	0.213	0.590	0.562	1.134
Pirmicarb	0.149	0.287	0.520	0.608	1.161
Plenum	0.127	0.209	0.610	0.550	1.136

The total numbers of aphids per plot following Spray 1 are shown in Figure 7.

Experiment 2a – second spray

Aphid numbers were much lower after the second spray, even in the untreated control plots. However, the overall effect of 'treatment' was statistically significant (p=0.007). Table 8 shows the estimated effects relative to the untreated control. The Biscaya, Exp X1 and Plenum treatments all displayed significantly positive effects, showing that they had counts significantly larger than the untreated control. Responses for each treatment as proportions of the untreated control are also shown in Table 8. Here the smallest proportion was for the Actara treatment (0.472).

Table 8: Experiment 2a, spray 2 – the effect of treatments relative to the untreated control treatment.

The significance of the effects was determined using a t probability value on 20 degrees of freedom and the terms significant at a 5% level are shown in bold

Treatments	Additional Effect	Standard Error	P value	Pr(>T)	Proportion of Control
Actara	-0.750	1.880	-0.400	0.694	0.472
Biscaya	**1.672**	**0.788**	**2.120**	**0.046**	**5.325**
Exp U	-0.140	1.640	-0.090	0.932	0.869
Exp X1	**2.128**	**0.716**	**2.970**	**0.008**	**8.395**
Exp X2	0.534	0.845	0.630	0.534	1.706
pirimicarb	0.213	0.954	0.220	0.825	1.238
Plenum	**1.565**	**0.734**	**2.130**	**0.046**	**4.785**

The total numbers of aphids per plot following Spray 2 are shown in Figure 4.

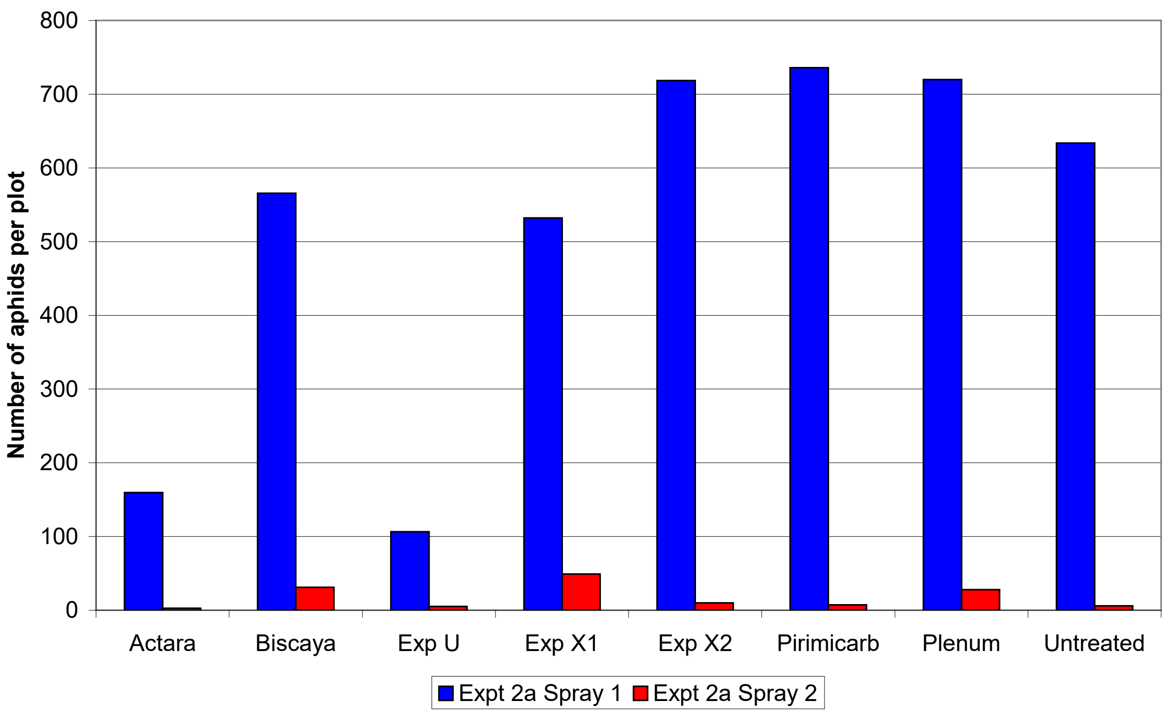

Figure 7: Insecticide spray treatments – Experiment 2a - Number of aphids per plot

Experiment 2b – first spray

The effects of some of the first treatments were statistically significant (p=0.013). Table 9 shows the effects of each treatment relative to the untreated control. Here all terms were negative, but only the Actara, Biscaya and Plenum treatments were significantly different from the untreated control. Responses are also shown as a proportion of the untreated control.

Table 9: Experiment 2b, spray 1 – the effect of treatments relative to the untreated control treatment.

The significance of the effects was determined using a t probability value on 20 degrees of freedom and the terms significant at a 5% level are shown in bold

Treatments	Additional Effect	Standard Error	P value	Pr(>T)	Proportion of Control
Actara	**-1.148**	**0.383**	**-3.000**	**0.007**	**0.317**
Biscaya	**-0.945**	**0.391**	**-2.420**	**0.025**	**0.389**
Exp U	-0.221	0.286	-0.770	0.448	0.801
Exp X1	-0.140	0.296	-0.470	0.641	0.869
Exp X2	-0.051	0.287	-0.180	0.860	0.950
Pirmicarb	-0.378	0.321	-1.180	0.253	0.685
Plenum	**-1.075**	**0.385**	**-2.800**	**0.011**	**0.340**

The total numbers of aphids per plot following Spray 1 are shown in Figure 8.

Experiment 2b – spray 2

The effect of treatment was statistically significant (p<0.001). Table 10 shows the effects of each treatment relative to the untreated control. All treatments apart from the Exp X1 treatment were significantly negative. It should be noted, however, that for the Actara treatment, there were only two aphids on all four plots. This may have had a detrimental effect upon the standard error for the effect, although the small number of counts is, in itself, evidence that the there is an effect due to this treatment. Responses for each treatment are also provided as a proportion of the untreated control.

Table 10: Experiment 2b, spray 2 – the effect of treatments relative to the untreated control treatment.

The significance of the effects was determined using a t probability value on 20 degrees of freedom and the terms significant at a 5% level are shown in bold

Treatments	Additional Effect	Standard Error	P value	Pr(>T)	Proportion of Control
Actara	**-5.820**	**2.330**	**-2.500**	**0.021**	**0.003**
Biscaya	**-1.037**	**0.267**	**-3.890**	**<.001**	**0.355**
Exp X2	**-0.427**	**0.176**	**-2.430**	**0.024**	**0.652**
Exp X1	-0.074	0.166	-0.450	0.659	0.928
Pirmicarb	**-0.699**	**0.214**	**-3.270**	**0.004**	**0.497**
Plenum	**-0.987**	**0.293**	**-3.620**	**0.002**	**0.373**
UKA378c	**-3.660**	**0.675**	**-5.450**	**<.001**	**0.026**

The total numbers of aphids per plot following Spray 1 are shown in Figure 5.

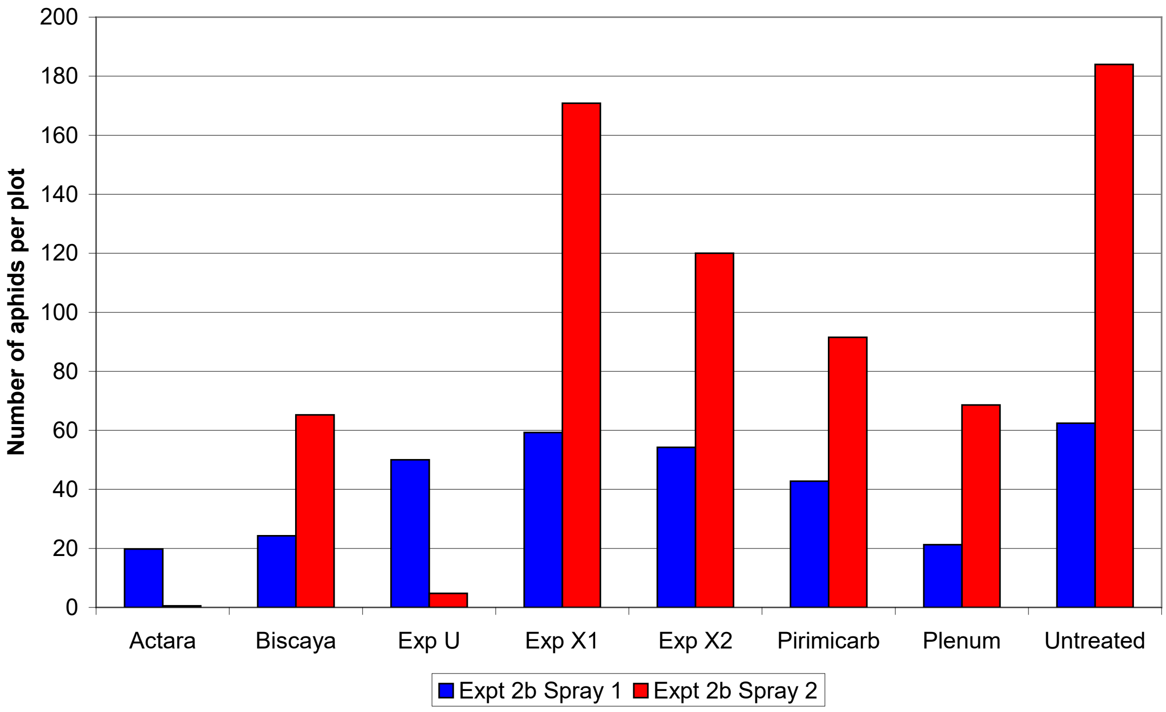

Figure 8: Insecticide spray treatments – Experiment 2b - number of aphids per plot

DISCUSSION

According to Met Office summaries, the summer of 2008 (June-August) was the third wettest in the last 40 years; the summer of 2007 receiving the most rainfall. Such conditions are unfavourable for the survival of several vegetable pests, including aphids. Consequently, all of the experiments were infested artificially with aphids (*Nasonovia ribisnigri*) from the culture maintained at Warwick HRI.

The wet weather also affected the first inoculation of the seed treatment experiment adversely. However, the information that was obtained suggested that the seed treatments were all performing well at his stage (6 weeks after planting). One of the seed treatments (thiamethoxam) still appeared to be particularly effective 9 weeks after sowing, but had failed after 12 weeks (crops of this age are unlikely to occur in commercial practice).

There were two insecticide spray experiments and two sprays were applied on two occasions to each experiment. In general, the sprays were pitched against relatively high numbers of aphids. The exception to this was the second spray in the first experiment where there appeared to have been a natural population crash, since aphid numbers on the untreated plots were also very low. In general, Actara and Exp U were the most effective insecticides applied as foliar sprays and this is logical since they both have a degree of systemic activity and so may reach aphids that would be inaccessible to insecticides that are only effective through contact action.

TECHNOLOGY TRANSFER

None to date.

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