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Survey of leafhoppers and damage to apple 1996

Undertaken for APRC

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Authentication

I declare that this work was done under my supervision according to the procedures described herein and that this report is a true and accurate record of the results obtained.

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Signature

Date ..3...January...1997.....

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Summary

A regional survey of leafhopper populations in commercial apple orchards was conducted in Kent in 1996. The aims of the survey were to identify which leafhopper species were present in infested apple orchards and to determine their relative abundance, to record the degree of leaf and fruit damage occurring and to correlate leafhopper incidence with growers' insecticide programmes.

Eight commercial fruit farms in Kent were visited on up to three occasions at approximately monthly intervals, *viz* late July to early August, late August to early September, and late September to early October 1996. At each farm, one or two orchards were surveyed. Samples of 100 adult leafhoppers were collected from the apple trees and the windbreaks separately, and the species identified by microscopic examination of the male genitalia. Twenty trees in each orchard were assessed for the degree of damage by leafhoppers. Feeding damage on five leaves from each of the inside and the outside of the canopy of each tree was scored on a scale from 0-6, the lowest scores indicating the least damage. The number of excrement (frass) specks on five fruits from each of the 20 trees were counted.

Leafhopper damage was most severe on leaves in the centre of the trees, with less on the outer zones of the tree. In orchards with large leafhopper populations, intense bleaching could be seen on some leaves, although a less intense speckling was more common. Frass contamination of the fruit was generally between 0-10 frass specks per apple, although more than 40 specks per apple were seen on some apples in orchards with high leafhopper levels.

The main species on apple was a fruit tree leafhopper, *Edwardsiana crataegi*. In some orchards, the rose leafhopper ,*Edwardsiana rosae*, was also found in low numbers (0-10% of the sample) on the last two sampling dates. The numbers of leafhoppers on the windbreaks were generally smaller than on apple. The main leafhopper species from the hawthorn windbreaks were *E. crataegi* and *E. rosae*, with some *Alnetoidia alneti* also being found. On the alder windbreaks the main species were *Alnetoidia alneti*, *Edwardsiana hippocastani* and *Eupterycyba jacunda*, with some *E. crataegi* and *E. rosae* being found occasionally.

The observed leafhopper incidence was correlated with growers' insecticide programmes and it appeared that approved applications of chlorpyrifos (Dursban, Spannit) had little effect. Orchards which had been sprayed with carbaryl (Thinsec) as a thinning agent were avoided in this study as this chemical appears to decrease the numbers of leafhoppers. In this study many of the leafhoppers had either internal or external parasitoids. Whilst the leafhoppers were not killed immediately by the parasitoids, the genitalia were reduced in size in some cases as a result of parasitisation.

Introduction

Leafhoppers have greatly increased in abundance in apple orchards in recent years, causing noticeable leaf damage. This damage occurs when the nymphs and the adults pierce the mesophyll cells of the leaves with their needle-like stylets during feeding, leaving characteristic white speckling. In 1994 and 1995, populations were very large in many

orchards and the damage was so intense that the leaves of the trees became bleached by the end of the season. It is probable that the photosynthetic activity of the trees was reduced, as the chlorophyll content is reduced by leafhopper activity (MacNeil, Hikichi and Downing, 1987). This could adversely affect tree vigour and returned bloom. This leaf damage was particularly apparent in some of the newer dessert varieties. Leafhopper excrement (frass) can also contaminate the surface of the fruits, although this is generally superficial and can be washed off by rain or during grading.

The reasons for the increase in leafhopper populations are not clear. The increase may be due to a reduction or changes in insecticide usage, poor spray timing, or resistance to insecticides. Resistance has been reported from New Zealand where the fruit tree leafhopper *Edwardsiana crataegi* has become tolerant to azinphos-methyl in several orchards, although carbaryl is still being used successfully (Charles, Walker and White, 1994).

While a number of studies on leafhoppers have been carried out in New Zealand to identify the key species and methods of control (Teulon and Penman, 1986a, 1986b, 1987), few studies have been done in this country. To assess the extent of the leafhopper problem in the UK, a regional survey was conducted in 1996 with the following main objectives:-

1 To identify which leafhopper species were present in infested apple orchards in Kent and to determine their relative abundance.

2 To record the degree of leaf damage and fruit contamination with frass.

3 To correlate incidence with growers' insecticide programmes.

Materials and methods

The survey was conducted over three main sampling occasions at approximately monthly intervals, *viz* late July to early August, late August to early September and late September to early October 1996.

Six farms were surveyed initially, Loyterton Farm (Sittingbourne), Howfield Farm (Chartham Hatch), Broadwater Farm (West Malling), Baretilt Farm (Hawkhurst), Ewell Farm (Faversham) and Elverton Farm (Teynham). Baretilt Farm was not included on the last sample date due to the low numbers of leafhoppers, although two extra farms Sandbanks Farm (Faversham) and Provender Farm (near Faversham) with larger populations of leafhoppers were included on the last two sample dates. At each farm either one or two orchards were assessed (Table 1).

Twenty trees in each orchard were assessed for the degree of leafhopper damage to the leaves and frass contamination of fruits. Feeding damage on five leaves from each of the inside and the outside of the canopy of each tree was scored on a scale from 0-6, with the lower categories showing the least damage. Five fruits on each of the 20 trees were scored for frass contamination. The number of frass specks on each apple were counted and classed as either 0, 1-2, 3-10, 10+, 20+, 30+, 40+ specks per apple. Fruits were not assessed on the last sample date as the crops were in the process of being picked.

Samples of approximately 100 adult leafhoppers were collected from the apple trees and the windbreaks of each orchard, using an aspirator (or pooter). All of the windbreaks were alder sp. apart from at site 3 where hawthorn windbreaks were sampled. The leafhopper species were identified by microscopic examination of the male genitalia and external characteristics such as the wing veination and markings (if present). As the female genitalia are similar between species it was not always possible to determine the species of each female, unless there were distinctive markings. The species of the males and sex of each leafhopper were recorded. Nymphs in the samples were also counted.

Results

The survey showed that leafhopper damage to the apple leaves was most severe in the centre of the trees, with less damage occurring on the outer leaves (Table 2). In orchards with large numbers of leafhoppers, intense bleaching could be seen on some leaves, although a less intense speckling was more common. In trees without a dense canopy structure, such as site 3, orchard 1, the distinction between the speckling levels on the inside and the outside of the tree was less clear. Intensity of leaf damage increased through the season at some sites.

Frass contamination of the fruit was seen at most sites (Table 3). Generally this was between 1-10 frass specks per apple, although more than 40 specks per apple were seen on a few apples in orchards with high leafhopper levels (sites 2, 7 and 8).

The main leafhopper species in all of the orchards was a pale yellow fruit tree leafhopper, *Edwardsiana crataegi* (Tables 4a, 4b and 4c). In some orchards the rose leafhopper, *Edwardsiana rosae*, was also found in low numbers (2-10% of the total leafhopper catch), but only on the last two samples dates (Tables 4b and 4c). Although most of the *E. crataegi* were typically pale yellow, some were almost white (similar to *E. rosae*), while others were orange. In samples of *E. crataegi*, approximately 58% were female and 42% were male.

The species of leafhopper from the windbreaks were generally more varied than from the orchards, and the numbers of leafhoppers were smaller (Table 5). The leafhopper species from the hawthorn windbreaks at site 3 were similar to the species found on the apple trees. Mainly *E. crataegi* and *E. rosae*, but also some *Alnetoidia alneti*, were found. In contrast, *E. crataegi* and *E. rosae* were only found occasionally on the alder windbreaks, with the main species being *Alnetoidia alneti* and *Edwardsiana hippocastani* (which look similar to the leafhopper species which are found on apple) and *Eupterycyba jacunda* (which has distinctive black and green markings).

In the insect samples, many of the leafhoppers had either internal or external parasitoids. Whilst the leafhoppers were not killed immediately by the parasitoids, the genitalia were reduced in some cases as a result of parasitisation.

The observed leafhopper incidence was correlated with growers' insecticide programmes (Table 6). It appeared that approved applications of chlorpyrifos (Dursban, Spannit) had little effect. Apart from site 1, the orchards chosen for this survey were not sprayed with carbaryl (Thinsec) as a thinning agent as this greatly decreases the numbers of leafhoppers. At site 1, there were no leafhoppers in the sprayed area on 2 September, compared to 33 leafhoppers

collected from the unsprayed region. In late September, only one leafhopper was collected from the sprayed rows, in contrast to 98 leafhoppers from the unsprayed rows. The single application of the insecticide heptenophos (Hostaquick) at site 5 on 15 July may have decreased the numbers of leafhoppers. This could help to explain why there were very few leafhoppers, although there was leaf damage which may have occurred prior to spraying. This chemical is approved for use on apples against aphids and it may also affect leafhoppers. It is registered for control of leafhoppers on tomatoes and cucumbers.

Discussion

Damage caused by adult and nymphal leafhoppers feeding in the mesophyll cells was apparent on many of the leaves where leafhoppers were present. Although this was generally seen as a light speckling of the leaves, the inner leaves of the tree canopy were almost bleached in some apple orchards with large leafhopper populations. Spots of frass on the fruit were also seen. Although the contamination was mainly superficial, greater contamination is likely to reduce fruit quality. Most of the apples assessed in this survey had small levels of frass contamination, although there was noticeable spotting of the fruits in orchards with high numbers of leafhoppers. If the increase in the incidence of leafhoppers seen in recent years continues, contamination of fruit by frass may become an increasing concern.

The fruit tree leafhopper *Edwardsiana crataegi* was the main leafhopper found in the apple orchards. The rose leafhopper *Edwardsiana rosae* was only found in low numbers later on in the season, but may also contribute to the leaf and fruit damage. *Edwardsiana crataegi* has two generations a year, overwintering under bark of small twigs or branches in the egg stage (Alford, 1984). This species can spend its entire life-cycle on apple and most studies suggest that its development can only be completed on apple or hawthorn. This agrees with the windbreak data, when *E. crataegi* was one of the main species on the hawthorn windbreaks. *Edwardsiana rosae* overwinters in the egg stage on rose bushes, and the adults only fly to the apple in June. The second generation occurs on apple before the adults fly back to the rose bushes to lay eggs. This host-alternation helps to explain why *E. rosae* was only found on the last two sampling dates. This species, like *E. crataegi*, was also found on the hawthorn windbreaks.

The main leafhopper species on the alder windbreaks were different from those found in the orchards, and therefore the windbreaks are unlikely to act as a reservoir for pests. The hawthorn windbreaks which contained *E. crataegi* and *E. rosae* may act as a reservoir for these species.

It appears that the insecticide chlorpyrifos is generally ineffective against leafhoppers, although good control is obtained by spraying with carbaryl. As low levels of resistance to the organophosphorous insecticide azinphos-methyl have been found in New Zealand (Charles, Walker and White, 1994), it is important to encourage an integrated pest management (IPM) approach, where natural enemies are conserved by using a selective or carefully timed insecticidal programme.

Many of the adult leafhoppers in the samples were parasitised heavily and, while they were not killed immediately, the genitalia were reduced in size in some cases. This might affect the breeding potential of the leafhoppers, which could be important in an IPM programme. Egg parasitism by *Anagrus armatus* (Mymaridae:Hymenoptera) has also been described (Teulon and Penman, 1986a).

It is important to consider the implications of large leafhopper populations for plant health, as some leafhoppers, such as *Fieberiella florii*, are known to be vectors of apple proliferation disease in many warmer European countries (Krczal, Krczal and Kunze, 1989). It is unlikely that the leafhoppers found on apple in this survey, all members of the family Typhlocybinae, would be vectors of such phytoplasmas, as they feed on the mesophyll rather than the phloem. Phloem-feeders belong to the family Deltocephalinae.

Conclusions

1 Leafhopper damage to leaves and frass contamination of fruits may be severe with a high incidence of leafhoppers.

2 *Edwardsiana crataegi* was the main leafhopper found in apple orchards in Kent.

3 *E. crataegi* is not a phloem feeder and is unlikely to be a vector of phytoplasmas such as apple proliferation disease.

4 Applications of the insecticide chlorpyrifos (Dursban) had little effect on leafhopper populations, although applications of carbaryl (Thinsec) greatly decreased leafhopper populations.

Recommendations for further work

1 The results of this initial study should be validated.

2 Bioassays should be conducted to examine the relative susceptibility of populations of *E. crataegi* from intensively sprayed and unsprayed orchards to insecticides, in particular chlorpyrifos, to determine whether resistance to insecticides has developed.

3 A range of insecticides should be screened for their efficiency for control of leafhoppers and for their effect on associated parasitoids.

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Table 1 Assessment sites for the leafhopper survey, 1996

Farm	Location	Orchard	
		Name	Cultivar/system
1 - Loyterton Farm	Sittingbourne	1 Russet Cox*	Cox (1 row)
2 - Howfield Farm	Chartham Hatch	1 Jubilee	Cox (1 row)
		2 Spindles	Cox (1 row)
3 - Broadwater Farm	West Malling	1 No 18	Standard Bramley
		2 No 4	Gala (1 row)
4 - Baretilt Farm	Hawkhurst	1 Waterland	Cox (3 row)
		2 Pond	Cox (3 row)
5 - Ewell Farm	Faversham	1 Long rows	Cox (3 row)
6 - Elverton Farm	Teynham	1 Bottom Leys	Cox (1 row)
		2 Queen Cox	Cox (1 row)
7 - Sandbanks Farm	Faversham	1 Back of wood	Cox (3 row)
8 - Provender Farm	Faversham	1 Fir tree	Cox (3 row)

* After the first sampling occasion, the orchard was sprayed with insecticide (carbaryl) apart from eight rows which were left unsprayed. The sprayed and unsprayed areas were compared on the last two sampling occasions

Table 2 **Percentage leaves with a damage score greater than two* (five leaves from each of the inside (in) and outside (out) of the tree canopy were scored for 20 trees per orchard)**

		July-Aug		Aug-Sept		Sept-Oct	
Site		In	Out	In	Out	In	Out
1	1 Cox - unsprayed	23	0	61	12	47	3
	1 Cox - sprayed after first sample	-	-	50	0	43	1
2	1 Cox	43	3	71	18	87	17
	2 Cox	74	9	81	9	94	19
3	1 Bramley	34	23	96	76	57	37
	2 Gala	58	2	14	0	2	1
4	1 Cox	0	0	0	0	-	-
	2 Cox	0	0	0	0	-	-
5	1 Cox	26	0	27	0	33	2
6	1 Cox	34	3	29	7	37	3
	2 Cox	23	1	36	6	12	1
7	1 Cox	-	-	38	2	8	11
8	1 Cox	-	-	37	0	64	1

* Damage score two = approximately 200 feeding marks per leaf which can be seen as a light speckling

Table 3 **Percentage fruits with more than two frass specks per apple (five fruits were assessed for 20 trees per orchard)**

Site	Orchard	July-Aug	Aug-Sept
1	1 Cox - unsprayed	16	0
	1 Cox - unsprayed after first sample	-	7
2	1 Cox	31	77
	2 Cox	45	53
3	1 Bramley	54	24
	2 Gala	0	0
4	1 Cox	0	0
	2 Cox	0	0
5	1 Cox	0	0
6	1 Cox	34	10
	2 Cox	23	33
7	1 Cox	-	38
8	1 Cox	-	57

Table 4a Leafhopper species found in Kent, July - August 1996

Site	Date	Orchard	Leafhopper numbers (and species)				
			Female	Male		Nymphs	Unidentified
				E crataegi	*E. rosae*		
1	25 Jul	1 Cox - unsprayed	52	59	0	11	0
2	25 Jul	1 Cox	80	56	0	17	5
	1 Aug	2 Cox	86	42	0	2	0
3	25-31 Jul	1 Bramley	67	60	0	9	3
	25-31 Jul	2 Gala	0	0	0	0	0
4	25 Jul	1 Cox	0	0	0	0	0
	25 Jul	2 Cox	0	0	0	0	0
5	1 Aug	1 Cox	1	0	0	0	0
6	2 Aug	1 Cox	34	27	0	0	0
	2 Aug	2 Cox	14	4	0	0	2

Table 4b Leafhopper species found in Kent, August-September 1996

Site	Date	Orchard	Leafhopper numbers (and species)				
			Female	Male		Nymphs	Unidentified
				E crataegi	*E. rosae*		
1	2 Sept	1 Cox - unsprayed	19	14	0	58	0
	2 Sept	2 Cox - sprayed	0	0	0	0	0
2	9 Sept	1 Cox	100	60	0	8	0
	9 Sept	2 Cox	90	57	0	17	0
3	21 Aug	1 Bramley	1	0	0	0	0
	21 Aug	2 Gala	9	2	0	1	0
4	21 Aug	1 Cox	0	0	0	0	0
	21 Aug	2 Cox	0	0	0	0	0
5	21 Aug	1 Cox	1	0	0	0	0
6	27 Aug	1 Cox	41	28	0	12	1
	2 Sept	2 Cox	20	5	0	17	2
7	16 Sept	1 Cox	65	42	1	16	2
8	16 Sept	1 Cox	107	88	10	12	4

Table 4c Leafhopper species found in Kent, September-October 1996

Site	Date	Orchard	Leafhopper numbers (and species)				
			Female	Male		Nymphs	Unidentified
				E crataegi	*E. rosae*		
1	27 Sept	1 Cox - unsprayed	49	49	0	8	0
	27 Sept	2 Cox - sprayed	1	0	0	0	0
2	30 Sept	1 Cox	107	77	0	33	0
	30 Sept	2 Cox	96	91	0	11	0
3	26 Spet	1 Bramley	67	74	0	13	0
	26 Sept	2 Gala	9	0	1	1	0
4	Not sampled	-	-	-	-	-	
5	27 Sept	1 Cox	1	1	0	0	0
6	27 Sept	1 Cox	101	117	0	5	0
	27 Sept	2 Cox	48	38	2	0	6
7	1 Oct	1 Cox	151	86	0	13	0
8	30 Sept	1 Cox	86	76	0	1	0

Table 5 Leafhopper species found in windbreaks in Kent, 1996

Site	Tree species	Species
1 Loyterton Farm	Alder	5 ♀*Edwardsiana* sp. (3 = ♀ *Edwardsiana hippocastani*), 3 ♂ *Edwardsiana* sp. (2 *E. crataegi*, 1 *E. hippocastani*
2 Howfield Farm	Alder	248 ♀ *Edwardsiana* sp., 210 ♂ *Edwardsiana* sp. (out of 69, 65 *E. hippocastani*, 4 ♂ *E. crataegi*), 59 ♀ & 6 ♂ *Alnetoidia alneti*, 20 nymphs, 4 unidentified
3 Broadwater Farm	Hawthorn	64 ♀ *Edwardsiana* sp. (27 = *E. crataegi*) 70 ♂ *Edwardsiana* sp. (58 = *E. crataegi*, 7 = *E. rosae*), 1 *Zygina* sp., 2 *A. alneti*, 5 nymphs, 4 unidentified
4 Baretilt Farm	Alder	1 ♀ *Eupterycyba jacunda*, 2 ♀ *Edwardsiana* sp., 4 ♀ & 3 ♂ *A. alneti*, 1 ♀ unidentified
5 Ewell Farm	Alder	4 ♀ *E. jacunda*, 1 ♀ & 1 ♂ *A. alneti*, 3 ♀ & 3 ♂ *E. hippocastani*
6 Elverton Farm	Alder	47 ♀ & 3 ♂ *E. jacunda*, 3 ♀ *A. alneti*, 3 ♂ *E. crataegi*, 16 ♀ *Edwardsiana* sp. (of which 10 *E. hippocastani*), 12 ♂ *Edwardsiana* sp. (of which 9 = *E. hippocastani*, 3 = *E. crataegi*), 1 nymph, 2 unidentified
7 Provender Farm	Alder	85 ♀ & 53 ♂ *Edwardsiana* sp. (mostly *E. hippocastani*), 2 ♀ *A. alneti*, 3 nymphs, 2 unidentified
8 Sandbanks Farm	Alder	7 ♀ & 5 ♂ *Edwardsiana* sp. (4 ♂ *E rosae*, 1 ♂ *E. hippocastani*)

Table 6 Insecticides applied to each of the orchards, 1996

Farm	Orchard No	Pre-blossom	Post-blossom
1 Loyterton Farm	1 Cox	Spannit (75%)	Gamma-col (100), 2 x Spannit (75%), Thinsec (75%)
2 Hayfield Farm	1 Cox	Dursban (100%)	Dursban (100%)
	2 Cox	Dursban (100%)	Dursban (100%)
3 Broadwater Farm	1 Bramley	Dursban (100%)	3 x Dursban (100%)
	2 Gala	Dursban (100%)	3 x Dursban (100%)
4 Baretilt Farm	1 Cox	Spannit (35%)	2 x Spannit (25%)
	2 Cox	Spannit (35%)	2 x Spannit (25%)
5 Ewell Farm	1 Cox	Dursban (50%)	Hostaquick (20%), 4 x Dursban (25%), 2 x Novosol (25%), Novosol (40%)
6 Elverton Farm	1 Cox	-	Aphox (100%), 2 x Spannit (100%)
	2 Cox	-	Aphox (100%), 2 x Spannit (100%)
7 Sandbanks Farm	1 Cox	-	Hostaquick (25%), 2 x Dursban (25%), 2 x Spannit (100%), 6 x Novosol (35%), 2 x Novosol (70%)
8 Provender Farm	1 Cox	Dursban (50%)	2 x Dursban (25%), Dursban (75%), 3 x Novosol (35%)