Strawberry : Monitoring and Control

of Capsid Bugs

Final Report November 1993

Project Number: SF34a

Project Title: Strawberry: monitoring and control of capsid bugs

Project Leaders: M.A. Easterbrook & J.V. Cross,

Horticulture Research International, East Malling, Kent

Location of Project: HRI East Malling

Project Co-ordinator: Hugh Lowe

Date Project commenced: 1.7.93

Date Project completed: 14.10.93

Key Words: strawberry, capsid bugs, monitoring, insecticides, fruit damage

CONTENTS

Relevance to Growers and Practical Application

Application

The most practical monitoring method for growers to use for capsids is likely to be tapping or shaking plants, particularly the flower/fruit clusters, over a white tray or dish. Careful monitoring of capsid populations is essential for effective timing of sprays and determining the need for treatment. Malathion, Spannit, Ambush, Dipterex, Talstar and Hostaquick were all shown to greatly reduce capsid populations and, if correctly timed, only one or two applications should be required to provide control over the susceptible period in July/August.

Summary

Objectives of the Project

The objectives were to find suitable methods to monitor capsid bugs in late-season strawberries and to test candidate insecticides for control in laboratory and field tests. The effects of these insecticides on *Phytoseiulus,* a predator of spider mite, were also to be evaluated, if possible.

Results

Various methods for sampling capsid bugs were compared. These were:-

1. Vacuum sampling of plants using a modified garden sweeper/vac (petrol driven).
2. Tapping plants over a white tray or dish.

3. Sweeping a net through plants.

4. Visual inspection of plants.

5. Hanging white or yellow sticky traps over the plants.

Of these, the vacuum sampling method proved to be the most effective in terms of numbers caught, but tapping plants was almost as good. Sweep netting was somewhat less effective; the effectiveness of both sweeping and tapping is likely to be reduced in windy weather. Visual inspection detected very few capsids in July and early August when other methods showed that numbers were increasing. The sticky traps caught only small numbers of capsids.

Monitoring in fields of 60-day and everbearer strawberries showed that in Kent in 1993, at the majority of sites, capsid numbers were very low at the beginning of July, but adult numbers built up during that month and laid eggs that produced nymphs from late July, reaching a peak in mid-August. These nymphs developed into a second generation of adults in late August/early September. Capsids were also found on various weeds, including scentless mayweed, fat hen, redshank and persicaria.

In one replicated field trial, Malathion, Ambush and Spannit, applied by overhead boom sprayer, had reduced numbers of capsid nymphs by over 94% compared to untreated areas, when sampled two days after treatment. Even by 15 days after treatment, numbers of nymphs were still 60-76% lower than on untreated plots. In a second trial, Dipterex and Talstar had given complete control of nymphs and adults at 2 days after application by air-assisted sprayer, with Hostaquick only slightly less effective. Control from

Talstar seemed rather more persistent, with capsid numbers still extremely low at 16 days after spraying, whereas numbers had started to increase in the areas treated with Hostaquick and Dipterex. Observations on commercial farms also showed effective control of capsids with Malathion. In laboratory tests Malathion and Spannit gave the best results when spray residues (rather than direct contact action) were tested on adult capsids. All the insecticides tested in the field trials showed high contact toxicity to capsid nymphs in laboratory tests, but Zolone and Biobit *(Bacillus thuringiensis),* which have low toxicity to bees and so could be useful alternatives showed little toxicity to capsid nymphs or adults.

Spannit, Malathion, Ambush, Talstar, Dipterex and Hostaquick all greatly reduced numbers of thrips in strawberry flowers.

The tests of effects of the insecticides on *Phytoseiulus* were largely inconclusive, due to the failure of the predators to establish, despite two releases. However, the results did indicate that, by three weeks after treatment, residues of Malathion, Spannit and Ambush from sprays applied to the tops of the plants were not sufficient to prevent the build-up of *Phytoseiulus.*

Despite the presence of capsids and thrips on untreated plots in the replicated field trials, amounts of malformed fruit were low. In the trial on everbearers no differences in malformation between untreated and treated plots were evident, while on Elsanta there was a small reduction of 5-7% in amounts of moderately or severely malformed fruits on insecticide-treated plots compared to untreated areas when fruits that had been flowers at the time of spraying matured.

Further strategic research is required to clarify the relationship between the insects that occur on late-season strawberries and malformation of fruit. A proposal has been submitted to MAFF for funding for this research.

Action Points for Growers

1. Monitor for capsids in 60-day and everbearer strawberries from late June/early July onwards, either by tapping or shaking plants, particularly flower/fruit clusters, over a white dish or tray, or by using a garden sweeper/vac machine (cost *c.* £200), modified by having a collecting bag inside the air intake nozzle. Take at least 3 or 4 samples along rows in different parts of the field, including the edges. Each sample should be of at least 50 plants, spread along the row.
2. Apply a spray when adult capsids become numerous, or when small nymphs appear (probably likely to be late July/early August at most sites in most years). More research is required to develop an action threshold for capsids, relating numbers to damage. However, as an interim working threshold, it seems prudent to spray when an average of 2 or more capsids (adults and/or nymphs) are found per 50 plants. Further investigation may allow this threshold to be raised. Suitable insecticides are Malathion, Dipterex, Hostaquick, Spannit or Dursban (note longer harvest interval), Ambush and Talstar. All of these

insecticides are approved for use on strawberry, but only Ambush has a specific recommendation for use against capsids. The pyrethroid insecticides Ambush and Talstar are likely to have a greater detrimental effect on any predators present, so are probably best used where no *Phytoseiulus* have been released and it is the final cropping season for the field. Sprays of insecticides applied without air assistance or ruffle bar are likely to have less effect on *Phytoseiulus*. Care must be taken to avoid danger to bees. Ambush, Talstar, Hostaquick, Dursban and Spannit are all classified as dangerous to bees, and Malathion as harmful to bees. Dipterex is likely to be the least harmful to bees.

Practical and Financial Anticipated Benefits

By careful monitoring of capsid populations the number of spray applications against them can probably be reduced to 1 or 2 sprays over the July/August period.

Previous research has shown that the use of an insecticide programme during the critical period in July/August can greatly reduce amounts of fruit malformation, and so have considerable financial benefits, although this was not demonstrated clearly in these trials.

Experimental Section

INTRODUCTION

In recent years large financial losses have been reported by some strawberry growers due to large proportions of fruits being malformed in 60-day and everbearer crops. A literature review (Easterbrook & Cross, 1993) concluded that much of this malformation could be due to insect pests, with capsid bugs one of the most likely causes.

The aims of this project were to investigate methods of monitoring capsids in strawberry fields, and to test the efficacy of candidate insecticides against this pest in laboratory and field trials. Also, if possible, the effects of field applications of these insecticides on the predatory mite *Phytoseiulus persimilis* were to be evaluated.

MATERIALS & METHODS

Monitoring

Weekly samples were taken from July to September in two strawberry plantations at HRI East Malling, both planted in 1993, one of '60-day' Elsanta planted on the flat and the other containing the everbearer cvs. Rapella and Calypso planted through blue polythene mulch on raised beds. These fields were *c.* 800 metres apart. Some samples were also taken in a plantation at HRI East Malling containing Rapella and Ostara, planted in 1992.

In addition, regular samples were taken, starting in early July, on several commercial farms in Kent, in fields of '60-day' Elsanta and of various everbearer varieties.

Several sampling methods were used:-

1. Visual inspection: inspecting a set number of plants whilst walking slowly past.
2. Tapping: tapping whole plants over a white tray or blossom/fruit clusters over a white dish.
3. Sweep netting: 'Sweeping' a net through plants.
4. Suction sampling: Vacuum sampling of plants, using a modified petrol driven garden sweeper/vac.
5. White and yellow sticky traps were hung above strawberry plants in two fields at East Malling and in one commercial field. Traps were replaced at regular intervals.

A minimum of two samples, each on 50 plants, was made on each occasion, but not all methods were used on each occasion.

As well as sampling the strawberry plants themselves, some samples were taken on weeds in and around strawberry fields.

Testing of insecticides

In the laboratory tests, insecticides were applied at doses equivalent to the field rates. Different types of test were used:-

1. The uppersides of detached strawberry flowers were sprayed using a Potter Tower, delivering a spray equivalent to *c.* 1000 litres/ha. After the

deposit had dried an adult capsid bug was confined on each flower and mortality assessed after 24 and 48 hours. Each insecticide treatment and water-sprayed comparison had at least 5 replicates.

2. Capsid nymphs were confined in filter paper arenas with glass rings. They were then immersed in a field-strength solution of the insecticide for 5 seconds. Nymphs were then transferred to arenas on untreated leaves and mortality assessed after 24 and 48 hours.

Two replicated field trials were carried out in strawberry fields at HRI East Malling:-

Trial 1 was in a field of cv. Elsanta, planted in June 1993 (half on 16th and half on 28th). Insecticides were applied on 10th August, using a Lely Autoglide Standard sprayer with boom, spraying at 400 litres/ha. There were four replicates of each insecticide treatment, and of an untreated control. Each replicate plot consisted of a 2 row x 30 plants section of 4 beds. The insecticides tested were chlorpyrifos (1 litre Spannit/ha), malathion (190 mls Malathion 60/100 litres) and cypermethrin (280 mls Ambush/ha).

Trial 2 was in a field of alternating beds of cvs. Rapella and Calypso, planted in May 1993. Insecticides were applied on 17th August, using a Hardi Mini air-assisted sprayer at 600 litres/ha. Again, there were four replicates of each treatment and untreated control, and plot size was the same as in Trial 1. The insecticides tested in this trial were heptenophos (1.7 litres Hostaquick/ha), trichlorfon (1 Kg Dipterex/ha) and bifenthrin (40 mls Talstar/100 litres). No rain fell in the 24 hours following application in either spray trial.

Capsid numbers were determined 1 day before and 2 days after spraying by vacuum sampling of 40 plants in the central pair of beds in each plot. Catches were taken back to the laboratory for examination. Capsids found in the pre-treatment sample were replaced in the same area of the field. Other insects in the flowers were sampled by removing 25 flowers/plot immediately before and 2 - 3 days after spraying and examining them under a stereomicroscope in the laboratory.

At the time of spraying 30 flowers and 30 young fruits (*c.* 1 cm diameter) were tagged so that the time when these ripened could be observed. This indicated when larger samples of fruit should be taken for determination of amounts of malformation. On maturation of these tagged fruits, samples of 100 fruits per plot were taken each week and graded into one of four categories:- no distortion, slight distortion, moderate distortion, severe distortion. The slight category included fruit with only slight modification of shape and little reduction of size; the severe category had fruit that are much reduced in size and severely misshapen, while the moderate category was intermediate between the two. Only those fruit in the moderate and severe categories would be likely to be downgraded.

The predatory mite, *Phytoseiulus persimilis,* was released in both fields at HRI East Malling in early July (Trial 1 on 15th, Trial 2 on 10th) when spider mite numbers were high in both locations. Approximately 9000 predators were released on each field with releases confined to the central beds of each plot, giving an average of *c.* 4.5 predators per plant. However, the predator was not detected on samples of leaves on 2nd August, so further releases of 8000 predators were made on central rows of treatment plots on 4th August (*c.* 16 per plant). Samples of 30 leaves/plot were taken before, and at intervals after, treatment with insecticides. Mites were brushed off the leaves, using a brushing machine, on to a glass plate coated with detergent and counted immediately.

In addition to these replicated trials, samples were taken wherever possible before and after insecticide treatments of commercial strawberry fields. Here there was no replication and, with one exception, no untreated comparison.

RESULTS

Build-up of capsid populations

When sampling began in early July capsids were either absent from fields or at extremely low levels in most cases. However, there were two exceptions. In a field at one farm, adults of various capsid species were found and at another farm nymphs were found as well as adults.

In most locations, including HRI East Malling, numbers of capsid adults increased gradually during July, reaching a maximum at the end of the month (Figs.1, 2 & 3). The numbers of first generation adults then declined, probably as a result of death rather than emigration. Nymphs developing from eggs laid by these adults began to emerge at the end of July and numbers reached a peak in mid-August. On untreated plots at East Malling these nymphs began to develop into the next generation of adults in late

August/early September. Mixed populations of adults and nymphs could still be found at the end of September.

Monitoring capsids

In late July when four sampling methods were compared, i.e. suction sampling, sweep netting, tapping plants over a tray and visual inspection, suction sampling proved to be the most effective, particularly for detecting the small capsid nymphs that were present at the time (Table 1). In samples taken earlier in July, when only adult capsids were present, suction sampling detected more than sweep netting on most occasions, and also recorded larger numbers than the tapping technique. In a sample taken on 16 August, when the population consisted mainly of nymphs of various sizes, there was little difference in sampling efficiency between suction sampling and tapping, and both detected considerably higher numbers than sweep netting. Visual inspection was the least effective method.

Sticky traps were suspended a few inches above strawberry plants, and so caught only adults in flight, and not nymphs, which are unable to fly. A few adult capsids were caught on the sticky traps, but numbers were very low, even when adult numbers were high in the field. There were no consistent differences in numbers caught between white and yellow traps.

Fig 1. Capsid populations on strawberry cv Elsanta, East Malling.

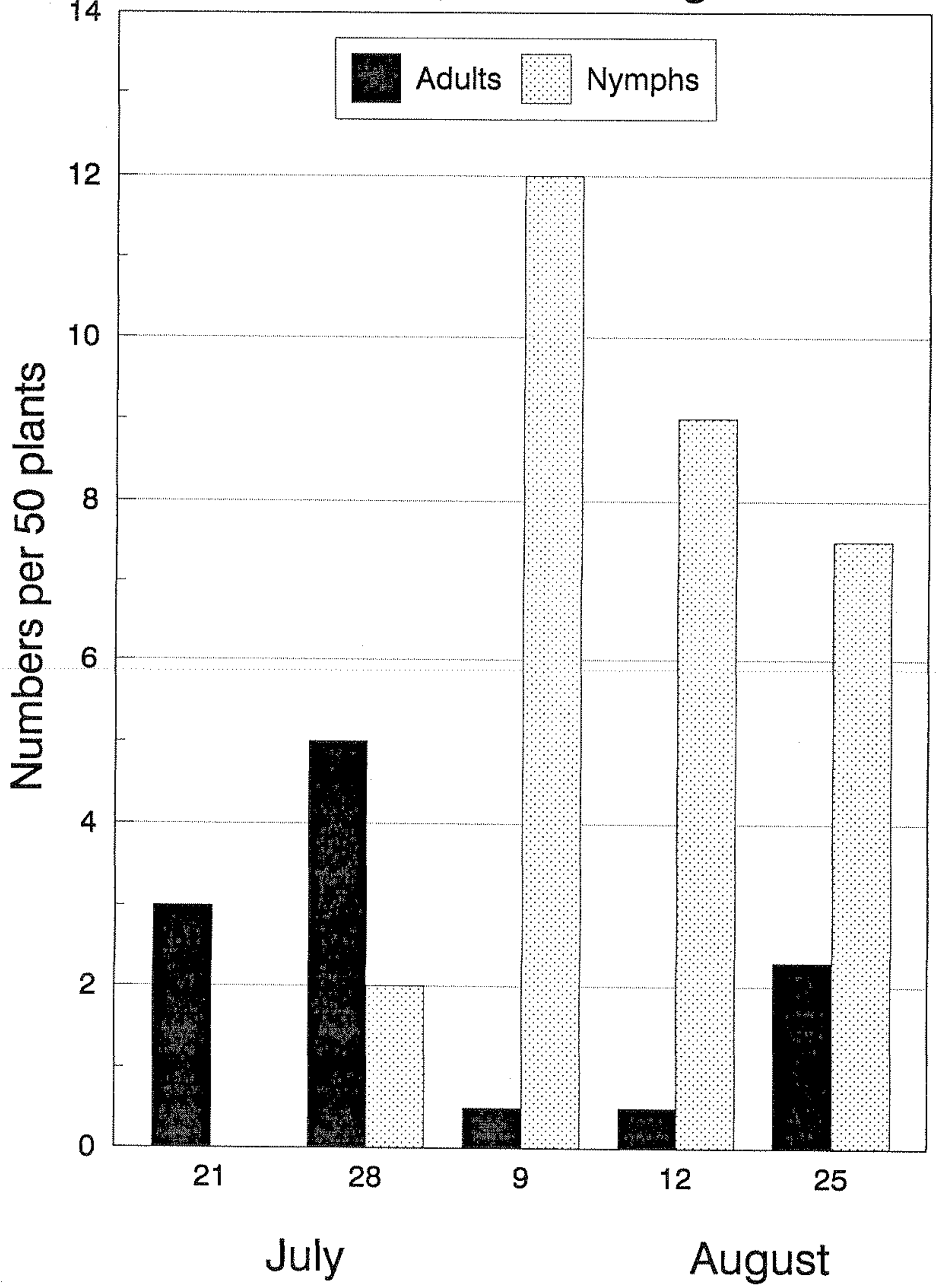


Fig 2. Capsid populations on everbearer strawberries, East Malling.

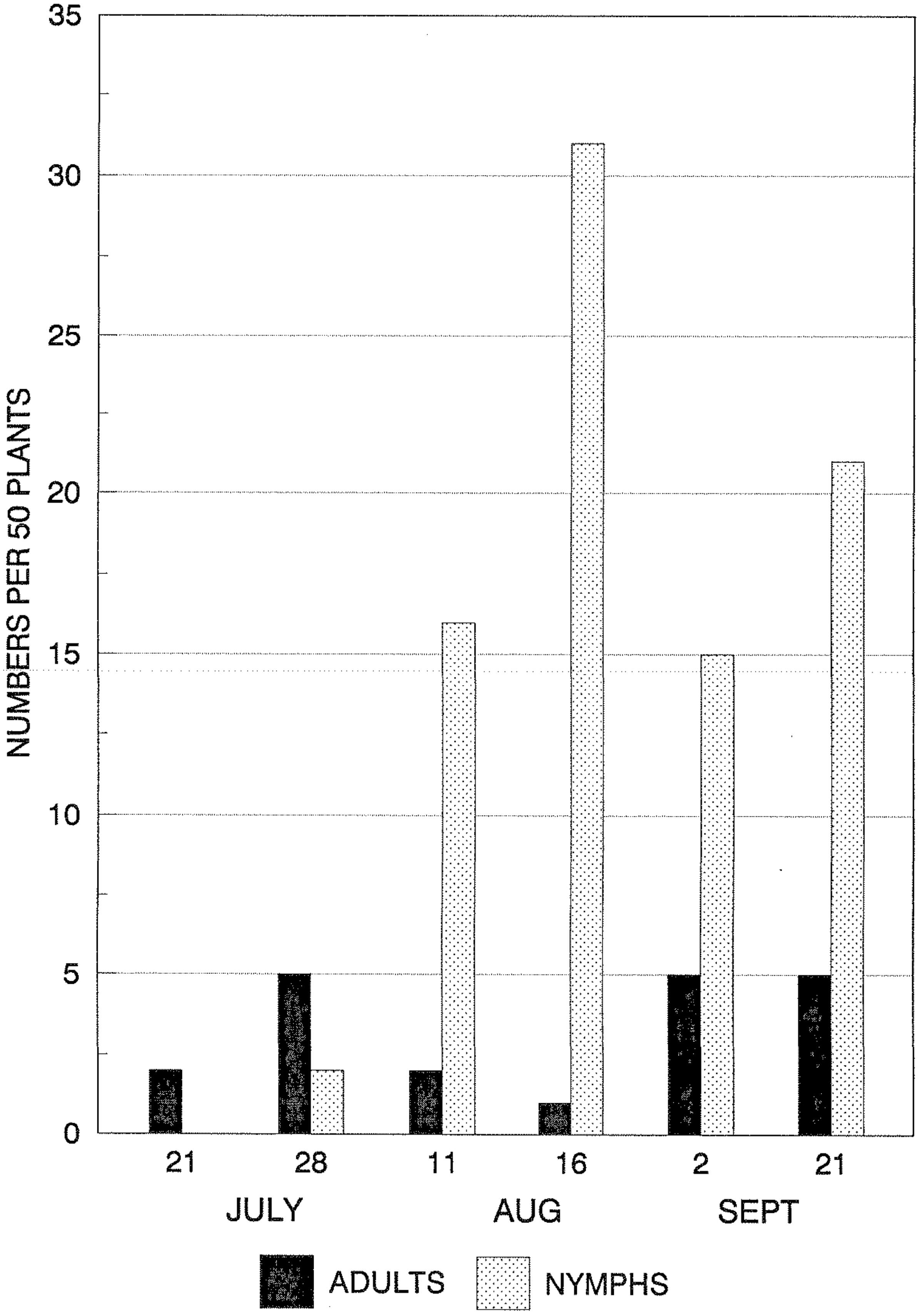
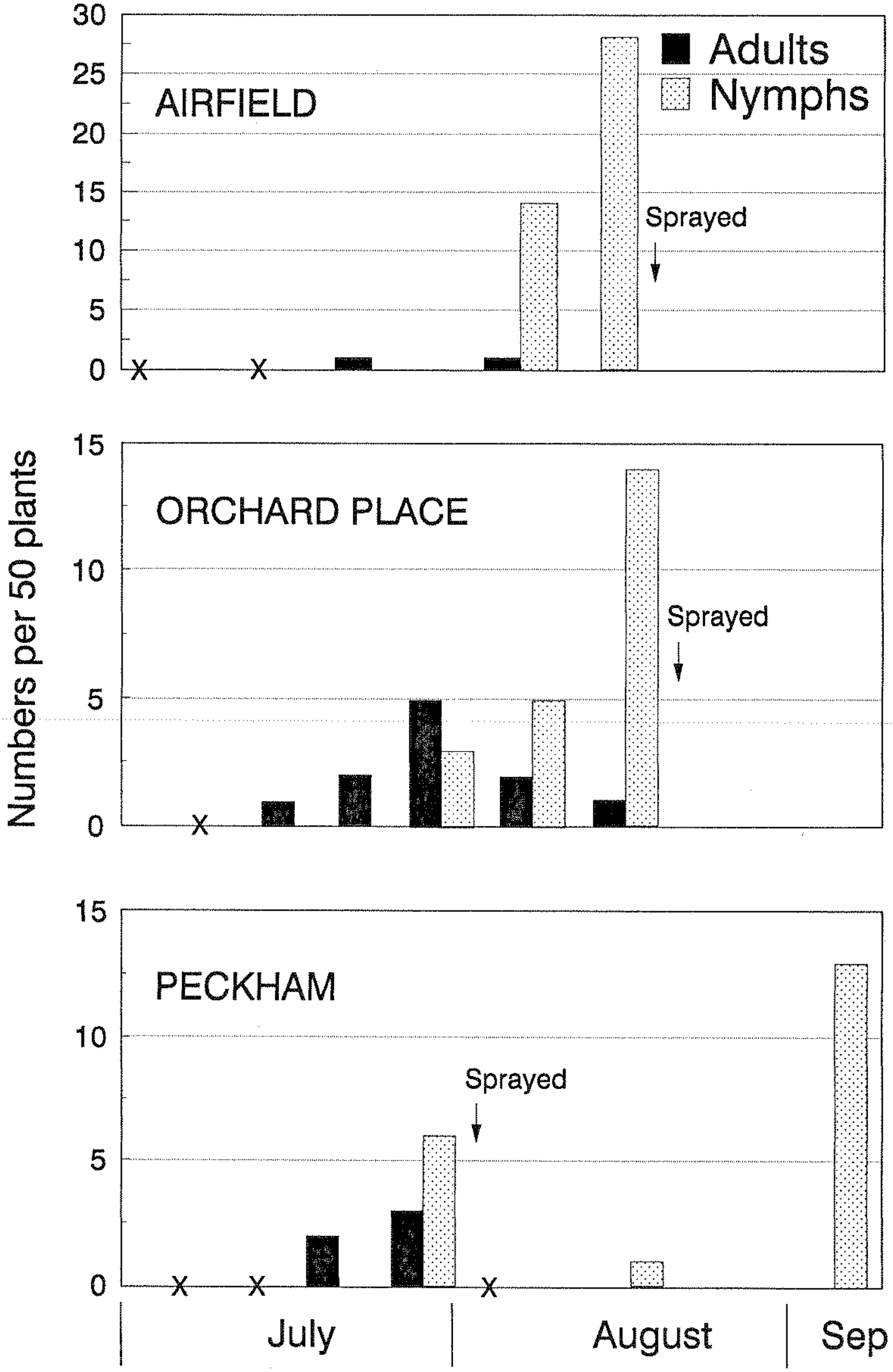


Fig. 3 Build-up of capsids on commercial farms.



X = none found

Table 1. Comparison of methods for sampling capsid bugs

Date	Location	Cultivar	Mean numbers per 50 plants							
			nymphs				adults			
			suction	sweeping	tapping	visual	suction	sweeping	tapping	visual
20 July	P	Rap 1 yr	0	0	0	--	5	1	1	--
20 July	OP	Rap 1 yr	0	0	0	--	2	1	1	--
21 July	EM	Els 1 yr	0	0	--	--	14	5	--	--
21 July	EM	Rap 1 yr	0	0	--	--	2	0	--	--
28 July	EM	Els 1 yr	2	0	0	0	5	1	4	0
28 July	EM	Rap 1 yr	3	0	0	0	5	0	1	0
28 July	P	Rap 1 yr	3	0	0	0	4	1	1	0.25
28 July	P	Rap 2 yr	16	0	0	--	3	3	0	--
16 Aug	EM	Rap/Cal 1 yr	23.5	4.5	21.3	--	1.25	0.5	0.25	--

EM = East Malling, P = Peckham, Kent, OP = Orchard Place, Kent

-- this sampling method not used.

Capsids on surrounding vegetation

Various species of capsids were found on weeds in and around strawberry fields, and some of these species also occurred on the strawberry plants. Scentless mayweed seemed particularly attractive, and capsids were also found on fat hen, redshank and persicaria. Species found included *Lygus rugulipennis, Plagiognathus chrysanthemi, Plagiognathus arbustorum* and *Calocoris norvegicus.*

Effect of Insecticides on Capsids

Laboratory tests

In contact tests on capsid nymphs Malathion, Talstar, Ambush, Dipterex and Spannit were all very effective, giving complete mortality after 24 hours (Table 2). Hostaquick was slightly less effective, while Biobit *(Bacillus thuringiensis)* and Zolone (phosalone) showed little toxicity. When adults were exposed to pesticide residues on flowers, however, only Malathion and Spannit caused a high mortality. Dipterex gave moderate toxicity as a residue, both to adults and nymphs. It is possible that residues of the pyrethroid insecticides Ambush and Talstar had a repellent effect on adults, as observations suggested that adult capsids favoured the underside of the flower, which probably had little spray deposit. This could explain the low mortality from these insecticides in the residue tests.

Field Trials

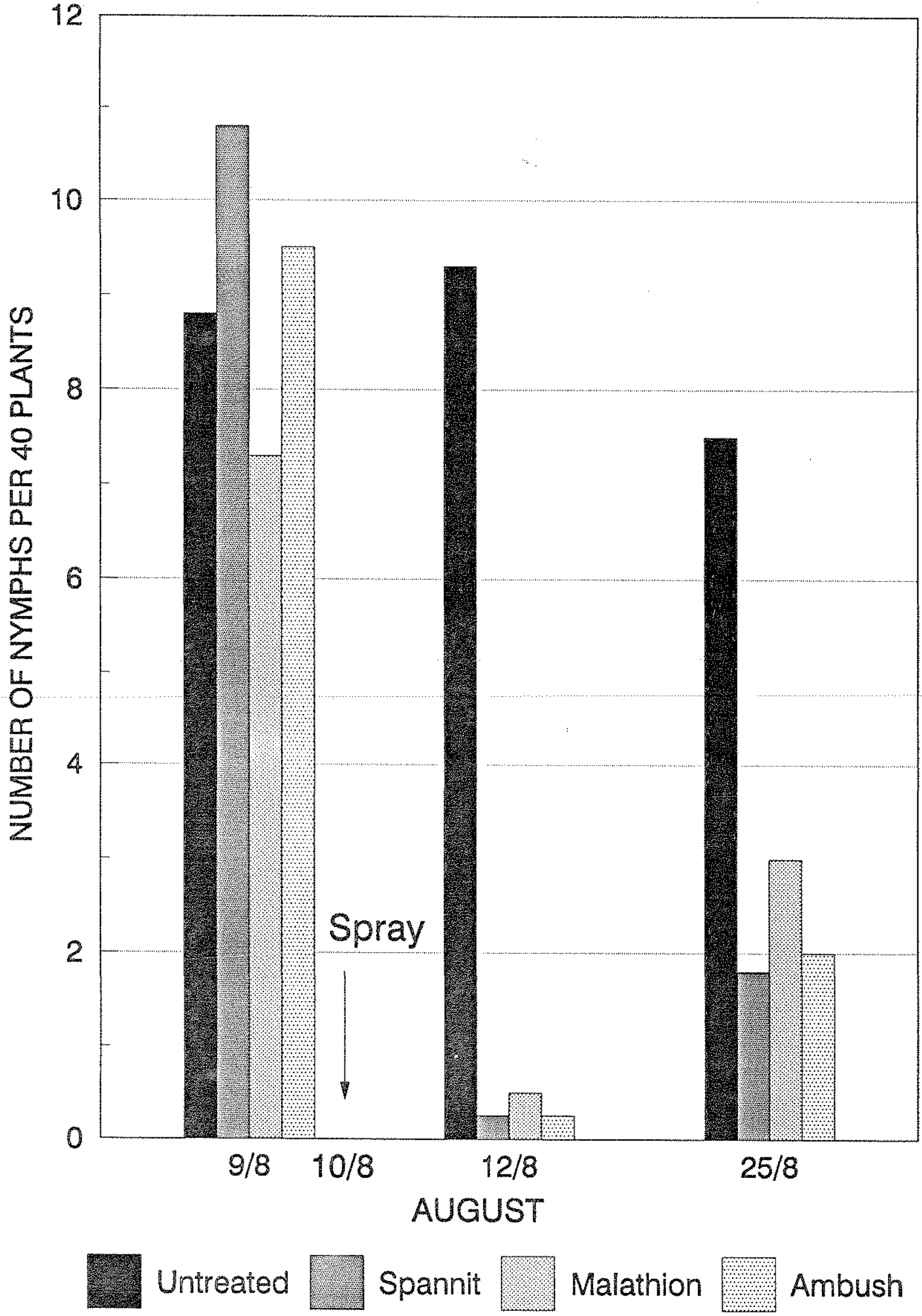
Effects on capsids

In Trial 1, Malathion, Ambush and Spannit, applied to the top of the Elsanta plants with a boom sprayer, all gave over 94% reduction in the numbers of

Table 2. Toxicity of insecticides to capsids in laboratory bioassays

Treatment	Test on adults (residues on flowers) % mortality after		Tests on nymphs (immersion) % mortality		Tests on nymphs (residues on flowers) % mortality	
	24 hrs	48 hrs	24 hrs	48 hrs	24 hrs	48 hrs
Test 1						
Water	10	10	10	10	--	--
Malathion	80	80	100	100	--	--
Hostaquick	20	20	80	80	--	--
Talstar	30	40	100	100	--	--
Ambush	20	40	100	100	--	--
Test 2						
Water	20	40	20	20	0	0
Dipterex	40	60	100	100	40	60
Spannit	80	100	100	100	--	--
Biobit	0	0	40	40	0	0
Zolone	--	--	40	40	0	0

Fig 4. Effect of insecticides on numbers of capsid nymphs, Trial 1, cv Elsanta.

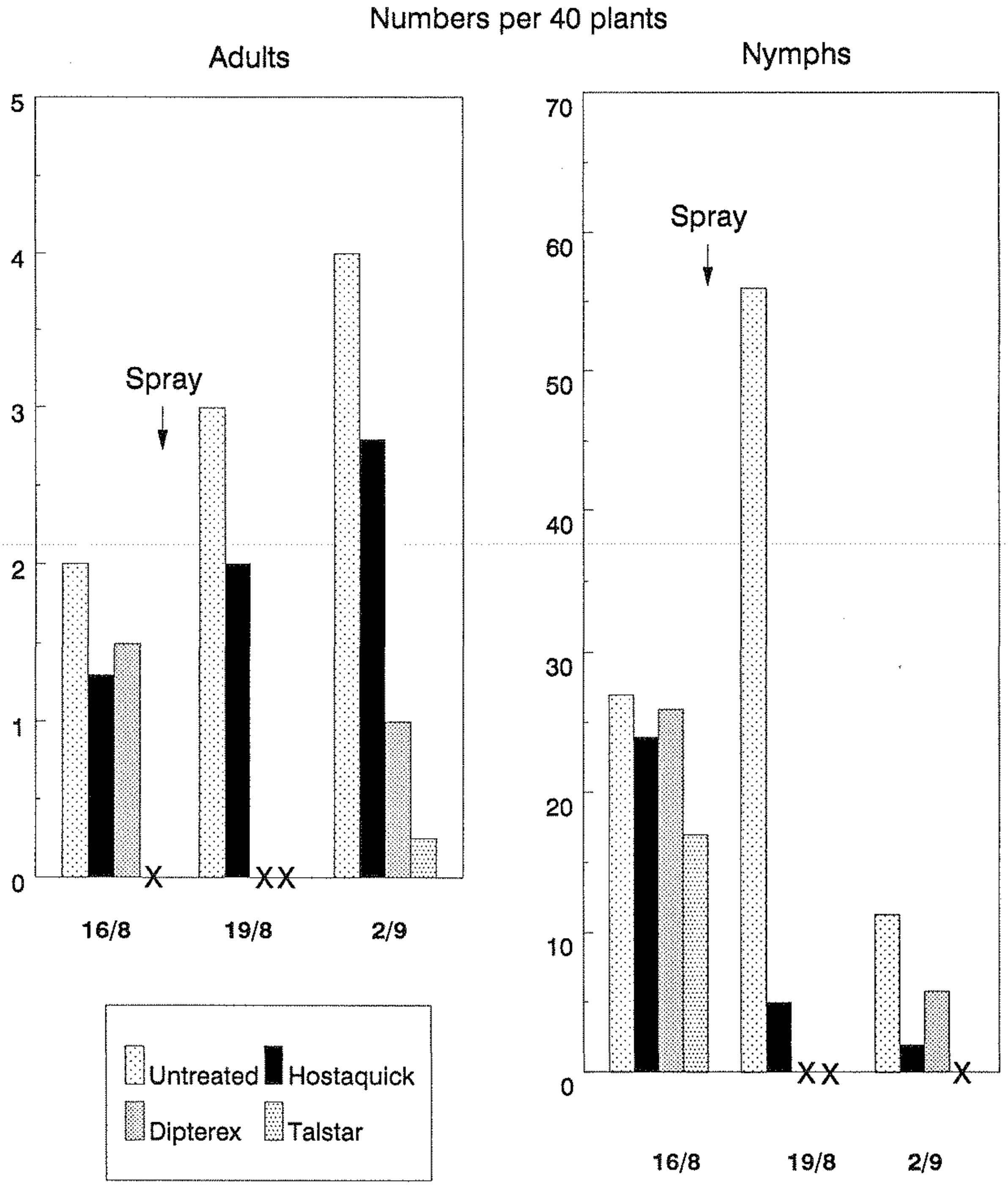


capsid nymphs compared to untreated plants, when sampled 2 days after treatment (Fig. 4). By 15 DAT (days after treatment) numbers of nymphs on treated plots had increased slightly, but were still 60-76% lower than on the untreated plots. The differences between insecticide treatments were not statistically significant. Numbers of capsid adults were too low at the time of spraying to show any differences between treatments in this trial.

In Trial 2 on Rapella/Calypso, the insecticides Dipterex and Talstar had given complete control of capsid nymphs and adults 2 days after treatment, with Hostaquick only slightly less effective (Fig. 5). In this trial the insecticides were applied with an air-assisted sprayer. By 16 DAT, capsid numbers were still extremely low on the Talstar-treated plots, but had started to increase on the areas treated with Hostaquick and Dipterex.

An opportunity was taken to sample an everbearer strawberry field on a commercial farm where half of the field had been sprayed with Malathion on the evening of 10th August. The next day suction samples were taken from the sprayed and unsprayed parts of the field. No live capsids were found in the sprayed area, compared to an average of 28 nymphs (no adults) per 50 plants in the untreated part. At another farm two fields of everbearers, one first year and one second year, were sprayed with Malathion on 29th July. There were no untreated comparisons in this case, but no capsids were found in suction samples from either field 5 DAT; in the two fields on the day before treatments 4 adults and 3 nymphs and 2 adults and 8 nymphs per 50 plants, respectively, were found in suction samples. Capsid numbers were still extremely low in these fields at 19 DAT, but numbers of nymphs had risen by 40 DAT. On another farm, samples

Fig. 5 Effect of insecticides on capsids Trial 2, everbearers.



X = none found

suggested that sprays of Ambush and Talstar had given poor control of capsids. There was no obvious explanation for this failure, which contrasted with the results obtained at HRI East Malling.

Effects on Thrips

Spannit, Malathion and Ambush all gave large reductions in numbers of thrips in Trial 1 (Table 3). Spannit was more effective than Malathion against thrips, though the latter still gave over 74% control. The differences in numbers between Spannit and Ambush treatments were not statistically significant.

In Trial 2 the thrips were mainly in the adult stage. Talstar, Dipterex and Hostaquick reduced adult numbers by 72-82%, compared to the untreated. It is possible that some adults recolonised the plots between spraying and the sampling 2 days later. Numbers of thrips nymphs were also reduced by over 75% by all three insecticides, with no significant differences between the three.

Samples were also taken on two fields of everbearers at a commercial farm, which had been sprayed with Malathion on 29th July. In a second year crop there were 3.5 adult thrips and 0.5 nymphs per 50 flowers 5 DAT, compared to 16.5 adults and 1.0 nymphs one day before treatment. In the first year crop adult numbers were reduced from 6 per 50 flowers before spraying to 1 per 50, 5 DAT. By 19 DAT numbers of thrips adults had increased again in both fields to 17-25/50 flowers. There was also some indication that Malathion reduced numbers of pollen beetles, but as numbers were already declining before the spray, and as there were no untreated comparisons, no firm conclusions can be drawn.

Table 3. Effect of insecticides on numbers of thrips and their predators

Trial 1. (Elsanta)	Numbers of thrips per 25 flowers			
	Pre-treatment		3 D A T	
Treatment	Adults	Nymphs	Adults	Nymphs
Untreated	13	37	6	17
Spannit	20	28	0.25	0
Malathion	11	39	2.8	4.3
Ambush	10	34	0.25	1.5

Trial 2 (Rapella)	Pre-treatment		2 D A T	
	Adults	Nymphs	Adults	Nymphs
Untreated	66	3.8	49.3	4.3
Hostaquick	50	5.8	13.8	0.5
Dipterex	58	7.0	10.3	0.8
Talstar	47	2.5	8.8	1.0

Numbers of Orius predators per 25 flowers

Trial 1	Pre-treatment		3 D A T	
	Adults	Nymphs	Adults	Nymphs
Untreated	1	1.5	0.25	2
Spannit	1	1	0	0
Malathion	0.5	0.25	0	0.5
Ambush	0	0.25	0	0
Trial 2	Pre-treatment		2 D A T	
	Adults	Nymphs	Adults	Nymphs
Untreated	1.0	0.25	2.5	1.2
Hostaquick	2.8	0.8	0.8	0.7
Dipterex	1.5	1.3	0.25	0
Talstar	1.5	1.0	0.8	0

Effects on *Orius* predators

Species of *Orius*, anthocorid bugs, prey on thrips in flowers. In one of the trials at East Malling *Orius* were present in small numbers at the time of spraying, and post-treatment samples indicated that Talstar, Dipterex and Hostaquick had all reduced numbers of *Orius* adults and nymphs (Table 3).

Effects on *Phytoseiulus*

Phytoseiulus persimilis released in early July on the two field trials at East Malling failed to establish, possibly because of the low temperatures and heavy rainfall during that month. Further releases were made in both fields on 4th August. Despite this, only very small numbers were detected in samples from Trial 1 taken on 13th August, 3 days after insecticide treatments (Table 4), making it impossible to draw any conclusions about the direct toxicity of these treatments. However, numbers of the predator had increased by the time of the sample on 31st August, 21 DAT. There may have been movement of *Phytoseiulus* between untreated and treated plots by this time, so conclusions about insecticide toxicity should be treated with caution. However, the results do show that any residues from the treatments of Spannit, Malathion and Ambush were not preventing establishment of the predator by 3 weeks after spraying. The insecticides were applied by overhead boom in this trial, and no ruffle bar was used, so there should have been less toxic residue on the undersides of leaves where the predators spend most of their time.

In the other trial small numbers of *Phytoseiulus* were found in a pre-treatment sample on 16th August, but in the post-treatment sample taken on 23rd

August, none were found. This was probably due to a depletion of spider mite numbers to very low levels as a result of a build-up of native predatory phytoseiid mites in this field.

Table 4. Effects of insecticides on *Phytoseiulus*, Trial 1

Treatment	*Phytoseiulus* per 30 leaves		
	3 DAT	21 DAT	
	actives	actives	eggs
Untreated	1.0	11	5.8
Spannit	0	15	15.5
Malathion	0.7	14	12.0
Ambush	0.5	13	18.0

Effects of insecticide treatments on fruit malformation

In the trial on Elsanta all treatments had 6-8% of fruit moderately or severely malformed at the end of August. At this time no treatment effects would be expected because the fruits maturing at this time would have been quite well developed at the time of spraying on 10th August. When fruit that were around 1 cm in diameter at spraying became ready for picking on 7th September there was a small, but not statistically significant, reduction in damage from 9% fruit moderately or severely distorted in the untreated plots to 5-6% in the treated plots (Table 5). On 15th September the fruits that had been at the flower stage when the insecticides were applied had matured. Again, there was a small reduction of

5-7% in moderately and severely malformed fruit between treated and untreated plots, and on this occasion the differences were statistically significant.

In the trial on everbearers levels of malformation were low on the untreated plots throughout the assessments, particularly on Rapella. The malformation on Calypso was mainly in the form of green seediness at the tip. This form of malformation was not reduced by the insecticide treatments (Table 6), and was probably due to mildew, which is known to cause these symptoms (D. Simpson, HRI-EM, pers. comm.). No differences were found between treatments in amounts of malformation in this trial on either cultivar.

Table 5. Effects of insecticide treatments on amounts of fruit malformation, Trial 1, cv. Elsanta

Date	Treatment	% fruit in each category of malformation			
		normal	slight	moderate	severe
10 August	Untreated	55	34	7	4
18 August	Untreated	67	28	5	0
24 August	Untreated	80	12	5	3
31 August	Untreated	74	19	5	2
	Spannit	79	14	5	2
	Malathion	71	21	7	1
	Ambush	79	15	5	1
7 September[1]	Untreated	65	26	8	1
	Spannit	79	16	4	1
	Malathion	68	26	5	1
	Ambush	73	22	4	1
15 Sept[2]	Untreated	68	19	9	4
	Spannit	82	12	5	1
	Malathion	77	17	5	1
	Ambush	78	14	6	2

[1] fruits of *c.* 1 cm diameter at time of spraying on 10th August now ripe

[2] fruits which were flowers at time of spraying now ripe

Table 6. Effects of insecticide treatments on amounts of fruit malformation

Trial 2

Date	Treatment	% fruit in each category of malformation							
		Rapella				Calypso			
		nor.	sl.	mod.	sev.	nor.	sl.	mod.	sev.
12 Aug	Untreated	92	8	0	0	44	53	3	0
24 Aug	Untreated	--	--	--	--	65	29	6	0
9 Sept	Untreated	87	12	1	0	--	--	--	--
	Hostaquick	92	7	1	0	--	--	--	--
	Dipterex	90	9	1	0	--	--	--	--
	Talstar	92	7	1	0	--	--	--	--
16 Sept[1]	Untreated	86	13	1	0	62	31	7	0
	Hostaquick	94	5	1	0	63	28	9	0
	Dipterex	91	7	2	0	68	27	5	0
	Talstar	95	4	1	0	63	27	8	0
24 Sept[2]	Untreated	87	11	2	0	64	26	10	0
	Hostaquick	82	14	4	0	71	18	10	1
	Dipterex	83	14	3	0	70	20	9	1
	Talstar	89	10	1	0	67	26	6	1

[1] fruits of *c.* 1 cm diameter at time of spraying on 17th August now ripe

[2] fruits which were flowers at time of spraying now ripe

CONCLUSIONS

In most fields of late-season strawberries in 1993, there were few capsids present at the beginning of July, but a gradual build-up of adults occurred during July. These adults laid eggs and by early August many nymphs could be found. These produced another generation of adults in late August/early September. Several species of capsids were found in strawberry fields, and on nearby weeds. Identifications made so far indicate that the dominant species on strawberries in August was *Lygus rugulipennis,* the European tarnished plant bug, but more research is required on species found and their potential for damage.

Of the monitoring methods tested, suction sampling using a modified garden sweeper/vac was the most effective. Tapping plants over a white tray or dish was shown to be a reasonable alternative. Sweeping the plants with a net was less effective, and both tapping and sweeping are probably less effective in windy weather. Visual inspection of plants detected very few capsids in the critical early part of the season. Previous observations suggest that the adult capsids feed in more exposed positions on strawberry plants later in the season (September). Only small numbers of capsids were caught by white or yellow sticky traps, so they do not appear to be a very useful monitoring tool.

Laboratory and field evaluations demonstrated the toxicity of several insecticides to capsids. Clearly, on late-season strawberries it is essential to use an insecticide with a short harvest interval. Malathion was very effective, as were Ambush and Talstar but these two pyrethroid insecticides are likely to be more damaging to populations of natural enemies. Dipterex gave good control, so may be an alternative to Malathion. Hostaquick was somewhat less effective, but may give reasonable short-term control. Spannit gave very good control, but has a longer harvest interval so would be most suitable for use on 60-day crops or for early use on everbearers before any fruit are present. It is desirable to have a bee-safe insecticide available for use. Among those tested, only Dipterex, Zolone and Biobit have this characteristic; Dipterex controlled capsids but laboratory tests with Zolone and Biobit showed low toxicity to capsids.

It is important to monitor the build-up of capsids in late-season strawberries, and apply a suitable insecticide once adult numbers are high, or when the first nymphs have hatched. If timed correctly it is probable that, at most, only one further spray will be required if there is further immigration of adults, or if capsid eggs have survived the spray. Most of the insecticides tested also controlled thrips.

Because of the failure of *Phytoseiulus persimilis* to establish, it is difficult to draw any firm conclusions about the toxicity of the insecticides to these predators. In the trial on Elsanta, numbers of *Phytoseiulus* were as high as on the untreated three weeks after treatment with Malathion, Spannit or Ambush. However, it is impossible to tell whether numbers had increased from those surviving the sprays, or whether there had been immigration from untreated areas by this time. This result does show that residues from these overhead-applied insecticides were not sufficient to prevent establishment of the predators by this time. The insecticides had given good control of capsids, so it may be better to apply them in this manner than with air assisted sprayers, which would probably produce more residue on the undersides of leaves, where it could be more toxic to predatory mites. MAFF-funded field experiments at HRI Kirton (Cross *et al.*, unpublished) have also shown that *Phytoseiulus* are able to survive and give effective biological control of two-spotted spider mite on strawberry plants sprayed 1-2 weeks before predator release with chlorpyrifos (Dursban, Spannit), or sprayed with Malathion 1 week after release.

The literature survey carried out by Easterbrook and Cross (1993) concluded that insect pests, particularly capsids, were likely to be an important cause of malformation of late-season strawberries. Previous trials have produced large reductions in fruit malformation on everbearers where a programme of insecticides was used (Buxton & Easterbrook, 1988; Easterbrook, unpublished). However, in the 1993 field tests at HRI East Malling, despite the presence of capsids and thrips in the fields before spraying and on the untreated plots after spraying, only low levels of fruit malformation were seen. There was a small reduction in malformation from insecticide treatments in the trial on Elsanta, but no reduction could be demonstrated on the everbearers, where the untreated Rapella showed very little malformation.

This illustrates that our understanding of the causes of fruit malformation is still incomplete. Further strategic research is required on the relationships between various pests and fruit damage, and of relevant aspects of their life histories. A proposal for such research has been submitted to MAFF, and, if successful, will commence in 1994.

REFERENCES

Buxton, J.H. & Easterbrook, M.A. (1988). Thrips as a probable cause of severe fruit distortion in late-season strawberries. *Plant Pathology* **37**, 278-280.

Easterbrook, M.A. & Cross, J.V. (1993). The role of capsid bugs in fruit malformation of strawberries. *Report to the Horticultural Development Council*, 26 pp.

ACKNOWLEDGEMENTS

We are grateful to Ciaran Walsh, a student from the University of Greenwich, for his hard work on the project. We thank Hugh Lowe and Farm Manager John Clark, William Pierce and Manager James Lutener, Don Pascoe and John Scott for allowing us to sample strawberry fields on their farms. We also thank Dr. G. Stonedahl of the International Institute of Entomology for identifying samples of capsids.

MAE/AP:16.12.93

Appendix 2 - Sampling Methods

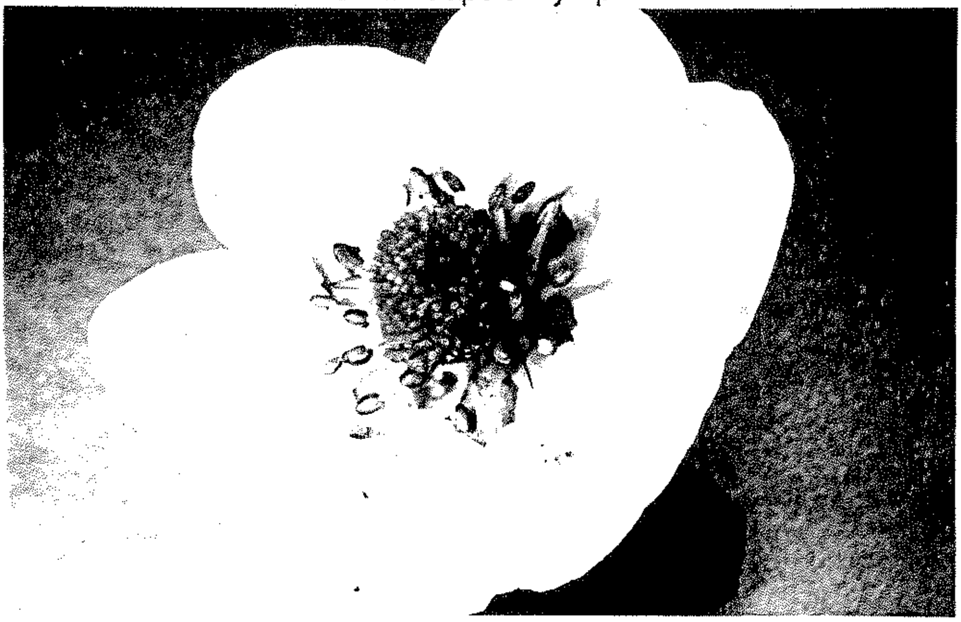
Suction sampling with Sweeper / Vac

Tapping plants over a tray

Sweeping plants with a net

Appendix 1 - Life stages of Capsid Bugs

Small Capsid Nymph



Large Capsid Nymph

Adult Capsid (European Tarnished Plant Bug)