Final Report To:	**HORTICULTURAL DEVELOPMENT COUNCIL**
Project number:	FV 185
Project title:	Leeks: control of thrips using chemical and supervised techniques
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CONTENTS

OVERALL SUMMARY

Work in the project studied four different aspects of control of thrips on leeks.

In a replicated experiment on a commercial crop of leeks, a range of insecticides, both approved and experimental, were compared for their effectiveness in control of thrips. None of the approved insecticides gave better control than the standard insecticide (chlorpyrifos) used. One experimental insecticide, AC 303,630, gave slightly better control than chlorpyrifos, but others gave equal or inferior levels of control.

In a similar experiment 10 different adjuvants, mixed with a standard insecticide (chlorpyrifos), were compared to see if they gave any enhancement of the control of thrips obtained with the standard insecticide alone. No significant differences were demonstrated, either in the number of thrips in the plants, or in the level of thrips damage recorded at harvest. Some slight differences in thrips numbers seen with Ashlade Adjuvant Oil and Codacide Oil, and crop damage where LI700 was used was slightly reduced.

Using a deltamethrin as the standard insecticide, a field study to identify a threshold for triggering a spray treatment for thrips control was unsuccessful. None of the thresholds used, varying from 1 thrips larva per 10 plants to 5 thrips larvae per plant significantly reduced plant damage at harvest. The results did indicate that spray timing may be crucial.

At two sites, experiments on thrips monitoring methods showed that thrips numbers caught water and sticky traps did reflect the number of thrips present in the crop, but the relationship varied with total thrips numbers. Water traps were difficult to use and had no advantages over sticky traps. Of the different colours of sticky traps used, yellow was the easiest to use and assess and was the most representative. Covering the traps with net or mesh markedly reduced the number of non-target species caught, and did not affect the trap catch relative to thrips numbers in plants. Mesh covers were better than net in most respects.

GENERAL INTRODUCTION

Although onion thrips (*Thrips tabaci*) has been recognised as a pest of leeks and other alliaceous plants for many years, until recently the damage has been largely disregarded as being mainly cosmetic and therefore not significant. However, in the 1970's, as the market requirement for quality produce increased, the leaf (flag) damage caused by thrips on leeks became less acceptable. Until this time, it was only damage caused to very young plants which was regarded as worth preventing by insecticide treatment. Even in the 1980's the market requirements relating to the amount of flag left on the final product varied considerably between different geographic regions of the UK. This meant that thrips damage to heavily topped products required by some markets was not important. Now most leeks are marketed with at least some green flag and thrips damage has become more important. Perhaps a more significant factor is that major retailers, who understandably try and extend shelf-life as much as possible, are reporting that leeks from thrips-damaged crops deteriorate much quicker than those from crops free of thrips damage.

Given this background HDC sponsored several projects in the 1980's to investigate both varietal susceptibility to thrips attack or damage, and the most effective insecticides for control. The work on varietal susceptibility was inconclusive, because all varieties were prone to attack and the difference in damage was not economically important. The work on chemical control did identify deltamethrin as one of the most effective insecticides, and subsequently HDC obtained an off-label approval for use of "Decis" on leeks for thrips control. Only malathion and nicotine have full approval for thrips control on leeks, but a number of other insecticides are approved on the crop for control of other pests or for 'general pest control'. A number of these "other" insecticides are known to be active against thrips, and growers treating leeks for autumn control with chlorpyrifos have reported good incidental thrips control. Part A of the work reported here specifically looked at the level of control obtained with products approved on the crop already, products approved on other edible crops, and on some insecticides still under development for the UK market.

Some of the previous HDC sponsored work had looked at the effect of adjuvants, both alone and with insecticides, on thrips control. This work was inconclusive, but since it was done the range of types of adjuvants available has increased considerably. Part B of the work reported here studied the effect of ten different adjuvants on the efficacy of an insecticide applied for thrips control. The adjuvants used represented the full range of types available from the simple surfactants to the latest silicone-based products currently being developed.

Onion thrips has a very short life cycle in the summer and consequently populations can build up and reach damaging levels very quickly. This poses two questions, firstly what is a damaging population and secondly how is it best to monitor thrips populations. It is clear that the larvae are the most damaging stage of the pest, particularly when they feed deep down in tiny gaps between or in the folds of developing leaves. No work has been done on establishing a spray threshold, and to date the decision to spray has been a rather arbitrary one based on field experience.

Consultants have tended to use a threshold of a mean of one larva per plant but this has never been scientifically tested. Part C of the work was designed to study the effect of spraying at different levels of the pest and subsequent pest damage.

The only way to date that thrips populations have been estimated in leeks has been by checks on leek plants. Given the difficulty of this method, alternative methods of assessment are needed. The easiest method of monitoring insects is by using pheromone traps, but no reliable pheromone traps have been developed for any thrips species, let alone onion thrips. Thrips populations in protected crops are monitored with sticky traps, while in the field small flies, e.g. carrot fly and bean seed fly, can be monitored with either sticky traps or water traps. Part D of the work was designed to establish the easiest and most reliable method of estimating thrips populations, and was based on experience of trapping these pests.

Given the increasing problems with thrips control experienced by growers, the whole study was done on commercial crops, thus enabling practical results to be passed to the industry minimising the need for further evaluation in field situations. The sites for the studies were chosen to be ones where leeks have been grown regularly in the vicinity for a number of years, and more particularly those with a history of significant attacks of thrips. Although thrips damage is now causing concern to growers in Northern England the largest established problems have been in East Anglia, the south-west Midlands and in the Thames Valley, and these three areas were chosen for the work.

PART A - COMPARISON OF INSECTICIDES

3. Practical section for growers

a) Application

The trial was done to compare new and existing insecticides with ones currently approved for use on field-grown leeks.

Assessments were made of the numbers of thrips per plant and of the amount of damage on the leaves at the end of the trial.

None of the treatments gave adequate control of a very heavy attack of thrips. Only two treatments, Dursban 4 (at 2.0 litres per ha.), the insecticide currently most widely used by growers, and a new Cyanamid insecticide, AC 303,630, reduced the numbers of thrips significantly. The latter also reduced the amount of damage recorded.

b) Summary

Objectives

In recent years onion thrips have become a major pest of leeks, and some other field-grown vegetable crops. The main symptom is a silvering caused by the insects as they graze on the surface of leaves. This spoils the appearance of the processed crop and reduces it shelf life and can lead to downgrading, and sometimes, rejection of the crop.

Effective control of thrips from programmes of sprays applied at frequent intervals has become progressively more difficult in recent years. Twelve different existing or experimental insecticides applied as sprays and two other treatments, a broadcast application of granules and a drench, were compared with sprays of Dursban 4. The spray treatments were applied five times at approximately 10-day intervals from early July, but the granules and the drench were applied once only.

Results

None of the treatments gave adequate control of a very heavy attack of thrips. Only two treatments, an experimental insecticide from Cyanamid, AC 303,630, and Dursban 4 reduced the numbers of thrips significantly. The new compound also reduced slightly the amount of damage present at the end of the experiment.

Action points for growers

The trial confirmed that Dursban 4 is still the most effective treatment for the control of thrips on leeks. Currently however, only two applications per crop (for the control of cutworms) are permitted.

Combinations of complementary treatments, such as seed treatments, sprays and physical methods of control may be necessary to achieve adequate control of thrips on leeks.

4. Experimental Section

Introduction

Onion thrips (*Thrips tabaci*) is a widespread pest of leeks, onions (particularly salad onions) and other vegetables and attacks have become increasingly important in recent years. Severe attacks on young plants may cause distortion, but the main damage to alliaceous crops is the silvering and flecking that develops when the insects graze on the surface of the leaves. This reduces shelf life and quality of crops which may be downgraded or rejected.

Thrips damage has been recognised for many years, but it has become progressively more serious over the last decade or so. Particularly serious attacks occurred in 1995 on leeks and salad onions in the Thames Valley and other leek growing areas. Growers were not able to control the pest adequately, despite the regular application of approved insecticides, that had hitherto been effective.

Materials and Methods

a) Site Details and Diary

These are shown in Table 1.

b) Treatments

Details of the treatments used are shown in Table 2.

c) Application of Treatments

The disulfoton granules were broadcast over the plants, using a "pepper pot" applicator.

The drench of imidacloprid was applied in 2000 litres per hectare, directed along the rows at the base of the plants. It was applied at 2 bar pressure through a Cooper Pegler CP3 sprayer fitted with a single flat fan nozzle (Lurmark Fan Tip Standard 80^{o} Flat Spray Tip - 08 F80).

The spray treatments were all applied at 2 bar pressure at 1000 litres per hectare with a CO_2-powered Oxford Precision Sprayer. This was fitted with a 4-nozzle boom with Lurmark "Swirl Tip" disc and core hollow cone spray tips (DC-06 discs and CR-45 cores). The four nozzles were adjusted so they lined-up centrally between the five rows of leeks in the beds. The boom was held so that it just brushed the tops of the leaves, about 450 mm above the ground.

After field testing other options, this combination of nozzle and boom height was selected because it appeared to direct the maximum amount of spray into the necks of the plants, where most of the thrips larvae congregated and the damage was done. The sprays were applied in 1000 litres of water per hectare, because this was considered to be the maximum amount of water that most growers would accept when spraying outdoor vegetable crops.

Table 1. Site Details

Location of trial :	Messrs W C Emmett and Sons, Severalls Farm, Wallingford, Oxon. O.S. Ref. : SU 609902
Cultivar :	Albana
Plot size :	7 x 1.9 m (i.e. 1 bed of 5 rows) 1 bed on either side of the trial, left as discard areas, were sprayed with the plot sprayer.
Trial design :	Randomised block - 16 treatments x 3 replicates.
Crop planted :	2 May
Application of treatments :	
Granules :	Broadcast over plots with a "pepper pot" applicator.
Drenches :	Cooper Pegler CP3 knapsack sprayer applied at 2 bar pressure through a single flat fan nozzle at 2000 l/h. (Lurmark Fan Tip Standard 80^{o} flat spray tip - 08 F80).
Sprays :	Oxford Precision Sprayer, powered by compressed CO_2 at 2 bar pressure, at 1000 litres water per ha.. 4 Nozzles boom fitted with Lurmark "Swirl Tip" disc and core hollow cone spray tips fitted with :- DC-06 (Yellow) discs and CR-45 (Green) cores.
Timing of treatments :	
Granules applied :	21 July
Drenches applied :	23 July
Sprays applied :	4 July 21 July 4 August 18 August 1 September
Plant sample for thrips assessments :	8 August 11 September
Crop damage assessed :	4 September

Table 2. **Insecticides evaluated for their effectiveness against onion thrips**

Treatment	Manufacture	Rate per Hectare	N^{o}. of Applications
Granules			
1) Disulfoton Granules	Bayer plc	14 kg	1
Drenches			
2) Admire	Bayer plc	125 g	1
Sprays			
3) Dichlorvos	Luxan (UK) Ltd	1.5 litres	5
4) Dichlorvos plus Slippa	Luxan (UK) Ltd and Interagro UK Ltd	1.5 litres (plus Slippa @ 0.1%)	5
5) CGA 8811B	Ciba Agriculture	800 g	5
6) CG Insegar	Ciba Agriculture	800 g	5
7) Masai	Cyanamid of Great Britain Ltd.	1.25 kg	5
8) AC 303,630	Cyanamid of Great Britain Ltd.	1.042 litres	5
9) Dipterex 80	Bayer plc	1.75 kg	5
10) Hallmark	Zeneca Crop Protection	150 ml	5
11) Decisquick	AgrEvo UK Crop Protection Ltd.	300 ml	5
12) Hostathion	AgrEvo UK Crop Protection Ltd.	1.25 litres	5
13) Malathion	Fisons	4.5 litres	5
14) Decis	AgrEvo UK Crop Protection Ltd.	300 ml	5
15) Dursban 4	DowElanco Ltd	2.0 litres	5
16) Untreated Control - Water only	-------		5

d) Assessments

i) Numbers of thrips on plants

Samples of 10 plants per plot, were taken twice, on 8 August and 11 September. Three plants were taken from the second and fourth row of each 5-row plot and 4 plants were taken from the central row. The samples were kept in cold stores at approximate 3 - 5°C until the plants were examined.

The numbers of thrips were assessed by counting the numbers of adults and larvae present on 20cm lengths of leaf (plus leaf sheath) on the 6 youngest, fully emerged leaves per plant. The oldest leaves examined consisted of approximately equal amounts of leaf and sheath, but the samples from the youngest leaves consisted mainly of leaf. In all cases the sections of each leaf examined were the parts of the leaf where most thrips were present

ii) Leaf damage

The amount of plant damage (silvering), caused by thrips was assessed on 4 September, 3 days after the fifth and final sprays were applied. The amount of damage was assessed on a 1 - 5 scale where :

1 = Worst - severe damage; plants (virtually) unmarketable.
5 = Best - no / trace of damage only.

Results

A heavy attack of thrips developed almost immediately the crop was planted and before the first treatments were applied in early July Almost every plant examined at the end of the experiment was infested with thrips, although the numbers on individual plants varied greatly - 0 to 148 (data available, but not shown).

None of the treatments gave adequate control of thrips or prevented serious damage to the crop.

Only two treatments, Dursban 4 (5 applications each at 2.0 litres per ha.) and an experimental insecticide from Cyanamid, AC 303,630 the more effective treatment, reduced significantly the numbers of thrips larvae present at the end of the experiment (Table 3; Appendices A1 to A6). Significantly fewer adult thrips were present on the plants sprayed with AC 303,630, which slightly reduced the amount of damage present on the plants at the end of the experiment. (Table 3; Appendix A7).

The single drench of Admire (imidacloprid) was ineffective and inexplicably, the application of Disyston Granules (disulfoton) appeared to increase the numbers of thrips present at the end of the experiment (Table 3; Appendices A1 to A6).

Table 3. Mean numbers of thrips per plant and levels of damage on leaves

Treatment	Mean Numbers of Thrips per Plant: 1st Assessment - 8 August: Adults N^os per plant	Log (n+1)	Larvae N^os per plant	Log (n+1)	Total N^os per plant	Log (n+1)	2nd Assessment - 11 September: Adults N^os per plant	Log (n+1)	Larvae N^os per plant	Log (n+1)	Total N^os per plant	Log (n+1)	Thrips Damage 1 = Worst 5 = Best
1) Disulfoton Granules	8.3	0.571	24.7	1.262	33.0	1.353	8.4	0.786	46.8 *	1.542	55.2 *	1.616	2.5
2) Admire - Drench	7.4	0.832	20.3	1.224	27.7	1.378	6.7	0.522	16.5	1.134	23.2	1.250	2.3
3) Dichlorvos	5.3	0.625	16.5	1.112	21.8	1.234	5.8	0.568	12.9	1.077	18.7	1.242	2.5
4) Dichlorvos * plus Slippa	6.0	0.763	20.5	1.248	26.5	1.376	4.5	0.460	18.7	0.958	23.2	1.097	2.0
5) CGA 8811B	9.1	0.740	29.4	1.291	38.5	1.40	8.0	0.451	17.6	1.065	25.6	1.177	2.7
6) CG "Insegar"	4.5	0.449	18.1	1.093	22.6	1.182	4.9	0.610	19.3	1.278	24.2	1.373	2.0
7) "Masai"	8.5	0.761	23.9	1.269	32.4	1.389	8.1	0.813	27.9	1.389	36.0	1.508	2.8
8) AC 303,630	3.4	0.460	13.1	0.963	16.5	1.085	3.4	0.121	4.2 **	0.348	7.6 **	0.563	3.2 *
9) Dipterex 80	4.9	0.653	15.9	1.191	20.8	1.304	6.9	0.494	23.0	1.321	29.9	1.412	2.7
10) Hallmark	4.4	0.194	17.1	1.082	21.5	1.160	4.9	0.559	21.0	1.268	25.9	1.357	2.3
11) Decisquick	4.8	0.641	14.5	1.121	19.3	1.253	4.1	0.189	11.1	0.808	15.2	0.921	2.0
12) Hostathion	5.2	0.590	15.8	1.105	21.0	1.222	4.3	0.492	22.1	1.278	26.4	1.354	2.5
13) Malathion	6.1	0.713	15.7	1.160	21.8	1.299	9.1	0.880	35.4 *	1.490	44.5 *	1.597	2.0
14) Decis	6.5	0.619	26.1	1.259	32.6	1.355	8.5	0.519	19.4	1.183	27.9	1.296	2.0
15) Dursban 4	3.9	0.550	9.6	0.934	13.5	1.084	3.3	0.232	6.0 *	0.564	9.3 *	0.736	2.8
16) Untreated Water only	5.7	0.519	21.7	1.191	27.4	1.277	6.6	0.512	14.6	1.081	21.2	1.213	2.5
SED (30 df)	-	n.s.	-	n.s.	-	n.s.	-	n.s.	-	0.2296	-	0.2146	0.32
CV (%)	-	52 %	-	21 %	-	19 %	-	54 %	-	25 %	-	21 %	16 %
LSD (P = 5%)	-	-	-	-	-	-	-	-	-	0.3896	-	0.3642	0.55

N.B : Numbers of thrips per plant were assessed by counting the numbers of adults and larvae present on 20 cm lengths of leaf (plus leaf sheath) on the 6 youngest, fully-emerged leaves per plant.

* Significantly different from Untreated plots (water only) at 5% probability level.
** Significantly different from Untreated plots (water only) at 1% probability level.

Discussion

Higher numbers of thrips were present in this trial than in the adjuvant trial (see Part B) even though similar sub-sampling procedures was followed when counting thrips. The numbers of thrips "per plant" are therefore comparable , but may be an under-estimate of the total numbers present.

None of the treatments tested controlled thrips adequately and with the exception of the new Cyanamid insecticide. None were better, and most were inferior to Dursban 4, which many growers consider to be the most effective insecticide against this pest. These findings are generally in line with results from FV 72, a previous HDC trial in which spray application methods were compared on three vegetable crops, including leeks. Here effective control was achieved with Dursban 4, but the level of control was similar irrespective of sprayer type, dose rate and spray volume. It was also found in that trial that sprays of Decis failed to control onion thrips.

It was particularly disappointing that the Luxan (non-phytotoxic) formulation of dichlorvos was ineffective. On protected crops this insecticide controls western flower thrips (WFT) reasonably effectively, even though WFT is normally more difficult to control than onion thrips.

Leeks are a difficult crop to spray efficiently with contact pesticides and they become progressively more difficult as the season progresses and the plants grow and become more waxy. In an HDC sponsored study on air-assisted sprayers in 1993 (FV 72b), it was noted that with fine spray droplets more and roughly equal amounts of spray were deposited on inner and outer leaves respectively with air assistance. The results from this adjuvants trial suggested, however, that none of the different types of adjuvant tested significantly improved the effectiveness of Dursban 4.

On leeks most thrips are found in the necks of the plants, so few are hit directly by spray droplets as they are applied. They might be expected to be vulnerable however if sprays are either applied to run-off so liquid runs down the leaves into the necks of plants, or when spray booms are adjusted to direct the droplets into this area, as was done in these trials. The silicone "super wetters", that were used in both trials, reduced the surface tension of the water dramatically and some liquid ran down into the necks of plants, but this still did not improve the control.

The results from these and earlier trials, which have tested a range of factors such as active ingredient, addition of spray additives, spray volume, pesticide rate and application equipment have not so far indicated ways of achieving adequate control of thrips. This suggests that a different approach may be necessary for the control this pest on leeks (and onions). Three possible options are suggested for consideration and comments by all the parties with an interest in the problem :-

i) Because thrips damage mainly affects the appearance and quality of leeks, rather than the yield, attempts should be made in critical shelf-life tests, to establish and measure the levels of damage that have a significant effect. It would also be useful to attempt to establish levels of damage on leeks that customers find acceptable, although this would be subjective and influenced by commercial as well as technical considerations.

ii) Dursban 4 kills thrips by contact and by fumigant action. The fumigant effect is probably important, but little R & D has been done in this area, although at least one grower sprayed Dursban 4 on calm nights in 1995 to try to maximise this effect. The size and density of the crop and wind speed, as well as the time of day, temperature and the amount of sun which affect convection currents within the crop, could all influence the fumigant effects of insecticides.In practical terms it is however unlikely that many growers would be able, or willing, to programme spray applications in this way.

iii) Although Admire (imidacloprid) was ineffective in this trial as a drench, in another trial in 1994 when applied as a seed treatment, this insecticide controlled onion thrips very effectively for at least four months. This trial was however only done on plants in seed trays in a glasshouse and would need to be evaluated in the field.

Conclusion

No treatment gave complete thrips control and none prevented significant plant damage. Of the approved insecticides Dursban 4 gave the best control of thrips. The experimental insecticide AC 303,630, gave the best control of any treatment and reduced plant damage compared to all other treatments.

PART B - EVALUATION OF SPRAY ADJUVANTS

3. Practical section for growers

a) Application

The trial was done to investigate whether adding adjuvants to sprays of chlorpyrifos (Dursban 4) improved the control of onion thrips on field-grown leeks. A range of Approved and novel adjuvants, including oils, wetters, spreaders, stickers and buffering agents were evaluated.

Sprays of Dursban 4 without an adjuvant reduced the numbers of thrips larvae on the crop by over 63% and 75% respectively when assessed in the middle and at the end of the trial, and they also reduced the amount of damage done to the crop.

Compared with sprays of Dursban 4 alone, none of the adjuvants improved the control of thrips significantly in a trial where the numbers of thrips per plant varied considerably. However the lowest numbers of thrips larvae at the end of the trial were found on plots sprayed with Codacide Oil (41% reduction) and Ashlade Adjuvant Oil (34% reduction).

b) Summary

Objectives

In recent years onion thrips have become a major pest of leeks and other vegetable crops in the UK. The main damage is a silvering caused by the insects when they graze on the surface of the leaves. This spoils the appearance of the processed crop and reduces its shelf life and can lead to downgrading and sometimes rejection of the crop.

Control with insecticide sprays currently approved for use on leeks has become progressively more difficult, even when they are applied frequently. The objective of the trial was to see whether spray adjuvants improved the effectiveness of a programme of sprays of Dursban 4, applied at approximately 14 day intervals starting in mid-June. Dursban 4 was selected because it is one of the most widely used and effective insecticides available for the control of thrips on leeks.

Results

Sprays of Dursban 4 alone reduced the numbers of thrips larvae, compared to an untreated control, by over 63% and 75% mid-way through and at the end of the trial. These sprays also reduced considerably the amount of damage done to the crop. These results were achieved at a site where a moderately severe attack of thrips occurred.

None of the adjuvants improved the control given by sprays of Dursban 4 alone, although the lowest numbers of thrips larvae at the end of the trial were found on plots sprayed with Codacide Oil (41% reduction, compared with Dursban 4 alone) and Ashlade Adjuvant Oil (34 % reduction).

There were no measurable differences in the levels of leaf silvering between treatments of Dursban 4 alone and Dursban 4 with any of the adjuvants. Some of the adjuvants, particularly the silicone "super wetters" e.g. "Slippa" and "Booster" had an obvious effect on the spray droplets. Deposits from these treatments spread out rapidly across the leaves changing the leaf colour to a bright green. This effect was not reflected in any increase in control of thrips. It must be stressed that few of the adjuvants tested are approved for use on leeks in the UK, and some are not approved for use on any crop.

Action Points for Growers

There was no real evidence that adding any of the 10 adjuvants tested to sprays of Dursban 4 improved the control of thrips on leeks. The apparent slight improvement in control with some products can not justify any recommendation for use commercially.

If different methods of applying sprays are to be investigated in future trials, the merits of the silicone super wetters should be evaluated. These are claimed to, and apparently do from visual effects seen in this trial, greatly reduce surface tension and dramatically improve leaf wetting and may therefore have some benefit with certain insecticides.

4. "Experimental Section"

Introduction

Onion thrips (*Thrips tabaci*) is a widespread pest of leeks, onions (particularly salad onions) and other vegetables and attacks have become increasingly important in recent years. Severe attacks on young plants may cause distortion, but the main damage to Alliaceous crops is the silvering and flecking that develops when the insects graze the surface of the leaves. This reduces shelf life and quality, and crops may be downgraded or rejected.

Thrips damage has been recognised for many years, but it has become progressively more serious over the last decade or so. Particularly serious attacks occurred in 1995 on leeks and salad onions in the Thames Valley and other leek growing areas. Growers were not able to control the pest adequately, despite the regular application of insecticides that had hitherto been effective.

It is said that the addition of spray adjuvants improves the efficacy of many pesticides, but critical evaluation and ratification of these claims is harder to come by. This experiment was designed to evaluate ten "Approved" or novel adjuvants, most with different chemistry and properties, to see whether they improved the control of onion thrips when they were tank-mixed with Dursban 4.

Materials and Methods

a) Site Details and Diary

These are shown in Table 4 below.

Table 4. Site Details

Location of trial :	Messrs W C Emmett and Sons, Severalls Farm, Wallingford, Oxon. O.S. Ref. : SU 609902
Cultivar :	Prelina
Plot size :	7 x 1.9 m (i.e. 1 bed of 5 rows) 1 bed on either side of the trial left as discard area, sprayed with the plot sprayer.
Trial design :	Randomised block - 10 treatments x 4 replicates.
Crop planted :	11 April

Sprayer and nozzles :	Oxford Precision Sprayer, powered by compressed CO_2 @ 2 bar pressure and fitted with a 4-nozzle boom
1st application	Lurmark Flat Fan Spray tips - 03 - 80^o (Red)
Other applications	Lurmark "Swirl tip" disc and core hollow cone spray tips fitted with :- DC-06 (Yellow) discs and CR-45 (Green) cores..
Spray dates and volumes of water applied :	13 June 500 l/h 30 June 1000 l/h 19 July 1000 l/h 4 August 1000 l/h 17 August 1000 l/h
Plant sample for thrips assessments :	26 July 31 August
Crop damage assessed :	25 August

b) Treatments

The plots were sprayed with chlorpyrifos 48 % e.c. (Dursban 4) at 2.0 litres per hectare plus the adjuvants shown in Table 5. The "Untreated" plots were sprayed with water only and these were treated first each time.

Table 5. Adjuvants evaluated to assess their effectiveness against onion thrips

Treatment	Concentration , rate / hectare	Adjuvant rate hectare (l/h) in:-	
		500 l water/h	1000 l water/h
1) Agral	0.03 %	0.78	1.7
2) Slippa	0.1 %	2.6	5.2
3) Booster	0.1 %	2.6	5.2
4) Ethokem	0.5%	13.0	26.0
5) Rapide	0.5%	13.0	26.0
6) Ashlade Adj. Oil	0.8 %	20.8	41.6

7) Codacide Oil	2.5 litres / ha.	13.0	13.0
8) LI 700	0.5%	13.0	26.0
9) Bond	0.1%	2.6	5.2
10) New Film P	0.1 %	2.6	5.2
11) Dursban - No adjuvant	Nil	Nil	Nil
12) Untreated - Sprayed with water only	Water only	Nil	Nil

c) Application of Sprays

The sprays were applied with an Oxford Precision Sprayer, powered by CO_2, set to spray at 2 bar and fitted with a 4-nozzle boom. The first set of sprays were applied through Lurmark Flat Fan Spray Tips at 500 l/h.

Subsequent sprays (4 applications) were applied through Lurmark "Swirl Tip" Disc and Core Hollow Cone nozzles, at 1000 litres per hectare. The four nozzles on the boom were adjusted so they lined-up centrally between the five rows of leeks in the beds. The boom was held so that it just brushed the tops of the leaves, about 450 mm above the ground.

After field testing other options, this combination of nozzle and boom height was selected because it appeared to direct the maximum amount of spray into the necks of the plants, where most of the thrips larvae were. The maximum spray volume of 1000 litres per hectare was chosen because this was considered to the maximum that most growers would accept when spraying outdoor vegetable crops.

d) Assessments

i) Numbers of Thrips on Plants

Samples, of 10 plants per plot, were taken on 26 July and 31 August. Three plants were taken from the second and fourth row of each 5-row plot and 4 plants were taken from the central row. The samples were kept in cold stores at approximate 3 - 5^{o}C until the plants were examined.

The numbers of thrips were assessed by counting the numbers of adults and larvae present on 20cm lengths of leaf (plus leaf sheath) on the 6 youngest, fully emerged leaves per plant. The oldest leaves examined consisted of approximately equal amounts of leaf and sheath, but the samples from the youngest leaves consisted mainly of leaf. In all cases the sections of each leaf examined were the parts of the leaf where most thrips were present.

Three assistants counted the numbers of thrips on the plants and on both occasions each assessor examined complete replicates.

ii) Leaf Damage

The amount of plant damage (silvering), caused by thrips was assessed on 25 August, 8 days after the fifth and final sprays were applied. The amount of damage was assessed by two people on a 1 - 5 scale where :

1 = Worst - severe damage; plants virtually unmarketable.
5 = Best - no damage or trace only.

Results

None of the adjuvants significantly improved the control of thrips compared with sprays of Dursban 4 alone, which reduced the numbers of thrips larvae by 63 and 78 per cent mid way through and at the end of the trial (Table 6; Appendices B1 to B6). This was achieved at a site where a moderately severe attack of thrips occurred.

The amount of leaf damage on plots sprayed with Dursban 4 alone or with an adjuvant was similar, although some of the adjuvants had a marked effect on the appearance and behaviour of the sprays on the leaf surface. In particular the silicone "super wetters" made the spray droplets spread out rapidly in a thin film across the leaves. These turned bright green because the surface wax was wetted thoroughly, due to a reduction in the surface tension of the water.

Discussion and Conclusions

Because the numbers of thrips were high and the plants were so big, only parts of each plant were examined (20cm of 6 leaves). The numbers of thrips "per plant" are therefore comparable between treatments, but an under estimate of the total numbers present.

Although they were not fully effective, a programme of sprays of Dursban 4 reduced both damage and the numbers of thrips present at harvest. This occurred at a site where there was a moderate attack of thrips and where control began early when there were few thrips on the crop.

These findings are in broad agreement with results from an earlier HDC-funded trials (Project FV 72), which compared spray application methods on three vegetable crops, including leeks. In these trials effective control was achieved with Dursban 4, although the level of control was unaffected by dose rate, spray volume or the type of sprayer used.

Except for the first application, the sprays were applied at high volume (1000 litres per hectare), through hollow cone nozzles. Such nozzles are recommended for applying insecticides (and fungicides). The boom was held at a height (approx. 0.45 m) that ensured that the maximum amount of spray impinged at "necks" of the plants, where the leaves emerged and where most of the thrips occurred.

Leeks are a difficult crop to spray efficiently with contact pesticides, and they become progressively more difficult as the season advances and the plants grow and become more waxy. The problem of spray penetration into the "neck" area was demonstrated in another trial (also part of Project FV72) in which it was found that with fine spray droplets, more spray was deposited with air assistance, but the amounts on inner and outer leaves was roughly equal. It was surprising that none of the adjuvants, particularly the "super wetters" which altered the appearance and behaviour of the spray deposits so markedly, had little effect on the pest. Codacide Oil and Ashlade Adjuvant Oil improved the control slightly, but not significantly, and possibly warrant further investigation.

Two aspects of thrips control not investigated in this or the accompanying trial are the effects of spray volume and the time of day when sprays are applied. Although the former has been investigated (see above), the time of day when volatile insecticides like Dursban 4 are applied could be important because they kill insects partly by fumigant action. Wind speeds and temperatures change considerably during the day and could have an effect on the level of control obtained. It must however be questioned whether growers would be willing, or more particularly able, to apply sprays at the most optimum time of day for maximum fumigant action.

Table 6. Mean numbers of thrips per plant and levels of damage on leaves

Treatment	Mean numbers of thrips per plant: 1st Assessment - 8 August						2nd Assessment - 11 September						Thrips Damage
	Adults N^{os} per plant	Log (n+1)	Larvae N^{os} per plant	Log (n+1)	Total N^{os} per plant	Log (n+1)	Adults N^{os} per plant	Log (n+1)	Larvae N^{os} per plant	Log (n+1)	Total N^{os} per plant	Log (n+1)	1 = Worst 5 = Best
1. Agral	0.3	0.094	3.5	0.588	3.8	0.607	3.1	0.560	9.3	0.983	12.4	1.095	3.5
2. Slippa	<0.1	0.010	3.3	0.608	3.4	0.610	1.6	0.403	6.2	0.829	7.8	0.925	3.6
3. Booster	0.4	0.138	5.4	0.691	5.8	0.728	2.3	0.496	6.4	0.856	8.7	0.970	3.5
4. Ethokem	0.3	0.126	5.0	0.685	5.3	0.712	3.0	0.542	10.2	0.990	13.2	1.117	3.5
5. Rapide	0.5	0.155	3.3	0.588	3.8	0.624	3.7	0.619	9.0	0.978	12.7	1.106	3.5
6. Ashlade Adjuvant Oil	0.2	0.073	4.9	0.746	5.1	0.757	2.9	0.506	5.6	0.820	8.5	0.966	3.9
7. Codacide Oil	0.5	0.155	4.0	0.621	4.5	0.623	2.9	0.540	5.0	0.705	7.9	0.877	3.6
8. LI 700	0.3	0.084	2.9	0.521	3.2	0.541	2.7	0.510	5.9	0.807	8.6	0.940	4.1
9. Bond	0.2	0.074	2.2	0.481	2.4	0.511	2.7	0.568	6.0	0.835	8.7	0.983	3.3
10. New film P	0.3	0.085	2.2	0.485	2.5	0.512	3.3	0.579	6.9	0.870	10.2	1.007	3.8
11. Dursban only	0.3	0.086	3.4	0.628	3.7	0.648	3.4	0.613	8.5	0.941	11.9	1.091	3.4
12. Control - Water only	3.1	0.513	9.9	0.921	13.0	1.025	6.3	0.775	33.3	1.525	39.6	1.592	1.9
SED (33 df)	-	0.0782	-	0.1170	-	0.1164	-	0.1010	-	0.1173	-	0.1005	0.32
CV (%).		83 %	-	26 %	-	25 %	-	26 %	-	18 %	-	14 %	13
LSD + / -	-	0.1597	-	0.2389	-	0.2377	-	0.2062	-	0.2395	-	0.2052	0.65
Mean of Dursban 4 - treated plots	0.31		3.65		3.96		2.87		7.18		10.05		
% control	90		63		70		54		78		75		

PART C - SPRAY THRESHOLDS

3. Practical Section for growers

a) Application

The aim of the experiment was to establish a spray threshold for thrips control which would prevent economic damage at harvest.

Using Decis for control and a range of spray thresholds from 1 thrips per 10 plants to 5 thrips per plant, the number of treatments applied varied from 8 to nil. No major differences in plant damage were seen during the growing season, or at harvest. Although not statistically significant at harvest was lowest on a treatment receiving two sprays. Treatment timing appeared to be critical. No immediate application for growers was identified, but the work did give a good lead for the direction of future investigations.

b) Summary

Objectives

At present the decision whether and when to spray for control of thrips on leeks is not based on any tested threshold. To a large extent treatment currently is based on the previous experience of the grower and/or their consultant(s). As customers' quality requirements increase it is becoming more important for growers to minimise thrips damage on harvested leeks, whilst still justifying their use of pesticides.

Currently checks on thrips numbers in leeks are made by destructive sampling of plants. Although this method of assessment may eventually be superceded by a trapping system, it is necessary to establish a spray threshold based on thrips numbers on plants initially. The number of thrips found also needs to be related to crop damage, particularly at harvest.

The experiment evaluated the damage caused by thrips when treatments were applied at different thresholds of numbers of young thrips in leek plants. The thresholds ranged from a low of one thrips per 10 plants to a maximum of 5 thrips per plant. Other treatments included routine treatment every 14 days, starting at the first presence of thrips, which resulted in 8 sprays being applied, and an untreated control. Thrips numbers were assessed weekly and the treatment was applied immediately the relevant threshold had been reached.

Results

The first thrips was found in late June but the first threshold for thrips larvae (1 per 10 plants) was not reached until mid July. Thresholds for two other treatments were reached one week later, but the highest threshold (5 per plant) was not exceeded during the season and no sprays were applied.

Flag/leaf damage shortly before the planned harvest in October was very low in all treatments and there were no statistical differences. The treatment giving the least damage at harvest was the lowest threshold for thrips larvae(1 per 10 plants). This threshold was only reached twice in the season compared to three times for two higher thresholds. The timing of the first spray appears to be critical. Any further work should be done on larger plots to overcome the patchy nature of the infestation seen in this experiment.

Action points for growers

Until further work is done the advice currently given to and used by many growers, i.e. spray when young thrips are first seen in the crop, should be followed. The need for repeat sprays should be assessed on the same basis..

4. EXPERIMENTAL SECTION

Introduction

The increased commercial importance of damage to leeks by thrips has resulted in an increased awareness of this pest by growers and consequently an increased incentive to apply thrips control treatments. This has to be balanced by the need to justify the use of control treatments which is driven by environmental, operator safety and economic considerations.

Although the pest is normally worse in hot dry years, it is a problem in most areas in most years, but the intensity and timing of attacks vary considerably. It is therefore necessary to monitor carefully for the pest in the crop. The results of the monitoring need to be used to make a decision on spraying, but herein lies a fundamental problem for growers, there is no proven or recognised treatment threshold for thrips control on leeks.

Until the 1980's most spray decisions were based on the noting of damage in the crop and/or the occurrence of a spell of hot dry weather, particularly when the crop was young. More recently the spray decision has been based on the presence of thrips larvae in the plants. Initially a mean of one thrips per plant was considered to be realistic, but more recently some growers have been advised to reduce the threshold to one thrips per 10 plants. Given the lack of a reliable threshold, an increasing number of growers use routine treatments throughout the growing season.

Apart from the obvious environmental risks involved with routine spraying, of particular concern to entomologists is the risk of speeding-up the selection of resistant pests. This is particularly true where there is a limited choice of effective insecticides. The risk of resistance selection can also relate to non-target pests. Although in leeks there are few other major pests, selection of resistance in a previously minor pest can dramatically increase the status of the pest.

The work reported was aimed at identifying a broad spray threshold, which could be refined and tested by subsequent work. The thresholds tested were chosen to give a wide range which would be practical to establish in the field. For example, in order to be sure a threshold of one thrips per 10 plants had been reached it may be necessary to check 50 plants, even if the sampling procedure was rigid and representative of the crop.

The choice of insecticide for the experiment was made on the basis of, firstly, a recommendation for use on the crop, secondly, approval allowing several applications to one crop and, thirdly, field experience on the effectiveness of the insecticide. The only insecticide which fitted these criteria was 'Decis' (deltamethrin).

Materials and methods

A single experiment was done in a commercial leek crop in Cambridgeshire on a farm with a long history of leek growing which had suffered problems with thrips damage over the last few years. The experiment was situated in a crop of over 10 hectares, on a very level ground with adjacent arable crops (cereals and sugar beat).

Site and Treatments

Location: Alpress Farms, Holly House Farm, Chatteris, Ely, Cambridgeshire. Field No. 54.

Cultivar: Albana

Agronomy: Direct drilled 19 April in beds of 1.84m width drilled with 4 rows of leeks, spaced at 40cm between the rows and 5 cm within the rows. The target plant population was 432,250/ha, with a final seed germination/plant stand of over 80 per cent.

Routine herbicides, fungicide, and foliar feeds were applied over the whole trial area. No insecticides, other than the treatments described below were applied. The soil type, a peaty loam, was uniform across the site.

Layout: 4 replicates of each treatment arranged in a randomised block design. Blocks were laid out across the beds with treatments within each block being in different beds. No guard blocks were included between plots in each block, tractor wheelings acting as the guard area. Each block was separated from adjacent ones by a 2m guard along the line of the bed. Plots were 8m long (by 1.84m bed width) and each contained a maximum of 1600 plants.

The area of the trial was guarded laterally by one full bed and a minimum 3m guard at the end of the beds.

Treatments: The treatment thresholds used were:-

1. Spray at first sign of thrips adults, repeat at 2 week intervals.
2. Spray when 1 larva present per 10 plants, repeat as needed.
3. Spray when 1 larva present per 2 plants, repeat as needed.
4. Spray when 1 larva present per plant, repeat as needed.
5. Spray when 5 larvae present per plant, repeat as needed.
6. Untreated.

Each time the threshold was reached, based on weekly assessments (see below), a single spray of 'Decis' was applied at 300ml/ha in 500 l. of water. Applications were done with an Oxford Precision Sprayer operating at a pressure of 2 bar fitted with 11002 nozzles.

For each treatment sprays were applied:-

1. 29 June; 13 and 27 July; 3, 10 and 24 August; 6 and 22 September
2. 20 July; 10 August
3. 27 July; 17 August; 13 September
4. 27 July; 17 August; 13 September
5. None (threshold not reached)
6. None (unsprayed control)

Assessments

(a) At approximately weekly intervals from late June, 10 leek plants were assessed from each treatment for thrips (adults or nymphs).

Date of assessments:- 23, 27 June; 3, 10, 17, 24, 31 July; 7, 14, 24, 31 August; 6, 13, 20, 28 September.

(b) On 28 September and 12 October, 10 leek plants were randomly collected from each plot and were assessed for thrips damage to the foliage. The assessment method used is given in Appendix C.

The final assessment was due to be representative of the crop at the planned harvest date. Due to higher than expected yield from earlier varieties on the farm, the harvest date in the experimental field was considerably delayed (10 December 1995). Despite this the sample taken on 12 October was typical of the normal harvest date of this variety. Further samples could not be taken as all plot markers were removed after the final assessment to facilitate uninterrupted harvesting of the whole field by the grower.

Due to the destructive sampling needed to establish thrips levels, no yield data could be collected from the experiment.

Results

Routine weekly assessments of thrips numbers in plants were used solely to determine spray timings. The threshold for treatment 1, first adult thrips, was exceeded on 23 June, but weather conditions prevented safe spray application until 29 June. Thereafter routine treatments were applied. The first threshold in treatment 2, one larva per 10 plants, was exceeded on 17 July and this treatment threshold was only exceeded once more, on 7 August.

The thresholds for treatments 3 and 4, one larva per 2 plants and one larva per plant respectively, were exceeded on 24 July, 14 August and 6 September and sprays were applied as soon as weather permitted after the threshold was reached. The threshold for treatment 5, 5 larvae per plant, was not reached during the experiment.

Table 7 shows the mean percentage leaf area damaged by thrips at the two assessment dates. The main data in the table are actual means but the analysis presented was done on the square root transformation of the data.

Table 7 **Mean percentage of leaf area affected by thrips damage**

	Assessment 28/9/95			Assessment 12/10/95		
Treatment No:	Lower	Middle	Top	Lower	Middle	Top
1. Routine programme	0.7	1.3	0.1	0.4	0.6	0
2. 1 larva per 10 plants	0.1	2.0	0.1	0.3	0.5	0.1
3. 1 larva per 2 plants	0.5	1.0	0.2	0.4	0.8	0.1
4. 1 larva per plant	0.2	0.2	0.1	0.7	1.0	0.1
5. 5 larvae per plant	0.2	0.5	0.2	0.5	0.6	0.1
6. Untreated control	0.3	0.8	0.1	0.5	1.2	0.1
SED (15 df) (transformed data)	0.2	0.3	0.2	0.3	0.4	0.1
CV (%) (transformed data)	47	63	158	71	78	133

The results showed no significant differences between the treatments.

It was noted during the assessments that there was considerable variation in thrips numbers and damage within individual plots. There did appear to be concentrations of attack/damage which sometimes crossed the guards between plots and in some cases, where there was a large focus of attack, it affected parts of several plots, regardless of treatment.This effect had not ben seen in previous work, nor in other experiments in this Project.

Rainfall recorded at ADAS Arthur Rickwood (4 km from experimental site) was 12.4mm in July and 3.9mm in August and temperatures from early July to mid August were above the long term average.

Discussion

Given the history of leek growing on the farm, the history of thrips damage and the dry summer, the level of damage recorded at harvest was low. The numbers of thrips larvae recorded remained relatively low, but even at this level, considerable damage would normally be expected. Therefore the low level of damage was particularly surprising. There is no obvious reason for this, particularly when the number of adult thrips was quite high in the adjacent area of the crop where the trapping experiment was done (see Part D).

A number of control treatments had been applied in the rest of the crop but none of these were allowed to contaminate the trial area.

Although there were no statistically significant treatment differences, of particular note was the lack of any trend in the results between the routine (8 spray) treatment and the untreated plots (Treatments 5 and 6). Also, the routine treatment gave no improvement in control compared to the plots receiving 2 (Treatment 2) or 3 sprays (Treatments 3 and 4).

In spite of regular monitoring it was not possible to differentiate some of the treatment thresholds. In every case when a threshold of one nymph per plant was exceeded, so was the threshold of one larva per 2 plants, so effectively these treatments were identical. This highlights a potential difficulty with thresholds for pests whose numbers can change quickly due to the short life cycle and rapidly increase in favourable conditions.

Although not statistically significant there was, in 5 out of 6 assessments (leaf location and date) of leaf damage, a lower level of damage where only two sprays had been applied, one of these sprays was uniquely applied in the experiment on 20 July. This suggests that timing of sprays may be critical. The spray on 20 July coincided with the start of a prolonged dry spell and, perhaps also importantly, with a sequence of relatively high minimum temperatures (17.9, 15.7 and 14.2°C). Observations in the trial showed that there were unexpected concentrations of thrips attacks in certain parts of the trial, and these occurred regardless of treatment. Further work on this pest should be done on larger plots than those used in this experiment. Plots size should be chosen to enable detailed measurements to be made on a representative number of plants and large enough to obviate any pest attack or infestation level variations. This may compromise the amount of replication which is practical, but in order to obtain results which will be of value to growers, this may be necessary.

Conclusion

None of the thresholds used significantly reduced thrips damage compared to an untreated control.

There was a suggestion that treatment timing may be critical but no specific conclusions could be drawn. Future work on thrips control should be done on larger plots to avoid the effect of concentrations of attack seen in this experiment.

PART D - TRAPPING METHODS

3. Practical Section for growers

a) Application

The aim of the experiment was to evaluate different methods of trapping thrips which could be used as a method of predicting the need to apply treatments for thrips control.

Yellow sticky traps were a reliable method of monitoring thrips numbers in the crop and were more easy to monitor than white or blue sticky traps. Results were similar with water traps but they were much less "user-friendly". Covering traps with netting or mesh improved their ease of use, without markedly affecting their relative efficiency in trapping thrips.

b) Summary

Objectives

No threshold has been established for thrips control on leeks, but growers and their consultants tend to use numbers of thrips larvae on plants as a guide to the need to spray. This method is not only destructive but needs considerable experience and no little patience to be reliable. Thrips are trapped on or in artificial media in other crops and the experiment reported compares a range of trapping systems with assessment of numbers on plants in the field. Thrips numbers caught on sticky traps placed in the crop of various colours (white, yellow or blue) were compared to water traps (either white or yellow) and to thrips numbers found on leek plants. Experience in other crops has shown that coloured sticky or watertraps are non-selective and the reliability of assessment of small insects such as thrips can be compromised by larger non-target insects. Extra treatments were included where a fine clear/opaque mesh or a coarse green plastic netting was used to cover the traps to reduce the number of contaminants.

Results

Similar overall results were obtained from the two different sites used, one in East Anglia and the other in the West Midlands. Sticky traps and water traps caught more thrips than were recorded on plants, with sticky traps catching slightly more overall. White and yellow water traps caught similar numbers of thrips, but white traps caught many more non-target species, especially large flies.

Overall yellow sticky traps caught more thrips than white or blue sticky traps. White sticky traps attracted far more non-target species than yellow or blue. Blue traps were more difficult to assess than other colours, due to the reduced contrast between the trap colour and the insect.

Total trap catches were reduced by covering with mesh and with net. The number of contaminants was reduced most with the mesh, probably solely due to the small mesh size. Mesh or net covering did not change the relative catch with the different coloured traps. Thrips catches on sticky traps or in water traps were similar to numbers on plants where overall thrips numbers were very low. As thrips numbers increased the variation between plants and thrips increased, with 100 times as many thrips on traps compared to single plants where thrips were present in very high numbers.

At certain times there were very high levels of non-damaging thrips species present on plants. Most common was the cereal thrips which would only cause problems as a contaminant on very early leeks, where adult thrips had left cereals and grasses after seeding before seeking overwintering sites.

4. Experimental Section

Introduction

In the absence of any selective trapping system, such as those using pheromones, monitoring of thrips in leeks will need to be done either on plants or using non-selective traps. Assessment on plants is very time consuming even on individual plants, but with plant populations approaching 0.5 million/ha, it is economically impractical to sample plants on a truely representative basis. Unlike for many other pests, plant sampling is destructive and cannot be done easily in the field because the youngest tightly furled leaves have to be checked for young thrips. Thrips larvae, which cause most damage, are very pale in colour and the initial damage they cause is quite indistinct, consequently they are easily overlooked. An alternative assessment is therefore needed for any threshold to be a practical option for growers, or their consultants.

Western Flower Thrips *(Frankliniella occidentalis)* has been successfully monitored in protected crops since the early 1980's, primarily using non-selective sticky traps. Various workers have reported a colour "preference" for thrips monitoring, but this "preference" has been based mainly on the reduced catches of non-target, and particularly neutral species. Blue traps have been most widely promoted for Western Flower Thrips monitoring, while white traps have been found to be useful for other types of insects. Overall monitoring of a wide range of species is most normally done with yellow traps. Non-selective sticky traps are only used exceptionally in non-protected situations, e.g. carrot fly and apply sawfly, and a more common type of trap is the water trap. White or yellow water traps have been found to be most effective.

Using this experience from other crops, the treatments were selected for the experimentation described below.

The main problem with these sort of traps is their very non-selective nature, and their inherent attraction to a wide range of flying insects. Some work has been done with other pests where traps are covered with a perforated physical barrier which restricts access to, but not necesarily the visibility of the trap. Given the small size of thrips this concept was evaluated in this study, using both large mesh rigid plastic netting (approx 1cm square netting) and small mesh flexible netting (approx 1mm square mesh, normally used as a crop cover), to see if the number or proportion of non-target types could be reduced.

The other area of concern was the range of thrips species which may be attracted to the traps. Could the total number of thrips be related to the number of onion thrips on the plants? This was checked in the experiment by identifying the thrips species caught on the traps during one assessment, and relating this to the number of onion thrips on the plants.

Given the geographical spread of leek growing in England, two trapping experiments were done in two of the main production areas. Ultimately, the results of this and similar studies could be tested on a field scale in all main production areas.

Materials and methods

The two sites used for the work were ones where there was a history of leek growing and thrips infestations. The site in Cambridgeshire was the same one used for the threshold experiment described in Part C of this report. The other site in Worcestershire was in the Vale of Evesham where leeks have been grown regularly for many years. Experimental treatments were identical at each site.

Sites

1. **Cambridge**: Alpress Farms, Holly House Farm, Chatteris, Ely, Cambs. Field - No. 54.

   Cultivar: Albana

   Agronomy: Direct drilled in late April in beds 1.84m wide with 4 rows spaced at 0.4m centres, germination was good and the final plant stand was very close to the target population. Routine herbicides, fungicides and nutrients were applied overall, but no insecticides were applied to the trial area.

   Layout: There were 4 replicates of each treatment arranged in a randomised block design. Traps were arranged along two rows 6 metres apart, with 7.5 metres between traps in the row.

2. **Worester**: Mr C Archer, Manor Farm, Ashton-under-Hill, Evesham, Worcs.
   Field - Groaten Back Lane

   Cullivar: Prelina

   Agronomy: Direct drilled in early May in single rows, spaced at 0.33m centre, with an in-row space of 5cm. Germination was poor and the final plant stand was considerably less than 100,000 per hectare. Routine herbicides, fungicides and nutrients were applied overall, but no insecticides were applied to the trial area. A serious attack by cutworm occured in August which further reduced the plant stand.

   Layout: There were 4 replicates of the 10 treatments arranged in a randomised block design. Traps were placed in the centre of plots 25 rows wide by 20m long.

Treatments: The water traps used were circular dishes approximately 17cm diameter and 6cm deep. The water traps were 'filled' to a depth of about 4cm with water aproximately 2ml of a nonionic surfactant was added. The surfactant was used to reduce the surface tension of the water and ensure that insects were submerged and drowned when they alighted. The water traps were placed directly on the ground between the plants.

The sticky traps used were obtained from Agralan and the catches given were taken from a total trapping area per trap of 110 cm^2 (double sided traps). The traps were secured on canes, at a height just below the top of the crop canopy.

Trapping was started on 13 July at Site 1 and on 9 August at Site 2.

Thrips were trapped by the following methods (at both sites):-

TREATMENT	TYPE OF TRAP	COLOUR OF TRAP	COVERING OF TRAP
1	Water	White	None
2	Water	Yellow	None
3	Water	Yellow	'Netlon'
4	Water	Yellow	'Enviromesh'
5	Sticky	White	None
6	Sticky	Yellow	None
7	Sticky	Blue	None
8	Sticky	Yellow	'Netlon'
9	Sticky	Yellow	'Enviromesh'
10	Ten Leek Plants	-	-

The 'Netlon' trap covering was a coarse rigid square green net with an aperture of approximately 1.5 x 1.5 cms. The 'Enviromesh' was a flexible clear/opaque square mesh with an aperture of approximately 0.1 x 0.15cms The trap coverings were secured so that there was no risk of them fouling the trapping surface with a gap of at least 2 cm.

Assessments

a) At each site traps were emptied and refilled (watertraps) or changed (sticky traps) weekly. The total number of onion thrips from each trap was determined in the laboratory.

Given the non-selective nature of the traps, the high numbers of thrips caught and the difficulty of identifying thrips to species, it was not practical to separate onion thrips from the total thrips count. However, the main contaminent found was the grain thrips (*Limnothrips cerealusm*) which is very easy to distinguish and the counts given for numbers of onion thrips excluded cereal thrips, but may contain some other species.

At site 1 two separate counts were made on each date giving total thrips numbers in addition to onion thrips numbers.

b) On two occasions thrips from a sub-sample of traps were identified to species level at site 1 (27 June and 5 September). On 16 August at site 2, the number of cereal thrips trapped on uncovered sticky traps and in leek plants were recorded.

c) At site 2 leaf damage assessments were made on plants from treatment 10 on two occasions (13 September and 20 September), the assessment method used is given in Appendix C

Results

Table 8 gives the weekly mean numbers of onion thrips from the Cambridge site. Water traps consistently caught less onion thrips than sticky traps with overall numbers being similar to numbers found in plants. Covering the water traps with net made little difference to catches, but the mesh covering reduced thrips numbers slightly. More thrips were caught on sticky traps than in water traps. Thrips numbers on sticky traps were higher than were found in plants. There was little difference between the catching efficiency of the different colours of the sticky traps. When thrips numbers were high, traps covered with net caught significantly fewer than uncovered traps, and with mesh covered traps this effect was even more pronounced with lower numbers in all assessments.

Table 9 gives the weekly mean numbers of all thrips, from the Cambridge site. Overall thrips numbers showed a similar pattern to that for onion thrips with one exception, much higher relative numbers of non-target thrips were found in plants than in traps.

Table 10 gives the mean numbers of onion thrips recorded each week at the Worcester site. Overall, water and sticky traps caught similar numbers of thrips with no difference in the efficiency of trapping of white and yellow water traps. Yellow sticky traps caught slightly more than either blue or white sticky traps. Excluding the first assessment where problems occurred with covered traps, net covers reduced thrip catches on most assessment dates with mesh covers producing a much bigger reduction. When thrip numbers were high or moderate the numbers in the traps were much higher than those recorded in plants, however at low thrip numbers the difference was much less. Where thrips numbers were low the number in or on traps was very similar to that found in plants.

The other thrips species recorded on traps in Cambridge on the two occasions when detailed identifications were undertaken were:-

Frankliniella tenvicornis
Anaphothrips intermedius
Aelothrips intermedius
Anaphothrips sylvarum
Thrips minutisimus
Limothrips spp. (including *L. cerealium,* the grain thrip).

The number of onion thrips and grain thrips recorded at the Worcester site on 6 August on sticky traps and plants is shown in Table 11.

Table 8. Mean number of onion thrips per trap, Cambridge

Treatment	Assessment date										
	20/7	27/7	2/8	10/8	17/8	24/8	31/8	6/9	15/9	21/9	28/9
1. Water, white	16	5	17	6	3	5	1	0	2	0	0
2. Water, yellow	7	4	15	3	3	15	3	1	0	0	0
3. Water, yellow + net	5	3	11	21	6	8	1	0	1	1	0
4. Water, yellow + mesh	4	3	5	1	7	0	2	1	0	1	0
5. Sticky, white	69	54	163	29	151	34	14	5	21	1	1
6. Sticky, yellow	13	45	229	19	201	37	6	9	11	1	2
7. Sticky, blue	23	83	233	41	70	24	3	3	9	1	2
8. Sticky, yellow + net	9	25	119	12	90	21	6	4	13	0	3
9. Sticky, yellow + mesh	3	8	41	10	20	9	5	2	4	0	1
10. Plants only	3	11	8	5	4	8	1	1	2	0	2
SED (27d.f)	20	33	70	14	47	7	3	2	4	1	1
CV (%)	201	193	131	136	122	66	114	108	89	163	142

Table 9. Mean number of thrips, all types, per trap, Cambridge.

Treatment	Assessment date										
	20/7	27/7	2/8	10/8	17/8	24/8	31/8	6/9	15/9	21/9	28/9
1. Water, white	29	12	22	13	4	6	3	0	2	0	0
2. Water, yellow	13	11	26	9	5	15	5	2	0	0	0
3. Water, yellow + net	10	9	14	35	7	9	2	0	2	1	0
4. Water, yellow + mesh	3	7	1	7	1	1	3	1	0	0	0
5. Sticky, white	103	180	212	74	175	41	16	6	32	2	4
6. Sticky, yellow	28	124	273	59	216	49	8	13	19	2	13
7. Sticky, blue	74	214	169	83	83	29	3	5	19	1	6
8. Sticky, yellow + net	19	73	147	28	96	24	8	4	20	1	5
9. Sticky, yellow + mesh	7	21	48	23	22	9	7	3	7	0	1
10. Plants only	32	72	101	37	66	10	6	1	2	0	4
SED (27d.f)	25	75	64	31	48	9	4	2	6	1	3
CV (%)	112	147	89	120	102	66	97	97	76	111	124

Table 10 Mean number of onion thrips per trap, Worcester.

Treatment	Assessment date								
	16/8	23/8	30/8	5/9	13/9	20/9	27/9	3/10	11/10
1. Water, white	344	291	140	198	30	29	31	14	25
2. Water, yellow	268	193	136	114	34	10	19	10	18
3. Water, yellow + net	302	91	79	49	30	3	11	11	10
4. Water, yellow + mesh	244	40	47	68	24	2	9	4	8
5. Sticky, white	230	319	156	93	24	12	21	3	32
6. Sticky, yellow	289	446	209	154	44	21	45	7	39
7. Sticky, blue	171	409	142	72	21	23	15	5	21
8. Sticky, yellow + net	x	183	102	108	31	22	35	12	20
9. Sticky, yellow + mesh	x	354	99	64	28	9	20	4	8
10. Plants only	5	4	22	5	2	4	4	5	5
SED (27d.f)	-	48.2	25.5	18.7	8.2	-	-	-	-
CV (%)	-	29.3	31.9	28.7	43.8	-	-	-	-

x = no data - = data not suitable for analysis (too variable)

Table 11 **Mean number of onion and grain thrips, on sticky traps and plants, Worcester.**

	Number per trap		
Trapping method	Onionthrips	Grainthrips	Total
White sticky trap	230	9	239
Yellow sticky trap	289	27	316
Blue sticky trap	171	11	182
Ten plants	5	0	5

The amount of thrips damage to the plants at the Worcester site on two dates is shown in Table 12. A higher level of damage was recorded than at the Cambridge site (see Part c), but this may reflect the much lower plant population in relation to slightly higher thrips numbers.

Table 12 **Percentage of leaf area damaged by thrips, Worcester.**

	13 September		20 September	
	Mean	(Range)	Mean	(Range)
Upper leaf	1.53	(0.5-3.5)	2.06	(0.5-5.5)
Middle leaf	8.80	(2.5-22.5)	10.18	(5.0-16.5)
Lower leaf	5.23	(1.5-12.5)	6.35	(1.5-17.5)

Apart from the specific results of thrips numbers given above there were several practical considerations that were identified in the experiment. These related to the problems of the different assessment methods and their ultimate practicability for growers or their advisers. Comments from the experimentors are given below under general trapping method headings.

<u>Water traps</u>
-in hot dry weather traps dried out between assessments, particularly in Worcester where the traps were very exposed due to low plant population.
-in very wet weather, or where irrigation was applied traps overflowed and the surfactant was diluted, probably resulting in loss of trapped insects.
-where rainfall was violent/heavy traps became heavily contaminated with soil.
-white traps attracted much higher numbers of large contaminant species, including butterflies and flies particularly from the Anthomiidae, Muscidae, Tabanidae and Tephritidae families.
-collecting the catch and sorting was very time-consuming and collecting was very prone to error due to spillage, not an easy trapping method to use.

Sticky traps -fiddly to use and to secure so that they do not come into contact with foliage.
-covering traps with clear "polythene" film before, or immediately on, removal did not affect trap catches and made transport and subsequent assessment very easy.
-white sticky traps were much more heavily contaminated with flies than other colours, making assessment of thrips numbers very difficult.
-blue traps caught fewer non-target species than white or yellow traps but were more difficult to assess due to the decreased contrast between the insect and the trap colour. The length of time taken to assess was much longer than for yellow traps.
-overall yellow traps were the easiest to assess.

Plants -need to be collected without roots and soil and to be placed in polythene bags and cold stored to prevent loss of thrips.
-very time-consuming to assess, if leeks kept at room temperature the thrips are active and may fly off once they warm up when plants are dissected.
-dead thrips may have been in the plants for several weeks before sampling and these will exagerate the figures, when leek plants were cold it was difficult to distinguish live and dead thrips.

Discusssion

The aim of the work was to identify a practical method of assessing thrips numbers and given that this was the first time that this had been attempted the results were very encouraging. Trapping was confirmed to be practically much easier than assessing thrips numbers in plants and the numbers on traps were generally proportioned to those trapped in plants.

Although it was expected that the use of any non-selective coloured traps would cause unacceptable problems, this did not prove to be the case, although traps varied considerably in both their effectiveness and ease of use.

Until the advent of non-selective sticky traps for carrot fly monitoring, vegetable pests had either been monitored by specific pheromone traps, or by non-selective water traps. Pheromone traps for thrips are not available and water traps in this experiment were so difficult and time-consuming to use that they must be considered impractical for thrips monitoring by growers. The lower numbers in water traps in Cambridge were almost certainly due to the much denser plant canopy and the reduced visibility of the traps to insects compared to Worcester.

The non-selective sticky traps proved reasonably easy to use but there were still major roblems. The work showed that, regardless of colour, catches were proportioned to numbers in plants, but that where thrips numbers are high one trap can catch more than 100 times the number of thrips present in 10 plants. This type of trapping would initially seem impractical, but the use of a physical barrier significantly reduced the number of thrips trapped on a number of occasions.

Both types of barrier used, the net and the mesh, were very effective in reducing the level of contaminant species, particularly in Worcester where the lower plant population meant the traps were more exposed to both thrips and non-target insects. At both sites the numbers of thrips caught where mesh was used was significantly reduced compared to catches on non-covered traps. Perhaps the most relevant aspect of the trapping was that the use of mesh where thrips numbers was low, and therefore more critical, resulted in very similar thrips numbers to those found in plants. Where thrips numbers are higher the trap catches exagerated this considerably, even when covered in mesh. It should therefore be possible to establish a relationship, albeit variable, between catches on mesh-covered yellow sticky traps and numbers in plants and therefore potential damage.

Detailed thrips species identification confirmed that onion thrips was the main species likely to be found and that grain thrips was the main non-target species trapped. Where mesh-covered yellow sticky traps were used the number of grain thrips caught was reduced dramatically compared to uncovered traps, particularly when grain thrips populations were very high, and this does offer a degree of selectivity for onion thrips trapping. At the Cambridge site a higher proportion of grain thrips were found in the plants than in or on traps in late July and early August. This may reflect a shelter-seeking behaviour combined with a site in an intensive agricultural situation. This can be compared to the Worcester site which was in a much more mixed agricultural and horticultural situation where grain thrips numbers were lower.

The level of thrips damage seen at the Worcester site was high compared to the Cambridge site (refer to Section C) with up to 20 per cent leaf damage on some leaves. This level of damage relates to a maximum of 2 adult thrips per plant (in late August). The relationship between adult thrips numbers and the amount of plant damage is unlikely to be directly proportional. This is because the majority of damage is caused by the thrips larvae and there is no guarentee that any adult thrips present will feed on the plant, they may simply be seeking shelter. The assessment of thrips larvae is even more time consuming than for adult thrips because they cannot be trapped and have to be counted after plant dissection. Before a robust threshold for treatment of thrips on leeks can be established the relationship between adult numbers, larval numbers and plant damage will need to be established. Other uncertain factors are the impact of thrips at different stages of plant growth and, more particularly, at different times of year. It is quite possible that the spray threshold would vary from say early July to mid September, and the 'late' thrips may cause little economic damage.

Conclusion

Yellow sticky traps covered with a fine opaque mesh were the easiest traps tested to use in the field. The numbers of thrips caught on the traps was generally higher than was found in plants, except at low populations when catches were similar.

5 OVERALL DISCUSSION

Work in the project was designed both, to give some information on control which would be of immediate benefit to growers, and to provide some background information for further studies on spray decision making. Although it may appear that the results on control were too negative to be of any immediate practical use, they did serve to emphasis that control of thrips in the field is very difficult to achieve. Growers will be well aware of the potential for thrips damage, but many question the value of some of the control measures that they apply. The work with insecticides showed just how unreliable current products are, but perhaps more worryingly failed to identify any 'new' product which was significantly better than products already Approved. Only one experimental insecticide (AC 303,630) showed any real improvement on control obtained with chlorpyrifos (as Dursban 4), but this insecticide is not currently marketed in the UK, nor any other EU country. In the short term growers will therefore have to maximise the effectiveness of Approved products with thorough and timely applications.

There is often considerable commercial pressure on growers to include spray adjuvants with a wide range of spray treatments. However there is little positive critical experimental evidence to justify their use with insecticides. Results reported here failed to show any real or consistent benefit from use of adjuvants with chlorpyrifos on the control of thrips. Although Ashlade Adjuvant Oil and Codacide Oil did reduce thrips numbers, this effect was not significant and was not reflected in reduced plant damage. Similarly the non-significant reduction in thrips damage with LI700 did not result from lower thrips numbers. This confirmed some previous HDC work on the same crop and pest. Although adjuvants do have certain very real physical properties, such as increased leaf wetting, this effect will only be of practical benefit if the active ingredient of the insecticide can be made to behave in the same way, ie as the adjuvant spreads does it 'carry' the insecticide with it? If adjuvants are to be made to work they must be selected for properties specifically needed for the particular pest and mode of action of the insecticide. Given the lack of any consistent positive effect in this and some previous work, any future work should be much more focused.

Increasingly growers are being asked to justify their use of spray treatments by their customers. With many pests there are very robust spray thresholds for triggering spray treatments, but not with onion thrips on leeks. The work reported above was designed to start the process of identifying a threshold to replace the 'see-one-and-spray-them', routine treatment or the 'gut-feeling' type decision currently used by necessity by some growers. Some progress was made, although it does take a little extricating from the apparently negative results presented. The main question posed by the results of the work was about spray timing. Some very useful leads have resulted from the work, which undoubtedly must be regarded as a long term study.

In contrast to previous parts of the work, some very positive results were obtained in relation to pest monitoring. The work showed a link between the numbers in the plant and those caught on traps and given the practical limitations on assessment in plants this has to be of real value in the long term. Yellow sticky traps, already widely used in other horticultural sectors, proved to be the most reliable and easiest to use. The use of 'selectively permeable' physical barriers, such as net or mesh, over the traps, was clearly shown to be beneficial in making the traps much easier to assess. More work is still needed however to relate the trap catches to the number of thrips larvae and to the amount of damage likely to occur.

Putting the results from the 4 different parts of the Project together, it appears that, in the short term, unless some new and very active insecticides become available, there is little likelihood that answers can be found from more insecticide or adjuvant screening. We do still need to establish a baseline for treatment of this pest, which this work failed to identify. A much more concerted effort on thresholds is essential before real progress can be made in giving growers the confidence that they can minimise damage by this pest, without the need to apply blanket or routine treatments. Although the trapping work gave some very positive results, without a spray threshold, the benefits are meaningless.

We may however be able to take results from some current work in Holland on new methods of use of existing molecules, even if the exact method of use is not available in the UK. Ultimately when EU pesticide legislation harmonisation becomes a reality very real advantages to growers would result from collaborative research with workers in other countries. This is reinforced by some work currently being done in France on trapping methods

6 OVERALL CONCLUSIONS

a) The standard insecticide, chlorpyrifos, gave the best overall thrips control of the approved products tested.

b) Of the experimental insecticides tested, only AC 303,630 gave good thrips control.

c) Adjuvants did not improve the thrips control, nor reduce the thrips' damage, obtained with chlorpyrifos used alone.

d) Work on thresholds was inconclusive, but spray timing may be critical for maximum control.

e) Yellow sticky traps, covered with a fine mesh were the best method of monitoring thrips numbers in the crop.

7 RECOMMENDATIONS

a) Further work on chemical control should be delayed until new insecticides, or methods of use, become available.

b) Any further work on adjuvants should be linked closely with the mode of action of the insecticide. Funding for this work should be obtained from the adjuvant manufacturers, with HDC providing the scientific validation of the work on the growers' behalf.

c) A concerted effort needed to establish a spray threshold which growers can use with confidence.

d) The relationship between the number adult thrips caught on traps, the number of thrips larvae found in plants and the resulting level of thrips damage at harvest needs to be established.

8 ACKNOWLEDGEMENTS

The work reported under Parts A and B was managed by Dr Mike Saynor and Mr Richard Suckling under a sub-contract from ADAS. They also were closely involved with the overall planning of the Project. Their contribution to this project was therefore substantial and is acknowledged with great thanks.

The co-operation of the growers who kindly provided sites for this work is worthy of particular thanks. Philip Emmett and John Heritage of W C Emmett and Son, Nick Alpress of Alpress Farms, and Charles Archer all provided resources without which the Project could not have been undertaken.

The help provided by Jennie Blood Smyth from the Projects inception to the completion of this report was particularly valuable.

Special thanks are due to Philippa Mansfield, Jackie Town and Louise Pierce who were responsible for the day-to-day running of the work at different sites and also did much of the data collation.

Thanks are also due to the various insecticide and adjuvant manufactures who provided samples for the work.

APPENDIX A1 : Chemical control
First assessment - thrips larvae per plant

Collected : 8 August

Treatment	Replicate				
	I	II	III	Total	Mean
1. Disulfoton gran.	20.7	47.0	6.3	74	24.7
2. Imidacloprid drench	16.8	36.4	7.7	60.9	20.63
3. Dichlorvos - DDVP	7.9	33.4	8.2	49.5	16.5
4. As 3. plus Slippa	8.1	31.9	21.4	61.4	20.5
5. Ciba Geigy A8811B	9.6	66.9	11.6	88.1	29.4
6. Ciba Geigy - "Insegar"	16.9	33.4	3.3	53.6	17.9
7. Cyanamid - "Masai"	16.3	46.9	8.4	71.6	23.9
8. Cyanamid - AC 303,630	8.9	27.1	3.3	39.3	13.1
9. Dipterex 80	15.2	20.4	12.1	47.7	15.5
10. Hallmark	13.8	33.7	3.9	51.4	17.1
11. Decisquick	7.5	13.9	22.2	43.6	14.5
12. Hostathion	8.0	31.1	8.3	47.4	15.8
13. Malathion	18.1	20.9	8.0	47.0	15.7
14. Decis	5.0	48.3	24.6	77.9	26.0
15. Dursban	4.2	13.7	11.0	28.9	9.6
16. Untreated control	10.1	47.0	7.9	65	21.7

APPENDIX A2 : Chemical control
First assessment - adult thrips per plant

Collected : 8 August

Treatment	Replicate				
	I	II	III	Total	Mean
1. Disulfoton gran.	3.6	20.5	0.7	24.8	8.27
2. Imidacloprid drench	9.5	8.9	3.7	22.1	7.37
3. Dichlorvos - DDVP	2.7	10.7	2.6	16.0	5.33
4. As 3. plus Slippa	4.3	8.4	5.4	18.1	6.03
5. Ciba Geigy A8811B	2.0	21.3	3.9	27.2	9.07
6. Ciba Geigy - "Insegar"	4.3	8.6	0.6	13.5	4.5
7. Cyanamid - "Masai"	6.1	17.5	1.8	25.4	8.47
8. Cyanamid - AC 303,630	3.7	5.4	1.2	10.0	3.33
9. Dipterex 80	5.4	7.0	2.4	14.8	4.93
10. Hallmark	4.5	8.5	0.1	13.1	4.37
11. Decisquick	2.7	7.4	4.2	14.3	4.77
12. Hostathion	2.9	10.7	1.9	15.5	5.17
13. Malathion	3.9	11.4	3.1	18.4	6.13
14. Decis	1.6	15.0	3.0	19.6	6.53
15. Dursban	1.8	5.5	4.5	11.8	3.93
16. Untreated control	2.0	13.9	1.3	17.2	5.73

APPENDIX A3 : **Chemical control**
First assessment - total thrips per plant

Collected : **8 August**

Treatment	Replicate				
	I	II	III	Total	Mean
1. Disulfoton gran.	24.3	67.5	7.0	103.3	34.43
2. Imidacloprid drench	26.3	45.3	11.4	83.0	27.67
3. Dichlorvos - DDVP	10.6	44.1	10.8	65.5	21.83
4. As 3. plus Slippa	12.4	40.3	26.8	79.5	26.5
5. Ciba Geigy A8811B	11.6	88.2	15.5	115.3	38.43
6. Ciba Geigy - "Insegar"	21.2	42.6	3.9	67.7	22.57
7. Cyanamid - "Masai"	22.4	64.4	10.2	97.0	32.33
8. Cyanamid - AC 303,630	12.6	32.5	4.4	49.5	16.5
9. Dipterex 80	20.6	27.4	14.5	62.5	20.83
10. Hallmark	18.3	42.2	3.9	64.4	21.47
11. Decisquick	10.2	21.3	26.4	57.9	19.3
12. Hostathion	10.9	41.8	10.2	62.9	20.97
13. Malathion	22.0	32.3	11.1	65.4	21.8
14. Decis	6.6	63.6	27.6	97.8	32.6
15. Dursban	6.0	19.2	15.5	40.7	13.57
16. Untreated control	12.1	60.9	9.2	82.2	27.4

APPENDIX A4: Chemical control
Second assessment - thrips larvae per plant

Collected : 11 September

Treatment	Replicate				
	I	II	III	Total	Mean
1. Disulfoton gran.	10.9	46.9	82.5	140.3	46.77
2. Imidacloprid drench	5.1	22.5	22.0	49.6	16.53
3. Dichlorvos - DDVP	15.4	16.8	6.6	38.8	12.93
4. As 3. plus Slippa	1.0	24.6	30.4	56.0	18.67
5. Ciba Geigy A8811B	3.3	36.4	13.0	52.7	17.57
6. Ciba Geigy - "Insegar"	14.8	19.9	23.2	57.9	19.30
7. Cyanamid - "Masai"	14.0	21.8	48.0	83.8	27.93
8. Cyanamid - AC 303,630	0.3	5.6	6.6	12.5	4.17
9. Dipterex 80	11.0	31.9	26.2	69.1	23.03
10. Hallmark	11.2	15.7	36.1	63.0	21.00
11. Decisquick	1.1	12.1	20.0	33.2	11.07
12. Hostathion	8.6	22.6	35.2	66.4	22.13
13. Malathion	18.3	25.9	62.1	106.3	35.43
14. Decis	5.1	30.0	23.2	58.3	19.43
15. Dursban	0.9	13.0	4.2	18.1	6.03
16. Untreated control	4.7	16.3	22.8	43.8	14.6

APPENDIX A5 **Chemical control**
Second assessment - adult thrips per plant

Collected : **11 September**

Treatment	Replicate				
	I	II	III	Total	Mean
1. Disulfoton gran.	1.7	13.5	9.9	25.1	8.37
2. Imidacloprid drench	0.5	14.7	5.0	20.2	6.73
3. Dichlorvos - DDVP	0.9	11.5	4.9	17.3	5.77
4. As 3. plus Slippa	0.7	9.0	3.8	13.5	4.5
5. Ciba Geigy A8811B	0.3	19.8	3.8	23.9	7.97
6. Ciba Geigy - "Insegar"	2.2	9.3	3.3	14.8	4.93
7. Cyanamid - "Masai"	2.7	14.5	7.0	24.2	8.07
8. Cyanamid - AC 303,630	0.1	6.4	3.6	10.1	3.37
9. Dipterex 80	0.3	11.5	8.8	20.6	6.87
10. Hallmark	1.0	6.7	7.1	14.8	4.93
11. Decisquick	0.1	7.1	5.2	12.4	4.13
12. Hostathion	1.0	8.3	3.6	12.9	4.30
13. Malathion	3.1	14.2	9.9	27.2	9.07
14. Decis	0.7	22.4	2.3	25.4	8.47
15. Dursban	0.5	8.3	1.2	10.0	3.33
16. Untreated control	0.4	12.6	6.8	19.8	6.6

APPENDIX A6 Chemical control
Second assessment - total thrips per plant

Collected : 11 September

Treatment	Replicate				
	I	II	III	Total	Mean
1. Disulfoton gran.	12.6	60.4	92.4	165.4	55.13
2. Imidacloprid drench	5.6	37.2	27.0	69.8	23.27
3. Dichlorvos - DDVP	16.3	28.3	10.2	54.8	18.27
4. As 3. plus Slippa	1.7	33.6	34.2	69.5	23.17
5. Ciba Geigy A8811B	3.6	56.2	16.8	76.6	25.53
6. Ciba Geigy - "Insegar"	17.0	29.2	26.5	72.7	24.23
7. Cyanamid - "Masai"	16.7	36.3	55.0	108.0	36.0
8. Cyanamid - AC 303,630	0.4	12.0	10.2	22.6	7.53
9. Dipterex 80	11.3	43.4	35.0	89.7	29.9
10. Hallmark	12.2	22.4	43.2	77.8	25.93
11. Decisquick	1.2	19.2	25.2	45.6	15.2
12. Hostathion	9.6	30.9	38.8	79.3	26.43
13. Malathion	21.4	40.1	72.0	133.5	44.5
14. Decis	5.8	52.4	25.5	83.7	27.9
15. Dursban	1.4	21.3	5.4	28.1	9.37
16. Untreated control	5.1	28.9	29.6	63.6	21.2

APPENDIX A7 : Chemical control
Damage scores at harvest

Assessed : 4 September

Treatment	Replicate				
	I	II	III	Total	Mean
1. Disulfoton gran.	2.5	2.5	2.5	7.5	2.5
2. Imidacloprid drench	3.0	2.0	2.0	7.0	2.3
3. Dichlorvos - DDVP	2.5	2.5	2.5	7.5	2.5
4. As 3. plus Slippa	2.0	2.0	2.0	6.0	2.0
5. Ciba Geigy A8811B	3.0	2.0	3.0	8.0	2.7
6. Ciba Geigy - "Insegar"	2.0	2.0	2.0	6.0	2.0
7. Cyanamid - "Masai"	3.0	3.0	2.5	8.5	2.8
8. Cyanamid - AC 303,630	3.0	3.0	3.5	9.5	3.2
9. Dipterex 80	3.0	2.5	2.5	8.0	2.7
10. Hallmark	2.0	3.0	2.0	7.0	2.3
11. Decisquick	2.0	2.0	2.0	6.0	2.0
12. Hostathion	2.0	3.5	2.0	7.5	2.5
13. Malathion	2.0	2.0	2.0	6.0	2.0
14. Decis	1.5	2.0	2.5	6.0	2.0
15. Dursban	3.0	2.5	3.0	8.5	2.8
16. Untreated control	2.5	2.5	2.5	7.5	2.5

APPENDIX B1 **Adjuvant evaluation**
First assessment - thrips larvae per plant

Collected **26 July 1995**

Treatment	Replicate					
	I	II	III	IV	Total	Mean
1. Agral	8.0	2.9	2.2	1.0	14.1	3.53
2. Slippa	4.2	5.3	2.3	1.5	13.3	3.33
3. Booster	12.2	5.7	3.1	0.6	21.6	5.4
4. Ethokem	11.2	5.1	2.5	1.1	19.9	4.98
5. Rapide	6.0	2.1	3.7	1.2	13.0	3.25
6. Ashlade Adjuvant Oil	7.0	2.5	6.3	3.7	19.5	4.88
7. Codacide Oil	9.1	3.8	2.3	0.9	16.1	4.03
8. LI 700	7.1	2.4	1.1	1.1	11.7	2.93
9. Bond	2.0	4.1	1.2	1.5	8.8	2.2
10. New film P	3.2	2.1	2.7	0.8	8.8	2.2
11. Dursban only	2.9	5.7	3.0	2.1	13.7	3.43
12. Control Water only	21.2	4.0	11.8	2.4	39.4	9.85

APPENDIX B2 **Adjuvant evaluation**
First assessment - adult thrips per plant

Collected **26 July 1995**

Treatment	Replicate					
	I	II	III	IV	Total	Mean
1. Agral	0.7	0.4	0	0	1.1	0.28
2. Slippa	0	0.1	0	0	0.1	0.03
3. Booster	1.1	0.1	0.1	0.4	1.7	0.43
4. Ethokem	0.6	0.3	0.4	0.1	1.5	0.38
5. Rapide	1.2	0	0.9	0	2.1	0.53
6. Ashlade Adjuvant Oil	0.5	0	0.3	0	0.8	0.2
7. Codacide Oil	0.8	0.1	1.1	0	2.0	0.5
8. LI 700	0.8	0	0	0.2	1.0	0.25
9. Bond	0.1	0.2	0.5	0	0.8	0.2
10. New film P	0.8	0	0.1	0.1	1.0	0.25
11. Dursban only	0.3	0.3	0.3	0	0.9	0.23
12. Control Water only	8.3	0.6	1.9	1.6	20.7	5.18

APPENDIX B3 Adjuvant evaluation
First assessment - total thrips per plant

Collected 26 July 1995

Treatment	Replicate					
	I	II	III	IV	Total	Mean
1. Agral	8.7	3.3	2.2	1.0	15.2	3.8
2. Slippa	4.2	5.4	2.3	1.5	13.4	3.35
3. Booster	13.3	5.8	3.2	1.0	23.3	5.83
4. Ethokem	11.8	5.4	2.9	1.2	21.3	5.33
5. Rapide	7.1	2.1	4.9	1.2	15.3	3.83
6. Ashlade Adjuvant Oil	7.5	2.5	6.6	3.7	20.3	5.08
7. Codacide Oil	9.9	3.9	3.4	0.9	18.1	4.53
8. LI 700	7.9	2.4	1.1	1.3	12.7	3.18
9. Bond	2.1	4.3	1.7	1.5	17.7	4.43
10. New film P	4.0	2.1	2.8	0.9	9.8	2.45
11. Dursban only	3.2	6.0	3.3	2.1	14.6	3.65
12. Control Water only	29.5	4.6	13.7	4.0	51.8	12.95

APPENDIX B4 Adjuvant evaluation
Second assessment -thrips larvae per plant

Collected 31 August 1995

Treatment	Replicate					
	I	II	III	IV	Total	Mean
1. Agral	15.1	5.9	10.8	5.5	37.3	9.33
2. Slippa	9.1	4.3	3.4	7.8	24.6	6.15
3. Booster	8.5	7.8/	5.1	4.2	25.6	6.4
4. Ethokem	10.8	11.4	2.7	15.8	40.7	10.17
5. Rapide	12.9	7.8	10.5	4.8	36.0	9.0
6. Ashlade Adjuvant Oil	6.2	6.1	4.9	5.3	22.5	5.63
7. Codacide Oil	11.0	4.1	1.4	3.5	20.0	5.0
8. LI 700	6.9	9.2	2.8	4.5	23.4	5.85
9. Bond	4.5	5.5	8.9	5.2	24.1	6.03
10. New film P	7.7	9.8	7.0	3.0	27.5	6.88
11. Dursban only	6.3	15.9	5.1	6.7	34.0	8.5
12. Control Water only	46.1	29.0	25.0	33.1	133.2	33.3

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APPENDIX B5 **Adjuvant evaluation**
Second assessment - adult thrips per plant

Collected **31 August 1995**

Treatment	Replicate					
	I	II	III	IV	Total	Mean
1. Agral	6.3	3.7	1.2	1.3	12.5	3.13
2. Slippa	1.6	2.0	1.5	1.1	6.2	1.55
3. Booster	3.7	1.7	2.3	1.3	9.0	2.25
4. Ethokem	3.6	5.5	2.5	0.4	12.0	3.0
5. Rapide	5.5	5.6	3.1	0.7	14.9	3.73
6. Ashlade Adjuvant Oil	4.0	2.7	4.7	0	11.4	2.85
7. Codacid Oil	6.0	2.5	1.8	1.1	11.4	2.85
8. LI 700	5.1	3.7	1.4	0.6	10.8	2.7
9. Bond	2.9	3.3	2.6	2.1	10.9	2.73
10. New film P	5.0	3.8	3.8	0.5	13.1	3.28
11. Dursban only	6.6	2.3	2.9	1.9	13.6	3.4
12. Control Water only	14.7	3.6	5.2	1.8	25.3	6.33

APPENDIX B6 Adjuvant evaluation
Second assessment - total thrips per plant

Collected 31 August 1995

Treatment	Replicate					
	I	II	III	IV	Total	Mean
1. Agral	21.4	9.6	12.0	6.8	49.8	12.45
2. Slippa	10.7	6.3	4.9	8.9	30.8	7.7
3. Booster	12.3	9.5	7.4	5.5	34.7	8.68
4. Ethokem	14.4	16.9	5.2	16.2	52.7	13.18
5. Rapide	18.4	13.4	13.6	5.5	50.9	12.73
6. Ashlade Adjuvant Oil	10.2	8.8	9.6	5.3	33.9	8.48
7. Codacide Oil	17.0	6.6	3.2	4.6	31.4	7.85
8. LI 700	12.0	12.9	4.2	5.1	34.2	8.55
9. Bond	7.4	8.8	1.5	7.3	35.0	8.75
10. New film P	12.7	13.6	10.8	3.5	40.6	10.15
11. Dursban only	12.9	18.2	8.0	8.6	47.7	11.93
12. Control Water only	60.8	32.6	30.2	34.9	158.5	39.63

APPENDIX B7 **Adjuvant evaluation**
Damage scores at harvest

Assessed **25 August 1995**

Treatment	Replicate					
	I	II	III	IV	Total	Mean
1. Agral	3.0	4.0	3.0	4.0	14.0	3.5
2. Slippa	3.5	3.0	4.0	4.0	14.5	3.6
3. Booster	3.0	3.5	3.5	4.0	14.0	3.5
4. Ethokem	4.0	3.0	4.0	3.0	14.0	3.5
5. Rapide	4.0	3.5	3.5	3.0	14.0	3.5
6. Ashlade Adjuvant Oil	3.5	4.0	4.0	4.0	15.5	3.9
7. Codacide Oil	3.0	4.0	4.0	3.5	14.5	3.6
8. LI 700	3.5	4.0	4.5	4.5	16.5	4.1
9. Bond	3.0	4.0	3.0	3.0	13.0	3.3
10. New film P	3.0	4.0	4.0	4.0	15.0	3.8
11. Dursban only	3.5	3.0	4.0	3.0	13.5	3.4
12. Control Water only	2.0	2.0	2.0	1.5	7.5	1.9

5 = Best **1 = Worst**

APPENDIX C

THRIPS ON LEEKS

DAMAGE ASSESSMENT METHOD

1. Select I0 typical plants at random per plot. Ignore plants which are bolting or are
not of about average size.

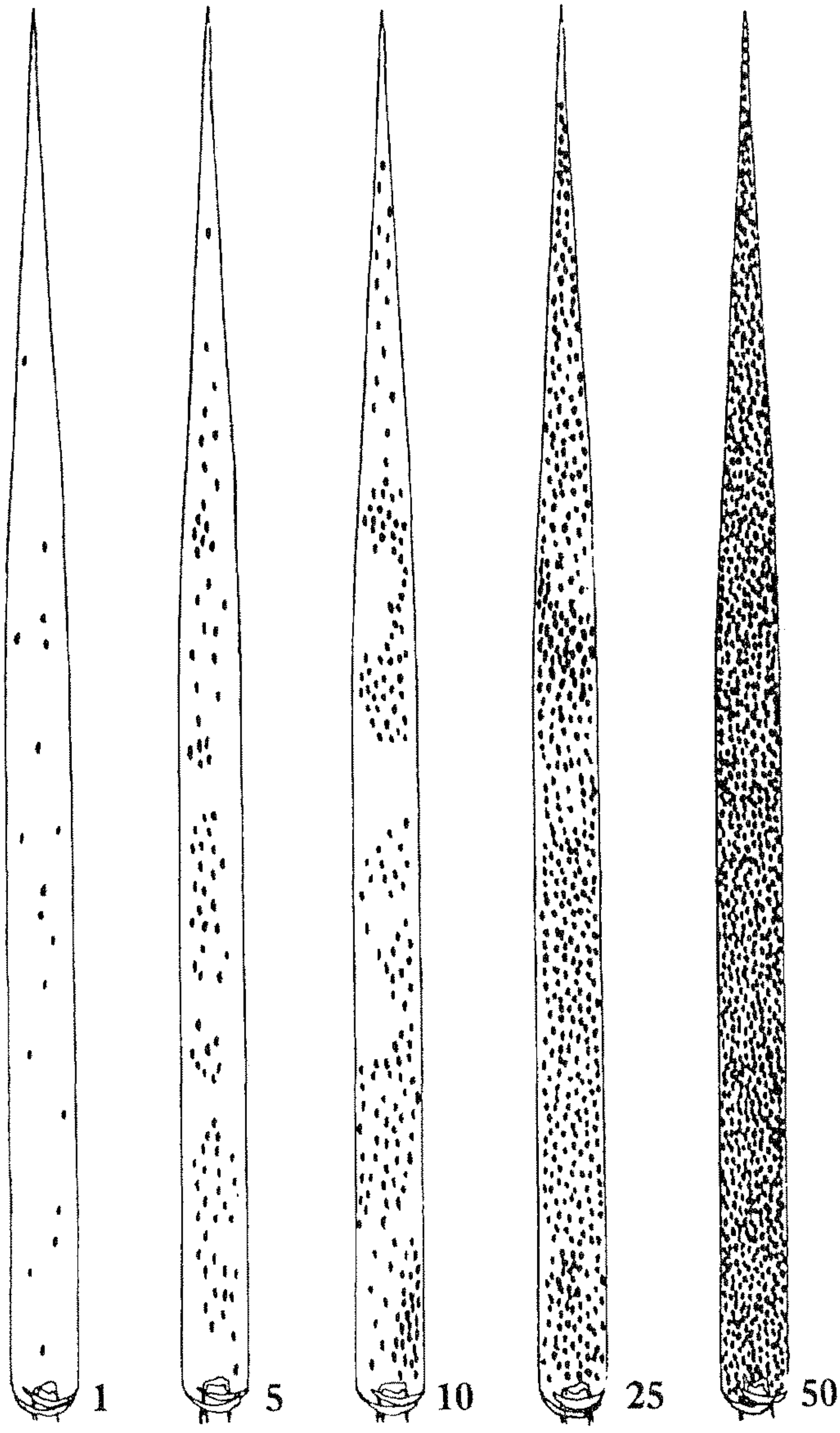
2. Assessment can be done either in the field, or the bulked plot sarnple should be stored in a polythene bag, kept cool and assessed within 3 days.

3. On each plant select three leaves: -
   a) the first (lowest) leaf remaining after the oldest leaves have been stripped oty to reveal at least 5 ems of clean white or very pale green shank
   b) the middle leaf (approx)
   c) the top leaf, this is the one with its' tip only exposed. this leaf will still be folded mainly

4. Use the attached key and estimate the area of damage on each side of each leaf, average the damage to give a mean figure for each leaf On the lower and middle leaves damage will show as silvering, but on the top leaf damage is much less obvious and will show as a sort of yellow bruising or scraped area. On the top leaf there will usually be some young thrips associated with the damage (unless they have recently been sprayed).

5. Keep damage scores separate for the three difterent leaf positions in each plot, ie
you will end up with three separate scores per plot. Mean the score for each position for each treatment.

KEY FOR THRIPS DAMAGE ASSESSMENT ON LEEKS



Percentage of leaf area affected

Contract between ADAS (hereinafter called the "Contractors") and the Horticultural Development Council (hereinafter called the "Council") for research/development project.

Contract No: FV 185
Contract Date: January 1996

1. TITLE OF PROJECT

LEEKS: CONTROL OF THRIPS USING CHEMICAL AND SUPERVISED TECHNIQUES

2. BACKGROUND AND COMMERCIAL OBJECTIVES

Onion thrips (*Thrips tabaci*) is a widespread and common pest of all alliaceous plants. Damage takes two forms. A severe attack on young plants may cause whole plant distortion and possible crop rejection. More commonly, the feeding damage on the flag part of the leaves, if still present at harvest, causes downgrading, or rejection of the crop. This problem is particularly relevant where supermarket outlets are used. Thrips damage has been recognised for many years but appears to have steadily increased over the last 10 years.

Particularly serious infestations of onion thrips occurred in 1994 in crops of leeks and salad onions. In spite of regular applications of approved pesticides, control was not achieved and a number of crops were rendered unmarketable.

The problem is usually most serious during periods of hot weather and control may only be restored with the onset of lower temperatures. 1994 was the first year when failure of normal control measures occurred on any scale, although the pest has been difficult to control locally for a number of years.

T.tabaci has also been confirmed in crops of round green cabbage causing oedema-like symptoms, again on a scale not seen in previous years, seriously reducing quality in a number of crops. Thrips damage is also reported regularly on iceberg lettuce.

Thrips in leeks are difficult pests to control because they live and feed for much of the time protected between the newest leaves in the centres of plants. Spray adjuvants are claimed to improve the effectiveness of many pesticides, but the best adjuvant to use is not known.

At present there are no thresholds for treatment for thrips on leeks and routine treatment has become normal. Further unknown factors are the effect of thrips feeding on the yield of leeks and the speed of development to marketable size. Most damage is done by young thrips feeding deep in amongst the tightly folded young leaves. Monitoring for presence of thrips is a time consuming process and the small size of the larvae combined with their pale colour make them easy to miss by all except the most skilled observers. At present monitoring can only be done by destructive sampling. Even when thrips are known to be present the relationship between numbers and crop damage has never been established.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

Successful conclusion to the project would:-

i. Identify the most effective insecticide for thrips control.

ii. Establish whether adjuvants can enhance the thrips control obtained with approval insecticides.

iii. Reduce the number of sprays necessary to minimise crop damage.

iv. Enable sprays to be timed accurately on the basis of simple crop monitoring.

These would all produce financial and environmental benefits. They would also enable growers to meet the terms of supermarket protocols.

The magnitude of losses to thrips in 1994 nationally is not known but an estimate of £125,000 from one area alone was made. Nationally it is possible that, due to crop rejection, losses exceeded £300,000 in 1994.

4. SCIENTIFIC AND TECHNICAL TARGET OF THE WORK

a. To evaluate novel and currently-approved insecticides, using single and multiple treatment programmes, including granular and liquid formulations.

b. To assess the crop safety of the insecticides.

c. To assess whether adjuvants enhance the performance of either chlorpyrifos or deltamethrin, the two insecticides most widely used for the control of thrips on leeks.

d. To establish a threshold of thrips numbers per plant. This would give the optimum spray timing to produce minimum crop damage. This may involve the establishment of a threshold range according to the target market - eg on processing leeks a much higher level of damage may be acceptable than for pre-packed leeks.

e. To evaluate methods of monitoring thrips populations in commercial crops.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

Between 1987 and 1989 ADAS evaluated the effect of thrips on leeks and the efficacy of a range of insecticides for thrips control for HDC. This work now needs updating in the light of new insecticides and changing market requirements. The proposed work will draw on experience of these thrips control experiments and also commercial control experience. Also work by Bayer, both in the UK and abroad, has demonstrated the effectiveness of some treatments proposed.

Some related work on thresholds for thrips is being done in Holland and the researcher has already been contacted.

6. DESCRIPTION OF WORK

Field trials will be done on commercial farms where thrips infestations regularly cause serious crop losses in leeks.

Two trials relating to chemical control of thrips are proposed. In the first 9 approved insecticides and 2 novel ones will be screened. The treatments include granular and liquid formulations (that will be applied as either sprays or drenches).

In the second trial spray adjuvants which are being widely promoted commercially, will be evaluated to identify any possible benefits from their use with a standard insecticide.

The third experiment would test a range of spray thresholds which would enable sprays to be timed more accurately.

The final part would evaluate a range of options of passive (non-selective) trapping methods for thrips which could obviate the need for laborious plant inspections to decide spray timing. Parts C and D of the proposal would be run on the same site with one extra satellite observation on trapping methods.

A Screening Trial

(Rates per hectare to be agreed after further discussions with the manufacturers)

i. Treatments

1. Disulfoton Granules - broadcast once - at first sign of thrips.

2. Disulfoton Granules applied in 2 bands close to the rows, then plants lightly "earthed-up" (one treatment only).

3. Drench of imidacloprid (Admire) - at first sign of thrips (one treatment only).

4. Dichlorvos (Luxan Dichlorvos 600 EC) sprays applied at first signs of thrips and repeated as necessary, up to 6 applications.

5. Malathion sprays applied at first signs of thrips and repeated as necessary, up to 6 applications.

6. Triazophos (Hostathion) sprays applied at first signs of thrips and repeated as necessary, up to 6 applications.

7. Deltamethrin plus heptenophos (Hostaquick) sprays applied at first signs of thrips and repeated as necessary, up to 6 applications.

8. Lambda-cyhalothrin (Hallmark) sprays applied at first signs of thrips and repeated as necessary up to 6 applications.

9. AC 801757 - Cyanamid (Masai) sprays applied at first signs of thrips and repeated as necessary, up to 6 applications.

10. Pymetrozine (Ciba-Geigy CGA 215944) sprays applied at first signs of thrips and repeated as necessary, up to 6 applications.

"Standard" Treatments and Controls

11. Chlorpyrifos (eg Dursban) sprays applied at first signs of thrips and repeated as necessary, up to 6 applications.

12. Deltamethrin (Decis) sprays applied at first signs of thrips and repeated as necessary, up to 6 applications.

13. Untreated control.

14. Untreated control.

ii. Methods

Site: Commercial Farm, Thames Valley

Plot size: 1 Bed (5 rows) x 7 m (approx)

Method of Application:

Granules - Broadcast over the rows - Treatment 1.

"Pepper-potted" along the rows and lightly incorporated, - to simulate earthing up - Treatment 2.

Drenches - Applied through a coarse nozzle at target rate of 600 litres water per ha - Treatment 3.

Sprays - Knapsack sprayer/Pressure sprayer to give a medium spray quality spray - all other treatments (250-500 l/ha according to crop stage).

Experimental Design: Randomised block - 14 treatments x 3 replicates.

Assessments:

Field - Two "Field Quality" assessments of the plots - to note and record crop vigour, spray damage (phytotoxicity) and pest damage:-

Mid August
Mid September

Quality and yield assessment at harvest:-

Numbers and weight of marketable leeks packed by the grower.

Laboratory - Numbers of adult and larval thrips on plants - counted twice:-

Late July/early August - according to the season, plus 4-6 weeks after the first assessment.

B Effects of Adjuvants Trials

i. Treatments

Sprays of either chlorpyrifos (eg Dursban) or deltamethrin (Decis) applied alone or with different spray adjuvants. Treatments repeated as necessary.

1. An emulsifiable vegetable oil, eg Codacide.
2. A refined mineral oil, eg Actipron.
3. A non-ionic alkyl phenol wetter/spreader, eg Agral.
4. A cationic surfactant containing a polyethoxylated tallow amine, eg Hyspray.
5. A polyacrylamide adjuvant, eg Atlas Companion.
6. A synthetic latex sticker/extender, eg Bond.
7. A spreader and buffering agent, eg Croptex ZIP.
8. No adjuvant.
9. Untreated control (no insecticide).

ii. Methods

Site: Commercial Farm, Thames Valley

Plot size: 1 bed (5 rows) x 7 m (approx)

Method of Application: Knapsack sprayer/Pressure sprayer to give a medium spray quality spray.

Experimental Design: Randomised block - 9 treatments x 4 replicates

Assessments: As in the Screening Trial (B)

Any differences to the behaviour and appearance of spray droplets and deposits caused by the adjuvants will be noted.

C Thresholds

i. Treatments

A standard insecticide will be used throughout. Treatments will be applied according to threshold. No adjuvants will be used.

1. Spray at first sign of thrips adults, repeat at 2 week intervals.
2. Spray when 1 larva present per 10 plants, repeat as needed.
3. Spray when 1 larva present per 2 plants, repeat as needed.
4. Spray when 1 larva present per plant, repeat as needed.
5. Spray when 5 larvae present per plant, repeat as needed.
6. Untreated.

ii. Methods

Site: Commercial Farm, Cambridgeshire.

Method of Application: Knapsack sprayer to give medium spray quality, volume 200-500 l/ha

Experimental Design: Randomised blocks - 4 replicates.

Assessments: Weekly counts of thrips in plants from mid June (to determine spray timing).

Qualitative assessment of thrips damage in field, early July to late September.

(Adult thrip numbers will be checked under part D below).

Continuous temperature recording (air and soil) on site. Rainfall on daily basis from nearest met site.

D Monitoring

i. Treatments (method of trapping)

Monitoring will be done at the site of part C, and at one other site in Western England.

1. Water trap - white
2. Water trap - yellow
3. Water trap - yellow, covered with "Netlon", approx 1.5 cm mesh (to exclude large insects).
4. Water trap - yellow, covered with "Environmesh", approx 1.5 mm mesh.
5. Sticky trap - white
6. Sticky trap - yellow
7. Sticky trap - blue
8. Sticky trap - yellow, covered as 3, (Netlon)
9. Sticky trap - yellow, covered as 4, (Environmesh)
10. Plant only - 10 plants

ii. Methods

Site: Commercial Farms in Cambridgeshire and Worcestershire

Assessments: Traps to be assessed and changed (or emptied) weekly.

Numbers of adult thrips will be recorded.

On two occasions a sub-sample of thrips will be identified to species.

7. COMMENCEMENT DATE, DURATION AND REPORTING

Start date 01.06.95; duration 9 months

Reporting will be mid December 1995.

The final report will be co-ordinated by Roger Umpelby and will be produced by the end of February, 1996.

It is possible that the work will be extended at the end of the first year, subject to satisfactory progress, and this will be discussed at the end of 1995.

8. STAFF RESPONSIBILITIES

Project Leader:	Mr Roger Umpelby (ADAS Worcester)
Other ADAS Staff:	Dr Jennie Blood Smyth (ADAS Support Staff at Worcester & Arthur Rickwood)
Other Consultants:	Dr Mike Saynor Mr Dick Suckling
Project Co-ordinator:	Mr Peter Emmett

Contract No:

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)

Signature ...M...C... Heath........
Position A.D.C. Account Manager
Date ....20/5/96..............

Signed for the Contractor(s)

Signature ....
Position ....
Date ....

Signed for the Contractor(s)

Signature ....
Position ....
Date ....

Signed for the Council

Signature ..E.R. Mal........................
Position: **RESEARCH MANAGER**
Date ....22.4.96................