Project title	Watercress and baby leaf Brassicas: monitoring and control of turnip sawfly
Project number:	FV 317
Project leader:	Dr Bill Parker, ADAS
Report:	1st Annual report, March 2008
Previous report	N/A
Key staff:	Mr Jon Oakley, ADAS (Contract Manager) Dr Bill Parker, ADAS (Study Director) Mr Robert Howells, ADAS (field trials)
Location of project:	The Watercress Company Ltd, Dorset Vitacress Salads Ltd, Hampshire
Project coordinator:	Dr Graham Clarkson, Vitacress Salads Ltd
Date project commenced:	1 April 2007
Date project completed (or expected completion date):	31 March 2009
Key words:	Watercress, turnip sawfly, *Athalia rosae*, baby leaf Brassicas, monitoring, control, insecticides, crop covers

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

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

Mr J Oakley

Principal Entomologist

ADAS

Signature ..... Date .....

Report authorised by:

Dr W E Parker

Horticulture Sector Manager

ADAS

Signature ..... Date .....

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GROWER SUMMARY

Headline

- Turnip sawflies infestations on baby leaf Brassicas can be effectively controlled by a combination of crop covers such as Enviromesh, and the use of currently approved pyrethroid insecticides.
- Turnip sawfly adults show a strong egg-laying preference for turnip (*Brassica rapa*) and this may offer the potential of a trap crop/distraction crop approach to reducing sawfly infestations in watercress.

Background and expected deliverables

Caterpillars of the turnip sawfly (*Athalia rosae*) are spectacular defoliators of Brassicas; serious infestations are capable of completely skeletonising plants. Although well-known in the past as a pest of turnips, it has been virtually absent as a pest of agricultural importance in the UK for much of the last 60 years. However, in recent years, populations have been increasing again, and in 2006 turnip sawfly infestations were widespread across much of southern and eastern England, including significant populations on oilseed rape, mustard, baby leaf Brassicas and watercress. With more frequent hot summers as a result of climate change, turnip sawfly is likely to become a regular pest. Although turnip sawfly (TSF) outbreaks are known to occur in hot dry summers when mass migrations can arrive in the UK from the continent, the high populations that occurred in 2006 may have increased the overwintering population reservoir in the UK, and therefore the pest may now have re-established a sufficient overwintering population to become a more regular pest on UK crops.

Controlling sawflies in watercress is particularly difficult as the presence of adults or larvae in the harvested watercress, and the feeding damage caused by larvae, severely reduces crop quality. Even minor infestations on baby leaf Brassicas make the harvest of a marketable crop very difficult due to the presence of both damaged leaves and live or dead larvae. There are no UK label recommendations for the insecticidal control of turnip sawfly. Although pyrethroid insecticides are approved in France for control of TSF on oilseed rape, mustard, cabbage, radish and ‘aromatic plants’, these cannot be used on or near watercourses and are therefore unsuitable for watercress production. Growers therefore require an environmentally acceptable means of combating the pest. On baby leaf Brassicas, it is likely that effective control with currently available insecticides can be achieved, but data on effective rates and timing are required.

The objectives of the project are therefore to:

1. To develop an early warning system for TSF on watercress by establishing the relationship between adult emergence in oilseed rape, catches of adults on sticky traps/trap plants in watercress and levels of egg-laying in watercress.
2. To evaluate the efficacy of novel methods for turnip sawfly control in watercress.
3. To determine the efficacy against TSF of insecticides currently approved on baby leaf Brassicas.

Summary of the project and main conclusions

- TSF adults emerging from oilseed rape fields tended to be found on traps up to 2 weeks before adults were caught on traps by neighbouring watercress beds.
- TSF adults show a strong preference for laying their eggs on turnip (*Brassica rapa*) even when other Brassica and related species are available at the same locations. This offers the potential for a trap crop/distraction crop control strategy.
- Enviromesh provided a high level of crop protection from egg-laying TSF. However, although this may be a suitable option for TSF control on baby-leaf Brassicas, it is not likely to be practical for watercress beds.
- TSF adults were shown to fly to up to 4 m high, possibly limiting the use of vertical barriers as a means of control. However, further work is required to verify this.
- The pyrethroid insecticides tested (Contest, Decis, Toppel 10) were consistently more effective at reducing TSF larval infestations than 'softer' products (Savona, Majestik, No-Fid).

Financial benefits

In 2006, growers were losing entire drillings of baby leaf Brassicas (i.e. total financial loss of the crop) to turnip sawfly damage after removing the net pre-harvest. This has an additional knock-on effect for bagged salad production, because if part of a salad mix is lost then the rest of the salad is no longer marketable and is also therefore wasted production. The work has identified which crop covers are likely to be most effective against TSF infestation, which should help reduce future losses.

Turnip sawfly larvae as contaminants in bagged salads also result in fines from retailers; the work should also help reduce the risk of such contamination at harvest.

Action points for growers

- First generation emergence of TSF from overwintering sites in the UK is likely to occur in early May, and susceptible crops should be closely monitored for sawfly adult and larval activity from May through to the end of September.
- The use of yellow sticky traps is a useful monitoring tool provided you can identify adult sawflies on traps.
- Crop covers can provide effective control of TSF. Initial work in the project suggests that Enviromesh is effective, but Envirofleece may not be.
- Established TSF larval infestations on baby leaf Brassicas are best controlled using pyrethroid insecticides currently approved for use on baby leaf Brassicas. These include Contest (alpha-cypermethrin), Toppel 10 (cypermethrin) and Decis (deltamethrin).

SCIENCE SECTION

Introduction

Caterpillars of the turnip sawfly (*Athalia rosae*) are spectacular defoliators of Brassicas; serious infestations are capable of completely skeletonising plants. Although well-known in the past as a pest of turnips, it has been virtually absent as a pest of agricultural importance in the UK for much of the last 60 years. However, in recent years, populations have been increasing again, and in 2006 turnip sawfly infestations were widespread across much of southern and eastern England, including significant populations on oilseed rape, mustard, baby leaf Brassicas and watercress. With more frequent hot summers as a result of climate change, turnip sawfly is likely to become a regular pest. Although turnip sawfly (TSF) outbreaks are known to occur in hot dry summers when mass migrations can arrive in the UK from the continent, the high populations that occurred in 2006 may have increased the overwintering population reservoir in the UK, and therefore the pest may now have re-established a sufficient overwintering population to become a more regular pest on UK crops.

Adult sawflies are predominantly orange in colour, with two black patches on the thorax and black joints on all legs. The adults usually appear in May, and eggs are laid in slits along the margins of host-plant leaves. Each female can lay 50 to 300 eggs. The larvae hatch in six to eight days depending on temperature and feed on the underside of leaves. They develop a distinctive velvety black appearance (hence the name 'black palmer') and feed for 10 to 13 days before moving into the soil to pupate. As a defensive mechanism, larvae accumulate glucosinolates and release concentrated globules of toxins to deter predators. Adults emerge about 21 days later. There are usually up to three generations over the summer, and pupae from the final generation overwinter in the soil in silken cocoons (Jones & Jones, 1974).

Controlling sawflies in watercress is particularly difficult as the presence of adults or larvae in the harvested watercress, and the feeding damage caused by larvae, severely reduces crop quality. Even minor infestations on baby leaf Brassicas make the harvest of a marketable crop very difficult due to the presence of both damaged leaves and live or dead larvae. There are no UK label recommendations for the insecticidal control of turnip sawfly. Although pyrethroid insecticides are approved in France for control of TSF on oilseed rape, mustard, cabbage, radish and 'aromatic plants', these cannot be used on or near watercourses and are therefore unsuitable for watercress production. Growers therefore require an environmentally acceptable means of combating the pest. On baby leaf Brassicas, it is likely

that effective control with currently available insecticides can be achieved, but data on effective rates and timing are required.

The objectives of the project are therefore to:

4. To develop an early warning system for TSF on watercress by establishing the relationship between adult emergence in oilseed rape, catches of adults on sticky traps/trap plants in watercress and levels of egg-laying in watercress.
5. To evaluate the efficacy of novel methods for turnip sawfly control in watercress
6. To determine the efficacy against TSF of insecticides currently approved on baby leaf Brassicas.

Materials and Methods

Early warning system for TSF

The aim of this work was to determine the relationship between the timing of emergence of TSF adults from overwintering sites in oilseed rape and the arrival of first generation adults in nearby watercress beds.

Site Location

Work was done in Dorset at and adjacent to The Watercress Company site at Waddock Cross, Dorchester, and the Vitacress site at Hollybush, Bere Regis. The oilseed rape site used was at Roke Farm, Bere Regis.

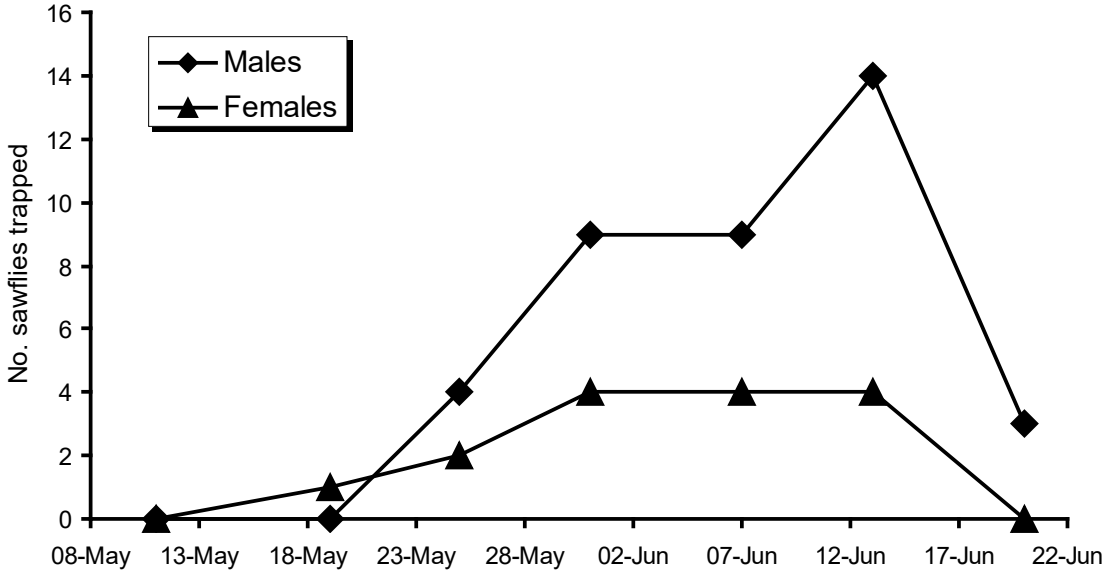
Methods

Two yellow sticky traps (Agralan, UK) of 254 x 202 mm were placed in the headland of the oilseed rape field on 11 May 2007. One yellow sticky trap was set out adjacent to watercress beds at Hollybush and Waddock,. The oilseed rape site was 0.8 miles from Hollybush and 4.6 miles from the Waddock site. Traps were checked at approximately weekly intervals until the end of June in order to determine the period of first generation activity.

Results

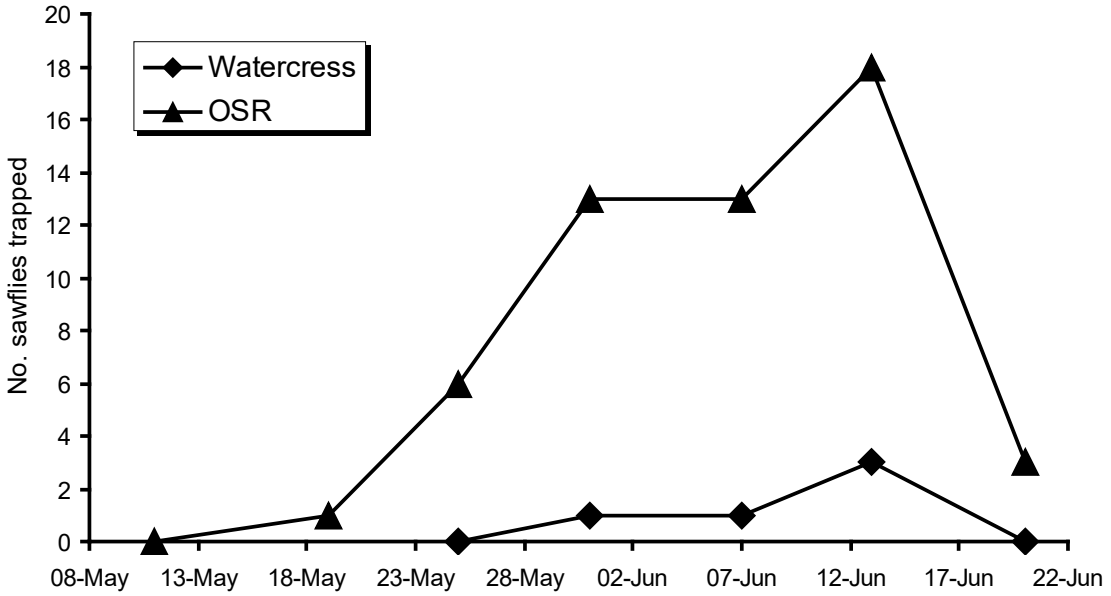
TSF adults were first caught at the oilseed rape site on 19 May 2007, and continued to be caught in the oilseed rape crop until 20 June 2007 when the crop had become too mature to retain any sawflies (Figure 1). Sawflies migrated from oilseed rape crops between 1 and 12 June 2007 when a warmer spell of weather allowed them to fly longer distances. Increased numbers were found arriving at watercress and baby leaf farms over this period.

Figure 1. Trap catches of male and female sawflies in oilseed rape at Bere Regis



Female TSF were caught on yellow sticky traps at both the Hollybush and Waddock watercress sites between 7 and 13 June. Adult TSF were most numerous on watercress at Waddock from 9 -12 June corresponding with the main migration from oilseed rape crops. The first appearance of TSF in watercress was c. 2 weeks after the first recorded emergence from the oilseed rape site (Figure 2).

Figure 2. Relative timing of trap catches of sawflies (males and females combined) in watercress and oilseed rape



Observations in baby leaf crops have confirmed that activity commences at around 10.00 h on sunny days and continues until at least 17.00 h. TSF adults spend a lot of time feeding on suitable nectar sources; hedge and cow parsley are preferred as nectar sources.

Very few larvae were found in oilseed rape crops suggesting that they will not be a major source of second generation adults. More larvae were been found on the wild hosts charlock and hedge mustard, which are likely to be the main sources of the second generation.

Efficacy of novel control methods

The aim of this work was to determine whether non-chemical means of control could be used, particularly on watercress, to prevent or reduce the level of TSF infestation. In the first year of the project, a series of small studies were done to help inform decisions about appropriate strategies to take in the second year of the project. Work was done to investigate the effect of crop covers, the potential of different Brassica (and related) species to act as trap crops, and the height of flight of TSF adults, the latter as a precursor to possible work on fences as an exclusion technique.

Site Location

Work on crop covers was done at Church Farm, Tincleton, Dorset (courtesy of The Watercress Company). Small-scale studies on the attractiveness of different potential host plants were done at Waddock Cross (The Watercress Company) and Mullens Farm, Pewsey, Wiltshire (Vitacress Salads Ltd). Height of flight of TSF adults was assessed at Church Farm and Mullens Farm.

Methods

Crop covers: a regenerated bed of Tatsoi (*Brassica rapa* var. *rosularis*) was used to test four different crop covers. These were bird netting, Enviromesh, Enviromesh Plus and Envirofleece manufactured by Agralan and sourced through Chase Organic Gardening. Both grades of Enviromesh have apertures of approximately 2 x 1 mm.. 4 m lengths of bed were covered on 28 August 2007 and 2 x 1 m^2 areas of crop covered by each treatment were assessed 18 days later (15 September 2007) for the presence of TSF larvae.

Host-plant attractiveness: Planters of six representative crop types were deployed at both sites (Tincleton and Pewsey) on 20 June. Host plants were sown in 800 x 180 x 170 troughs filled with potting compost on 6 June. Two species were sown per trough. The crop species tested are given in Table 1.

Table 1. Potential host plants used to determine relative attractiveness to TSF

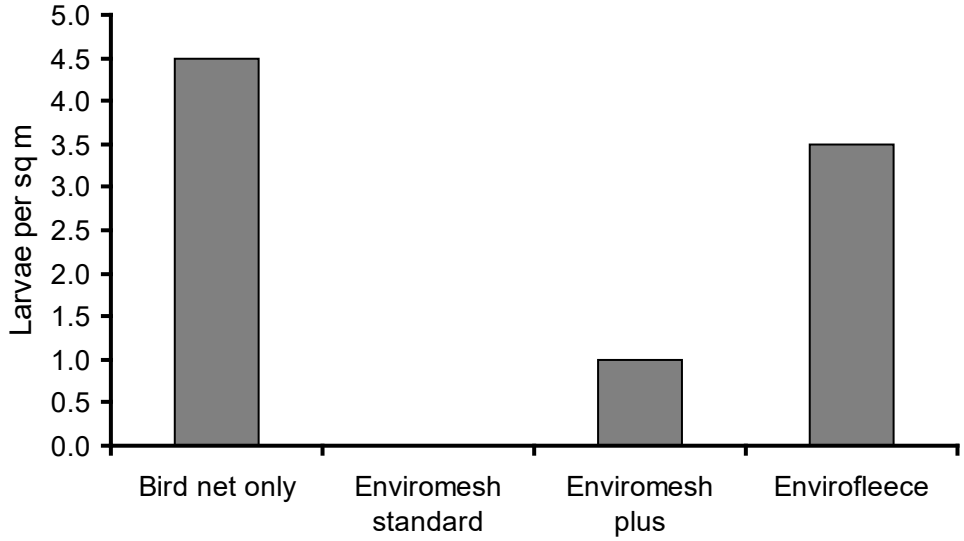
Common name	Latin name
Charlock	*Sinapsis arvensis*
White mustard Tilney	*Sinapsis alba*
Mustard Osaka Purple	*Brassica juncea*
Tatsoi Tah Tsai	*Brassica rapa* v. *rosularis*
Turnip Market Express	*Brassica rapa*
Watercress	*Nasturtium officinale*
Saisai leaf radish	*Raphinus sativus*
Oilseed rape	*Brassica napus*

Height of flight of TSF: at both sites, yellow sticky traps were attached to a vertical pole at 0.4, 1.6, 2.8 and 4.0 m above the ground. Traps were set up on 12 September 2007 and removed on 15 September 2007 and assessed for the presence of TSF adults.

Results

Crop covers: the results of the crop covers experiment are shown in Figure 3.

Figure 3. TSF larvae $m^{2\ -1}$ on Tatsoi at Tincleton under different crop covers

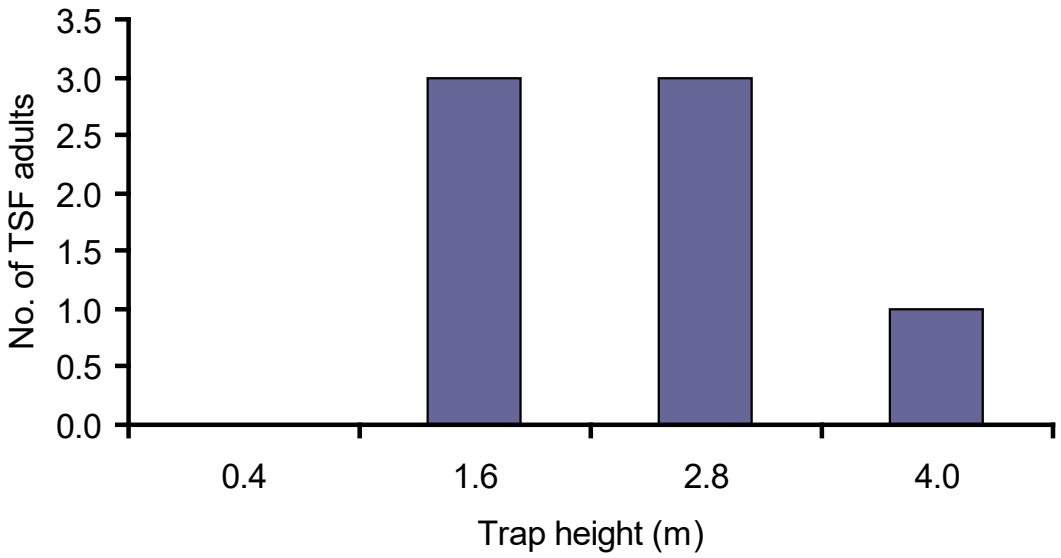


The Enviromesh standard and Enviromesh plus were effective at preventing or eliminating TSF larval infestation. Surprisingly, Envirofleece was ineffective particularly as no holes were evident and it remained well sealed around the edges. It is possible that the fleece built up a sufficient crop odour to stimulate the sawflies to lay eggs on or through its surface.

Host-plant attractiveness: at Tincleton after eight days exposure the plants were removed for examination. No eggs or larvae were found. During three observation periods, single TSF adults were seen to land on the turnip and Tatsoi plants, but not the other species, Pigeons damaged the plants at Mullens, which were replaced with a different batch and then covered with bird netting.

Height of flight of TSF: the trap system at Mullens Farm did not remain stable and did not give useful results. The results from Tincleton are given in Figure 4.

Figure 4. Trap catches of TSF adults at different heights above the ground – Tincleton 2007.



The results showed that most fly higher than 1m above ground level and some 4m or more. This contrasted with cabbage root fly (*Delia radicum*) where 98% were caught below 1 m. The height and strength of TSF flight make it unlikely that an effective barrier could be developed.

Efficacy of currently approved insecticides against TSF

Site location

The work was done at Church Farm, Tincleton, Dorset (courtesy of The Watercress Company) on two beds of regenerated Tatsoi.

Experimental design

The experiment was a randomized complete block design with seven treatments replicated five times. Plot size was one bed width (1.35 m) x 10 m. Treatments are given in Table 2.

Table 2. Experimental treatments used for chemical control of TSF (all products are currently approved for use on baby leaf Brassicas).

Code	Product	a.i.	Product rate ha^{-1}	Water volume L ha^{-1}
A	Contest	alpha-cypermethrin	67 g	200
B	Toppel 10	cypermethrin	250 ml	200
C	Decis	deltamethrin	300 ml	200
D	No-Fid	nicotine	1.34 L	200
E	Savona	Fatty acids	20.0 L	2000
F	Majestik	Plant extract	25 ml	1000
G	Untreated	-	-	-

Single applications of each product were made on 14 September 2007 using a hand-held CO_2-powered sprayer using flat-fan nozzles. All treatments were made to the crop with bird netting *in situ*.

Assessments

Numbers of live larvae on plants were assessed one and five days after treatment. Assessments were made by plucking plants from a measured area and counting the numbers of live larvae dropping to the ground. Two 0.5 x 0.5 m areas were cleared on the first assessment and one 1 m square area on the second.

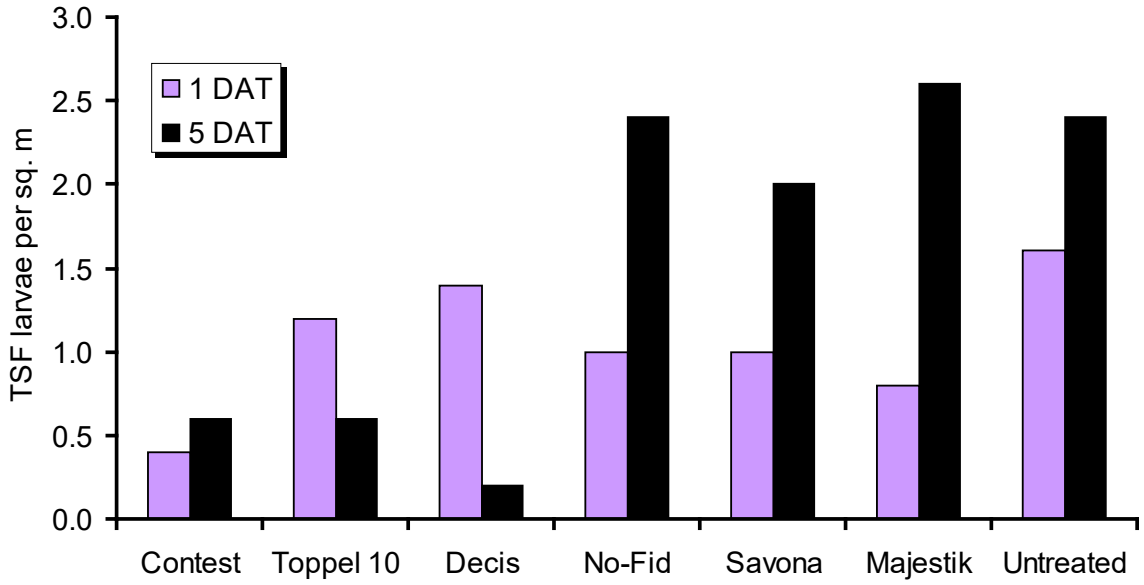
Phytotoxicity was also scored on a 1-10 scale on both occasions.

Results

The pyrethroid products (Contest, Toppel 10 and Decis) were more effective than any of the other alternatives tested, particularly by 5 days after treatment (Figure 5). The infestation consisted of second and young third stage larvae which stayed feeding mainly on the undersides of the leaves. Pyrethroid insecticides that would kill by ingestion were therefore more effective than those that needed to kill by direct contact. In practical terms No-Fid, Savona and Majestik may kill large larvae feeding on the upper surface of the leaf, but are unlikely to have a role against larvae in the earlier stages of attack.

None of the treatments caused any phytotoxicity.

Figure 5. Mean number of TSF larvae $m^{2\,-1}$ on Tatsoi one day after treatment (1 DAT) and 5 days after treatment (5 DAT).



Analysis of variance (ANOVA) indicated that there were no differences between treatments 1 DAT ($F_{6,24}$ = 0.79, *P* = 0.584; SED = 0.627) or at 5 DAT ($F_{6,24}$ = 1.4, *P* = 0.255; SED = 1.231). However, at 5 DAT all the pyrethroid products gave consistently higher numeric reductions in numbers of larvae compared with the other products.

Discussion

The monitoring in oilseed rape and neighbouring watercress crops indicated that the timing of appearance in TSF was substantially later in watercress, indicating that it took some time for adult TSF to move from emergence sites to watercress. However, this is unlikely to be a consistently useful effect and the distance of watercress from local oilseed rape crops is likely to vary considerably from year to year. There is therefore more value in determining exactly when TSF adults first appear in different geographical locations and using this to time the implementation of other control measures. A trap network including sites on the south coast to pick up first emergence or first immigration would be particularly useful as a means of providing early warning for crops grown at sites further north and west.

Work on alternative hosts indicated clearly that TSF has strong host-plant preferences. This merits further investigation as this offers the potential for implementing a 'distraction cropping' strategy in the vicinity of watercress beds. This will be the subject of further work in 2008. The experiment with different crop covers also clearly indicated that standard Enviromesh was very effective at excluding sawflies at hence preventing egg-laying. Surprisingly, Envirofleece was not effective.

The initial indications from the work on the height of flight of TSF adults suggested that fences may have limited application for excluding TSF from crop areas. However, this merits further investigation as evidence from Kenya suggests that sawfly species there can be excluded by suitable fences.

The work on insecticides demonstrated that pyrethroid products were effective at reducing TSF larval populations, although control was not complete, probably due to the fact that young larvae tend to feed on the underside of leaves and therefore do not pick up a lethal dose of insecticide until they are large enough to chew right through to the treated upper surface of the leaf.

Conclusions

- TSF adults emerging from oilseed rape fields tended to be found on traps up to 2 weeks before adults were caught on traps by neighbouring watercress beds.
- TSF adults show a strong preference for laying their eggs on turnip (*Brassica rapa*) even when other Brassica and related species are available at the same locations. This offers the potential for a trap crop/distraction crop control strategy.

- Enviromesh provided a high level of crop protection from egg-laying TSF. However, although this may be a suitable option for TSF control on baby-leaf Brassicas, it is not likely to be practical for watercress beds.
- TSF adults were shown to fly to up to 4 m high, possibly limiting the use of vertical barriers as a means of control. However, further work is required to verify this.
- The pyrethroid insecticides tested (Contest, Decis, Toppel 10) were consistently more effective at reducing TSF larval infestations than 'softer' products (Savona, Majestik, No-Fid).

Technology transfer

7 February 2008: Presentation to Speciality Produce Growers Association meeting (Boxworth, Cambs.).

17 March 2008: Presentation to Watercress Company Ltd & Vitacress Salads Ltd agonomists (St Mary Bourne, Hants).

References

Jones, F G W & Jones, M G J (1974). *Pests of Field Crops.* London: Edward Arnold 448 pp.

Acknowledgements

We are grateful to staff at Vitacress Salads Ltd (Graham Clarkson, Sam Pociecha) and The Watercress Company Ltd (Tom Amery, Jeremy Martin) for their assistance with this work and the provision of watercress and baby leaf sites, and to Mr George Ireland, Bere Down Farm, Bere Regis, Dorset, for access to oilseed rape fields for monitoring.

Appendices

Appendix 1: Raw data from insecticide field trial

Work done on Tatsoi at Church Farm, Tincleton, Dorset. Treatments applied 14 September 2007. DAT = days after treatment.

			Larvae $m^{2\ -1}$	
Plot	**Block**	**Treatment**	**1 DAT**	**5 DAT**
1	1	1	0	1
2	1	3	1	0
3	1	2	1	0
4	1	6	0	1
5	1	4	0	0
6	1	7	0	3
7	1	5	2	2
8	2	3	0	0
9	2	4	1	1
10	2	5	1	3
11	2	6	0	4
12	2	7	2	2
13	2	1	1	1
14	2	2	0	1
15	3	3	4	1
16	3	1	0	1
17	3	4	2	9
18	3	5	1	1
19	3	7	2	4
20	3	6	1	1
21	3	2	3	1
22	4	2	1	1
23	4	7	1	1
24	4	1	1	0
25	4	5	0	3
26	4	3	2	0
27	4	4	0	2
28	4	6	1	0
29	5	3	0	0
30	5	2	1	0
31	5	1	0	0
32	5	4	2	0
33	5	5	1	1
34	5	7	3	2
35	5	6	2	7