Project Title:	Herbs: an independent field and crop evaluation of pesticides to fill identified gaps
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DISCLAIMER

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.

CONTENTS

GROWER SUMMARY

Headline

- New herbicides for herbs have been identified to potentially replace pentanochlor and prometryn, which will be lost in EC review of pesticides
- The most effective insecticide again all three pest (leafhopper, flea beetle, carrot fly) was Hallmark Zeon.
- Alternating fungicide treatments provides better protection of herb crops from rust and leafspot.

Background and expected deliverables

Culinary, medicinal and aromatic herbs are very minor crops and for this reason are not tested for crop safety by Agrochemical Companies. In addition they encompass a wide range of plant species and varieties, which makes testing for crop safety even more difficult. Before any further trials could be considered it was important to appreciate the crop safety of the herbicides tested. The purpose of these screening trials was to evaluate a wide range of herbicides at normal dose rates recommended for other crops and double rates to determine tolerance of a range of annual and perennial herb species including medicinal herbs. The latter have only recently been added to the LTAEU (Long Term Arrangements for the Extension of Use 2002) and in most cases the phytotoxicity of permitted products to each herb species is unknown. Because of the limited number of materials available for use on herb crops, the herbicides tested also included new materials, which have currently no form of approval for herbs in the UK. This screening trial was to determine the phytotoxicity of the herbicides, but where possible weed species controlled were recorded.

- the efficacy of insecticides for the control of leafhoppers (sage), flea beetles (rocket) and carrot fly (parsley)
- the crop safety and efficacy of novel strobilurin and triazole fungicides (applied either alone or in an alternating programme) on culinary and medicinal herbs, for the control of rust in mint and *Septoria* in parsley.

The work will be designed to provide sufficient data for approval evaluation in the UK and partner state(s).

Summary of the project and the main conclusions

Herbicides

The following crops were either direct drilled or transplanted; Spearmint, Parsley, Coriander, Tarragon, Chives, Dill, Rosemary, German chamomile, Basil, Wild lettuce. Each treatment/ species plot was $2m^2$.

The herbicides tested were:
Pre-emergence: Goltix (metamitron), Centium (clomazone), Totril (ioxynil), (prosulfocarb) *to be registered in France as Boxer*, Ramrod Flo (propachlor), Flexidor (isoxaben), Ronstar (oxadiazon), (clomazone + trifluralin + linuron) *registered in France as Centaure*.

Post emergence: Asulox (asulam), Ronstar (oxadiazon), Sencorex (metribuzin), Betanal Flo (phenmedipham), Basagran (bentazone), (diflufenican), Ardent (diflufenican/trifluralin), Impuls (pendimethalin + bentazone), (prosulfocarb), Kerb Flo (propyzamide), Frontier (dimethenamid) Kerb Flo was used as a standard reference herbicide, hence no double rates.

Crop tolerance to herbicides tested

Pre-emergence

– **All crops:** Goltix and Totril were safe on all the crops tested.

- **Umbells:** Centium, prosulfocarb and Ramrod Flo and Ronstar showed good weed control and were safe to use on the umbells tested as was the combination of a lower dose of Centium in Centaure.
- **Chives;** Goltix, Totril, and Flexidor were safe on chives. Centium was very damaging.
- **Wild lettuce:** Goltix, Totril, prosulfocarb, Ramrod Flo, Flexidor and Centaure were safe.
- **Chamomile:** All the herbicides tested delayed the emergence of chamomile.
- **Dill:** appeared tolerant of all herbicides tested.
- **Echinacea failed to emerge. Perennial species** suffered damage from rabbits but were not assessed pre-emergence.

Post-emergence

- **All crops:** Asulox (which can be used at present for the spot treatment of docks) was safe on all species tested but did not control many of the weeds present. Frontier was safe on all crops tested but only showed residual activity. Kerb Flo was also safe on all crops tested but only showed residual activity on pre-emergent dicotyledon weeds and annual and perennial grasses. Prosulfocarb gave good weed control and was safe on most crops tested although a lower dose would be preferable with umbells.
- **Parsley and coriander:** Apart from the above herbicides only prosulfocarb was relatively safe post emergence although there was some damage after 14 days. A lower dose than 5 l/ha may give more crop safety.
- **Basil:** Betanal Flo and Basagran were safe. Basagran gave good weed control
- **Chives:** tolerant of Ronstar, Betanal Flo, Ardent and possibly Impuls.
- **Wild Lettuce:** tolerant of Ronstar, Betanal Flo.
- **Rosemary:** tolerated all treatments.
- **Spearmint:** Sencorex, Betanal and Basagran appeared safe.
- **Tarragon:** was tolerant of Ronstar, Betanal Flo and prosulfocarb.
- **Dill:** was sensitive to most herbicides except possibly prosulfocarb.
- **Chamomile:** tolerated Betanal Flo, Ardent and prosulfocarb, but Basagran and Impuls were very damaging.
- **Echinacea failed to emerge** and assessments were not possible
- **Sencorex** gave good weed control and was tolerated by the perennial herbs rosemary, spearmint and tarragon.

- **Impuls** gave good weed control and was safe on chives and the perennial herbs tested at the commercial dose.

Weed Control

There was a limited range of weed species, mainly groundsel, and an uneven distribution over the large trial area.

Fully replicated trials should be undertaken for those herbicides which show good weed control and crop safety to some of the culinary, medicinal and aromatic crops.

Insecticides

Sage plants were transplanted into large modules and covered with insect-proof cages. Treatments were applied; Hallmark Zeon (lambda-cyhalothrin), Tracer 480SC (spinosyn) and Calypso (thiocloprid) and water (control). Leaf hoppers were counted before and after spraying. Hallmark and Calypso were effective against leafhoppers, Hallmark had a more rapid 'knockdown' effect. Spinosad did not reduce leafhopper numbers.

Trays of roquette were placed in the field and sprayed with the following treatments; Hallmark Zeon (lambda-cyhalothrin), Tracer 480SC (spinosyn), Calypso (thiocloprid) and water (control treatment). Damage was assessed as percentage of damaged plants and no. of holes per plant. Hallmark was the most effective treatment, reducing damage up to 7 days after spraying, but did not prevent damage completely. Tracer and Calypso were least effective.

Parsley was treated with the following treatments; Trigard 75WP, Hallmark Zeon, Tracer 480SC and a water control. The crop was uncovered and exposed to carrot fly. Both Hallmark and Trigard reduced the percentage of damaged parsley roots. However, Hallmark was considerably more effective. Spinosad was ineffective.

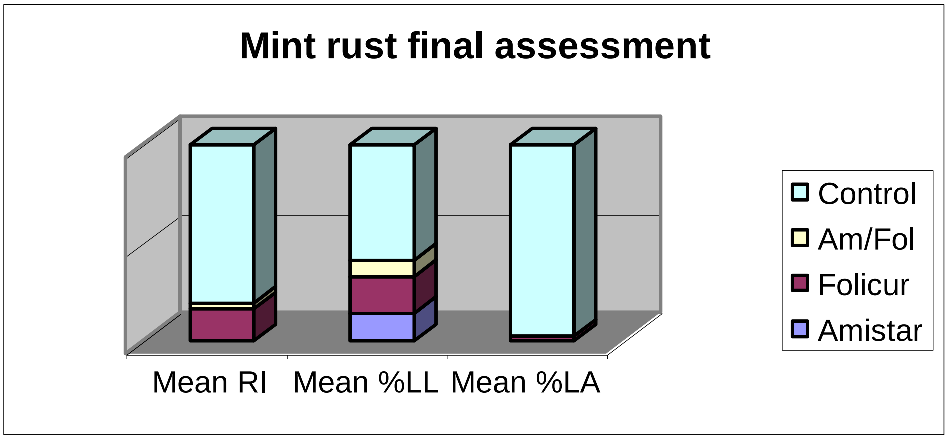
Fungicides

The trial site chosen for this project had an established peppermint crop 4 beds x 100 m, which had been planted in Spring 2000. Mint rust levels in 2000 and 2001 were moderate after the first cut in early July. The crop had received no fungicide treatments, before the start of the project. A similar trial area comprising 4 beds x 100 m of parsley was established in the Spring 2002.

The trials were set out in randomised plots with 4 treatments Amistar, Folicur, Amistar/Folicur and an untreated control with 4 replicate plots/treatment. The fungicides were applied, every 14 days, sequentially (x4) singly and as a combination treatment Amistar then Folicur (x2).

Crop assessment mint rust

The crop was assessed before each treatment and 14 days after the final treatment. Ten stems from each plot were scored (0-5) for severity of mint rust **RI rust index**, the percentage of leaves lost **%LL** and the percentage of the area of the 6th leaf covered with rust pustules **%LA.**



Mint rust infection was severe in the untreated control, RI 4.9, and almost 50% of the leaves had been lost. All fungicide treatments were effective in reducing the mint rust index to <1 and the number of leaves lost to < 14%, Amistar and Amistar/Folicur combination were slightly more effective than Folicur alone. At this stage the Amistar/Folicur combination did not appear more effective than the Amistar alone.

Field peppermint crop

Mint rust infection was severe in the untreated control, RI 4.9, and almost 50% of the leaves had been lost. All fungicide treatments were effective in reducing the mint rust index to <1 and the number of leaves lost to < 14%, Amistar and Amistar/Folicur combination were slightly more effective than Folicur alone. At this stage the Amistar/Folicur combination did not appear more effective than the Amistar alone.

Treatment	RI	%LL	%LA
Amistar	0.0	9.9	0.0
Folicur	1.0	13.2	0.3
Amistar/Folicur	0.2	5.8	0.0
Control	4.9	41.5	11.8

Protected spearmint crop

Disease infection was assessed on 28 November. Crate vigour showing a large amount of variability – 2 of the control plots and one Plover plot showing very good vigour – tall healthy plants. Other crates with very patchy growth, and many dead plants, cutting material taken and plants had not recovered. No premature leaf abscission was seen in this protected crop, as had been seen in the field crop. Very low levels of rust seen throughout the trial with none on treated plots.

Treatment	RI	%LL
Amistar	0.07	0
Plover	0.03	0
Plover/Amistar	0.07	0.2
Control	0.77	3.4

Crop assessment parsley leaf spot

Field crop

Septoria infection was light and was only detected in September after dry summer. Infection was varied across the plots; the highest incidence was in plots to the South and East of the site making comparisons of the treatments difficult. Because of the uneven level of infection across the plots to determine the level of control infection scores SI were divided by the incidence of infection I.

Treatment	Mean SI/I
Amistar	0.29
Folicur	0.32
Am/Fol	0.32
Control	0.38

Protected parsley crop

Disease was assessed on the 28 Nov. There were very low levels of infection in the 4 control plots and no disease seen in the treated plots.

Treatment	Control	Amistar	Plover	Amistar/Plover
Mean % infection	6.25	0	0	0.5

Financial Benefits

Herbicides, insecticides and fungicides. The results should help inform growers what to expect from their currently approved pesticides, however, the greater benefit should be seen if new approvals are successfully obtained for the industry. E.g. an effective treatment for mint rust could save growers up to £0.5M from spearmint and peppermint crops and £0.1M from peppermint crops grown for essential oils each year. Access to adequate crop protection products could be a licence to operate for this sector.

Action Points for Growers

Herbicides

It is somewhat premature to make recommendations based on these results; however these results are being used to select candidate products for further trials in 2003. Below summarises further action to be undertaken;

Pre-emergence herbicides

Further trials are needed to investigate reduced dosage of Goltix, on coriander and parsley with sequential applications at two sites (one site with light, sandy, soil).

Further trials to investigate the effect of different harvest dates on the susceptibility of parsley and coriander to phytotoxic damage by Centium. Centium is a cleavers-killer and needs a partner to cover a wide weed spectrum.

No further action required on Totril except information to growers.

Further information on weed profile controlled by prosulfocarb, (some information available from carrot and pea trials and Syngenta)

No further action required on Ramrod Flo except information to growers

Application for a SOLA for Flexidor would be particularly useful to pot herb growers.

Ronstar is an old product and requires a high dosage - it showed no advantage over Flexidor so no further action required.

Action on the tank-mix (clomazone + trifluralin +linuron) should be on hold until SOLA on Centium approved – the lower dose may be less effective on cleavers.

Post-emergence herbicides

Application needed for a change in use from spot treatment, and a reduction in harvest interval to 4-6 weeks for Asulox.

Information to growers as to crop safety of Betanal Flo on Labiates.

Potential use of Basagran on labiate crops will require residue data from Europe for SOLA.

Further trials, through to harvest, should ascertain whether lower doses of Ardent were crop safe.

Further information on weed profile controlled by prosulfocarb (known gaps in the weed spectrum include mayweeds and groundsel seems only moderately susceptible).

Growers should determine further information as to time of application, of Kerb, on different soil types. Kerb has a limited weed spectrum used in other crops to control grass weeds.

No further action required on Ronstar, Sencorex, Impuls or diflufenican alone.

Insecticides

Hallmark was the most effective product at controlling sage leaf hopper, flea beetle and carrot fly.

Fungicides

SOLA required for Plover.

Sprays should be applied as soon as mint rust detected.

Prophylactic sprays should be applied after the first mint harvest if mint rust has been a problem.

Alternating strobilurin and triazole fungicides gives as good protection against mint rust as either compound applied individually and should reduce the probability of the pathogen developing resistance to the fungicides.

SCIENCE SECTION

<u>Evaluation of Herbicides for Pre-emergence and post emergence herbicides for the control of annual weeds on a range of herb crops</u>

Introduction

The crop species chosen in the trial include culinary, aromatic and medicinal herbs. Currently there are no herbicides with on-label or Specific Off-Label Approval on some of the medicinal crops included in this evaluation, and they have only recently been included in extrapolations under the LTAEU but there is increasing interest in this area and they belong to the same plant families. The herbicides evaluated included some materials, which have currently no form of approval for use in herbs. The aim of the trial was to screen a range of herbicides applied at normal and twice normal (overlap) dose rates recommended for other crops, for crop tolerance. Herb phytotoxicity was assessed and the level of weed control was noted where possible.

Materials and methods

Product (Marketing Co)	Active ingredient	Approval Status	Normal rate/ha
Pre-emergence			
1. Goltix (Bayer CropProtection)	metamitron 700g/l	SOLA perennial leaf herbs (not umbelliferous)	2l/ha
2. Centium (FMC)	clomazone 360CS	UK carrots, peas etc	0.25l/ha spring,
3.Totril (Bayer CropProtection)	ioxynil 225g/l	UK onions, SOLA carrots	1.0l/ha
4. ? (Syngenta)	prosulfocarb 800g/l	to be registered as Boxer for carrots in France, for UK cereals under another name by Syngenta	5 l/ha
5. Ramrod Flo (Monsanto)	propachlor 480g/l	UK brassicas etc	9.0l/ha
6. Flexidor (Dow)	isoxaben 125g/l	UK bush fruit etc	600ml/ha
7. Ronstar (Certis)	oxadiazon 250g/l	UK bush fruit etc	4.0l/ha
8. Centium (FMC) + trifluralin+ linuron (linuron not used)	clomazone (360 CS) + trifluralin (480g/l) + linuron. (500g/l)	UK carrot + UK SOLAs triluralin & linuron herbs. This is equivalent to Centaure approved for some veg crops in France. Incorporation trifluralin not needed in France.	0.2 + 2.0 + (sand soils) 0.75l/ha <u>Linuron not used</u>

Product (Marketing Co)	Active ingredient	Approval Status	Normal rate/ha
Post-emergence			
9. Asulox (Bayer Crop Protection)	asulam 400g/l	UK mint, tarragon & parsley spot treat	1.0l/ha
10.Ronstar (Certis)	oxadiazon 250g/l	UK cane, bush fruit	4.0l/ha
11. Sencorex (Bayer Crop Protection)	metribuzin 70%w/w	UK potatoes, SOLA carrots	0.5kg/ha light soil
13. Betanal Flo (Bayer Crop Protection)	phenmedipham 160g/l	SOLA spinach & lettuce	5.0l/ha
14. Basagran (BASF)	bentazone 480g/l	UK beans etc	3.0l/ha
15.Conf	diflufenican 500g/l	no UK registration for use alone, work in France other crops	3.0l/ha
16. Ardent (Bayer Crop Protection)	diflufenican/trifluralin 40/400g/l	UK cereals	2.5l/ha
17. Impuls (BASF)	pendimethalin 400g/l + bentazone 480g/l	UK peas	2.0 + 1.5 l/ha
18. ? (Syngenta)	prosulfocarb 800g/l	See above.	4 l/ha
19. Kerb Flo (Dow) MRL	propyzamide 400g/l	UK SOLA lettuce MHI 42d	3.5l/ha
Post-em of crop, pre-emergence of weeds (residual herbicide)			
20.Frontier (BASF)	dimethenamid	no UK registration	1.5l/ha

Site and Soil type

NHC Warmington, sandy loam

Herbicide Application

Herbicides were applied at the standard normal rate and twice the normal rate. All treatments were applied in 3 l water (equivalents to 300l/ha water volume) using a precision knapsack sprayer.

Trial design and layout

The purpose of this trial was to screen 8 pre emergence and 211 post emergence herbicides applied as application of at Normal and twice Normal (overlap) dose rates recommended for other crops before drilling and also as contact material applied 1 month after transplanting or drilling. All treatments were applied in 3 litres water (equivalent to 300l/ha) using a precision knapsack sprayer. The trial was a non-randomised field experiment with no replication.

Each crop species was direct drilled or transplanted in plots 80 m long in beds 1.8 m wide. To give a treatment plots of 1m ^{2} and 0.5 m between treatments.. Plots were defined by strings stretched across the crops.

Trials Diary

The site was power harrowed in the spring 2002 and a base dressing of 400kg of a 7:5:12 compound fertilizer was applied.
Annual crops were drilled on 15 May. Coriander, basil, wild lettuce, chives, dill and parsley were direct drilled at the commercial rate, chamomile was broadcast at the commercial rate. Eight residual herbicide treatments (1 to 8) were applied on 17 May after drilling but pre-crop and weed emergence. The weather was sunny and the temperature 18^{0}C. There was no rain immediately following application. Germination occurred over a period of three weeks, some species germinating much quicker than others but all drilled seed had emerged by 7 June with the exception of basil and echinacea, which were affected by a sudden cold spell during late May and June and did not begin to emerge until 11 June. Germination was poor under these conditions and these species were tested again in a pot trial.

Spearmint, tarragon and rosemary plugs were transplanted on the 24 May. Transplants were raised in 12x7 modular trays for transplanting at the trial site and planted in each bed 30 cm apart in the row and 45 cm apart between the rows.

Irrigation was not needed as plenty of rain fell during May and June 2002. Rabbits caused damage to crops.

The first assessment (treatments 1 to 8) for crop phytotoxicity was made on the 13 June when most species except basil had emerged and were at the first true leaf stage. The second assessment was made 14 days later on the 3 July.
Ten post-emergence treatments (9 to 19) were applied to transplanted and drilled herbs on the 3 July. Frontier was applied at the same time although several weeds had emerged by then. The weather was sunny, with some cloud cover, and the temperature was 18^{0}C.
The first assessment of post-emergence herbicides was made on the 10 July, 7 days after treatment; the second assessment was made on the 18 July.

Crop Assessments

Crop phytotoxicity was assessed on a score 1-10 where 0 = total crop kill and 10 = no damage.
A score of 7 was considered commercially acceptable for market depending on the herb species; whether total crop yield was important, e.g. chamomile, or unblemished foliage of culinary herbs such as parsley, was essential. The type of damage, such as bleaching of leaves, was recorded for each herbicide and herb species. Herbicide efficacy was not assessed, but some notes were made on weed control. Assessors were Rosemary Cole and Cathy Knott. Weed efficacy was not assessed

Summary of results

Pre emergence Herbicide Screening trial NHC/H/HDC/1 sown 15 May; sprayed 17 May.

Assessment 13th June. Crop damage assessed on a score 1-10 where 0 = crop killed and 10 = no damage a score of 7 was considered commercially marketable.

Treatment	Basil (pot test)	Parsley	Chives	Lettuce	Chamomile	Coriander	Dill	Comment assessment after further 14 days on 3 July
Goltix X 1 (Normal) X 2 (twice Normal dose)	10 10	10 10	10 10	10 10	7 (10) 5 (10) del	10 10	10 10	Good weed control, chamomile completely emerged.
Centium X 1 X 2	4 (3) 2 (2) bl	10 (8) 10 (6)	1 1 bl	6 3 bl	0 (10) 0 (10) bl	10 10	10 10	Good control. After 2 weeks chamomile emerged and scored 10/10, lettuce did not recover significantly, some bleaching on parsley and basil
Totril X 1 X 2	8 (10) 6 (10) del	10 10	10 10	10 (10) 8 (10) del	7 (10) 5 (10) del	10 10	10 10	Good control. Basil, lettuce recovered and chamomile emerged
Prosulfocarb X 1 X 2	7 6 del	10 10	8 6 del	10 10	1 (7) 1 (6)	10 10	10 10	Good control. Chamomile emerged
Ramrod Flo X 1 X 2	5 (4) 4 (3) del (ch)	10 9 ch	10 10	10 (8) 10 (7)	8 (8) 6 (7) del (ch)	10 10	10 10	Good control. Stunting on lettuce and chamomile and chlorosis on basil.

				(st)				
Flexidor X 1 X 2	5 4 del	8 6 del	10 10	10 10	2 (5) 1 (4)	10 10	10 10	Good control except control mayweed, chamomile emerged and recovered slightly
Ronstar liquid X 1 X 2	4 3 ch del	10 9 ch coty	5 (6) 2 (4) red em	7 (8) 5 (5) del	2 (3) 1 (2) del	10 9	10 10	Good control. Chives, lettuce some recovery but chamomile did not recover
Centium+trifluralin (without linuron)	4 (3) 3 (2) bl	10 8	8 (2) 2 (2) bl	10 (9) 9 (6) bl	0 (3) 0 (2) del	10 10	10 10	Good control. More damage apparent on basil, chives, lettuce, chamomile emerged
GS untreated at date of assessment	Cotyl 1TL	1- 2TL	Cotyl 1TL	Cotyl 1TL	Cotyl 1TL	Cotyl 1TL	Cotyl	Basil pot trial

Damage: st=stunting, ch=chlorosis, nec=necrosis, Del=delayed emergence, bl=bleaching, Red=reduced emergence; GS=Growth Stage, Coty=cotyledon, TL=true leaf

Post-emergence Herbicide Screening trial NHC/H/HDC/1 Sown/transplanted 15 May, sprayed 5 July, assessed 12 July and 18 July (shown in brackets). Crop damage score 1-10 where 0 = crop killed and 10 = no damage; a score of 7 was considered commercially marketable.

Treatment	Basil (pot test)	Parsley	Chives	Lettuce	Chamomile	Coriander	Dill	Rosemary	Spearmint	Tarragon	Comment
Asulox X2	10 8	10 10	10 10	10 8	10 8	10 10	10 10	10 10	10 8	10 7	Higher doses caused some tipburn on spearmint and tarragon. No control groundsel.
Ronstar X2	4 3	7 (5) 5 (3) ch	10 10	10 10	7 5 ch	7 (4) 6 (2) ch	7 (8) 5 (7) ch	10 10	10 (7) 10 (6) (pur)	10 (9) 10 (7)	No control clover. After 14 days damage increase on parsley, dill, coriander also damage appearing on spearmint purpling and tarragon. Groundsel only MS
Sencorex X2	3 0	4 (0) 2 (0) sc	10 (4) 10 (2)	4 (3) 2 (1) ch	6 (5) 0 (0) sc	0 0	7 2 pur	10 10	10 (9) 10 (7)	10 (9) 10 (0)	Effect more obvious after 14 days parsley, chives , lettuce, chamomile , dill 0/0 , coriander 6/1 spearmint and tarragon 9/0. No control groundsel.
Betanal Flo X2	10 7	7 5 ch	10 10	10 7 ch	10 7 ch	7 5 sc	3 1 pur	10 10	10 7 ch	10 7 ch	Groundsel controlled.
Basagran X2	10 8	1 0 ch	7 5 ch	0 0	0 0	2 0	0 0	9 9	10 8 ch	5 (0) 2 (0) ch	Tarragon killed after 14 days. Good weed control except clover
(diflufenican) X2	3 0	5 (2) 5 (1) bl	7 5 bl	0 0	8 6 bl	4 (2) 3 (1) bl	2 1 bl	10 10	3 (2) 3 (1) bl	4 (3) 4 (2) bl	Parsley , coriander, spearmint and tarragon damage worse after 14 days, Good weed control
Ardent X2	3 1	10 (6) 8 (4)	10 10	8 6 bl	10 7 bl	5 3 bl	5 (2) 3 (2) bl	10 10	6 4 bl	8 7 bl	Parsley, dill, spearmint worse after 14 days. No control groundsel.or clover

		bl									
Impuls X2	4 2	6 (0) 2 (0) bl	10 (9) 10 (5)	10 (8) 10 (5)	0 0	7 4	2 1	10 10	10 (7) 10 (6)	10 (7) 7 (6)	x2 effective against weeds. Parsley, chives (little ones), lettuce, spearmint, tarragon damage increase after 14 days
(prosulfocar b) X2	4 2	10 (7) 10 (5)	10 10	10 10	10 10	10 (7) 10 (5)	10 (8) 10 (6)	10 10	10 (8) 10 (6)	10 10	Parsley, dill, and coriander and spearmint increase damage after 14 days. No control groundsel.
Kerb Flo	7	10	10	10	10	10	10 (5)	10	10	9	Not much effect on dicot weeds, dill worse after 14 days
Frontier X2	10 10	10 10	10 10	10 10	10 10	10 10	10 10	10 10	10 10	10 10	Residual activity only - no effect on emerged weeds

Damage code: st=stunting, ch=chlorosis, nec=necrosis, del=delayed emergence, bl=bleaching, sc=scorch, pur=purpling

Evaluation of Insecticides for the control of leafhoppers (sage), flea beetles (rocket) and carrot fly (parsley)

Leafhoppers on sage

The chrysanthemum leafhopper (*Eupteryx melissae*) damages a wide range of herbs. Sage is the main species damaged, but balm, basil, bergamot, French lavender, mints, marjoram, rosemary and thyme are also affected (HDC Project PC 178). Leafhoppers feed on plant sap through their piercing mouthparts. As a result of leafhopper feeding, the leaves become speckled with pale spots and begin to turn yellow. Leafhoppers are not virus vectors, but significant costs are incurred in spraying and removing damaged leaves. In a recent survey of nurseries, plant losses ranged from 1-50% (HDC Project PC 178). In the past, most growers used heptenophos (Hostaquick) for leafhopper control, but this is no longer approved.

Materials and methods

Sage seed was sown into modules at the National Herb Centre and the seedlings were raised in a greenhouse. Once they were sufficiently large, the plants were transported to HRI Wellesbourne and transplanted into larger modules (24 cells (5 cm^3)/tray (36 cm x 23 cm)). The trays were placed in a small isolation greenhouse and infested with adult and juvenile leafhoppers (collected from *Salvia* and *Phlomis* spp. outdoors).

Once the leafhoppers had established on the plants, each tray was placed into a separate insect-proof cage (38 cm^3). There were 16 cages in total (4 treatments x 4 replicates) and the treatments were arranged on benches in a large greenhouse in a randomised block design. The treatments were:

1. Lambda-cyhalothrin (Hallmark Zeon) (0.03 g a.i./l, 7.5 g a.i./ha)
2. Spinosad (Tracer 480SC) (0.40 g a.i./l, 120 g a.i./ha)
3. Thiacloprid (Calypso) (0.40 g a.i./l, 120 g a.i./ha)
4. Water

As the leafhoppers move rapidly when disturbed, the plants were not removed from the cages at any stage of the experiment. On the first morning of the experiment (7 October 2002), the numbers of leafhoppers resting on the foliage were counted on two occasions (starting at 8:30 and 10:30) and then the plants were sprayed with insecticide using a hand sprayer (3 ml solution/cage). The insecticide-free control was sprayed with 3 ml water. The numbers of leafhoppers remaining after treatment were then counted twice (at 8:30 and 10:30), one, three and eight days after spraying.

The two sets of counts for each day were averaged and analysed using a Generalised Linear Model Analysis with a log-link function and Poisson distribution. The post-spray counts were analysed by including an adjustment for the mean pre-spray count in each cage.

Results

Although the pre-spray counts varied between individual cages, there were no consistent differences between treatments prior to spraying. Figure 1 shows predictions of the number of leafhoppers remaining after treatment. The predictions are adjusted to a single mean spray count. Both lambda-cyhalothrin and thiacloprid were effective against the leafhoppers. Lambda-cyhalothrin had a more rapid 'knock-down' effect. Spinosad did not reduce leafhopper numbers.

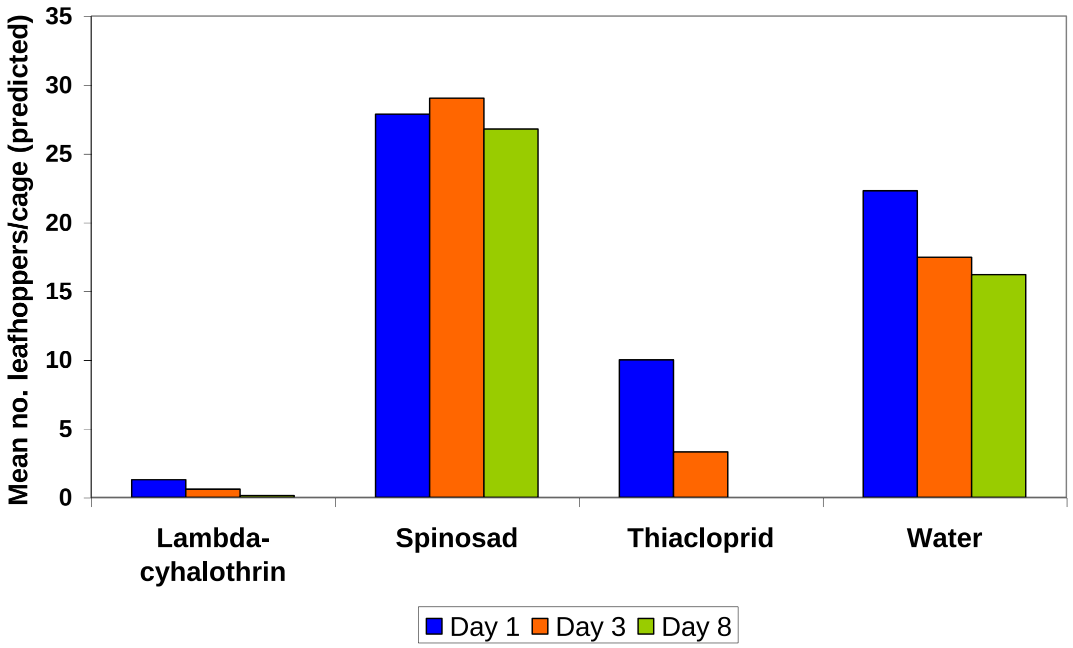


Figure 1. The mean numbers of leafhoppers/cage resting on sage plants 1, 3 and 8 days after spraying with insecticide (predictions following Generalised Linear Model Analysis)

Flea beetles on rocket

Flea beetles (*Phyllotreta* spp.) are becoming an increasing problem, and often cause serious damage to cruciferous crops. There are several species of flea beetle, but all have similar life cycles. They are a particular problem on speciality salad vegetables (e.g. mizuna and rocket), because they cause cosmetic damage, and on drilled brassicas (such as swede). Adults form holes in the leaves and stems, and their feeding may check or even destroy young plants.

Severe damage, caused by beetles feeding on seedlings below the soil surface, sometimes results in patchy crops.

Recent HDC-funded work on swede and turnip (HDC Project FV 222) showed that the effects of sprays of lambda-cyhalothrin, deltamethrin, cypermethrin or spinosad were broadly similar. A single spray treatment suppressed the flea beetle population for at least one or two days, although damage on treated and untreated plots was similar by seven days after the first treatment. However, seedling survival was substantially increased by a single spray of all the products, and was maintained by a second spray applied nine days after the first. Imidacloprid seed treatment (Gaucho), which has Specific Off-Label Approval for control of *Myzus persicae* on some brassica crops, may also control flea beetles.

Materials and methods

Rocket seed was sown in sixteen 150-cell Hassy trays (100 seeds/tray) on 20 June 2002 and allowed to germinate in the greenhouse at HRI Wellesbourne.

On 27 June, once the majority of seedlings had emerged, the trays were placed in the open field in the wheelings between some newly emerged swede seedlings, which were a source of flea beetles. The trays were laid out in a randomised block design (4 trays/wheeling, 2m between trays along wheelings and one bed (1.83 m) between wheelings) and sprayed immediately with insecticide at a water rate of 387 l/ha.

There were four replicates of each of four treatments, which were:

1. Lambda-cyhalothrin (Hallmark Zeon) (7.5 g a.i./ha)
2. Spinosad (Tracer 480SC) (120 g a.i./ha)
3. Thiacloprid (Calypso) (120 g a.i./ha)
4. Insecticide-free control

Damage (percentage of damaged plants and mean number of feeding holes/plant) was recorded on all plants 1, 4 and 7 days after spraying.

The data were subjected to Analysis of Variance. The percentage data were angle-transformed prior to analysis.

Results

Percentage damaged plants

Treatment with lambda-cyhalothrin reduced damage compared with the untreated control one, four and seven days after spraying ($p<0.05$), but did not prevent damage completely (Figure 2). The other insecticide treatments were less effective.

Mean number of feeding holes/plant

Differences between all three insecticide treatments and the untreated control were statistically significant ($p<0.05$) one, four and seven days after spraying. Seven days after spraying, lambda-cyhalothrin was more effective than spinosad ($p=0.008$).

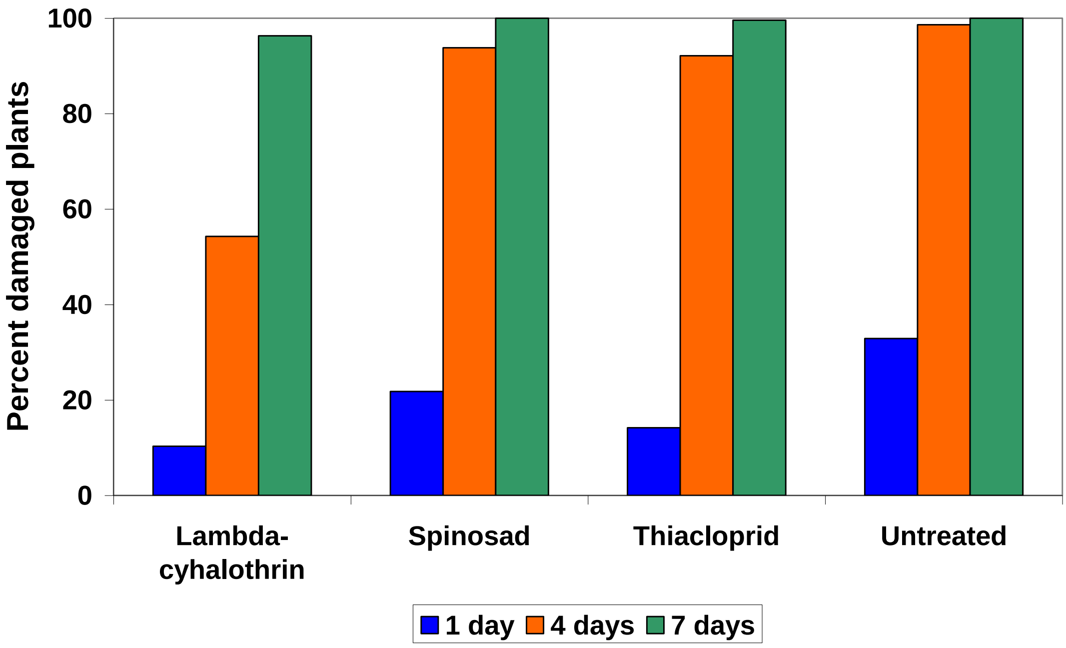
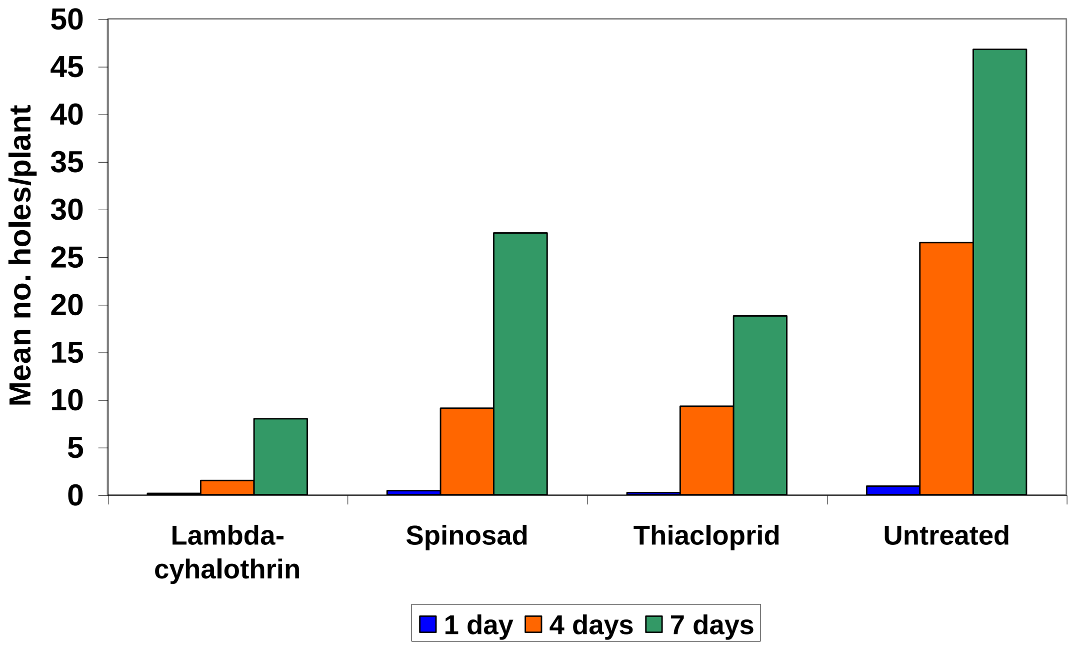


Figure 2. The percentage of plants damaged by flea beetles 1, 4 and 7 days after rocket plants were sprayed with insecticide (back-transformed means from Analysis of Variance).



.Figure 3. The mean number of flea beetle feeding holes per plant 1, 4 and 7 days after rocket plants were sprayed with insecticide.

Carrot fly on parsley

Carrot fly (*Psila rosae*) is a widespread and often serious pest of umbelliferous crops including parsley. The larvae feed on the roots, and young plants may be stunted or killed. On carrot and parsnip crops, adult carrot flies are controlled using foliar sprays of pyrethroids (lambda-cyhalothrin, deltamethrin). Some batches of seed are treated with tefluthrin (Force), which is believed to provide some control of carrot fly larvae.

Materials and methods

The parsley (cv. Champion Moss Curled) was drilled in 4-row beds at a rate of 100 seeds/m on 20 June 2002. The crop was covered with fleece on 16 July to promote growth and exclude carrot fly prior to spraying. The covers were removed on 1 August and the rows were divided into plots. Each plot was 1 bed wide x 2.5 m long and adjacent plots were separated by 1 m of bed.

The first set of insecticide treatments was applied immediately after the plots were uncovered. The second set of treatments was applied on 15 August. There were four replicates of four treatments, which were:

1. Cyromazine (Trigard 75WP) (225 g a.i./ha)
2. Lambda-cyhalothrin (Hallmark Zeon) (15 g a.i./ha)
3. Spinosad (Tracer 480SC) (120 g a.i./ha)
4. Untreated control

The plots were sampled on 9 October by removing 0.7m row from the middle two rows of each plot. The foliage was discarded and the roots were washed and assessed for damage. The numbers of mines (caused by larval feeding) on each root were recorded.

The data were subjected to Analysis of Variance. The percentage data (percentage plants with more than one mine) were arcsine transformed prior to analysis.

Results

Both lambda-cyhalothrin and cyromazine reduced the percentage of damaged parsley roots ($p<0.001$) (Figure 4). However, lambda-cyhalothrin was considerably more effective than cyromazine. Spinosad was ineffective. Similar treatment effects were observed for the mean number of mines per plant ($p=0.001$) (Figure 5). Treament with lambda-cyhalothrin and cyromazine reduced the numbers of mines per plant by 86% and 41% respectively when compared with the insecticide-free control.

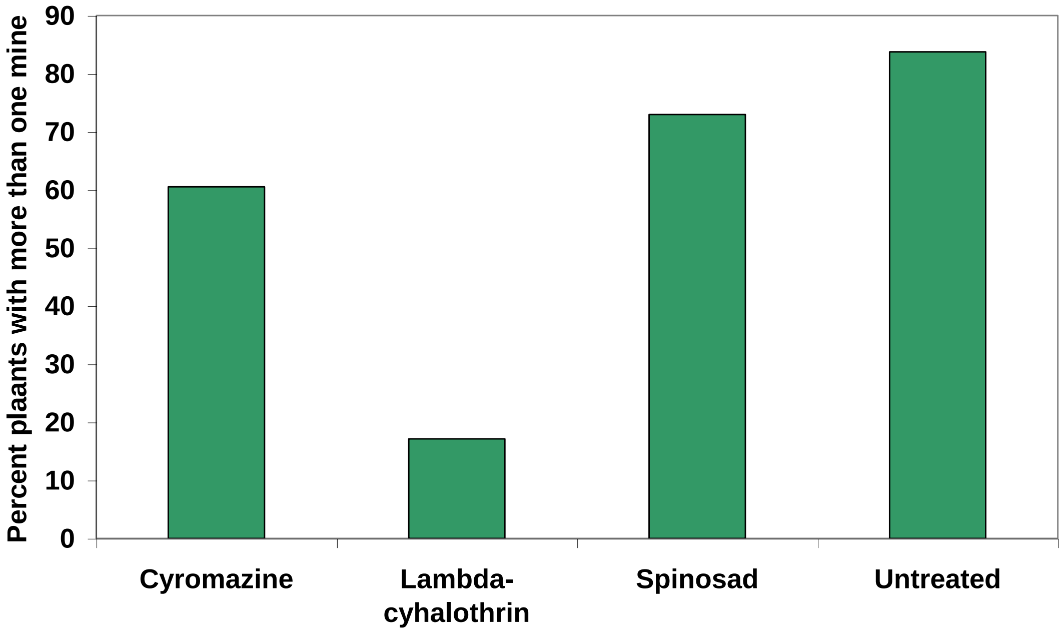


Figure 4. The percentage of parsley roots with more than one carrot fly mine (back-transformed means from Analysis of Variance).

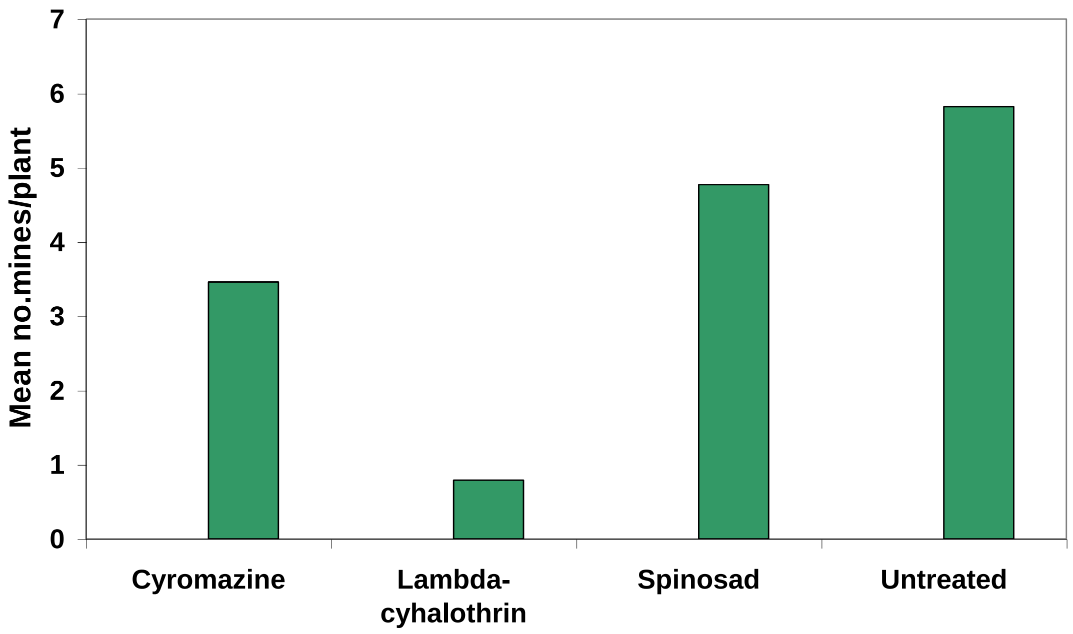


Figure 5. The mean numbers of carrot fly mines per parsley root.

Discussion

The insecticide doses tested were based on manufacturers' recommendations for other crops and as such could possibly be increased to improve control or may have to be reduced to prevent unacceptably high residues at harvest. These considerations were beyond the scope of these trials.

All three trials showed clear differences between insecticide treatments at the doses tested. Lambda-cyhalothrin (Hallmark Zeon) was the most effective insecticide against all three pests (leafhopper, flea beetle, carrot fly) and this confirms that it is a potent, broad-spectrum insecticide. As a consequence, it may also kill non-target and possibly beneficial species.

The three trials were done in the environments (field or greenhouse) where each pest species was likely to be most harmful. As a consequence, insecticides for controlling carrot fly and flea beetles were evaluated in the open field where the plots were re-invaded by pests over a period of days or weeks. Whilst the lambda-cyhalothrin treatment (two sprays) was relatively persistent against second generation carrot fly, a single spray against flea beetles persisted for less than seven days (based on percentage infested plants), confirming previous studies on swede and turnip (FV 222). The leafhopper trial was done in cages in the greenhouse and the plants were therefore not exposed to re-invasion. As a consequence, it is not possible to estimate the persistence of the various insecticide treatments.

References

FV 222 Brassicas: biology and control of brassica flea beetles by integrating trap crops with insecticide use.
PC 178 Protected herbs: control of glasshouse whitefly and leafhoppers within IPM programmes.

Evaluation of fungicides for the control of rust, powdery mildew and other prevalent diseases on mint (*Mentha piperita* and *M. spicata*) and leaf spot caused by *Septoria apium* on parsley (*Petroselinum crispum*) in both outdoor and protected crops

Introduction

Currently there are few effective fungicides with on-label or off-label approval for herb crops for the control of predominant disease problems such as rust, and powdery mildew and leaf spots. In addition many fungal pathogens develop resistance to fungicides when they are applied too often and without alternatives making them ineffective. This has already happened in the use of strobilurin fungicides for other pathogens. The purpose of this efficacy trial was to screen novel strobilurin and triazole fungicides applied either alone or in an alternating programme for the control of the predominant fungal pathogens of these herb crops with a view to identifying effective treatment protocols. The relative performance of the applied fungicides were measured against the primary pathogens and data obtained on their relative crop safety.

Experimental details of field trials on peppermint and parsley

Site Location

Wobbly 2 at NHC
Peppermint beds 14-18
Parsley beds 20-25

Species treated

Mentha piperita and *Petroselinum crispum*

Crop production system and trials design

Peppermint

The peppermint plot, 4 beds x 100m, of an established crop, planted Spring 2000. Disease levels in 2000 and 2001 were moderate (scores 5-6) after the first cut in early July. The crop had received no fungicide treatments.

Parsley

The trial area will comprise 4 beds x 100 m. The site will be power harrowed in April 2002 and base dressing of 400kg/ha of a 10:10:10 compound fertilizer was applied before herbicide application. Trifluralin (2.3 l ha^{-1}) was incorporated into the soil before drilling. Curley parsley cv Smadg (Elsoms) was drilled with a Stanhay precision drill at 40plant/metre bed 4 rows to the bed. Irrigation was not require after drilling as 35mm of rain fell in the following 3 weeks and crop establishment was good.

Experimental design: The trials were set out in randomised plots with 4 treatments x 4 replicates plots/treatment. The treatments randomised within blocks (ref 2 SOP). The fungicides (Amistar, Folicur, Amistar/Folicur) were applied sequentially (x4) singly and as a combination treatment Amistar then Folicur (x2). The treatments were applied at the manufacturers recommended concentrations.

Rep	1	2	3	4
1	Amistar	Control	Amistar/Folicur	Folicur
2	Control	Folicur	Amistar	Amistar/Folicur
3	Amistar/Folicur	Folicur	Control	Amistar
4	Control	Amistar	Amistar/Folicur	Folicur

Replicates: 4

20 m x 1 m

Plot size: $800m^2$ plot 100mx 8m

5 metres buffer between replicate blocks

1 metre between treatments

Harvest: No harvest

Treatments

Treatments		Product	Compound	Application timing*	Rate
1	4 sequential treatments	Amistar single	azoxystrobin	14 day intervals	0.75litre/ ha
2	4 sequential treatments	Folicur single	tebuconazole	14 day intervals	0.75litre/ ha
3	Alternating treatments	Amistar/Folic ure	azoxystrobin/teb uconazole	14 day interval	0.75litre/ ha
4		Control			

Infection

The peppermint was infected with mint rust during late June and all plots had mint rust by early July. There was no evidence of parsley leaf spot until mid September possible due to the dry summer. Leaf spot was identified on all plots before fungicide treatments were applied and during the following 42 days 2 cms rain fell on the crop which should have provided suitable conditions for the spread of infection on the control and treated plots

Treatment dates:

Peppermint The sprays were applied at 14day intervals, after mint rust had been identified and the crop have been cut.

Parsley The sprays were applied at onset of disease symptoms and then at 14 day intervals

Rate of use: As above

Water volume: Spray treatments applied in 4 litre of water. Treatments were applied using a knapsack sprayer with a boom attachment operating at a pressure of 2 bars.

Field Trials Diary NHCFHDC1

Disease infection and fungicide treatments

Peppermint

On 20th June mint rust was identified on the peppermint and on 25th June the mint crop was cut. On the 22nd July the mint crop was assessed for mint rust to obtain a baseline level of mint rust infection. This data was recorded in spreadsheet NHCFHDC1. The same day the1st fungicide treatment (Amistar, Amistar/Folicur,Folicur) were applied. The weather weather was sunny with some cloud cover, no rain, a temperature of 20°C and windspeed 10 mph. Amistar was applied 1st for the Amistar/Folicur combination. The peppermint crop was assessed for mint rust on the 6th August and infection data recorded in spreadsheet NHCFHDC1. The 2nd fungicide treatment was applied that day. The weather was cloudy, no rain, with a temperature of 17^0 C, and a windspeed of 6mph. On the 20th August the peppermint crop was assessed for mint rust and the infection data was recorded in spreadsheet NHCFHDC1. The peppermint crop received the 3rd fungicide treatment on the 21st August. The weather was sunny, no rain, a temperature of 20^0 C, with a windspeed of 6mph. On the 4th September the peppermint crop received the 4th and final fungicide treatment. The weather was sunny, no rain, a temperature of 17°C, with a windspeed of 8 mph. The crop assessed by Dr Martin McPherson (Stockbridge House Technology Centre) on the 16th September.

Parsley

Septoria was detected in the parsley trial on the 16th Sept and this was confirmed on 17th September by Dr Martin McPherson. On the 19th Sept the parsley assessed for septoria infection and all plots have evidence of infection. That day the crop received a 1st spray (Folicur, Amistar, Folicur /Amistar) Folicur was applied 1st for the Amistar/Folicur combination. The weather was sunny with some cloud cover, no rain, a temperature of 15°C, with a windspeed of 7mph. The parsley received a 2nd spray fungicide spray on the 2nd October, the weather was cloudy, no rain, a temperature of 15°C, with a windspeed of 7mph. The 3rd fungicide spray was applied on the 16th of October, the weather was sunny with some cloud cover, no rain but there had been a lot of rain on the previous two days, the temperature was 7°C, with a windspeed of 8mph. The 4th and final fungicide spray was applied on the 31st Oct October, the weather was misty, a temperature 8.9°C, with a windspeed of 5mph SE. There had been lot of rain on the previous day.

Crop assessment for mint rust Puccinia menthae

An assessment was carried out before spraying to obtain a baseline level of infection and 14days after each spray treatment. In each plot, 10 stems of mint were chosen along the plot and the number of leaves counted without infection. Crop phytotoxicity- observations were made on any adverse effect on plants, at 7, 14 and 42days after each application. The data was logged as a percentage (0-100%), where 0% = no damage. A final assessment was made 14 days after the 4th treatment. The rust index RI was assessed on a score of 1-5, 0 = no rust, 5 = very severe rust infection. The % of leaves lost was assessed on 10 stems %LL and the percentage of leaf area with rust pustules on the 8th leaf from the top of the shoot was assessed on 10 stems %LA.

Results

Peppermint

Crop phytotoxicity

Amistar — Slight darkening of the leaf where rust infection had been. Leaves were darker and greener.

Folicur — Slight darkening of the leaf where rust infection had been.

Amistar/Folicur — Slight darkening of the leaf where rust infection had been. Leaves were darker and greener.

Disease infection

Mint rust infection was very severe in the untreated control, rust index RI 4.9, and almost 50% of the leaves had been lost. All fungicide treatments significantly (p=0.01) reduced mint rust infection. Treatments were effective in reducing the mint rust index to <1, the number of leaves lost to < 14% and the percentage of leaf area infected to <0.35%. Amistar and Amistar/Folicur combination were slightly more effective than Folicur alone (Table below). At this stage the Amistar/Folicur combination did not appear more effective than the Amistar alone.

Table Mint rust assessment scores from peppermint crop

Treatment	RI	%LL	%LA
Amistar	0.0	9.9	0.0
Folicur	1.0	13.2	0.3
Amistar/Folicur	0.2	5.8	0.0
Control	4.9	41.5	11.8

Crop assessment for Septoria leaf spot on parsley

Disease assessment was made on12 Nov 2002 by Cathryne Lambourne. Very little *Septoria* was seen in the 16 plots. There was no distinguishable leaf discolouration or difference in vigour across the trial. Patchiness of growth and height differences were seen within the plots, but not linked to treatments.

Plots A-D (furthest from the edge of the field) showed the highest levels of *Septoria*, but plants were generally poorer and growth sparser in this part of the trial.

Assessment of the amount of *Septoria* was made by pulling together a clump of parsley to produce a circle roughly 20cm in diameter. The percentage of *Septoria* infection on the surface of this clump was recorded. No account of infection in the lower leaves was made, as it could not be determined whether the pathogen was viable or had been killed by the spray treatments. Because of the uneven level of infection across the plots to determine the level of control infection scores SI were divided by the incidence of infection I

Table Septoria assessment scores on field parsley

Treatment	Mean SI/I
Amistar	0.29
Folicur	0.32
Am/Fol	0.32
Control	0.38

Experimental details of protected crop trials on spearmint and parsley

Site Location

Isolation polytunnel at NHC

Species treated

Mentha spicata and *Petroselinum crispum*

Crop production system and trials design

Production system

Spearmint

Protected crops were raised in crates 60x30 cm, Spearmint has been raise from stolons planted Dec 2001. The trial consisted of a randomised block of 4 treatments x 4 replicate plots/treatment. Each plot comprised of a single crate. The outer plants in each plot formed a picture frame, guard area and only the central plants were assessed.

Parsley

Parsley was sown into crates 60x 30 cm. The trial will consist of a randomised block as for the spearmint but because of problems experienced with damping off each plots was later changed to parsley sown into 21, 9cm pots held in a pot holder.

Experimental design: The trials were set out in randomised plots with 4 treatments x 4 replicates plots/treatment. The treatments randomised within blocks (ref 2 SOP). The fungicides (Amistar, Plover, Amistar/Plover) were applied sequentially (x4) singly and as a combination treatment Amistar then Plover (x2). Of the combination treatment Plover was applied as the first treatment. The treatments were applied at the manufacturers recommended concentrations.

Rep	1	2	3	4
1	Amistar	Control	Amistar/Plover	Plover
2	Control	Plover	Amistar	Amistar/Plover
3	Amistar/Plover	Plover	Control	Amistar
4	Control	Amistar	Amistar/Plover	Plover

Harvest: No harvest

Treatments

Treatments		Product	Active ingredient	Application timing*	Rate
1	4 sequential treatments	Amistar single	azoxystrobin	14 day intervals	0.75litre/ ha
2	4 sequential treatments	Plover single	tebconazole	14 day intervals	0.75litre/ ha
3	Alternating treatments	Amistar/Plov er	azoxystrobin/ tebuconazole	14 day interval	0.75litre/ ha
4		Control			

Rate of use: As above

Water volume: Spray treatments applied in 4 litre of water. Treatments were applied using a knapsack sprayer with a boom attachment operating at a pressure of 2 bars.

Fungicide treatments: The sprays were applied at 14 day intervals, after mint rust had been identified and the crop had been cut. For parsley sprays were applied at onset of disease symptoms and then at 14 day intervals.

Protected crop trials diary NHCFHDC1

Plant material and disease infection

Spearmint

Stolons of spearmint CV 1 were heat treated Dec 2001 (to kill rust spores) and planted into crates. When mint rust was identified on the peppermint, infected leaves were soaked in water for 24 hrs, with a drop of Tween 80 to help remove spores and each spearmint plot was sprayed. No mint infection was apparent. Peppermint is known to be far more susceptible to infection by mint rust than spearmint. Literature also suggests that there is a difference in those isolates of mint rust that infects the different species of mint, although occasionally mint rust can spread from one species to the other. When mint rust was identified on spearmint crops in the field at the NHC an infective sprays was prepared as described above. When this also failed to infect the spearmint cultivar CV1 used in the experiment a second cultivar CV2 was placed in the polytunnel on 28th August. There was only sufficient plant material for 3 replicate treatments of this cultivar. This cultivar was sprayed with mint rust spores originating from the same cultivar found in the field at the NHC and also cuttings taken from spearmint infected with rust were planted into the crates. The mint plants were cut back to two leaves to attempt to even out irregularities between plots.

Parsley

Curley parsley cv Smadg (Elsoms) was sown quite densely 22nd April 2002 but suffered from damping off (identified by Martin McPherson). The crop was re-sown 17th June but again suffered from damping off. A final sowing was made on 28th August, at a lower density into pots. A plot consisted of 21 x 9 cm pots in a pot-holder. On 19th September parsley plants, with septoria, were lifted from the infected field crop and an infected plant was potted and placed in the centre of the pot-holder.

Treatment with fungicides

Mint rust was detected on the spearmint and septoria on parsley on the 2nd October. Both the mint and parsley received the 1st fungicide spray (Plover, Plover/Amistar, Amistar). The weather was cloudy with a temp 15°C. The experiment received a 2nd fungicide spray (Plover, Amistar /Plover, Amistar) on the 16th October. The weather was sunny with clouds and the temperature 16°C. The 3rd fungicide spray (Plover, Plover/Amistar, Amistar) was applied on the 30th of October. The weather was cloudy with a temperature of 16°C. The final fungicide spray (Plover, Amistar/Plover, Amistar) was applied on the 18th of November. The weather was cloudy with a temperature of 18°C.

Disease Assessments

***Septoria* on Parsley (Protected)**

Disease was assessed on the 28 Nov. There were very low levels of infection in the 4 control plots and no disease seen in the treated plots.

Table Septoria infection on protected parsley crop

Treatment	Control	Amistar	Plover	Amistar/Plover
Mean % infection	6.25	0	0	0.5

Rust on Mint (Protected)

Disease infection was assessed on 28 November. Crate vigour showing a large amount of variability – 2 of the control plots and one Plover plot showing very good vigour – tall healthy plants. Other crates with very patchy growth, and many dead plants, cutting material taken and plants had not recovered. No premature leaf abscission was seen in this protected crop, as had been seen in the field crop. Very low levels of rust seen throughout the trial.

Table Mint rust assessment from protected spearmint crop

Treatment	RI	%LL
Amistar	0.07	0
Plover	0.03	0
Plover/Amistar	0.07	0.2
Control	0.77	3.4