Horticultural
Development
Company

Grower summary

FV 318

Outdoor herbs: Integrated management of parsley Septoria and coriander bacterial blight

Annual Report 2009

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The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of the full report, please email the HDC office (hdc@hdc.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Headlines

In a coriander bacterial blight spread trial, around 10% of the crop was affected from a primary infection level equivalent to transmission by 1 in 15,000 seeds. Hot water looks to be the most promising seed treatment option for coriander bacterial blight; useful reductions were also obtained with thyme oil and biological control agents.

Amistar (azoxystrobin), Signum (boscalid + pyraclostrobin) and Karamate Dry Flo Newtec (mancozeb) were effective as foliar fungicides for control of Septoria leaf spot on parsley. Amistar and Signum significantly reduced spore germination of *Septoria petroselini* when applied to lesions of Septoria leaf spot on parsley.

Background and objectives

Parsley and coriander are the two major field-grown herb crops in the UK, with areas estimated as 1,100 ha and 1,500 ha respectively. Feedback from growers has confirmed that the priority diseases on these crops are parsley leaf spot (*Septoria petroselini)* and coriander leaf blight (*Pseudomonas syringae pv. coriandricola, Psc*).

Parsley leaf spot is seed-borne but can also survive on over-wintered crops and crop debris between seasons. Lesions develop on leaflets and when infection is severe can result in complete death of the foliage. However, even slight leaf spotting can render a crop unacceptable to retailers. Grower observations suggest that flat leaf parsley is more prone to leaf spot than curly leaf parsley. The disease is favoured by conditions of long leaf wetness duration and warm temperatures. Once symptoms develop, the disease can spread rapidly between beds by rain-splash and irrigation. Growers face the challenge of maintaining disease-free crops that are usually planted sequentially from April to early October.

Coriander bacterial leaf blight is a recurring problem on field-grown coriander. The disease is primarily seed-borne, but it may also survive on crop debris, although the relative importance of these inoculum sources is unknown. Disease development is favoured by dense plant spacing and wet conditions (e.g. regular irrigation). Seed health is key to ensuring a clean crop.

The overall objective of the proposed work is to develop integrated strategies for the management of parsley Septoria and coriander leaf blight, taking account of both seed health and field production issues. The specific objectives are to:

1. Determine appropriate seed health standards for parsley Septoria and coriander leaf blight.
2. Identify alternative methods for treatment of parsley and coriander seed, for control of *Septoria petroselini* and *Pseudomonas syringae* pv *coriandricola*, respectively.
3. Determine the efficacy of different fungicides when applied at specific timings in relation to infection events, for control of parsley Septoria.

4. Identify existing forecasting approaches that could be modified and validated to aid spray timing for management of parsley Septoria.
5. Optimise fungicide programmes for the management of parsley Septoria in inoculated field trials
6. Prepare a fact sheet on integrated strategies for management of parsley Septoria and coriander leaf blight

This report contains the results of work done during the second year of the project.

Summary of results and conclusions

Coriander bacterial blight seed transmission

Quantifying the dose-response relationship for seed to seedling transmission of the pathogen is the first step in developing a disease model which can be used to set effective seed health tolerance standards. To examine transmission we used a 'one-hit' theoretical model for infection, which makes the assumption that each individual pathogen cell is inherently capable of infection, but the probability of this occurring may be very small. The aim of the dose-response experiments is to estimate this 'one-hit' probability.

The previous coriander transmission experiment in Year 1 used both naturally-infested and artificially inoculated seed to look at dose/response relationships. Transmission occurred at a lower frequency than expected and was only detected at the highest inoculum level, providing an unreliable estimate. Therefore in order to obtain a more robust estimate, the transmission experiment was repeated in the second year using the two highest plus an additional dose. Seed (fruits) were sown in '308' module trays and watered via capillary matting to avoid secondary spread. Rather than relying on the appearance of symptoms, transmission was assessed by collecting samples of plants of different sizes and analysing these for the presence of the pathogen. Transmission was detected in the two highest doses in this second experiment and the results combined with earlier data to provide an estimate of the one-hit transmission probability of 1.6×10^{-4} and a dose (scaling) parameter of 0.282. These values can be used to predict the likelihood of disease transmission for seedlots with different levels of infestation and bacterial number per infested seed, and examine these values in relation to the probability of detection for different seed health testing schemes (See Table 1). Examination of the scenarios in the table suggest that an appropriate testing scheme could be effective in reducing the prevalence of coriander bacterial blight.

Table 1. Some example scenarios for expected transmission in a block sown with 1,000,000 coriander seeds (fruits), equivalent to approx. 0.36 ha and two different seed testing schemes.

1 inf seed in:	% inf	CFU per inf seed	Pr. transmission[1]	Pr. detection[2] in seed test on:	
				1 x 3k	3 x 5k
15,000	0.007	100	0.038	0.05	0.11
15,000	0.007	1,000	0.072	0.17	0.55
15,000	0.007	10,000	0.133	0.18	0.63
15,000	0.007	100,000	0.240	0.18	0.63
10,000	0.010	100	0.057	0.07	0.14
10,000	0.010	1,000	0.106	0.25	0.67
10,000	0.010	10,000	0.193	0.26	0.78
10,000	0.010	100,000	0.337	0.26	0.78
5,000	0.020	100	0.111	0.13	0.17
5,000	0.020	1,000	0.201	0.44	0.82
5,000	0.020	10,000	0.349	0.45	0.95
5,000	0.020	100,000	0.561	0.45	0.95
1,500	0.067	100	0.324	0.25	0.18
1,500	0.067	1,000	0.527	0.83	0.86
1,500	0.067	10,000	0.761	0.86	1.00
1,500	0.067	100,000	0.936	0.86	1.00
1,000	0.100	100	0.444	0.27	0.18
1,000	0.100	1,000	0.674	0.92	0.86
1,000	0.100	10,000	0.883	0.95	1.00
1,000	0.100	100,000	0.984	0.95	1.00

[1] Probability of at least one infected seedling in the block.

[2] Probability of detection in seed test performed according to PHS standard method.

Coriander bacterial blight spread trials

Quantifying the rate of disease spread in the field provides the information required for the second step in developing a disease model to set effective seed health tolerance standards. Field trials were done on the organic land at Ryton (Garden Organic/HDRA). Plots consisting of 3 (5-row beds) x 10 m were drilled on two occasions with healthy coriander seed. To provide a point source of inoculum and simulate a single transmission event, the cotyledons of a few seedlings in the centre of the plots were inoculated with *Psc* shortly after emergence. The presence/absence of visible symptoms in each 0.5 m length of each row was then recorded at regular intervals, and used to generate a disease map.

The first drilling provided some useful data and a mathematical model was successfully fitted (Figure 1). These model parameters will assist in defining appropriate seed health standards. At the time of the final recording when the crop was in flower, up to 10% of the crop was affected following a primary infection level equivalent to transmission by 1 in 15,000 seeds (fruits).

Unfortunately due to delays in drilling (due to wet weather in August 2008), the second crop provided little useful data.

The trials will be repeated in Year 3, and the results from the first trial indicate that there is no need to change the approach.

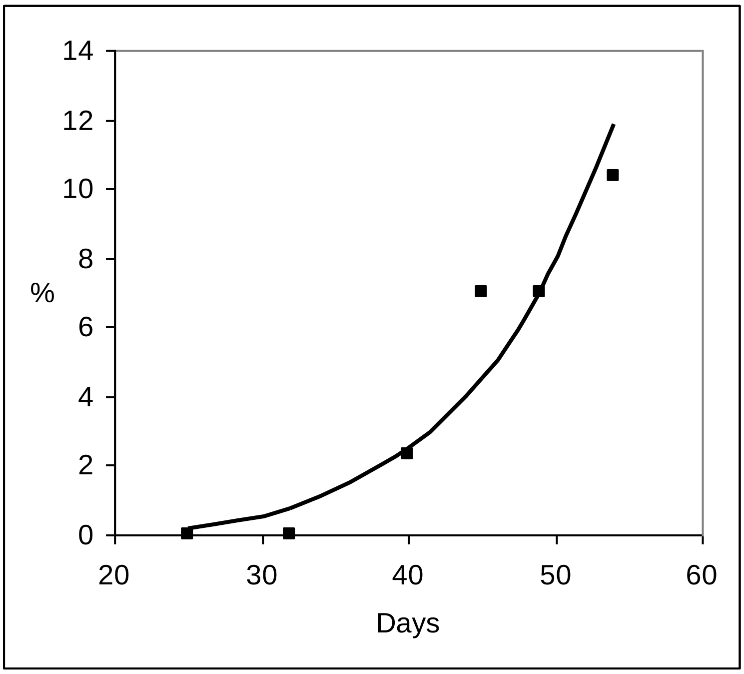

Figure 1. Change in the percentage of quadrats with bacterial blight symptoms in a field plot (10 m x 3 beds) of coriander with a single central point source of inoculum. The line represents the fitted model.

Coriander bacterial blight seed treatment

Coriander seed infested with *Psc* was treated with a range of hot water treatments, chlorine dioxide, thyme oil, and two biological control agents (BCAs) (Subtilex and Serenade Max).

Table 2. Summary of seed tests on bacterial blight infested coriander seed (seed lot S1072) following hot water/chemical treatment.

Treatment[1]	% Infested[2]			Log_{10} (Bacteria)[3]	
	Estimate	Lower	Upper	Estimate	s.e.
Untreated	>0.93	0.93	100	4.20	0.06
ClO_2 (100 ppm)	>0.18	0.18	100	4.03	0.20
ClO_2 (50 ppm)	>0.18	0.18	100	3.23	0.43
HW 50°C 15 min	1.1	0.22	3.7	-0.43	2.96
HW 50°C 30 min	0.029	0.002	0.14	0.30	0.62
HW 55°C 15 min	<0.067	0	0.067	-	-
HW 55°C 30 min	<0.067	0	0.067	-	-
Thyme oil (10%)	2.2	0.39	7.3	1.49	0.91

[1] ClO_2 = Chlorine dioxide; HW = Hot water

[2] % infested and lower and upper 95% confidence limits estimated from multiple seed tests using STPro™

[3] Log_{10} (Numbers of bacteria per seed) are a weighted mean obtained as predictions from a GLM in Genstat, together with standard errors

The efficacy of the physical/chemical treatments was evaluated by testing multiple sub-samples of the treated seeds, and then using the results to provide an estimate of the infestation level. The results suggest that hot water is the most promising treatment and is worthy of more detailed investigation of treatment parameters, and with more seed lots, in the final year of the project. All hot water treatments gave very significant reductions in *Psc*. The best treatment, 55°C for 15 min, reduced *Psc* numbers to undetectable levels in the naturally infested seedlot examined, without any reduction in germination. Thyme oil also gave a significant reduction and may be worthy of continuing investigation, but most surprisingly chlorine dioxide at the concentrations used (100 and 500 ppm) appeared to have no effect.

Because of the presumed ways in which the BCAs work, seed testing cannot be used to test their efficacy. The two BCAs (Subtilex and Serenade Max) were therefore evaluated in glasshouse transmission experiments using both inoculated and naturally infected seed lots. This requires a lot more effort than seed testing and limits the number of experimental units and total numbers of seeds (effectively 2,000 v 6,000) which can be examined and hence the ‘statistical power’ of the data analysis. Nevertheless clear indications of reductions in transmission and bacterial populations were obtained for both BCAs (Table 3).

Table 3. Summary of transmission studies on two bacterial blight infested coriander seedlots treated with BCAs

Treatment	Symps.[1]	No. trays[2]	%Transmission[3]			Log_{10}((Bacteria)[4]	
			Estimate	Lower	Upper	Estimate	s.e
Inoculated (S1081)							
Untreated	6	10	>0.67	0.67	100	5.99	0.05
Subtilex	8	10	>0.67	0.67	100	5.79	0.06
Serenade Max	2	10	>0.67	0.67	100	5.64	0.07
Nat. Inf. (S1072)							
Untreated	0	3	0.18	0.04	0.47	1.28	0.89
Subtilex	0	1	0.05	0.003	0.23	1.02	1.15
Serenade Max	0	0	<0.15	0	0.15	-	-

[1] Total number of plants with visible symptoms in all ten trays
[2] Number of trays in which *Psc* was detected by 'leaf washings'
[3] % transmission and lower and upper confidence limits estimated using STPro™, assuming each sample represents the whole tray of 200 seeds
[4] Log_{10} (Numbers of bacteria per plant) are a weighted mean obtained as predictions from a GLM in Genstat, together with standard errors

Fungicides for parsley Septoria
Experiments using curly leaf parsley in trays or pots in a glasshouse were done to:

- Evaluate the relative protectant and curative activity of approved and novel fungicides applied at specified intervals before and after an infection event, for the control of parsley leaf spot.
- Determine the effects of fungicides applied after lesion and pycnidial development had occurred on parsley leaves inoculated with *Septoria petroselini.*

The following fungicide products significantly reduced the incidence and severity of parsley Septoria caused by *S. petroselini*: Amistar (azoxystrobin), Signum (boscalid + pyraclostrobin), Folicur (tebuconazole) and Karamate Dry Flo Newtec (mancozeb). Mancozeb was the most effective fungicide tested, reducing mean disease incidence to 14% at 34 days after inoculation compared to 100% in the untreated control (Figure 2).

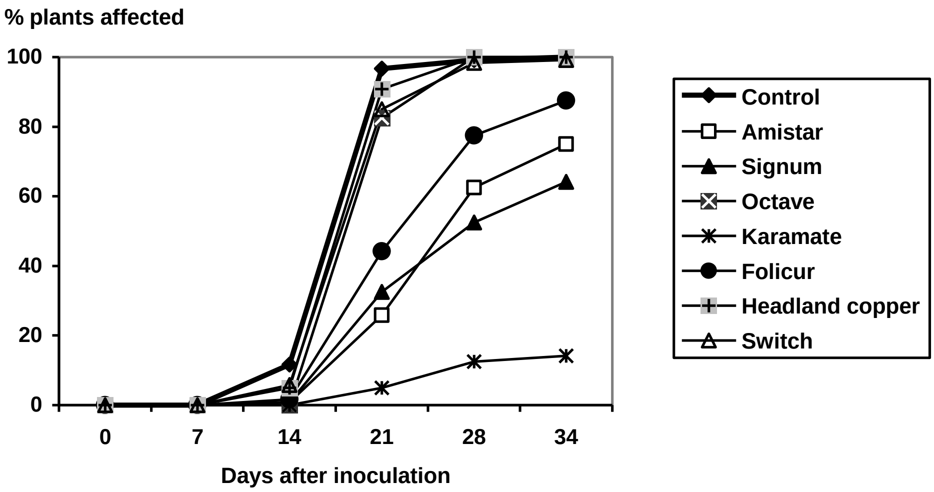

Figure 2. Incidence of Septoria leaf spot (*Septoria petroselini*) on parsley following fungicide applications, with data averaged across timings

Products were applied either 5 days before, 2 days before or 2 days after artificial inoculation. Overall, fungicides were most effective when applied 2 days before or 2 days after inoculation. Amistar was most effective when applied 2 days before inoculation, while Karamate gave excellent control even when applied 5 days before inoculation.

When the same range of fungicides was applied to lesions of Septoria leaf spot containing mature pycnidia, all fungicides tested except Switch (cyprodinil + fludioxonil) reduced spore germination, with Amistar and Signum being particularly effective (Figure 3). This mode of action could be useful in controlling a disease such as parsley leaf spot which is polycyclic, i.e. having many disease cycles within a season. Application of a strobilurin product to mature Septoria lesions will not necessarily affect development of the fungus in the plant, but could at least limit secondary spread of the disease by limiting germination of spores present in pycnidia.

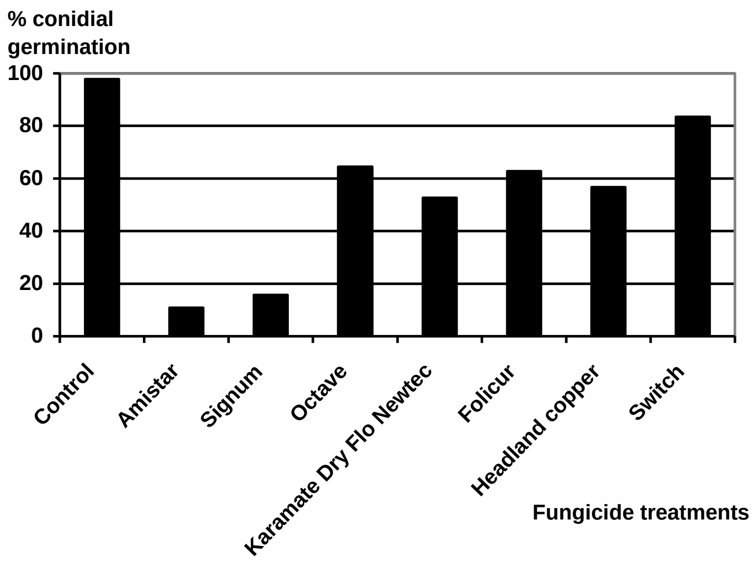

Figure 3. Effect of fungicide treatments applied to lesions of parsley leaf spot, on the germination of conidia of *Septoria petroselini*

Financial benefits

None to date.

Action points for growers

- It is not possible to guarantee that coriander seed is completely free from *Pseudomonas syringae pv. coriandricola (Psc)*.
- Where possible growers should request coriander seed which has been tested for *Psc* to tolerance levels agreed with the supplier.
- Be aware that seed testing results for parsley that quote percentage seeds infected with Septoria, may not provide a reliable measure of pathogen viability or disease risk to the crop.
- Parsley seed can be treated with Agrichem Flowable Thiram (thiram warm water soak) for the control of Septoria (follow label instructions).
- Broad spectrum disinfectants/biocides are not permitted for use as seed treatments for coriander or parsley.
- The following fungicides are permitted for use on outdoor parsley and are effective against parsley leaf spot (*Septoria petroselini*). Follow SOLA conditions of use.

Amistar	Azoxystrobin	SOLA 1293/02
Signum	Boscalid + pyraclostrobin	SOLA 1984/04
Scotts Octave	Prochloraz	SOLA 0650/01
Karamate Dry Flo Newtec	Mancozeb	SOLA 1978/06