Horticultural
Development
Company

Grower summary

FV 318

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

Annual Report 2008

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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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Headline

- A significant proportion of coriander seed lots tested were found to be infested with the coriander bacterial blight pathogen (*Psc*).
- Tests with parsley seed lots infested with *Septoria petroselini* demonstrated that neither the percentage of seeds with spore cases nor the percentage of seeds showing spore release provides a reliable measure of pathogen viability or subsequent disease risk to the crop.
- First estimates have been obtained for seed to seedling transmission probabilities for both coriander/bacterial blight and parsley/Septoria.

Background and expected deliverables

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*).

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:

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 factsheet on integrated strategies for management of parsley Septoria and coriander leaf blight.

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

Summary of the project and main conclusions

Coriander seed testing

Nine coriander seed lots were tested for the presence of the bacterial blight pathogen (*Psc*) using a method developed by Plant Health Solutions. Six out of the nine coriander seed lots examined were found to be infested with *Psc*. Infestation levels together with upper and lower confidence limits, are shown in Table 1, and ranged from 0.4 to 5% in infested seed lots. It is important to note that in the lots where *Psc* was not detected and in common with all seed health tests, it is not possible to be completely certain that they are healthy. This is due to the effects of sampling and the detection limits inherent in the test method. Therefore, for lots where *Psc* was not detected only an upper 95% confidence limit is provided. This implies that we can be 95% confident that the true infestation level is below this limit.

The seed test results indicate that a significant proportion of coriander seed lots may be infested with *Psc*. This would go some way to explaining the prevalence of this disease and perhaps also gives some optimism that improving seed health through a programme of effective testing to achieve a defined tolerance standard will go someway to reducing the problems caused by coriander bacterial blight. Work done in this and subsequent years will attempt to define such a tolerance standard.

Table 1. Results of seed tests on coriander seeds naturally infested with *Pseudomonas syringae* pv. *coriandricola.*

Sample No.	% of seeds infested		
	Mean	95% confidence limits	
		Lower	Upper
S1040	<0.03	0.00	0.03
S1041	<0.02	0.00	0.02
S1042	0.7	0.12	4.6
S1043	3.9	0.37	22
S1044	5.0	0.40	33
S1045	4.4	0.38	26
S1046	<0.015	0.00	0.015
S1047	0.7	0.12	4.6
S1060	>0.009	0.009	100

Some of the seed lots examined had apparently already been tested for bacterial blight but had been reported as negative. This highlights the importance of ensuring that seed health testing labs have the appropriate, experience, expertise and test methods for the pathogen in question. Growers should not assume that a particular laboratory has the expertise or methodology to perform a particular test and should always query the detection limits and test sensitivity of the method.

Coriander 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 coriander transmission experiment used both naturally infested and artificially inoculated seed to look at dose/response relationship (i.e. the relationship between the numbers of bacteria on the seed and the proportion of plants emerging which are contaminated). Seed was inoculated with a range of doses of bacteria (from 2×10^1 to 7×10^4 bacteria or CFU per seed) in two different ways (to simulate surface and more deep-seated infestation). The seed was then sown in module trays and grown on capillary matting to avoid water-splash and prevent plant to plant spread of the pathogen. Emerged plants were then assessed for the presence of the pathogen.

Transmission occurred at a lower frequency than expected and was only detected at the highest inoculum levels. As the two doses where transmission was detected were close together, it was not possible to fit a meaningful model to the data. The one-hit probability of transmission was therefore calculated separately for each of these treatments to provide a mean estimate of the one-hit probability of transmission of 3.6×10^{-7}. This cannot be considered to be a robust estimate, as the form of the dose/response relationship (i.e. the model) means that the data is relatively uninformative when all units are negative (i.e. when transmission is not detected). An additional transmission experiment is now underway with a higher dose than in the previous experiment.

Parsley seed testing

The objective was to determine for individual parsley seed lots:

- Percentage incidence of seeds with pycnidia (spore cases) of *Septoria petroselini*
- Percentage incidence of seeds that gave conidial (spore) release from pycnidia and subsequent germination
- Mean numbers of conidia per seed, using seed with and without pycnidia
- The frequency of transmission of *S. petroselini* from parsley seed to seedlings

Seven separate seed lots were used that were supplied by two commercial seed houses and reported to be infected with *S. petroselini.*

When seeds were examined microscopically, pycnidia (spore cases) of *S. petroselini* were visible on seed from all seven batches tested, with one batch containing 40% of seeds with pycnidia (Table 2). Spore release from pycnidia was observed for five of the seven seed lots (there was no spore release from lots E and F). However, subsequent germination of released spores (indicating pathogen viability) was only observed for two out of the seven lots (lots D and G).

Table 2. Characterisation of parsley seed lots to determine infection levels of *Septoria petroselini.*

Seed characteristic	Parsley seed lot code						
	A	B	C	D	E	F	G
% seed with visible pycnidia	40.3	34.3	0.5	6.3	2.0	0.5	11.0
% seed with spore release at 0 h	1.5	13.5	0.3	1.8	0.0	0.0	2.0
% seed with spore release at 24 h	9.8	31.0	0.3	5.0	0.0	0.0	7.8

% seed with spores germinating after 24 h	0.0	0.0	0.0	0.3	0.0	0.0	2.0

Examination of washings from all seven seed lots showed that spores of *S. petroselini* can be present on seeds both with and without visible pycnidia. For all seed lots (except lot C for which few seeds with pycnidia could be found), spore numbers for seeds with pycnidia were equal to or greater than for seeds without pycnidia.

The results demonstrate that neither the percentage of seeds with pycnidia nor the percentage of seeds showing spore release from pycnidia give a useful measure of pathogen viability or subsequent risk to a parsley crop. Finding a reliable measurement of the percentage seeds with viable infection is now further confounded by the result that spores of *S. petroselini* are not just restricted to parsley seeds with pycnidia but can also be found on seeds that are visibly free from pycnidia. In summary, a seed batch with pycnidia could pose no risk, while a seed lot that is apparently healthy (i.e. without visible pycnidia) could contain viable spores. These findings may impact on future seed testing methods for parsley Septoria.

Parsley seed transmission

As for coriander seed, 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.

The frequency of pathogen transmission was studied using seven seed lots supplied by two commercial seed houses and reported to be infected with *S. petroselini*. For each seed lot, seedlings in module trays were exposed to conditions conducive for Septoria in controlled environment cabinets and were subsequently monitored for lesion development.
Transmission of *S. petroselini* to seedlings was demonstrated only using the seed lot for which the pathogen was shown to be viable from seed testing results (lot G). Estimates

of the one-hit probability of transmission (probability of transmission of one spore on one seed) varied, with values of 9.0×10^{-5}, 8.7×10^{-5} or 6.2×10^{-5}, depending on whether primary foci of infection were considered at the seedling, cell or cluster level, respectively. The transmission rate for *S. petroselini* from seed to seedling was estimated using a single seed lot. To further verify this rate, and to investigate further the relative contributions of seeds with and without pycnidia, seed lots with different mean doses of viable spores would be required.

Alternative seed treatment methods

The relevant literature was searched and evaluated to identify potential seed treatments for coriander and parsley, particularly those that provide alternatives to conventional fungicidal seed treatments, for testing in project year 2.

There are currently no products approved for the control of *Psc* in coriander, and there are no products approved for seed treatment. Parsley seed can currently be treated for Septoria using a warm water thiram soak. None of the fungicides approved for foliar treatment of parsley leaf spot are approved as seed treatment formulations.

Broad spectrum disinfectants/biocides are often considered as potential seed treatments for control of seedborne bacterial diseases. Sodium hypochlorite (bleach) and peroxyacetic acid (e.g. Jet 5) both currently have pesticide approval as Commodity Substances, and it is therefore often assumed that they can be used as seed treatments. The situation has been clarified with the Pesticides Safety Directorate (PSD) and it is clear that Commodity Substances can only be used for the crops/situations specifically mentioned in the approval, therefore their use as seed treatments is illegal, unless or until such time as a specific approval is obtained. This does not mean their potential as seed treatments should not be investigated, but it should be made clear that pesticide approval would be required before their legal use could be permitted.

Several potential seed treatments have been identified and these will be examined in Year 2 of the project. These will include: hot water, thyme oil, at least one biological (e.g. Serenade™) and one conventional disinfectant (chlorine dioxide).

Potential forecasting approaches for parsley Septoria

Knowledge of environmental conditions that are favourable or unfavourable for the development of parsley Septoria can help to minimise spray applications. Forecasting models, based on temperature and leaf wetness duration, are available. These could potentially be validated or used as a basis for a simple decision-tree as an aid to spray timing for management of parsley Septoria. A literature review was done to summarise known information on environmental conditions conducive for the development of parsley Septoria, and possible forecasting approaches.

Key points from literature on the impact of environmental conditions on the development of parsley Septoria are as follows:

- The mean number of lesions per unit leaf area increased with inoculum concentrations from 10^4 to 2×10^6 conidia ml^{-1}.
- The optimum temperatures for lesion development were 20 and 23°C. At those temperatures, the optimum leaf wetness duration was 72 h.
- Low levels of Septoria blight on parsley developed across a wide temperature range.
- Under optimum conditions, symptoms of Septoria developed 9 days after inoculation.

There are no models that have been developed specifically for predicting the development of Septoria on parsley. However, there are three models that have been developed or adapted for the prediction of the closely related disease, Septoria late blight on celery (*S. apiicola*) and one model that has been developed for early blight of celery (*Cercospora apii*).

Of the models reviewed, the Tom-Cast system has the advantage that it has been validated for use in a range of crop/disease situations, and has been shown to enable reduced spray numbers in certain seasons while still maintaining marketable quality. The system utilises the duration of leaf wetness and average temperature during the wetness period to calculate a daily disease severity value (DSV). A fungicide is applied when the cumulative DSV reaches a predetermined threshold. The model has been validated for celery Septoria in Michigan state and Florida USA, and has also been introduced to celery growers in Victoria, Australia. Data can be downloaded from a temperature/leaf wetness sensor in the canopy and run through the Tom-Cast programme to provide a spray decision. It requires relatively inexpensive equipment, provides a straightforward output and has been implemented by growers. Use of Tom-cast for scheduling sprays for control of parsley Septoria will be trialled in project year 3.

Evaluation of fungicides for parsley Septoria

A replicated, inoculated pot experiment using flat leaf parsley was carried out from July 2007 to determine 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. The experiment was repeated in October 2007, using curly leaf parsley.

Fungicide treatments were applied to parsley plants at four timings: 3 days before, 1 day before, 1 day after, or 3 days after artificial inoculation with *Septoria petroselini*. Products applied are shown in Table 3. It should be noted that Amistar Top does not have approval for use on outdoor herbs.

There were no phytotoxic effects or growth benefits following application of any of the fungicides to parsley in either of the experiments. The efficacy of the products against parsley Septoria could not be assessed because there was no development of Septoria on any of the parsley plants, despite use of viable inoculum. The experiment will be repeated in 2008, using modified conditions to increase the chance of disease development within experimental plots. Possible modifications include use of a higher concentration of spores and a longer period of leaf wetness following inoculation.

Table 3. Fungicide treatments evaluated against parsley Septoria

	Product	Active ingredient	Product rate
1	Untreated control	-	-
2	Amistar	Azoxystrobin	1 L/ha
3	Signum	Boscalid + pyraclostrobin	1.5 kg/ha
4	Scotts Octave	Prochloraz	0.2 kg/ha
5	Karamate Dry Flo Newtec	Mancozeb	3.9 kg/ha
6	Folicur	Tebuconazole	0.75 L/ha
7	Headland Inorganic Liquid Copper	Copper oxychloride	4.0 L/ha
8	Switch	Cyprodinil + fludioxonil	0.8 kg/ha
9	Amistar Top	Azoxystrobin + difenoconazole	1 L/ha

Notes:

Amistar – SOLA 1293/02

Signum – SOLA 1984/04

Octave – SOLA 0650/01

Karamate Dry Flo Newtec – SOLA 1978/06

Folicur – SOLA 1873/03

Headland Inorganic Liquid Copper – SOLA 1057/05

Switch – SOLA 2079/07

Amistar Top – Administrative Experimental Approval (use rate from SOLA 1476/06 on parsley root)

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. Plant Health Solutions can provide such a testing service (see: www.seedtesting.co.uk).

- 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.