Horticultural
Development
Company

Grower summary

FV 357

Outdoor lettuce: evaluation of novel fungicides for downy mildew control

Final Report 2010

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

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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

Invader (dimethomorph + mancozeb), Previcur Energy (fosetyl-aluminium + propamocarb hydrochloride), Revus (mandipropamid), Signum (boscalid + pyraclostrobin), Valbon (benthialvalicarb-isopropyl + mancozeb) and a coded product (HDC F3) were the six products that gave good control of lettuce downy mildew (*Bremia lactucae*) in an artificially inoculated pot experiment, out of the eleven fungicides tested.

Background and expected deliverables

Downy mildew caused by the oomycete pathogen *Bremia lactucae* is the most important disease problem in field-grown lettuce. Some varieties are resistant but major gene resistance can be overcome quite rapidly. Fungicides are thus required to support genetic resistance to maintain control of this disease. No screening of novel products for lettuce downy mildew control has occurred in the UK for almost 10 years despite significant developments in potato blight fungicides and related products during this same period. There is commercial support to extend the use of some of the products on lettuce and other vegetables. The project aimed to provide new information on fungicide efficacy to help growers improve on disease management to reduce wastage. The work complemented studies on other lettuce diseases in HDC funded projects that aim to provide growers with up-to-date information on the control of major lettuce pathogens.

Spray timing is likely to be critical for downy mildew control as its latent period is only a few days and frequent applications may be required to protect new growth. Programmes at 10 versus 14 days and at different timings in relation to infection events (protectant and curative), would identify weaknesses in product efficacy and persistence. Testing and ranking of fungicides enables growers to select the best products for the range of diseases they encounter. The current choice of fungicides is limited so growers need a selection of products to combine in programmes to reduce the risks of selecting fungicide resistant strains of the disease. Results from this project will also be useful for product selection on other crops.

The overall aim of the project was to determine the efficacy of new and standard fungicides for control of downy mildew in outdoor lettuce. The specific objectives were:

1. To confirm methods that ensure consistent development of lettuce downy mildew in

screening experiments, using artificial inoculation with *Bremia lactucae* and; to produce inoculum sufficient for use in objective 2;

2. To determine the crop safety and activity of novel and standard fungicides against lettuce downy mildew;

3. To define the dose response activity of the most promising products and;

4. To quantify the persistence of products, to guide timing of treatments.

Summary of the project and main conclusions

Three experiments were done to determine the efficacy of a range of existing and novel fungicides against lettuce downy mildew (*B. lactucae*), in terms of timing, dose and persistence. The three experiments were run in an unheated polythene tunnel at ADAS Boxworth, Cambs from June to October 2009, and managed to provide conditions conducive for downy mildew development. The cos lettuce variety Frisco was used throughout (Figure 1), as this was observed to be susceptible to lettuce downy mildew in previous experiments. In each experiment, lettuce blocks were transplanted into F2+S compost in 13 cm diameter pots (3 pots of 4 plants per plot). Inoculum of *B. lactucae* was applied to plants as a spore suspension prepared from a combination of fresh or frozen leaves with sporulating downy mildew. Following inoculation, plants were covered with a polythene ‘tent’ for 48 hours to maintain leaf wetness and to increase relative humidity. Fungicides were applied to plants at different timings in relation to artificial inoculation. Disease incidence (proportion of plants affected), disease severity (percentage plant area affected) and phytotoxicity were assessed at intervals after inoculation and spray applications.

Fungicides used in Experiment 1 were selected based on current availability of products on lettuce, and other potential fungicide products for downy mildew control following discussions with the grower coordinator and agro-chemical industry contacts,.

Figure 1. Sporulation of downy mildew on lettuce var. Frisco (left) and set-up of Experiment 3 in a polytunnel (right)

Fungicide efficacy and timing

In Experiment 1, 11 fungicides were applied either 5 days before (26 June), 2 days before (29 June), immediately prior to artificial inoculation (1 July), or 2 days after inoculation on 3 July (Table 1).

Table 1. Fungicide products included in Experiment 1

	Product	Active ingredient	Product rate / ha
1	Untreated control	-	-
2	Amistar	Azoxystrobin	1.0 L
3	Aliette 80 WG	Fosetyl-aluminium	3.0 kg
4	Fubol Gold	Mancozeb + metalaxyl-M	1.9 kg
5	Invader	Dimethomorph + mancozeb	2.0 kg
6	Previcur Energy	Fosetyl-aluminium + propamocarb hydrochloride	2.5 L
7	Revus	Mandipropamid	0.6 L
8	Signum	Boscalid + pyraclostrobin	1.5 kg
9	HDC F 1	Not disclosed	2.5 L
10	HDC F 2	Not disclosed	0.8 L
11	HDC F 3	Not disclosed	2.5 kg
12	Valbon	Benthialvalicarb-isopropyl/mancozeb	1.6 kg

Notes:

Amistar	SOLA 1465/01 for outdoor lettuce
Aliette 80 WG	SOLA 3522/06 for outdoor lettuce
Fubol Gold	SOLA 2142/03 for outdoor lettuce
Invader	SOLA 3044/06 for outdoor lettuce
Previcur Energy	SOLA 0513/04 for outdoor lettuce
Revus	Administrative Experimental Approval COP 2009/00865
Signum	On-label for outdoor lettuce
HDC F1	Administrative Experimental Approval COP 2009/00865
HDC F2	Administrative Experimental Approval COP 2009/00865
HDC F3	Administrative Experimental Approval COP 2009/00865
Valbon	Administrative Experimental Approval COP 2009/00865

At 1 week after inoculation, slight phytotoxicity was observed on the plants as scorch or yellow blotches but this was not specific to fungicide treatments. There was a lower incidence of phytotoxic symptoms on treatments that had received the final spray application (2 days after inoculation), due possibly to cooler conditions at the time of this fungicide application.

Symptoms of downy mildew were first observed 13 days after inoculation. Mean downy mildew incidence was 12% in the untreated control at 15 days after inoculation and had increased to 19% by 21 days after inoculation. There was a significant effect of timing at both assessments, irrespective of fungicide treatment, with lower downy mildew incidence resulting from fungicide treatment at -2, 0 and +2 day timings compared with treatment 5 days before inoculation (*P*=0.006). At 21 days after inoculation, all of the fungicides except Fubol Gold had reduced downy mildew incidence by at least half compared with the untreated control. Signum, Valbon and Previcur Energy were the best performing products, followed by Revus, Invader and HDC F3, all reducing disease incidence compared with Fubol Gold (*P*<0.029) and the untreated control (Figure 2). There was no significant fungicide x timing interaction effect. Disease severity remained low throughout the experiment (mean of less than 0.5% in the untreated control) and there were no significant differences between fungicide treatments.

Fungicides to include in the 2nd experiment were selected largely on the basis of their effects on downy mildew incidence, since they could not be sufficiently differentiated using disease severity data. Previcur Energy, Revus, Signum and Valbon were selected as the most effective products. Invader and HDC F3 were similar to each other in efficacy, so Invader was selected for further experimentation since it is currently available for industry use. The poor performance of Fubol Gold (no different from the untreated control) in Experiment 1 was possibly due to use of a strain of *B. lactucae* with resistance to metalaxyl-M.

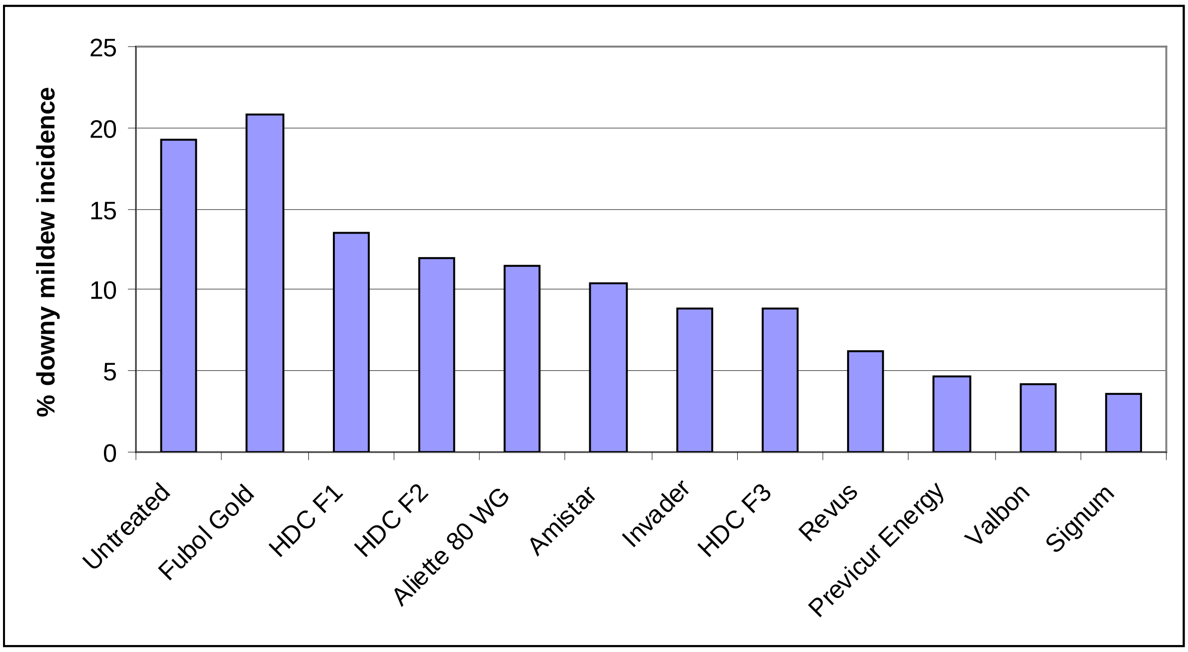


Figure 2. Effect of fungicides on incidence of lettuce downy mildew in Experiment 1 (averaged over four timings), 21 days after inoculation (LSD = 9.8)

Fungicide dose

Five products selected from Experiment 1 were evaluated to confirm efficacy and to identify the most effective products in relation to dose. The use of half dose treatments was done to help define the robustness of the treatments rather than to pursue low rates of application. Each fungicide treatment (Table 2) was applied at full rate or half rate at one of four different timings (-5, -2, 0 or +2 days in relation to inoculation).

No symptoms of phytotoxicity were observed in this experiment. Disease incidence increased from 11% in the untreated control at 7 days after inoculation to 84% at 16 days after inoculation. At 16 days after inoculation, there was a significant fungicide x timing interaction (*P*<0.001), when disease incidence was averaged across doses. This was due largely to a decrease in disease incidence when Invader and Valbon were applied 5 days before inoculation. Disease severity in the untreated control was higher than that recorded in Experiment 1. Fungicides significantly decreased downy mildew severity and there were significant differences between fungicides, but no effect of fungicide dose (Table 2).

There was a significant interaction effect of fungicide x dose on disease severity (*P*=0.046). Invader and Valbon were found to be more effective when applied at half dose, while Previcur Energy, Revus and Signum were similarly effective when used at full or half dose.

Table 2. Effect of fungicide doses on severity of downy mildew, 16 days after inoculation (Experiment 2)

	Fungicide treatments	Mean % disease severity		Fungicide means
		Full dose	Half dose	
1	Untreated control	-	-	3.1
2	Water only control	-	-	2.0
3	Invader	1.8	0.8	1.3
4	Previcur Energy	1.3	1.2	1.2
5	Revus	1.1	1.3	1.2
6	Signum	1.9	2.2	2.0
7	Valbon	1.9	1.0	1.5
	Dose means	1.6	1.3	
	LSDs (144 df)			
	Fungicides v.	0.64		
	untreated	0.52		
	Fungicides only	0.74		
	Fungicides.dose	Ns		
	Dose			

Fungicide persistence

A third inoculated experiment was done to define the persistence of disease control in relation to timing of fungicide programmes. An interval of either 10 or 14 day between the two sprays was used for the most promising five products at full rate. Two infection events were included in this experiment. The five fungicide treatments were applied on the day of 1st inoculation (day 0) and either 10 days later (immediately before 2nd inoculation) or 14 days later.

At the 10 day spray timing, Revus was applied instead of Signum, and vice versa, in error; all other spray applications were correct. The data for these plots was included in statistical analyses and is shown in the results as Revus / Signum, or Signum / Revus programmes.

No phytotoxicity was observed in this experiment. Disease development was rapid with 71% downy mildew incidence in the untreated control by 10 days after 1st inoculation. Treatment differences were already visible at 14 days after the 1st inoculation (Figure 3). At 20 days, disease incidence was less than 50% for all of the fungicide treatments compared with 100% in the untreated control (Table 3). Up until and including 27 days after inoculation, all of the fungicides still significantly reduced disease incidence in comparison with the untreated and water controls. At 34 days, disease incidence was still significantly lower than the controls for the two Invader programmes and the Revus programme at 0 & 14 days. Irrespective of fungicide timing, the Previcur Energy treatments, and programmes commencing with Signum were less effective in reducing downy mildew incidence at 14 and 20 days after inoculation compared with Invader, Revus (and Signum), and Valbon. Invader was the most effective product over the duration of the experiment.

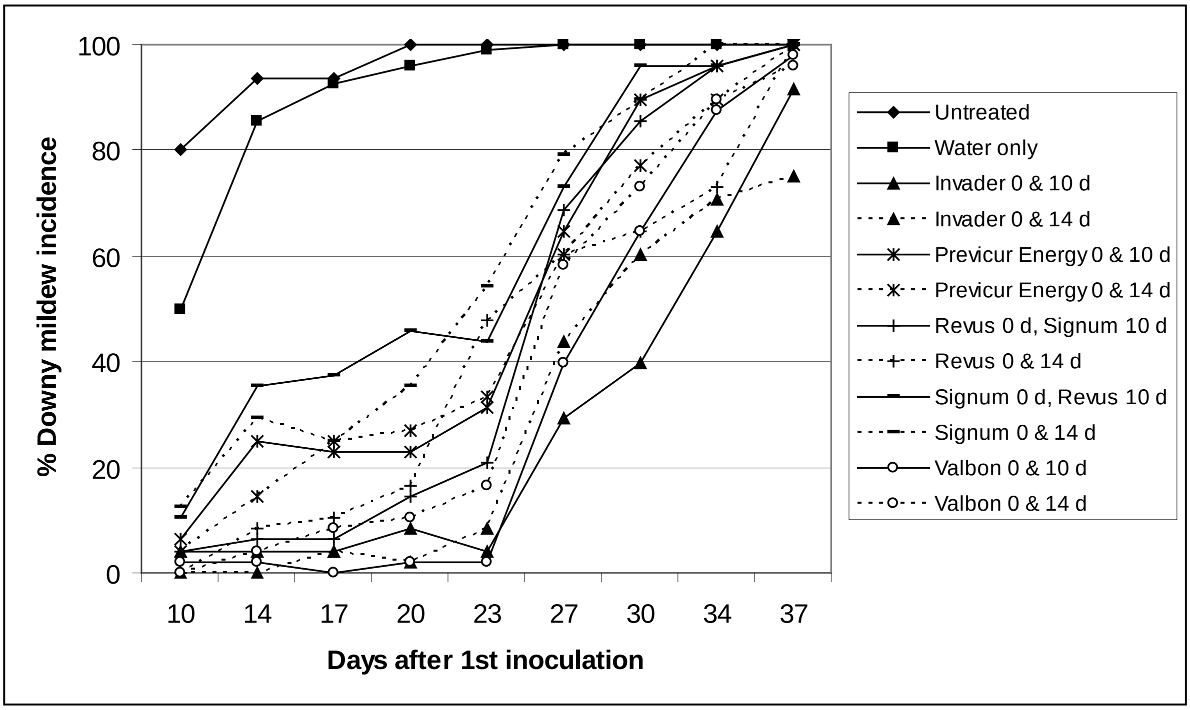
Disease severity increased to 18% of leaf area affected at 34 days after the 1st inoculation compared with 7% or less in the fungicide treatments (data for this is shown in the full report: table 11 & figure 3). The fungicide treatments significantly reduced disease severity in comparison with the controls at all of the assessment dates. Up until 27 days, disease severity remained low (1.6% or less), irrespective of fungicide product or spray intervals. At 34 days, disease severity was lower for the Invader programmes and Valbon programmes compared with Signum (0 & 14 days).

Invader was also the only product for which a spray interval of 10 days gave significantly better control than a 14 day interval; for the other products, downy mildew incidence did not vary significantly with spray timing interval. However, from looking at Figure 4, it is apparent that the rate of disease development on fungicide-treated plants was generally more rapid from day 20 after 1st inoculation. A similar trend was observed for disease severity data. This would suggest that in a field situation, a third spray at day 20 (ie 10 day spray intervals) might have checked disease development more than 14 day spray intervals, under a situation of high disease pressure.

Figure 3. Lettuce treated with Valbon (left) compared with untreated control plants, 14 days after 1st inoculation

Table 3. Effect of fungicide timing intervals on incidence of downy mildew (Experiment 3)

	Fungicides	Timing	% downy mildew incidence at intervals after inoculation			
			14 days	20 days	27 days	34 days
1	Untreated control	-	93.8	100.0	100.0	100.0
2	Water control	-	85.4	95.8	100.0	100.0
3	Invader x 2	0 & 10 days	4.2	8.3	29.2	64.6
4	Invader x 2	0 & 14 days	0.0	2.1	43.7	70.8
5	Previcur Energy x 2	0 & 10 days	25.0	22.9	64.6	95.8
6	Previcur Energy x 2	0 & 14 days	14.6	27.1	60.4	89.6
7	Revus/Signum	0 & 10 days	6.3	14.6	68.7	95.8
8	Revus x 2	0 & 14 days	8.3	16.7	60.4	72.9
9	Signum/Revus	0 & 10 days	35.4	45.8	72.9	95.8
10	Signum x 2	0 & 14 days	29.2	35.4	79.2	100.0
11	Valbon x 2	0 & 10 days	2.1	2.1	39.6	87.5
12	Valbon x 2	0 & 14 days	4.2	10.4	58.3	89.6
	LSDs (41 df):					
	Controls vs fungicides		11.90	12.72	18.44	18.31
	Fungicides		13.74	14.79	21.29	21.14



Note: 2nd inoculation at 10 days after 1st inoculation

Figure 4. Effect of fungicides on incidence of downy mildew at intervals after first inoculation (Experiment 3)

Financial benefits

Problems with downy mildew continue in all lettuce producing areas. A national loss in production of 10% is worth about £4 million/annum. Judicious use of effective fungicides can help to reduce this loss.

Action points for growers

- Of the fungicides currently approved for use on outdoor lettuce: Invader, Previcur Energy and Signum all have good activity against lettuce downy mildew, without causing phytotoxicity.
- The efficacy of Fubol Gold against lettuce downy mildew may be reduced if strains of *B. lactucae* resistant to metalaxyl-M are present.
- Valbon (approved for onion downy mildew) and Revus (approved for potato blight), were also effective against lettuce downy mildew in this project. Further work on residues may be warranted to determine whether Specific Off Label approvals for use of these fungicides on outdoor lettuce could be sought.