

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

AUTHENTICATION

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

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CONTENTS

	Page
Grower Summary	1
Headline	1
Background and expected deliverables	1
Summary of the project and main conclusions	1
Financial benefits	1
Action points for growers	2
Science section	
Introduction	3
Materials and Methods	3
Results and Discussion	3
Conclusions	5
Technology transfer	6
References	6

Grower Summary

Headline

- Outbreaks of spinach downy mildew in the UK in 2006 indicated that downy mildew Races 5 and 7 were present with a further three race profiles being identified with two appearing to represent Race 10 profiles.
- The “Race 10” populations are producing a different infection pattern on commercial varieties compared to standard typed races obtained from The Netherlands. This indicates emerging differences in UK populations and growers should be aware that unexpected infection can occur on some varieties.

Background and expected deliverables

Spinach downy mildew (*Peronospora farinosa*) causes considerable losses to UK spinach growers. Crops with low levels of infection may be completely unsaleable, resulting in substantial loss of income. Controlling the disease requires the use of expensive fungicides, and growers need high levels of disease resistance in varieties in order to be able to reduce fungicide use. There are a number of resistance (“R”) genes available, which can confer immunity to the disease. However, several of these have been “overcome” by changes in the pathogen and the variety then becomes susceptible.

Knowledge of the R gene content of a variety will tell growers whether or not to expect disease and what approaches for disease control are most appropriate. The validity of this information for the UK is therefore critical. Growers receive information on the “R gene” content of varieties from breeders, but there have been instances when a variety expected to be resistant has been susceptible. This may be due to the emergence of new races, or to errors in the claimed resistance profile.

The project proposes to carry out independent testing of varieties nominated by the Speciality Produce Growers Association (SPGA) with the most up to date typed isolate set from the Netherlands and also local UK collections. This will provide growers with an independent assessment of resistance gene content, and a prediction of the risk of attack on different varieties in the main UK production areas.

Summary of the project and main conclusions

The main conclusion to date is that UK populations of spinach downy mildew have been identified which do not conform to the expected “virulence profiles” of Races 1 to 7. As yet, the tests carried out cannot confirm whether these populations are new races in the UK. However, it is clear that the populations obtained are producing different reactions on a set of commercial varieties compared to known races and indicate strongly that new pathotypes are emerging in UK production areas.

Financial benefits

No clear financial benefits can be described at present until race identities are confirmed.

Action points for growers

- Varieties with resistance to downy mildew races 1 to 7, or 1 to 8, should be monitored very carefully for signs of disease.
- Fungicide application may still be needed on varieties with comprehensive R gene content.

Science Section

Introduction

Spinach downy mildew (*Peronospora farinosa* f.sp. *spinaceae*) exists as a number of races which are able to overcome resistance genes in the host. Races 1 to 7 have been identified in Europe and a typed set of isolates is available from The Netherlands. In the US, races 8-10 have been identified using a further set of differential varieties. In the UK, varieties with claimed resistance to at least races 1 to 7 have become infected, indicating the emergence of new races, or possibly errors in the claimed resistance profile. Different host reactions between cotyledons and true leaves have been reported (Irish *et al*, 2003), and this may be a further source of variation between expected resistance profiles and observed infections in the field. The aim of this project is to evaluate spinach varieties of interest to UK growers at the cotyledon and true leaf stage to typed races and to investigate the possibility that new races are emerging in the UK leading to unexpected loss of resistance in some material.

Materials and Methods

Seed of the European spinach differential set was obtained from NAKG in The Netherlands together with either fresh or frozen material of the type races 1 to 7. These were maintained on cv Giant Winter in a growth room at 15° C with a 16h day. Samples of downy mildew from outbreaks of disease in the UK were received from growers and transferred onto Giant Winter before testing on the differential set of varieties and a larger set of 21 commercial cultivars. Inoculations were carried out by spraying a spore suspension at 10⁵ spores/ml on cotyledons, and covering the plants with either small plastic domes or larger polythene bags for 48h. These were then allowed to grow for a further 7 to 10 days, before covering again for 48h to induce sporulation. Cotyledons were scored for the presence or absence of infection. All tests were carried out in growth room at a constant 15° C, with a 16h day. A total of 20 plants were used for differential tests, and 42 plants for variety tests.

Results and Discussion

The typed isolates from the Netherlands were successfully cultured with the exception of Race 3, and a further supply is being purchased. Race 2 had a very low level of viability, and no tests have been carried out so far with this race. Further stocks will be purchased if necessary.

A total of 11 isolates from 3 UK growing sites was received in 2006, of which six were successfully increased on Giant Winter and tested on differentials. Results are shown below in Table 1.

Table 1: Six isolates of Downy Mildew from three UK growing sites tested on Spinach Differential Varieties

Spinach Differential Cultivars	Downy mildew samples and source or variety where known					
	a	b	c	d	e	f
	Cherokee			Manza		RX22059
Nores	+	+	+	+	+	+
Califfay	+	+	+	-	-	+
Polka	+	+	+	-	-	+
Rushmore	+	+	+	-	-	+
Bolero	+	+	+	+	+	+
Spinnaker	+	+	+	-	-	+
Spicer	+	+	-	+	+	+
San Felix	+	+	+	-	-	+
Clermont	+	+	+	+	+	+
Lion	+	-	+	-	-	+
Eagle	+	-	-	+	+	+
Boeing	+	-	+	-	-	+
	?race 10	Race7	??	Race 5	Race 5	?race10

The putative race 10 identification has been discussed with NAKG. No other race 10 has been reported in Europe and the identification must remain as an unknown until further tests are complete. NAKG provided a further coded differential in December 2006 which is resistant to race 10, and this has been included in a repeat test, together with isolate c from the table, which did not correspond to any known race profile.

Variety tests with isolates received from UK sources are summarized below (Table 2) as % of cotyledons infected.

Table 2: Isolates form UK Sources as a Percentage (%) of Cotyledons Infected with Downy Mildew

Variety	Sample					
	a race 10?	b race 7	c unknown	d race 5	e race 5	f race 10?
Giraffe	100	0	100	14	0	80
Grizzly	100	0	100	14	0	95
Apollo	100	0	95	0	0	80
Crocodillo	9	0	2	0	0	5
Swan	0	0	0	0	0	0
Toscane	19	100	70	5	0	95
Campania	19	100	85	0	0	85
PV 0385	19	0	95	5	0	70
PV 501	2	5	0	0	0	0
Tarpy	19	35	1	2	0	0
SP 890	5	5	19	0	0	2
SP 896	5	9	0	0	0	0
Verdi	14	7	2	0	0	0
Bach	9	12	2	0	0	0
Bizet	9	42	4	0	0	5
Tirza	0	0	0	0	0	0
RX 2084	7	0	0	0	0	0
Allegro	2	0	0	0	0	0
Ventis	0	0	0	0	0	0
RX 1340	2	0	0	0	0	0
Whale	70	0	70	0	0	48

Tests with the same variety set as shown in Table 2 but using typed Pf races from The Netherlands are shown below with tests on race 3 and race 2 not yet complete, (Table 3).

Table 3: Tests Using Typed Pf Races from The Netherlands with Results Expressed as % Cotyledons Infected with Downy Mildew.

Variety	Netherlands Pf races				
	Pf 1	Pf 4	Pf 5	Pf 6	Pf 7
Giraffe	0	0	0	0	0
Grizzly	0	0	0	5	0
Apollo	0	0	0	0	0
Crocodillo	0	0	0	0	0
Swan	0	0	0	0	0
Toscane	0	0	5	7	0
Campania	0	0	2	0	5
PV 0385	0	0	0	0	0
PV 501	0	0	9	0	5
Tarpy	0	0	0	0	0
SP 890	0	0	0	0	0
SP 896	0	0	0	0	0
Verdi	0	0	0	0	0
Bach	0	0	0	0	0
Bizet	0	0	0	0	0
Tirza	0	0	0	0	0
RX 2084	0	0	0	0	0
Allegro	0	12	33	2	0
Ventis	0	0	0	0	0
RX 1340	0	0	0	0	0
Whale	0	0	0	5	12

Conclusions

Tests of Pf typed races against grower selected varieties were as expected for the majority of interactions, but some unexpected results were obtained (e.g. lack of infection on Campania with race 6, low levels of infection on Toscane with race 6) and some re-tests will be undertaken on cotyledons, in addition to a further set of tests on true leaves. During the production of inoculum for FV 293, which used Toscane in a fungicide experiment, the Pf 6 isolate did produce heavy infection on true leaves of this variety.

Though the designation of races collected from disease outbreaks in 2006 remains to be confirmed, it was clear the two putative race 10 types and the unknown race profile were producing very different infection levels compared to the other populations. Giraffe, Grizzly (claimed 1 to 7 resistance) and Apollo were all consistently infected by these populations, as was Whale, which has claimed resistance to races 1 to 8. However, all of these interactions are yet to be examined at true leaf stages.

Surprisingly, the isolate typed as Race 7 from the UK samples produced a high level of infection on Toscane and Campania, which have race 1,2,3,4,5 and 7 resistance. It is possible that the isolate was a mixture, containing Race 6 and 7, though differential results did not indicate that. The isolate appeared not to infect Eagle, which should be susceptible to Race 6. Tests on true leaves may however produce different results and these will be carried out in the next phase of the project.

Technology transfer

A summary of results on UK race testing was included in the proceedings booklet of the British Leafy Salads Conference, November 2006.

An article on the project and related work on fungicide control is scheduled to appear in February HDC News

References

B M Irish, J C Correll, S T Koike, J Schafer, T E Morelock, 2003. Identification and cultivar reaction to three new races of the spinach downy mildew pathogen from the United States and Europe. *Plant Disease*, **87**, pp 562-72