

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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Grower Summary

Headline

- Race 8 and Race 10 pathotypes of spinach downy mildew have both been found in the UK, but as occurrences have been limited in site and season, they cannot be regarded as established at present.
- Several varieties tested have resistance to the confirmed race 10.
- Cotyledon tests used to determine resistance profiles in breeding programmes appear to give the same reactions as true leaf tests.

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 thus what approaches for disease control are most appropriate. The validity of this information for the UK is thus 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 SPGA with the most up to date typed isolate set from the Netherlands, and also with 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

Both race 8 and race 10 have been identified in the UK. Though their distribution and prevalence is not established, it is clear that new pathotypes are emerging in UK production areas. Resistance to the Race 10 pathotype found in the UK has been found in a number of varieties.

Financial benefits

No clear financial benefits can be described at present until new races can be accepted as established in the UK

Action points for growers

- Varieties with resistance to downy mildew races 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. *spinaciae*) exists as a number of races which are able to overcome resistance genes in the host. Races 1 to 8 have been identified and confirmed as established in Europe, and Race 10 types have been detected. In the US, races 8-10 have been identified using European and additional differential varieties (Irish *et al.*, 2007). In the UK, varieties with claimed resistance at least to 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 profile 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 Natkuinbouw in The Netherlands at the start of the project. A further differential, coded 069727, which has race 10 resistance, was obtained at the end of 2006. All isolates were maintained on cv Giant Winter in a growth room at 15° C with a 16h day, or frozen at -20 °C until used. Samples of downy mildew from outbreaks of disease in the UK were transferred onto Giant Winter before testing on the differential set of varieties. 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 putative race 10 isolates obtained in 2006 were re-tested on the differential series including the race 10 resistant line. The results are summarized in the table below, and confirm a race 10 profile (samples a and f). A third sample (c) which had previously given an avirulent reaction on Spicer and Eagle gave a mixed reaction in the re-test, but was completely avirulent on the race 10 resistant differential. It is likely that this isolate was also a Race 10.

Differential	2006 sample codes and source or variety where known		
	a	f	c
	Cherokee	RX22059	
Nores	+	+	+
Califlay	+	+	+
Polka	+	+	+
Rushmore	+	+	+
Bolero	+	+	+
Spinnaker	+	+	+
Spicer	+	+	+
San Felix	+	+	+
Clermont	+	+	+
Lion	+	+	+
Eagle	+	+	+
Boeing	+	+	+
069727	-	-	-

The differential tests confirm a race 10 type. The isolates had been received from a single source (site).

Only two samples from growers were received in 2007. Industry contacts confirmed that the disease was seen very rarely in the 2007 growing season, despite the favourable conditions. The samples received were tested on differentials and found to be Race 8 (see table), though initial scores on Boeing were not clear (negative score on this differential would give a Race 5). A further test of another isolation from one of the samples confirmed Race 8 was present.

Differential	Sample and source variety		
	a	b	c
	Toscane	Divina	Divina
Nores	+	+	+
Califlay	-	-	-
Polka	-	-	-
Rushmore	-	-	-
Bolero	+	+	+
Spinnaker	-	-	-
Spicer	+	+	+
San Felix	-	-	-
Clermont	+	+	+
Lion	-	-	-
Eagle	+	+	+
Boeing	+	+	+
069727	-	-	-

A comparison of cotyledon and leaf reactions was carried out with one Race 8 isolate with the differential series. In general, cotyledon reaction predicted leaf reaction; though in the majority of cases leaves sporulated to a lesser degree than cotyledons despite inoculation to run off.

	Mean % cotyledon area sporulating	Mean % leaf area sporulating
Nores	75	50
Califlay	0	0
Polka	0	0
Rushmore	0	0
Bolero	100	55
Spinnaker	0	0
Spicer	50	50
San Felix	0	0
Clermont	50	92
Lion	0	0
Eagle	55	20
Boeing	100	40
069727	0	0

Varieties tested at the cotyledon stage in 2006 were examined for reactions of true leaves to two races, Pfs: 7 and 10. Sporulation on the true leaves was assessed on a 0-4 scale, where 0 = no visible sporulation, 1 = 1-25% leaf area cover, 2 =26-50% leaf area cover, 3 = 51-75% leaf area cover and 4= >75% cover (see table below).

	Race 7	Race 10
Giraffe	0	3
Grizzly	0	3
Apollo	0	2
Crocodillo	0	0.5
Swan	0	0
Toscane	3	2
Campania	3	2
PV 0385	0	2
PV 501	0	0.5
Tarpy	1	2
SP 890	0	0.5
SP 896	0	0.5
Verdi	0	1
Bach	0.5	1
Bizet	1	1
Tirza	0	0
RX 2084	0	0.5
Allegro	0	0.5
Ventis	0	0
RX 1340	0	0.5
Whale	0	3

There was no evidence of either increased resistance or increased susceptibility at the true leaf stage compared to cotyledons for the varieties and races examined. The variety Whale is thought to show “field” or “adult plant” resistance to the US isolates of Race 10, but true leaves appeared susceptible in the tests here. However, these were still seedling plants, and further tests will be carried out on more mature plants. Irish et al., (2007) published a series of reactions of US commercial varieties to the race 10 pathotypes predominating in California. Only two varieties, Tarpy and Whale, were common to the UK panel of varieties, but reactions to race 10 appear to be consistent, with both varieties susceptible

Conclusions

Race 8 and Race 10 have both now been identified in the UK. However, it has not been possible to confirm them as “established” in the UK. This would require identification in two consecutive seasons, and at more than one site. The relative absence of downy mildew in crops during 2007 is surprising, but nevertheless, the threat of new pathotypes in the UK cannot be ignored.

Tests of true leaves, rather than cotyledons, with two races did not suggest either any breakdown or increase in resistance at the later growth stage.

Technology transfer

An article on the project and related work on fungicide control appeared in May 2007 HDC News.

References

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