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A glasshouse progeny test for resistance to tuber blight (*Phytophthora infestans*)

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Zusammenfassung, Résumé p. 537

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Summary

The susceptibility to tuber blight (*Phytophthora infestans*) of seedling progenies from ten crosses involving resistant and susceptible parents was assessed by inoculating tubers grown in the glasshouse and in the field. The mean level of tuber blight in each progeny corresponded with the resistance category of the cross, and the rank order of increasing susceptibility was almost identical in both tests. It is suggested that two samples of ten glasshouse-grown seedlings, each seedling providing two tubers harvested as the plants begin flowering, is an adequate sample size on which to predict the tuber blight susceptibility of a progeny.

Introduction

Screening seedlings can be a very efficient method of selecting resistant progenies, and a rapid and effective way of identifying superior parental genotypes. A seedling screening test for resistance to foliage blight has been developed and used routinely in breeding work at the Scottish Crop Research Institute (SCRI) for the past few years (Caligari et al., 1984) to screen 200 – 250 progenies annually. This paper describes a new glasshouse test for resistance to tuber blight, and compares results obtained in 1984 with those from field-grown plants in 1985.

Materials and methods

Glasshouse test

Ten progenies were selected from crosses between cultivars/clones of known reaction to tuber blight (Table 1): four progenies were from resistant parents scoring 6 – 8 on a 1 – 9 scale of increasing resistance, three progenies from susceptible parents (one scoring 4, the other 2, 3 or 4 in each case) and three progenies from resistant × susceptible crosses involving these same parents. The resistance scores were assigned on the basis of several years' experience in field trials, and are close to those derived from official tests in England and Wales (Stewart et al., 1983).

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Table 1. Identities of progenies in tuber blight test. Susceptibility to late blight (1–9 score of increasing resistance) in parenthesis.

		Cara (6)	Sheriff (8)	3683 (7)	Redskin (4)	Maris Piper (4)
Cara	(6)		RR1	RR4	RS1	
S. Enterprise	(7)	RR2	RR3			
P. Javelin	(4)		RS3	RS2	SS3	
K. Edward	(3)					SS2
11233	(2)					SS1

RR = resistant × resistant; RS = resistant × susceptible; SS = susceptible × susceptible. Resistant — *Resistent — Résistant;* susceptible — *Anfällig — Sensible.*

Tabelle 1. Identität der Nachkommen im Knollen- Braunfäuletest. Anfälligkeit gegen Braunfäule (1–9 Skala mit ansteigender Resistenz) in Klammern.
Tableau 1. Identités des lignées dans le test mildiou des tubercules. Sensibilité au mildiou (échelle 1–9 de résistance croissante) entre parenthèses.

Two replicates of 40 seedlings of each progeny were pricked out into 10-cm pots of peat-based compost and grown for 9 weeks on a sand bed in an unheated glasshouse. The tubers were harvested in early September when flowering was about to begin and before the tubers were fully mature. Each block of 40 seedlings was divided into four samples of 10, and the two largest undamaged tubers were taken from each pot and distributed between two sub-samples. Thus each progeny was represented by two replicates of four paired samples (i.e. 16 samples), each of 10 tubers. Each sample was contained in one of the pots in which the seedlings had been grown. The tubers were inoculated immediately after harvest by dipping the pots momentarily in a suspension of a complex race of *P. infestans* containing 4×10^4 zoospores/ml, and storing them for 24 h in a constant environment chamber at 15°C and 100% RH before transferring them to an unlit store at ambient temperature (12 – 18°C) for 8 days. The number of infected tubers in each sample was recorded, ignoring any infections which had penetrated the skin through a wound or the stolon scar.

Laboratory test on field-grown tubers

Glasshouse-grown tubers raised from the same 10 progenies in 1984 were planted in the field in 1985. A field tuber blight test in situ is impracticable under Scottish conditions due to the erratic level of infection which develops. Tubers from the field-grown plants were therefore inoculated in the laboratory with the method described by Stewart et al. (1983).

Seedlings were grown in the glasshouse in individual 10-cm pots in a block of 50 per progeny, and those seedlings which produced at least two tubers at harvest were apportioned at random between two equal sets, each containing between 16 and 23 seedlings. The two sister tubers of each seedling were planted in separate replicates in the field. Thus each progeny was represented by two replicates of two sets of seedlings. Due to a shortage of tubers, one progeny (SS2) was represented by one plot of 25 seedlings in each replicate. Tubers were planted 0.7 m apart on 29 April and dug by hand 22 August. Two undamaged tubers were selected from each plant and placed rose end uppermost in separate plastic trays (Stewart et al., 1983). A sample thus consisted of one tuber from each plant in a plot. The

samples were inoculated on the day of harvest with a suspension containing 5×10^4 zoospores/ml applied with a hand sprayer. After incubating for 24 h at 15°C and 12 days at 12 – 18°C the incidence of infection was assessed as already described and converted to angles for analysis.

Table 2. Mean percentage of blighted tubers from glasshouse- and field-grown plants.

Progeny No	Glasshouse (16 samples × 10 tubers)		Field (8 samples × 16 – 25 tubers)	
	tubers blighted (%)	rank	tubers blighted (%)	rank
RR1	36.8	2	0.0	1
RR2	31.6	1	2.3	2
RR3	42.7	3	2.5	3
RR4	50.4	5	3.5	4
RS1	50.3	4	3.7	5
RS2	70.8	6	8.7	6
RS3	75.7	7	11.7	7
SS1	88.0	9	34.9	8
SS2	80.3	8	42.0	9
SS3	93.2	10	49.4	10

Tabelle 2. Mittlerer Prozentsatz braunfauler Knollen von im Gewächshaus und auf dem Feld angezogener Pflanzen.
Tableau 2. Pourcentage moyen de tubercules mildiousés à partir de plantes cultivées sous serre et en plein champ.

Table 3. Analysis of variance for percent blighted tubers in glasshouse progeny test (angles).

	d.f.	MS	$\chi 2$
Resistance category	2	15 437.33	43.9***
Replicate	1	8.44	NS
Category × replicate	2	88.80	NS
Progenies within categories	6	702.64	20.0**
Replicates × progenies within categories	6	157.96	NS
Samples within progenies	54	210.51	100.4***
Clones within samples	72	113.22	

** $P<0.01$; *** $P<0.001$

Tabelle 3. Varianzanalyse für den Prozentsatz braunfauler Knollen im Gewächshaus-Nachkommentest (Winkel).
Tableau 3. Analyse de variance du pourcentage de tubercules mildiousés dans le test des lignées sous serre (transformation angulaire).

Table 4. Relationship between number of samples and detectable differences in percent susceptibility in glasshouse test.

Number of samples (10 seedlings)	1	2	3	4
Number of replicates (tubers/seedling)	2	2	2	2
S.E. of the Difference[a]	3.2	1.6	1.1	0.8
L.S.D. 5%[a]	11.8	6.0	4.1	3.1

[a] Transformed from angles to % — *Transformiert aus Winkeln in Prozent — Transformation angulaire en %.*

Tabelle 4. Beziehungen zwischen der Probenzahl und merkbarer Differenzen in der prozentualen Anfälligkeit im Gewächshaus-Test.
Tableau 4. Relation entre le nombre d'échantillons et les différences significatives de sensibilité dans le test sous serre.

Results and discussion

The mean percentage of blighted tubers per progeny is set out in Table 2, and an analysis of variance in Table 3. There are significant differences between the sixteen samples within a progeny, and between progenies within each resistance category (R × R, R × S or S × S), but there are also significant differences between the categories. Despite the much higher level of blight in the glasshouse test, in both tests the progenies fall broadly into three groups according to the resistance category of the cross. The rank order of susceptibility is very similar in both tests ($r = 0.96$). The glasshouse test would thus appear to have satisfactorily predicted the susceptibility of the progenies in the test on field-grown tubers.

Table 4 shows the minimum difference in the percentage of infected tubers that could have been detected in the glasshouse test if different numbers of 10-tuber samples had been used. Thus two samples of 10 seedlings, each seedling providing two tubers, were adequate to distinguish a 6% difference at $P<0.05$. If a similar level of infection can be obtained in future tests this number of seedlings would seem to be both appropriate and practicable.

Experiments carried out in glasshouse and field in 1982 on a much smaller sample size also suggested that tuber blight susceptibility of progenies could be satisfactorily predicted on glasshouse-grown plants. The glasshouse test is simple and quick to use, and if employed as a sequel to a foliage blight progeny test it will provide the opportunity to screen for resistance to both foliage and tuber blight in the same year.

It is worth noting too that the glasshouse test will provide an opportunity to classify the resistance of parents if they are crossed with a susceptible cultivar and the behaviour of the progeny assessed. The test can thus assess the breeding value of phenotypically resistant material. The correlation between the mid-point parental values for tuber blight resistance (1–9 scale) and the offspring mean was −0.83.

The regression coefficient obtained when the progeny mean is regressed on to the mid-parent value gives a measure of heritability. In this case, however, the two are measured on different scales: the former as a percentage, the latter on a 1–9 scale, and the regression coefficient, using values from the glasshouse test, is −11.97. Percentage can be converted to a 1–9 scale on a purely mathematical basis by using a divisor of

11.1 and reversing the scale, thus giving a heritability of 100%. Although such a calculation is based on assumptions it suggests that the true estimate of heritability is very high. Likely progeny values, at least on material such as this, can thus be obtained from a knowledge of the parental scores.

Work is now in progress to explore the correlation between resistance to both foliage and tuber blight shown in progeny tests.

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Zusammenfassung

Ein Nachkommen-Test auf Resistenz gegen Knollenbraunfäule (Phytophthora infestans)

Die Anfälligkeit gegen Knollenbraunfäule von 10 Nachkommen, einmal von Knollen im Gewächshaus angezogener Sämlinge (1984), zum anderen von im Feld gewachsener Pflanzen (1985), wurde verglichen. Vier Nachkommen von resistenten Eltern, drei von anfälligen Eltern und drei aus 'resistent × anfällig'-Kreuzungen (Tabelle 1) wurden in zwei Blocks von 40 Pflanzen 9 Wochen lang in 10 cm-Töpfen angezogen. Acht Proben von 10 Pflanzen wurden von jedem Nachkommen entnommen (und zwei Knollen von jedem Topff zu Beginn der Blüte Anfang September), durch Tauchen in eine Zoosporen-Suspension von *Phytophthora infestans* inokuliert, und 8 Tage danach die Anzahl der infizierten Knollen festgestellt. Der mittlere Grad von Braunfäule bei jedem Nachkommen entsprach der Resistenzgruppe der Kreuzung (Tabellen 2 und 3).

Im Gewächshaus angezogene Knollen der gleichen Nachkommen wurden im Feld in zwei Wiederholungen (Blocks) mit 16 bzw. 23 Sämlingen je Nachkommen ausgepflanzt. Die beiden Blocks wurden mit Schwester-Knollen bepflanzt, so dass jeder Sämling in beiden Blocks vorhanden war. Die Knollen wurden nach 16 Wochen geerntet, danach inokuliert und wie zuvor geschildert ausgewertet. Die Rangfolge mit ansteigender Anfälligkeit war in beiden Tests fast identisch (Tabelle 2).

Daraus wird geschlossen, dass zwei Partien von 10 Sämlingen mit je 2 Knollen eine angemessene Probengrösse zur Vorhersage der Knollenfäule-Anfälligkeit eines Nachkommens darstellen (Tabelle 4). Der Test ist schnell und einfach in der Handhabung und ermöglicht in Verbindung mit einer Prüfung der Krautfäuleanfälligkeit die Möglichkeit einer Auslese sowohl auf Krautfäule als auch auf Knollen-Braunfäule im gleichen Jahr.

Résumé

Test de lignées sous serre pour la résistance au mildiou du tubercule (Phytophthora infestans)

La sensibilité de 10 lignées au mildiou du tubercule est évaluée à partir de tubercules issus de plantules cultivées en serre (1984) et en plein champ (1985). Quatre lignées de parents résistants, 3 de parents sensibles et 3 de croisements résistant × sensible (tableau 1) sont cultivés dans deux blocs de 40 plantes mises en pots de 10 cm pendant 9 semaines. Huit échantillons de dix plantes sont prélevés dans chaque lignée et deux tubercules sont retirés de chaque pot au premier stade de la floraison début septembre, puis inoculés par trempage dans une suspension de zoospores de *P. infestans;* le nombre de tubercules contaminés est enregistré après 8 jours. Le niveau moyen de contamination dans chaque lignée correspond à la catégorie de résistance du croisement (tableaux 2 et 3).

Les tubercules issus de la serre et appartenant aux mêmes lignées sont plantés en plein champ dans deux blocs, chacun comprenant deux échantillons de 16 à 23 plantules par lignée. Les deux blocs sont plantés avec des tubercules d'un même pied, de sorte qu'il y a deux répétitions pour chaque plantule. Les tubercules sont récoltés après 16 semaines puis inoculés et notés comme précédemment. Le classement par ordre croissant de sensibilité est pratiquement identique dans les deux tests (tableau 2).

En conclusion, deux lots de 10 plantules, chacune produisant deux tubercules, constituent un échantillon approprié pour analyser la sensibilité d'une lignée au mildiou des tubercules (tableau 4). Le test est simple et rapide, et combiné au test sur feuille, il offre la possibilité de détecter la résistance au mildiou des feuilles et des tubercules dans la même année.

References

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