RESISTANCE TO LATE BLIGHT IN *ANDIGENA* POTATOES

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SUMMARY

Andigena clones derived from mass-selected seedling populations which had been subjected to several generations of natural selection in the field for late blight resistance were studied. The average level of resistance (score about 3 on scale 1–5) was better than a sample of *Tuberosum* potatoes (score about 4) and the best individual clones were very resistant indeed. It is concluded that *Andigena* has the genetic capacity for excellent response to selection for resistance and that thus one major obstacle to the use of the Group in potato breeding has been removed.

1. INTRODUCTION

The tetraploid *Andigena* potatoes of South America are, so far as is known, all extremely susceptible to late blight caused by *Phytophthora infestans*, as could be expected from their history. The north temperate *Tuberosum* Group, derived from them, were initially as susceptible as their parents but have built up some field resistance during the past 120 years. *Andigena* × *Tuberosum* hybrids have often been found to be productive but have rarely been used in potato breeding because, reflecting the *Andigena* contribution, they are too susceptible to blight (HOWARD, 1963). If *Andigena* is to be used, therefore, blight resistance must first be constructed and the history of the *Tuberosum* Group (as well as obvious *a priori* considerations) encouraged the belief that this should not be difficult. In the event, it has been shown that blight resistance can indeed be built up by the simple expedient of exposing successive generations of seedlings to natural selection in the field. This result emerged from a long-term mass selection experiment designed to recreate the *Tuberosum* Group from *Andigena* materials. The experiment has now been running for three generations over a period of 7 years and general progress has been described elsewhere (JOHN INNES INST., 1966; SIMMONDS, 1966). It should perhaps be emphasised that no *conscious* selection for blight resistance *per se* was made; selection was for survival and yielding ability in the presence of natural attack by the pathogen. There are no *R*-genes in Andigena so hypersensitive resistance does not enter the picture.

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The purpose of this note is to assess the level of field resistance attained in comparison with the *Tuberosum* Group.

2. MATERIAL AND METHODS

The plant material used was a collection of nearly 100 *Andigena* clones selected for general field characters from populations that had undergone two or three generations of natural selection for field resistance to blight. As controls, standard potato clones were available, together with a collection of 120 *Tuberosum* breeding clones (of various origins and unselected for resistance) which were growing alongside the *Andigena*'s in field and glasshouse.

An isolate of *Phytophthora infestans* race 1,2,3,4,5,7 was used throughout this work, since the control materials, though not the *Andigena*'s, possessed several *R*-genes.

The main pathological method used was a new detached leaflet test. In this, detached leaflets were held at 13°–16°C on sheets of cellulose tissue in boxes lined with moist peat and inoculated by spraying with a suspension of sporangia. From each clone, two of the youngest fully developed leaflets (opposite laterals where possible) were inoculated, one on the adaxial and the other on the abaxial surface. The results for the two leaflets were averaged, readings being taken at day 6 as follows:

% lamina affected	*Type of lesion*	*Susceptibility group*
0– 5	restricted	1
5– 25	very slowly progressive	2
25– 50	moderately progressive	3
50– 75	normally progressive	4
75–100	rapidly progressive	5

The whole-plant spraying test (BLACK, 1960) was also used, results being scored on a scale 1–5. This latter test has been in standard use for some years and much experience goes to show that it gives a fairly reliable picture of field response. The detached leaflet test has been less extensively used but promises to be valuable for quick screening at a moderate level of accuracy.

3. RESULTS

Table 1 shows that the average level of blight resistance displayed by the *Andigena* clones was rather better than that of *Tuberosum* material. Two sets of tests, on leaflets taken from field and glasshouse, agreed well as to ranking, though field scores were slightly lower. For comparison, samples of standard clones tested in parallel gave:

older *Tuberosum* clones 4–5; two known moderate resisters, 3–3.5; two known high resisters, 1–1.5. Of the three *Andigena* sub-samples (Table 1), the second and third were, on average, a generation more advanced than the first and a corresponding advance in resistance is evident. Under British conditions a blight resistance level of about 3 may be considered satisfactory so it is evident that many *Andigena*'s have already reached an acceptable level of resistance from the breeding viewpoint and this about three sexual generations removed from their South American ancestors.

Though the ranking agreement between samples is good, the clone-by-clone correlations between tests are not high:

Tuberosum clones r = 0.387 [106]
Andigena clones r = 0.449 [82]

but both are positive and highly significant. Replicate tests would thus be required for accurate assessment of any one clone by the detached leaflet technique. Additional evidence of the validity of the test was obtained by growing a sample of 12 clones as cuttings and subjecting them to the standard whole-plant test along with *Tuberosum* controls. The *Andigena*'s were selected for a wide range of response. Results were: leaflet test, mean score 3.2 (range 1.0–4.8); plant test, mean score 3.3 (range 2.0–4.8); correlation, r = 0.736 [10], p = 1%; the slope of the regression line of test on test did not diverge significantly from unity (b = 0.6868 ± 0.200, t = 1.57); controls

Table 1. Blight resistance scores from detached leaflet tests of potatoes grown in field and glasshouse (scale: 1 = very resistant, 5 = very susceptible)

*Plant material**[1]	*Glasshouse samples*[2]			*Field samples*[3]		
	clones tested[4]	*mean score*[5]	*% 3 or less*[6]	*clones tested*[4]	*mean score*[5]	*% 3 or less*[6]
Tuberosum	120	4.1 ± 0.07	14	115	3.7 ± 0.07	17
Andigena 1	19	4.0 ± 0.20	21	16	3.7 ± 0.16	25
Andigena 2	22	3.4 ± 0.19	45	23	2.7 ± 0.16	78
Andigena 3	53	3.4 ± 0.12	45	48	2.9 ± 0.15	65

* Andigena 2 and 3 significantly more resistant than Andigena 1 and Tuberosum in both tests (see text) – *Andigena 2 und 3 waren in beiden Prüfungen bedeutend resistenter als Andigena 1 und Tuberosum (siehe Text)* – *les Andigena 2 et 3 significativement plusrésistants que Andigena 1 et Tuberosum dans les deux tests (voir texte)*

[1] *Pflanzenmaterial – matériel "plants"*
[2] *Muster aus dem Glashaus – échantillons de serre*
[3] *Muster vom Feld – échantillons du champ*
[4] *Anzahl getestete Klone – clones testés*
[5] *Durchschnittsnote – cote moyenne*
[6] *Prozent 3 oder weniger = % de cote 3 ou moins*

Tabelle 1. Bewertung der Krautfäuleresistenz auf Grund des Einzelblatt-Testes bei Kartoffeln, die im Feld und im Glashaus gezogen wurden (Skala: 1 = sehr resistent, 5 = sehr anfällig)

Tableau 1. Cotes de résistance au mildiou de tests de folioles détachées de pommes de terre poussées au champ et en serre (échelle: 1 = très résistant, 5 = très susceptible)

were in the expected range (two standard varieties, 3.0–4.0; one known resister 2.2). The leaflet test thus gave a reasonably accurate prediction of the whole plant test and the bigger the sample the better the prediction.

The question of correlation between resistance and field characters deserves comment, because it has often been found that resistance goes with late maturity (e.g. TOXOPEUS, 1958). Of the sample of nearly 100 *Andigena* clones studied, some were discarded for reasons unconnected with this work and 75 remained for selection. They were all in the maincrop maturity range and were divided into two maturity categories; they were also classified on a select/discard basis after inspection of tuber characters. The results (Table 2) give no convincing evidence that blight response is related to maturity or general desirability in this material.

Table 2. Blight resistance scores (leaflet tests) of *Andigena* clones classified for maturity and breeding value; numbers of clones in brackets for each entry. Test of differences between scores entered in main body of table: variance ratio (n 3.71) 2.05, not significant.

	Maturity[1]		
	earlier[2]	*later*[3]	*means*[4]
Selected[5]	3.5 (15)	3.0 (27)	3.2 (42)
Discarded[6]	3.0 (16)	2.7 (17)	2.8 (33)
Means[4]	3.2 (31)	2.9 (44)	3.1 (75)

[1] *Reifezeit – maturité*
[2] *Früher – précoce*
[3] *Später – tardive*
[4] *Mittel – moyenne*
[5] *Ausgelesen – sélectionnés*
[6] *Verworfen – éliminés*

Tabelle 2. Bewertung der Krautfäuleresistenz (Einzelblatt-Teste) bei Adigena-Klonen, eingeteilt nach Reifezeit und Züchtungswert; in Klammern die Anzahl Klone pro Posten. Varianzanalytische Untersuchung der Differenzen zwischen den in den Tabellen enthaltenen Werten: F-Wert "variance ratio" (n 3,71) 2,05, nicht signifikant.

Tableau 2. Cotes de résistance au mildiou (tests de folioles) de clones Andigena classés pour la maturité et la valeur culturale; nombre de clones entre parenthèses pour chaque introduction. Test des différences entre les cotes introduites dans la partie principale du tableau: variance rapport (n 3,71) 2,05, non significatif.

There may in fact be a weak correlation between lateness and resistance but differences are non-significant and it is clear that selection involves, at most, trivial loss of blight resistance. This does not mean that, over a wide range of maturity, the correlation with blight resistance is negligible; it merely means that, at the maincrop maturity level, satisfactory resistance can be maintained without risk of significant loss due to unconscious selection.

4. CONCLUSIONS

Earlier work, based on simple field observations, showed that blight resistance rose with successsive generations of mass selection and that highly resistant clones were produced (SIMMONDS, 1966). Last season (1966) advanced generation *Andigena* seedlings were grown under heavy blight attack in Northern Ireland; they showed a good average level of resistance and some strikingly resistant segregates (K. G. PROUDFOOT, personal communication). The present observations show: that whole populations of *Andigena* clones selected for field characters (but not for blight resistance *per se*) now have a general level of resistance somewhat better than the *Tuberosum* average; that many individuals (*ca.* 8%) are in the highly resistant range (score 2 or less); that satisfactory levels of field resistance can be achieved very simply by *natural* selection and without the aid of wild species; and that blight susceptibility need no longer be an obstacle to the use of the *Andigena* Group in potato breeding. The last conclusion is particularly timely because Paxman has recently shown (JOHN INNES INST., 1966) that there is approximately 60% yield heterosis to be had in F_1 *Andigena* × *Tuberosum* hybrids – in agreement with the prediction of HOWARD (1963).

ZUSAMMENFASSUNG

ÜBER DIE KRAUTFÄULERESISTENZ BEI *ANDIGENA*-KARTOFFELN

Es wurden *Andigena*-Klone verwendet, die durch Massenauslese aus Sämlingspopulationen gewonnen wurden. Diese Sämlingspopulationen wurden während mehrerer Generationen der natürlichen Auslese auf *Phytophthora*-resistenz im Feld unterworfen. Ungefähr 100 Klone wurden mittels des Einzelblatt-Testes mit einer grösseren Zahl von *Tuberosum*-Klonen verglichen. Aus den Ergebnissen in Tabelle 1 geht hervor, dass der durchschnittliche Resistenzgrad von *Andigena* (ungefähr Note 3 bei einer Skala von 1 bis 5) bedeutend besser war als der von *Tuberosum* (ungefähr Note 4); derjenige der besten *Andigena*-Einzelklone war wirklich sehr gut (Note 1 bis 2). Andere Ergebnisse (Tabelle 2) betreffen das Verhältnis zwischen Krautfäuleresistenz und Reifezeit; in diesem Material gab es keine signifikante Korrelation, und es war offensichtlich, dass eine befriedigende Resistenz hätte aufrechterhalten werden können, sogar ohne durch Auslese auf Frühreife gefährdet zu werden. Daraus wird geschlossen, dass die *Andigena*-gruppe, obwohl in ihrem Urzustand sehr anfällig für Krautfäule, die genetische Fähigkeit zu ausgezeichneter Reaktion in der Resistenzzucht besitzt und dass ein Haupthindernis für die Anwendung dieser Gruppe in der Kartoffelzüchtung beseitigt wurde. In diesem Zusammenhang wird auf die von Paxman kürzlich gemachte Feststellung hingewiesen, dass es im Vergleich mit reinen *Tuberosum*-Familien in *Andigena Tuberosum* F_1-Hybrid-Familien ungefähr 60% Ertragsheterosis gibt.

RÉSUMÉ

RÉSISTANCE AU MILDIOU DANS LES POMMES DE TERRE *ANDIGENA*

Les auteurs ont utilisé les clones *Andigena* provenant d'une sélection massale dans des populations de plantules soumises pendant plusieurs générations à la sélection naturelle au champ vis-à-vis du mildiou. Ils ont comparé quelque 100 clones au moyen d'un test sur

foliole détachée avec un vaste échantillon de clones *Tuberosum*. Les résultats (Tableau 1) montrent que le niveau moyen de résistance des Andigena (cote : 3 environ sur une échelle 1–5) est significativement meilleur que ceux de *Tuberosum* (cote de 4 environ) et que les meilleurs clones individuels sont réellement très bons (cote 1–2). D'autres résultats (Tableau 2) concernent la relation entre la résistance au mildiou et la maturité; il n'y a aucune corrélation significative dans ce matériel et il apparait qu'une résistance satisfaisante peut être maintenue sans risque sérieux de perte due à la sélection pour la précocité. Il est conclu que le groupe *Andigena*, quoique hautement susceptible au mildiou dans son état primitif, possède la capacité génétique de répondre excellemment à la sélection pour la résistance et qu'un obstacle majeur à l'utilisation du groupe dans l'amélioration de la Pomme de terre a été éliminé. A ce sujet, l'attention est attirée sur la récente découverte de Paxman qu'il y a approximativement 60% de production d'hétérosis dans les familles hybrides F_1 *Andigena* × *Tuberosum* en comparaison avec les familles pures *Tuberosum*.

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