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Australasian Plant Pathology, 2008, **37**, 592–599 www.publish.csiro.au/journals/app

Characterisation of *Phytophthora infestans* populations from Vietnam

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Abstract. In 2002–03, 597 *Phytophthora infestans* isolates were collected from potato and tomato crops in nine provinces of Vietnam. A representative set of isolates were characterised for mating type, metalaxyl sensitivity, virulence, mitochondrial DNA (mtDNA) haplotype and RG57-fingerprint. All of the 294 tested isolates were of mating type A1. Metalaxyl-resistant isolates were found on both the potato and tomato hosts, and dominated the population in Lam Dong province (south of Vietnam). Nine known virulence genes were found among 27 tested isolates, although virulence to resistance gene R5 was not found. Among the 95 isolates tested for mtDNA haplotype, all were Ib type. Of these, all 34 isolates fingerprinted showed US-1-like genotype. Mating type, mtDNA haplotype and RG57-fingerprint data from this study indicate that the *P. infestans* population on tomato and potato from Vietnam still consist of the 'old' population.

Additional keyword: DNA fingerprinting.

Introduction

Late blight, caused by the oomycete *Phytophthora infestans* (Mont.) de Bary, is the most important disease of potato (*Solanum tuberosum*) and tomato (*Lycopersicon esculentum*) worldwide. *Phytophthora infestans* is heterothallic with two mating types, A1 and A2, with sexual structures (antheridia and oogonia) only induced in the presence of the opposite mating type. Fusion of sexual structures results in oospores that can survive in soil in the absence of a host (Fry *et al*. 1992). Oospores in soil might become a source of inoculum for late blight epidemics, and sexual recombination might generate new genotypes of *P. infestans* that are particularly aggressive (Fry and Goodwin 1997). Late blight epidemics in agriculture are caused by asexual sporangia, which can be dispersed for tens of kilometres (Fry *et al*. 1992). The origin of *P. infestans* (Mexican or South American) has been a subject of debate since its first appearance in Europe in 1845 (Goodwin *et al*. 1994; Abad and Abad 1997), but recent analysis strongly supports a South American (Andes) origin (Gómez-Alpizar *et al*. 2007). However, new strains of *P. infestans*, including the A2 mating type, were introduced to Europe in the late 1970s. These originated from Mexico, a location with high levels of *P. infestans* nuclear genetic diversity, and were later spread around the world via the international trade of seed potatoes (Fry *et al*. 1993). The first report of A2 isolates outside Mexico was in Switzerland (Hohl and Iselin 1984), with analyses of allozyme data indicating that the A2 mating type in Europe was introduced by migration from Mexico (Spielman *et al*. 1991). Additional population genetic studies have fully supported the migration hypothesis (Drenth *et al*. 1994; Goodwin *et al*. 1994). In each location studied, the first detection of A2 isolates coincided with the appearance of new alleles at allozyme, DNA fingerprint and mtDNA loci. *Phytophthora infestans* strains belonging to the new population have been identified in several countries in Asia, although Vietnam was not included in these studies (Koh *et al*. 1994; Nishimura *et al*. 1999; Gotoh *et al*. 2005).

In 2002, Vietnam had a total potato production area of ~35 000 ha (Dao 2004). About 97% of this area is concentrated in the north, mostly in the Red River Delta, where the main crop is grown during the winter season from November to February. Potato production in this part of Vietnam is limited by climatic factors and only one crop per year is possible. Some potatoes are also grown in the highlands at Lao Cai, in northern Vietnam, and in the highlands of Lam Dong, in southern Vietnam (both are ~500 m above sea level). At these highland locations, potatoes are cropped almost all year round. Before the 1980s, most of the potato cultivars used in Vietnam were imported from Europe, and all of these cultivars were susceptible to late blight. Vietnam subsequently established potato and tomato trade with its neighbouring country, China (Pham 2000; Dao 2004). Potatoes imported from China accounted for 99% of the total potato import in 2002 (Dao 2004). There is no formal seed certification system in Vietnam (Pham 2000), and seed potatoes imported from China are often contaminated with various pathogens (Pham 2000; Dao 2004). The first report of studies of *P. infestans* in Vietnam was in 1967 (Vu 1967). In all potato growing regions, late blight is considered as the most destructive disease of this crop, with losses observed in the range of 5–50% (Pham 2002; Dao 2004).

 10.1071/AP08061 0815-3191/08/060592

In 2003, the total tomato production area in Vietnam was ~18 000 ha. Tomato production occurs throughout the year, with provinces in the north, and Lam Dong, accounting for ~90% of this production. Crop losses in tomato caused by late blight in the northern provinces have been observed in the range of 40–50% (Vu 1967).

With the lack of quality seed and the moderate level of resistance to late blight in the widely used varieties of potato and tomato, fungicide application is the major measure for controlling late blight. The most commonly used fungicides are cymoxanil, mancozeb, zineb, copper and metalaxyl. Fungicides are either used individually or as mixtures containing different active ingredients. Under rainy conditions with high air humidity and high disease pressure, it has been recommended to apply high rate of fungicides at short intervals (5–7 days) (Pham 2002).

The main objective of our study was to characterise *P. infestans* isolates from different parts of Vietnam in order to decide the best control strategies for tomato and potato late blight in this country. Knowledge of *P. infestans* metalaxyl sensitivity and virulence will allow for the optimisation of fungicide use and testing late blight resistance, respectively. Examining the mating types and genetic variation of *P. infestans* populations by mtDNA haplotype and RG57 fingerprinting will allow a better understanding of the epidemiology of this pathogen in Vietnam.

Materials and methods

Sources of isolates

During January 2002, and November 2002 to March 2003, *P. infestans*-infected leaves and stems from tomato and potato were collected from 51 and 26 fields, respectively (Table 1) in a total of nine Vietnamese provinces (Fig. 1). Eight of these provinces (Ha Noi, Hung Yen, Hai Phong, Hai Duong, Lao Cai, Ha Tay, Bac Giang and Bac Ninh) are in northern Vietnam, while one province (Lam Dong) is located in the south. Severe epidemics were more common in tomato than in potato in the northern provinces, and so most of the samples were collected from tomato fields. In the Lam Dong province, late blight occurred all year round on both crops. Our sampling strategy was designed to obtain up to 16 isolates from as many fields as possible, with a minimum distance between fields of 1 km. Commercial crops, home gardens and experimental fields with different levels of disease were all sampled. Normally, 16 samples from each field were collected; these were four samples from each of four plants, ~6 m apart.

Isolation of *P. infestans* from both hosts was performed from leaves and stems with single lesions. Two small pieces of tissue (5 × 5 mm) were cut from the edge of a lesion and placed under a surface-disinfected tuber slice of potato (5 mm thick) in a Petri dish. The Petri dishes were put in a plastic bag and incubated at 18°C for 5–7 days. Once sporulation was observed on the tuber slice, isolation was performed by transferring sporangia and mycelium to pea agar. Pea agar was prepared by boiling 125 g of frozen peas in 1.2 L of ion-exchanged water for 45 min. Then the peas were removed by filtering through cheesecloth and the broth was autoclaved after adding 15 g/L agar. Rye B agar (Caten and Jinks 1968) with 2% glucose instead of sucrose was used in a few cases. Pure isolates were obtained after one to two transfers of hyphal tips to new agar plates. Isolates were kept in the dark on pea agar plates at 18°C and transferred every 4–6 weeks until characterisation or storage. Isolation directly onto selective rye B agar as described previously (Hermansen *et al*. 2000) was also used in the beginning of the sampling period but was abandoned because of problems with bacterial contamination.

Four isolates (from individual plants) per field were selected for mating type test. In some provinces, where few fields were sampled, up to 10 isolates per field were tested. From the total of 294 isolates from 77 fields tested for mating type, isolates were further randomly selected for testing of metalxyl sensitivity, MtDNA haplotypes and RG57 fingerprint. However, isolates for virulence tests were selected only among isolates from the first sampled fields (Table 1).

Phenotypic characterisation

Determination of mating types and metalaxyl sensitivity

In total, 166 isolates from tomato and 128 isolates from potato were examined for mating type. *P. infestans* isolates 981353(A1) and 96172(A2) from Norway (Bioforsk-Plant Health and Plant Protection Division), or isolates 90209(A1) and 88055(A2) from

Table 1. Origin and number of *P. infestans* isolates collected in Vietnam from 2002 to 2003
P, potato; T, tomato

Provinces	Number of fields		Number of isolates tested for									
			Mating type		Metalaxyl sensitivity		Virulence		MtDNA haplotypes		RG57 fingerprint	
	P	T	P	T	P	T	P	T	P	T	P	T
Lao Cai	9	6	23	16	20	15	2	0	5	10	2	4
Ha Noi and Hung Yen	1	17	10	44	10	39	7	4	4	15	1	1
Ha Tay	0	6	0	20	0	15	0	0	0	5	0	4
Hai Phong and Hai Duong	3	8	20	59	20	50	12	5	7	18	1	6
Bac Giang	1	2	5	7	5	6	0	0	4	3	4	3
Bac Ninh	0	1	0	3	0	3	0	0	0	1	0	0
Lam Dong	12	11	70	17	63	15	20	2	17	6	6	2
Total	26	51	128	166	118	143	41	11	37	58	14	20

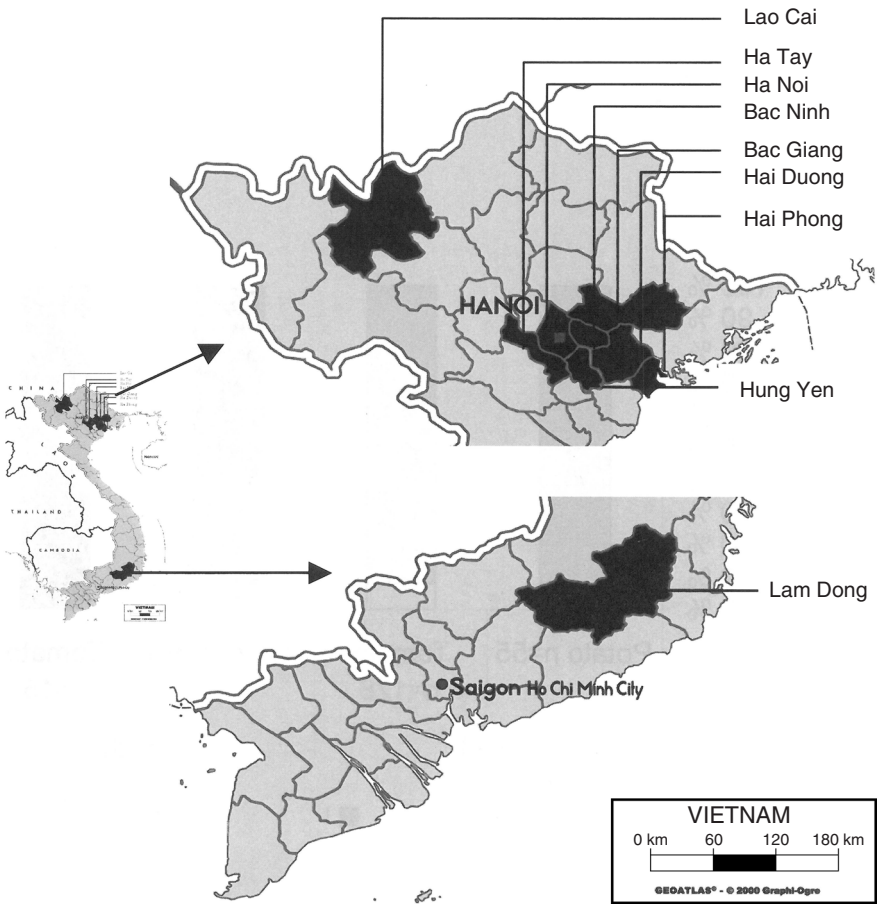

Fig. 1. Map of Vietnam showing provinces where *P. infestans*-infected samples were collected.

the Netherlands (obtained from Cyanamid Forschung GmbH, Germany), were used for mating type pairing. The mating type was examined on rye B agar or pea agar as described by Hermansen *et al*. (2000). Metalaxyl sensitivity was determined for 118 isolates from potato and 143 isolates from tomato on pea agar plates (diameter 90 mm) with or without 10 mg/L of technical grade metalaxyl (Syngenta) as described by Hermansen *et al*. (2000). The fungicide was dissolved in 0.1% dimethylsulfoxide (Sigma). Isolates were grouped into three sensitivity categories according to their growth on metalaxyl-amended agar compared with a negative control: sensitive, <10% growth; intermediate, 10–60% growth; and resistant, >60% growth (Shattock 1988). Each isolate was tested in duplicate. The metalaxyl sensitivity of *P. infestans* in each host and province was subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure. The statistical program used was MINITAB® release 14.20 (www.minitab.com, verified 28 August 2008).

Virulence test

Fifty-two isolates (representing both potato and tomato) were tested for virulence by MTT Agrifood Research Finland (Table 1). Isolates were tested using leaf discs of potato differentials floated in distilled water in 50-mm plastic Petri plates, essentially as described by Hermansen *et al*. (2000). Black's R-gene differential set, including single R-gene clones R1–R11 provided by Scottish Agricultural Science Agency (SASA), Edinburgh, UK, was used to determine the virulence profile of the *P. infestans* isolates. In the test, Bintje was used instead of R0, and R9 was not included in the differential set. Each isolate was tested using six separate leaf discs, with each leaf disc inoculated with a 20 µL droplet (10^5 sporangia/mL). For some isolates, however, the highest concentration of sporangia reached was around 1000 spores/mL. After 7 days incubation at 15°C under low light (16 h cold white fluorescent light and 8 h dark), each leaf disc was rated for sporulation of *P. infestans* using a stereomicroscope. If sporulation was observed, the interaction was rated compatible, while if no sporulation was observed, the interaction was rated incompatible. Virulence was marked as present if there was sporulation in any of the six disks. Tests were only used in which there was sporulation on leaf discs of Bintje (without any R-genes). Isolates that gave no sporulation on leaf discs of Bintje were retested.

Isolation of DNA

Phytophthora infestans was grown on plates of pea agar for 2 weeks at 18°C in the dark for DNA extraction. Mycelium was scraped off the plates with a scalpel blade and blotted dry with

filter paper. DNA was extracted using the FastDNA Kit (Qbiogene) or DNeasy Plant Mini Kit (QIAGEN), according to the manufacturer's instructions. An additional purification step was performed using a Micro Bio-Spin Chromatography Column (Bio Rad, Hercules, CA) filled with insoluble polyvinylpyrrolidone (PVPP) powder (Sigma).

Genotypic characterisation

Identification of mtDNA haplotypes

MtDNA haplotypes of isolates were determined by PCR-RFLP using the method of Griffith and Shaw (1998). DNA from 58 isolates from tomato and 37 isolates from potato (Table 1) was amplified with two pairs of oligonucleotide primers (F2/R2 and F4/R4) synthesised by Eurogentec according to the sequences given by Griffith and Shaw (1998). Amplification reactions were performed in a GeneAmp PCR System 9700 (Applied Biosystems). Each PCR reaction (20 µL) contained 200 µM of each dNTP, 7.5 mM $MgCl_2$, 20 pmol of each oligonucleotide primer, 1 × PCR buffer (10 mM TRIS-HCl, 50 mM KCl, pH 8.3), 1 U *Taq* DNA polymerase and ~10 ng genomic DNA. All reagents were supplied by Roche Diagnostics GmbH (Mannheim, Germany). The amplification program consisted of one denaturation cycle of 94°C for 30 s followed by 40 cycles of 94°C for 30 s; 64°C (primers F2/R2) or 55°C (primers F4/R4) for 30 s and 72°C for 60 s. Digestion of 3–6 µL of each PCR product was performed using 1 U of *Msp*I (for primer pair F2/R2 products) or 1 U *Eco*RI (for primer pair F4/R4 products) in a 20-µL volume at 37°C overnight. Restriction patterns were revealed after electrophoresis of the digested DNA through a 1.5% agarose gel. A 100-bp DNA ladder (New England Biolabs) was used as a size marker. DNA haplotype of an isolate was assigned by determining the molecular weight of the individual restriction fragments of each PCR-RFLP profile (by comparison with the molecular size markers) and referring to the published literature (Griffith and Shaw 1998).

RG57 DNA fingerprinting

Total genomic DNA from each isolate was digested with *Eco*RI (Promega, Madison, WI). Restriction products were fractionated by electrophoresis on 0.8% agarose gels and blotted to a Hybond N+ (Amersham Lifescience Ltd, UK) membrane. RG57, a 1.2-kb *Eco*RI-fragment of genomic DNA of *P. infestans* cloned in pBluescript (Stratagene, San Diego, CA) (Goodwin *et al*. 1992*a*, 1992*b*) was randomly labelled with ^{32}P using Oligolabelling Kit (Amersham Pharmacia Biotech) and hybridised to the blots according to the protocol of Church and Gilbert (1984). A 1-kb DNA Ladder (New England Biolabs Inc., Beverly, MA) was used as a size marker.

Results

Phenotypic characters

Mating types and metalaxyl sensitivity

After all 294 isolates tested were shown to be mating type A1, after producing oospores only with the A2 mating type, 261 isolates were tested for metalaxyl sensitivity. Of the 118 and 143 isolates from potato and tomato, respectively, there was a marked difference in frequency of metalaxyl resistance isolates between the Lam Dong province in south Vietnam, and the eight northern provinces (Fig. 2). In Lam Dong, 100% and 59% of the isolates from tomato and potato, respectively, were resistant to metalaxyl. In the northern provinces, however, only 2% of the tomato isolates, and no potato isolates, were resistant to metalaxyl. In this region, 90% of tomato and 96% of potato isolates showed intermediate sensitivity to metalaxyl (Fig. 2). ANOVA indicated no significant difference ($P = 0.066$) in response to metalaxyl between isolates from potato and tomato (Fig. 2). A statistically significant difference in metalaxyl sensitivity ($P < 0.005$) was only observed between isolates from Lam Dong province and from each of the eight northern provinces.

Virulence phenotypes

Despite three to four retesting procedures, several isolates did not infect Bintje. Some isolates grew very poorly on potato leaves, and a sufficient number of sporangia could not be obtained for the virulence tests. The race could be determined only for 27 isolates, 21 from potato and six from tomato (Table 2). Among these, 20 isolates were from provinces in the north. Race 3,4,7 was the most common race, comprising 11 of the isolates tested from the northern provinces of Vietnam. These isolates were from both potato and tomato. There were more complex races among isolates from Lam Dong, where four or more virulence factors were present in six of the seven isolates. Only in this region virulence for resistance gene R1 and R11 was found.

Genotypic characters

MtDNA haplotypes

Of the 95 isolates tested, primer pair F4/R4 produced a 964-bp PCR product in all cases. Digestion with *Eco*RI generated restriction fragments of ~394 bp, 361 bp and 209 bp in length. Primer pair F2/R2 gave an amplicon of 1070 bp. Digestion with *Msp*I gave restriction fragments of ~641 bp, 350 bp and

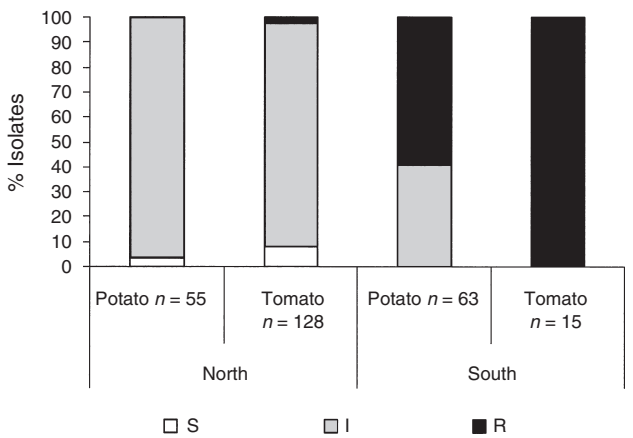

Fig. 2. Metalaxyl sensitivity among isolates of *P. infestans* from Vietnam sampled in 2002–03. S = sensitive, I = intermediate and R = resistant as described in Materials and methods. North = isolates from eight provinces in the north of Vietnam, while South = isolates sampled from the Lam Dong province in the south of Vietnam.

Table 2. Number of physiological races of *Phytophthora infestans* isolated from potato or tomato in Vietnam

Race[A]	Isolates from the north (20)		Isolates from the south (7)
	Potato	Tomato	Potato
1,2,4			1
1,2,4,10,11			1
1,2,4,7,10,11			1
1,2,4,7,10			1
1,3,6,7,10			1
1,4,10,11			2
2,3,7	1		
3	1		
3,4,7	7	4	
3,4,7,10	2		
3,4,7,8	2	1	
4		1	
4,7,10	1		

[A]Virulence to R9 was not tested.

79 bp for all the isolates (Fig. 3), which is indicative of mtDNA haplotype Ib.

RFLP fingerprints

A representative set of 34 isolates from both sampling years was selected for RG57 fingerprinting (Table 1). Three of the selected isolates were sensitive and four resistant to metalaxyl. The other 27 showed intermediate sensitivity to metalaxyl. All the 34 isolates tested using the RG57 fingerprint probe showed identical fingerprint pattern (Fig. 4). RG57 hybridised to 11 fragments, corresponding to fragment number 1, 3, 4, 7, 9, 10, 13, 14, 16, 20 and 21 described by Forbes *et al*. (1998). RG57 also gave faint signals to bands larger than number 21, i.e. larger than 10 kb. Although the experiment was repeated three times with different lots of DNA, these signals could not be distinguished as clear bands. Looking at the 11 fragments $\leq$10 kb (fragment number 21 and below), the Vietnamese fingerprint pattern is very similar to genotype US-1 (Forbes *et al*. 1998), but lacks band 5.

Discussion

The new *P. infestans* population, including the A2 mating type, was discovered in Europe, Asia, the Middle East, South America and North America several years ago. Representatives of the new migrating population were expected to rapidly disperse to all locations that have seed potato trade with Western Europe (Fry *et al*. 1993). In this study, where 246 Vietnamese isolates were tested for mating type, only isolates with mating type A1 were found. This makes Vietnam, along with Taiwan, one of the few Asian countries that still has a population of *P. infestans* containing only mating type A1 (Nishimura *et al*. 1999; Deahl *et al*. 2002; Gotoh *et al*. 2005). Our finding is somewhat surprising, given that Gotoh *et al*. (2005) detected both mating types in Vietnam's neighbouring countries Thailand and China. In China, only a low percentage of isolates were of the old population (Nishimura *et al*. 1999), with the 5–38% of isolates being of mating type A2 (Zhang *et al*. 2001). Asexual sporangia of *P. infestans* can be dispersed for tens of kilometres (Fry *et al*. 1992), which could allow the new population to be acquired from these neighbouring countries. Furthermore, Vietnam imports yearly hundreds of tons of seed potatoes from developed countries and several thousand tons of table potatoes from China (Dao 2004). These provide further routes by which the new strains of *P. infestans* could be introduced into Vietnam, especially given ~50% of the potatoes imported from China were in fact used as seed for planting (Dao 2004). Why A2 strains seem to be absent in Vietnam is therefore hard to explain.

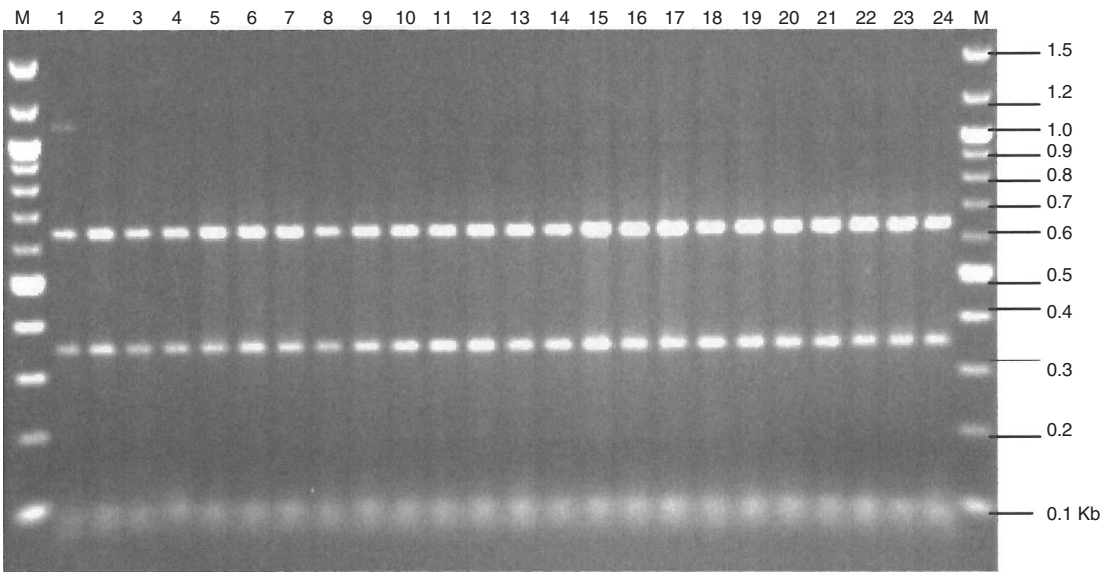

Fig. 3. Mitochondrial DNA haplotype. *Msp*I digestion of PCR products amplified from *P. infestans* with primer pairs F2-R2. Numbers above each lane indicate different isolates. Molecular weights of 100 bp size marker are indicated on the right.

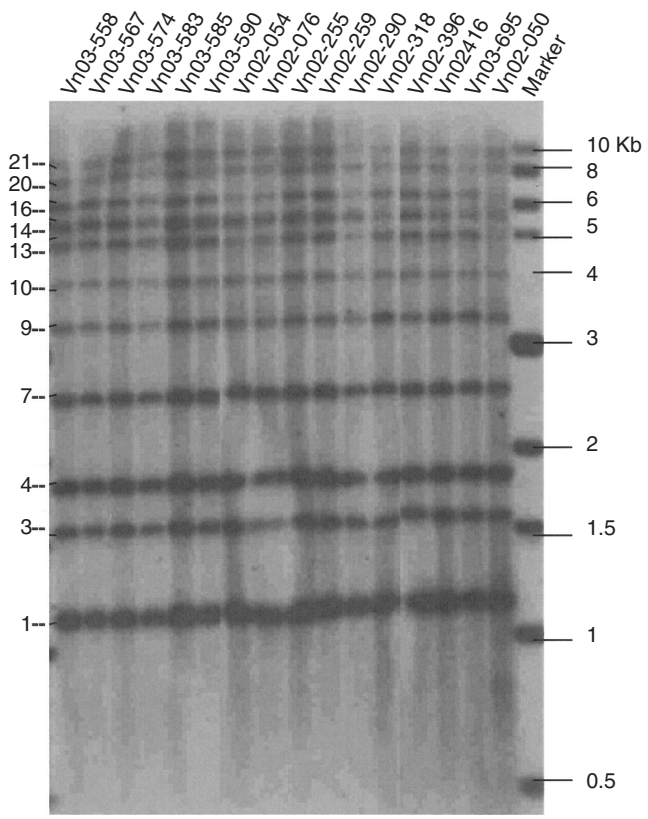

Fig. 4. DNA fingerprint patterns of 16 isolates of *P. infestans* from Vietnam. Total genomic DNA was digested with *Eco*RI and probed with ^{32}P-labelled RG57 DNA in Southern blot analysis. Isolate numbers are indicated above each lane. The band numbers indicated at the left correspond to those used by Goodwin *et al*. (1992*a*, 1992*b*). Molecular weights of 1 kb size marker are indicated on the right.

Reduced sensitivity to metalaxyl was detected in *P. infestans* isolates from the main potato and tomato production areas (northern Vietnam). Most of the isolates from provinces in the north showed intermediate sensitivity to metalaxyl, but were in fact close to sensitive. However, only very few fully metalaxyl sensitive isolates were encountered. The frequency of metalaxyl resistant isolates from Lam Dong was higher compared to isolates from provinces in the north. Tomato isolates from Lam Dong tended to be more resistant to metalaxyl than potato isolates. Metalaxyl is one of the most commonly used chemicals to control late blight, especially in Lam Dong (Pham 2002). The frequent use of formulations containing metalaxyl has probably selected for resistant isolates in this province. Anti-resistance strategies should be used in the future to prevent resistance problems occurring in northern Vietnam, and to reduce the existing problem in Lam Dong.

Resistance to phenylamides (e.g. metalaxyl) became established in A1 populations of *P. infestans* around the world before the appearance of the A2 mating type (Gisi and Cohen 1996). In the Taiwan population, changes in *P. infestans* were associated with the appearance of resistance to metalaxyl (Deahl *et al*. 2002). Extreme sensitivity to metalaxyl seems to be the ancestral phenotype for the US-1 clonal lineage of *P. infestans* (Goodwin 1997). Mutations resulting in metalaxyl resistance within the US-1 clonal lineage of *P. infestans* must be relatively rare, since they have not been detected widely in the world (Goodwin *et al*. 1996). Metalxyl-resistant US-1 isolates were collected in Ireland in 1980 (Goodwin 1997), later in the Philippines (Koh *et al*. 1994) and South Africa (McLeod *et al*. 2001), and were also found in Vietnam in this study.

Four mtDNA haplotypes (Ia, Ib, IIa and IIb) have been defined in *P. infestans* and these can easily be distinguished using a PCR-RFLP strategy (Griffith and Shaw 1998). Before the 1980s, worldwide populations of *P. infestans* were dominated by a single clonal lineage, the US-1 genotype with Ib mtDNA haplotype (Goodwin *et al*. 1994). This lineage has since been displaced by the other haplotypes, Ia, IIa and IIb (Ristaino *et al*. 2001). All the 95 Vietnamese isolates tested for mtDNA haplotype in this study, originating from both tomato and potato, were Ib. All the 34 tested isolates from both hosts had a fingerprint similar to that of US-1.

All our data indicate that *P. infestans* populations attacking potato and tomato in Vietnam are genetically very similar. Similarities in *P. infestans* genotypes from tomato and potato populations in defined geographic regions have been reported previously from Mexico (Jaime-Garcia *et al*. 2000), sub-Saharan Africa (Vega-Sánchez *et al*. 2000) and South Africa (McLeod *et al*. 2001). However, differences in genotypic structure between populations from tomato and potato have also been found in several countries around the world (Goodwin *et al*. 1994; Erselius *et al*. 1998; Oyarzun *et al*. 1998; Wangsomboondee *et al*. 2002; Suassuna *et al*. 2004).

Only 27 isolates were examined for virulence phenotypes (race structure) present in populations of *P. infestans* from potato and tomato in Vietnam. There was no evidence of a difference in race structure between isolates from the different hosts. Overall, nine races were found using a potato differential set, and the race 3,4,7 was the most common race found in the northern part of Vietnam. More complex races, able to infect plants with up to six different R-genes, were found among isolates from Lam Dong. Potato production in the north is only carried out in the winter season, however in southern province of Lam Dong, potato crops are grown all year round. In contrast, tomato crops are present more or less all year round in both regions. Tomato crops may therefore function as a reservoir for the late blight pathogen and an important inoculum source of Vietnamese late blight. This may also explain the similarity in phenotypes and genotypes of potato and tomato isolates in this study. The introduction of potato to the Red River Delta in 1890 by European missionaries (Nguyen 1984), and the open import of seed potato before the 1980s, may explain the migration of *P. infestans* to Vietnam. Our data about mating types, mtDNA haplotype and fingerprint RG57 indicate that the *P. infestans* populations in Vietnam still belong to 'old' population, which was distributed worldwide before the 1980s.

In Taiwan, a *P. infestans* population with the new genotypes completely displaced the old population in less than 3 years (Deahl *et al*. 2002). Vietnam's limited quarantine system, seed trade system and geographic location seem to be vulnerable for introduction of new *P. infestans* strains. Why new strains are not already established in Vietnam is rather surprising since the new genotypes are common in countries exporting seed potatoes to

Vietnam (Andrivon *et al*. 1994; Drenth *et al*. 1994; Zhang *et al*. 2001). One solution to avoid the occurrence of new strains is to prevent import of new strains to the country; however, this is probably impossible without banning import of seed potatoes. In order to fight late blight in Vietnam, a better understanding of the driving force of the epidemic development of *P. infestans* populations is needed. One important element of this work is to study the aggressiveness and competitive fitness of isolates from potato and tomato on both hosts in the country. Considering the apparently simple *P. infestans* population structure in Vietnam today, tracking the future population(s) using modern technology could give valuable knowledge regarding development of late blight epidemics in general.

Acknowledgements

The authors thank Asko Hannukkala and his co-workers at MTT in Finland for carrying out the virulence tests of the isolates. We are also grateful to students at Hanoi Agricultural University for participating in parts of this study. This work was part of the project 'NORAD RAS 2016 – Integrated Pest Management (IPM) – Vietnam' which was supported by grants from The Norwegian Agency for Development Cooperation (Norad)

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Manuscript received 15 February 2008, accepted 25 July 2008