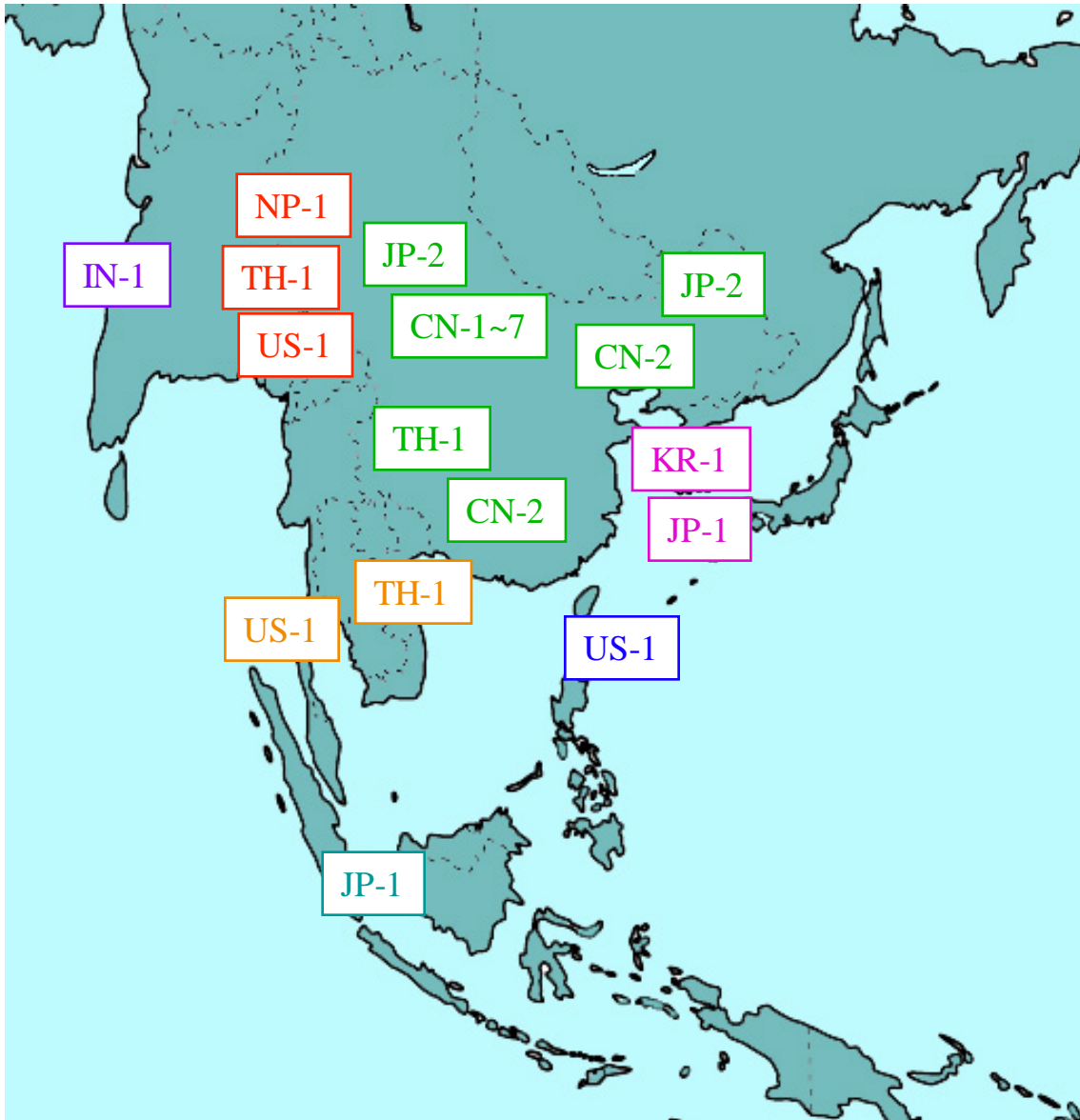


Recent genotypic changes of *Phytophthora infestans* in Japan (1997-2007) - an intimate relationship with European population

S. Akino¹, M. Kato² and N. Kondo¹

¹ Laboratory of Plant Pathology, Hokkaido University

² Japan International Research Center for Agricultural Sciences



Korea

China

Taiwan

Thailand

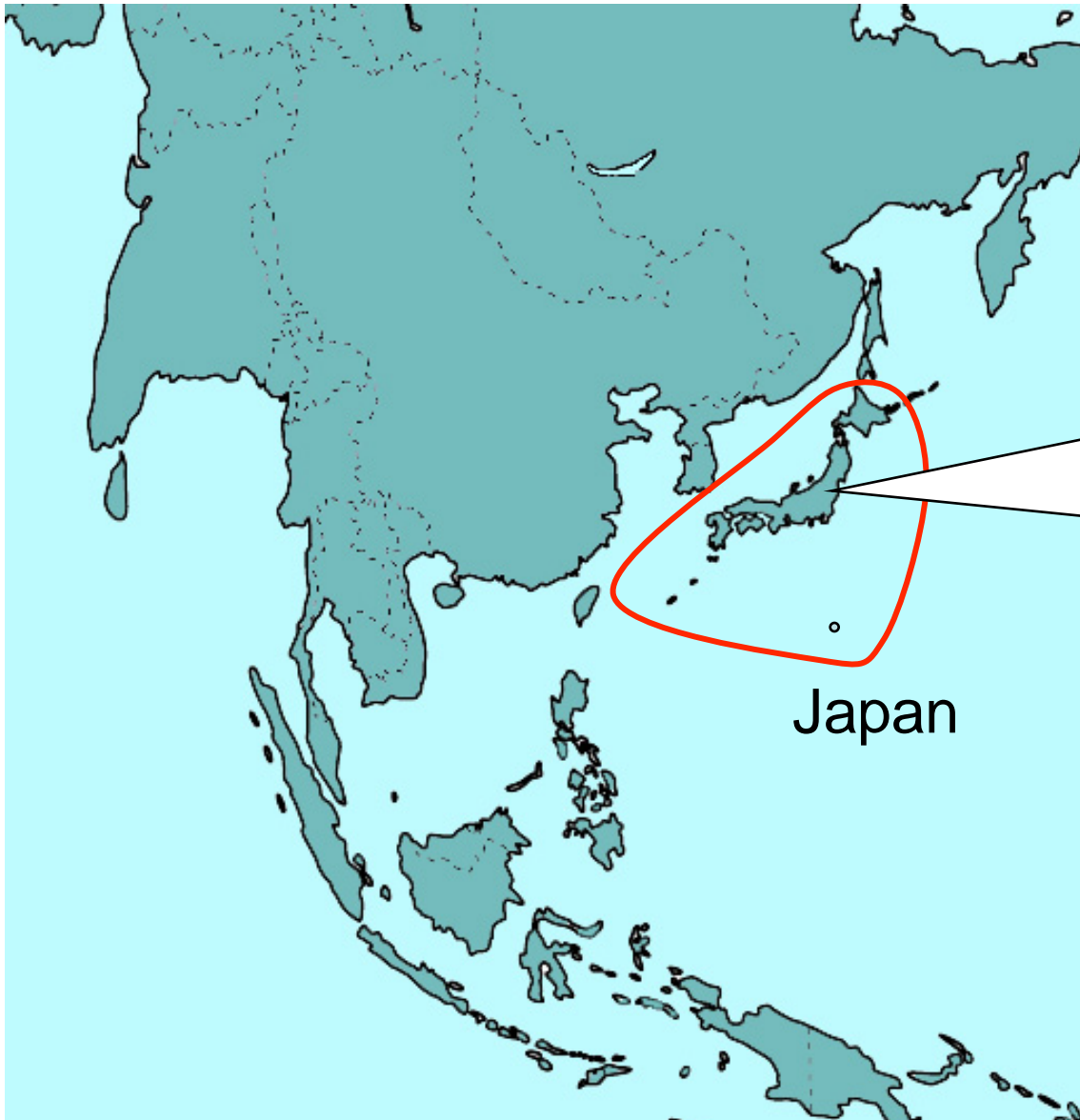
Indonesia

Nepal

India

Genotypes of *P. infestans* in Asian Countries 1992-2000

(Gotoh et al. 2005)



Genotypes of
P. Infestans
in Japan



Population of *P. infestans* in Japan

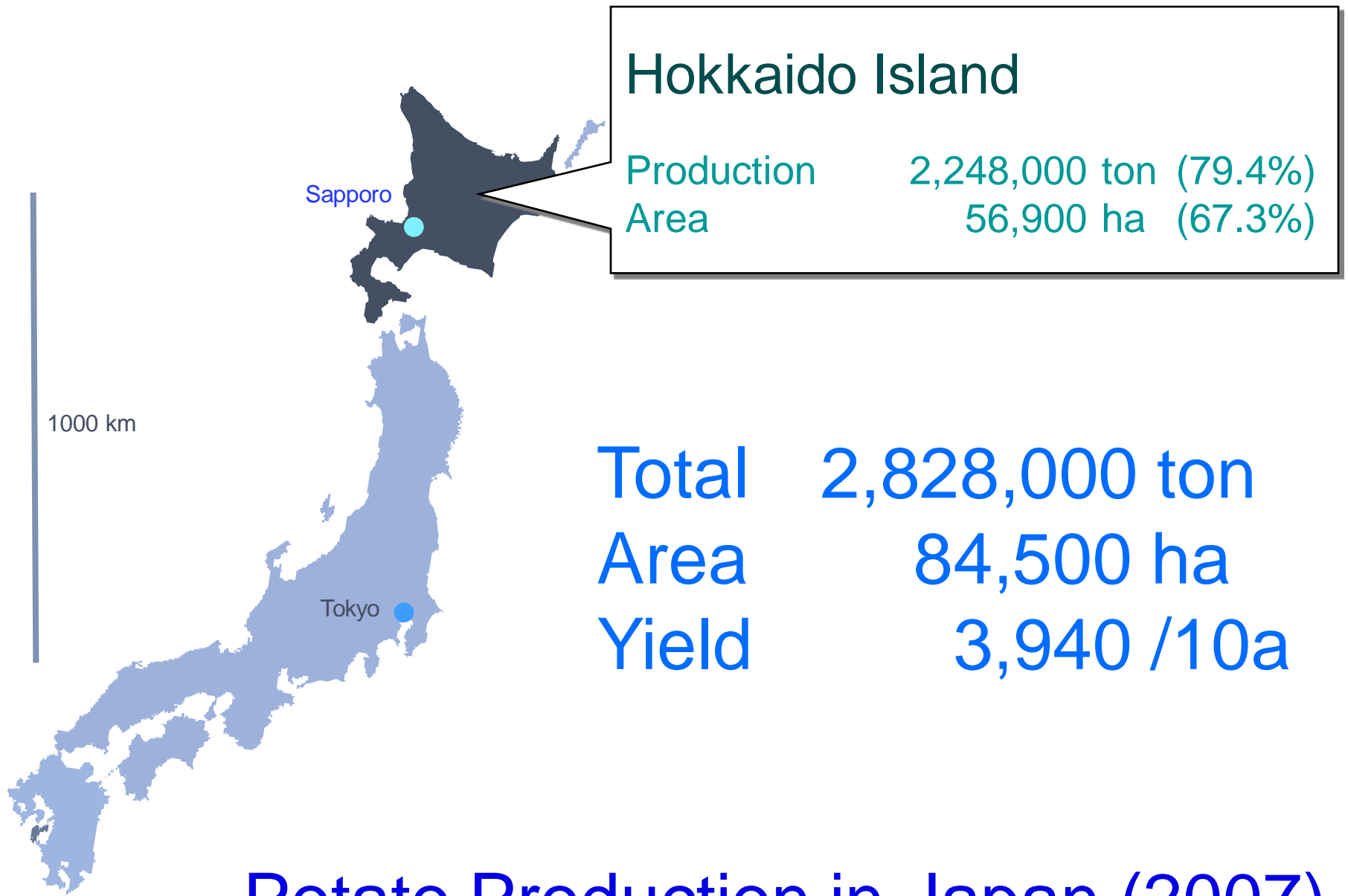
1. Transition of Japanese population
2. Genetic relationship among the dominant groups
3. Relationship with European population
4. Characters of Japanese isolates



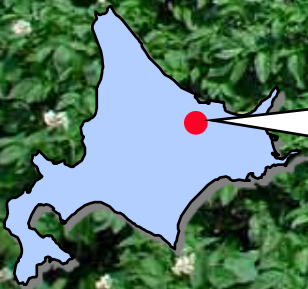


Total	2,828,000 ton
Area	84,500 ha
Yield	3,940 /10a

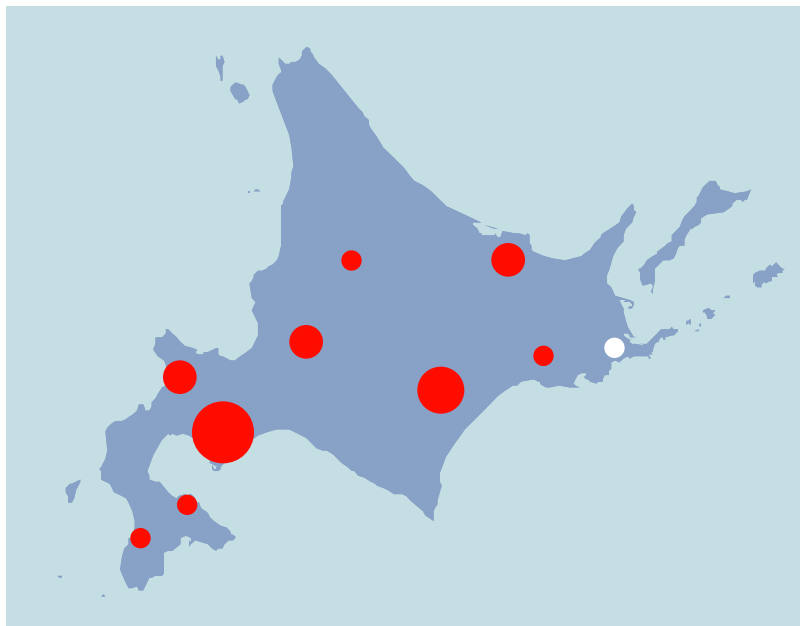
Potato Production in Japan (2007)



Potato Production in Japan (2007)

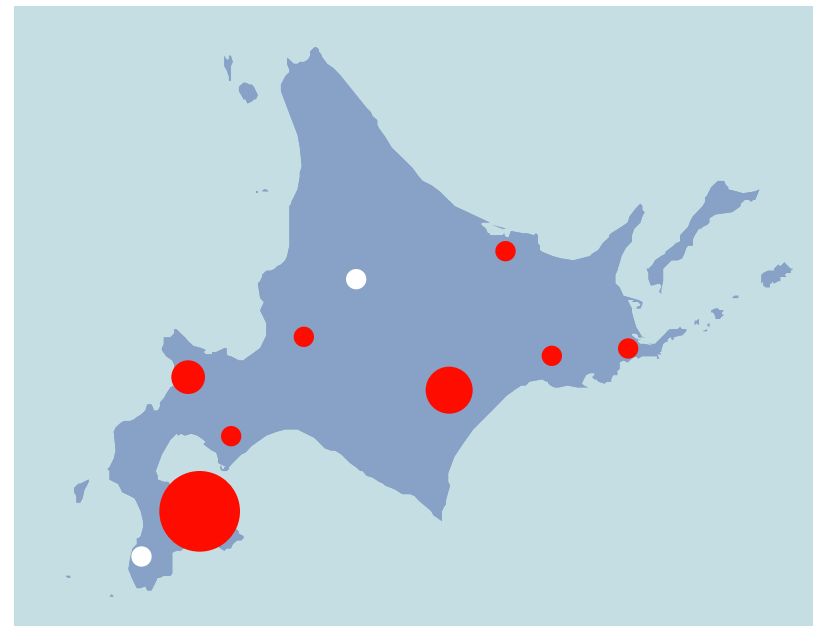
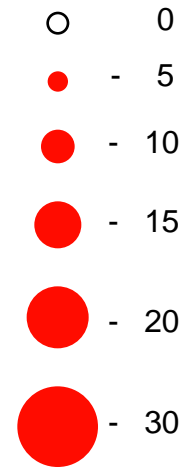


Kitami
Hokkaido



July 2006

% Plant



July 2008

The rate of diseased plants in Hokkaido

Data : Hokkaido Plant Protection Office

Population of *P. infestans* in Japan

1. Transition of Japanese population

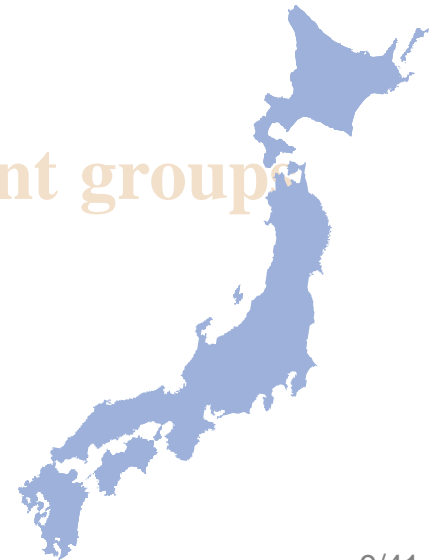
Identification of Japanese type of isolates

Temporal changes of Japanese population

Genetic relationship among the dominant groups

Relationship with European population

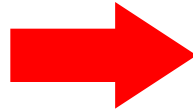
Characters of Japanese genotypes



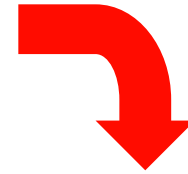
Characterization of Japanese isolates of *P. infestans*



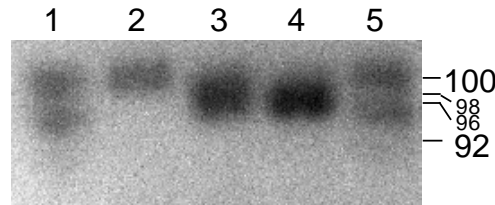
Diseased leaves



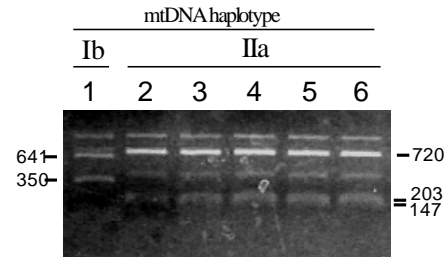
Isolates of *P. infestans*



Mating type



Allozymes
(*Gpi* / *Pep*)



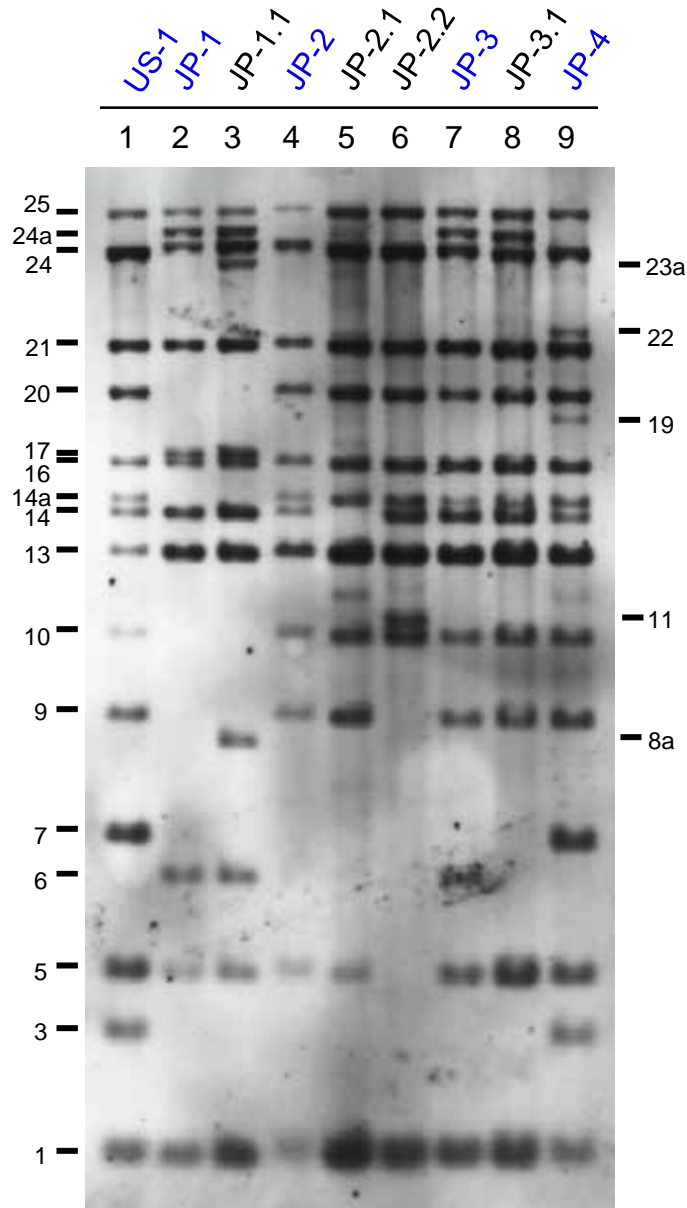
mtDNA
haplotypes



RG57
fingerprints

Multilocus genotypes of Japanese *Phytophthora infestans* based on mating type, two allozymes, RG57 fingerprint and mtDNA haplotype

RG57 type	Mating type	<i>Gpi</i>	<i>Pep</i>	RFLP (RG57: Bands 1-25, 8a, 14a, 23a and 24a)	mtDNA haplotype	Number of isolates
US-1	A1	86/100	92/100	101 010 101 100 110 100 011 001 101 00	Ib	70
JP-1	A2	100/100	96/96	100 011 000 000 110 110 001 001 100 01	IIa	404
JP-1.1	A2	100/100	96/96	100 011 000 000 110 110 001 001 110 11	IIa	3
JP-2	A1	100/100	100/100	100 010 001 100 110 100 011 001 101 00	IIa	136
JP-2.1	A1	100/100	100/100	100 010 001 100 100 100 011 001 101 00	IIa	2
JP-2.2	A1	100/100	100/100	100 000 001 110 110 100 011 001 101 00	IIa	1
JP-3	A1	100/100	96/100	100 011 001 100 110 100 011 001 101 00	IIa	325
JP-3.1	A1	100/100	96/100	100 010 001 100 110 100 011 001 101 00	IIa	1
JP-4	A1	100/100	96/100	101 010 101 100 110 100 111 101 101 00	IIa	156

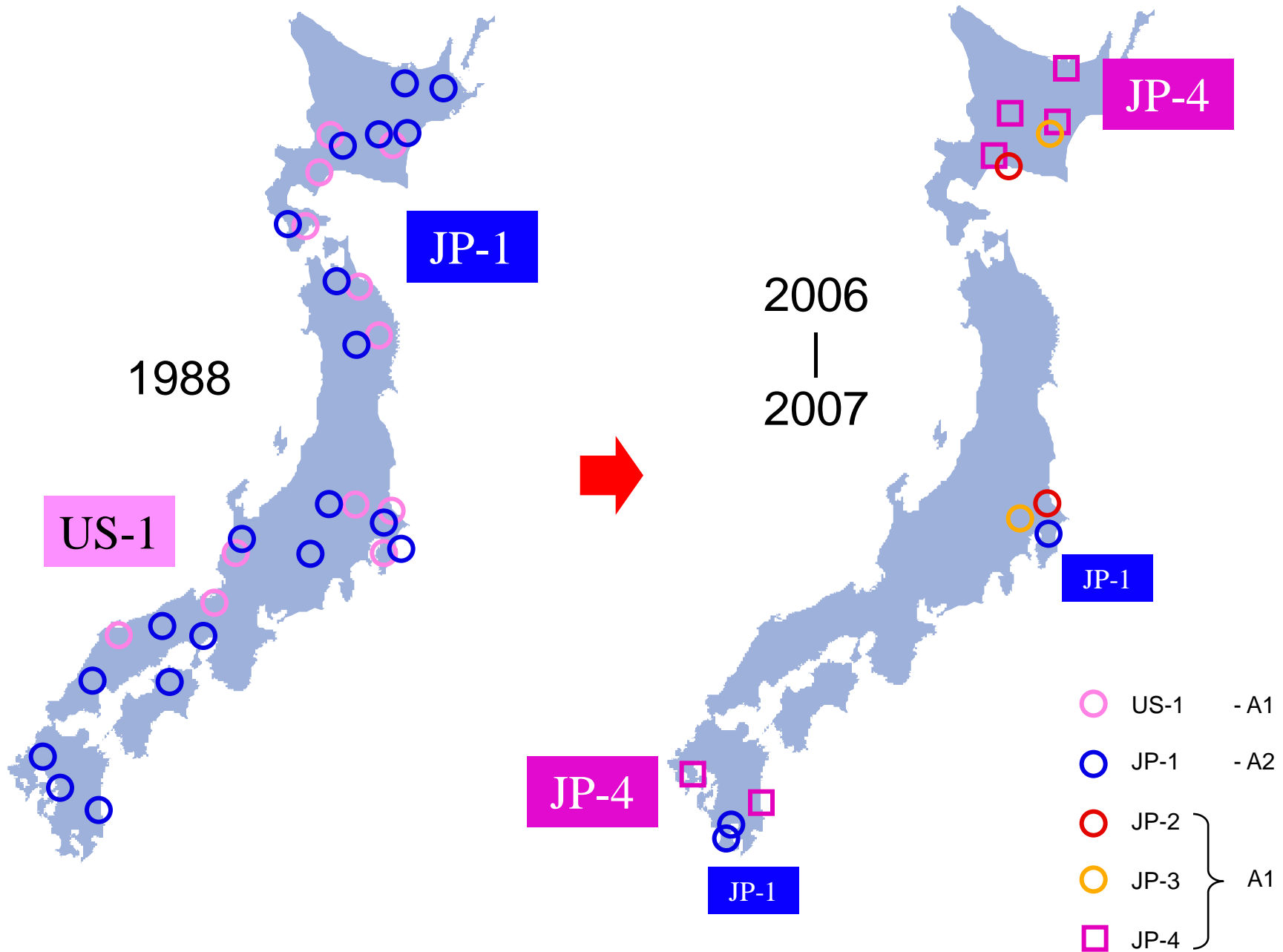


RG57 fingerprints of Japanese isolates

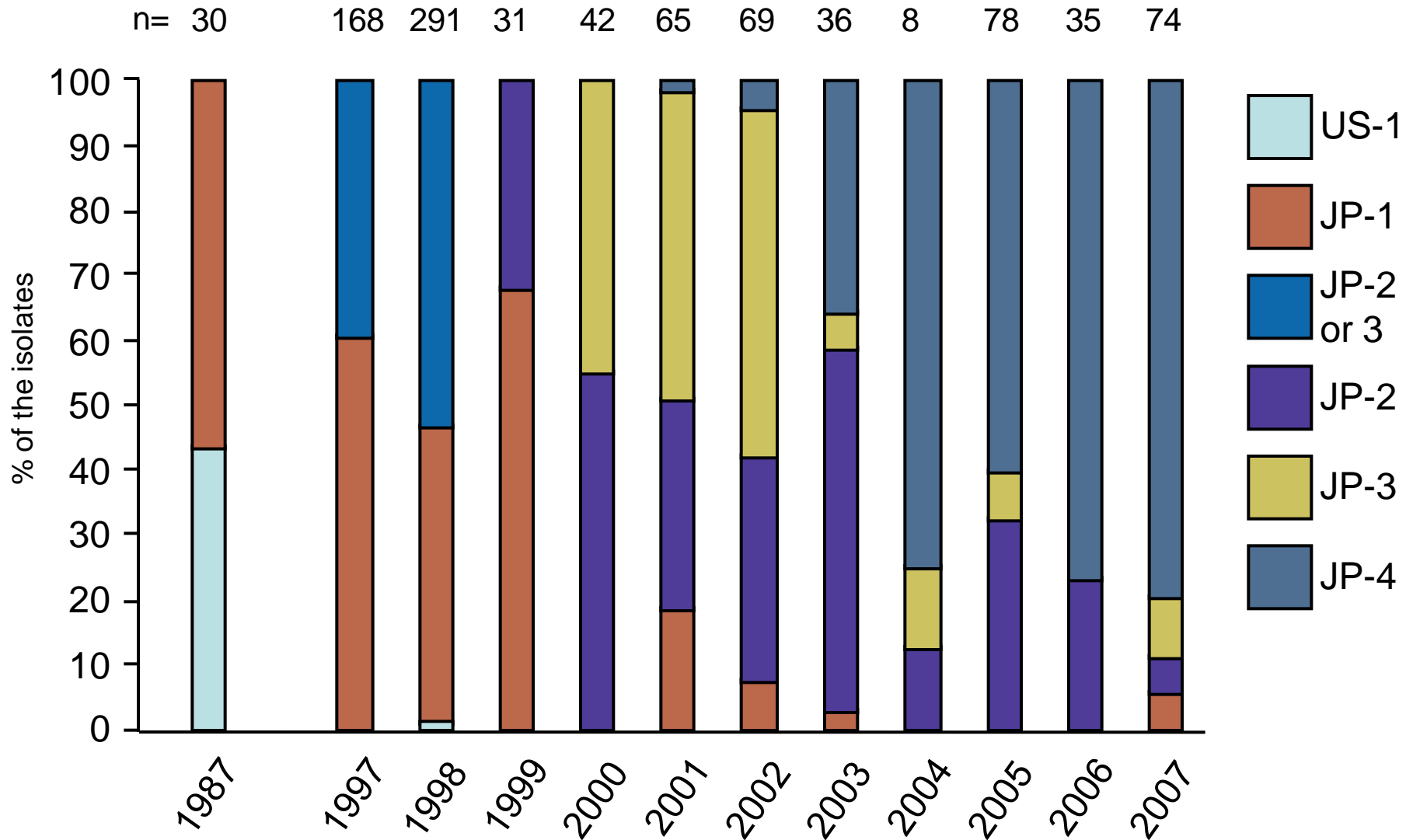
Fig. Genomic restriction fragment length polymorphisms (RFLPs) using the RG57 probe of each isolate. Lanes: 1, ATCC940501 (US-1 multilocus genotype, control); 2, HK0112 (JP-1); 3, DN0217-2 (JP-1.1); 4, KM0125 (JP-2); 5, SS0115 (JP-2.1); 6, KM0103 (JP-2.2); 7, TK0120 (JP-3); 8, KS0108 (JP-3.1); 9, KM0102 (JP-4). The numbers on the left and right are band numbers, as indicated in Forbes et al. (1998)

Multilocus genotypes of Japanese *Phytophthora infestans* based on mating type, two allozymes, RG57 fingerprint and mtDNA haplotype

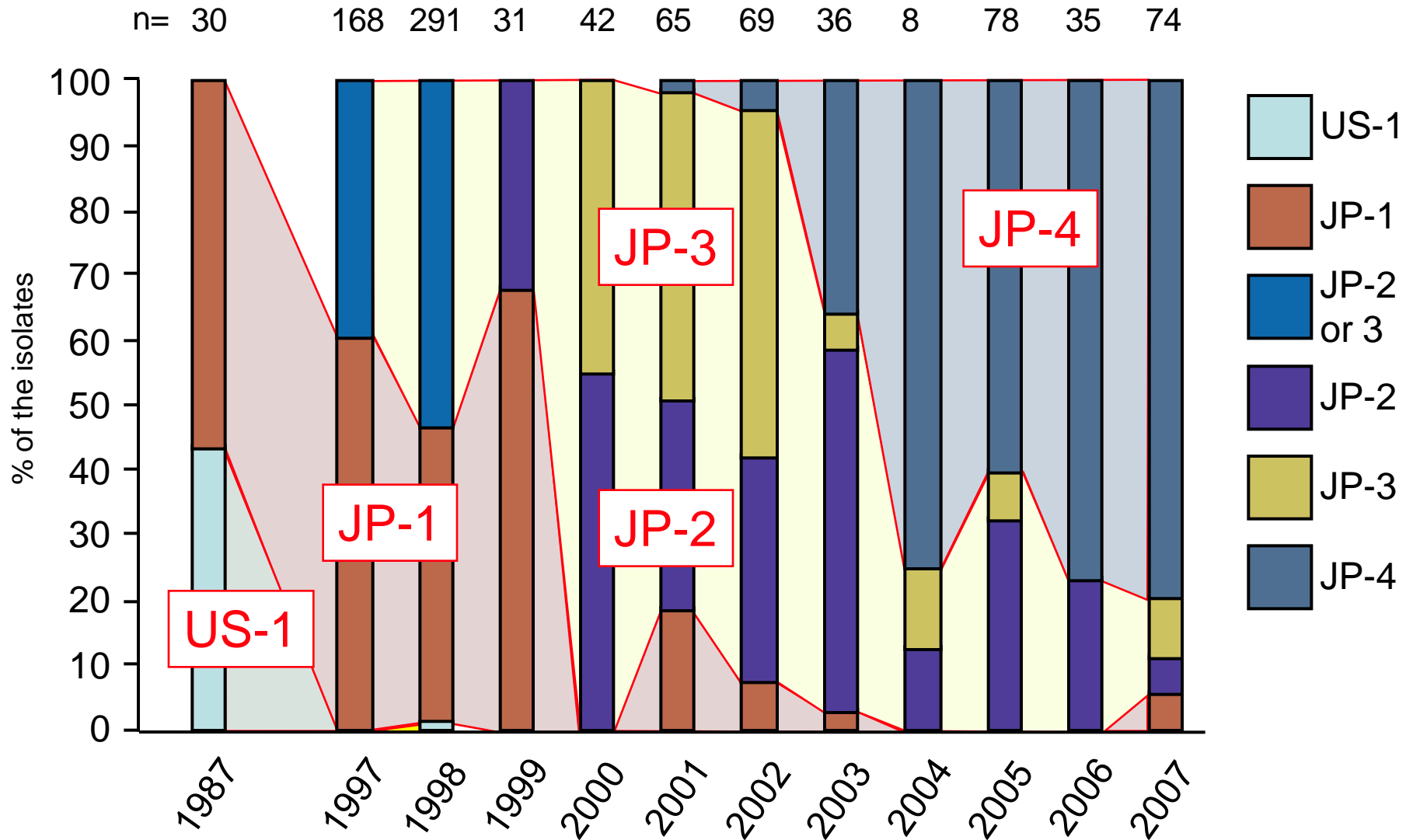
RG57 type	Mating type	<i>Gpi</i>	<i>Pep</i>	RFLP (RG57: Bands 1-25, 8a, 14a, 23a and 24a)	mtDNA haplotype
US-1	A1	86/100	92/100	101 010 101 100 110 100 011 001 101 00	Ib
JP-1	A2	100/100	96/96	100 011 000 000 110 110 001 001 100 01	IIa
JP-2	A1	100/100	100/100	100 010 001 100 110 100 011 001 101 00	IIa
JP-3	A1	100/100	96/100	100 011 001 100 110 100 011 001 101 00	IIa
JP-4	A1	100/100	96/100	101 010 101 100 110 100 111 101 101 00	IIa



Temporal changes of Japanese population



Temporal changes of Japanese population



Temporal changes of Japanese population

Population of *P. infestans* in Japan

Transition of Japanese population

2. Genetic relationship among dominant groups

JP-1

JP-2

JP-3

JP-4

Estimation of a parent - progeny relationship

Migration and sexual reproduction -

Cause of the appearance of new genotypes

Relationship with European population

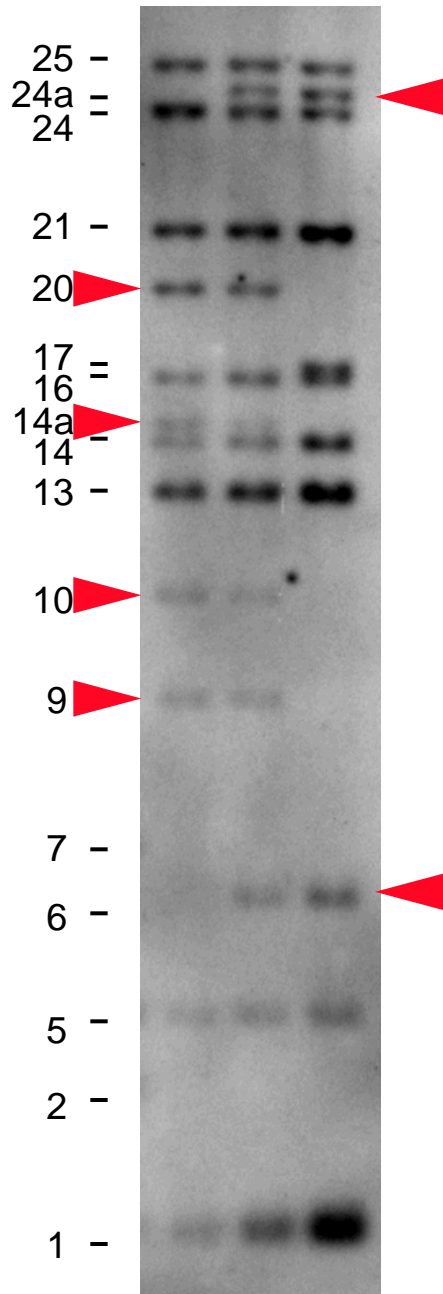
Characters of Japanese isolates



Characters of Japanese isolates of *P. infestans*

RG57 type	mating type	<i>Gpi</i>	<i>Pep</i>	mtDNA
JP-1	A2	100/100	96/96	Ila
JP-2	A1	100/100	100/100	Ila
JP-3	A1	100/100	96/100	Ila
JP-4	A1	100/100	96/100	Ila

JP-2 3 1



(A1)

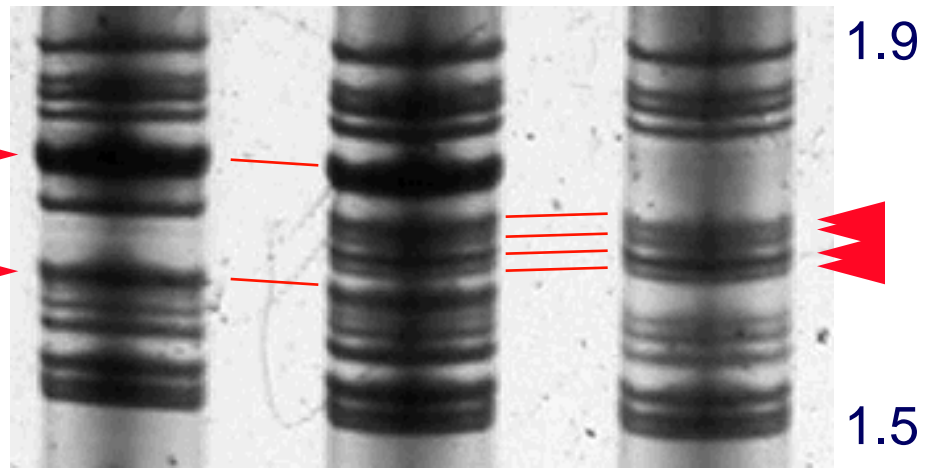
JP-2

(A2)

JP-3

JP-1

(kb)

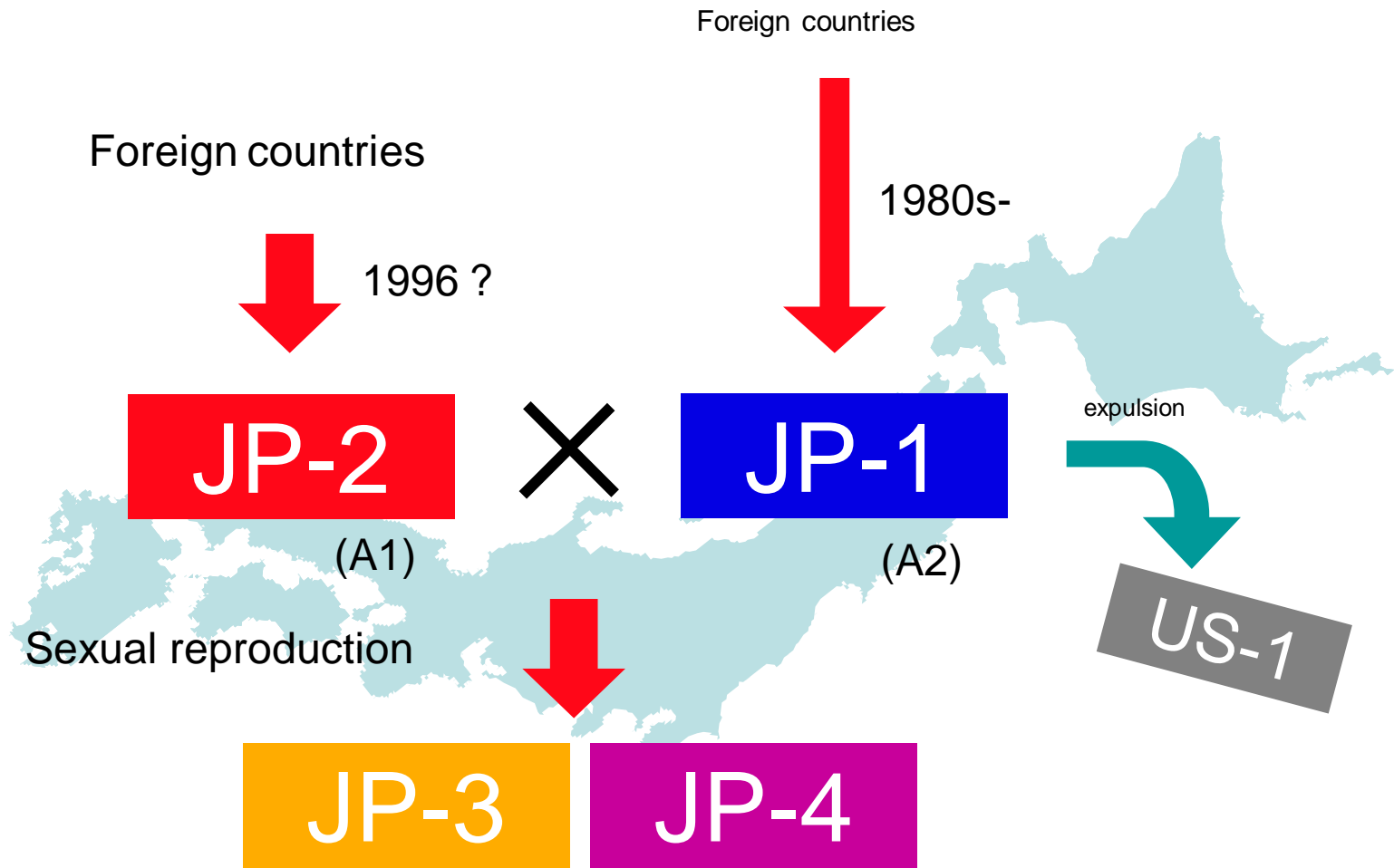


AFLP fingerprints

E-AT / M-CAA primers
6% Urea-PAGE

Bands: **JP-1** + **JP-2** → **JP-3**

RG57 fingerprints



Progeny (A1): domestic genotypes

Populations of *P. infestans* in Japan

Transition of Japanese populations
Genetic relationship of dominant groups

3. Relationship with European population

The Domestic and the international groups in Japan

JP-2

the pan-Eurasian groups of *P. infestans* ?

Characters of Japanese isolates



Multilocus genotypes of Japanese *Phytophthora infestans* based on mating type, two allozymes, RG57 fingerprint and mtDNA haplotype

RG57 type	mating type	<i>Gpi</i>	<i>Pep</i>	RFLP (RG57: Bands 1-25, 14a and 23a)	mtDNA haplotype
US-1	A1	86/100	92/100	101 010 101 100 110 100 011 001 110	Ib
JP-1	A2	100/100	96/96	100 011 000 000 110 110 001 001 101	IIa
JP-2	A1	100/100	100/100	100 010 001 100 110 100 011 001 110	IIa
JP-3	A1	100/100	96/100	100 011 001 100 110 100 011 001 111	IIa
JP-4	A1	100/100	96/100	101 010 101 100 110 100 111 101 110	IIa

Multilocus genotypes of Japanese *Phytophthora infestans* based on mating type, two allozymes, RG57 fingerprint and mtDNA haplotype

RG57 type	mating type	<i>Gpi</i>	<i>Pep</i>	RFLP (RG57: Bands 1-25, 14a and 23a)	mtDNA haplotype
US-1	A1	86/100	92/100	101 010 101 100 110 100 011 001 110	Ib
JP-1	A2	100/100	96/96	100 011 000 000 110 110 001 001 101	IIa
JP-2	A1	100/100	100/100	100 010 001 100 110 100 011 001 110	IIa
JP-3	A1	100/100	96/100	100 011 001 100 110 100 011 001 111	IIa
JP-4	A1	100/100	96/100	101 010 101 100 110 100 111 101 110	IIa

Domestic groups in Japan

Multilocus genotypes of Japanese *Phytophthora infestans* based on mating type, two allozymes, RG57 fingerprint and mtDNA haplotype

RG57 type	mating type	<i>Gpi</i>	<i>Pep</i>	RFLP (RG57: Bands 1-25, 14a and 23a)	mtDNA haplotype
US-1	A1	86/100	92/100	101 010 101 100 110 100 011 001 110	Ib
JP-1	A2	100/100	96/96	100 011 000 000 110 110 001 001 101	IIa
JP-2	A1	100/100	100/100	100 010 001 100 110 100 011 001 110	IIa
JP-3	A1	100/100	96/100	100 011 001 100 110 100 011 001 111	IIa
JP-4	A1	100/100	96/100	101 010 101 100 110 100 111 101 110	IIa

RG57 type	mating type	<i>Gpi</i>	<i>Pep</i>	RG57 (Bands 1-25, and 14a)	mtDNA haplotype
JP-2	A1	100/100	100/100	100 010 001 100 110 100 011 001 11	IIa
Korea		————		(2002)	Ryu (2002)
China		He-Gan A1-A		(1996)	Akino et al. (2004)
		————		(1999)	Guo et al. (2008)
Russia		SIB1		(1993)	Elansky et al. (2001)
England		RF06		(1996)	Purvis et al. (2001)
Ireland		NI-1		(1998)	Cooke et al. (2006)
Scotland		(Type b)		(1995)	Cooke et al. (2003)

RG57 type	mating type	<i>Gpi</i>	<i>Pep</i>	RG57 (Bands 1-25, and 14a)	mtDNA haplotype
JP-2	A1	100/100	100/100	100 010 001 100 110 100 011 001 11	IIa
					14a

Korea — (2002) 14a OK! Ryu (2002)

China He-Gan A1-A (1996) 14a OK! Akino et al. (2004)

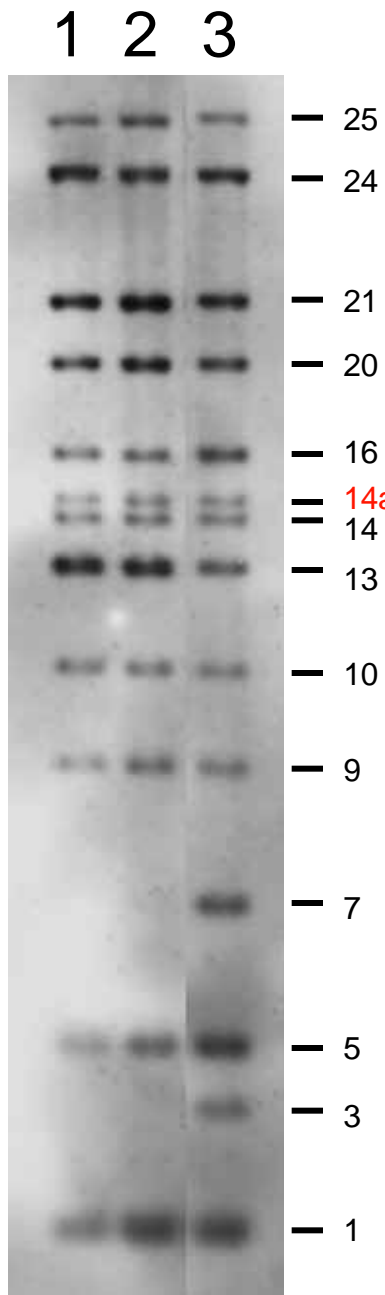
— 14a? (1999) Guo et al. (2008)

Russia SIB1 14a? (1993) Elansky et al. (2001)

England RF06 14a? (1996) Purvis et al. (2001)

Ireland NI-1 14a? (1998) Cooke et al. (2006)

Scotland (Type b) 14a? (1995) Cooke et al. (2003)



1: He-Gan A1-A (China)
2: JP-2 (Japan)
3: US-1 (United States)

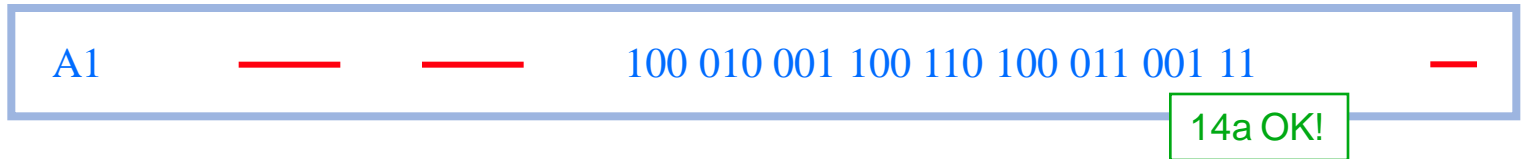
14a

Band 14a in
the RG57 fingerprints

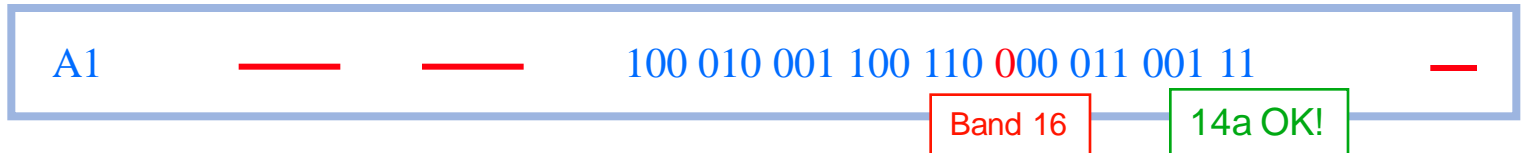
Akino et al. (2004)

RG57 type	mating type	<i>Gpi</i>	<i>Pep</i>	RG57 (Bands 1-25, and 14a)	mtDNA haplotype
JP-2	A1	100/100	100/100	100 010 001 100 110 100 011 001 11	IIa
					14a

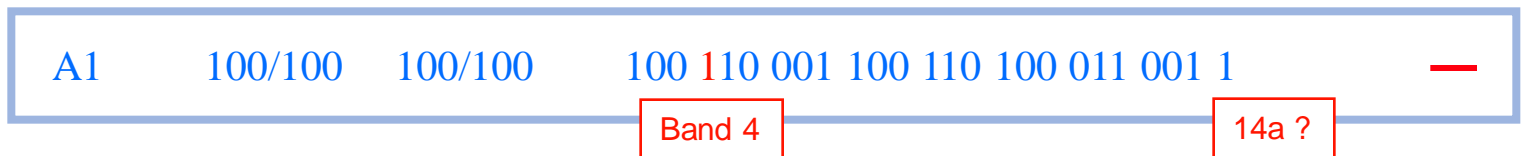
Norway / Finland N-1 (1996) / F-2 (1992) Bruberg et al. (2002)

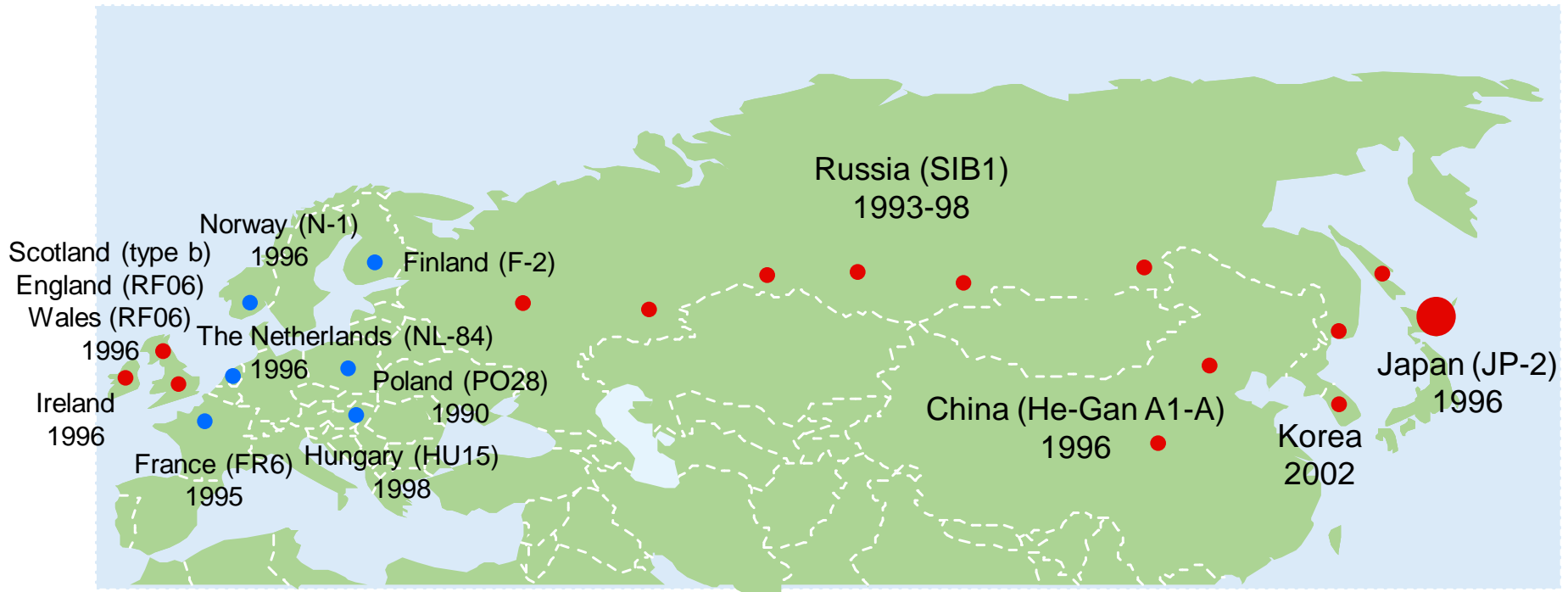


The Netherlands NL-84 (1996) Zwankhuisen et al. (2000)



Poland PO-28 (1990) Suikowski et al. (1994)





Distribution of JP-2 analogues in the Eurasian Continent

- Identical with JP-2 in mating type, allozymes, mtDNA haplotype and RG57 pattern (without band 14a)
- Similar with JP-2, but slightly difference in RG57 pattern or some character unknown

Populations of *P. infestans* in Japan

Transition of Japanese populations
Genetic relationship of dominant groups
Relationship with European population

4. Characters of Japanese isolates

JP-1

JP-2

JP-3

JP-4

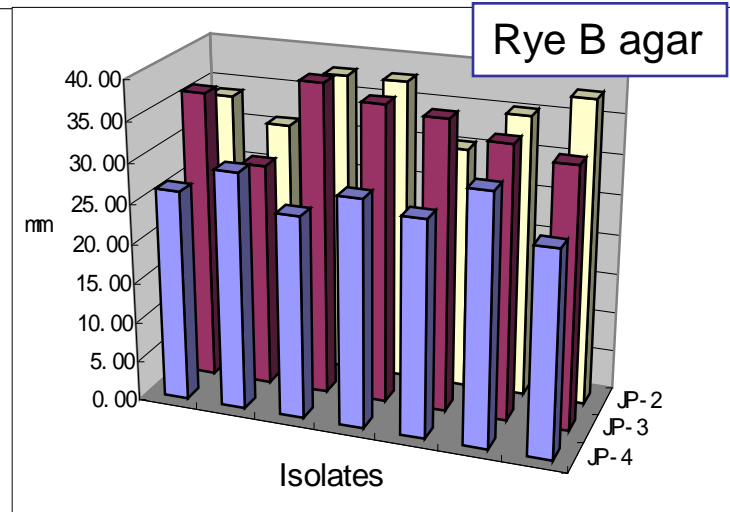
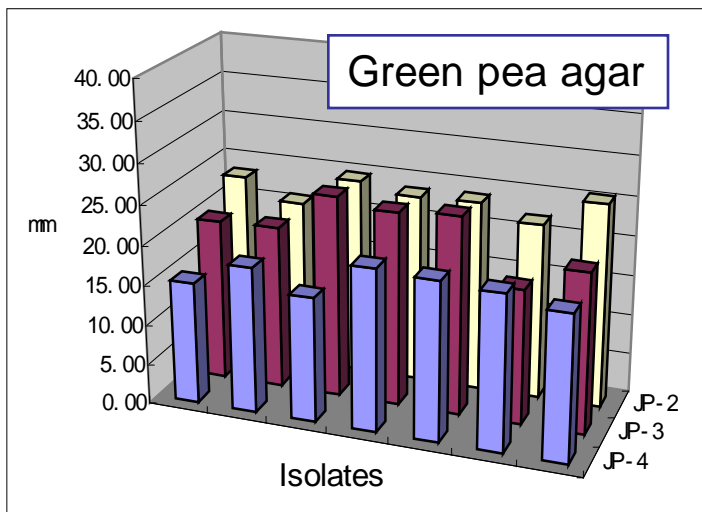
Characters on agar culture / ploidy

Aggressiveness against potato and tomato

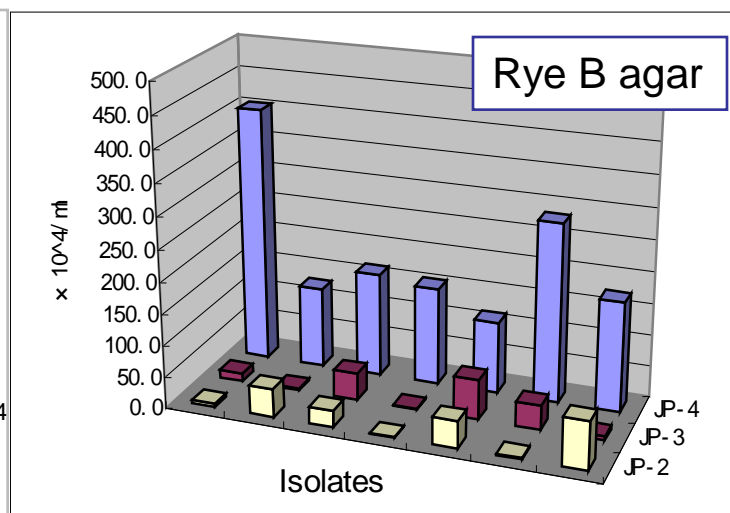
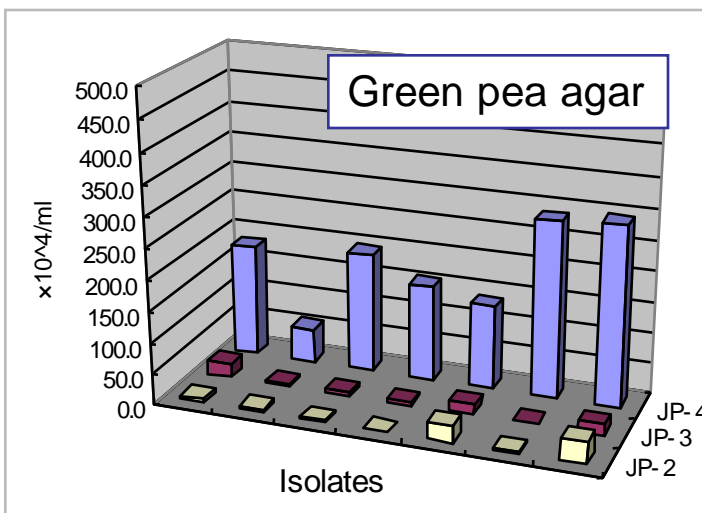
Metaraxyl sensitivity



Hyphal growth



Sporangia formation

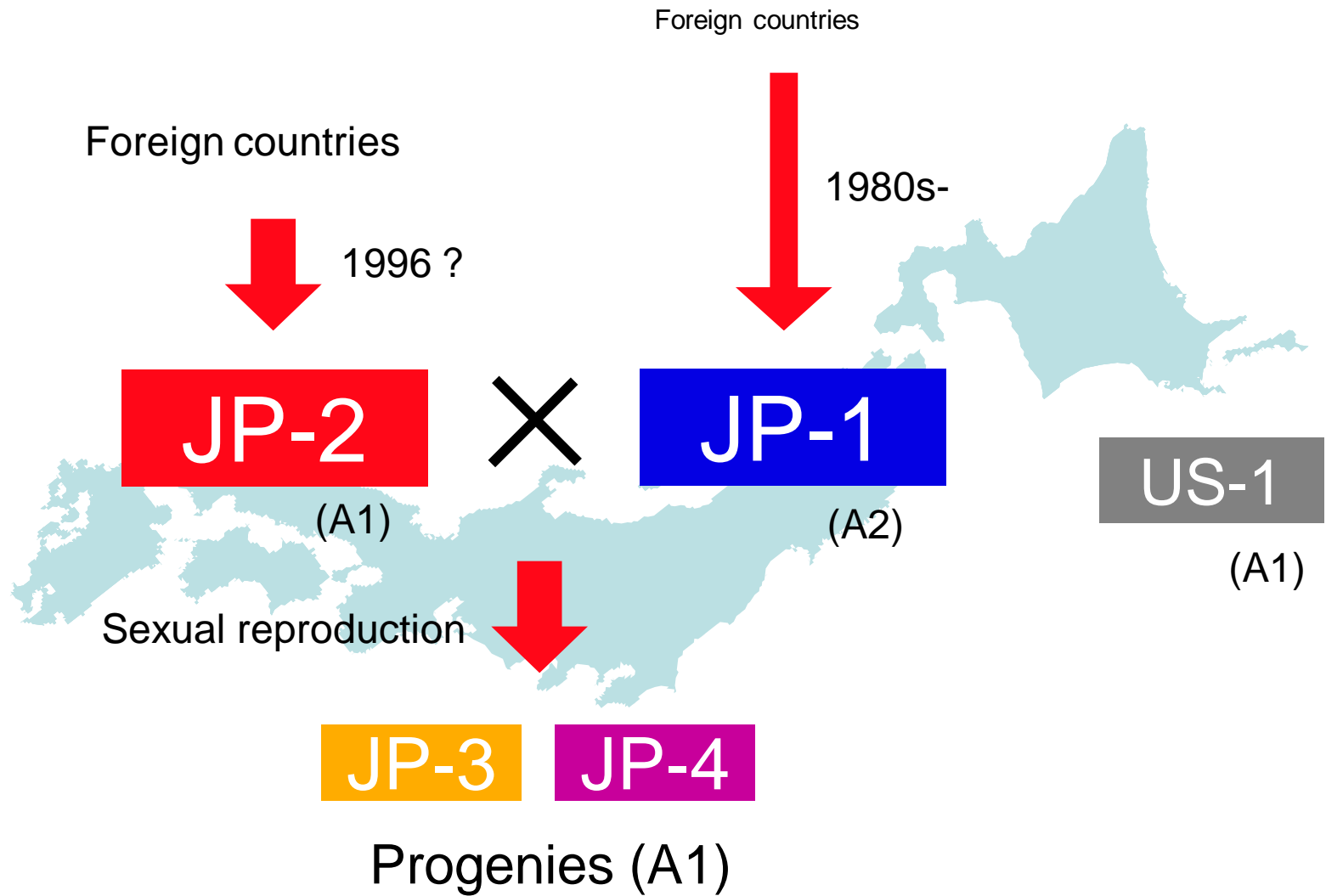


Characters on agar cultures

JP-2

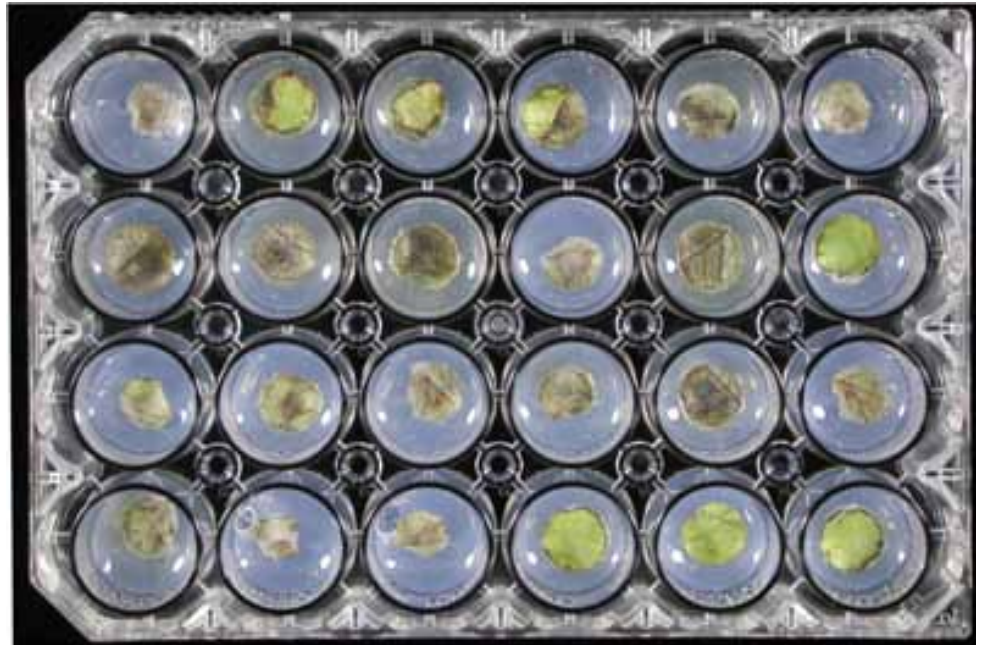
JP-3

JP-4

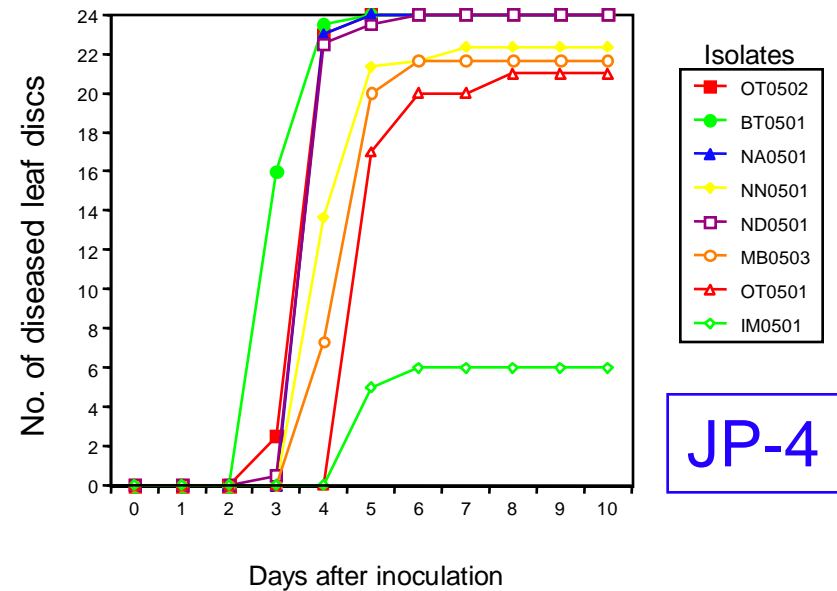
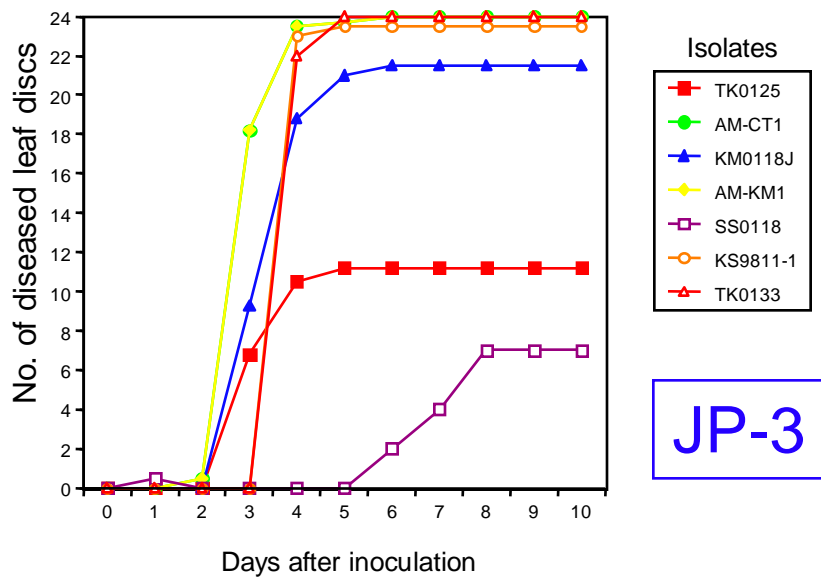
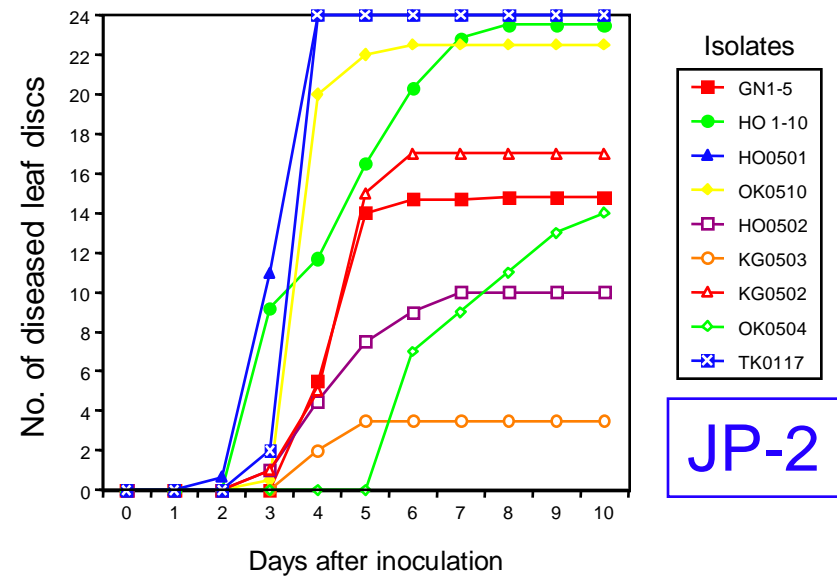
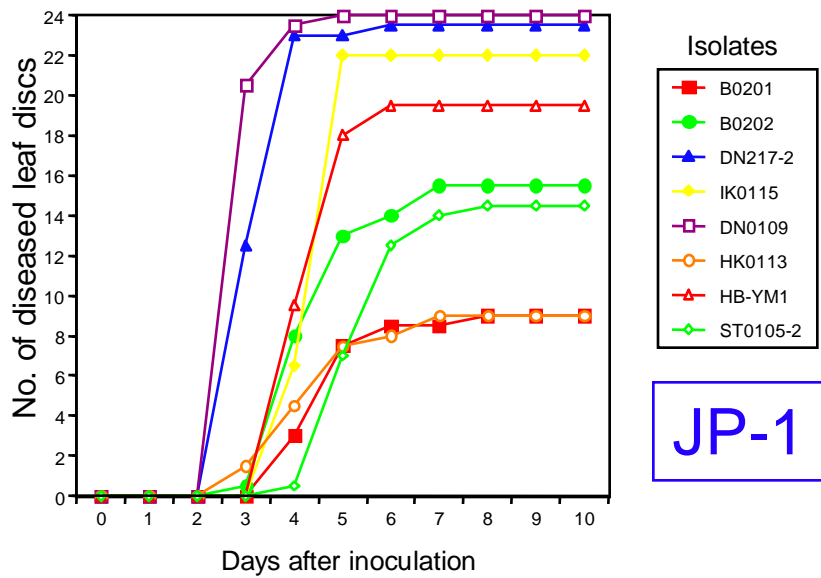


Ploidy of Japanese isolates

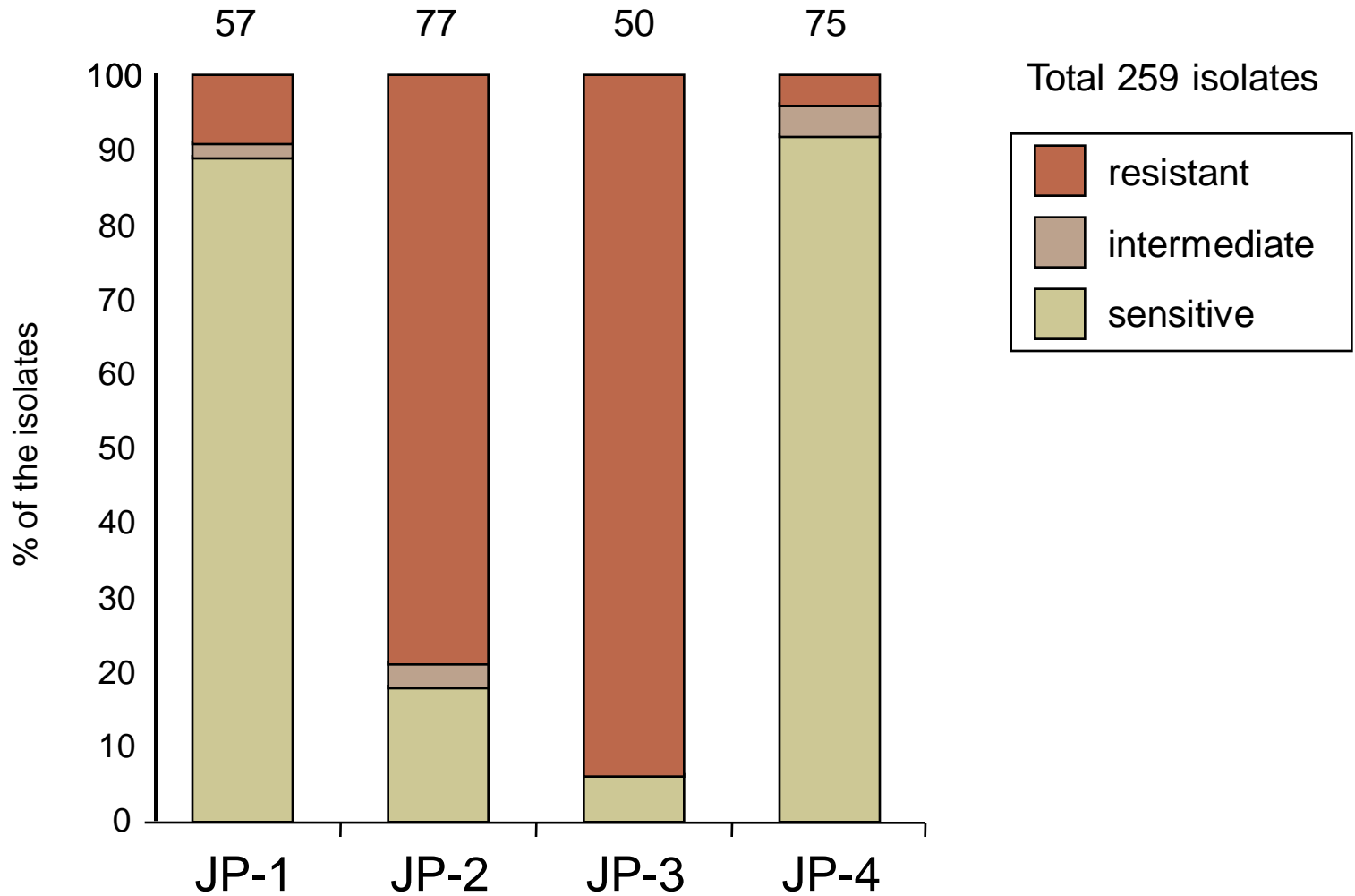
Inoculation of zoosporangia (200 sporangia / disc)



**Foliar aggressiveness test using detached leaves
and leaf disc method**



Foliar aggressiveness of Japanese isolates of *P.infestans*



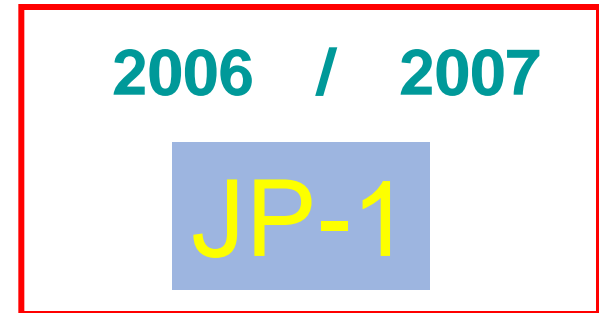
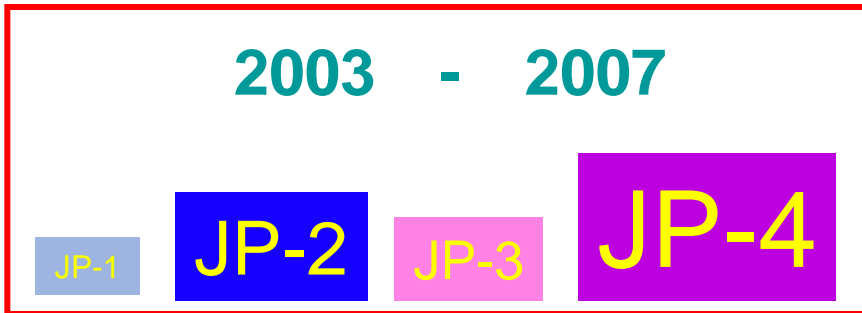
Metalaxyl sensitivity of Japanese isolates



Potato - Field



Tomato - Greenhouse



**Dominant groups of *P.infestans*
in potato and tomato**



JP-1



JP-4

Symptoms on tomato leaves

50 sporangia / drop
cv. Momotaro-fight



JP-1

JP-2

JP-3

JP-4

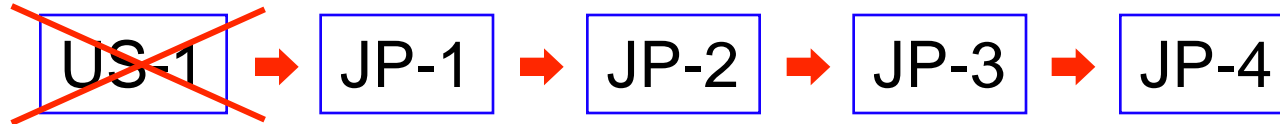
The cause of changes in the population...

Survival in winter season ?

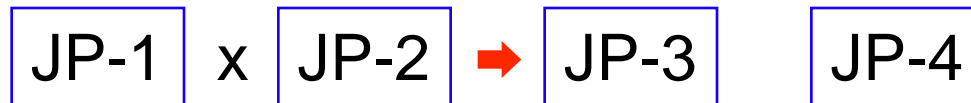
Competitive ability in potato fields ?

Populations of *P. infestans* in Japan

1. Transition of Japanese populations



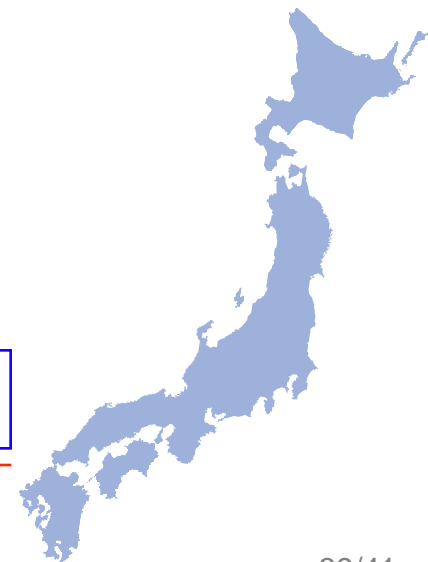
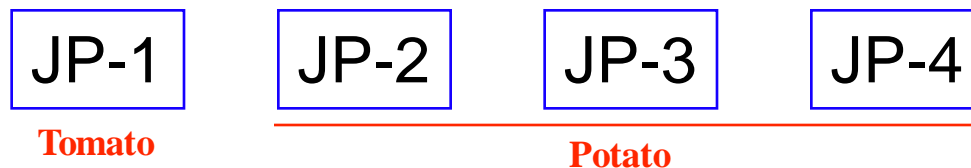
2. Genetic relationship of dominant groups

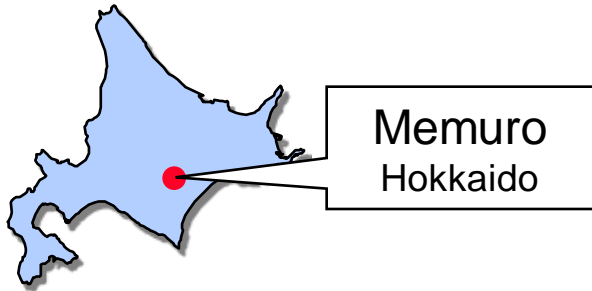


3. Relationship with European population



4. Characters of Japanese isolates

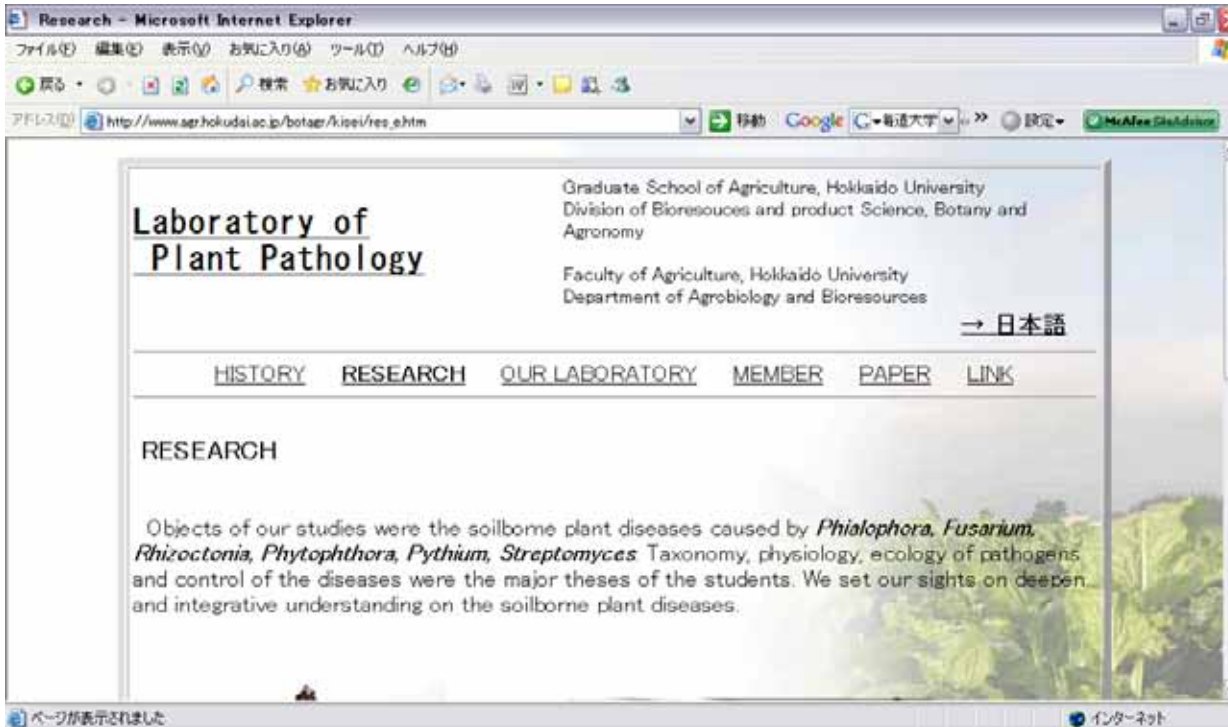




Late blight control in Japan: awaiting solution

Information about pathogens, varieties, fungicides

Introduction of the integrated control methods



Laboratory of Plant Pathology, Hokkaido University

