Blackleg of Canola – New Advances in Control and Resistance

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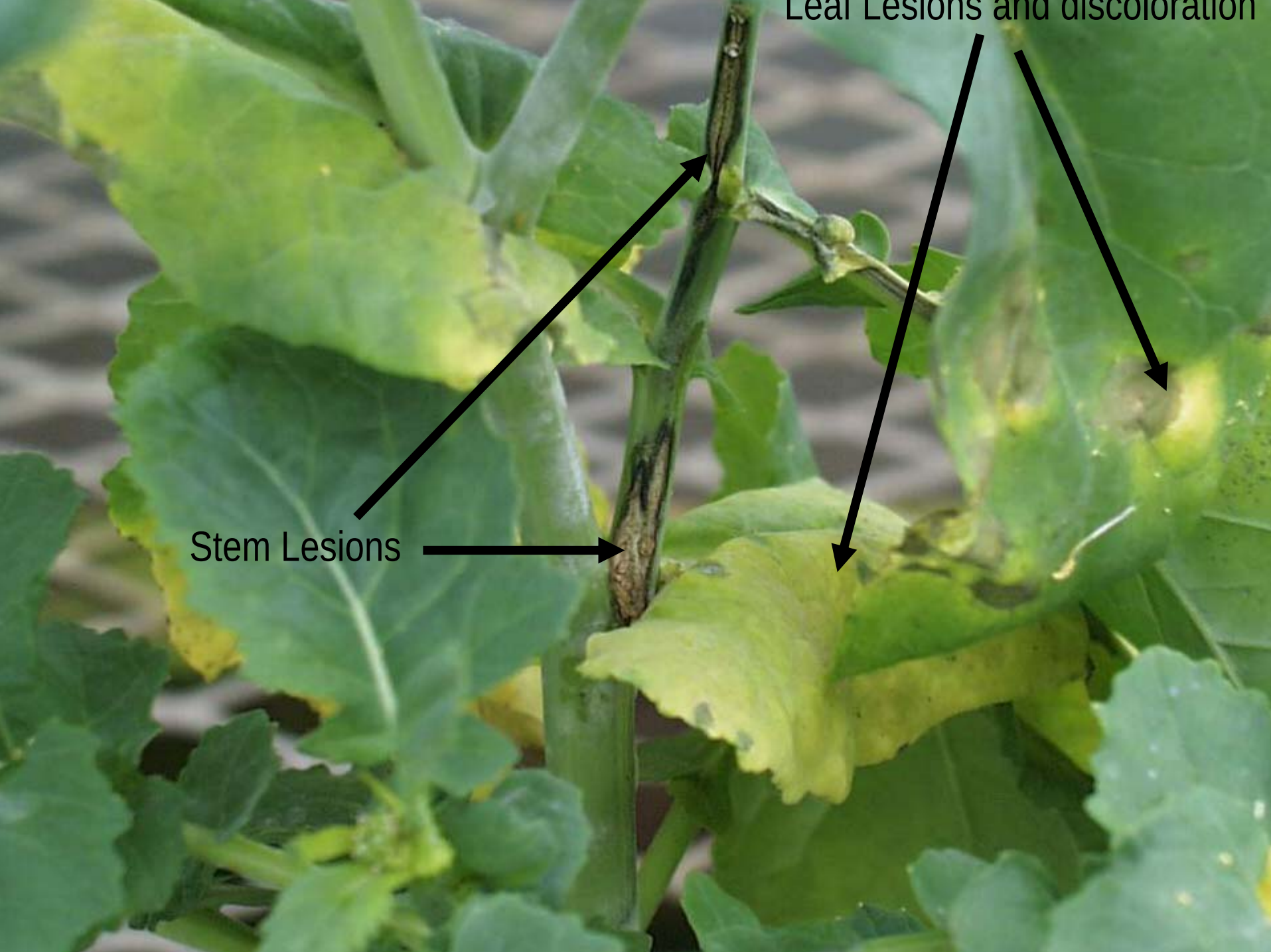
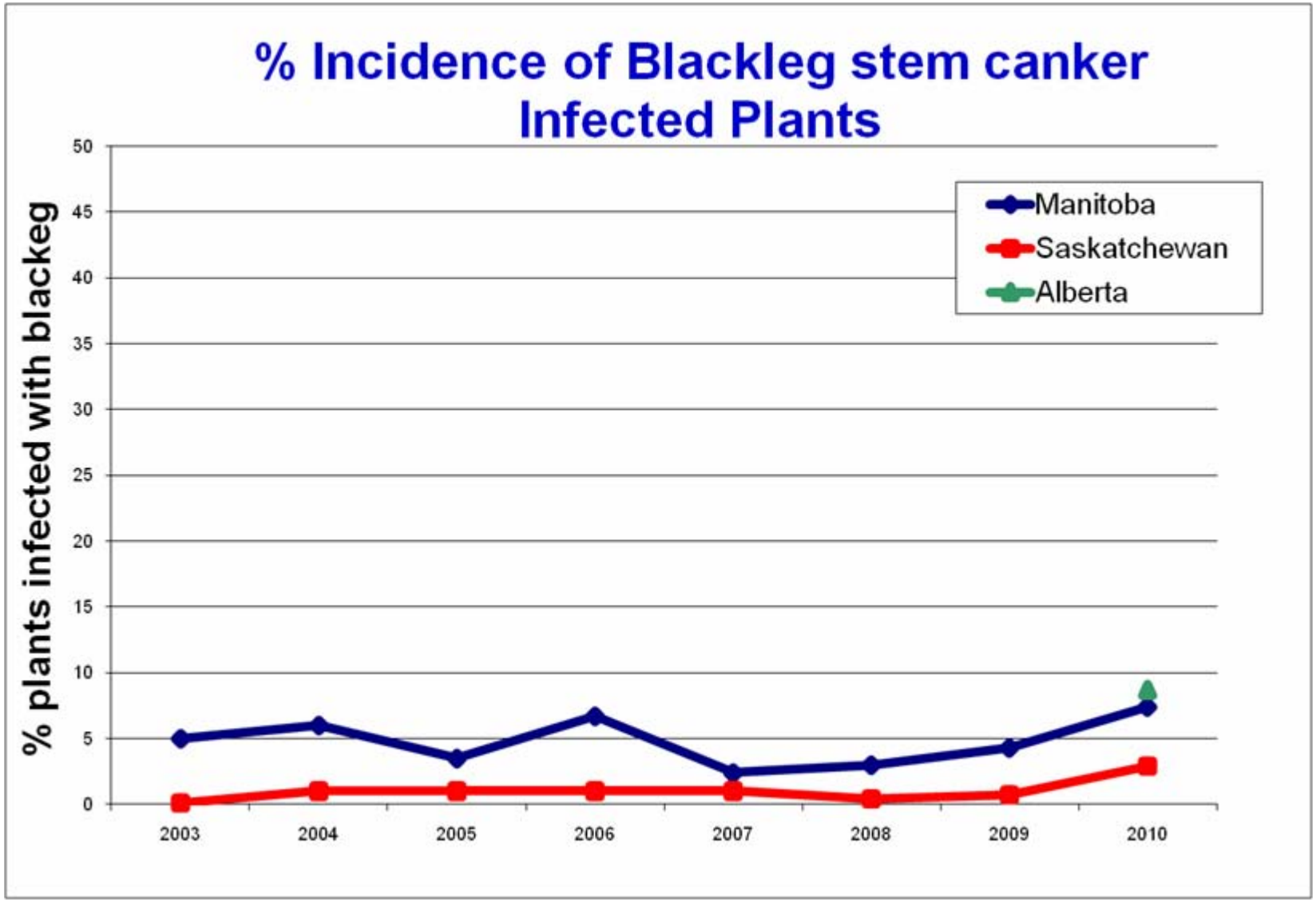
Symptoms of Blackleg


Leaf Lesions and discoloration
Stem Lesions

Canadian Situation



Courtesy Clint Jurke and Faye Dokken-Bouchard

Two types of resistance to *L. maculans*

R **gene-mediated resistance (complete resistance)**

Quantitative resistance (partial resistance)

susceptible

resistant

How should resistance be deployed?

- Resistance can fail if it is not applied correctly, as has happend in Australia and France.

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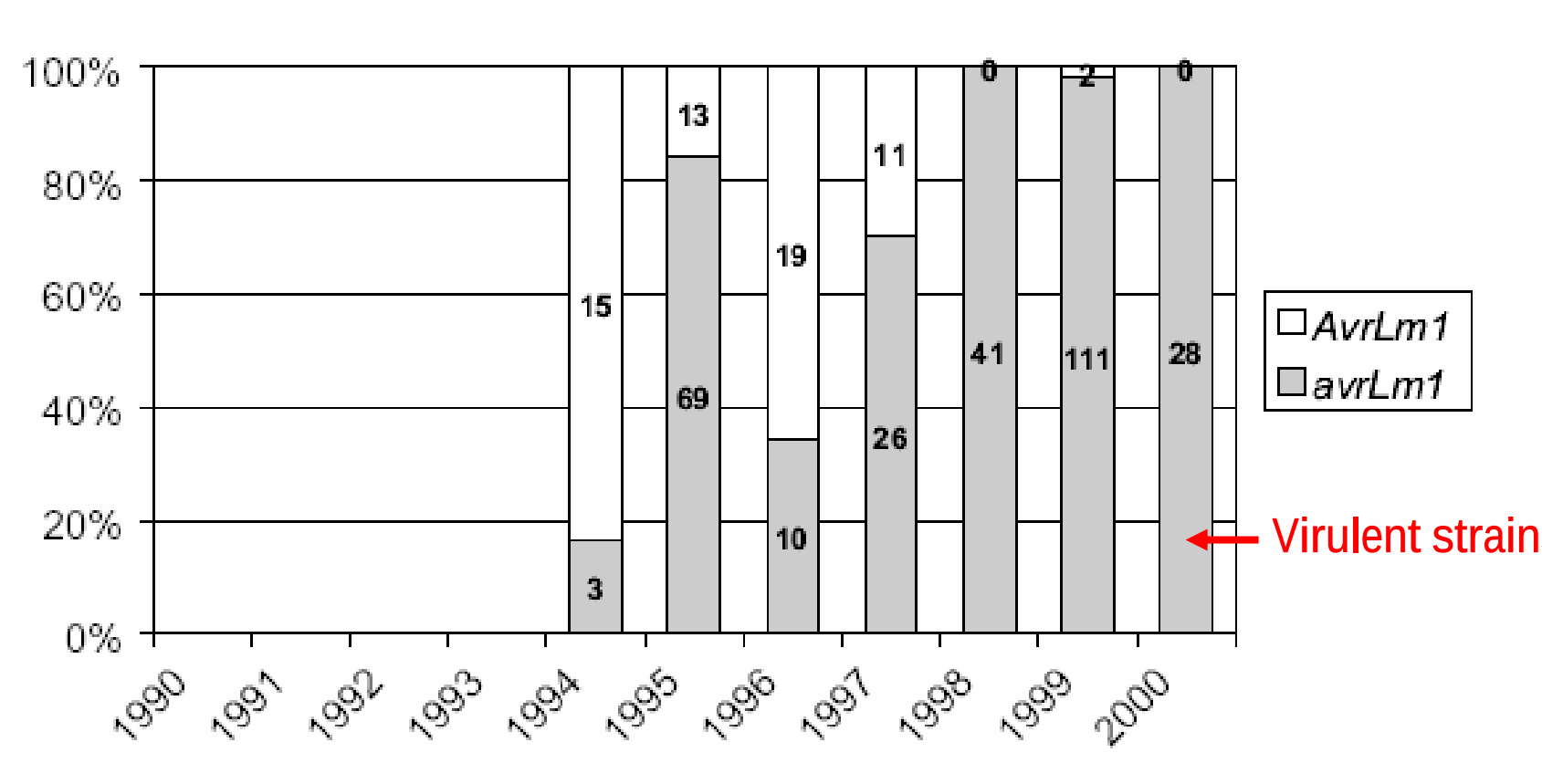
Situation in France

- **In France, the large-scale use of single *Rlm1* gene for ten years (1990 to 2000) shifted the population of isolates from *Avrlm1* to others (Rouxel et al., 2003) .**

- **Therefore the efficiency of resistance of the commercially successful cultivars harboring *Rlm1* decreased consistently between 1995 and 2003 in France. (Rouxel et. al. 2003)**

Frequency of isolates harboring *AvrLm1* or *avrLm1* from Cultivars with the major resistance gene *Rlm1*



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Rouxel et. al. 2003

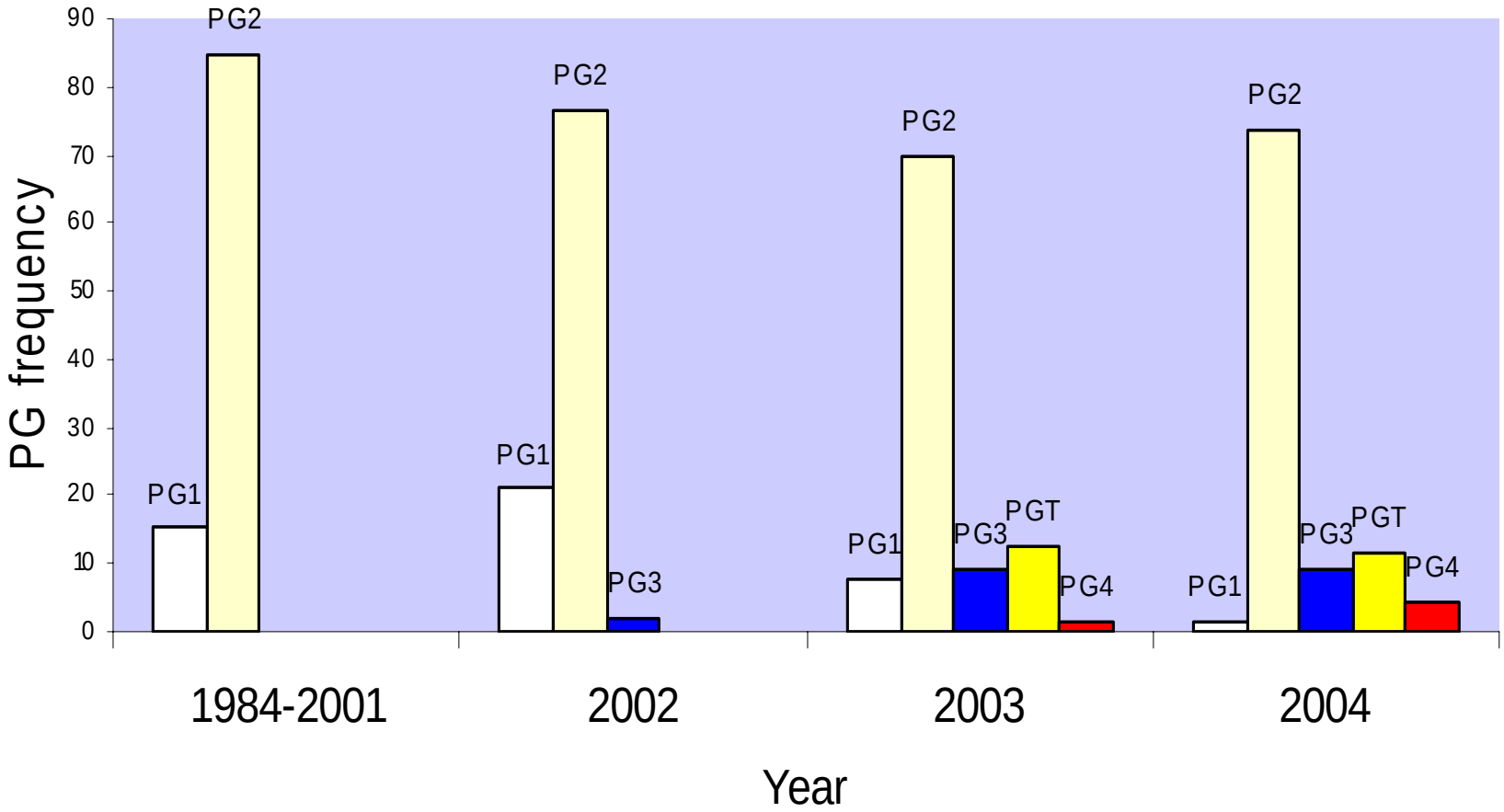
Situation in Australia

- **The Surpass 400 (*LepR3* gene resistance) derived cultivars became susceptible to blackleg within 2 years after being released – 'Boom and Bust'!**

- **Cause - due to large-scale use of single gene resistance (2001 to 2003) – loss $ 5 – 10 million / year**

- **Dominant single gene resistance being easily overcome by pathogen population shifts (Li et al, 2003).**

Situation in Western Canada in early 2000's

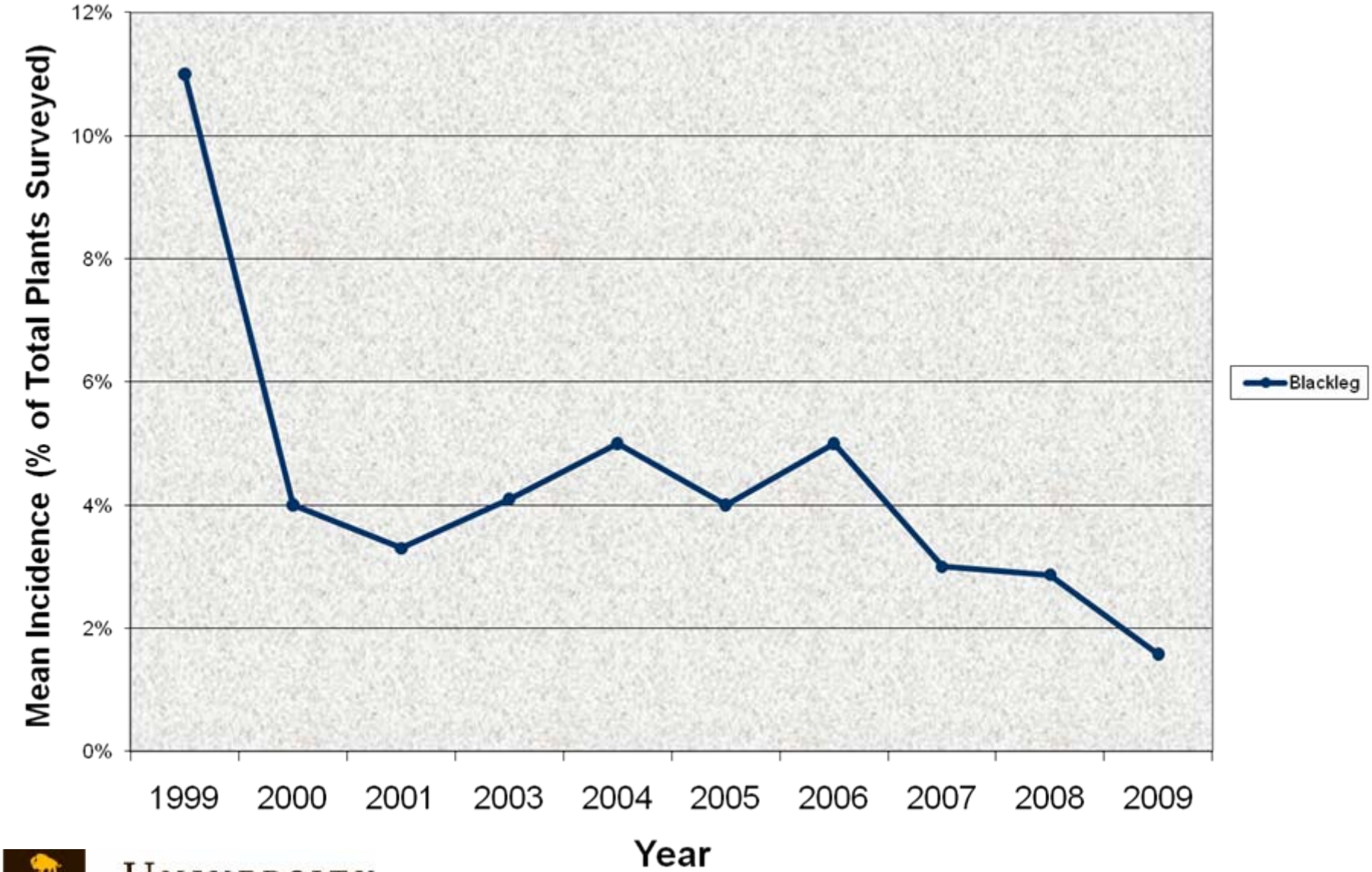


Chen and Fernando, 2006 Can J of Plant Pathology

Identification of 16 races among 87 isolates of *L. maculans* from western Canada collected between 1997-2005 – R. Kutcher et.al

Race designation[1]	Number of isolates of each race	Frequency (%)	Number of avirulence alleles
Av1-2-3-4-5-(6)-7-(8)-9-10-(LepR3)[2]	1	1.2	8
Av1-2-4-5-(6)-7-(8)-9-10-(LepR3)	1	1.2	7
Av1-2-3-6-(8)-9-10-(LepR3)	1	1.2	6
Av1-2-4-6-7-(8)-10-(LepR3)	1	1.2	6
Av1-4-5-6-7-(8)-10-(LepR3)	1	1.2	6
Av2-3-6-(8)-9-10-LepR3	7	8.1	6
Av2-4-6-7-(8)-10-LepR3	13	14.9	6
Av1-2-6-7-(8)-10-(LepR3)	1	1.2	5
Av1-2-6-(8)-9-10-(LepR3)	20	23.0	5
Av1-4-6-7-(8)-10-(LepR3)	1	1.2	5
Av2-4-6-7-(8)-10	1	1.2	5
Av2-6-7-(8)-10-LepR3	3	3.5	5
Av2-6-(8)-9-10-LepR3	19	21.8	5
Av4-6-7-(8)-10-LepR3	1	1.2	5
Av1-2-6-(8)-10-(LepR3)	13	14.9	4
Av2-6-(8)-10-LepR3	3	3.5	4

The success in Breeding for disease resistance - the future?



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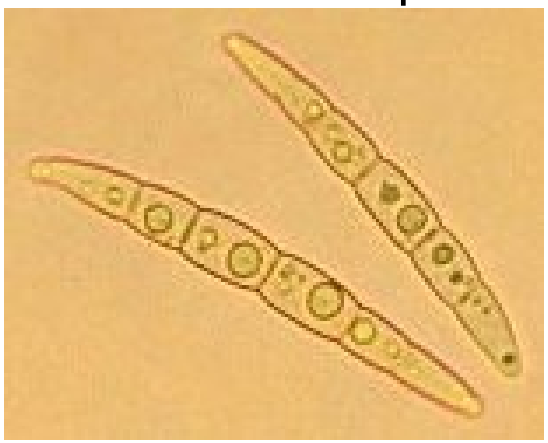
Courtesy Faye Dokken-Bouchard

Strategy for stable resistance deployment

- Therefore resistance should be deployed as part of a larger strategy to control this disease.

- Stewardship of blackleg resistance and agronomic practices designed to control blackleg should be recommended together.

Air-borne ascospores



***R* gene resistance**

Infection

Phoma leaf spots

QTL resistance

Early canker

Damage

Severe canker (harvest)

QTL resistance

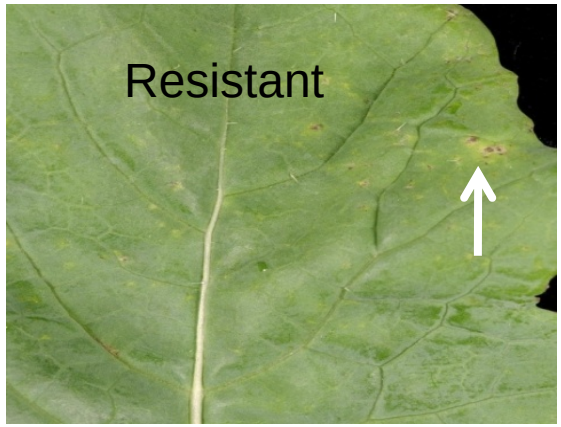
Major gene mediated resistance

- **Race specific, high risk of overcoming resistance**
- **Effective only if corresponding *Avr* allele is predominant in pathogen population**
- **Information on pathogen races is essential**
- **Many factors (e.g. host cultivar, pathogen fitness cost, temperature) affect race composition of populations**

Temperature affects *R* gene resistance

15°C

25°C



Darmor

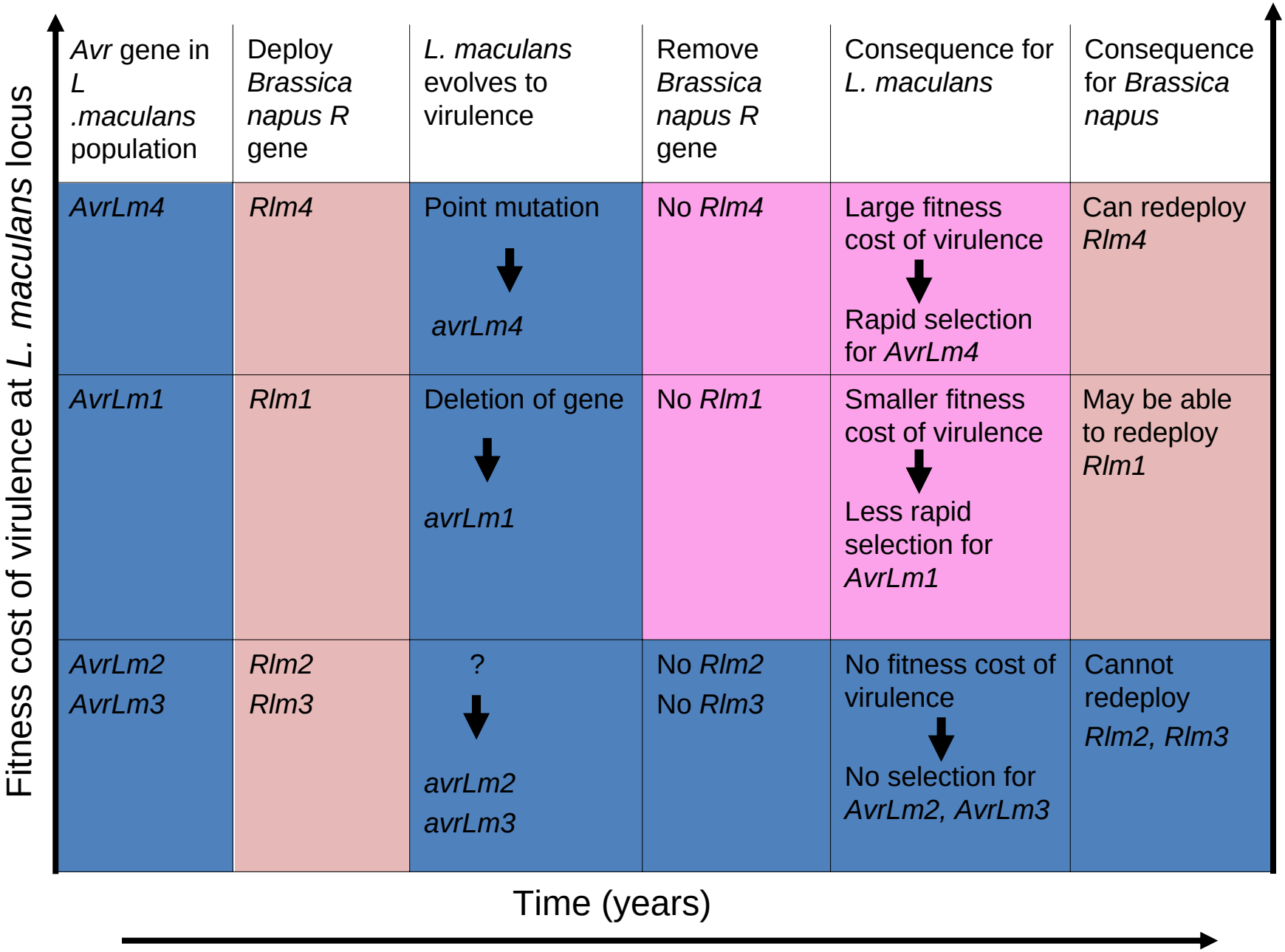
DarmorMX (*Rlm6*)

Huang *et al.,* 2006, New Phytologist, 170, 129-141

Fitness cost of virulence can be used as indicator of durability of the corresponding *R* gene

- Near isogenic isolates at *AvrLm1* or *AvrLm4* loci
- Host without the corresponding *R* gene (no selection pressure)

Fitness cost of virulence & potential durability of *R* gene resistance



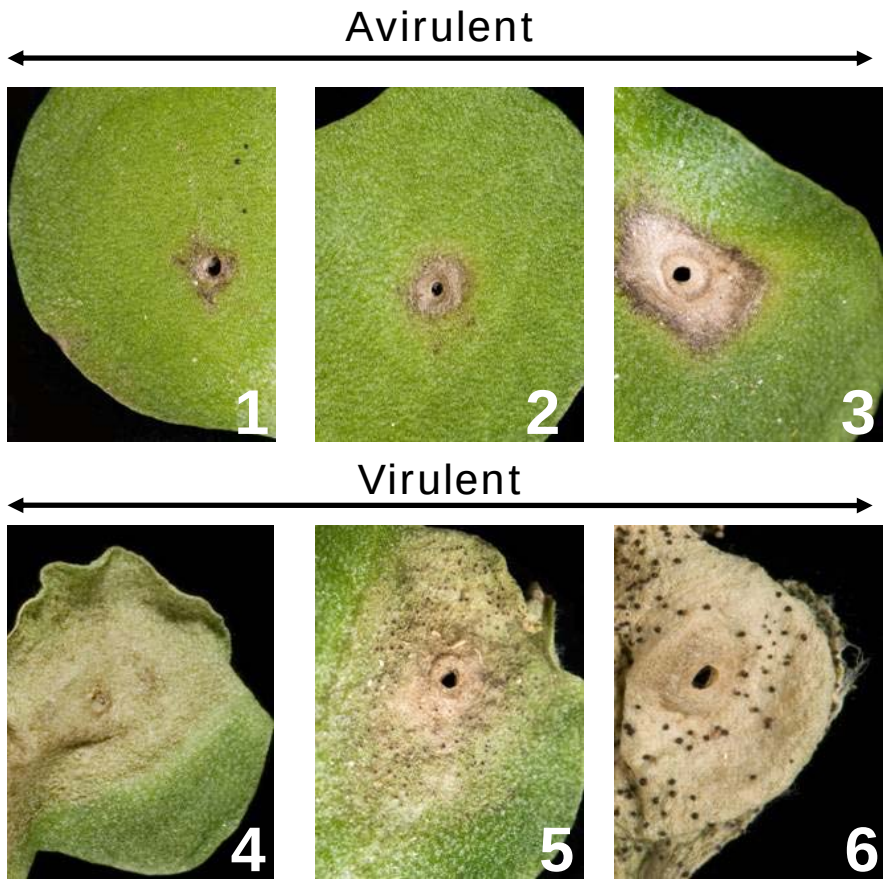
Avr gene in *L .maculans* population	Deploy *Brassica napus R* gene	*L. maculans* evolves to virulence	Remove *Brassica napus R* gene	Consequence for *L. maculans*	Consequence for *Brassica napus*
AvrLm4	*Rlm4*	Point mutation ↓ *avrLm4*	No *Rlm4*	Large fitness cost of virulence ↓ Rapid selection for *AvrLm4*	Can redeploy *Rlm4*
AvrLm1	*Rlm1*	Deletion of gene ↓ *avrLm1*	No *Rlm1*	Smaller fitness cost of virulence ↓ Less rapid selection for *AvrLm1*	May be able to redeploy *Rlm1*
AvrLm2 *AvrLm3*	*Rlm2* *Rlm3*	? ↓ *avrLm2* *avrLm3*	No *Rlm2* No *Rlm3*	No fitness cost of virulence ↓ No selection for *AvrLm2, AvrLm3*	Cannot redeploy *Rlm2, Rlm3*

Monitoring pathogen population

***R* gene is effective only if corresponding *Avr* allele is predominant in pathogen population, so it is needed to monitor pathogen population**

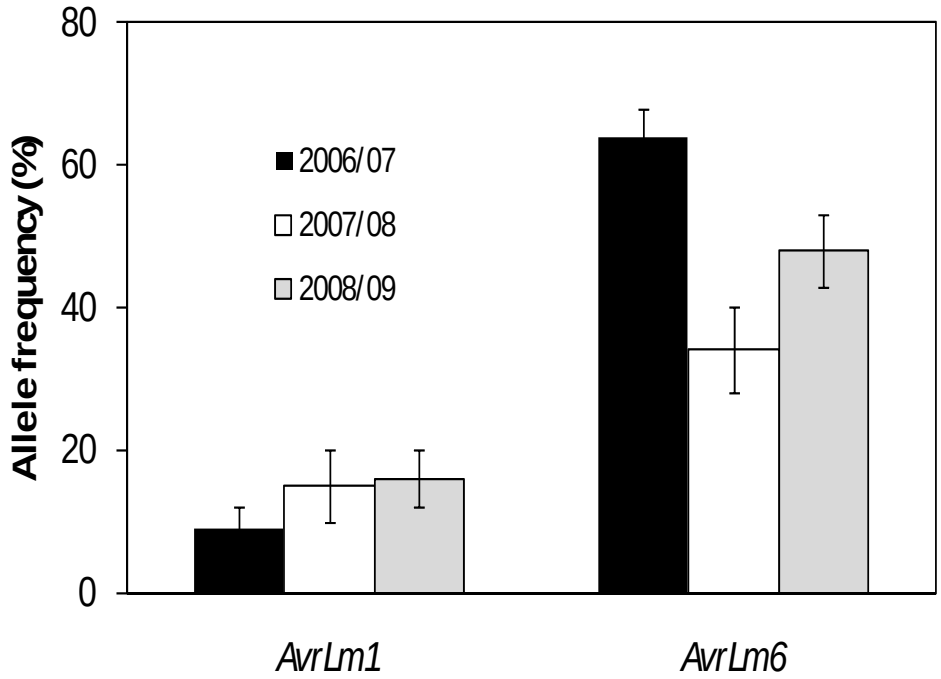
- Collection of isolates from leaf spots or stem cankers
- Collection of ascospores from air samplers
- Determination of pathogen race structure using pathogenicity test or specific PCR primers

Detect *Avr* allele by inoculation (Pathogenicity Test)



Air sampling to determine alleles

Spore sampler surrounded by diseased OSR stem debris



Van de Wouw et al., 2010

Advantages

- Samples larger population
- Quicker, cheaper
- Less laborious than cotyledon assays

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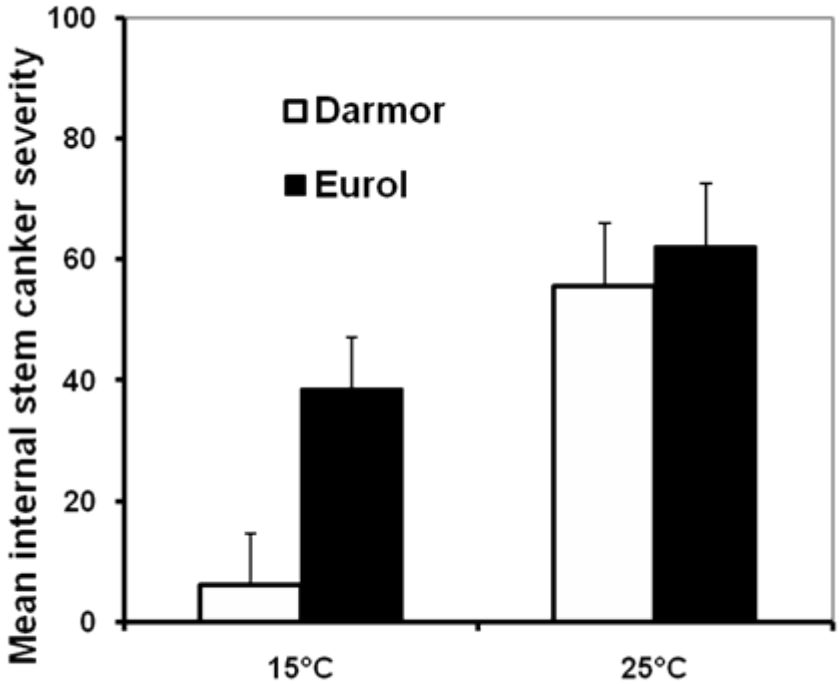
Quantitative resistance

- **Quantitative resistance is non race specific**
- **Quantitative resistance is durable**
- **Difficult to screen for - at seedling stage**
- **Screening for quantitative resistance currently relies on field assessment at harvest**
- **May operate during long period of symptomless growth after initial leaf**

Temperature affects quantitative resistance



Darmor (with quantitative resistance)

Eurol (without quantitative resistance)

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Huang et al., 2009, Plant Pathology

Management of Blackleg of Canola

Cultural control:

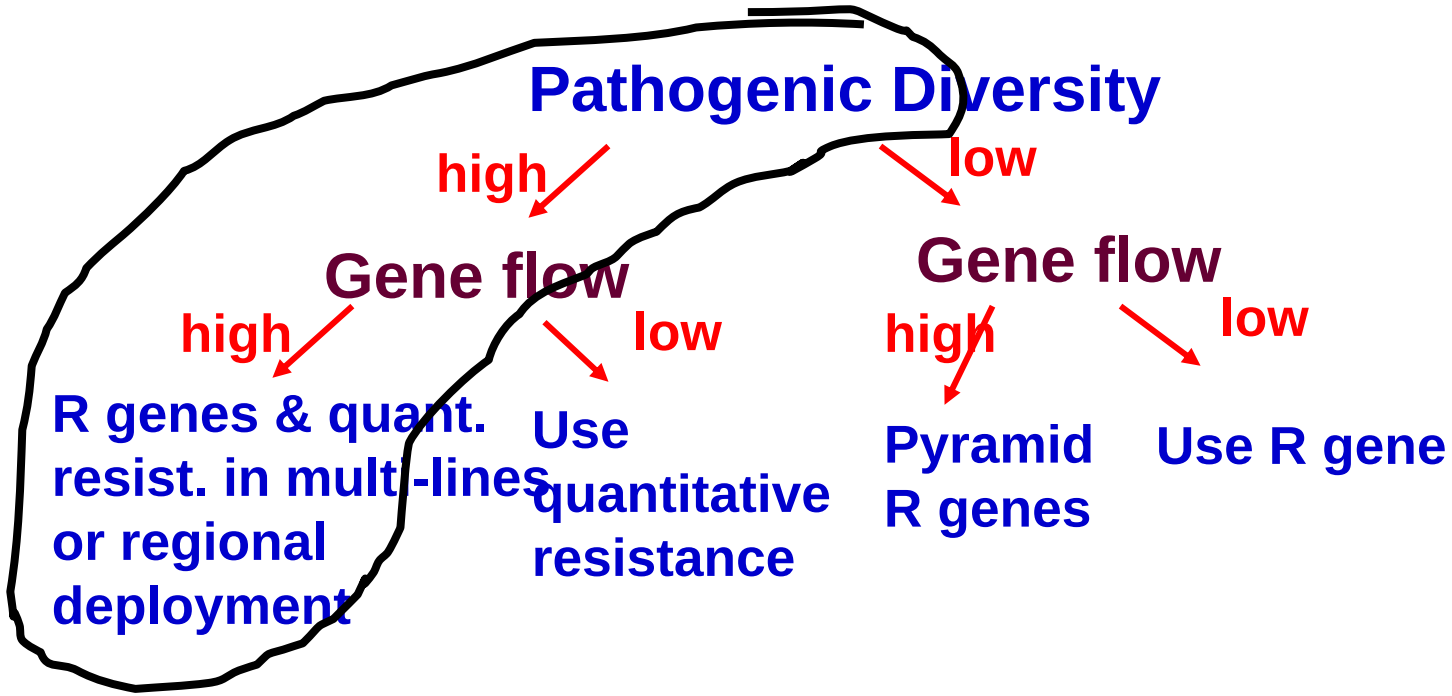
Crop rotation for at least 3 years.
Tillage – conventional tillage helps reduce inoculum
Weeds and volunteer canola removed.
Pathogen-free seed.

Genetic resistance:

Resistant cultivars — the most important and sustainable means of blackleg control in Canada for the past three decades.

Keeping Resistance to Blackleg Alive!

- ***How should resistance be deployed?***



McDonald BA. and Linde C. Euphytica 124 (2): 163-180, 2002

Acknowledgements

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Thank you