

# Decision Support System 2.0: Combining plant resistance with monitoring virulence

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# Outline

- **Phytophthora in perspective**
- **DSS 1.0: Umbrella Research Plan Phytophthora: 2003 – 2012**
  - Focus on spray management
- **Durable resistance: DuRPh research plan: 2006 – 2016**
  - Focus on multiple resistance genes
- **DSS 2.0: adding monitoring virulence genes**



# Phytophthora 2002: increasing problem



- Adaptation to cultivar resistance
- New virulence by sexual mating  
→ Current R-genes 'broken'
- Increased aggressiveness → rapid epidemics (LP < 3 days).
- Broadening of host plant range
- **Legislative problems: → 15 x sprays, environment issue, 50% of all fungicides used in NL**



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# Co-innovation: Umbrellaplan Phytophthora

## Consortium formation in 2003:

- Applied Plant Research
- Plant Research International
- Univ. Dept. Sciences
  
- Agribusiness (breeders, growers, trade, intermediates)
- Min. Agriculture

Aim: 75% reduction of negative  
impact of pesticides in 10 years

Budget: 1.5 M€ per year



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# Epidemiology → DSS 1.0



## ■ Research aims:

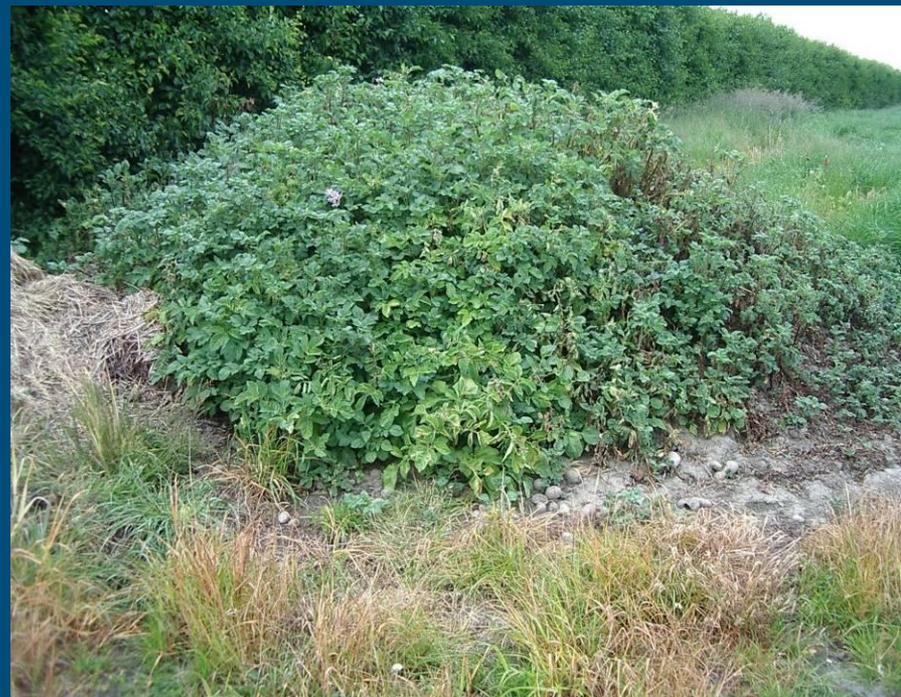
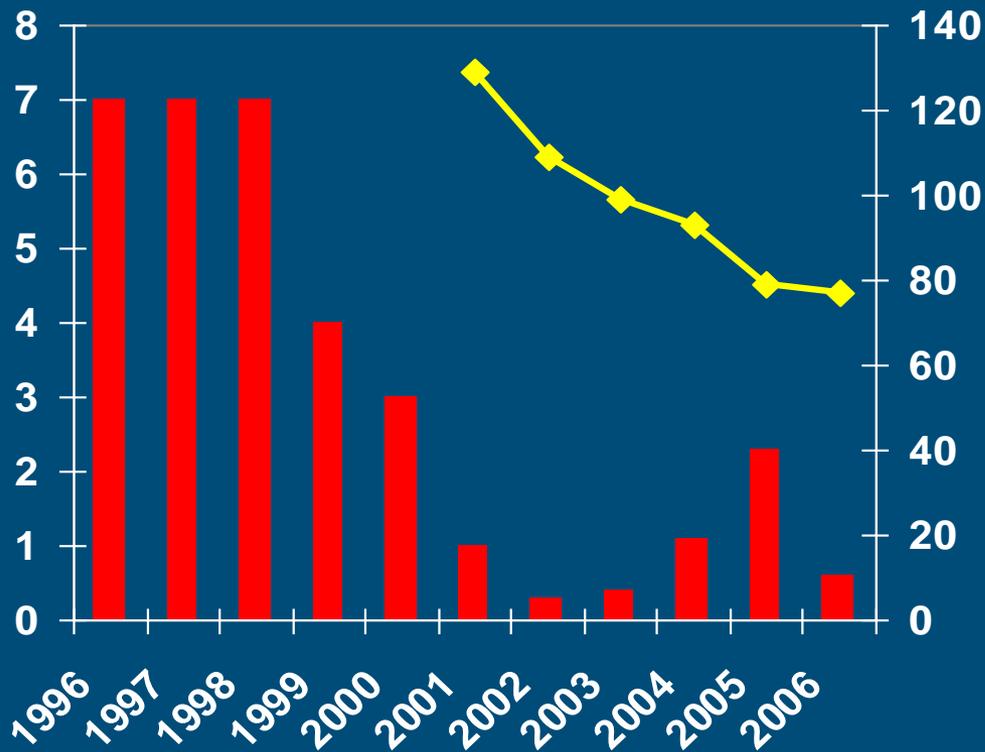
- factors involved in disease development & spread
- Additional control points in life cycle
- Role of partial resistance of potato

## ■ Aim for practice:

- What can farmer do for prevention
  - Life cycle of disease in practice (what to spray)
  - Refining control strategy (when to spray)
  - Use of resistance (how much to spray)
  - Convincing farmers (communication)
- Implementation DSS 1.0



# Incidence of uncovered dumps: prevention



# Control strategy: **What** to spray



cymoxanil

Fubol Gold

Ranman

Ranman

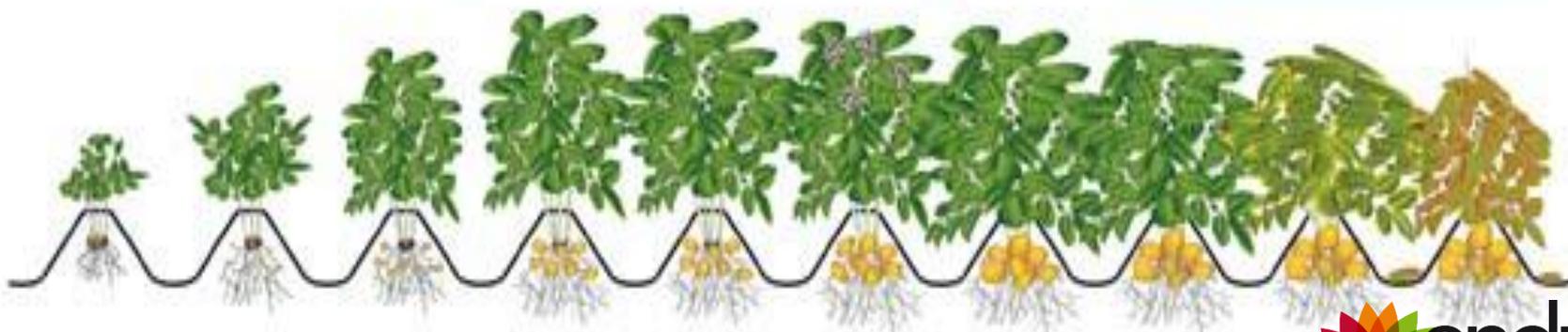
Valbon/Acrobat/Tattoo/Curzate /Sereno/Unikat Pro

Shirlan

Reduced dose rates when possible

Loofgroeifase

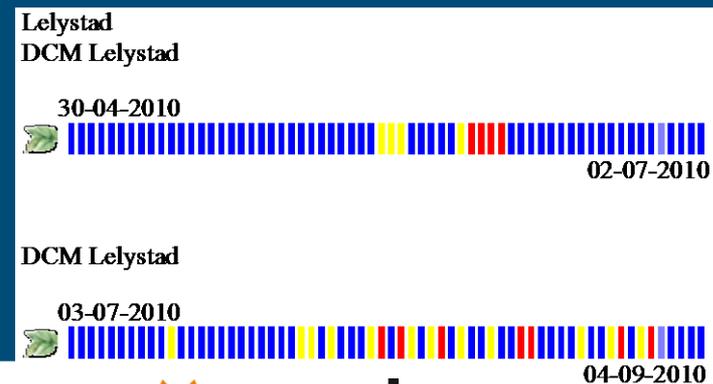
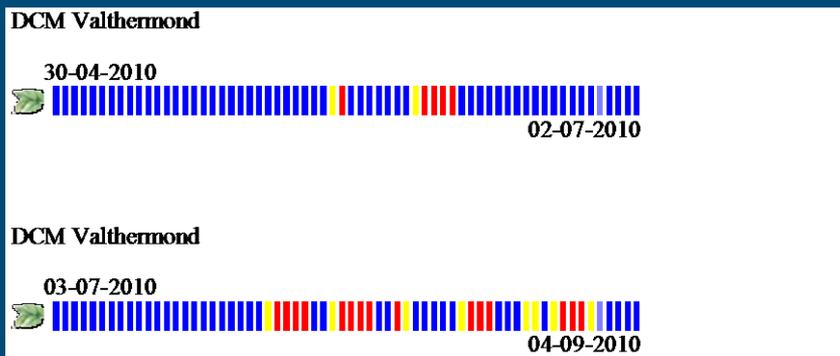
Knolbeschermingsfase



# DSS 1.0: When to spray



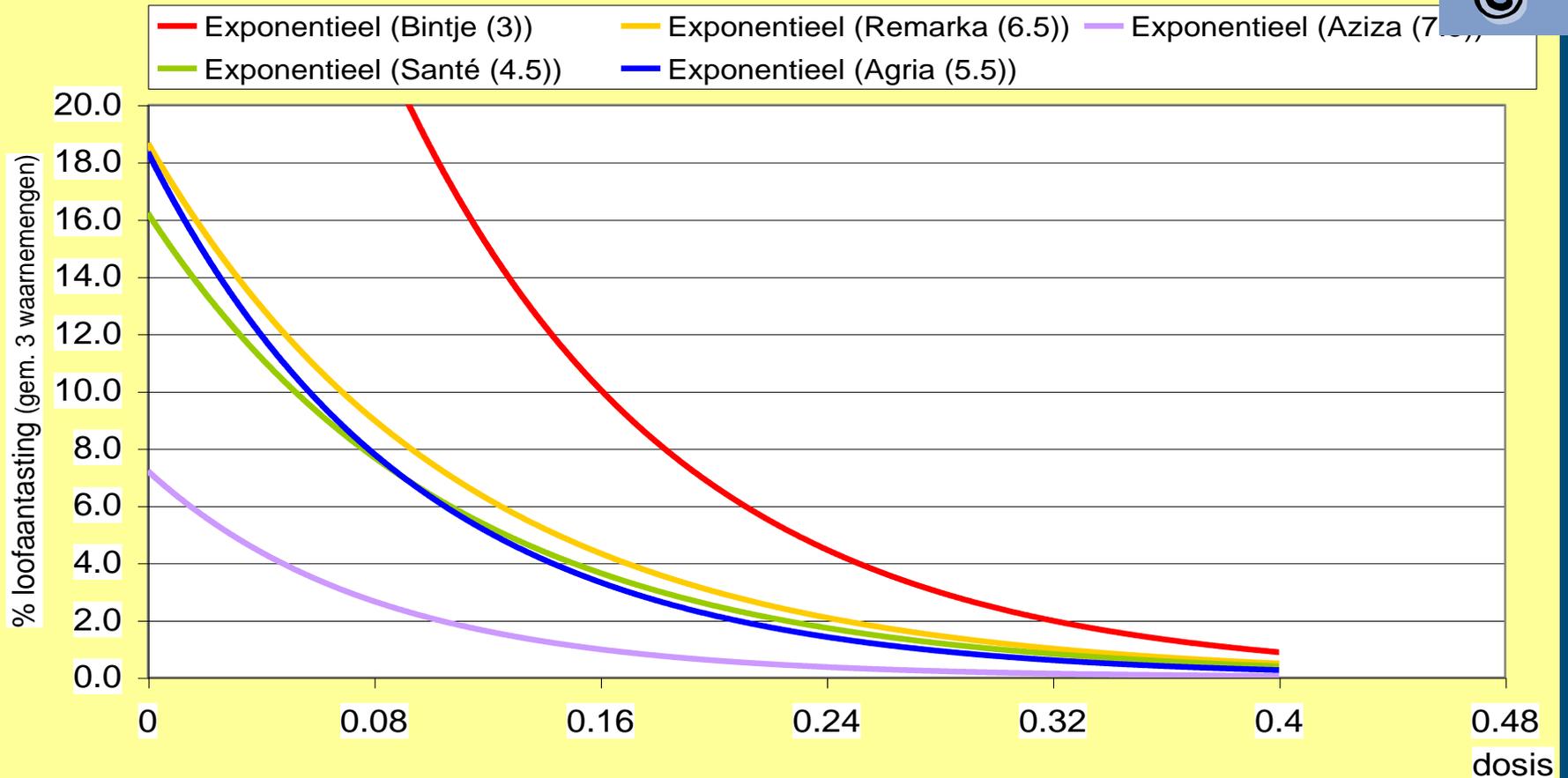
- Accurate weather predictions
- Critical infection circumstances (commercial models)
  - Spores present?
  - Weather conditions favourable for spread and survival of spores?
  - Leaf-wetness favourable for infection?
  - Breakdown time of previously applied fungicide?
  - Canopy development → unprotected areas?



# Relative resistance: **how much** to spray



dosis-response grafiek 2004 consumptierassen



# Demo trials 2007: communication



- Cultivar resistance & reduced dose rates
- 7 locations
- Spray timing: DSS
- Published weekly
  - Farmers magazines
  - Internet



# Results Umbrellaplan Phytophthora



DSS 1.0 implemented:

- Only spray when necessary
- Use the right modern fungicides
- Only spray at optimal conditions
- Use lower dose depending of relative resistance
- Use high tech spray-equipment
- Spray-free zones

More than 75% reduction of negative impact on environment accomplished

**BUT: STILL DEPENDANCE!!**



# New sources for resistance breeding



Results	Genotypes	
Resistant	1209	30%
Intermediate	714	18%
Susceptible	2109	52%
Total resistance data	4032	100%



# Durable Resistance against Phytophthora (DuRPh)

# DuRPh

duurzame resistentie tegen  
*Phytophthora* in aardappel door  
cisgene merkervrije modificatie

**Duration**      2006 – 2015  
**Budget**        €10 M€  
**Source**        MinistryLNV



# Durable Resistance against Phytophthora

## Principles of DuRPh

**Cisgene:** only use genes from crossable species with *S. tuberosum*

**Gene stacking:** combining 2-6 genes per cassette,

**Maintain varieties:** DuRPh maintains present varieties as they are

**Deployment:** spatial and temporal variation (Flexible varieties)

**Marker free:** no antibiotics marker

**Transparency:** communication with all stakeholders concerned

**Exploitation:** securing intellectual property and sharing breeding rights



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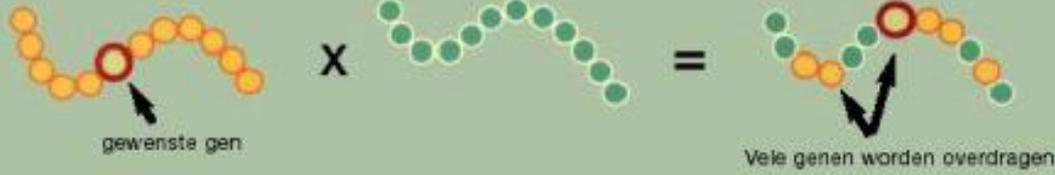


DuRPh

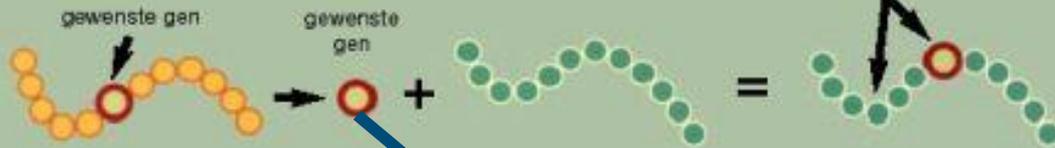
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TRADITIONELE VEREDELING

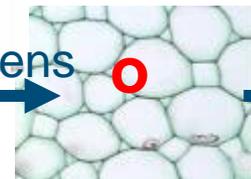
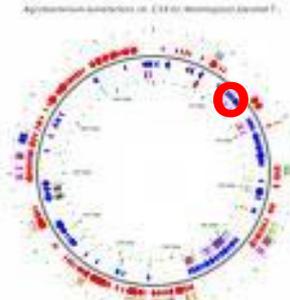
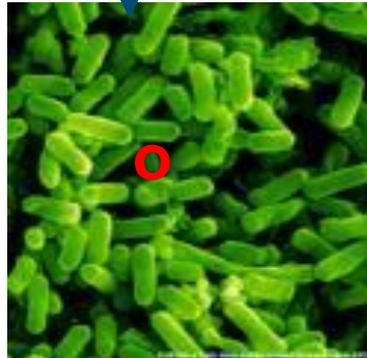
Crossing



GENTECHNOLOGIE



Modification



# Some combinations of R-genes

## R-gene cassettes (August 2009)

- Made construct (combination)
  - Rpi-blb1
  - Rpi-blb2
  - R3a
  - Rpi-blb1 + Rpi-blb2
  - Rpi-sto1
  - Rpi-blb3
  - Rpi-blb1 + R3a
  - Rpi-sto1 + R3a
  - Rpi-sto1 + Rpi-blb3



# Durable Resistance against Phytophthora



## Selection on

- Resistance level
- True to type
- Desirable traits

# Genes for potato late blight resistance

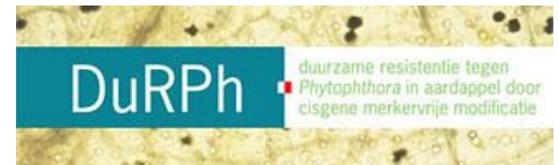


Aveka Blb2

Aveka



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# But...

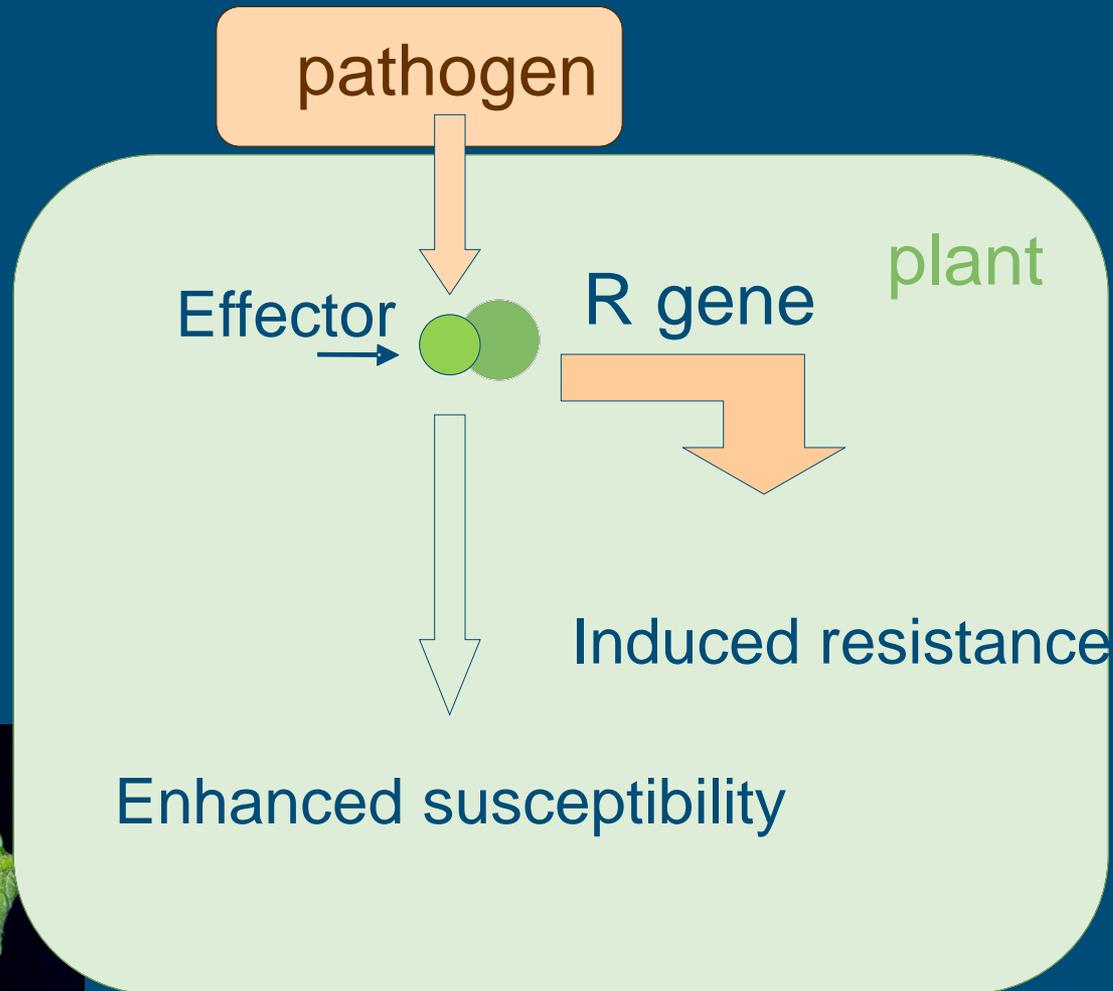
- Will multiple resistance be sustainable?
- When:
  - Temporal and spacial mixing of R-genes
  - Replacing R-genes in time
- Phytophthora will select genotypes that break resistance → precious R-genes will be lost!!

# Outline

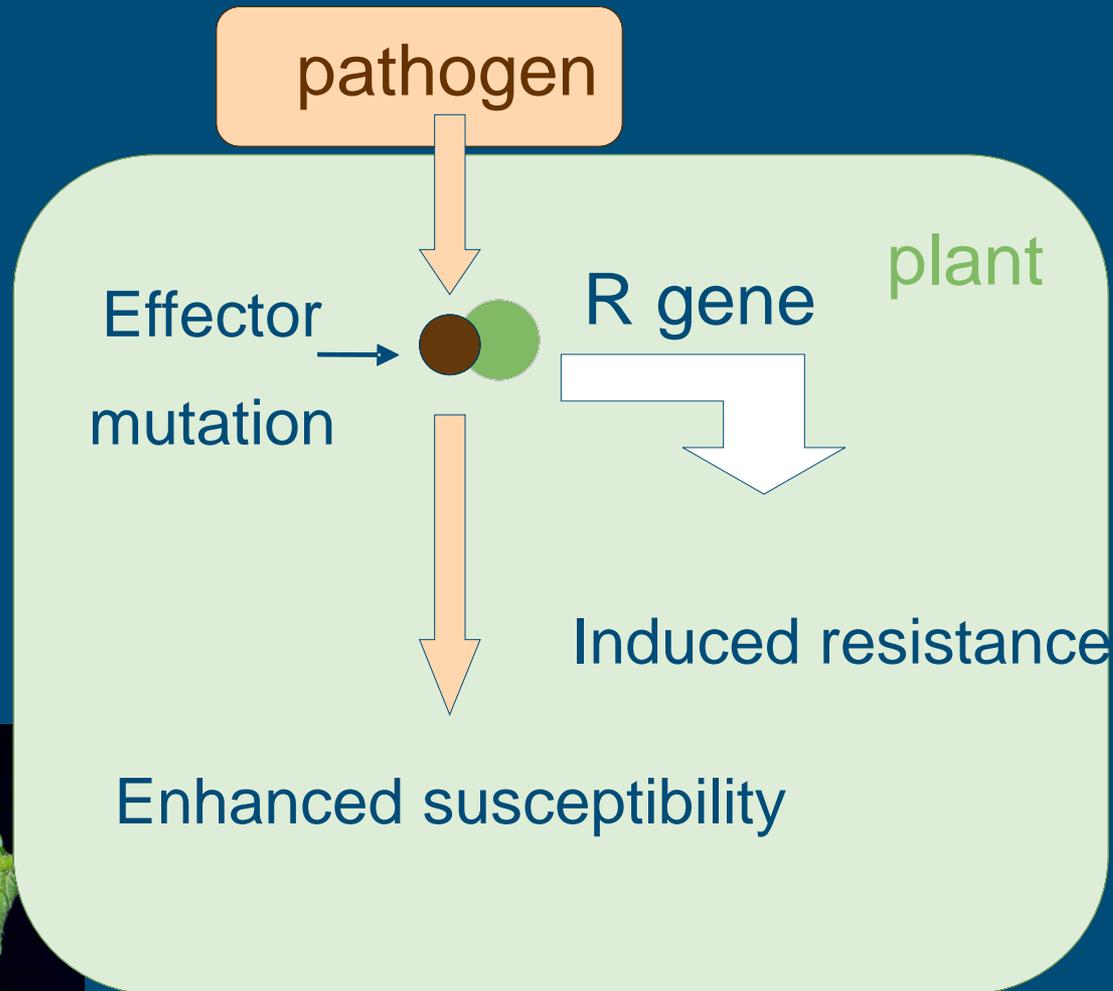
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# Effectors and Virulence: a key role for recognition



# Effectors and Virulence: a key role for recognition



# Pilot: Real-time monitoring of Blb1 breakers

- Small bait fields in close to an experimental field
  - Valthermond
  - Lelystad



# Pilot: Real-time monitoring of Blb1 breakers



# Real-time monitoring of Blb1 breakers

- Advanced TaqMan to monitor alterations in Blb-1 effector gene
- 3 times a week suspicious samples were screened: all NEGATIVE
- But on August 18:
  - 633 suspicious leaf samples were screened **in 8 hr!!!**
  - 75 did not contain *P. infestans*
  - 557 we scored avirulent (intact effector) for Blb1
  - Only ONE sample had a mutated Blb 1 effector gene and is scored virulent

Blb2	LS-17-Bionica		4C10	AVIRULENT
R1R3R10	LS-17-Escort	18-aug-2010	4C11	AVIRULENT
R1R3R10	LS-17-Escort		4C12	AVIRULENT
R1R3R10	LS-18-Escort	18-aug-2010	4D1	AVIRULENT
R1R3R10	LS-18-Escort		4D2	AVIRULENT
Blb2	LS-18-Bionica	18-aug-2010	4D3	<b>VIRULENT</b>
Blb2	LS-18-Bionica		4D4	AVIRULENT
Blb2	LS-19-Bionica		4D5	NO INFESTANS



# Principle of DSS 2.0 monitoring in practice

- If a farmer has only Blb 1 cultivars
- Without DSS 1.0: about 15 sprays
- With DSS 1.0: 50% less sprays, with lower dose
- With DSS 2.0 monitoring: result of test in 8 hr, in this year, only ONE SPRAY

→ No breakers, no spray!



- Blb1 is an effective R gene (in the Netherlands)
- Blb1 may be combined with new R genes
- Other effector genes are identified:
  - Avr2, Avr3a, Avr3b, Avr4, AvrVnt1, AvrCh1, AvrBlb1
- Pyramiding could be effective to decrease chance for breaking R
- Monitoring is required to extend the life time of R genes!!!

# Towards sustainable control of Phytophthora



Can DSS 2.0 also be developed for other crop – pathosystems??



# Thank you for your attention

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