Decision Support System 2.0: Combining plant resistance with monitoring virulence

IHAR, September 6, 2011

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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

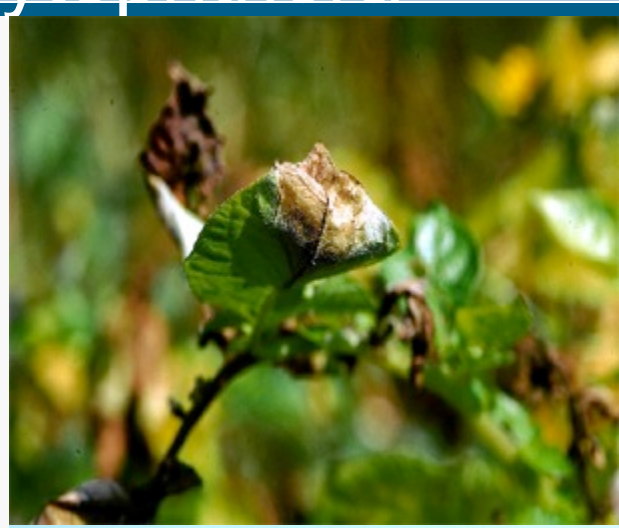
Consortium formation in 2003:

- 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 yea

Budget: 1.5 M€ per year



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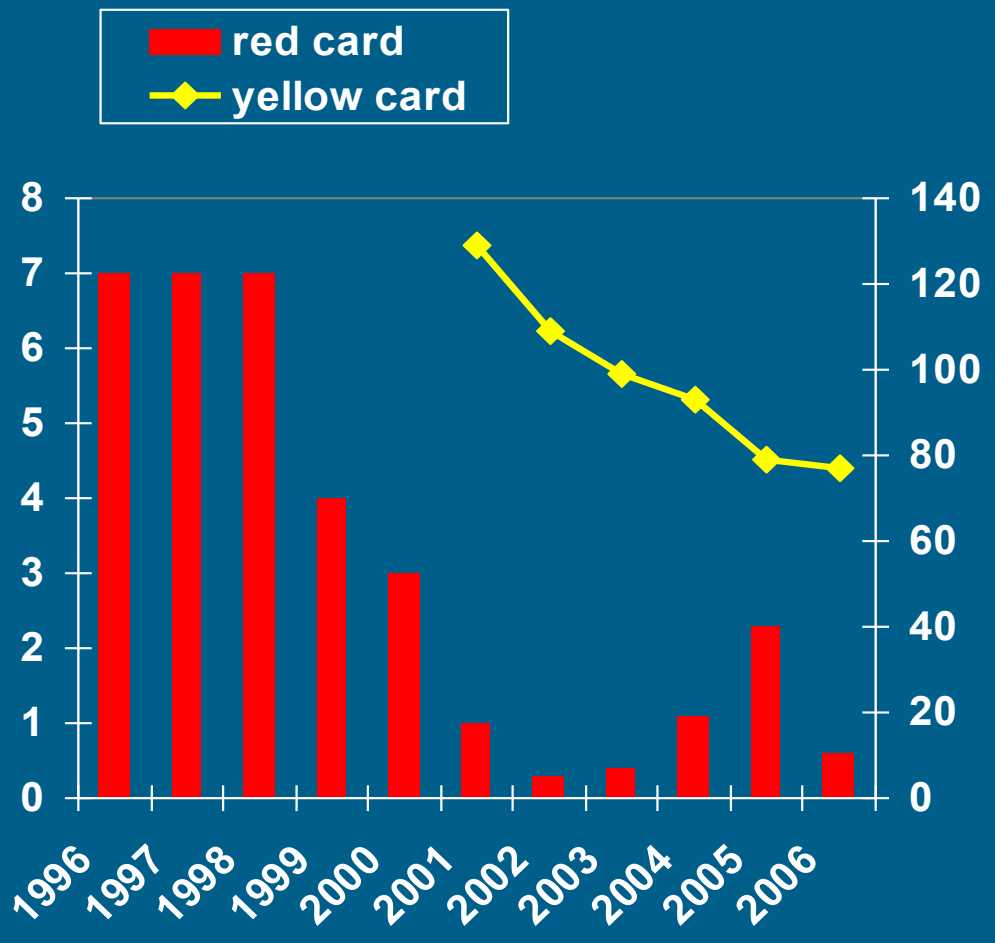
Epidemiology → DSS 1.0

- 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



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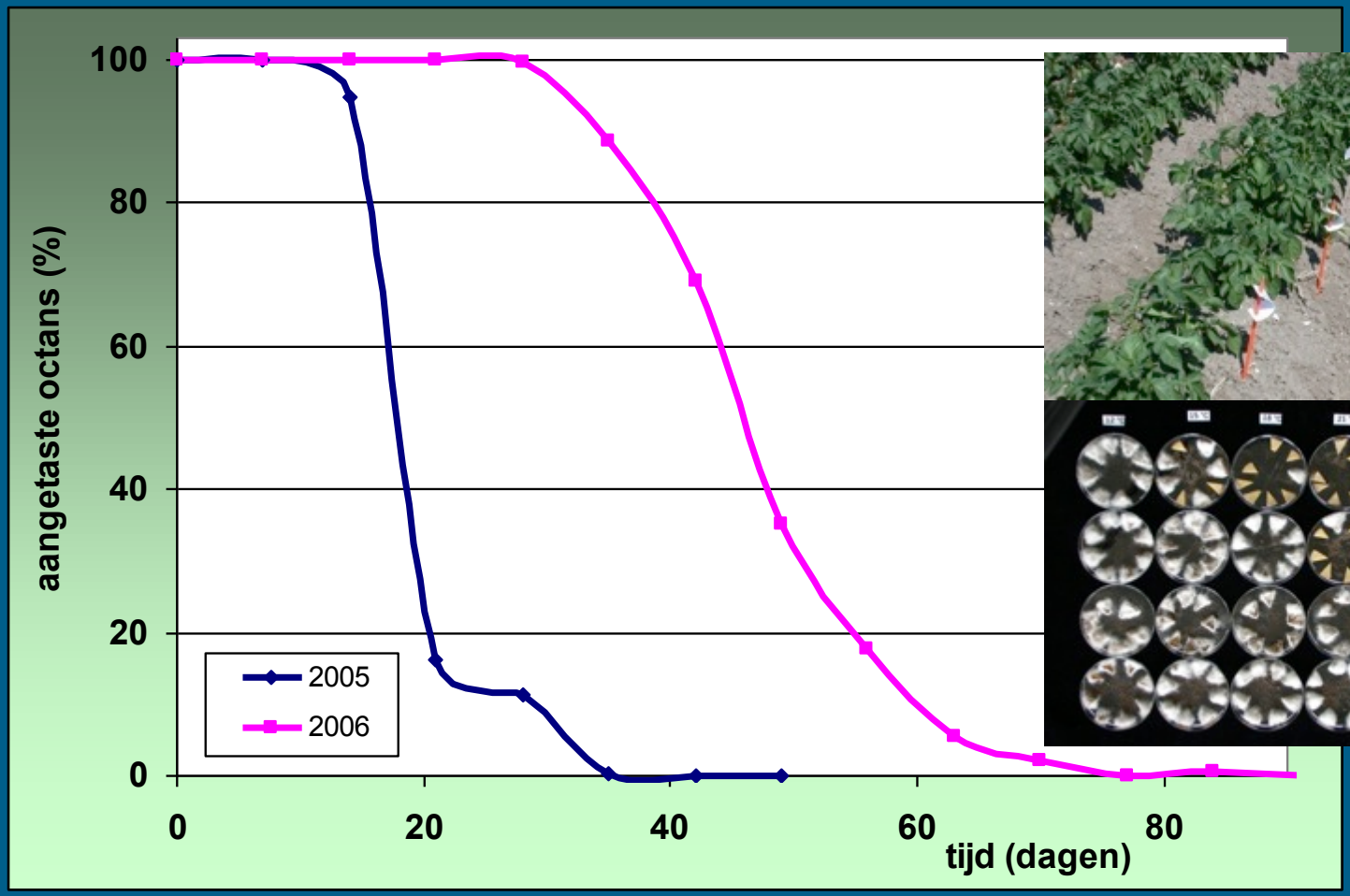
Survival of sporangia in soil: prevention and what to spray



Control strategy: What to spray

cymoxanil

Fubol Gold

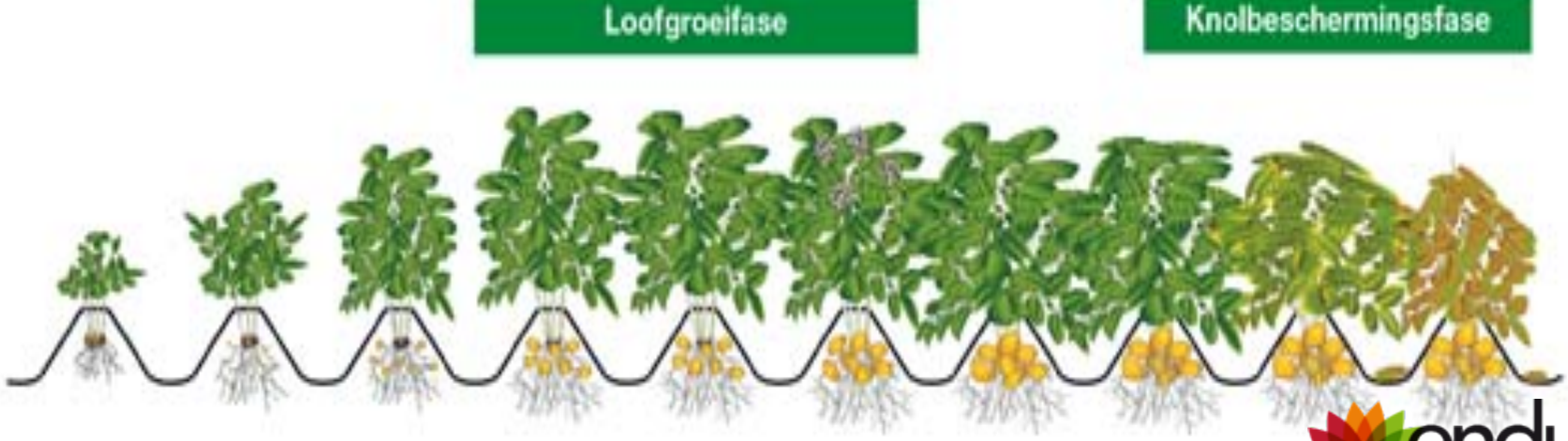
Ranman

Ranman

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

Shirlan

Reduced dose rates when possible



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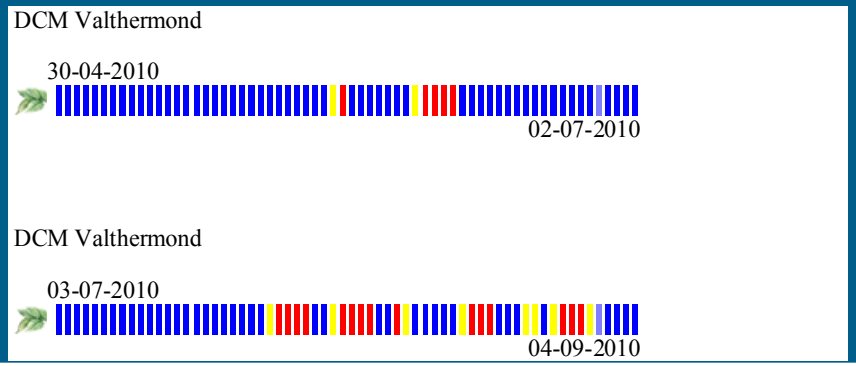
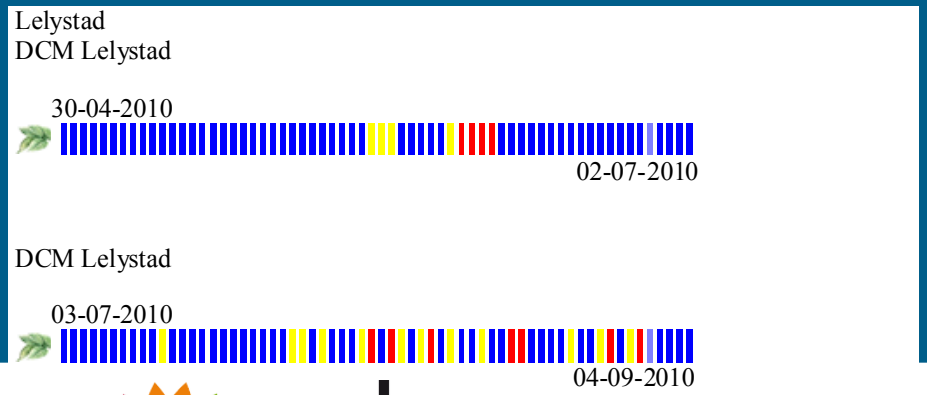
DSS 1.0: When to spray

- 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?





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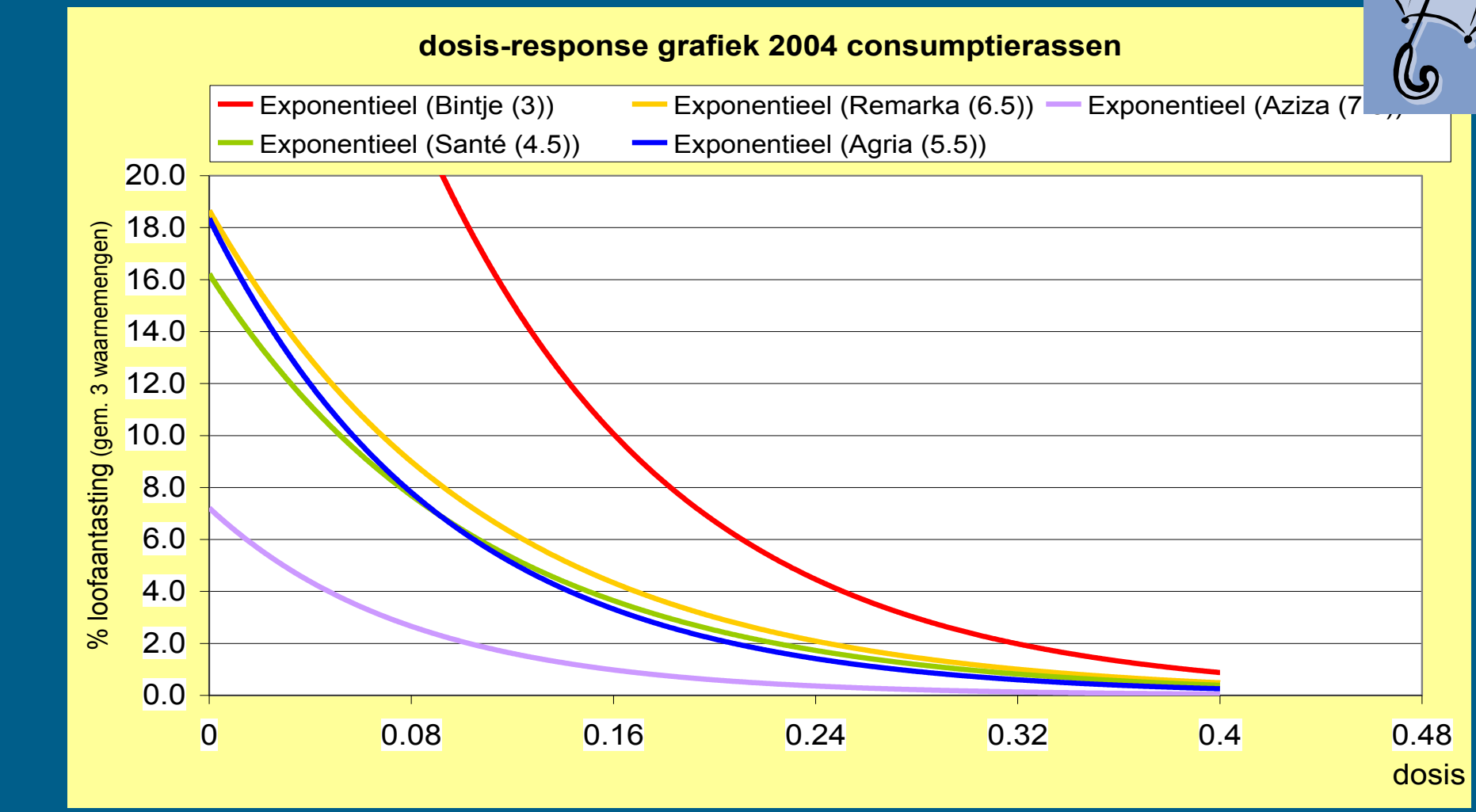
Relative resistance: how much to spray



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%

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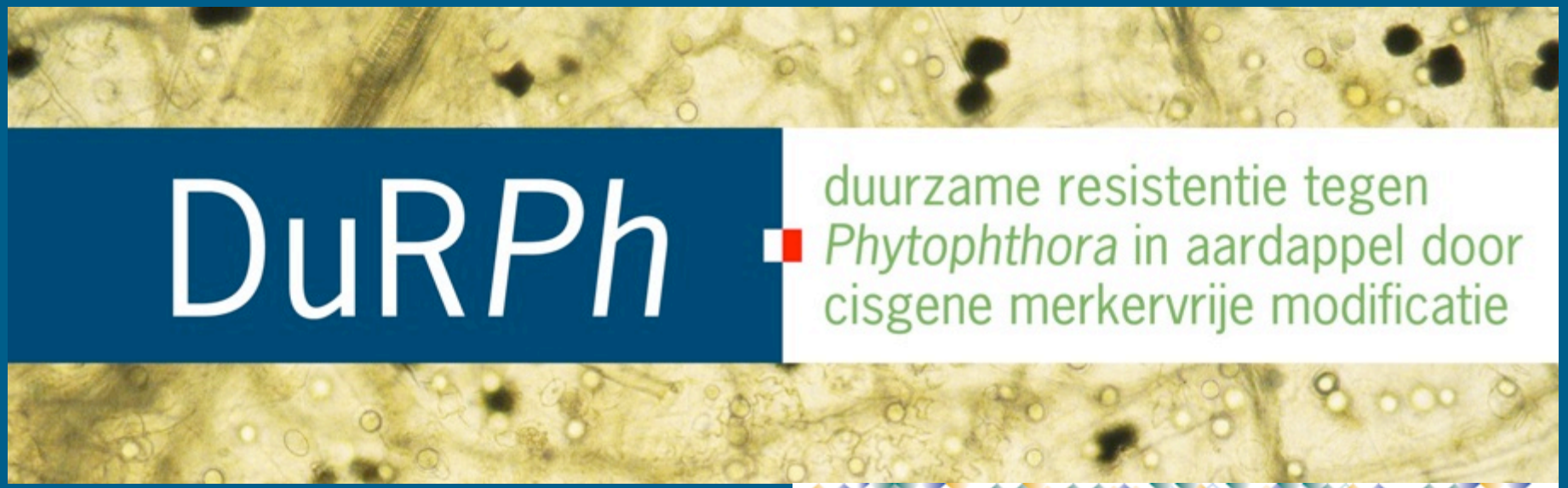
Durable Resistance against Phytophthora (DuRPh)



Duration 2006 – 2015
Budget €10 M€
Source MinistryLNV

Voedsel en groen
van internationale klasse

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landbouw, natuur en voedselkwaliteit

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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,

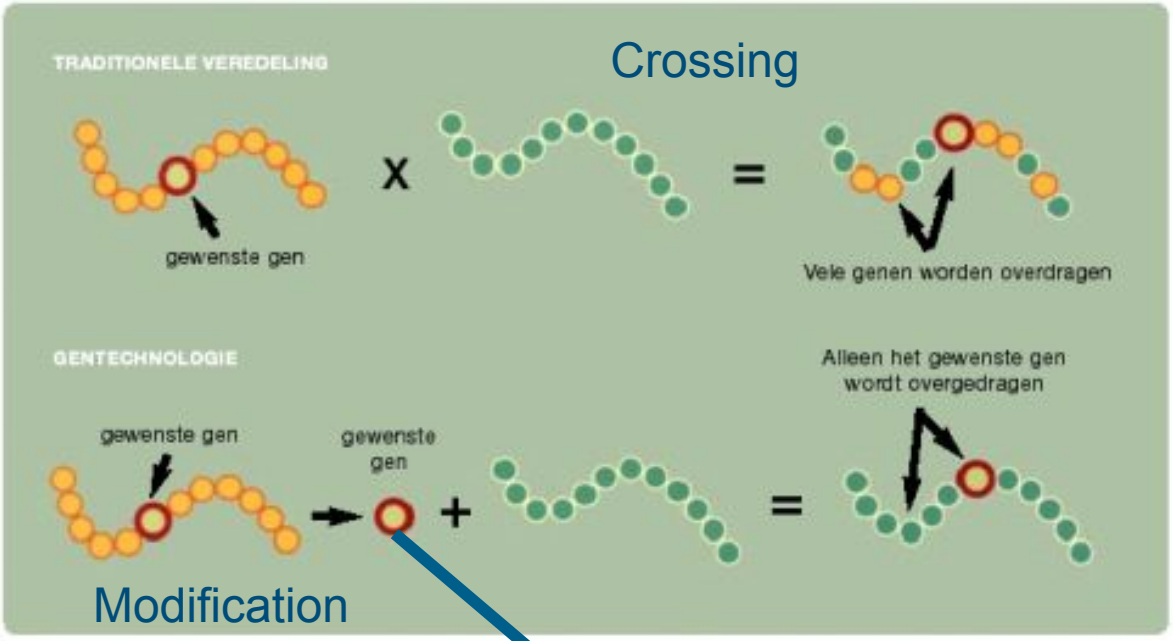
Maintain varieties: DuRPh maintains present varieties as they are

Deployment: spatial and temporal variation (Flexible varieties)

Marker free: no antibiotics marker

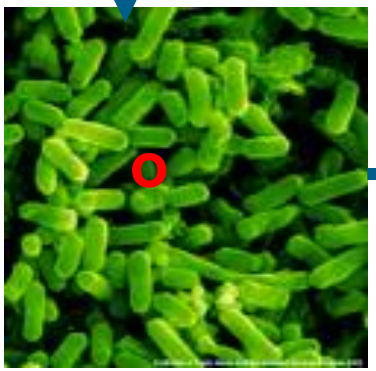
Transparency: communication with all stakeholders concerned

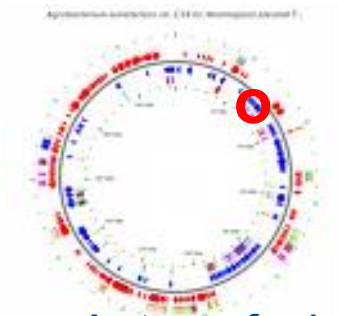
Exploitation: securing intellectual property and sharing breeding rights



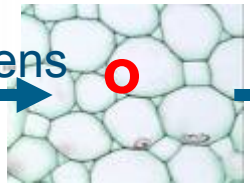
Tissue culture

E. coli





A. tumefaciens



Potato cells

Callus

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

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

Genes for potato late blight resistance

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!!

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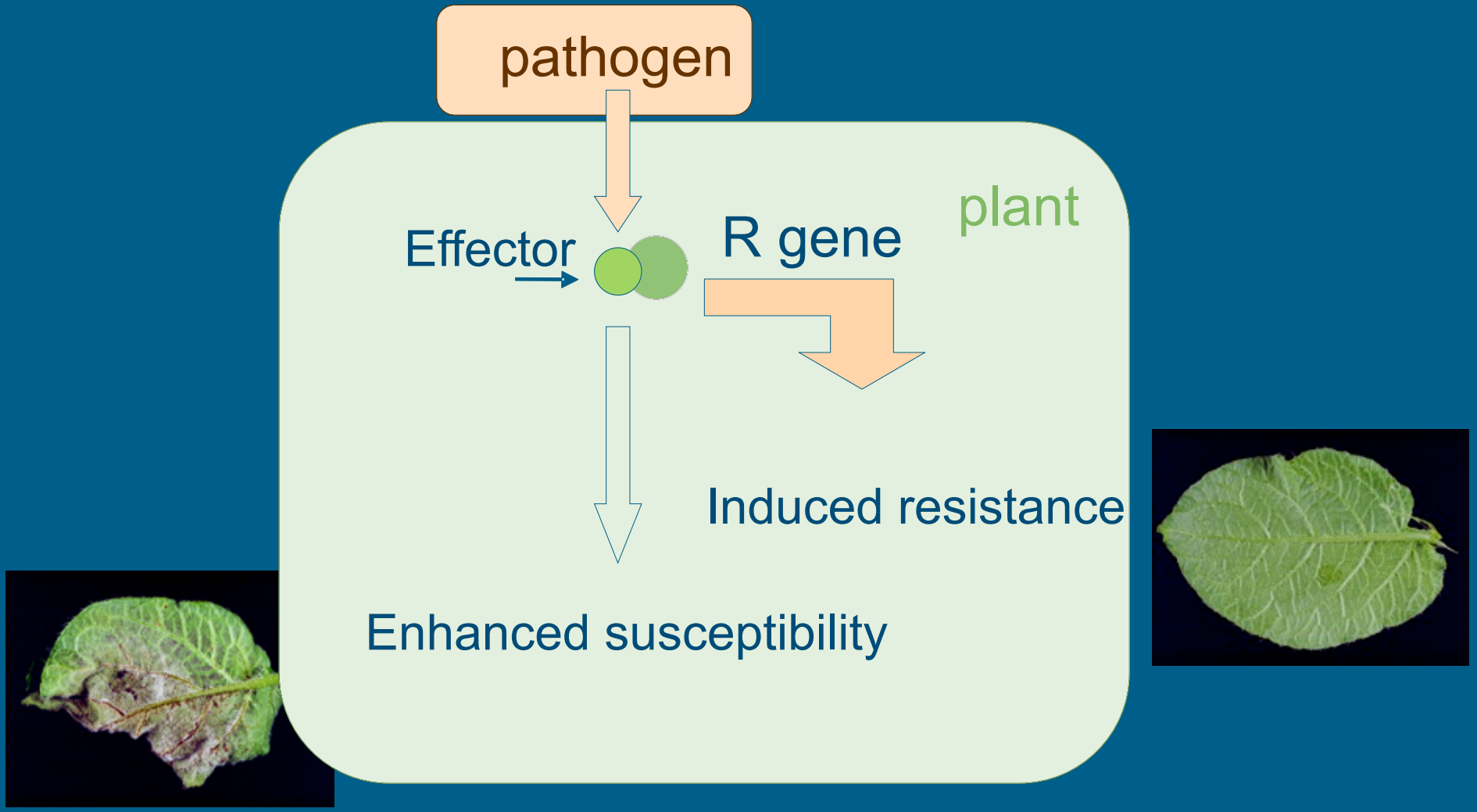
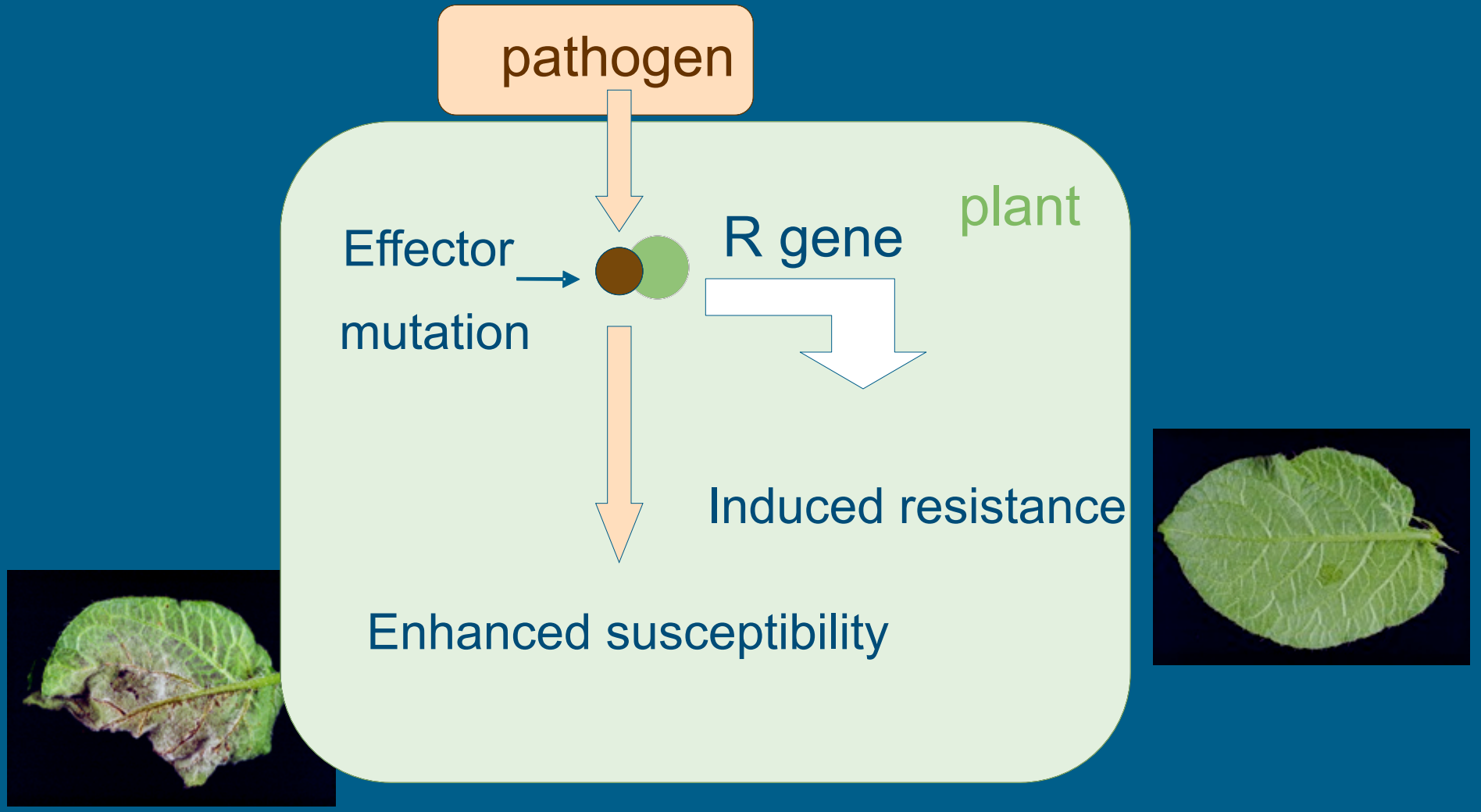
Effectors and Virulence: a key role for recognition

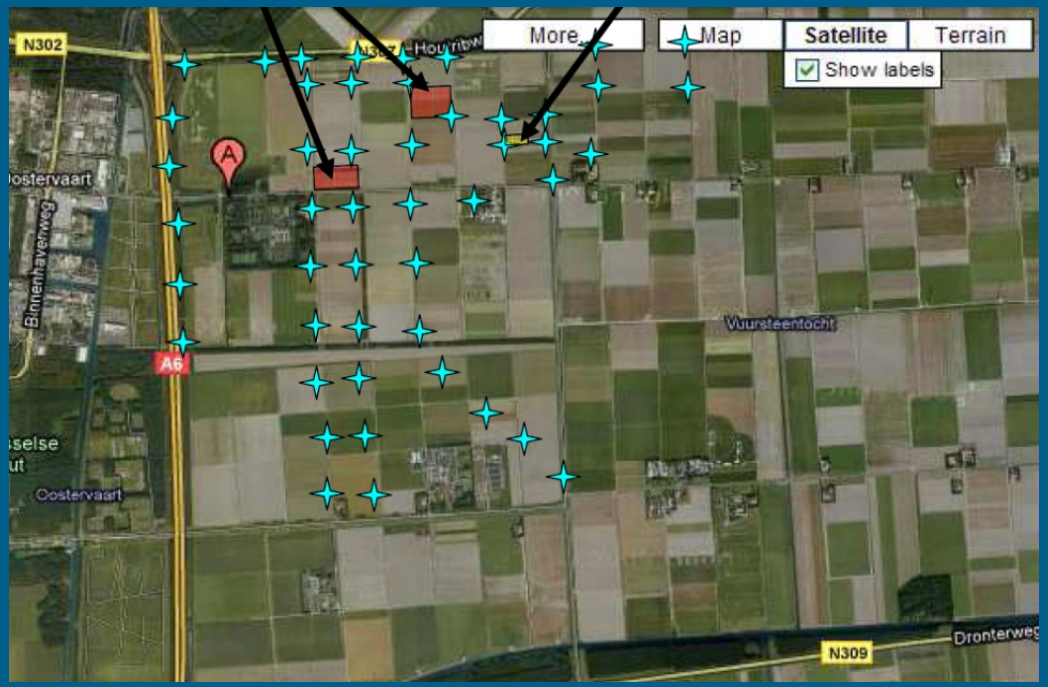


Effectors and Virulence: a key role for recognition



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	VIRULENT
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!

Outlook R-gene management

- 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 extent the life time of R genes!!!

Towards sustainable control of Phytophthora

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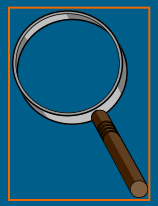
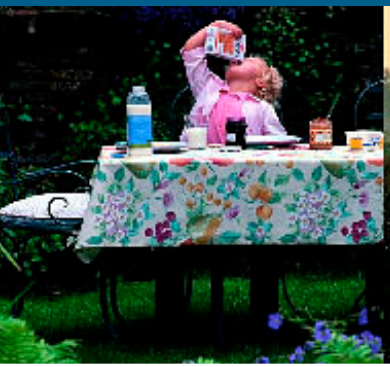


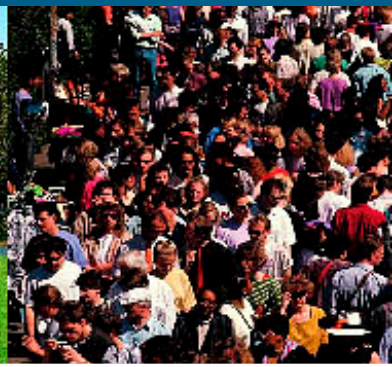
= **IPM +**

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

Thank you for your attention







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