IPM 2.0 approach to Potato late blight Control

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Outline

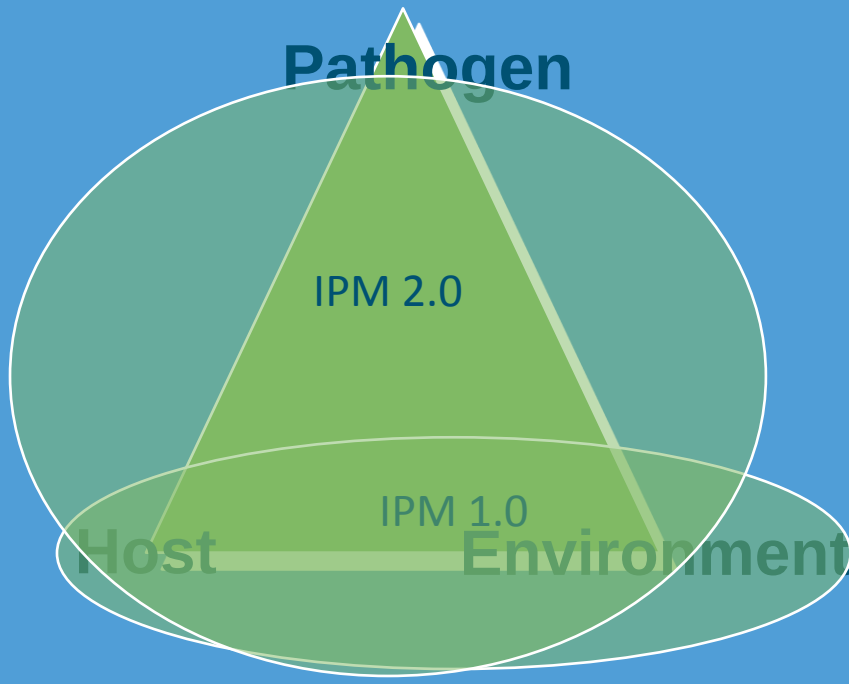
- Background on IPM
- *Phytophthora infestans (*in the Netherlands)
- Breeding efforts in Wageningen
- A potato late blight control strategy based on host resistance and *P. infestans* population monitoring

IPM (EU directive 2009)

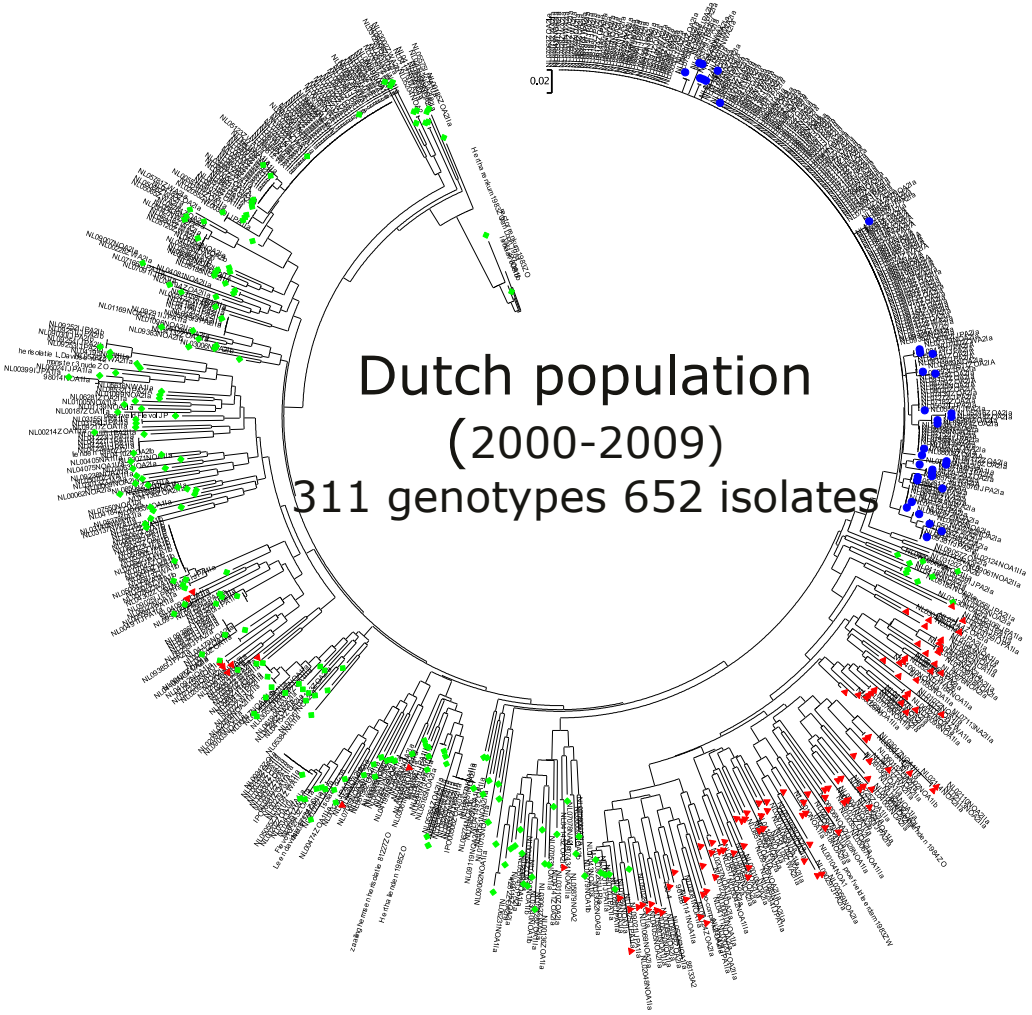
- IPM components:
  - Prevention (rotation, sanitation, host resistance, healthy seed, landscaping)
  - Monitoring pathogens
  - Appropriate, science-based, measures
  - Biological → Physical → non-chemical →chemical
  - No side-effects
  - Sustainable application
  - limit chance resistance / virulence development
  - Professional use

Disease development & Spray decisions

- Weekly spray schedules ("IPM")
  - Host is present
- IPM 1.0
  - Host is present
  - Weather suitable for infection 1st generation DSS's
- IPM 2.0
  - Host is present
    - Susceptible?
    - Resistant? Which R-genes?
  - Weather suitable for infection (DSS's)
    - For how long?
    - Do spores survive atmospheric transport (DWIP)
  - Pathogen is present
    - How much? (disease pressure)
    - Specific genotypes?
      - Specific virulences?
      - Fungicide resistance?



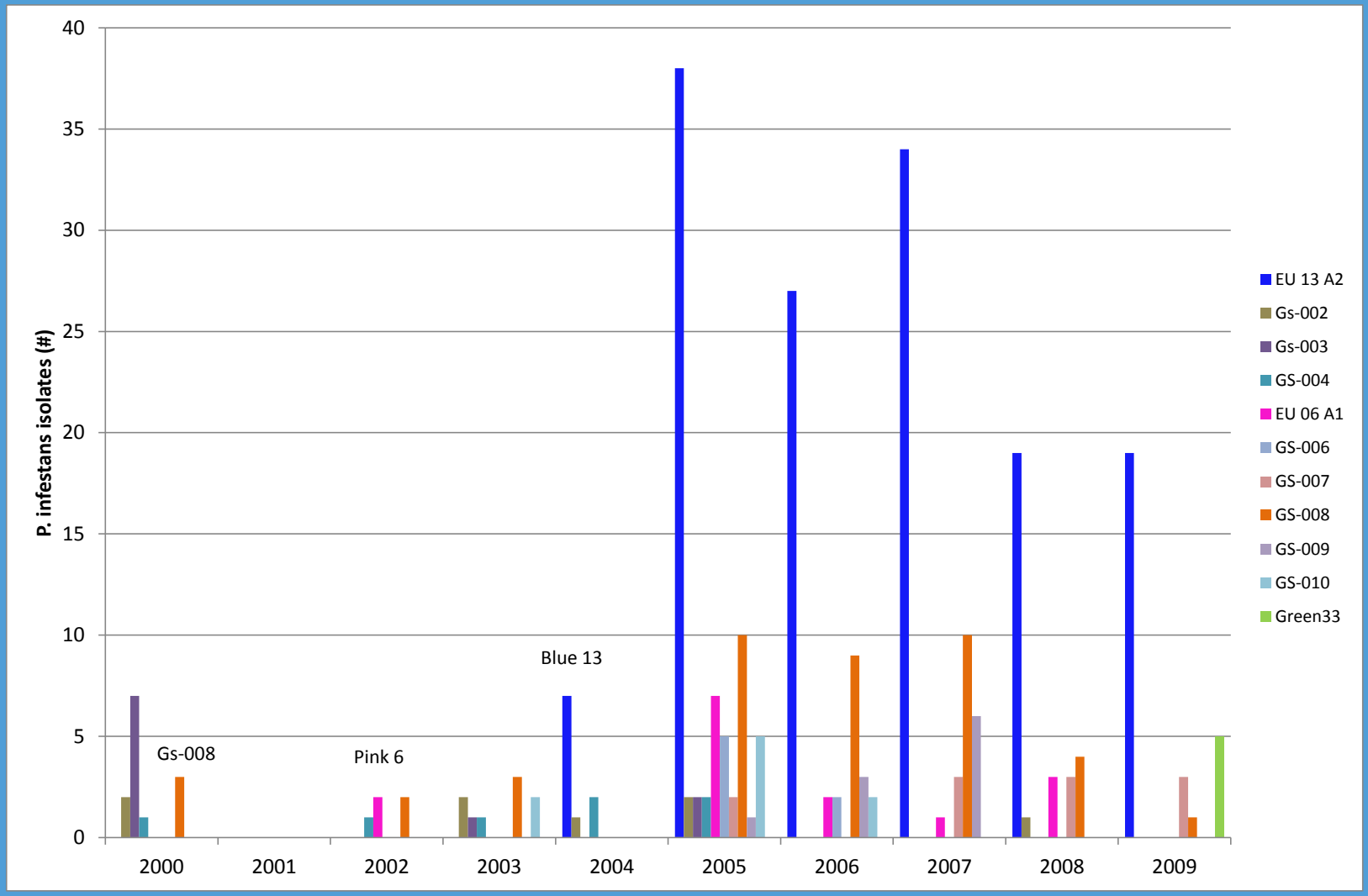
Phytophthora infestans in the Netherlands



Blue = Group 1
Red = Group 2
Green = Group 3

3 groups were distinguished based on "PCA" & STRUCTURE results

Phytophthora infestans in the Netherlands



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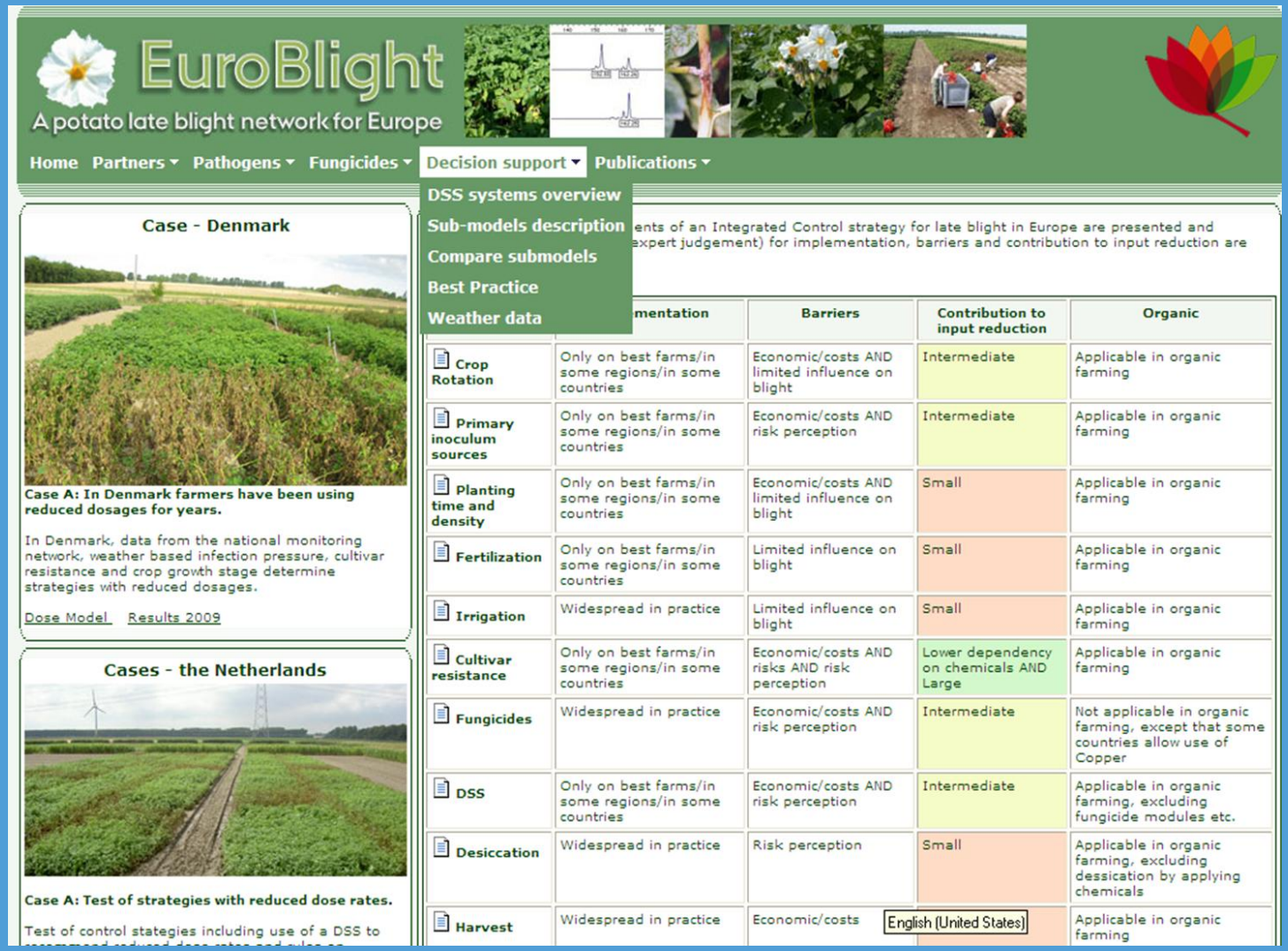
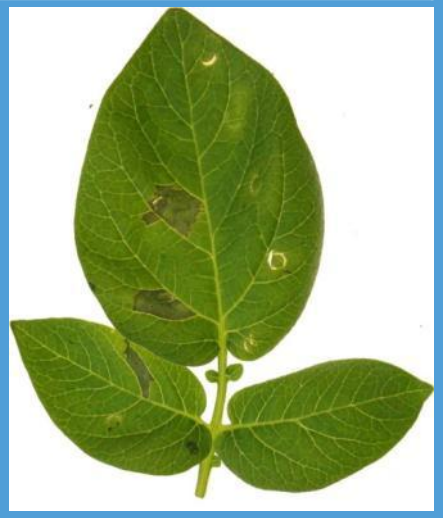
Effectiveness of IPM components



New technologies

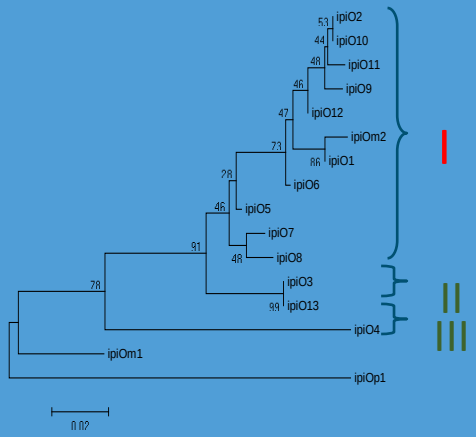
- Host plant resistance:
  - Identification/cloning of many R-genes
  - Marker assisted breeding
  - GM breeding (www.DuRPh.nl)
- Environment:
  - Improved weather forecasts
  - DSS systems
  - Precision agriculture
- Pathogen:
  - Identification of Avr genes incl. variation
  - Effectoromics
  - Direct PCR assays for virulence in pathogen

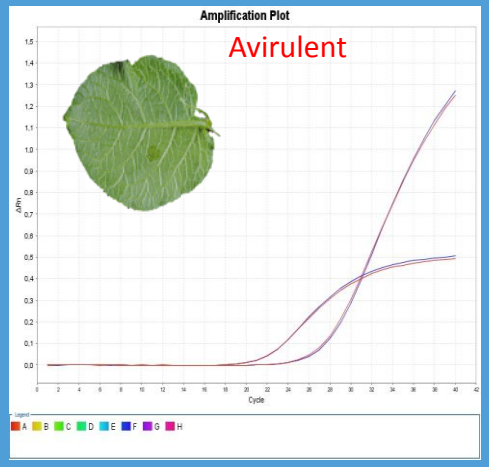
Avr	Ref
Avr1	Govers (pers comm)
Avr2	(Gilroy et al., 2011)
Avr3a	(Armstrong et al., 2005)
Avr3b	(Li et al., 2011)
Avr4	(van Poppel et al., 2008)
Avrblb1	(Vleeshouwers et al., 2008)
Avrblb2	(Oh et al., 2009)
Avrvnt1	(Vleeshouwers et al., 2011)
AvrSmira1	(Rietman et al., 2012)
AvrSmira2	(Rietman et al., 2012)



Monitoring for virulence with *Avr-blb1*

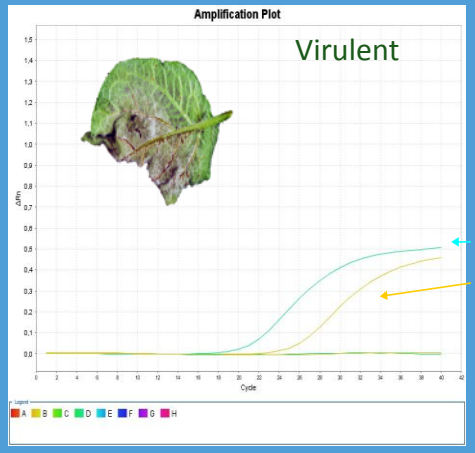
- Rpi-blb1
  - Class I Avr-blb1 absent: Virulent
  - Real time monitoring
  - Q-PCR for Blb1 virulence on P. infestans





Class I Avr-blb1

P. infestans control



P. infestans control

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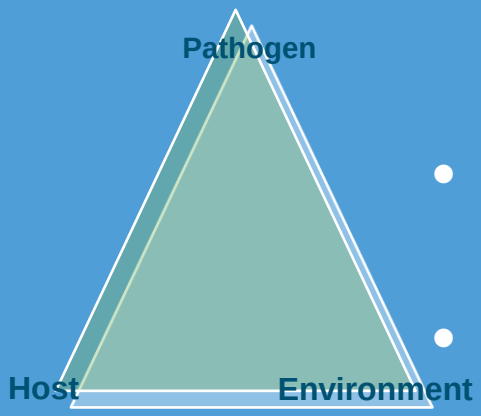
Theo van de Lee

Champouret et al 2009 MPMI

An IPM 2.0 control strategy for PLB

- Proof of concept
- IPM 2.0 control strategy for Potato Late Blight (PLB):



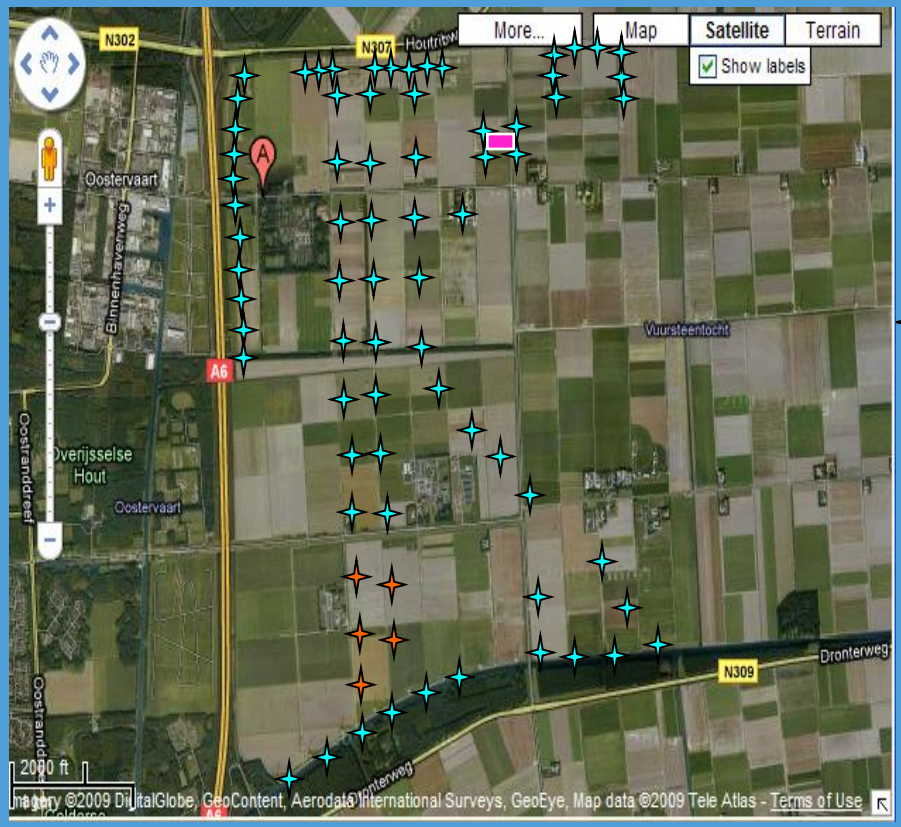
- **Host:**
  - presence / absence & growth stage
  - residual fungicide protection
  - Resistance→ reduced dose rates of protectants
- **Pathogen:**
  - DWIP → go / no go on resistant cultivars (Skelsey et al 2009)
  - Virulence for R gene(s) used
- **Environment:**
  - Significant infection event predicted (DSS)
  - Length of infection event: → reduced dose rates

- **<u>We DO NOT spray unless … ALL</u>** criteria for disease development are full filled
- Goal:
  - More durable and efficient use of resistance and fungicides
  - Durable cultivation of potato

Field Trials

- Two years (2010 & 2011)
- Two locations (Lelystad & Valthermond)
- Default Strategy:
  - Range of host resistance: S - MR - HR
    - Bintje/Starga S 100% dose rate protectant
    - Escort (R1R3R10) or Santé (R1R10) MR 50% dose rate protectant
    - Bionica (Blb2) HR 25% dose rate protectant
    - Chc1 HR 25% dose rate protectant
    - Blb1 HR 25% dose rate protectant
    - Vnt1 (2010) HR 25% dose rate protectant
  - Custom experimental IPM 2.0 DSS → Spray timing
- WITH or WITHOUT Continuous monitoring for virulence:
  - Weekly lesion counts in monitoring plots
  - Weekly lesion samples → PCR analysis Blb1 virulence

Field trial set up in Lelystad & Valthermond



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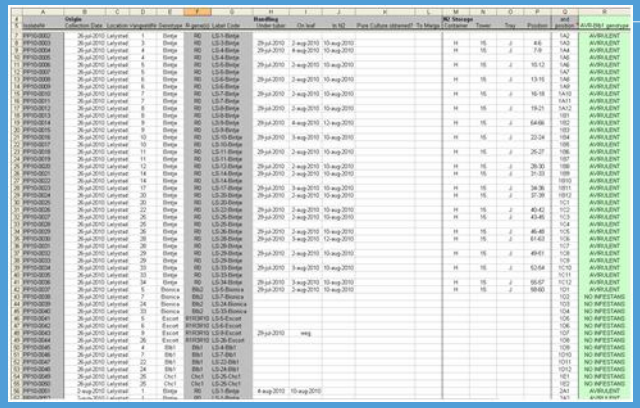
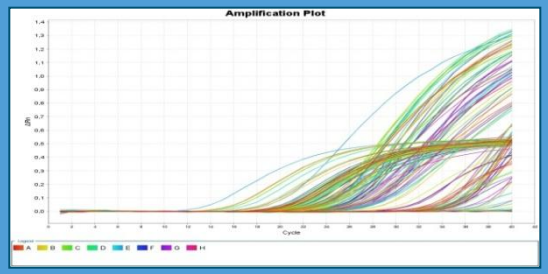
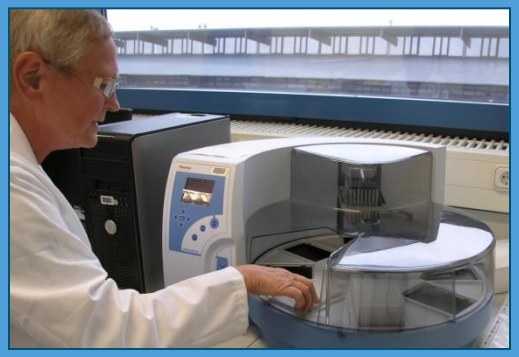
Avr-Blb1 virulence assay within 5 hrs



Start





96 well format

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Lelystad 2010

Valthermond 2010

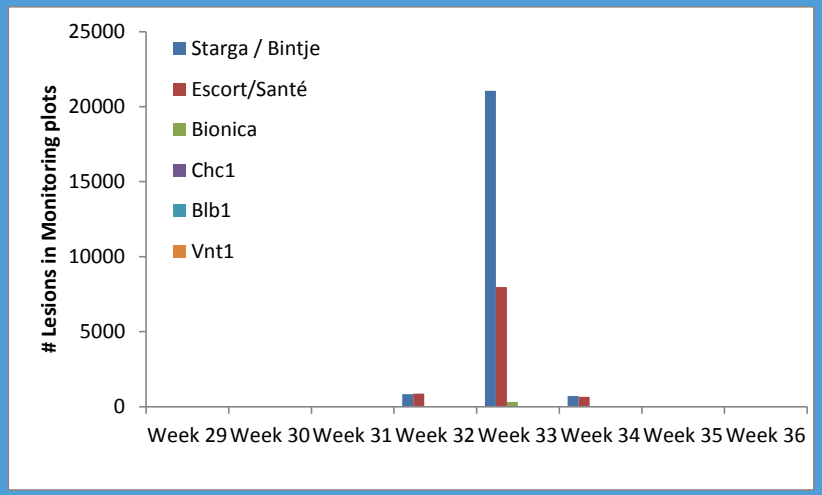
Monitoring plots Lelystad & Valthermond

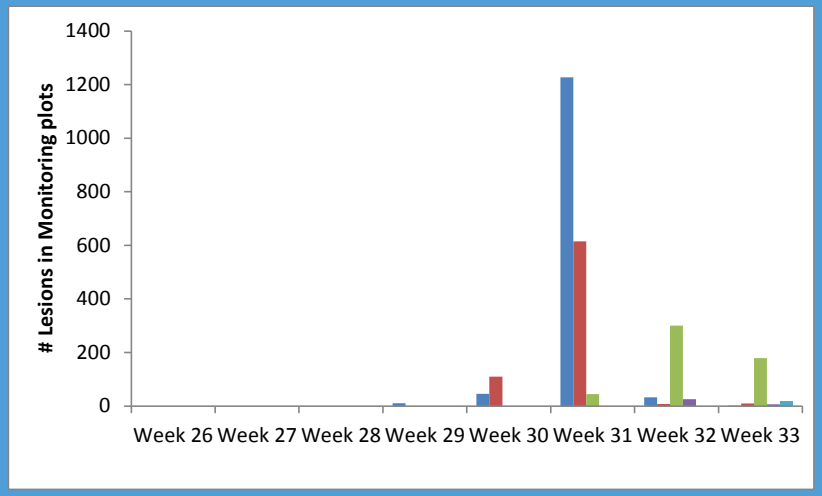
Lesion counts monitoring plots

2010

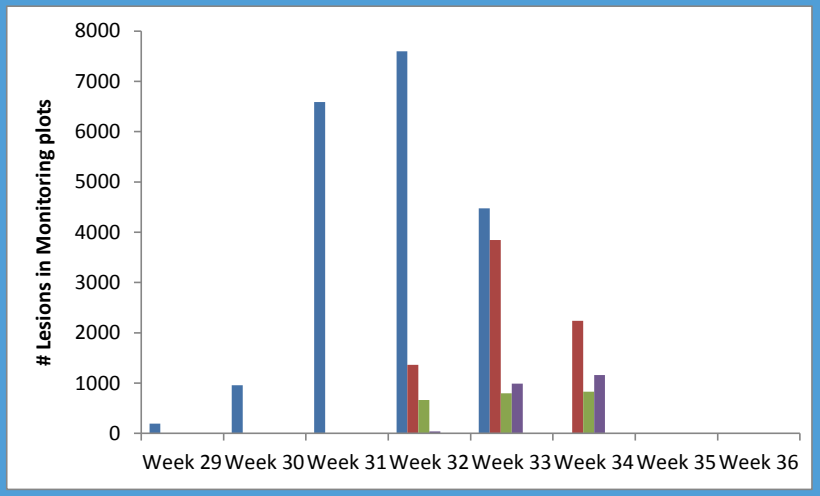
2011

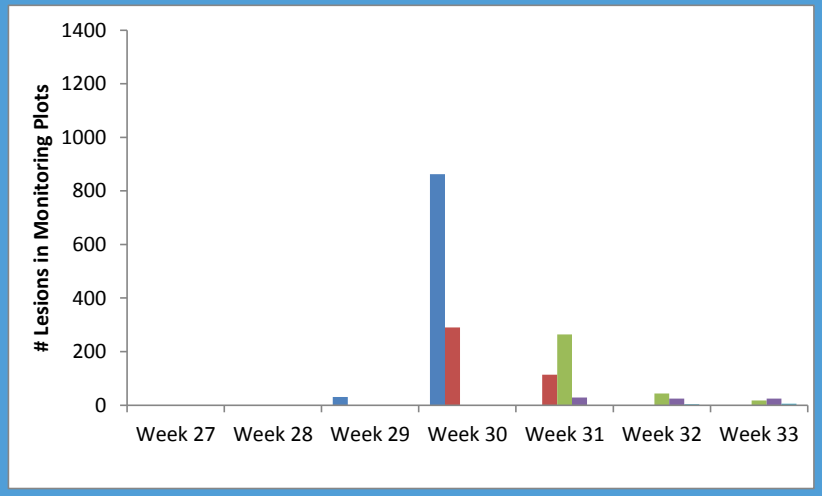
Valthermond





Lelystad





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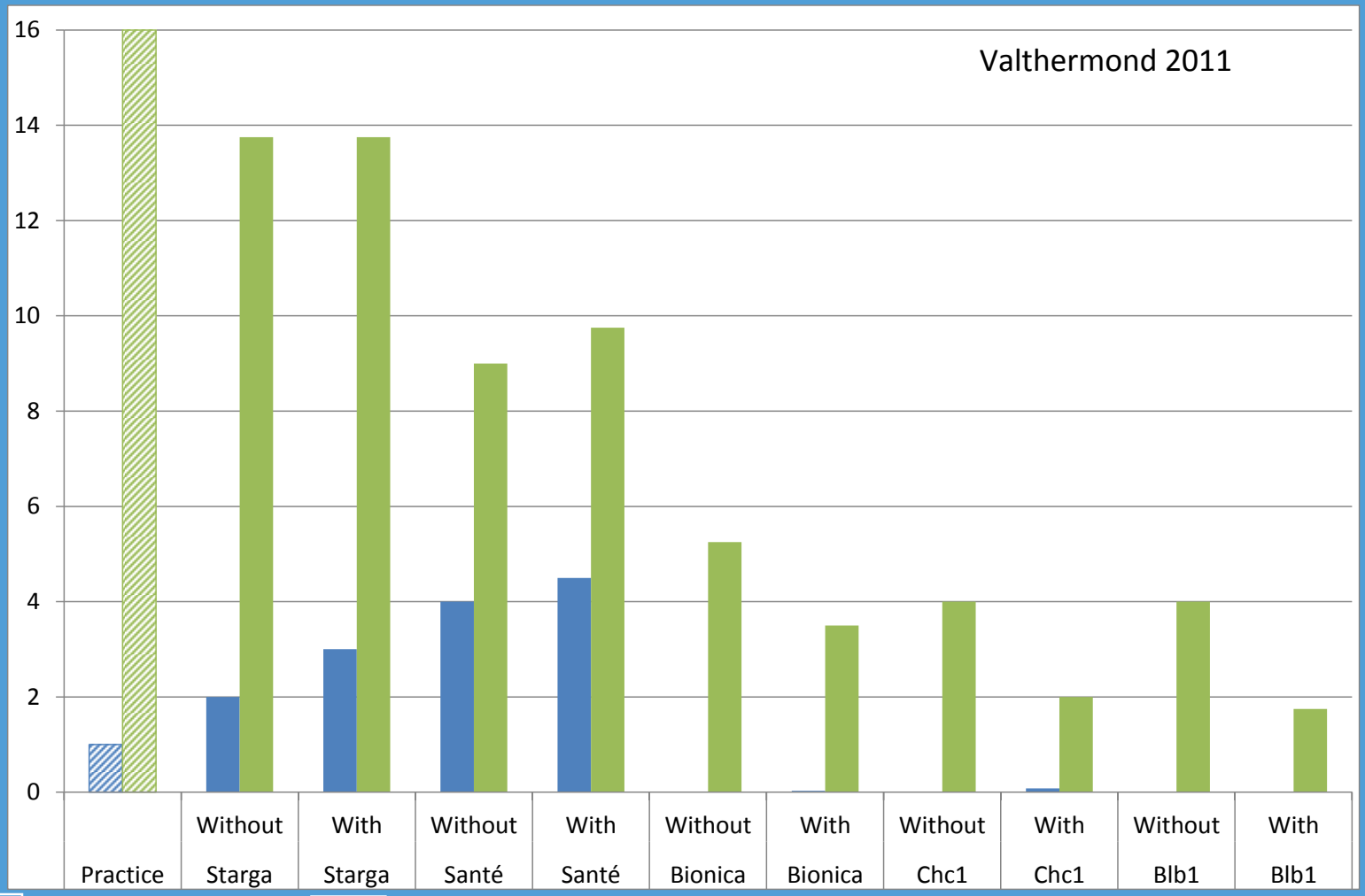
Avr-Blb1 effector Screening

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

- 2010
  - NO infections on Blb1 plant material
  - PCR: 633 samples, **1 virulent isolate** in Lelystad Confirmed in Bio Assay!
- 2011
  - First infections on Blb1 plant material:
    - Lelystad: 8 August 2011
    - Valthermond: 15 August
  - First PCR positive Blb1 virulent isolates:
    - Lelystad: 25 July 2011 (Bintje & Bionica)
    - Valthermond: 15 August 2011 (Blb1 plant)

Results

- Valthermond 2011



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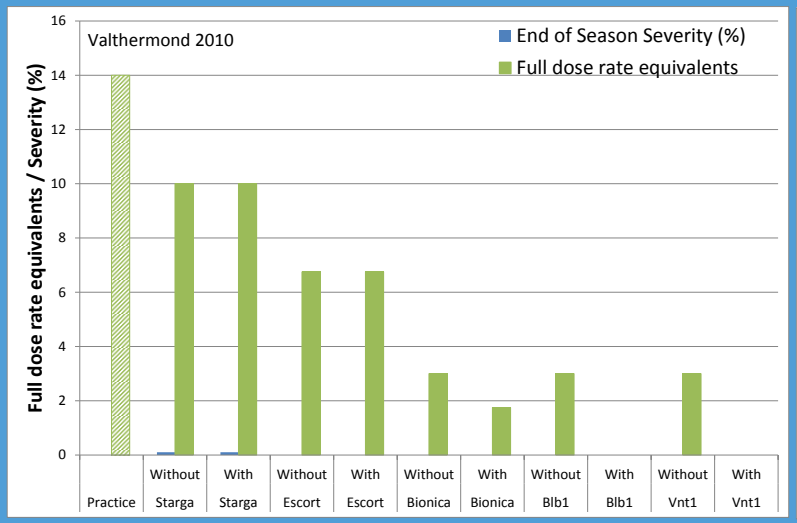
Results

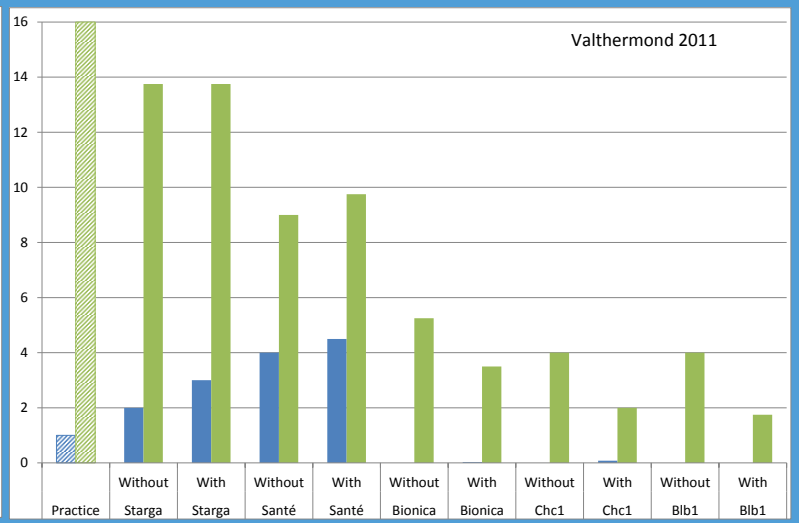
2010

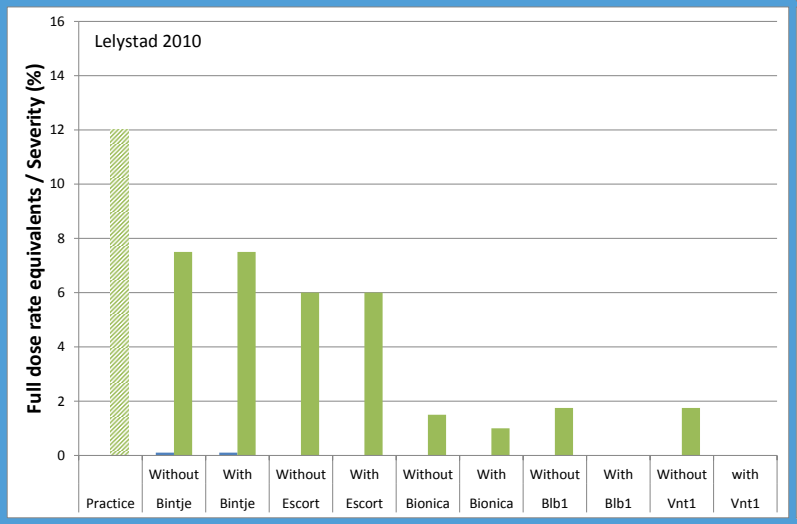
2011

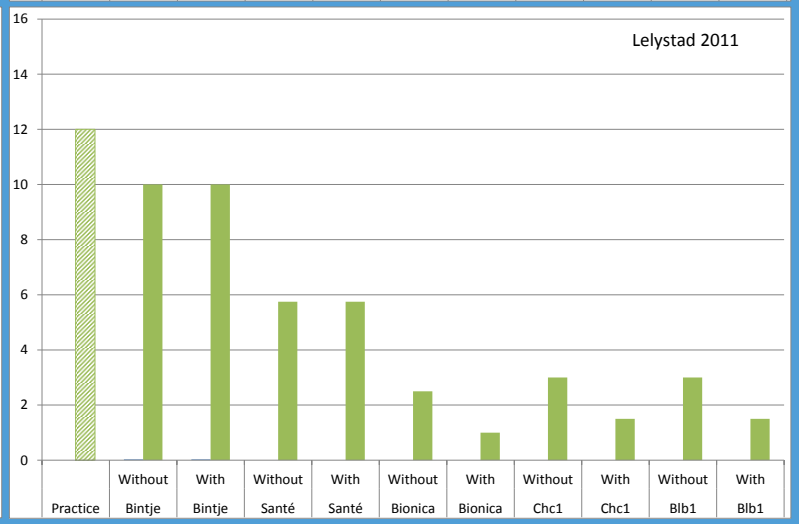
Valthermond

Lelystad









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Conclusions

- The full potential of IPM in PLB control is not yet realized, ... not even close!
- Ample room for improvement **IF** host resistance is introduced
- *P. infestans* highly adaptive → Resistance should be designed / introduced in the most durable way (stacking of R-genes, multilines, landscaping etc.)
- Resistance should be managed after introduction. It's NOT a silver bulet
- Fungicides remain an integral part of the control strategy but input is lower
- Spin off of IPM 2.0 control strategy for PLB to other "aerial" pathosystem e.g. rusts & mildews in cereals, downy mildew in grapes, apple and pear scab ...