

IPM 2.0 approach to Potato late blight Control

Geert Kessel, Bert Evenhuis, Trudy van den Bosch, Marieke Förch and Huub Schepers



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)

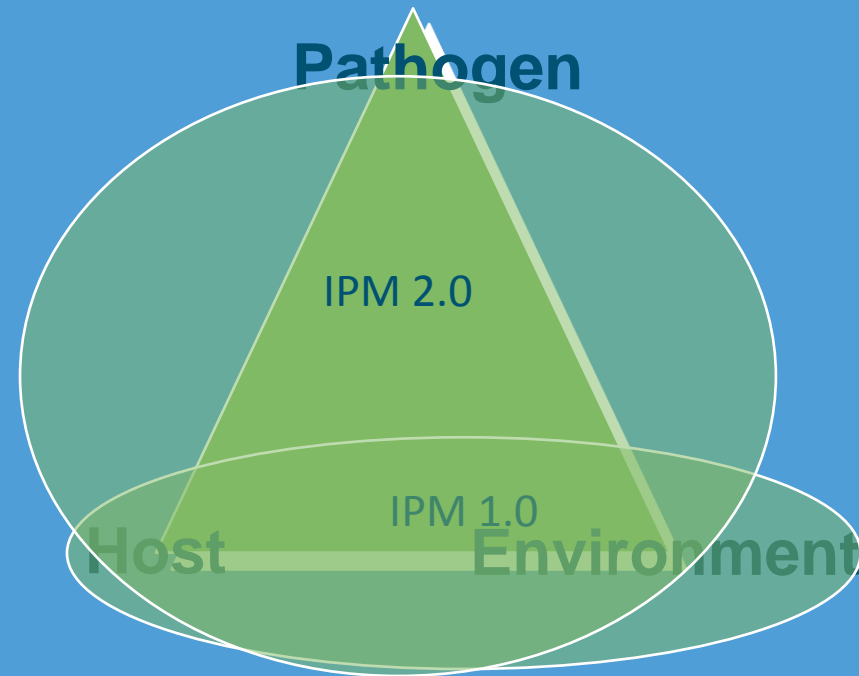
■ IPM components:

- 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

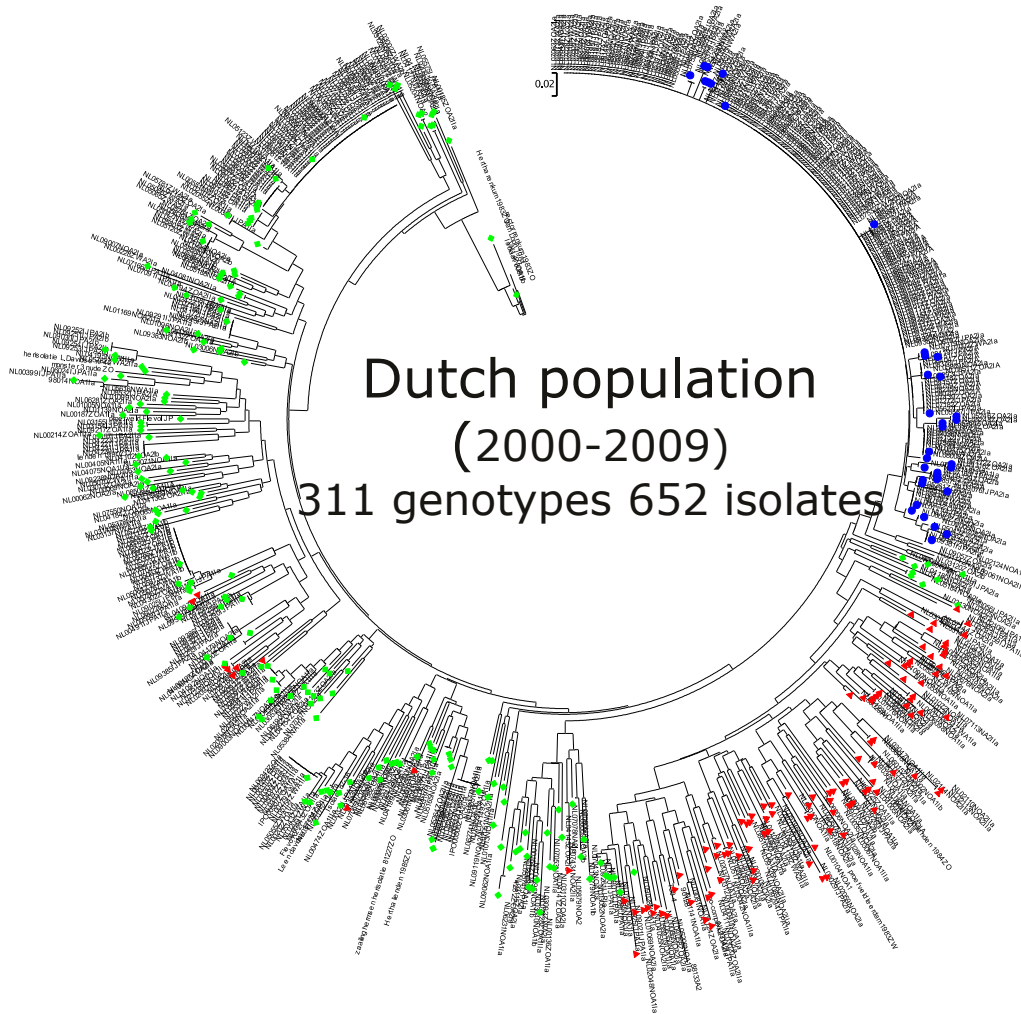


Disease development & Spray decisions

- 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?



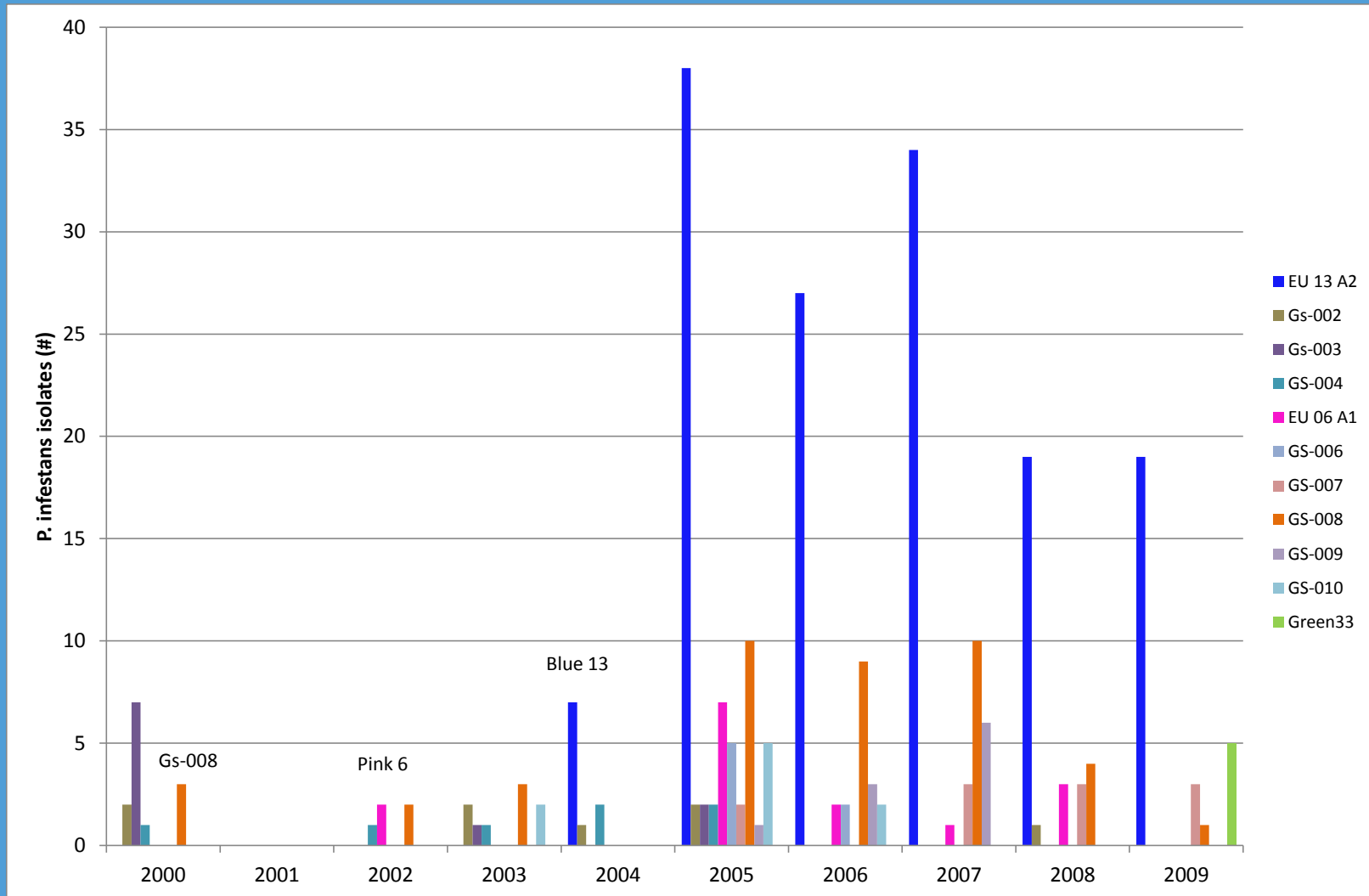
Phytophthora infestans in the Netherlands




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


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

Phytophthora infestans in the Netherlands




Effectiveness of IPM components





Home
Partners ▾
Pathogens ▾
Fungicides ▾
Decision support ▾
Publications ▾

Case - Denmark



Case A: In Denmark farmers have been using reduced dosages for years.

In Denmark, data from the national monitoring network, weather based infection pressure, cultivar resistance and crop growth stage determine strategies with reduced dosages.

[Dose Model](#) [Results 2009](#)

DSS systems overview

Elements of an Integrated Control strategy for late blight in Europe are presented and (expert judgement) for implementation, barriers and contribution to input reduction are


Sub-models description

Compare submodels

Best Practice

Weather data	Implementation	Barriers	Contribution to input reduction	Organic
Crop Rotation	Only on best farms/in some regions/in some countries	Economic/costs AND limited influence on blight	Intermediate	Applicable in organic farming
Primary inoculum sources	Only on best farms/in some regions/in some countries	Economic/costs AND risk perception	Intermediate	Applicable in organic farming
Planting time and density	Only on best farms/in some regions/in some countries	Economic/costs AND limited influence on blight	Small	Applicable in organic farming
Fertilization	Only on best farms/in some regions/in some countries	Limited influence on blight	Small	Applicable in organic farming
Irrigation	Widespread in practice	Limited influence on blight	Small	Applicable in organic farming
Cultivar resistance	Only on best farms/in some regions/in some countries	Economic/costs AND risks AND risk perception	Lower dependency on chemicals AND Large	Applicable in organic farming
Fungicides	Widespread in practice	Economic/costs AND risk perception	Intermediate	Not applicable in organic farming, except that some countries allow use of Copper
DSS	Only on best farms/in some regions/in some countries	Economic/costs AND risk perception	Intermediate	Applicable in organic farming, excluding fungicide modules etc.
Desiccation	Widespread in practice	Risk perception	Small	Applicable in organic farming, excluding desiccation by applying chemicals
Harvest	Widespread in practice	Economic/costs	English (United States)	Applicable in organic farming

Cases - the Netherlands



Case A: Test of strategies with reduced dose rates.

Test of control strategies including use of a DSS to

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

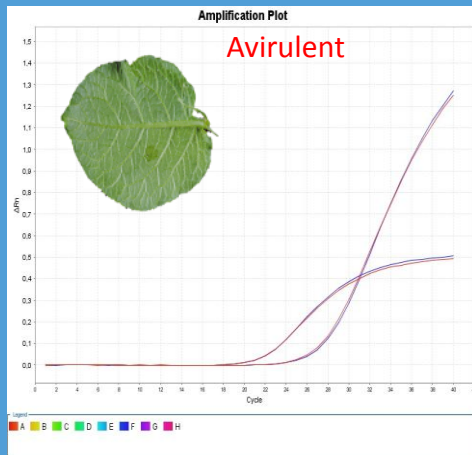
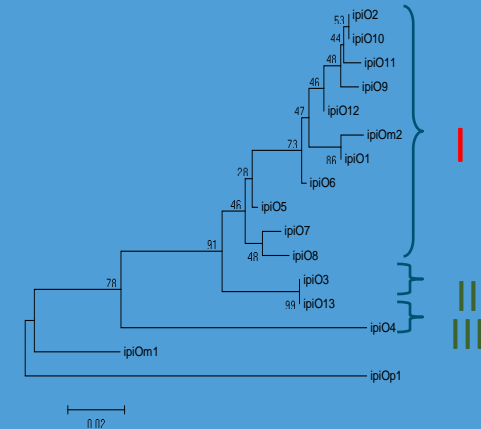
Avr	Ref
Avr1	Govers (pers comm)
Avr2	(Gilroy et al., 2011)
Avr3a	(Armstrong et al., 2005)
Avr3b	(Li et al., 2011)
Avr4	(van Poppel et al., 2008)
Avrblb1	(Vleeshouwers et al., 2008)
Avrblb2	(Oh et al., 2009)
Avrvnt1	(Vleeshouwers et al., 2011)
AvrSmira1	(Rietman et al., 2012)
AvrSmira2	(Rietman et al.,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



Monitoring for virulence with *Avr-blb1*

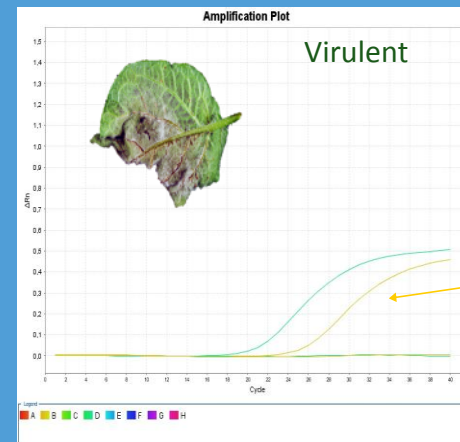
■ Rpi-blb1

- 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

An IPM 2.0 control strategy for PLB

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

Pathogen

- **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

Environment

Host

- **We DO NOT spray unless ... ALL** criteria for disease development are full filled

- Goal:

- More durable and efficient use of resistance and fungicides
- Durable cultivation of potato

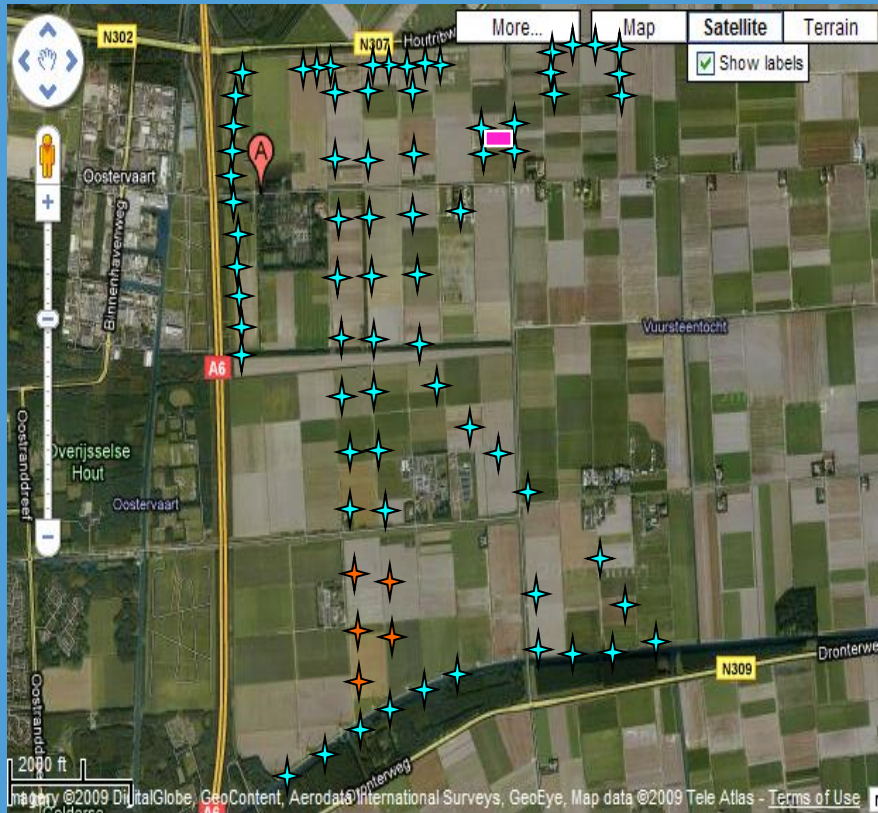


Field Trials

- 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



Lelystad 2010



Valthermond 2010



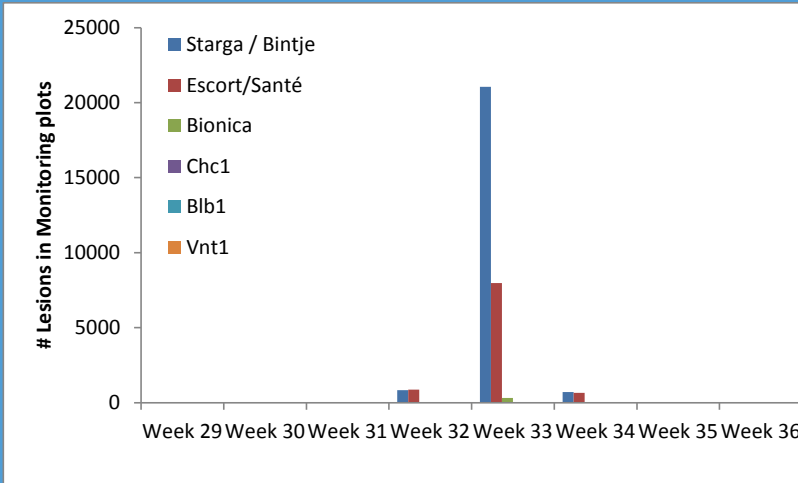
Monitoring plots Lelystad & Valthermond



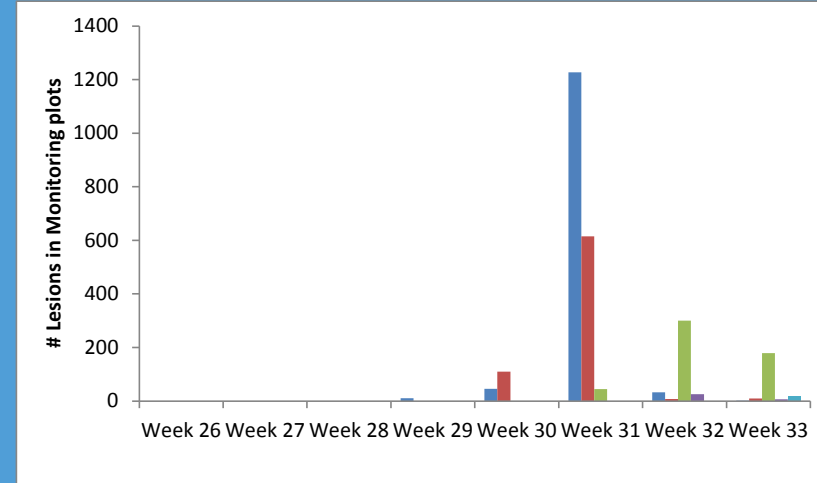
Lesion counts monitoring plots

Valthermond

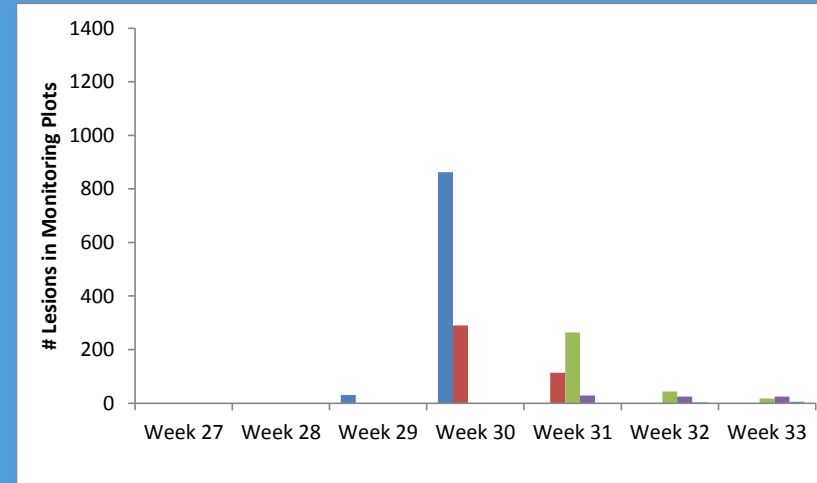
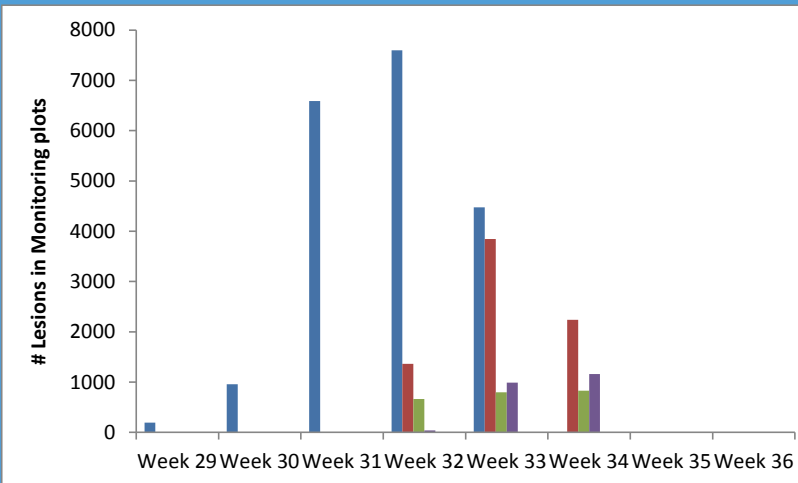
2010



2011



Lelystad



Avr-Blb1 effector Screening

■ 2010

- NO infections on Blb1 plant material
- PCR: 633 samples, **1 virulent isolate** in Lelystad
Confirmed in Bio Assay!

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

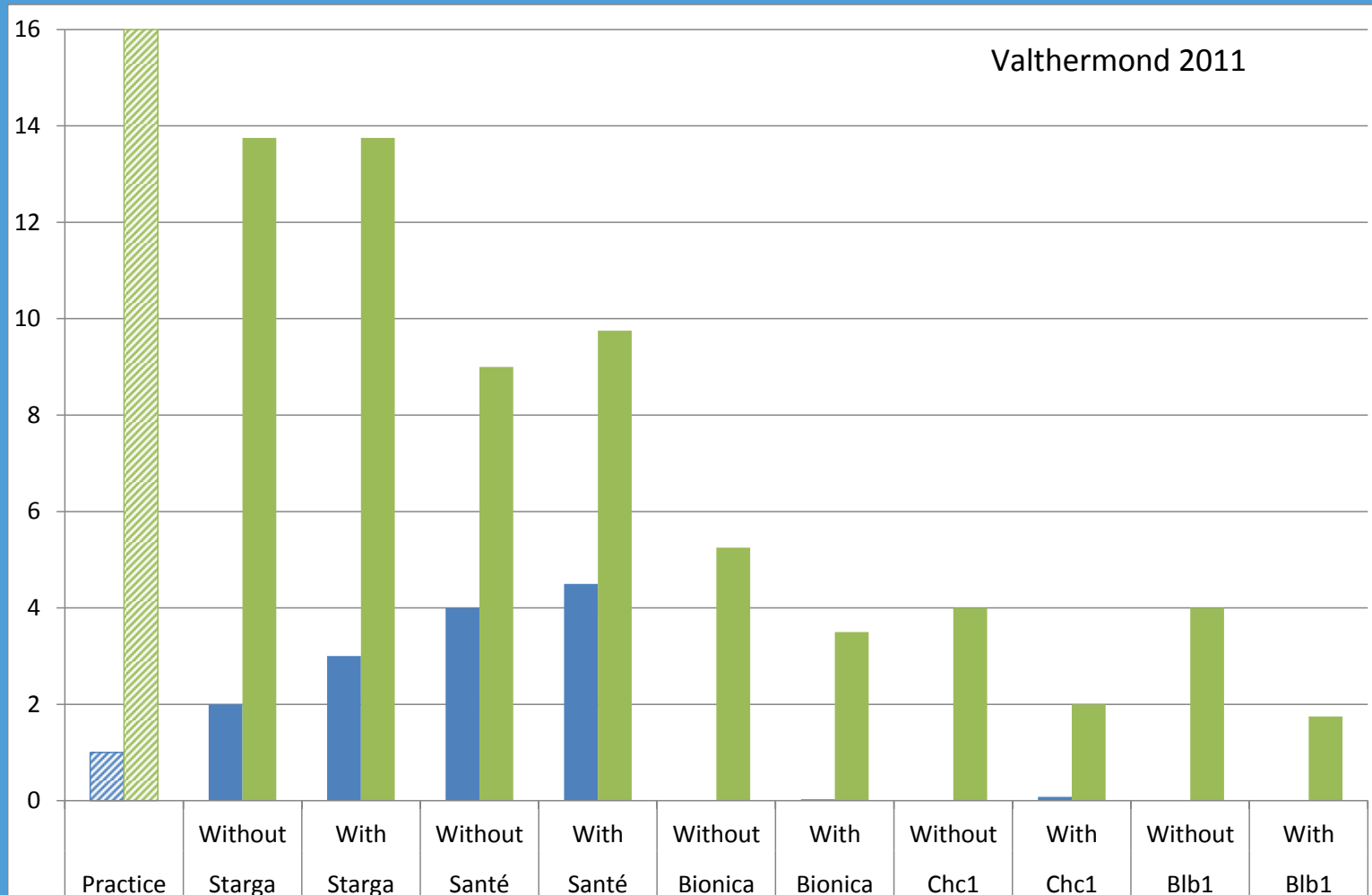
■ 2011

- 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

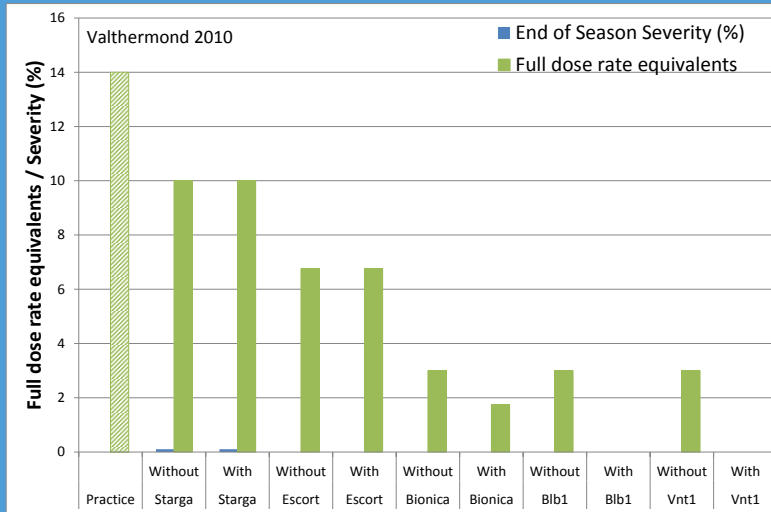
■ Valthermond 2011



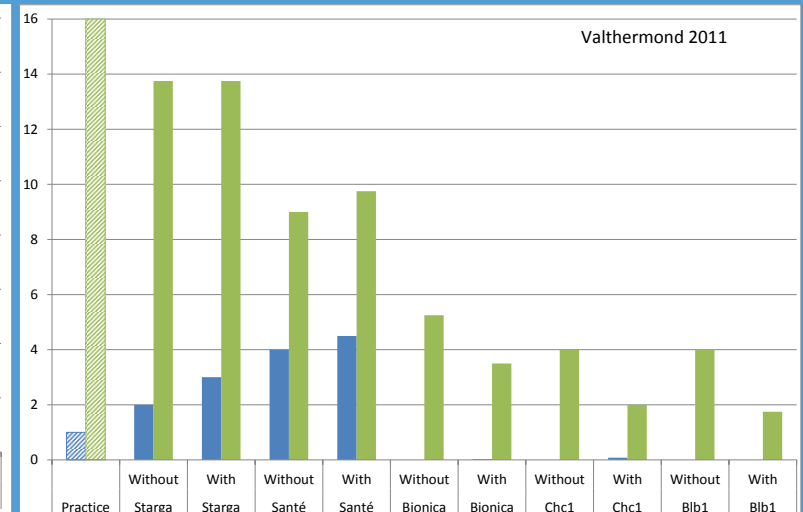
Results

Valthermond

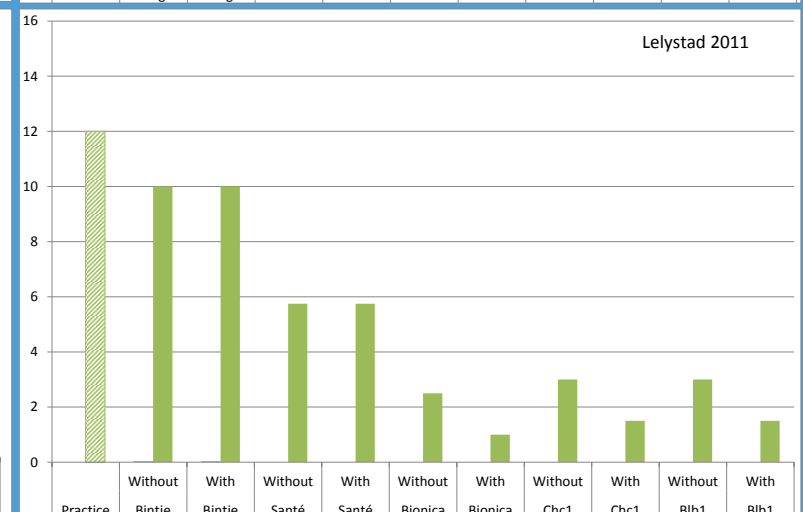
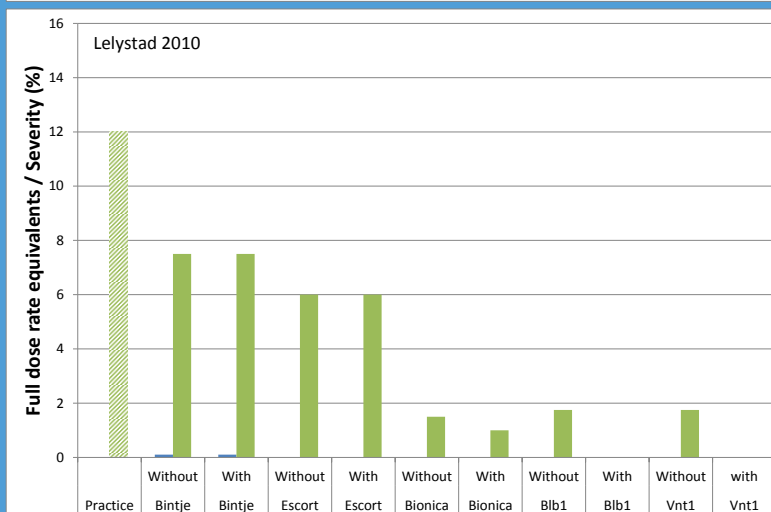
2010



2011



Lelystad



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 bullet
- 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 ...

