IPM 2.0 for Potato late blight Control

A control strategies using host resistance and pathogen virulence

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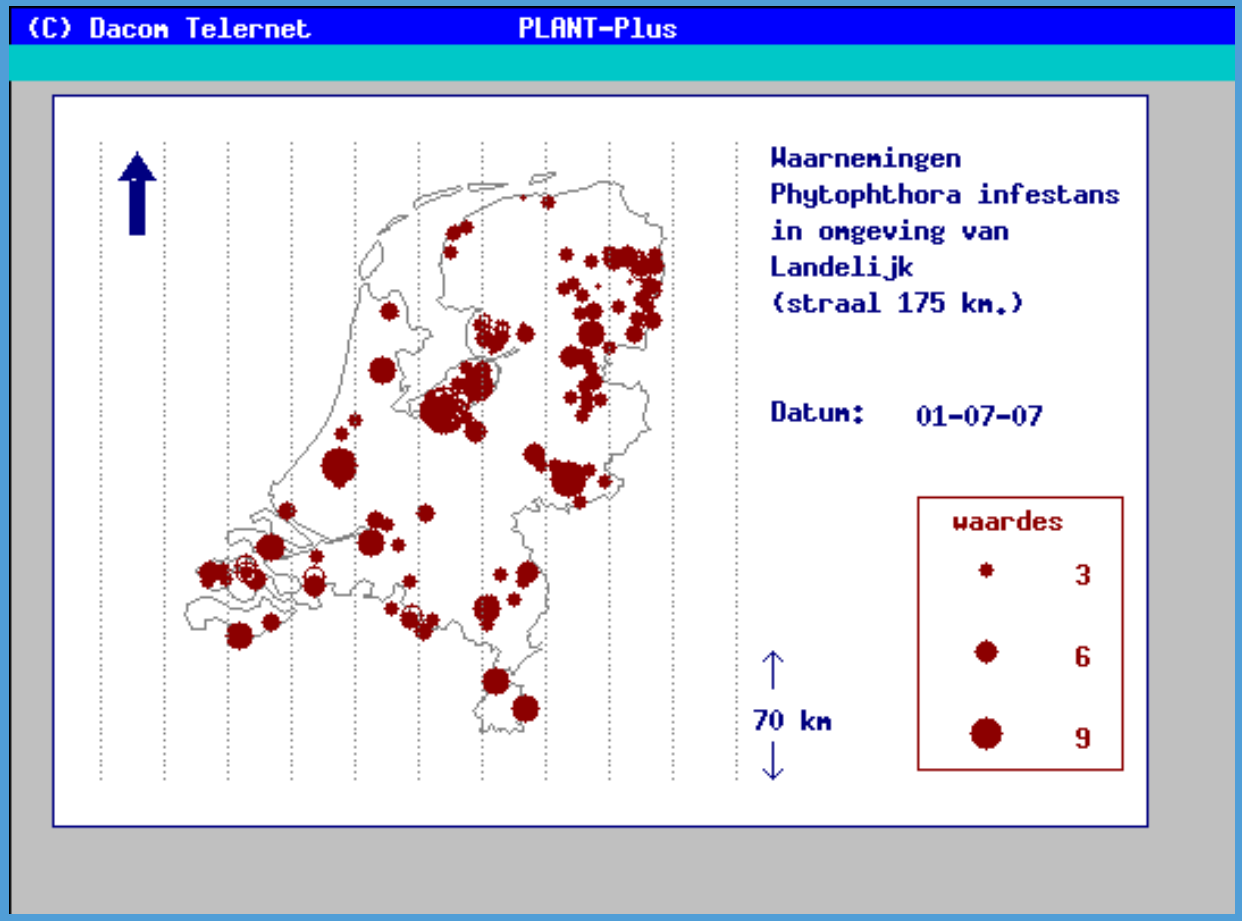
Potato & PLB control

- Potatoes in the Netherlands:
  - Ware potato: 75 000 ha 50 t/ha
  - Seed potato: 40 000 ha 35 t/ha
  - Starch potato: 50 000 ha 45 t/ha
  - Total: 165 000 ha → 7.9 Mt/year ≈ 790 M€/year
- Costs of PLB control in the Netherlands:
  - 12 – 15 sprays per season, 1424 ton's a.i. / year
  - Costs (fungicides, spraying, losses): 124 M€/yr (15 % of farm gate turn over)
- EU and Global costs of PLB control: ≈ 900 M€/yr and 4800 M€/yr resp.

Ref.: Haverkort et al 2008

PLB in the Netherlands (1 July 2007)



masterplan Phytophthora

www.kennisakker.nl

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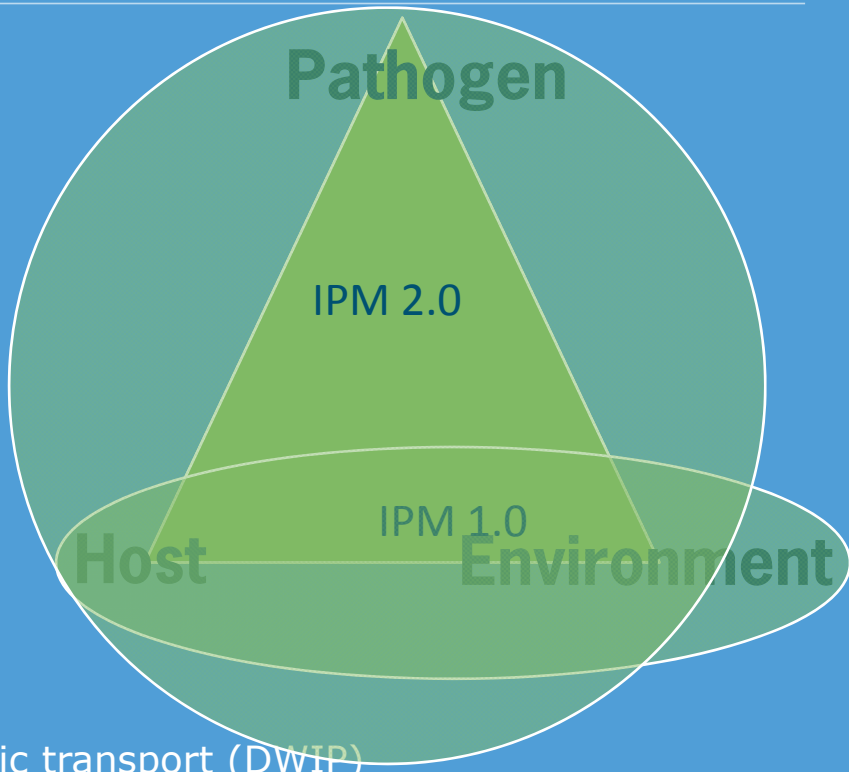
What is IPM (EU directive 2009)

- IPM for the National Action Plans
  - 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

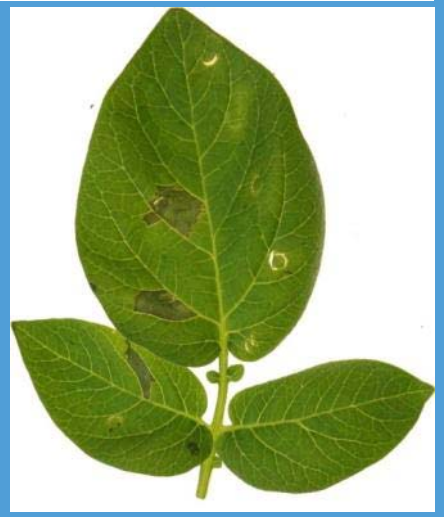
- Weekly spray schedules ("IPM")
  - Host is present
- IPM 1.0
  - Host is present
  - Weather suitable for infection
    1st generation DSS's
- IPM 2.0
  - Host is present
    - Susceptible?
    - Resistant? Which R-genes?
  - Weather suitable for infection (DSS's)
    - For how long?
    - Do spores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



New technologies

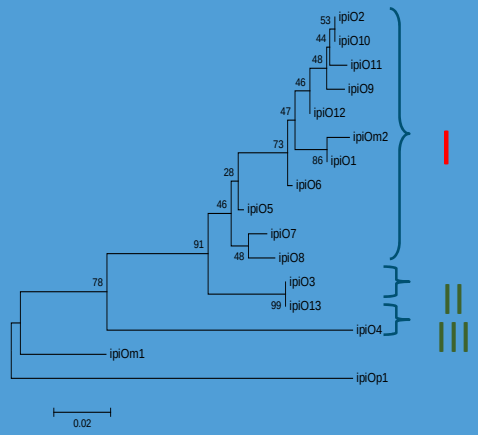
- Host plant resistance:
  - Identification/cloning of many R-genes
  - Marker assisted breeding
  - GM breeding (www.DuRPh.nl)
- Environment:
  - Improved weather forecasts
  - DSS systems
  - Precision agriculture
- Pathogen:
  - Identification of Avr genes incl. variation
  - Effectoromics
  - Direct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

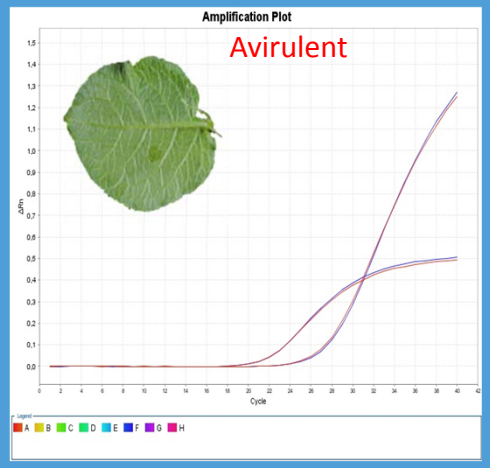
Avr	Ref
Avr1	Govers (pers comm)
Avr2	(Gilroy et al., 2011)
Avr3a	(Armstrong et al., 2005)
Avr3b	(Li et al., 2011)
Avr4	(van Poppel et al., 2008)
Avrblb1	(Vleeshouwers et al., 2008)
Avrblb2	(Oh et al., 2009)
Avrvnt1	(Vleeshouwers et al., 2011)
AvrSmira1	(Rietman et al., 2012)
AvrSmira2	(Rietman et al.,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



Monitoring for virulence with *Avr-blb1*

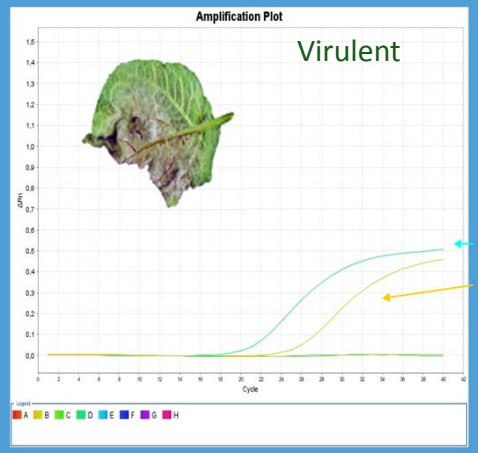
- Rpi-blb1
  - Class I Avr-blb1 absent: Virulent
  - Real time monitoring
  - Q-PCR for Blb1 virulence on P. infestans





Class I Avr-blb1

P. infestans control



P. infestans control

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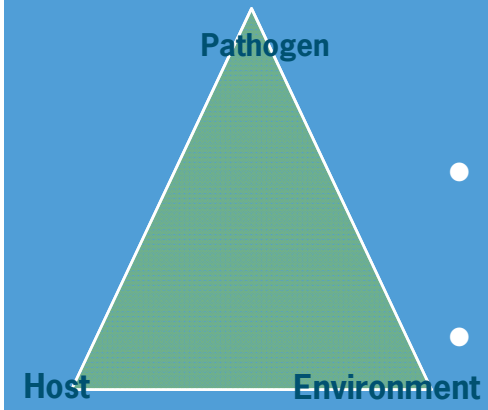
Theo van de Lee

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

- **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

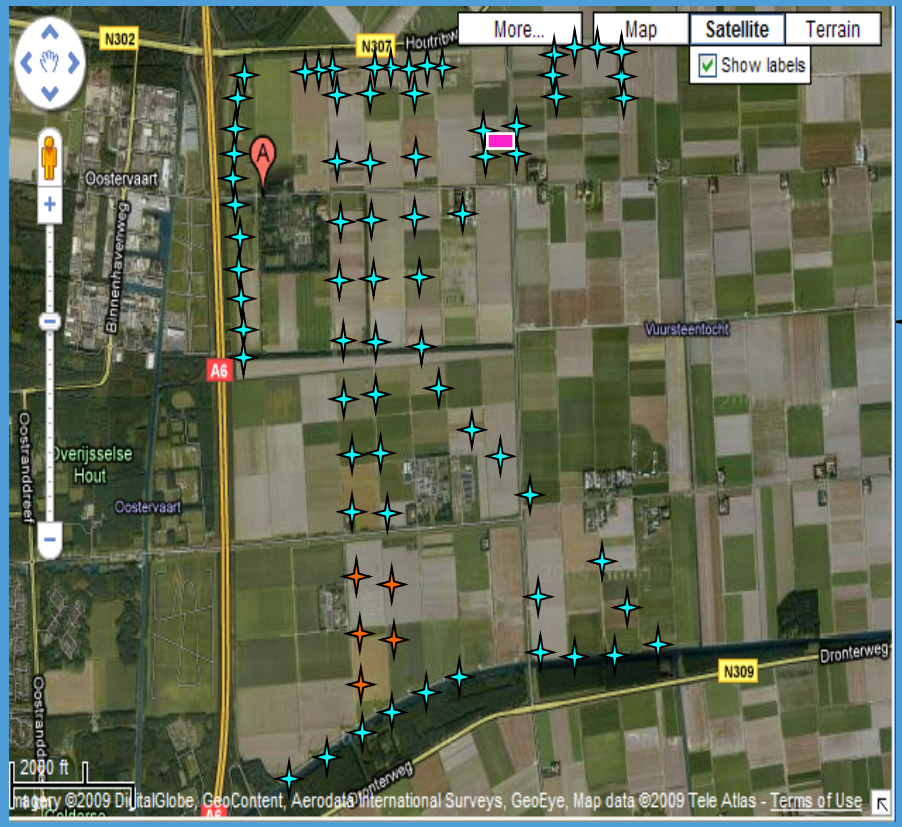
- Two years (2010 & 2011)
- Two locations (Lelystad & Valthermond)
- Range of host resistance: S - MR - HR

• 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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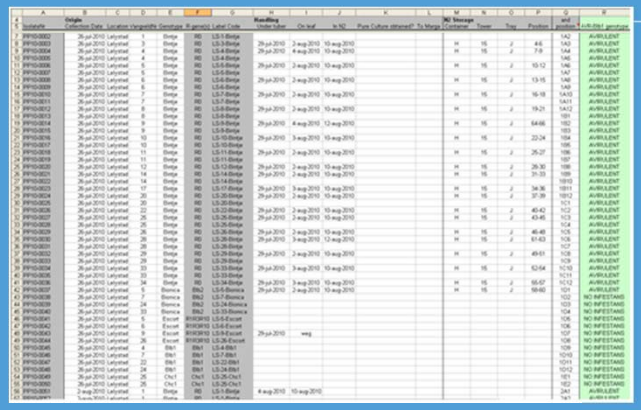
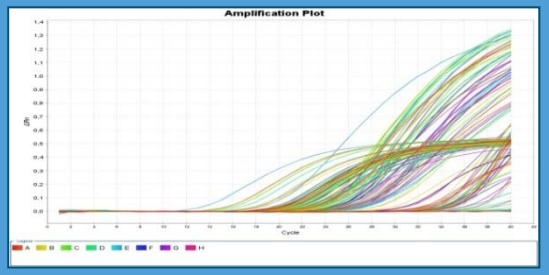
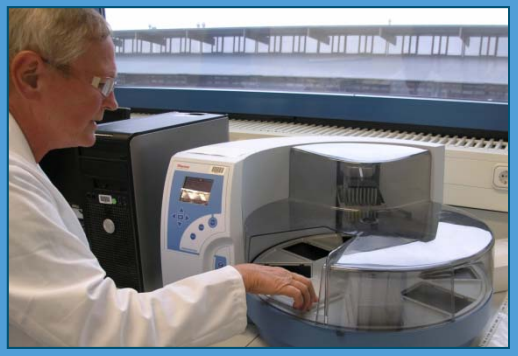
Avr-Blb1 virulence assay within 5 hrs







Start

96 well format

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Lelystad 2010

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Valthermond 2010

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Monitoring plots Lelystad & Valthermond

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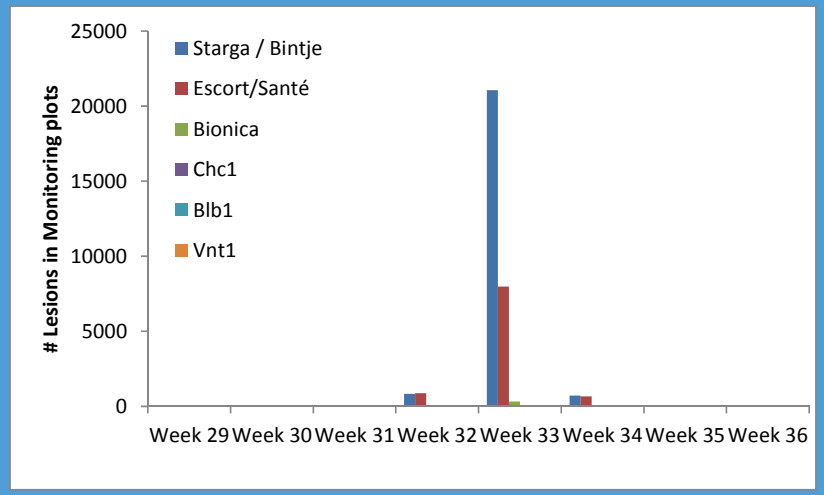
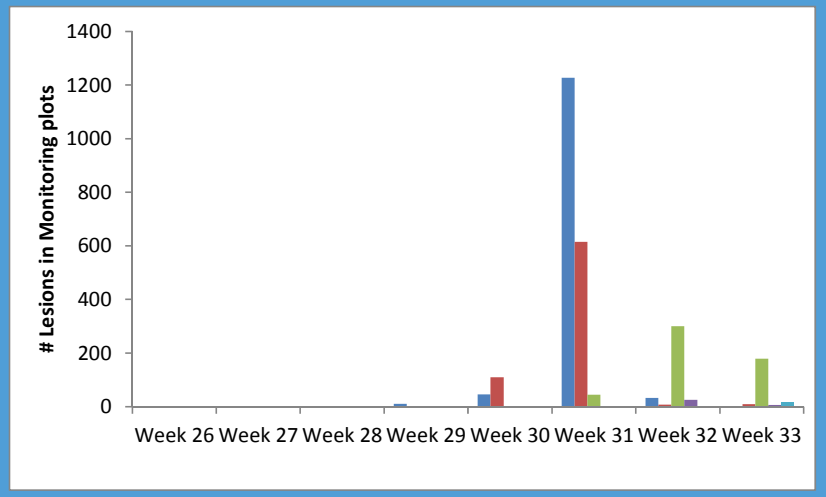
Lesion counts monitoring plots

2010

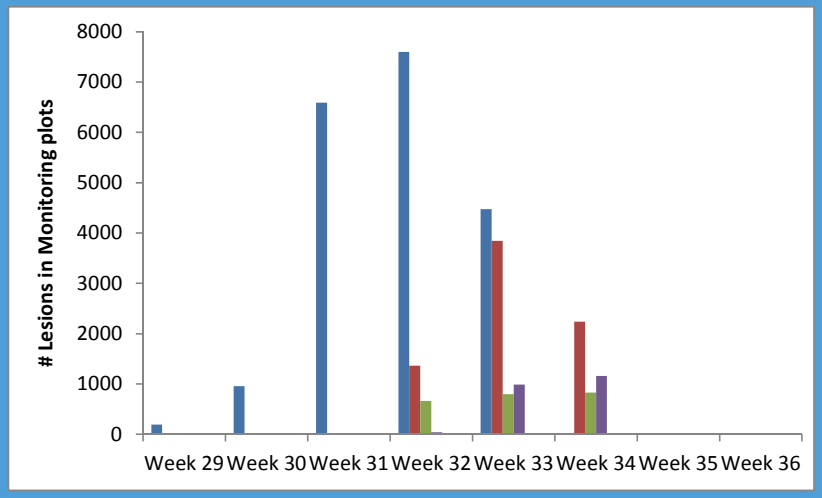
2011

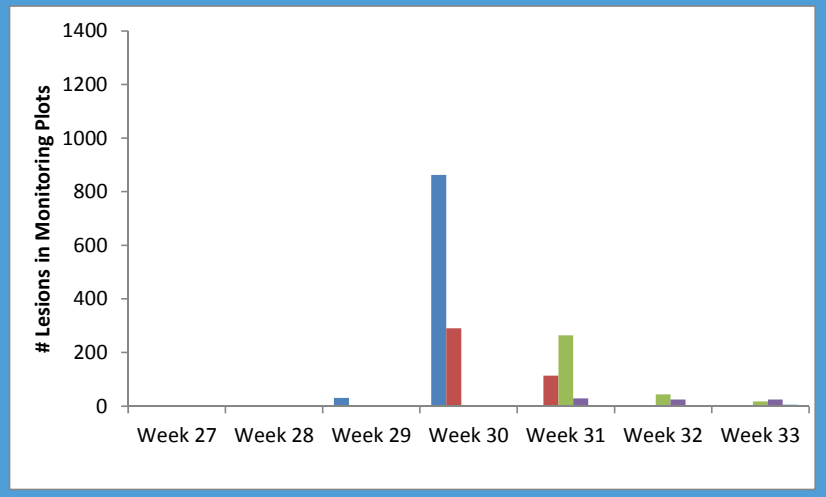
Valthermond





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

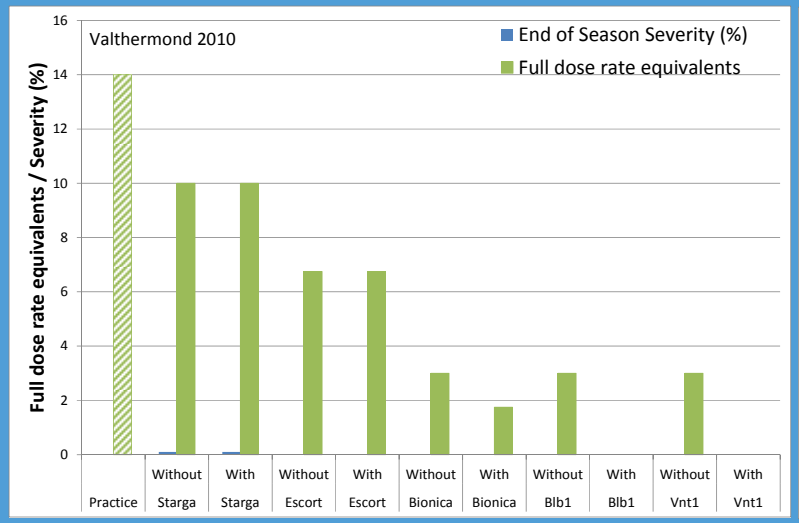
- 2010
  - NO infections on Blb1 plant material
  - PCR: 633 samples, **1 virulent isolate** in Lelystad
    Confirmed in Bio Assay!
- 2011
  - First infections on Blb1 plant material:
    - Lelystad: 8 August 2011
    - Valthermond: 15 August
  - First PCR positive Blb1 virulent isolates:
    - Lelystad: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

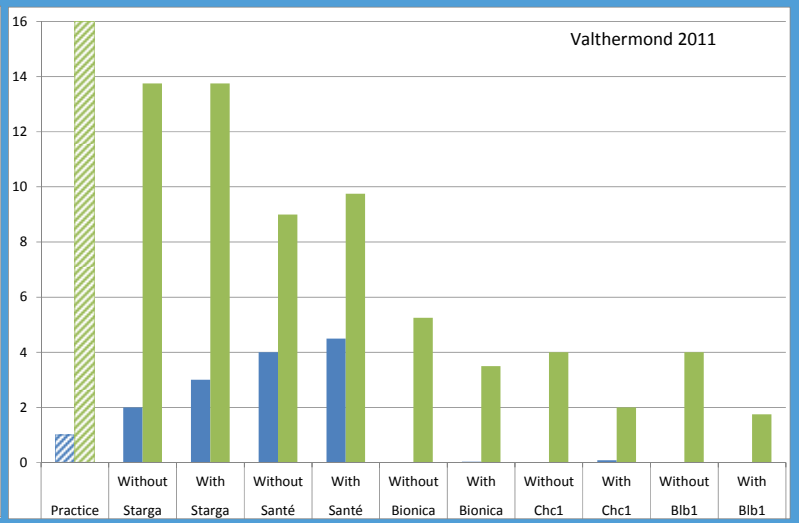
Results

2010

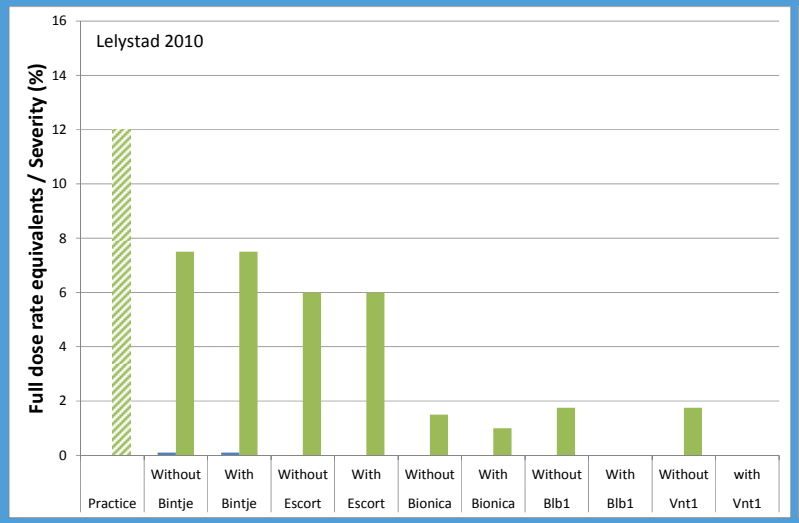
2011

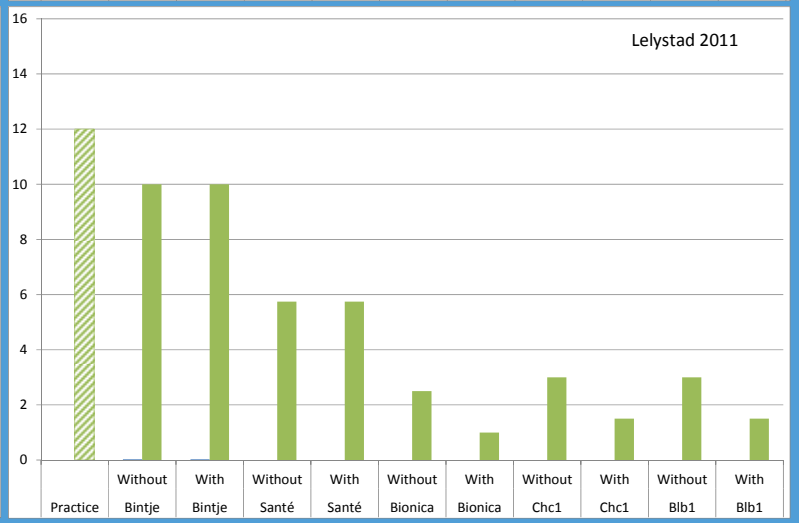
Valthermond





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
- Resistance should be designed / introduced in the most durable way e.g. stacking of R-genes, multilines, landscaping etc. R-genes are too valuable to waste!
- Resistance should be managed after introduction!! It is NOT a silver bulet
    - We do not spray unless ....
    - Monitoring of the pathogen population
    - Adjust control strategy as needed
    - Protect the R-genes = Protect the environment!
- Fungicides remain an integral part of the control strategy but input **much** 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 ...

The future?

- A Green agricultural landscape
- Resistant crops
- Online pathogen monitoring systems (e.g. automated spore traps ...
- On site phenotypic analysis for the various pathogens
- Central EU database for resulting data (e.g. Euroblight)
- DSS systems that include up to date resistance and virulence data in advice
- Low environmental foot print of agricultural production