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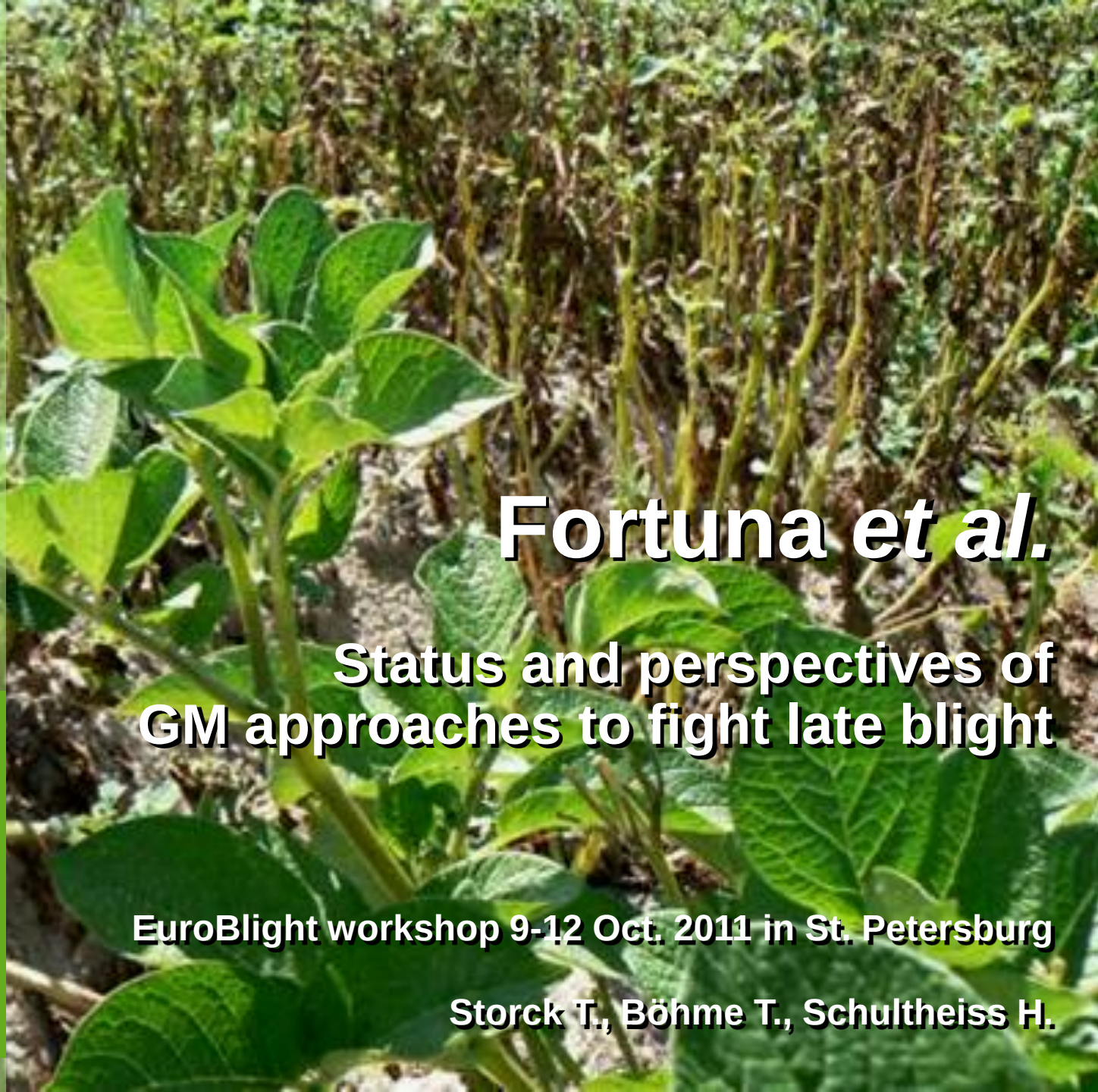

Fortuna *et al.*

Status and perspectives of GM approaches to fight late blight

EuroBlight workshop 9-12 Oct. 2011 in St. Petersburg

Storck T., Böhme T., Schultheiss H.

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Our goal

- Develop potato varieties which
  - Contain broad and durable resistance to *Phytophthora infestans*
  - Possess all features of a competitive cultivar
  - Bring benefits to the value chain

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A solution created by nature

- Durable resistance to late blight has evolved in several wild potato species
  - E.g. in *Solanum bulbocastanum*
  - Hybrids of *S. bulbocastanum* and *S. tuberosum* maintain resistance
  - For ~50 years breeders try to transfer this resistance to modern potato varieties
  - Backcrossing difficult due to suppression of recombination
  - Results so far are unsatisfactory because of low agronomic performance

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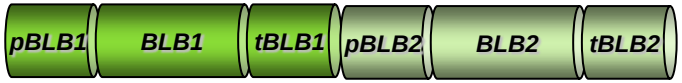
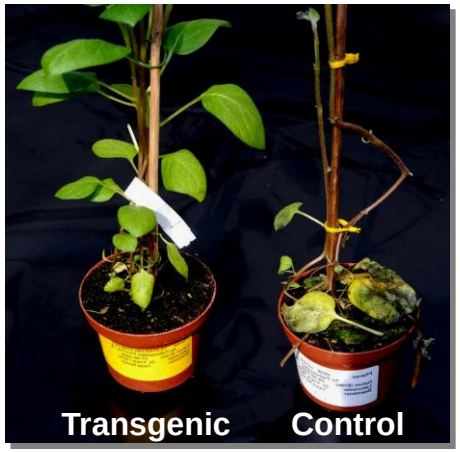
“The making of” Fortuna

- Use two resistance (*R*) genes *Rpi-blb1*[1] and *Rpi-blb2*[2] from *S. bulbocastanum* with their native regulatory elements



- Genes introduced in European processing variety “Fontane” via Agrobacterium-mediated transformation



[1] Song et al. (2003), PNAS 100, 9128; Van der Vossen et al. (2003), Plant J. 36, 867
[2] Van der Vossen et al. (2005) Plant J. 44, 208

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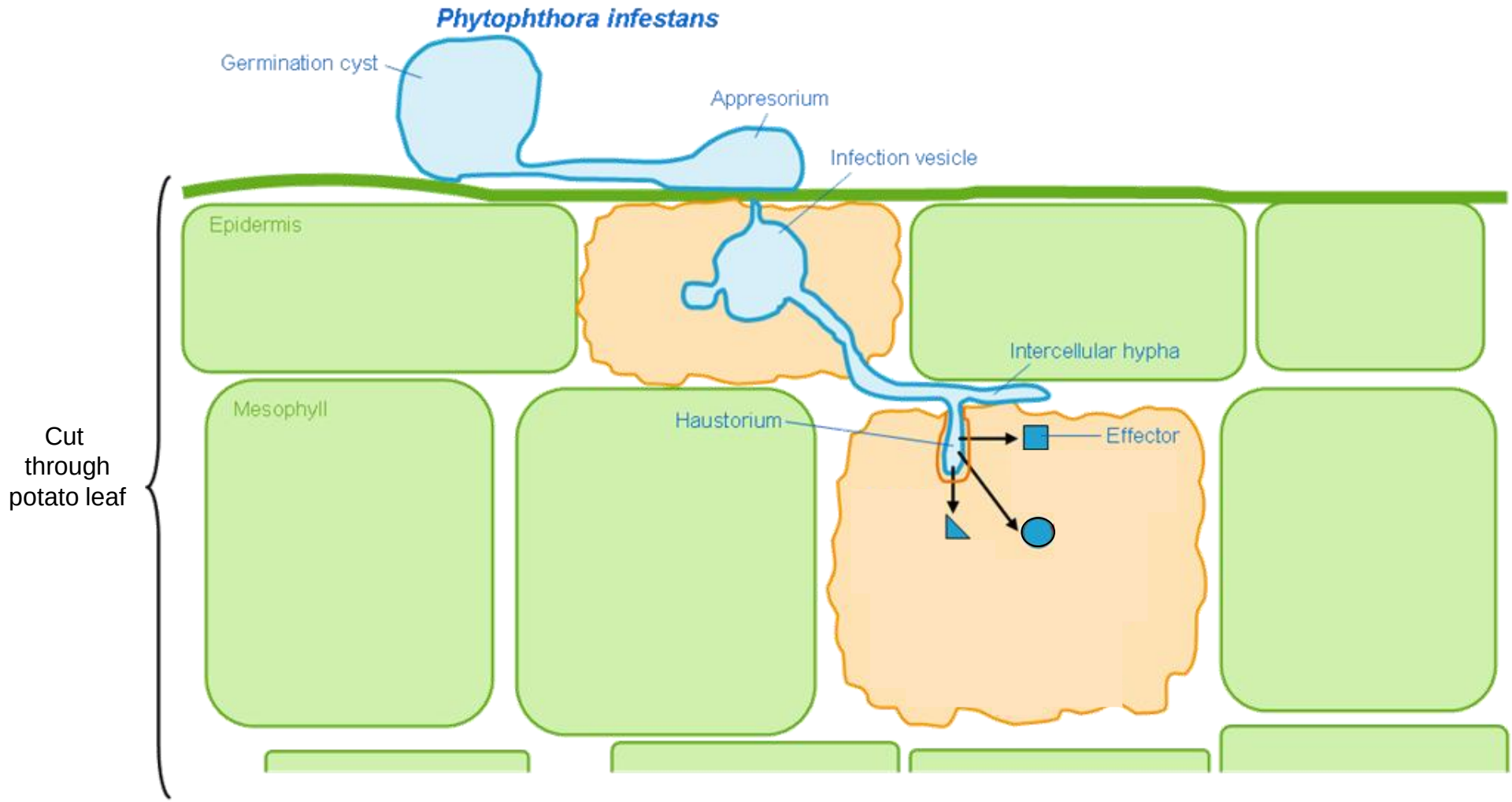
Fortuna‘s resistance mechanism



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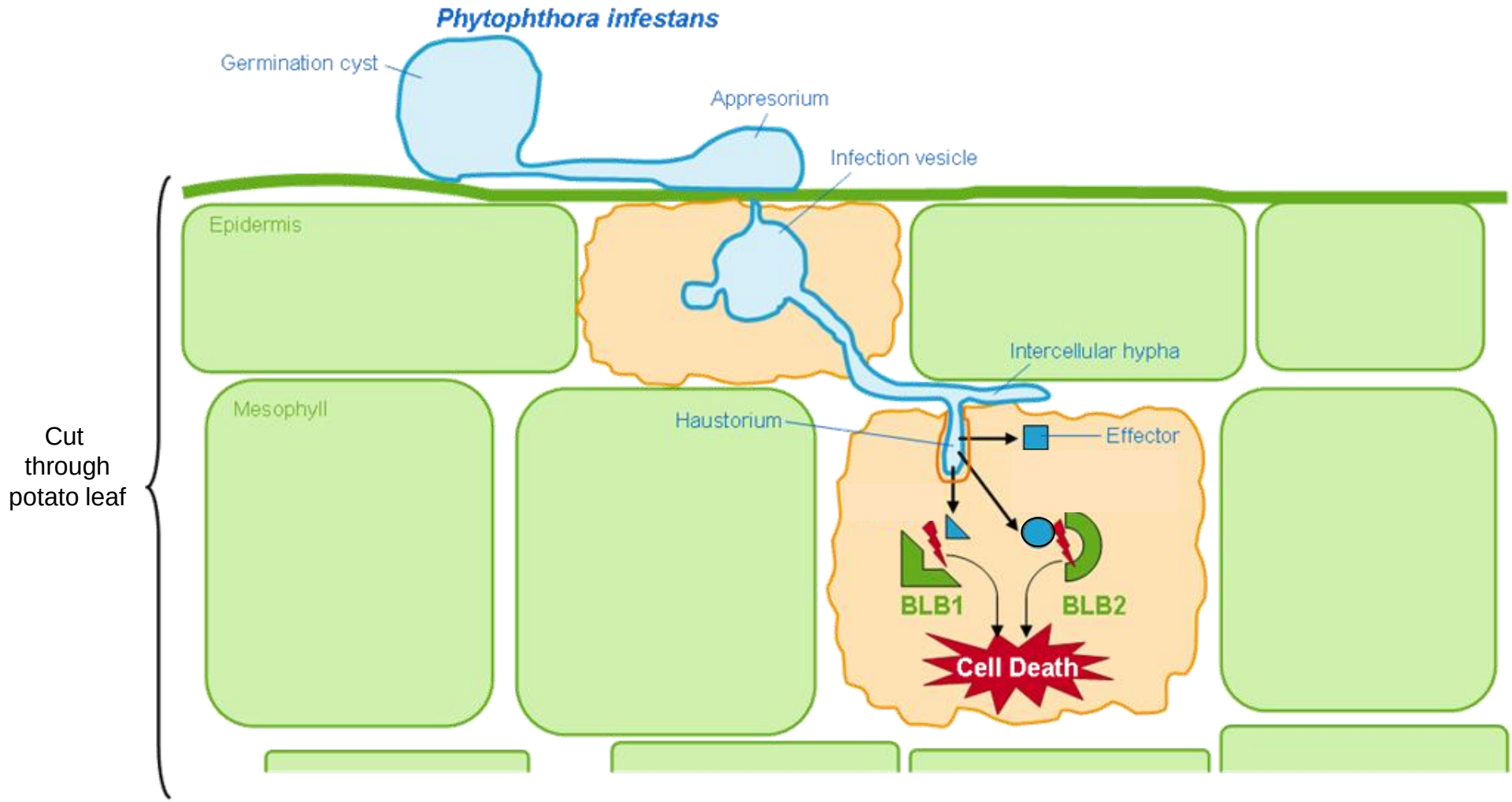
Fortuna‘s resistance mechanism



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Resistance monitoring

- **Greenhouse screenings**
  - Continuous sampling and testing of European *P. infestans* isolates from BPS field sites and other locations
  - Hundreds of isolates tested – resistance shows stability against all isolates
- **Molecular monitoring of the avirulence factors of *R* genes in isolates**
  (collaboration with S. Kamoun, The Sainsbury Laboratory)
  - Monitor distribution of polymorphisms
  - Functional analysis of new alleles

Fortuna possesses a full and broad spectrum resistance against late blight …

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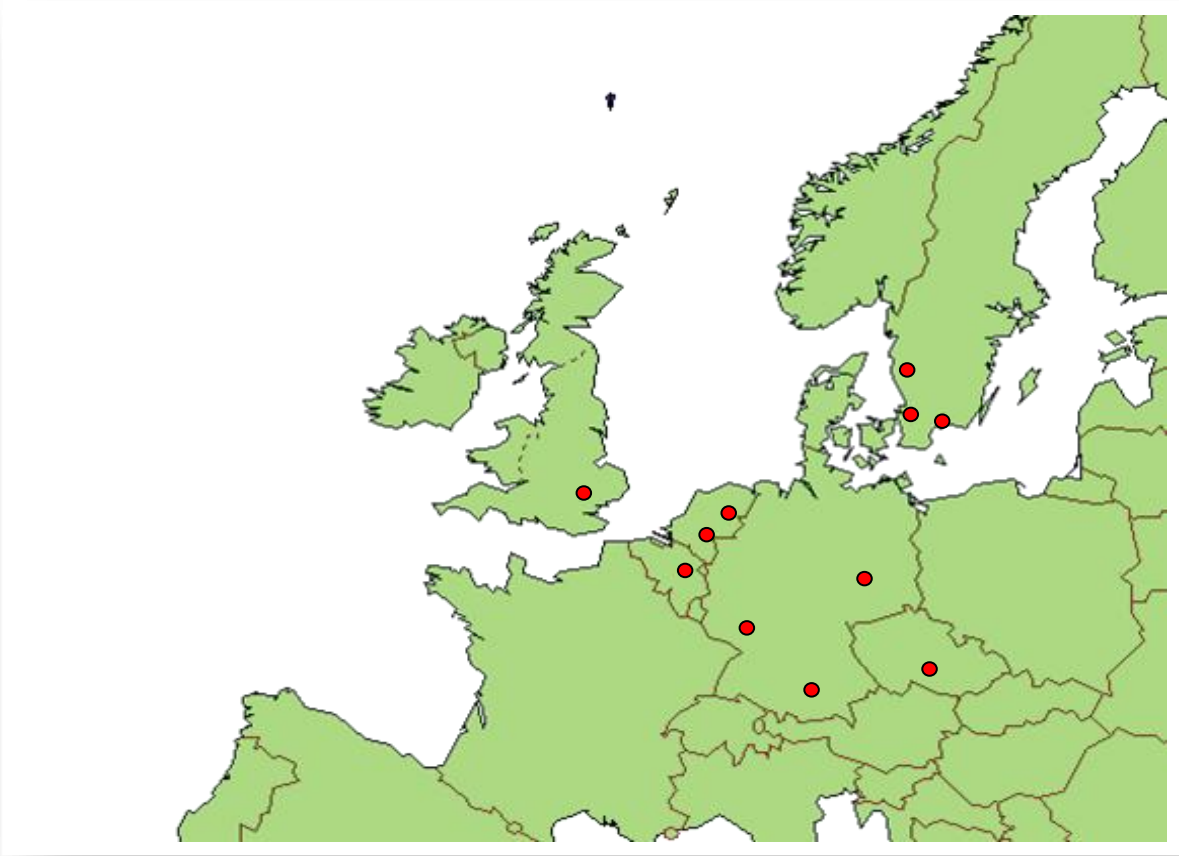
Fortuna field trials since 2006

- **Germany**
  - Baalberge
  - Limburgerhof
  - Möttingen
- **Sweden**
  - Borgeby
  - Halmstad
  - Kristianstad
- **The Netherlands**
  - Angeren
  - Valthermond
- **England**
  - Cambridge
- **Czech Republic**
  - Humpolec
- **Belgium**
  - Wetteren



… and maintains all characteristics of its mother variety

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Fortuna field trial (Angeren, NL)

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Fortuna field trial (Limburgerhof, DE)

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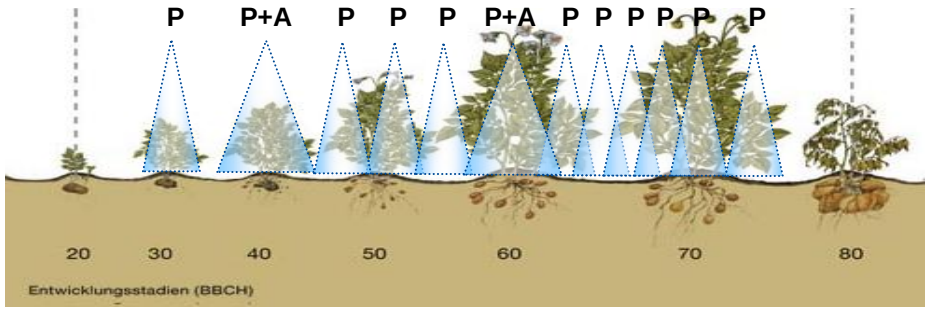
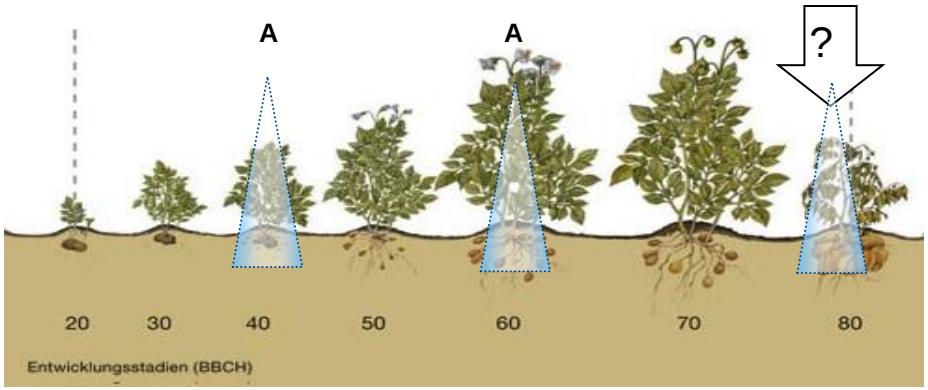
Fungicide applications in potato cultivation

- Conventional varieties
  - 10 to 16 fungicide applications in the main European processing potato cultivation regions in an average season - up to 22 applications in strong years (e.g. 2007 in NL)
- Fortuna
  - Applications against Alternaria need to be maintained
  - We are currently investigating how to best support the durability of resistance through additional applications against Phytophthora in particular during senescence (with H. Schepers, G. Kessel and B. Evenhuis)





Applications against Alternaria (A) and Phytophthora (P)

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Fortuna‘s advantages

- “Insurance” against late blight
- Replaces majority of fungicide applications in potato growing (2 – 3 applications remaining mainly against Alternaria and resistance management)
  - Saving of fungicide costs
  - Saving of application costs (fuel, work force)
- Reduces work load at peaks
- Less focus on late blight allows for more focus on other agricultural measures
- Less tractor passages → less soil compaction
- Higher yield expected because of permanent protection
- Higher storage stability expected

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GM approaches towards late blight resistant potatoes in Europe

- DuRPh project at Wageningen University
- Sainsbury Laboratory at the John Innes Centre, Norwich
- BASF Plant Science, Limburgerhof

Picture kindly provided by A. Haverkort, Wageningen University

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The DuRPh project – Durable resistance against Phytophthora in potato

Information kindly provided by A. Haverkort

- Organization and scope:
  - Run by Wageningen University and Research Center, funded by the Dutch natural gas resources (national investment in innovation)
  - Cloning, analyzing R-genes from wild potatoes, testing R-genes in field trials, resistance management strategy
- Field trials
  - First field trials with Phytophthora resistant GM potatoes in 2007
  - Trials located at different sites in NL, one in BE
  - R-genes tested in 2011 field trials: R3a, sto1, blb3, vnt1 in single gene constructs and in double and triple stacks, more genes upcoming
- Technology
  - Cisgenic, marker-free genetic modification, dynamic cultivars
- Path to the farmer:
  - Variety development through breeders of a consortium
  - Target varieties to be decided by consortium members
  - Envisioned market launch: (?)
  - Requires change in the existing GM regulations, market acceptance

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The John Innes Centre's approach

Information kindly provided by J. Jones

- Organization and scope:
  - Run by the Sainsbury Laboratory, funded by the UK's Biotechnology & Biological Sciences Research Council (BBSRC)
  - Cloning, analyzing R-genes from wild potatoes, testing R-genes in field trials
- Field trials
  - First field trials with Phytophthora resistant GM potatoes in 2010
  - Trials located at one sites in the UK
  - R-genes tested in 2011 field trials: Vnt1, mcq1, more genes upcoming
- Technology
  - Field trials with NPT KanR genetic modification
- Path to the farmer:
  - Public/private partnership or through outlicensing R-genes
  - Target varieties: Maris Piper and Desiree
  - Envisioned market launch: dependent on commercial partner
  - Requires partner for the development, market acceptance

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BASF Plant Science's approach

- Organization and scope:
  - Funded by BASF SE
  - Making use of exisiting potato fungicide knowledge
  - Inlicense R-genes, develop Phytophthora resistant varieties, conduct regulatory safety studies, strive for regulatory approval and commercialization
- Field trials
  - First field trials with Fortuna in 2006
  - Trials performed at > 20 sites in DE, NL, BE, UK, CZ, SE
  - R-genes tested in 2011 field trials: Blb1, blb2
- Technology
  - Transgenic modification, use of herbicide resistance selection marker (no field effect)
- Path to the farmer:
  - Regulatory approval for cultivation in EU, global import approvals
  - Target variety: Fontane
  - Envisioned market launch: Mid of decade
  - Requires local market acceptance

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Concluding remarks

- Genetic modification allows to develop potato varieties which
  - Contain broad and durable resistance to *Phytophthora infestans*
  - Possess all features of competitive cultivars
- To create a solution that can be offered to the farmers some significant hurdles need to be taken
  - Regulatory approval
  - Acceptance in the market place
- Late blight resistant potatoes are good examples for bringing the public discussion around GM from a rather theoretical to a product based one

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