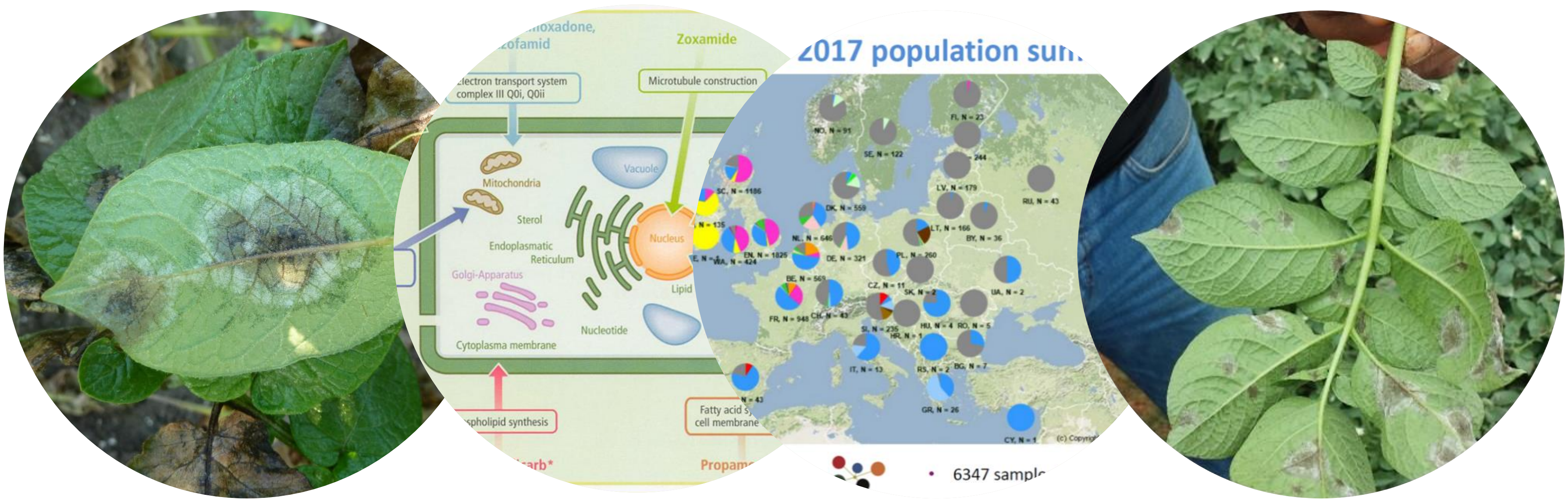
How does the EuroBlight network help to control the aggressive potato late blight pathogen

Huub Schepers, Alison Lees & Jens Grønbech Hansen

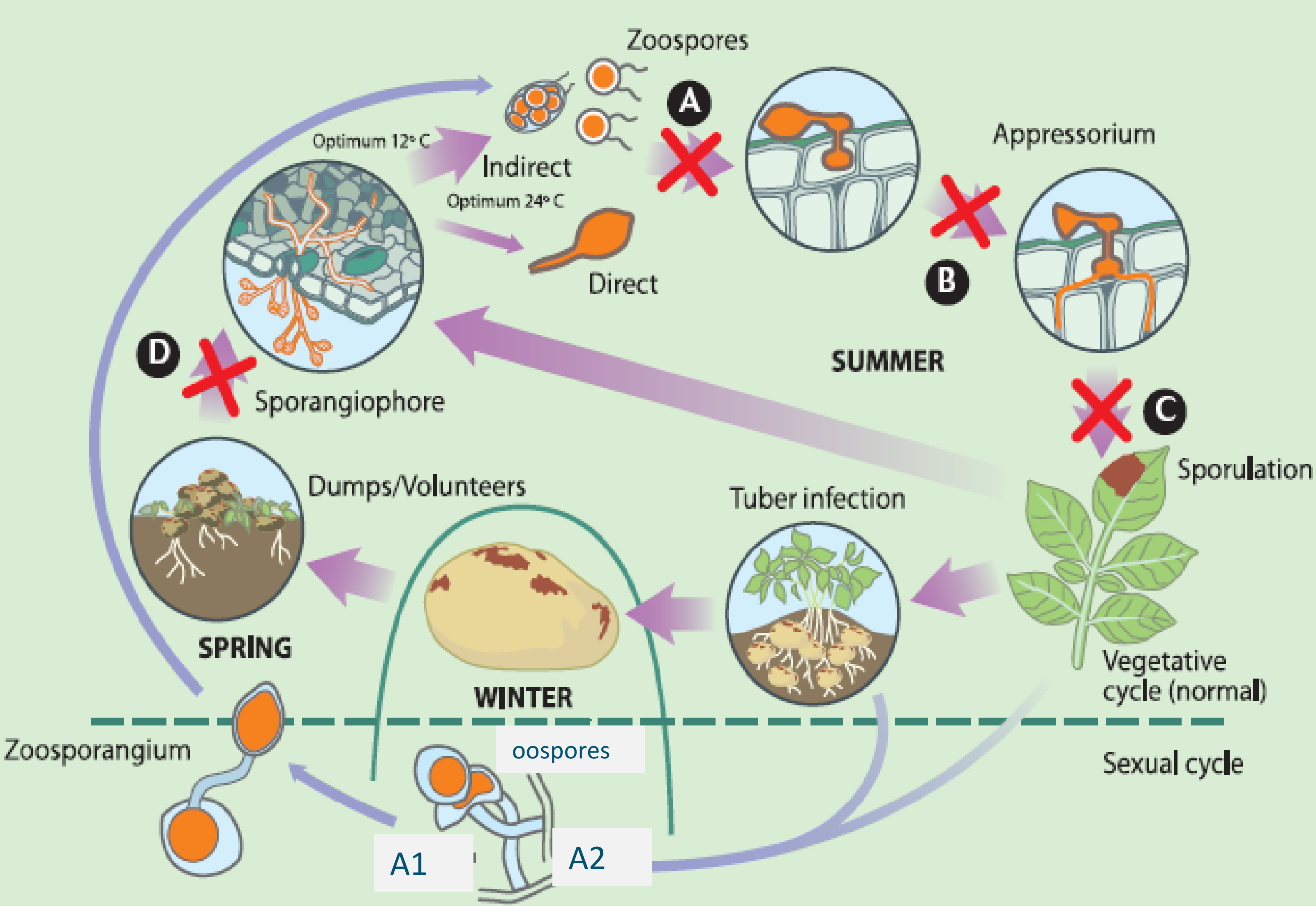


Outline of presentation

- Introduction Late Blight
- EuroBlight
  - Population monitoring
  - Fungicide efficacy
  - Best Practices
    - Primary inoculum sources
    - Resistant varieties
    - Fungicides
    - Decision Support Systems
- Conclusions

Symptoms late blight

Life cycle *Phytophthora infestans*



Late Blight: damage

- Worldwide 21 million ha and € 10 billion damage
- In Holland 165.000 ha
  - turnover € 750 million year
- 12-15 sprays/year
- Costs per year
  - Fungicides € 60 million
  - Spraying € 60 million
  - Damage: € 30 million
  - Total € 150 million (=20% of the turnover)

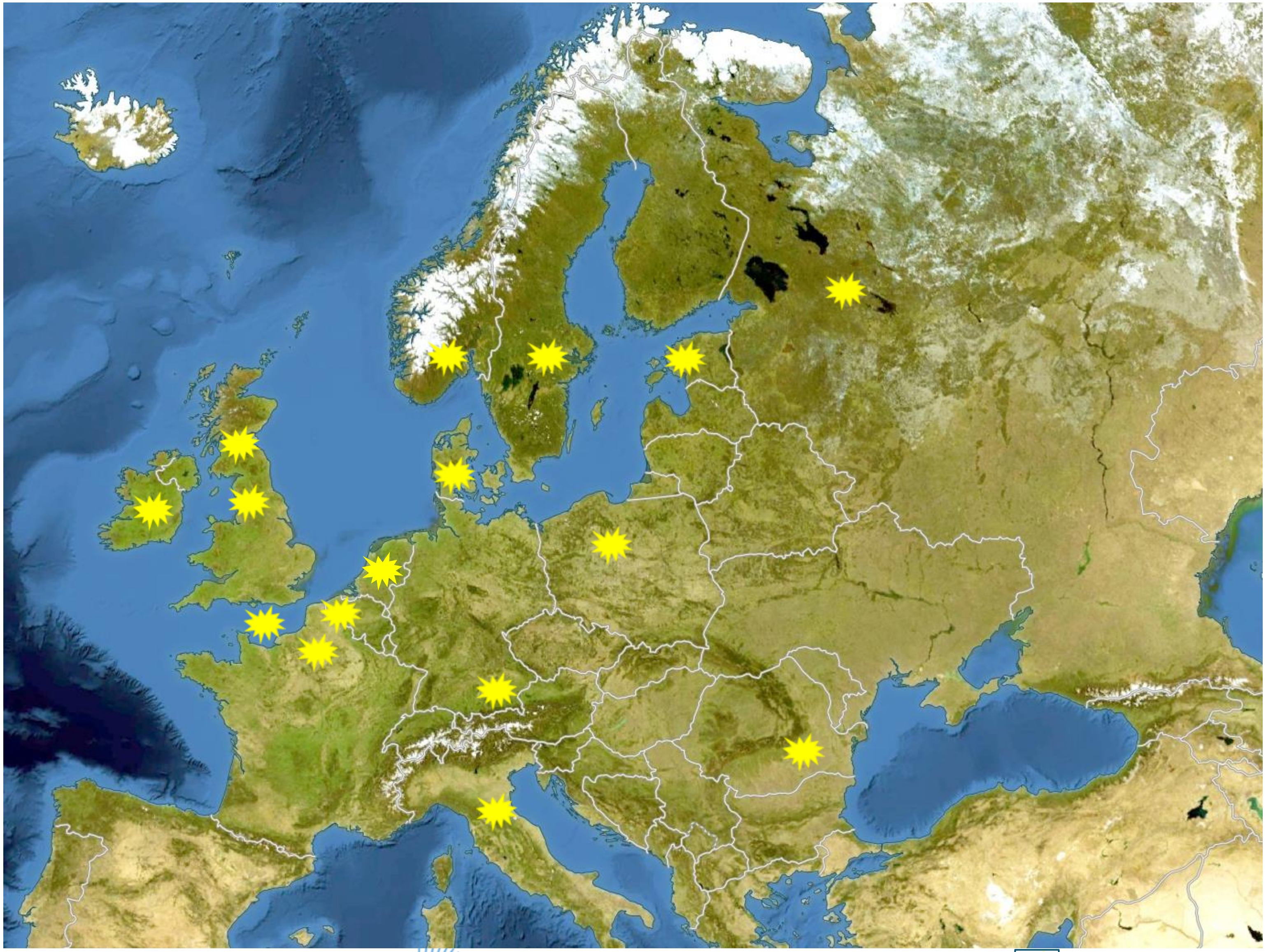
What is EuroBlight?

EuroBlight
A potato late blight network for Europe

- Consortium of research, commercial & extension staff
- Arose from 2 European Union funded projects
- Meetings sponsored by industry & research funded by EU, national or commercial programmes
- An enduring model for other international networks
- Managed by Huub Schepers (NL), Jens Grønbech Hansen (DK) & Alison Lees (UK)

www.euroblight.net

17 workshops: 1996-2019



Challenges for EuroBlight

- New *P. infestans* populations that are more agressive & less sensitive to some active ingredients
- Early blight increasing probem in Europe / fungicide resistance
- List of available fungicides shortened / risk of fungicide resistance
- How to use alternative products (e.g. BCA and PDS)
- How to protect new and more resistant cultivars?
- Active ingredient & resistance gene stewardship
- National research communities – less people
- Update Best Practises with new technologies i.e. Molecular data, new sensors, satellite information etc.

Workshops-Proceedings

- EuroBlight coordinators + local organizer
- Maximum of 100 participants
- Plenary & subgroup
  - Epidemiology
  - Host-pathogen
  - Control Strategies
- Excursion to potato sector
- Proceedings 17 x

EuroBlight

A potato late blight network for Europe

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News

[Results of the EuroBlight potato late blight monitoring in 2018]

03.05.2019 | SCIENCE AND TECHNOLOGY

EuroBlight is continuously examining the ongoing evolution of the European population of the potato late blight pathogen and now reports on the 2018 results. Approximately 1000 samples were genotyped from 22 countries.

[EuroBlight propose a high rating for new fungicide]

06.02.2019 | SCIENCE AND TECHNOLOGY

New report - "Fungicide evaluation to rate efficacy to control leaf late blight for the Euroblight table"

EuroBlight Fungicide Table

EuroBlight evaluate the effectiveness of fungicide products/co-formulations for the control of *P. infestans* based on the **highest** rate registered in Europe. These ratings are the opinion of the Fungicides Sub-Group, and are based on field experiments and experience of the products performance when used in commercial conditions.

Go to table

Publications

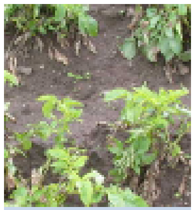
Fungicide evaluation to rate the efficacy to control earlyblight for the EuroBlight table Results 2015-2016 here.

EuroBlight Statement 2019

EuroBlight
A potato late blight network for Europe

17th EuroBlight Workshop
York, United Kingdom, 12-15 May 2019
'Fostering the sustainable management of early and late blight in potato'

EuroBlight Workshop, York 2019



The 17th EuroBlight workshop held in York in May 2019 was attended by 110 scientists and industry stakeholders from 22 countries. The delegates included representatives of similar networks in North America, Latin America, Asia and Africa, thus offering a unique global forum for the review of late blight and early blight. These devastating diseases are adapted to conventional and organic potato and tomato production, crops grown under commercial or subsistence practices and in both developed and developing countries. Under discussion were the striking scientific advances made since the previous workshop in Aarhus (May 2017), and the current challenges and opportunities for improved control and management strategies. Participants of the 17th EuroBlight workshop unanimously adopted the following statements:

Optimal disease management is dependent on understanding the pathogens and their evolution

The emergence of new clonal lineages of the late blight pathogen *Phytophthora infestans* in Europe was presented. Genotypes EU_36_A2 and EU-37_A2 are spreading in north-west regions and replacing genotypes such as EU_13_A2 and EU_6_A1 and over the past 3 years, genotype EU_41_A2 has become established in previously sexual Nordic populations. Progress in genetic characterisation, including typing with SSR markers and genotyping by sequencing of selected effector genes, provide new opportunities to track emergences. The recent spread of older European *P. infestans* genotypes worldwide has also been tracked, including for example the recent discovery of genotype EU-2_A1 in Latin America, eastern Asia and eastern sub-Saharan Africa, with potentially major consequences for disease control.

Population surveys have also been instrumental in understanding the composition of the early blight species complex dominated by *Alternaria solani* and *A. alternata*, and its epidemic dynamics. *A. alternata* is often associated with early attacks, whilst *A. solani* occurs later but has more severe impacts on yield. The use of specific molecular markers to target genes involved in the mode of action of active ingredients such as the strobilurin and SDHI fungicides, which are important for the control of early blight, has enabled a better understanding of the distribution of insensitive isolates in European potato-growing areas. Populations with resistance to more than one mode of action, which are particularly difficult to control, have been identified.

Despite these advances, and new quantitative data on the geographic distribution of major phenotypic traits, critical information which would allow population data to be used for predictive management of pathogen emergence and disease outbreaks is lacking. In particular, the connection between genotypic and phenotypic variation in *P. infestans* remains elusive. Reasons for the rapid changes in population structure are untested, in part due to the absence of accurate curated data on the distribution of fungicide use and cultivar deployment, which would allow quantification of selection in the pathogen population to these drivers.

Recommendation 1: Develop the global genetic landscape

EuroBlight recommends that global efforts to monitor pathogen population changes are continued. Where possible, new markers closely predictive of specific phenotype should be developed. The global data should be compiled and collated into an integrated database along with information on fungicide use and cultivar deployment.

Euroblight is willing to collaborate with AsiaBlight, Tizon Latino, USABlight and AfricaBlight to build capacity to establish regional infrastructures for continuous population monitoring.

Addition of innovative tools to the blight control toolbox

As pathogen populations are evolving quickly, the arsenal of sustainable control methods is also expanding and this was reflected in an increasing number of presentations in this area. For example, targeted breeding of resistant potato cultivars and the development of biocontrol options either through plant defence stimulation or microbial biological control. Decision Support Systems and risk assessment methods have been improved thanks to cutting-edge technologies including machine learning, in-field sensors and pathogen detection, GIS and satellite data. These innovations are at various stages of development and their use in practice, in some cases, will require changes to production systems.

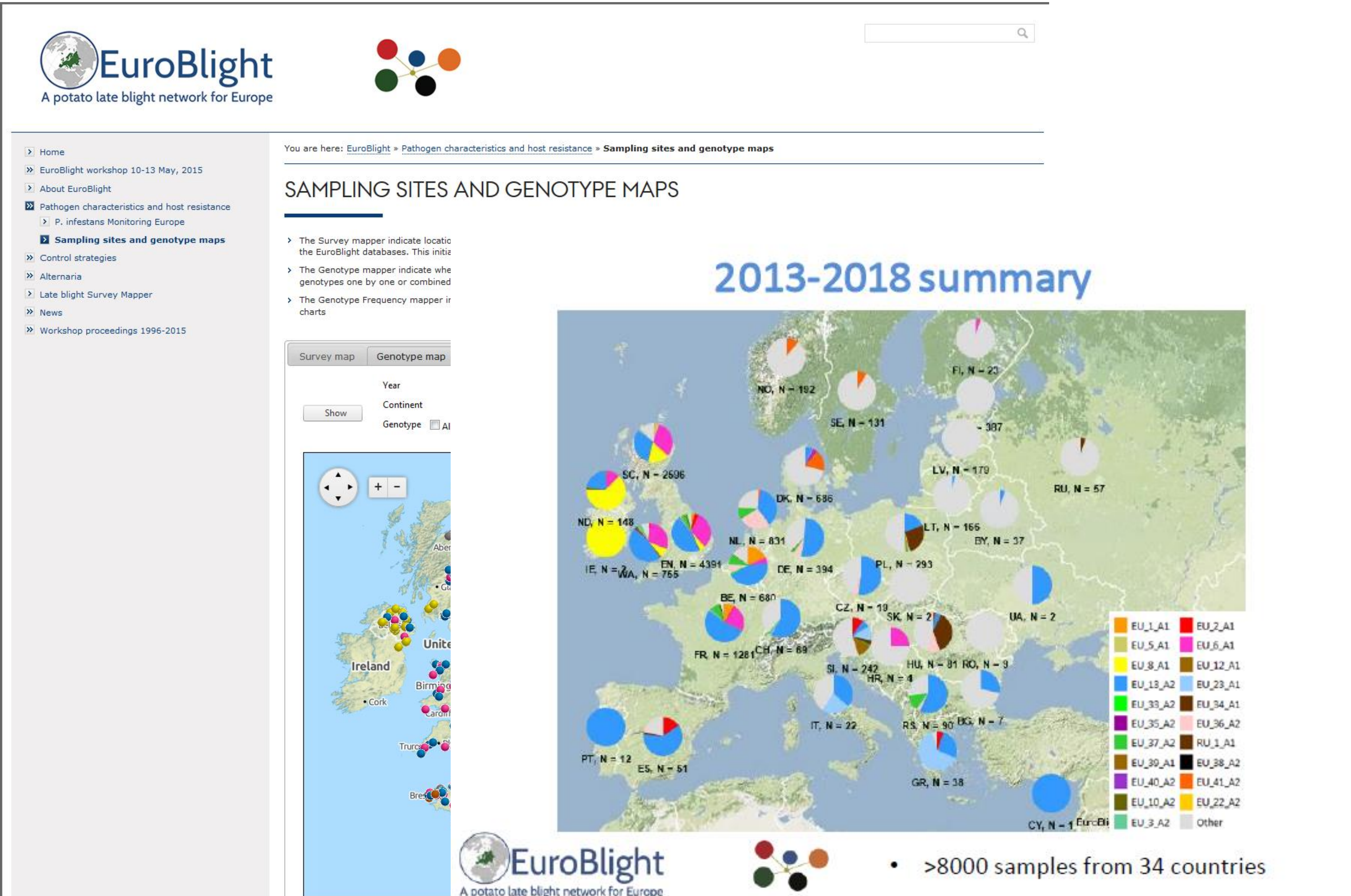
Recommendation 2: Adopt innovative IPM technologies

Faced with increasingly stringent regulations on pesticide approval and use and a desire to meet Integrated Pest Management targets, EuroBlight strongly recommends that efforts to develop, assess and implement innovative technologies are strengthened.

Recommendations:

1. Develop the global genetic landscape
2. Adopt innovative IPM technologies
3. Work together and share resources

Mapping Late Blight population Europe



EuroBlight Fungicide table

- Late & Early Blight
- Ratings for different characteristics
- Quantitative ratings for leaf & tuber blight
  - EuroBlight trial protocol
- Qualitative rating for other characteristics

ADAMA
Arysta LifeScience
BASF We create chemistry
BAYER Science For A Better Life
BELCHIM Crop Protection
CERTIS
FMC
GERMICOPA
Gowan Crop Protection Ltd
UPL
Mancozeb Taskforce
INDOFIL INDUSTRIES LIMITED
Nufarm
ORO AGRI
DUPONT The miracles of science
syngenta
ISK BIOSCIENCES

LATE BLIGHT FUNGICIDE TABLE

Updated 31 October 2017

The effectiveness of fungicide products/co-formulations for the control of *P. infestans based* on the **highest** rate registered in Europe. These ratings are the opinion of the Control strategies Sub-Group at the EuroBlight workshop, May 2017 and are based on field experiments and experience of the products performance when used in commercial conditions.

Use **Mouse Over** on header titles to find **explanation** on variables e.g. mobility mode of actions C, T and S. You can click on the header texts to **multiple sort the table** (1. click= Descending, 2nd click=ascending, 3rd click=unsort). Use this PNG version for mobile phones

Product (Dose rate [litre or kg/ha])	Leaf blight	Tuber blight	New growth	Stem blight	Protec-tant	Curative	Anti sporulant	Rain-fastness	Mobility	Year
copper				●	●◖	0	0	●	C	1900
dithiocarbamates (2.0)[1]	2.0	0.0		●	●●	0	0	●◖	C	1961
chlorothalonil				◖	●●	0	0	●●◖	C	1964
cyazofamid (0.5)	3.8	3.8	●●	●	●●●	0	0	●●●	C	2001
fluazinam (0.4)	2.9			●	●●●	0	0	●●◖	C	1992
zoxamide + mancozeb (1.8)	2.8			●[5]	●●●	0	0	●●◖	C + C	2001
amisulbrom + mancozeb (0.5+2.0)	4.5	3.7		●	●●◖	0	?	●●●	C + C	2007
ametoctradin + mancozeb (2.5)	3.7		?[8]	?[8]	●●◖	0	0	●●●	C + C	2011
fluazinam + azoxystrobin (0.5)	3.6								C + C	2016
famoxadone + cymoxanil				●◖	●●	●●	●	●●◖	C + T	1996
(zoxamide + mancozeb) + cymoxanil (1.8+0.2)	3.4								C + T	2001
mandipropamid (0.6)	4.0		●●	●◖	●●●	●[6]	●◖	●●●	C/T	2005
mandipropamid + difenoconazole (0.6)	4.0		●●	●◖	●●●	●[6]	●◖	●●●	C/T + C	2005
benthiavalicarb + mancozeb (2.0)	3.7			●◖[5]	●●●	●◖	●	●●◖	T + C	2003
cymoxanil + metiram				●◖	●●	●●	●	●●	T + C	1976
cymoxanil + copper				●◖	●●	●●	●	●●	T + C	1976
cymoxanil + mancozeb				●◖	●●	●●	●	●●	T + C	1976
dimethomorph + mancozeb (2.4)	3.0			●◖	●●◖	●	●●	●●◖	T + C	1988
dimethomorph + fluazinam (1.0)	3.7	3.3	●	●	●●◖	●	●●	●●◖	T + C	2012
fenamidone + mancozeb (1.5)	2.6			●◖[5]	●●◖	0	●◖[5]	●●	T + C	1998
(zoxamide + cymoxanil) + fluazinam (0.45+0.4)	4.0								C/T + C	2013
(zoxamide + dimethomorph) + fluazinam (1.0+0.4)	4.2								C/T + C	2015
mandipropamid + cymoxanil (0.6)	4.4		●●	●◖	●●●	●●	●◖	●●●	C/T + T	2013
(pyraclostrobin + dimethomorph) + adjuvant (2.5+1.0)	4.0[7]								C/T + T	2012
benalaxyl-M + mancozeb[2]	3.0		●●	●●	●●◖	●●◖	●●◖	●●●	S + C	1981
metalaxyl-M + mancozeb[2]			●●	●●	●●◖	●●◖	●●◖	●●●	S + C	1977
metalaxyl-M + fluazinam[2]			●●	●●	●●◖	●●◖	●●◖	●●●	S + C	
propamocarb + cymoxanil + cyazofamid ((2.0)+0.5)		4.6							S + T + C	2012
propamocarb + cymoxanil (2.0)					●◖	●●◖[9]	●●◖		S + T	2011
propamocarb-HCl + fenamidone (2.0)	2.5		●◖	●●	●●◖	●●	●●	●●●	S + T	1998
propamocarb-HCl + fluopicolide (1.6)	3.8	3.9	●●	●●	●●●	●●	●●◖	●●◖	S + T	2006
oxathiopiprolin (0.15)			●●◖	●●◖	●●●	●●	●●◖	●●●	S	2017

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Best Practice

In **Table 1** the essential elements of an Integrated Control strategy for late blight in Europe are presented and estimated ratings (based on expert judgement) for implementation, barriers and contribution to input reduction are given.

Table 1

Elements	Implementation	Barriers	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.

Reduce primary inoculum sources

From Science to Field
Potato Case Study – Guide Number 1

Reducing Primary Inoculum Sources of Late Blight

Summary

The first step in an integrated control strategy for late blight is reducing the primary sources of inoculum. This Guide identifies the most common sources and ways to reduce the risk.

In a number of European countries it has been shown that in most years late blight epidemics start from infected plants on dumps and in the Netherlands, for example, a regulation forces growers to cover dumps with black plastic before April 15 each year.

Infested seed tubers are another major inoculum source and certified seed should be used where possible. Testing for latent infections in seed tubers remains problematic and this Guide provides advice on strategies for tackling this.

Oospores are another threat, especially when short crop rotations are employed, and volunteer potatoes, which are readily found in European countries with mild winters, must be controlled, even though this may be difficult and labour-intensive. Indeed, there were strong indications that in 2007 infected volunteers acted as primary infection sources rather than serving to accelerate the late blight epidemic.

Early crops covered with perforated polythene also pose a threat and this Guide recommends spraying fungicides (plus adjuvants) over covered crops to provide a level of protection for potato leaves combined with measures such as warning neighbouring growers when covers are to be removed and immediate spraying after cover removal.

For further information please contact:

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About ENDURE

ENDURE is the European Network for the Durable Exploitation of Crop Protection Strategies. ENDURE is a Network of Excellence (NoE) with two key objectives: restructuring European research and development on the use of plant protection products, and establishing ENDURE as a world leader in the development and implementation of sustainable pest control strategies through:

- Building a lasting crop protection research community
- Providing end-users with a broader range of short-term solutions
- Developing a holistic approach to sustainable pest management
- Taking stock of and informing plant protection policy changes.

Eighteen organisations in 10 European countries are committed to ENDURE for four years (2007-2010), with financial support from the European Commission's Sixth Framework Programme, priority 5: Food Quality and Security.

Website and ENDURE Information Centre

www.endure-network.eu

This publication was funded by EU grant (Project number: 031499), under the Sixth Framework Programme, and is catalogued as ENDURE Potato Case Study – Guide Number 1, published in September, 2008.

From Science to Field
Potato Case Study – Guide Number 1

Reducing Primary Inoculum Sources of Late Blight

Didier Andrivon, INRA, France; Bert Evenhuis and Huub Schepers, WUR, Netherlands;
Denis Gaucher, ACTA, France; Jozefa Kapsa and Renata Lebecka, IHAR, Poland;
Bent Nielsen, AU, Denmark; Michelina Ruocco, CNR, Italy

Photo © Belchim Crop Protection

endure diversifying crop protection

Food Quality and Safety

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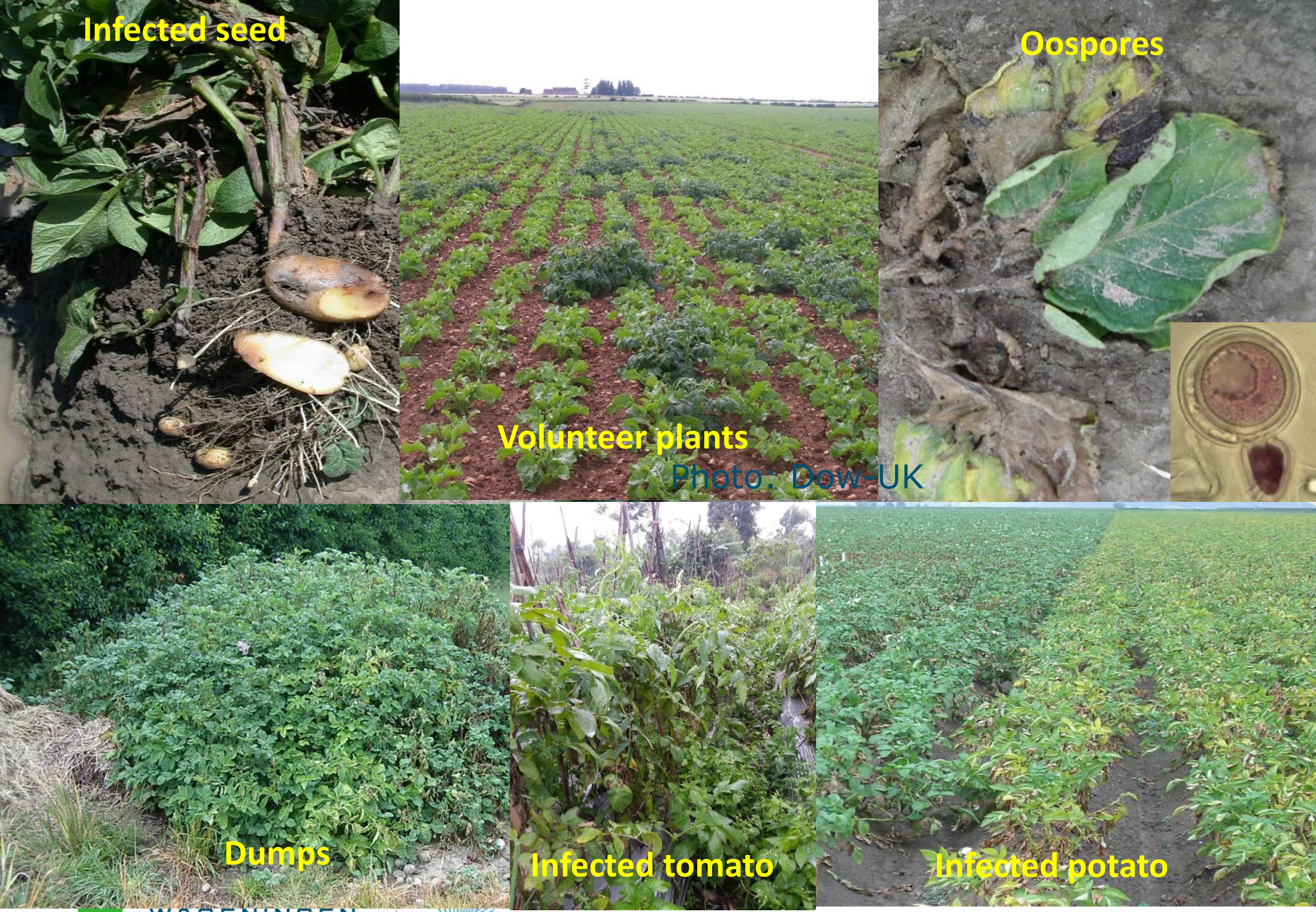
100years 1918 — 2018

Observation for the way of primary infection of *Phytophthora infestans* in potato

Tongle Hu, Hans Hausladen, Zhenjie Zhao, Daichao Zhou, Feiyue Jin and Keqiang Cao

Hebei Agricultural University (HEBAU)
Technical University of Munich (TUM)

E-mail: tonglemail@126.com



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Reduce primary inoculum sources

- Regulations of Board for Arable Products
- Inspected by NAK
  - Dumps: cover with black plastic before 15 April
  - Volunteers: control after 1 Juli when > 2 plants/m^2 per 0,3 ha
  - Excessive blight: control when:
    - > 1000 diseased leaflets/20 m^2
    - > 2000 diseased leaflets/100 m^2
- Warning: yellow card
- Red card: money fine

Use resistant varieties

From Science to Field
Potato Case Study – Guide Number 4

Using Cultivar Resistance to Reduce Inputs Against Late Blight

Summary

The late blight resistance of a cultivar offers significant potential in reducing fungicide inputs as part of an integrated control strategy. Both partial resistance (lower susceptibility) and fungicides can slow the development of late blight and many reports show that partial resistance in the foliage can be used to complement fungicide applications, cutting fungicide use through reduced application rates or extended intervals between sprays.

The use of resistant cultivars varies across Europe. In Western Europe, resistant cultivars are not grown on a large scale because commercially important characteristics such as quality, yield and earliness are usually not combined with late blight resistance in the same cultivar. However, in countries where fungicides are not available or very expensive, the use of resistant cultivars is one of the most important ways to reduce blight damage.

Breeders are constantly trying to produce cultivars that combine commercially important characteristics with late blight resistance, either by conventional breeding or using GMO techniques. Using cisgenesis - genetic modification using a natural gene from a crossable plant - may prove more publicly acceptable. However, a major barrier remains the durability of resistance, testing for which should be conducted according to EUCABLIGHT's harmonised protocols.

This Guide examines the current situation in Europe, the prospects for further progress and sources of information for advisers and growers.

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Bent Nielsen, AU, Denmark; Michelina Ruocco, CNR, Italy

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Food Quality and Safety

The Future?

Fungicide applications under extreme disease pressure:				
Variety	Strategy	# sprays	TFI	% Infection
Desiree	NoControl	0	0	100.00
Desiree	WeeklySchedule	12	12	5.01
Desiree	IPM2.0	11	10.333	5.02
SarpoMira	NoControl	0	0	1.09
SarpoMira	WeeklySchedule	12	12	0.00
SarpoMira	IPM2.0	3	0.75	0.00
A15-31	NoControl	0	0	0.01
A15-31	WeeklySchedule	12	12	0.00
A15-31	IPM2.0	3	0.75	0.00

Exploiting hybrid potato breeding for accelerating introgression & stacking of new resistance sources against *P. infestans* - Asmaa Youssef

Targeted use of fungicides

From Science to Field
Potato Case Study – Guide Number 3

Fungicides for Tackling Late Blight

Summary

Fungicides play a crucial role in the integrated control of late blight. Integrated Pest Management strategies to control late blight balance a number of factors concerning fungicides including efficacy and side-effects (both environmental and toxicity) but also economic and social factors in addition to the legislation in place.

Control strategies are primarily preventive, but when blight enters the crop the strategy must focus on stopping or reducing the epidemic. This means growers and advisors need all the information and tools necessary to control blight efficiently.

A control strategy can be based on a schedule with more or less fixed intervals or based on recommendations derived from a Decision Support System (DSS). In a strategy, the first spray, product choice, dose rates, timing and last spray are important elements that can differ from country to country depending on growing conditions, varieties, registered fungicides and weather conditions.

Important phases in crop growth can also be identified: emergence to start of rapid haulm growth, rapid haulm growth, end of rapid haulm growth to start of senescence and start of senescence to complete haulm destruction. It is important that information on all these elements is available and that the adviser and/or farmer make his decisions accordingly.

This Guide identifies sources for obtaining this information and a table of fungicides registered for late blight control in five European countries.

For further information please contact:

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Website and ENDURE Information Centre

www.endure-network.eu

This publication was funded by EU grant (Project number: 031499), under the Sixth Framework Programme, and is catalogued as ENDURE Potato Case Study – Guide Number 3, published in September, 2008.

From Science to Field
Potato Case Study – Guide Number 3

Fungicides for Tackling Late Blight

Didier Andrivon, INRA, France; Bert Evenhuis and Huub Schepers, WUR, Netherlands;
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Photo © INRA, France

endure diversifying crop protection

Food Quality and Safety

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Economic Affairs,
Education &Research EAER
Agroscope

Use of alternative products for the control of late and early blight on potatoes

T. Musa, H.R. Forrer, S.Vogelgsang, K. Sullam
Agroscope, Ecological Plant Protection in Arable Crops

EuroBlight Workshop, 12.-15. May 2019, York

Potato blight fungicides

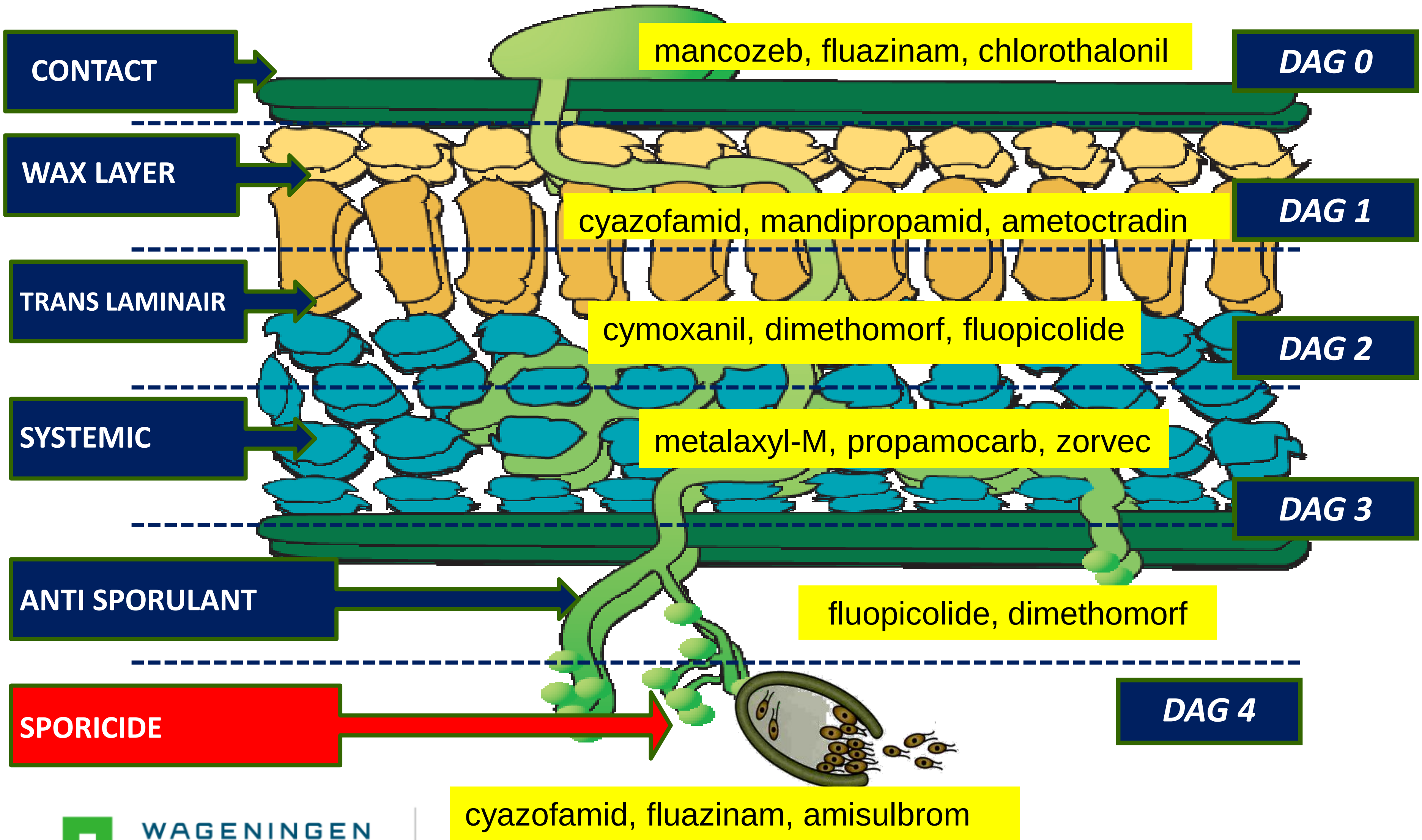
Biological efficacy

- *Protectant:* has to be present on (or in) the leaf/stem surface before spore germination/penetration
- *Curative (kick-back):* is active during the immediate post infection period, but before symptoms appear
- *Eradicant:* fungus is killed/inhibited when sprayed on lesions (incl. anti-sporulant)

Mobility in plant

- *Contact:*
  - on the surface of the potato plant
  - in the wax layer
- *Local-systemic:* limited to translaminar movement and hardly any translocation from leaf to leaf and stem to foliage
- *Systemic:* translocation upwards (and downwards) in the plant

Potato fungicides



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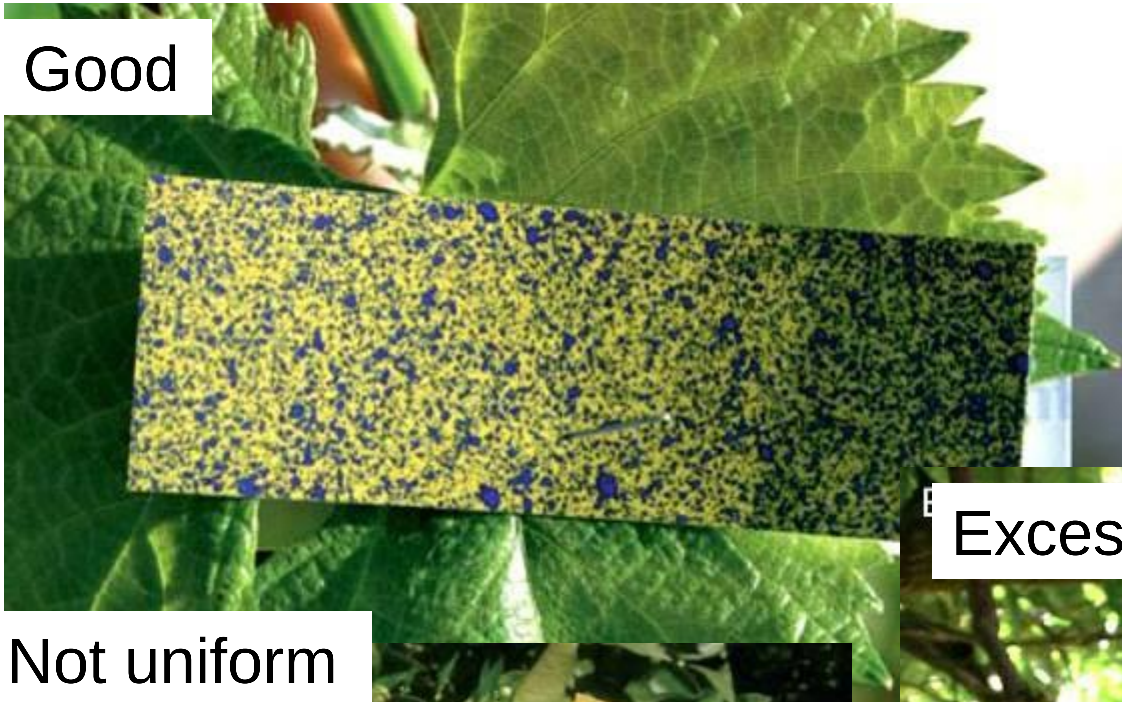
Application quality

Good



Excessive – run off

Not uniform

Decision Support Systems

From Science to Field
Potato Case Study – Guide Number 2

Using Decision Support Systems to Combat Late Blight

Summary

Decision Support Systems (DSS) integrate all relevant information to generate spray recommendations and much can be gained by their wider adoption. DSS increase the efficacy of control strategies without increasing risk and can also be used to justify fungicide inputs and as a source of advice in situations where the number of sprays or product choice is limited by legislation.

ENDURE's Potato Case Study has considered all DSS in Europe, where all potato growing regions have one or more DSS available. These DSS can improve the efficacy of control strategies and optimal timing of sprays can, on average, produce a saving of one or two sprays per season. Applying an effective preventive strategy can also avoid dramatic disease outbreaks that have to be stopped by using intensive spraying regimes.

This Guide examines the DSS currently in use in Denmark, France, Italy, The Netherlands and Poland and what the immediate future holds for these systems. The Danish system (www.planteinfo.dk), for example, is part of the wider Web-blight monitoring network which covers all countries around the Baltic Sea. A Nordic test-and-development DSS called Blight Management is currently being used to test new applications before implementation in each country's own DSS. In France, the Plant Protection Service and ARVALIS have each developed a DSS, but are now working on a single DSS scheduled to go online from 2009.

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About ENDURE

ENDURE is the European Network for the Durable Exploitation of Crop Protection Strategies. ENDURE is a Network of Excellence (NoE) with two key objectives: restructuring European research and development on the use of plant protection products, and establishing ENDURE as a world leader in the development and implementation of sustainable pest control strategies through:

- Building a lasting crop protection research community
- Providing end-users with a broader range of short-term solutions
- Developing a holistic approach to sustainable pest management
- Taking stock of and informing plant protection policy changes.

Eighteen organisations in 10 European countries are committed to ENDURE for four years (2007-2010), with financial support from the European Commission's Sixth Framework Programme, priority 5: Food Quality and Security.

Website and ENDURE Information Centre

www.endure-network.eu

This publication was funded by EU grant (Project number: 031499), under the Sixth Framework Programme, and is catalogued as ENDURE Potato Case Study – Guide Number 2, published in September, 2008.

From Science to Field
Potato Case Study – Guide Number 2

Using Decision Support Systems to Combat Late Blight

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endure diversifying crop protection

Food Quality and Safety

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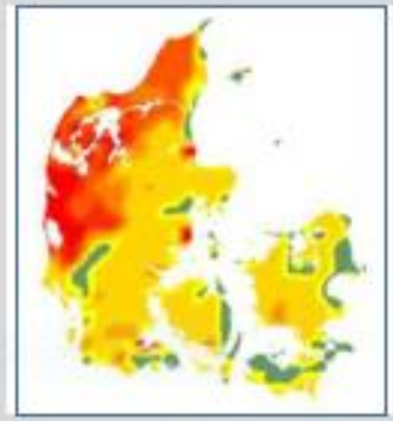
100years 1918 — 2018

IPM 2.0: Test of a DSS including information from a trap nursery - J.G. Hansen

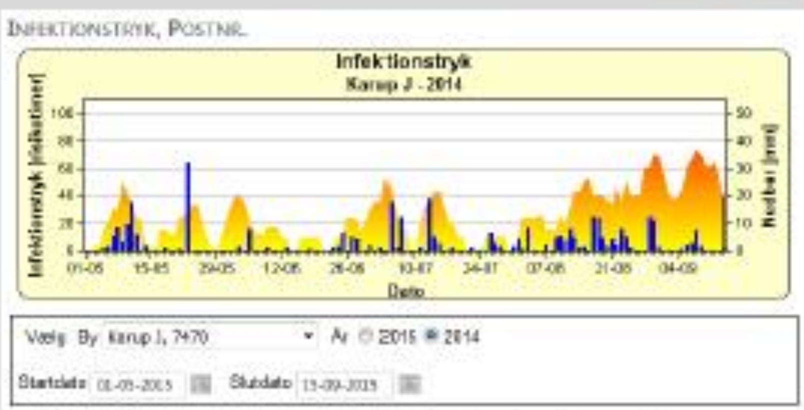
Toolbox approach – When to start

Surveillance network

Rain during crop emergence: Risk of oospores



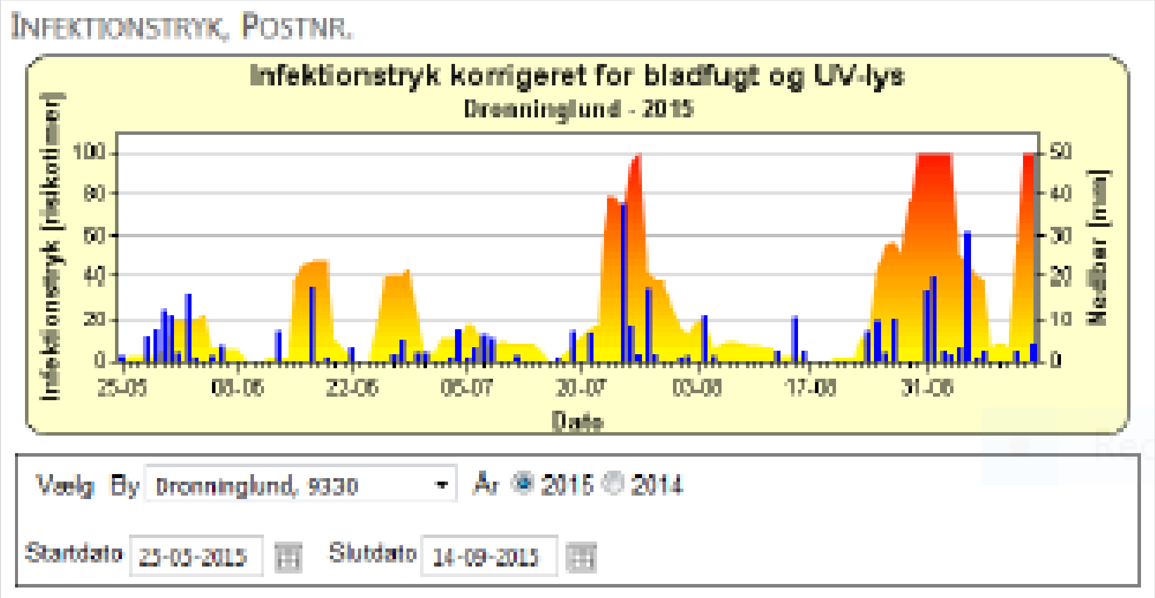
Regional infection pressure

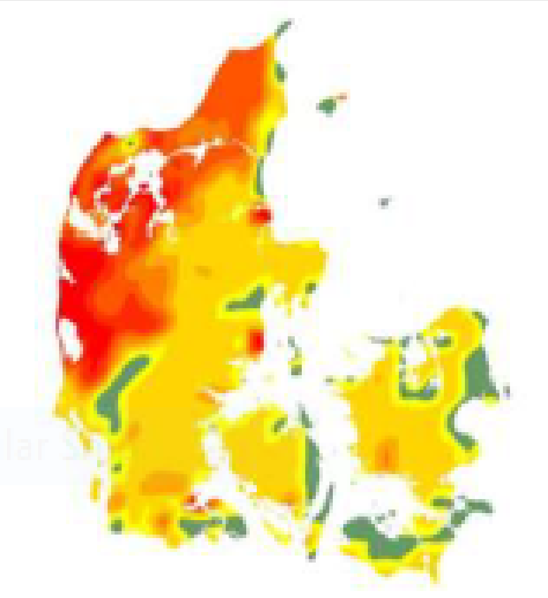


Infection pressure + Rain (postal code)

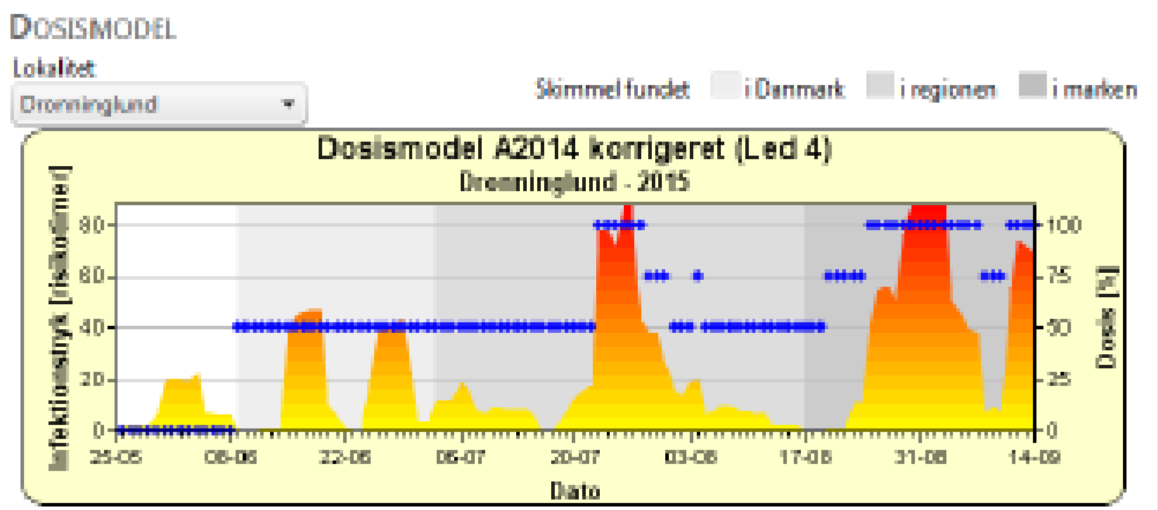
Infection risk from infected tubers

From infection pressure to Dose model





Choice of fungicide based on Infection pressure, Host resistance,
How much blight in the area



Conclusions

- Evolution of blight is an ongoing process
- **Reduction of primary sources** of inoculum is an important aspect of IPM
- Input of fungicides can be reduced in potato varieties with **durable resistance**
- Link **fungicide** characteristics with disease pressure and plant growth
- IPM increases efficacy of control, reduces costs and environmental side effects

Thank you for your attention

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