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PU Public	**X**
PP Restricted to other programme participants (including the Commission Services)	
RE Restricted to a group specified by the consortium (including the Commission Services)	
CO Confidential, only for members of the consortium (including the Commission Services)	

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Glossary

For a glossary of terms related to plant pathology we refer to an excellent glossary available at http://www.inra.fr/hyp3/glossary.htm

Partners in Potato Case

- WUR: Wageningen Universiteit & Researchcentrum (NL)
- INRA: Institut National de la Recherche Agronomique (F)
- ACTA: Association de Coordination Technique Agricole (F)
- AU: Aarhus University (DK)
- IHAR: Plant Breeding and Acclimatization Institute (PL)
- CNR: Consiglio Nazionale delle Ricerche (I)
- IBMA: International Biocontrol Manufacturers' Association

DSS: Decision Support System
IPM: Integrated Pest management
GILB: Global Initiative on Late Blight

Summary

Late blight (caused by the pseudo-fungus *Phytophthora infestans*) is the most serious potato disease. A conservative minimum estimate of combined losses and costs of control (mainly fungicides) of potato late blight worldwide is 4 billion Euros per annum; half of this figure for Europe alone. More fungicide is applied to control blight than is used in any other crop.

Integrated management of potato late blight requires a combination of management techniques in order to keep disease levels low and at the same time maintain the quality of the environment.

In this report the Best Practices in the control strategies for late and early blight in potatoes are surveyed for Denmark, France, Italy, The Netherlands and Poland.
Important control measures (Best Practices) that could potentially contribute to reduction of the environmental input of fungicides are described. The following Best Practices are presented and discussed:

- Crop rotation;
- Reduction of primary inoculum sources;
- Planting time and density;
- Optimal fertilization;
- Irrigation;
- Use of cultivar resistance;
- Fungicides;
- Decision Support Systems;
- Spraying technique;
- Desiccation, harvest & storage

An estimation is given of the degree of implementation of these Best Practices in Europe. Also indications are given on the barriers that still exist for a widespread implementation and their contribution to input reduction. For the following measures with a large and intermediate contribution to input reduction, separate leaflets are published:

- ❖ Primary inoculum sources
- ❖ Cultivar resistance
- ❖ Fungicides
- ❖ Decision Support Systems

1 Introduction

Late blight (caused by the pseudo-fungus *Phytophthora infestans*) is the most serious potato disease and, when first introduced into Europe in the 1840s, was responsible for the Irish Potato Famine. A conservative minimum estimate of combined losses and costs of control (mainly fungicides) of potato late blight worldwide is 4 billion (4×10^9) Euros per annum; half of this figure for Europe alone. More fungicide is applied to control blight than is used in any other crop. Host resistance is available, but its practical application is currently limited: agronomic and market requirements place constraints on its use. In Eastern Europe, including all the pre-accession states, late blight is an even more serious problem. Many producers cannot afford the number of 'routine' sprays applied in W. Europe and typically spray only twice per annum. Consequently, larger losses are suffered; Poland can lose upwards of 20% of the potato crop directly to the disease in 'bad' years with 15-20% losses every year due to secondary rots in storage. As the agricultural economies in E. Europe align with those of W. Europe, the quantity of fungicides applied to the potato crop will increase substantially. Knowledge transfer regarding the integrated use of fungicides, decision support systems and the organization of extension services is required from Western to Eastern Europe and *vice versa* the exchange of information on potato production systems based mainly on crop resistance with limited use of pesticides.

Changes in the world-wide *P. infestans* populations and the presence of both AI and A2 mating types of the pathogen in Europe pose the risk of increased diversity, earlier disease epidemics and the rapid breakdown of host resistance.

Integrated management of potato late blight therefore requires a combination of management techniques in order to keep disease levels low and at the same time maintain the quality of the environment.

Important tools for integrated control include:

- Hygiene measures to keep the number of primary sources of inoculum low
- The use of cultivars with stable resistance for foliar and tuber blight
- Cultural practices such as early planting and moderate nitrogen fertilisation
- Targeting fungicides preventatively by using information on infection conditions based on weather data and disease pressure.

Decision Support Systems (DSS) are currently used to integrate and organise all the available information required for decisions to control late blight. The overall conclusion from the validation of DSS by EU.NET.ICP was that the use of a DSS combined good disease control with a reduction of fungicide input.

The integrated control strategies of early and late blight of Denmark, France, Italy, The Netherlands and Poland are presented in DR 1.4. In this report the integrated control strategies are analysed and possibilities to transplant key factors to other European potato growing regions are discussed. All information regarding important Best Practices are presented in leaflets that can be uploaded on the ENDURE Competence Centre.

2 Best practices

A Workshop was held in Lelystad, The Netherlands from 11-12 October 2007. On the first day of the Workshop all participants in the Potato Case presented the control strategies in their countries (DR 1.4). The PowerPoint presentations can be found in the Potato Case folder on the Endure website. On the second day of the Workshop the essential elements in the Integrated Control strategies of late blight (*Phytophthora infestans*) and early blight (*Alternaria spp*.) were listed and discussed.

Control measures can be divided in strategic measures and tactical measures. Strategic measures are rotation, cultivar choice and measures to prevent primary inoculum sources. These strategic measures are mainly influenced by economical and social factors. Tactical measures include fungicide choice, number of sprays and use of DSS. The advisor/farmer decides on the tactical measures directly related to control of late blight. By restricting the fungicide choice, residues or environmental input consumers/buyers/government can influence the strategic and tactical decisions.

Best Practices are effective measures still under development. For widespread implementation in practice a number of barriers (economic, costs, risk) have to be solved. These measures are being tested in practice for their effectiveness and further developed.

Crop rotation

A crop rotation shorter than 1:3 will increase the risk of early infection sources caused by dumps, volunteers and oospores. This will on average result in an earlier start of the late blight epidemic. It is very difficult to quantify the effect of rotation on late blight. In other words: it is difficult to say what the benefit is for a late blight control strategy of a 1:3 rotation compared to a 1:2 rotation. An analysis of first outbreaks in Denmark showed that late blight occurred earlier in fields with shorter rotations (Bødker et al., 2006). A survey of early outbreaks in The Netherlands showed also a tendency for earlier outbreaks in fields with shorter rotations (Evenhuis et al., 2007). The rotation in starch potatoes (1:2) is shorter compared to ware and seed potatoes (1:3 & 1:4) and the rotation in organic potatoes is even longer (1:5 or 1:6). In France the recommended rotation for IPM grown potatoes is 1:3. We assume that the rotation only moderately influences the fungicide input.

Primary inoculum sources

- **Dumps:** In The Netherlands a regulation exists that forces growers to cover dumps with black plastic before 15th April (www.productschapakkerbouw.nl) . In the UK the influence of dumps on the late blight epidemic is an important part of the Fight against Blight campaign (www.potato.org.uk). It is again difficult to quantify the effect of eliminating dumps. Maybe the time between the first appearance of blight in a region and the appearance in production fields could be used as an indication of the influence the elimination of dumps.
- **Alternative hosts:** In Sweden hairy nightshade (*Solanum physalifolium*) was observed to be seriously infected with late blight (Andersson et al., 2003). It is unknown whether this weed is occurring in other countries. Also little information is available about the compatibility of the late blight isolates on this weed and potato.
- **Oospores:** Usually the ratio of the A1 and A2 mating types in the same field is used as an indication for the (possible) occurrence of oospores. Monitoring for both mating types can help to assess the risk for the occurrence of oospores. There are still a lot of questions regarding oospores. What triggers their germination? Probably water, but maybe also the temperature change during winter (freezing/thawing) plays a role. Nothing is known about the effect of organic matter on survival and germination and whether certain crops can be

used as a trap plant. It is stated that the best way to reduce the influence of oospores is to prevent the development of late blight in the previous crop and to control volunteers (in which oospores can be formed abundantly).

- **Seed potatoes:** It is recommended to use certified seed but this is not a guarantee that the seed will be completely free from blight since blight can be latently present in the seed tubers. In for example Poland the availability of certified seed is limited. It is technically possible (PCR) to detect latent infections in seed tubers. The problem is however that when 1:10,000 tubers is infected it can already create a primary inoculum source. With such a low frequency of occurrence it will be almost impossible to find it in sample of a reasonable size. It might also be possible that infected tubers not only infect a plant that grows from this tuber but that it can also infect daughter tubers without infecting aboveground plant parts. In order to assess the risk for the occurrence of latently infected tubers it is recommended to survey the history of the growing season in which the seed potatoes were grown. The incidence of late blight in the crop and the choice of the fungicides and their timing will provide information that can be used to assess the risk for the occurrence of latently infected tubers.
- **Uncontrolled late blight:**
    - Volunteers: the number of volunteers is mainly influenced by weather conditions in winter. Milder winters result in more volunteers. Usually volunteers are not a primary infection source. But in 2007 there are strong indications that infected volunteers also acted as primary infection sources. Depending on the crop in which the volunteers occur, control is usually difficult and labour intensive. A real-time vision detection of volunteers in sugar beet fields is developed in The Netherlands (Nieuwenhuizen et al., 2005).
    - Early (covered) crops: control must be emphasized either by spraying over the crop cover or directly after removal of crop cover (Spits et al., 2003). The cover should be removed on days with weather conditions that are not critical for spreading of viable spores.
    - Unsprayed/organic crops/allotment gardens: In The Netherlands there is a regulation that forces growers to treat (or destroy) a crop with an excessive infection of late blight (www.productschapakkerbouw.nl). Usually these infected fields do not occur early in the season and are therefore not considered to be important primary infection sources.

Planting time & density

In the EU-project BlightMOP, that investigated measures that could be used to control late blight in organic crops, no effect of planting density and planting time was observed (www.ncl.ac.uk/tcoa/blightmop.html). Only at a very low (unpractical) density an influence on late blight was observed. In the case of late blight epidemics that started late in the growing season, measures that accelerated growth and early bulking, such as pre-germination of seed and early planting, could help to escape an epidemic.

Fertilization

It is suggested that higher nitrogen levels promote the development of late blight by (1) resulting in a dense crop with a more humid micro-climate and (2) increasing the susceptibility of the potato tissue for late blight infections. Under practical conditions these effects do not substantially contribute to a control of late blight (www.ncl.ac.uk/tcoa/blightmop.html). In the case of early blight, higher nitrogen levels during active crop growth do stimulate the development of early blight by increasing the susceptibility of the tissue. Nutrient stress at the end of the growing season resulting in an earlier senescence of the crop also stimulates the development of early blight.

Irrigation
When foci are present in the field, there is risk of local spread by irrigation. Irrigation will also change the micro-climate but during the daytime this effect will only last for 2 hours. Irrigation in the evening or morning could extend the period of leaf wetness and in this way increase the risk for infection. We assume that there is only a minor influence of irrigation on the development of late blight.
In irrigated fields, fungicides can be sprayed before irrigation by selecting a fungicide with an excellent rainfastness. After irrigation, the accessibility of a field is usually difficult for a number of days. In the USA fungicides are also applied by adding them to the overhead irrigation system (fungigation). The level of control of fungigation is less compared to a normal fungicide spray.

Cultivar resistance
Usually resistance is not the most important characteristic for the choice of a cultivar. In Poland the resistance to viruses is being utilized, while resistance to late blight is not sufficient in widely grown potato cultivars. When there is a strong demand by buyers, super markets or governments for less fungicide input or no input at all (organic), the late blight resistance of a cultivar provides an important tool to achieve this.
The stability of resistance is very important. In each of the countries present the cultivars are tested for resistance to late blight. It is important to know how frequently these tests are updated. It is recommended that the harmonized protocols developed in EUCABLIGHT are used to test the resistance and stability of resistance (www.eucablight.org). Resistance genes used in cultivars are not known. It is also difficult to find information on the use and distribution of resistant cultivars.

In France the resistance is monitored during the season so that information can be applied in IPM control strategies during the same season. In most DSS, resistance is taken into account. To make a better use of resistance it is recommended that the influence of resistance on the epidemic is described in a better way, so that the IPM control can be adapted accordingly.

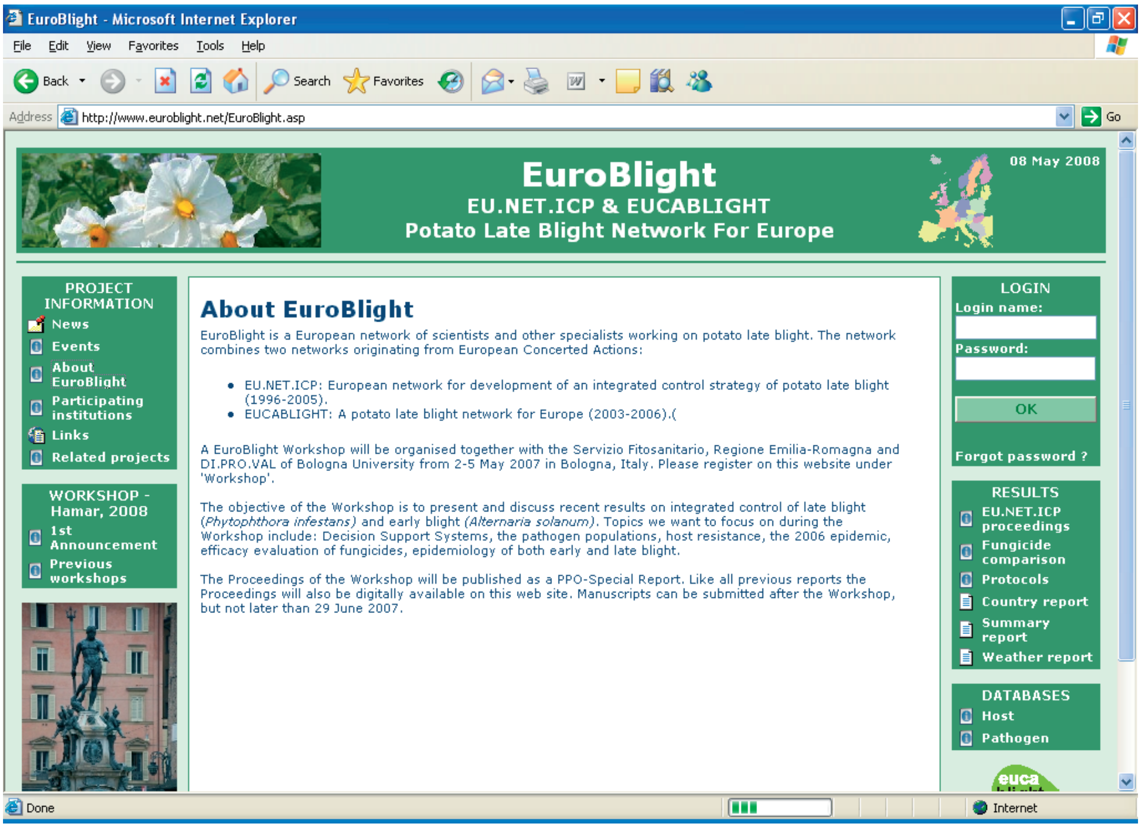
Regarding early blight, there are no standardized data available on resistance. Cultivars are **not** rated for resistance to early blight in National lists.
It is technically possible to extract resistance genes from other species (transgene) or from sexually compatible Solanum species (cisgene), combine them into cassettes and insert them into potato cultivars (www.durph.wur.nl/UK). It is not known whether this resistance is durable. The acceptance by consumers and governments will be an important barrier for use in practice, but utilization of cisgenesis to introduce high resistance to "market selected" potato cultivars seems to be the most perspective way to reach the goal, as this method may receive public acceptance much easier than transgenesis. Cisgenesis is a genetic modification of a recipient plant with a natural gene from a crossable –sexually compatible-plant. Besides the technique of insertion of the desired gene it does not contain antibiotic resistance marker genes or strong promotors originating from not related organisms.
It is recommended that these GMO cultivars should be tested using the EUCABLIGHT procedures.

Fungicides
The threshold for late blight is zero; growers do not tolerate blight. Fungicides play an important role in controlling blight. The efficacy and side-effects (environment, toxicity) but also economic, social factors and legislation will influence the IPM strategies to control late blight.
The control strategy is primarily preventive but when blight enters the crop the strategy will have to focus on trying to stop/reduce the epidemic. It is important that growers and advisors have all the information/tools necessary to control blight efficiently. A control strategy can be based on a schedule with more or less fixed intervals or can be based on the recommendations derived from a DSS. In a strategy the first spray, the product choice, the dose rates, the timing and the last sprays are important elements. These elements can differ from country to country depending on growing conditions, varieties, registered fungicides and weather conditions. It is important that information on these element/bricks is available and that the advisor/farmer can make his own decisions accordingly, depending on his own perspectives. It is important to clarify the relative effect of each of these elements/bricks on late blight control. In the EU-project BlightMOP one of the main objectives was to make clear what the consequence for late blight control in organic potatoes was of banning copper fungicides (www.ncl.ac.uk/tcoa/blightmop.html).

A lot of data exist on efficacy of control strategies but these data are not readily available to farmers/advisors.

EuroBlight is a European network of scientists and other specialists working on potato late blight. The network combines two networks originating from European Concerted Actions:

- EU.NET.ICP: European network for development of an integrated control strategy of potato late blight (1996-2005).
- EUCABLIGHT: A potato late blight network for Europe (2003-2006).



The EuroBlight network could play a role in making these data readily available (www.euroblight.net). Euroblight is also a platform for weather based DSS. This platform could be used to calculate blight risk for each country using country specific DSS, thus providing information on number of sprays and justification that can be used to compare and discuss with farmers/advisors.

- **Product choice & timing**: the first priority of farmers/advisors is efficacy. The European network EuroBlight publishes a fungicide table with all important characteristics of fungicides. Sometimes dose rates can be reduced in relation to weather conditions and/or cultivar resistance. In Poland it is not allowed to use lower dose rates than those mentioned on the label. In The Netherlands strategies in which efficacy, costs and environmental input are taken into account are tested under practical conditions to convince growers of their robustness.

EuroBlight
EU.NET.ICP & EUCABLIGHT
Potato Late Blight Network For Europe

Fungicide comparison - Updated 15 May 2007

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 (independent scientists and representatives from the crop protection industry) at the Bologna late blight workshop, 2007 and are based on field experiments and experience of the products performance when used in commercial conditions.

Product [1]	Effectiveness				Mode of action			Rainfastness	Mobility in the plant
	Leaf blight	New growth	Stem blight	Tuber blight	Protectant	Curative	Anti sporulant		
copper	●	?	●	●	●◐	0	0	●	contact
dithiocarbamates [2]	●●	?	●	0	●●	0	0	●◐	contact
chlorothalonil	●●	?	◐	0	●●	0	0	●●◐	contact
cyazofamid	●●●	●●	●	●●●	●●●	0	0	●●●	contact
fluazinam	●●●	?	●	●●◐	●●●	0	0	●●◐	contact
zoxamide + **mancozeb**	●●●	?	● [4]	●●	●●●	0	0	●●◐	contact + **contact**
famoxadone + **cymoxanil**	●●	?	●◐	N/A	●●	●●	●	●●◐	contact + **translaminar**
benthiavalicarb + **mancozeb**	●●●	?	●◐ [4]	●◐	●●●	●◐	●	●●◐	translaminar + **contact**
cymoxanil + **mancozeb**	●●◐	?	●◐	0	●●	●●	●	●●	translaminar + **contact**
cymoxanil + **metiram**	●●◐	?	●◐	0	●●	●●	●	●●	translaminar + **contact**
cymoxanil + **copper**	●●◐	?	●◐	0	●●	●●	●	●●	translaminar + **contact**
dimethomorph + **mancozeb**	●●◐	?	●◐	●●	●●◐	●	●●	●●◐	translaminar + **contact**
fenamidone + **mancozeb**	●●◐	?	●◐ [4]	●●	●●◐	0	●◐ [4]	●●	translaminar + **contact**
benalaxyl + **mancozeb** [3]	●●	●●	●●	N/A	●●◐	●●◐	●●◐	●●●	systemic + **contact**
metalaxyl-M + **mancozeb** [3]	●●●	●●	●●	N/A	●●◐	●●◐	●●◐	●●●	systemic + **contact**
metalaxyl-M + **fluazinam** [3]	●●●	●●	●●	N/A	●●◐	●●◐	●●◐	●●●	systemic + **contact**
propamocarb-HCl + **mancozeb**	●●◐	●◐	●●	●●	●●◐	●●	●●	●●●	systemic + **contact**
propamocarb-HCl + **chlorothalonil**	●●◐	●◐	●●	●●	●●◐	●●	●●	●●●	systemic + **contact**
propamocarb-HCl + **fenamidone**	●●◐	●◐	●●	●●	●●◐	●●	●●	●●●	systemic + **translaminar**
propamocarb-HCl + **fluopicolide**	●●●	●●	●●	●●●	●●●	●●	●●◐	●●◐	systemic + **translaminar**

[1] The scores of individual products are based on the label recommendation and are NOT additive for mixtures of active ingredients. Inclusion of a product in the list is NOT indicative of its registration status either in the EU or elsewhere in Europe, [2] Includes maneb, mancozeb, propineb and metiram, [3] See proceedings for comments on phenylamide resistance, [4] Based on limited data

Key to ratings: 0 = no effect ; ● = reasonable effect ; ●● = good effect ; ●●● = very good effect ; N/A = not recommended for control of tuber blight; ? = no experience in trials and/or field conditions.

Whilst every effort has been made to ensure that the information is accurate, no liability can be accepted for any error or omission in the content of the tables or for any loss, damage or other accident arising from the use of the fungicides listed herein. Omission of a fungicide does not necessarily mean that it is not approved for use within one or more EU countries.

- **Decision Support Systems**: these systems integrate all relevant information to generate spray recommendations. There is room for improvement but since the DSS are already technically on a high level we estimate the effect will be small. More can be gained by increasing the use of (parts of) the DSS by farmers/advisors. It is important to convince farmers/advisors that information from DSS will increase the efficacy of their control strategy without increasing the risk. In other words: DSS should primarily not aim at a high reduction in the number of sprays but it should aim at an effective control of late blight (including a large enough safety margin). On average the use of DSS can save 1-2 sprays per season. DSS can also be used to justify the input of fungicides and to advice in situations when the number of sprays (or product choice) is limited by legislation. In the Endure Workshop on DSS held in Flakkeberg, Denmark in March 2008 all DSS in Europe were presented.
- **Spray technique**: should always be optimal. Little improvement is to be expected in efficacy but by selecting the right spray techniques and regulations large improvements can be made in drift reduction. In The Netherlands regulations regarding drift reduction (crop free zones, spray techniques) have contributed to a large extent in reducing the environmental impact of fungicide to control late blight.
- ***Phytophthora* population**: monitoring for fungicide resistance, virulence and aggressiveness of isolates can assist in the design of IPM strategies. It is recommended that the harmonized protocols for host characteristics developed in EUCABLIGHT are used to be able to monitor developments in the pathogen population in Europe (www.eucablight.org). In France the cultivars are divided into 4 resistance classes but depending on the pathogen population that is present cultivars can shift from one class to another.
- **New fungicides**: it is important to monitor the development of fungicide resistance in an early stage. In future SSRs can possibly be used to monitor these developments real-time. The sample size and location should be representative for a region. Important to compare the data from the lab with data in the field.
- **Alternative fungicides**: substances that provide **S**ystemically **A**cquired **R**esistance (SAR) and/or strengthen the resistance of the plant might in

combination with fungicides improve the efficacy and enable reduction of dose rates. Registration of these substances might be a problem. It is potentially interesting (good results under controlled conditions) but the efficacy will also have to be tested under field conditions.

- **Impact (environmental, residues, toxicity):** In Denmark the treatment index (number of sprays x dose rate) is used as a yard stick to measure the input of agrochemicals. In the Netherlands each agrochemical is rated for its environmental side-effects for leaching to ground water, soil and water organisms. These pollution points, calculated by CLM based on data from the registration dossier of the agrochemical company, are used as a yard stick to measure the input of agrochemicals (www.milieumeetlat.nl).
- . For late blight the pollution points have been decreased >80% in 2003 compared to the reference period 1996-1998. It is recommended to compare the systems in the countries involved and formulate pro's and contra's.

Desiccation
The timing of desiccation of blighted (organic) crops influences the infection pressure in a region. Desiccation can also influence the amount of tuber blight in the field itself. Depending on the amount of blight in the crop and the weather, it can be recommended to add a sporicidal fungicide to the desiccant. It is recommended that current practices are monitored. A sensor has been developed that allows adjustment of the dose rate of the desiccant to the greenness of the crop. Using this sensor can save considerable amounts of desiccant without loosing effectiveness.

Harvest
It is recommended to harvest under dry weather conditions a number of weeks after desiccation. The skinset of tubers is an important factor in its susceptibility for infection by late blight. During harvest viable sporangia in the ridge can come into contact with (damaged) tubers and result in tuber blight. Fast drying of potatoes after harvest is important to prevent "tuber-wetness" which is needed for spores to infect tubers. The weather forecast can be used to predict possibilities for drying potatoes in storage. Most DSS provide recommendations to prevent blight in the canopy. New DSS-modules are developed to predict the occurrence of tuber blight.

Storage
Only limited information is available (Ireland) regarding the possibility of infected tubers to infect neighbouring tubers in storage.

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

Table 1. Essential elements of an Integrated Control strategy for potato late blight in Europe

Elements	**Implementation[a]**	**Barriers[b]**	**Contribution to input reduction[c]**	**Organic[d]**
Crop rotation	2	1,5	3	1
Primary inoculum sources	2	1,4	3	1
Planting time & density	2	1,5	4	1

Fertilization	2	5	4	1
Irrigation	1	5	4	1
Cultivar resistance	2	1,3,4	1,2	1
Fungicides	1	1,4	3	1,2[e]
DSS	2	1,4	3	1,2
Desiccation	1	4	4	1
Harvest	1	1	4	1
Storage	1	1	4	1

a. Implementation: 1 = widespread in practice; 2 = only on best farms/some regions/countries; 3 = only on research farms/in development.
b. Barriers: 1=economic/costs; 2=labour; 3= risks; 4=risk perception; 5=limited influence on blight
c. Contribution to input reduction**:** 1 = lower dependency on chemicals; 2 = large; 3 = intermediate; 4 = small; 5 = none
d. Organic: 1 = elements is applicable in organic farming; 2 = element cannot be used in organic farming.
e. In some countries copper is registered for use in organic crops.

3 Discussion & recommendations

The state of the art of late & early blight control strategies was surveyed in Denmark, France, Italy, The Netherlands and Poland. All elements that are internationally recognised as important elements of an integrated control strategy for potato late blight are part of the control strategies in the 5 countries that were part of the survey. For the Nordic countries, UK and The Netherlands the recent developments regarding late blight in potato are described by Cooke et al. (2008).

The European and Mediterranean Plant Protection Organization (EPPO) published a Guideline on good plant protection practise in potato (**www.eppo.org**). In this guideline the basic strategy for control of late blight is presented and information is provided on the following topics:

- Destruction of initial inoculum: waste heaps, volunteers, infected seed potatoes
- Optimum timing of the first application: follow recommendations of a warning system or when not available based on phenological stage of the crop
- Deciding the frequency and timing of later applications: the basic strategy is always protective. The timing will depend on local conditions. Warnings from systems can be followed or general rules.
- Protection of the tubers at the end of the season: use of a different set of fungicides in combination with haulm killers
- Problems with fungicide resistance: the risk of resistance should be taken into account in spray programmes.

In the EPPO guideline also the strategy to control early blight is shortly presented. It is stated that: "Disease severity can be reduced by keeping 3-year intervals between potatoes. In many countries, attack remains at a low level which does not require any chemical control. In countries with risk of severe attack, fungicide sprays should be applied from appearance of the first symptoms on the leaves. Normally a single treatment should be sufficient. Most fungicides applied against late blight will also control *A.solani*."
The Sustainable Agriculture Initiative Platform is a food industry platform to support the development of and communicate about sustainable agriculture, involving all stakeholders of the food chain (www.saiplatform.org). On there website a working document is published entitled "SAI Platform Sustainable Potato & Vegetable principles and practices". This paper compiles in form of a table basic principles and practices for the sustainable production of potatoes and vegetables worldwide. It provides recommendations for producers to continuously improve the sustainability of their agricultural practices along three pillars of sustainability: economic, social and environmental. It is a working document meant to be revised and improved on the basis of feedback received by producers involved in a number of pilot projects as well as at follow-up workshop(s) involving key stakeholders. Ultimately, final recommendations for basic principles and practices shall be developed, to prevailing conditions (according to the region and its climates, ecological variables, farming systems, cultures etc.) as well as respecting national laws and regulations. The following topics are presented:

- Sustainable farming systems:
  - Site selection and management
  - Planting material
  - Integrated crop management (IPM is strongly encouraged)
  - Sustainability management system
  - Access to information and support services
- Economic sustainability
  - Safety, quality and transparency
  - Financial structure

  - Relation to the market
  - diversification
- Social sustainability
  - Labour conditions
  - Training
  - Strengthening local economy
- Environmental sustainability
  - Soil conservation
  - Water conservation
  - Biodiversity conservation
  - Integrated waste and crop-by-product management
  - Energy conservation
  - Air conservation

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

Crop rotation: There are indications that with the new population of *P. infestans* the importance of rotation as a measure in IPM strategies to control late blight is increasing. Since farmers will not change the rotation only to reduce the infection pressure of late blight, we recommend that the element of rotation and its influence on late blight has to play an important role in the “Arable crop system study” that will start in M19.

Primary inoculum sources: With the new more aggressive population of *P. infestans* it is increasingly important to prevent the occurrence of early primary infection sources. Although it is impossible to quantify the effect of postponing outbreaks, it can certainly contribute to a reduction of input. It is recommended that programmes that increase awareness of preventing early infection sources (NL, UK) are transplanted to other potato growing regions in Europe. A separate leaflet on primary inoculum sources is published.

Planting time & density: the contribution to input reduction is considered small.

Irrigation: the contribution to input reduction is considered small.

Cultivar resistance: This element of the integrated Control Strategy is considered to have the largest potential for reduction of the fungicide input. 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 in the same cultivar with late blight resistance. In the grower’s perspective, the savings in fungicide input that can be achieved with resistant cultivars are not compensated for by the higher (perceived) risk for blight. In countries where fungicides are not available or very expensive, the use of resistant cultivars is one of the most important ways to reduce damage from blight. Another barrier for use of resistant cultivars is the risk that the resistance proves not to be durable. Especially with the sexually reproducing population of *P. infestans* the risk for breaking the resistance could be increased. Breeders are constantly trying to produce cultivar that combine commercially important characteristics with late blight resistance: either by conventional breeding by crossing and selection or by GMO-techniques. Information regarding the late blight population, the present status of cultivar resistance and the fungicide strategies to make optimal use of the already existing resistance in commercially interesting cultivars can be transferred to other European potato growing areas. The EUCABLIGHT website already contains all lot of this information. A separate leaflet on cultivar resistance is published.

Fungicides: A whole range of different fungicides are registered to control late and early blight. Information regarding the specific characteristics of fungicides and spray programmes can be transferred to other European potato growing regions. In the EuroBlight network already a lot of information is shared between research groups and agrochemical companies. By optimising the spray programmes the control efficacy will be increased. The number of sprays will not be reduced, but by selecting fungicides with a “green environmental profile” there is certainly the potential for an intermediate to large reduction in the environmental impact of fungicides. A separate leaflet on fungicides is published.

Decision Support Systems: All potato growing regions in Europe have one or more regional DSS available. It is important to realize that growers/advisors will only use these DSS when they help them to increase the efficacy of their control strategy. By timing the sprays in an optimal way, on average a reduction in 1-2 sprays per season can be obtained. By applying an effective preventive strategy it is also prevented that dramatic disease outbreaks occur that have to be stopped by intensive spraying schemes. Information regarding all aspects of Decision Support Systems can be transferred to other European potato growing regions. A separate leaflet on Decision Support Systems is published.

Desiccation, Harvest, Storage: the contribution to input reduction is considered small.

4 Gaps of knowledge: new projects

A lot of work to identify relevant scientific issues with respect to host resistance, pathogen populations and integrated pest management is ongoing. Many relevant research projects are funded at the national level (DR1.3) and the Potato Case participants and participants of the EuroBlight network have access to this research and also expertise in potato production systems and a wide range of other pests and diseases of potato. Most research projects are dealing with *P. infestans*, only some projects are ongoing on Alternaria. In addition, the facilities required to carry out cropping systems research for potato are available. For example, the participants in the Potato Case amongst many others, have excellent resources (e.g climate chambers, semi-field facilities, rain simulators etc.) These facilities are also available within agrochemical companies connected to the EuroBlight network.

The EUCABLIGHT project has collated, harmonised and disseminated methods for the phenotypic and genotypic characterisation of the pathogen and for host resistance screening. In addition, existing and newly generated data has been collected using a data entry tool specifically designed for the purpose. This data is held in databases, facilitating analysis of the pooled data on a European scale. In the EU.NET.ICP network, a harmonised protocol was developed to validate DSS for control of late blight in different European Countries. Also the fungicide characteristics (to be included in the DSS) are rated according to harmonised protocols for testing the effectiveness and mode of action.

Both projects are now combined in EuroBlight and deliver experience in modelling, testing candidate strategies and software tool technology. Whilst collectively, EuroBlight participants have experience with a wide range of potato pests (fungal, bacterial and nematode) and would envisage that these were built into an integrated disease management programme, a concentration of effort towards the control of late blight (and early blight) will result in the best contribution to a reduction of chemical input in potatoes.

It will be important to ensure that the lessons learned from the proposed potato-late blight model are applicable to other potato pest problems and also across crops (for example cereals and grapes). There must be inter-disciplinary and inter-crop dialogue to deliver a true European IPM strategy.

The EuroBlight networks consists of all the important scientists and specialists in potato pathology and it is recommended that this network would be ideally placed to identify gaps in the current knowledge, and importantly, gaps that must be filled in order to formulate a working and transferable strategy for the reduction in pesticide applications to potato. It is therefore recommended that to come to a better utilisation of research, the 4 subgroups of EuroBlight (DSS, fungicides, pathogen, host resistance) will use the information presented in this report to come to a better coordination of research programs and harmonised protocols. The next meeting of this network will be held 28-30 October 2008 in Hamar, Norway. The results of the discussions will be communicated to the ENDURE network.

Within ENDURE the results of the Potato Case study can be integrated in RA2 “Designing innovative crop protection strategies” and/or RA4 “Improving the basic understanding of the biology of the crop-pest systems”.

- RA2: Discussions are ongoing to start a System Case study in M19 in which 2 potato-based rotations will be included: one in The Netherlands and one in France. The results of the Potato Case study regarding late and early blight will be integrated in this System Case.
- RA4.1: Pesticide resistance management: relevant information on pesticide resistance in potato can be used in this activity

- RA4.2: Exploitation of plant genetic resistance: relevant information on cultivar resistance of potatoes and virulence of *Phytophthora infestans* can be used in this activity.

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