ENDURE

European Network for Durable Exploitation of crop protection strategies

Project number: 031499

Network of Excellence
Sixth Framework Programme

Thematic Priority 5
FOOD and Quality and Safety

Deliverable DR1.4

Survey of "the state of the art of late and early blight control strategies (agricultural practises and toolboxes)"

Due date of deliverable: M14

Actual submission date: 18 February 2008

Start date of the project: January 1st, 2007 **Duration**: 18 months

Organisation name of lead contractor: PPO (WUR)

Revision: V1

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)	
Dissemination Level	
RE Restricted to a group specified by the consortium (including the Commission Services)	**X**

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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 control strategies for late and early blight in potatoes are surveyed for Denmark, France, Italy, The Netherlands and Poland.
In these countries the importance of potatoes and the occurrence of early and late blight is described. Estimations are provided of the input of fungicides. Important control measures (Best Practices) that could potentially contribute to reduction of the environmental input of fungicides are described. The following elements are presented as Best Practices in one or more countries:

- Reduction of primary inoculum sources;
- Use of resistant varieties;
- Optimal fertilization;
- Decision Support Systems;
- Targeted use of fungicides including environmental profile of fungicides;
- Optimal spraying technique including reduction of spray drift

The registered fungicides for control of late and early blight are presented in an overview table as well as the most important (resistant) seed, ware and starch varieties.
National Plans to reduce Pesticide Impact in Denmark, France, Italy and The Netherlands are described.

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 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 organisation 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 Al 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.

In this report the integrated control strategies of early and late blight are presented for Denmark, France, Italy, The Netherlands and Poland.

2 Control strategies in Denmark

Importance of late and early blight: occurrence, damage

Late blight is the most damaging pathogen to yield and quality in Danish potato production. Conventional growing of potatoes is today characterized by intensive use of fungicides, and the treatment frequency index has been increasing for the last 10-15 years and is now an average of 7-9 treatments with 10-14 sprays in starch potatoes. In DK the production value of potato is approximately € 92 million.

Early blight is in general regarded as a minor problem. Alternaria usually attacks the crop later in the season resulting in 10-15% lower yields in some cases. Usually Alternaria is controlled by using late blight fungicides with a side-effect on Alternaria (*mancozeb*). One specific Alternaria fungicides (Amistar) is now registered.

Size of potato area and fungicide input in Denmark

	Acreage (ha) 2006	**Yield (kg/ha) 2006**	**Costs fungicides (€/ha) 2006**	**Active ingredient (kg/ha)**	**Number sprays/ha (2006)**
Ware	15.210	32.300	84	8	5-7
Seed	4.032	26.800	84	8	5-7
Starch	18.712	39.700	126	12	10-12
Total	37.954	35.364	101	9,5	7,2

Best Practices (important control measures that could potentially contribute to a reduction of the environmental input).

- **Primary inoculum sources**: Primary measures to reduce the primary inoculum sources are to use healthy seed and to avoid dumps and volunteers. It is generally agreed, that there is only minor problems with primary inoculum from volunteers and dumps in DK, however this has not been investigated. In some years, where the ridges are saturated with water around germination, there can be primary infections from soil born inoculum, primarily in starch potato in narrow crop rotations.

- **Resistant varieties**: Many varieties grown in DK are susceptible to late blight and tuber blight. However differences appear, e.g. starch varieties (Kuras) which are more resistant (moderate resistant) compared to other potato production varieties. The differences in treatments often relates to the potato type where frequency and timing of fungicide applications depends on the foliar resistance of the cultivar, e.g. in the moderate resistant starch potato Kuras, fungicides are used at a lower dose under low disease pressure. On www.Eucablight.org a list is published with resistance levels of Danish varieties.

- **Fertilization**: Not normally taken into consideration in disease control strategies and farmers are recommended to use N according to recommendations and to be aware that high N levels could increase the susceptibility of the crop directly or could also indirectly influence the microclimatic conditions.

- **Decision Support Systems**: Information and decision support about the control of late blight is available via www.Planteinfo.dk (Jensen et al., 2000). Three partners operate this system together: University of Aarhus (AU), the Danish Agricultural Advisory Service (DAAC) and the Danish Meteorological Institute (DMI). A dedicated "Potato late blight web page" integrates all available information about late blight control, including tools like monitoring of early attacks (similar to the UK fight against blight campaign), weather based late blight infection pressure, general weather information and -forecast, regional blight weather and -forecast, fungicide information (based on Euroblight), cultivar database with information about late blight resistance based on methods from Eucablight etc. In a dedicated text frame experts from DAAC and AU have the possibility to include comments on the blight situation, report observations from the field or make advice on how to use the tools available. The separate DSS components are not integrated to provide specific decisions on timing and use of a specific fungicide type and dosage. PlanteInfo provides advice on some basic strategies for the control of potato late blight, and how the user can use the tools in PlanteInfo to make decisions about first spray, spray intervals, fungicide type and dosages, when to use systemic compounds and how to protect against tuber blight. Several components of the DSS were developed in the frame of ongoing collaboration between the Nordic countries. The Web-blight monitoring network covering all countries around the Baltic Sea has been in operation since 2000 (Hansen et al., 2003). A Nordic test-and-development DSS called Blight Management is currently operated to test new ideas and applications before implementation in each country's own DSS (Hansen et al., 2005a; Hansen et al. 2005b; Hansen et al., 2006)

- **Fungicides:** To prevent infections, it is recommended to protect the potato crop whenever an infectious period occurs. The first sprays normally starts at G.S. 20-35 when conditions are favorable for late blight. Important elements in the control strategy are cultivar resistance, fungicide characteristics, rate of growth of new foliage, weather conditions, irrigation and incidence of blight in the region. Timing, fungicide dose and intervals depend on these factors and the farmers are always recommended to spray preventively with contact fungicides before infection periods appear. The most widely used protective product is mancozeb (Dithane NT), fluazinam (Shirlan) and cyazofamid (Ranman). Before high risk periods it is recommended to use fungicides with curative activity. Ridomil Gold (metalaxyl+mancozeb), Tyfon (propamocarb+fenamidone) and to some extent Tattoo (propamocarb + mancozeb) and Acrobat WG (dimethomorph+mancozeb) are used in situations with higher disease pressure. In DK Ridomil Gold can only be used for one application after G.S. 60. In second half of the growing season fluazinam and cyazofamid is used for control of tuber blight.

- **Spray techniques:** Different sprayer systems have been tested in DK for optimizing the control of late blight (e.g. hydraulic sprayers, air assisted sprayers and the Danfoil Airsprayer) but no system have shown significant improvement in blight control compared to the standard hydraulic sprayer.

Recent trials have shown an increased efficacy by using angling of the spray nozzles on ordinary hydraulic sprayers, but more experiments are needed to verify these results

- **Alternaria:** Control of early blight is normally obtained by using late blight fungicides with effect on Alternaria (Dithane NT, Sereno or Electis). In some fields Alternaria can be a problem in the second half of the growing season and two treatments with a specific Alternaria product (Amistar) can be used.

Efficient strategy in combination with a reduced environmental impact of fungicides

In such a strategy all elements of IPM will have to include:

- Prevention: healthy seed, reduction of primary sources, use of resistant varieties
- Crop measures: N-fertilization, scouting for earl infection
- DSS: integrate all relevant information such as weather, variety resistance, plant growth, fungicide characteristics, disease pressure
- Fungicides: fungicide choice, dose rates, environmental profile
- Application technology: drift reduction

National programs to reduce Pesticide Impact

The Danish Pesticide Action Plan (2004-2009) aims to reduce the treatment frequency index (TFI) for all pesticides in Danish agriculture to 1.7 on farm level by the end of 2009. The target is to be achieved through targeted communication and consultancy at farm level to bring existing knowledge to the farmers. In potato the aim is a treatment frequency index of 7.5 in starch potato and 5 in seed and ware potato by 2009.

The treatment frequency index in potato has been increasing for the past 10-15 years and is now an average of 7-9 treatments with 10-14 sprays in starch potatoes and the very blight favorable weather in e.g. 2006 and 2007 will probably contribute to an even higher TFI.

3 Control strategies in France

Importance of late and early blight: occurrence, damage

Late blight is still the most important and frequent disease of potato in France. It is prevalent and often severe in the oceanic areas where potato cultivation is important (Nord Pas de Calais, Picardie, Normandy, Brittany), less severe in more continental (Beauce, Champagne, Alsace) and southernmost (Aquitaine, Languedoc Roussillon) production areas. Direct estimates of losses are not available, but yield reductions are often limited due to intensive fungicide spraying schedules. Losses are important in organic crops. Late blight is also present on tomato (mainly in outdoor crops), but rather sporadic as these crops are mostly grown in the southern half of the country.

Size of potato area and fungicide input in France

	Acreage (ha) 2005	Yield (t/ha) 2005	Costs fungicides (€/ha) 2005	Active ingredient (kg/ha)	Number sprays/ha
Early	7600	25			
Ware	104500	42.5			
Seed	15000	25			
Starch	27000	45			
Total	154100	41	160* (100-200)	16.5 (10-24)	13 (6-18)

* 160€ = only fungicides costs. The total costs (fungicides and sprays) are between 150 and 350 € per ha.

Late blight epidemics usually start in May in oceanic areas with early planted crops (Brittany, Atlantic isles), and towards the end of June/early July in main crop production areas (Nord Pas de Calais, Picardie, etc.). However, year to year differences in the dates of first outbreaks are important, because these dates are highly dependent on local climatic conditions.

Early blight is not as widespread as late blight, but recent observations and reports suggest that its occurrence is increasing. Early blight symptoms are most often observed in the second half of the crop season (hotter periods), and seem to be most severe in some cultivars.

Epidemic development

The main sources of primary inoculum for late blight epidemics in France lie in infected tubers overwintering in (volunteers) or close to the fields (dumps). These sources are monitored regularly by the Plant Protection service, and the observations are exploited in the preparation of the warnings (see Serge Duvauchelle's papers in EU NET ICP reports about the warning system in France).

There is to date little or no evidence that oospores may contribute to the primary foci. The widespread use of certified seed is thought to limit the risk of seed-borne primary infection, although such infections probably occur in a small proportion of outbreaks.

Tuber infection is not the main concern in France for ware crops, because the conditions in late summer and up to lifting of most crops are usually not very conducive to tuber infection. It is a more serious problem for starch crops, which are harvested later (end of September and well into October).

No systematic monitoring and epidemiological studies are currently carried out regarding early blight. Little is therefore known as to the inoculum sources and epidemic development of this disease in France.

Best Practices (important control measures that could potentially contribute to a reduction of the environmental input).

- **Prophylactic measures**: The use of certified seed tubers to prevent seed borne infection is highly recommended. The rate of use of certified seed is high in France (more than 80 %). The destruction and/or covering of dumps is also advised, but not mandatory or regulated; it is very unevenly performed, and many growers still do not take this elementary precaution.

- **Resistant cultivars**: The currently most widely grown cultivars in France (Agata, Bintje, Charlotte, Kaptah Vandel…) are quite susceptible to late blight. However, there are a number of cultivars registered on the French national list that obtained good resistance ratings (equal or greater than 6 on a 1-9 scale of increasing resistance) in the registration trials, and several of the most recently registered had scores of 7 or more (see list compiled within EUCABLIGHT and available on the EUCABLIGHT website - www.eucablight.org). These cultivars generally owe their high resistance ratings to the presence of race specific resistance genes (notably R2, present in cultivars like Naturella, Eden or Bondeville), which are liable to break down rapidly. A low number of these cultivars, such as Eden, combine these race-specific resistance genes with quantitative resistance, potentially more durable.
  Field observations suggest that differences in the susceptibility of currently popular French cultivars to early blight exist. However, this trait is not assessed during the registration tests for the French national list, so no comprehensive information regarding cultivar behaviour to Alternaria is available to date in France.

- **Fungicides:** Late blight control in France relies primarily on fungicide applications. The most commonly used active ingredients are mancozeb solo (50%), maneb solo (20%) and fluazinam (10%), followed by cymoxanil (8 to 14% according to the year), dimethomorph, cyazofamid, zoxamid, propamocarb and mefenoxam, The total number of sprays per crop ranges between 6-8 in early and seed crops to 14 - 18 in ware and starch crops (see EU NET ICP reports).
  Anti resistance strategies designed to prevent the extensive development of mefenoxam-resistant isolates limit the use of mefenoxam-based products to a maximum of 2 sprays per crop and before the beginning of July. A monitoring of sensitivity of P. infestans populations to major active ingredients is carried out by the Plant Protection Service, Loos en Gohelle. Many active ingredients used against late blight, in particular the dithiocarbamates, are also suitable to control early blight. Therefore, the spraying programmes used in most regions are directed to both diseases.

- **Decision Support Systems**: The French Plant Protection Service issues late blight warnings since the mid 1960s. These were initially based on the Guntz-Divoux forecasting model, later complemented with the MILSOL model (see Duvauchelle, EU NET ICP 1996). During the past few years, the French Plant Protection Service and ARVALIS have each developed a Decision Support System, known as MILPV and MILDI-LIS respectively.

MILPV is based on the MILSOL forecasting model, and includes an explicit tailoring of recommendations according to the levels and types of cultivar resistance; it also includes information on the legislation and technical rules applicable to the products. MILPV also includes an 'organic' version, where the recommendations take into account the specific constrains of organic production. MILPV is used by 150 to 200 growers for 3 years.
MILDI LIS is based on the Ullrich and Schrodter negative prognosis forecast, and also includes a tailoring of recommendation according to cultivar resistance (www.arvalisinstitutduvegetal.fr). Mildi-LIS is used by 450 to 500 growers for 4 years. In 'standard' years, both DSS allow to substantially reduce the number of sprays (1 to 5-6 according to cultivar resistance) relative to a calendar, once a week-spraying schedule without any decrease in control performance. In extreme years, such as 2007 with a very early and prolonged epidemic, the DSS allow a better timing of the sprays. ARVALIS and the Plant Protection Service are now working on building a single DSS from their two current ones. This new DSS is planned to be online for the beginning of the year 2009.

- **Alternaria**: Because early blight is still regarded as a minor disease in France, there has been no effort so far to develop forecasting or decision support systems for this disease under French conditions.

National programs to reduce Pesticide Impact
A first plan was launched last year (2006-2012) by the Ministry of agriculture. The aim of this plan is to reduce the risks that the use of pesticides (plant health and biocides) can generate on health (in particular that of the users), the environment and the biodiversity using five strategies. It envisages the reduction of 50% of the sold quantities of the most dangerous active ingredients.

1. To act on the products by improving their conditions of marketing
2. To act on the practices and to minimize the recourse to the pesticides
3. To reinforce the training of the professionals, the protection of the users of pesticides and their information
4. To reinforce knowledge and the transparency as regards medical and environmental impact of the pesticides
5. To evaluate progresses

It is possible that a second plan is in preparation by the French ministry of ecology.

4 Control strategies in Italy

Importance of late and early blight: occurrence, damage
Late blight is one of the most important diseases in potato in Italy, and may result extremely severe in Northern (Emilia Romagna, Veneto) and Central region. Insurgence of resistant pathotypes of *Phytophthora infestans* is one of the main risk factors associated to epidemiology of the disease. A DSS system is implemented in the Emilia Romagna region and is helping in reducing the amount of fungicides required to control the disease.

Size of potato area in Italy

The annual production is around 2 million tons (FAO, 2004), whereas the annual consumption is around 43 kg per capita, much lower than the EU average, corresponding to 75 kg per capita (EUROSTAT, 2004). Potato production in Italian regions ranks at first place Campania, with more than 0,3 million tons, followed by Emilia Romagna (0,23 m. tons), Sicily (0,23 m. tons), Abruzzo (0,16 m. tons), Calabria (0,16 m. tons), Apulia (0,145 m. tons) and Veneto (0,13 m. tons) (ISTAT, 2004). In Italy early potato and extra seasonal potato have major importance, their production being concentrated mainly in Southern regions, with a cultivated surface in 2004 of more than 20.000 ha (Sicily 9.660 ha; Apulia 5.548 ha; Sardinia 1.530 ha, Campania 3.945 ha) (ISTAT, 2004). The extra seasonal potato is the most consistent Italian export even if in last years it showed a significant reduction: in 2004 it was exported for a total of 123 thousand tons, with an economic value of around 40 million Euros.

The industrial potato production represents more than 5% of total Italian production, but this value may be underestimated. In the industrial potato production we have three main sectors: starch, alcohol production and food products transformation. Actually in Italy the first two sectors are of low interest, since Italy imports almost all the starch required, whereas distillation encounters several technical and economical obstacles. The industrial transformation of potato for human food products (chips, snacks, sticks, frozen products, etc.) represents an important sector for potato production.

Size of potato area and fungicide input in Italy

	Acreage (ha) 2006	Yield (kg/ha) 2006	Costs fungicides (€/ha) 2005	Active ingredient (kg/ha)	Number sprays/ha
Ware	62250.90 *	22146.3*			
Seed	< 5%	< 5%			
Starch	<5 %	<5 %			
Total	72451.00	24607.05		3 kg / ha	4-8

* *estimated*

Best Practices (important control measures that could potentially contribute to a reduction of the environmental input).

- **Primary inoculum sources**: Environmental conditions conducive to an epidemic of late blight include minimum daily relative humidity of 65%, and a mean relative humidity greater than 90% for 6 hours on 3 to 4 days with temperatures from 10 to 12.8 C. Temperatures above 35 C after penetration can stop disease spread even after infection occurs. The fungus can survive inside living plant tissue to resume the development of late blight when cool and moist conditions occur. Prevention based on the use of healthy propagation material and the eventual planting in soils that were not cropped with potato, tomato or other Solanaceae in the preceding seasons, is considered a good agronomic practice.

- **Fertilization:** Plants too vigorous, often produced through fertilization plans too rich in nitrogen, predispose potato crops to late blight attack.

- **Treatments:** Alert systems may result very helpful not only for the correct identification of the first treatment date, but also for the following ones, which may be delayed in case of absence of infective foci. In organic agriculture, copper is the product mainly used, in combination with other co-adjuvants like propoli and potassium salts (soap). The action of copper is preventive, and after intense rains or with high humidity a treatment is necessary, and in areas particularly wet or rainy, treatments scheduled at intervals of 7-10 days are applied. Copper based products showed greater efficacy when applied before rather than after a rainy period, within the threshold of 35-40 rainfall ml.

- **Resistant varieties**: several available, see table for some varieties in use or tested

- **Decision Support Systems**: To forecast the appraisal and evolution of late blight infections on potato and tomato, in the Emilia-Romagna region (Servizio Fitosanitario Emilia-Romagna) two models based on climatic variables are applied, Model IPI (Indice Potenziale Infettivo) and Model MISP (Main Infection and Sporulation Period). Model IPI is informative about the occurrence of the disease and suggests if it is necessary (and when) to proceed with the initial treatment, based on a series of climatic parameters. It was set up in 1990 by the *Servizio fitosanitario regionale* in Emilia-Romagna and is integrated, for potato, by Model MISP, elaborated in Switzerland, which provides indications on the following infective events.

- **Provisional model IPI**: Model IPI evaluates the probability of the evolution in time of the infective potential of *P. infestans*, in a monitored environment. It is a "negative prognosis" model, since it does not show the exact date of disease insurgence, showing instead a time period during which the disease is not probable, lowering by this way the number of required field treatments. The INPUT data are the date of emergence or crop transplant, the minimum, mean and maximum daily temperatures (°C), the mean daily relative humidity (%) and the amount of total daily rainfall (mm). The OUTPUT is an index of daily cumulative potential risk, and the limit date of high risk threshold, showing the first treatment on potato or tomato. This model generates infection potential indexes (IPI) that predict the most probable inoculum increase of *P. infestans* in the environment. In Italy, IP indexes are used along with indicator plants plus spore traps to warn farmers about when to start spraying. The model does not give recommendations about subsequent fungicide applications. The cumulative daily IPI over a defined period is used to evaluate late blight risk. A network of unsprayed plots of 100 m^2 are planted in strategic locations with a susceptible tomato cultivar (Heinz) and used to record and follow late blight epidemics. These plots are examined weekly and used to report late blight attacks in advance. Spore traps at the ground level are used to monitor sporangia of *P. infestans* in the air every two hours throughout the tomato growing season. Rapid increase of the amount of sporangia collected is positively correlated with occurrence of first symptoms during the next few weeks. Cumulative IPI plus disease data from unsprayed plots and populations of sporangia are considered together to recommend control strategies for specific areas. IPI values below 15 indicate no risk of disease according to historical data from Emilia-Romagna. An IPI above 15 shows high disease risk and is used to determine when fungicides should start being sprayed, but the model does not give any recommendations about further treatments. Model developers recommend adjustment of threshold for specific locations. For model validation see: Cavanni, Ponti & Marinelli (1990) and Ponti *et al*., (1985). Model implementation: tomato growers in Emilia Romagna achieved a 50% reduction in fungicide sprays by following the model recommendations. To provide correct recommendations, the model, which is driven by weather data, should be combined with data from unsprayed tomato plots and sporangia traps.

- **Provisional model MISP:** Model MISP was set up by the Research Station for Agroecology and Agriculture in Zurig. Aim of the model is to identify the epidemic development moments of potato late blight. The model identifies as favourable day for a disease infection event a period of 24 hours with at least 6 rain hours, 6 consecutive hours with relative humidity >90% and mean temperature >10 C. The period of incubation is eventually calculated, using the method of Schrödter & Ullrich (1967), after which the first symptoms of late blight are expected. INPUT meteorological data required are the hourly temperatures (°C), relative humidity (%) and rainfall (mm). The OUTPUT is a date showing the theoretic infection day and hour, together with the end of the incubation period.

- **Fungicides:** Period *2003-2004 :* Average number of treatments = 1.5; average number of fungicides = 3 (Source ISTAT). Preventive agronomic practices do not allow total protection of crops in case of unfavourable climatic conditions. Protection strategies are hence required, mainly based the application of fungicides distributed in preventive treatments, to avoid late blight insurgence in the field. For first treatment and where available, it is recommended to rely on an early alert system based on provisional models. Knowledge about the real need for a crop treatment is one of the basic principles of the integrated potato production. Unfortunately, provisional models work only on a regional basis and they do not result always reliable, since they cannot perfectly adapt to local conditions. For these reasons it is important to carry out regular crop inspections to spot disease foci in the field. After the first treatment, a turn of 6-12 days may be adopted for the following ones depending on seasonal trends, chemicals persistence, varieties used and crop phytosanitary status. The fungicides available for P. infestans control may be distinguished in contact, cytotropic and systemic molecules. Contact product (es. copper salts, cyazofamide, dodine, famoxadone, fenamidone, fluazinam, mancozeb, zoxamide) remain active for max. 6-8 days; cytotropic (i.e. cimoxanil, dimetomorf) and systemic products (es. benalaxyl, fosetyl-Al, iprovalicarb, metalaxyl) may allow a longer protection. The use of the last group is limited because of the costs and the risk of favouring the development of P. infestans resistant strains. During initial phases of the cropping cycle products based on copper, fluazinam, famoxadone and mancozeb are preferred. During higher vegetative growth phases, systemic or cytotropic fungicides like metalaxyl, iprovalicarb or dimetomorph in association with copper are used. By the end of the crop cycle, before harvest, products based on molecules with a short retention time are used, like i. e. fluazinam, fenamidone, cyazofamide, zoxamide or some copper based formulates. In Italy fluazinam was registered and introduced for control of late blight. The use of famoxate and azoxystrobin increased, both on potato and tomato. In the Po Valley the first spray usually is carried out with metalaxyl or fluazinam when the plant canopies cover the row. Afterwards, the normal control strategy using cymoxanil and dimetomorph is applied. Overall, 5-8 sprays are carried out on potato and 6-10 on tomato to control the disease. Copper oxychloride is also used particularly at the end of the season. Average number sprays/season may range from 4-5 to 6-8 up to 8-10, depending on the season wetness.

The number of treatments and the product used are chosen based on variables like:

- the fenologic phase and the condition of crop development;
- climatic and meteorologic trends;
- farm surface;
- availability of spraying machines;
- properties of the fungicides (efficacy, toxicity, residues, cost, collateral activity against other pathogens etc.).

To preserve efficacy of available products, it is recommended to alternate fungicides with different modes of action.

Efficient strategy in combination with a reduced environmental impact of fungicides

There is agreement about the fact that in such a strategy all elements of IPM must be included, but a further improvement may derive from recent advances in GPS, IT and other technologies:

- **Prevention**: healthy seed, reduction of primary sources, use of resistant varieties, use of organic products for infective propagules suppression in soil.
- **Crop and agronomic measures**: N-fertilization, monitoring for early infection.
- **Development of regional DSS** based on weather, variety resistance, plant growth, fungicide characteristics, disease pressure with Information Technology applications for early farmers information programs, internet applications for on line modeling of local data, data retrieving through regional information processing and spread etc.
- **Fungicides**: fungicide choice, dose rates, environmental profile, research and development of biological antagonists.
- **Application technology**: development of more efficient spraying machines, application of GPS and Remote Sensing technologies to identify, monitor and treat foci of early disease insurgence in the field.

National programs to reduce Pesticide Impact
In Italy organic farming is steadily growing up to more than 1 million Ha invested with this practice, of which vegetables represent almost 10%. Consumers' demand of organic products increased, and the reduction of pesticides input concerns political as well as social actions. Organizations like AIAB (Associazione Italiana per l'Agricoltura Biologica) and others promote several actions at the political and research level.

5 Control strategies in The Netherlands

Importance of late and early blight: occurrence, damage
Late blight is the most important disease in potatoes. When fungicides are not used the crop (canopy & tubers) can be destroyed completely in less than 2 weeks. When fungicides are used it is estimated that in ware potatoes 1 year in 5 years on 10% of the acreage a 5% loss in yield is caused by less quantity and quality. In NL € 30 million is used for control of late blight in potatoes of a total turnover of agrochemicals of € 350 million
Early blight is an increasing problem. Alternaria usually attacks the crop later in the season and can shorten the growing season with several weeks resulting in lower yields. When potatoes are harvested under very dry conditions also tubers can be damages by Alternaria. Usually Alternaria is controlled by using late blight fungicides with a side-effect on Alternaria. Two specific Alternaria fungicides are now registered.

Size of potato area and fungicide input in The Netherlands

	Acreage (ha) 2005	**Yield (kg/ha) 2005**	**Costs fungicides (€/ha) 2005**	**Active ingredient (kg/ha)**	**Number sprays/ha**
Ware	65.829	50.400	384	10,93	14
Seed	39.262	34.645	389	10,20	8
Starch	50.692	54.024	309	14,04	14
Total	155.783	47.609	361	11,80	8-14

Best Practices (important control measures that could potentially contribute to a reduction of the environmental input).

- **Primary inoculum sources**: A number of measures to reduce the primary inoculum sources (seed, dumps, volunteers, oospores, early crops) are part of the control strategy (see detailed description Cooke et al., in press).

- **Resistant varieties**: field trials were carried out to estimate the infection efficiency and the minimum dose rate of fluazinam required to achieve protection of the 30 most important cultivars in the Netherlands. In 2007, recommendations based on these results have been published. These recommendations to reduce fungicide input in resistant cultivars are validated and demonstrated in 2007 on 7 locations to convince growers of their robustness. On www.eucablight.org a list is published with resistance levels of European varieties.

- **Fertilization:** use N according to recommendations. High levels of N could increase the susceptibility of the crop directly and could also indirectly influence the microclimatic conditions in the crop (higher RH).

- **Decision Support Systems**: Plant-Plus is developed and marketed by Dacom Plant Service BV (www.dacom.nl). The model supplies information about the optimum time to spray and the type of fungicide to use. A starting point in the model is provided by the protection offered to the crop by the previous spraying, in combination with the risk of disease infections occurring. In a clear presentation, the calculation is accounted for each step of the way, and presented by a graph and a report. With input of weather data like temperature, wind speed, rainfall and humidity combined with input of the grower on crop conditions, PLANT-Plus calculates when an infection event occurs. This result in a crop protection advice: when to apply a new spray and what type of chemical to use.
  ProPhy is developed and marketed by Opticrop (www.opticrop.nl). Local weather stations and regional weather forecasts are used to identify critical conditions for the development of blight. The duration of protection of the crop with fungicides is calculated. The duration of protection depends on the fungicide used, the dose rate, the variety resistance, the rain fastness of the fungicide, the disease pressure, and the growth of the crop. In combining weather and protection with fungicides a recommendation is calculated: a preventative spray is necessary as soon as critical conditions are expected in combination with an insufficient level of fungicide protection of the crop. The system provides the grower with a complete advice (yes/no spray, product choice and dose rate).
  It is estimated that of the approximately 10.000 potato growers in The Netherlands 30% (=3.000) uses the one of these DSS either with a PC-version or with information on fax, phone and internet. As a part of the Masterplan Phytophthora every grower/advisor in The Netherlands receives on his phone a message during the growing season when a critical period for late blight development is foreseen. In 2007 information about critical weather and blight infected fields is also provided on www.kennisakker.nl.

- **Fungicides**: Fungicides play a crucial role in the integrated control of late blight. In order to optimise the use of fungicides it is important to know the effectiveness and type of activity of the active ingredients to control blight. During the yearly workshops on integrated control of potato late blight, the fungicide characteristics of the most important fungicide active ingredients used for control of late blight in Europe are discussed and ratings are given. The ratings are based on the consensus of experience of scientists in countries present during the workshop (Table 1). The frequency and timing of fungicide applications should depend on the foliar resistance of the cultivar, fungicide characteristics, rate of growth of new foliage, weather conditions, irrigation and incidence of blight in the region. In the Netherlands the average number of sprays per season varies from 7 to 20 depending on the weather, disease pressure and crop (seed, ware, starch). To prevent the crop from being infected the best policy is to protect the crop whenever an infectious period occurs. The first sprays should start immediately after emergence of the crop, when weather circumstances are favorable for late blight. The most widely used protective product is fluazinam (Shirlan). By using Shirlan in a flexible way (interval, dose rate) effective control of leaf and tuber blight can be achieved during the complete growing season. Curzate M (mancozeb, cymoxanil) is the most widely used fungicide which combines a protectant (mancozeb) and a translaminar product (cymoxanil). It is mainly used in the first part of the growing season because of its good protective and curative properties. Shirlan and Curzate M are the products with the largest market share. The characteristics of the fungicides can be used to optimize their efficacy by combining their strong points with specific situations in the growing season concerning infection pressure and plant growth. When in the beginning of the growing season an early disease pressure (originating from infected tubers or oospores) coincides with a rapid crop growth, field trials have shown that products containing metalaxyl-M or cymoxanil result in a good control. In the second half of the growing season when conditions are critical for the occurrence of tuber blight, fluazinam and cyazofamid have been shown to control tuber blight very well. Different strategies, in which efficacy, costs and environmental side-effects are recorded, are tested on 7 regional farms situated in important potato growing regions in the Netherlands. During the growing season everything happening in these trials, including types of products used, timing and occurrence of late blight, can be followed on the internet (http://www.kennisakker.nl). The results of these trials are used in discussions with farmers and comparisons are made between the trial results and their spraying schedules regarding efficacy, costs and environmental side-effects.

- **Alternaria:** Control of Alternaria is only relevant in the second half of the growing season. Control can be achieved by using late blight fungicides with a side –effect on Alternaria such as mancozeb, Sereno or Unikat Pro. Since in the second half of the growing season also tuber blight is relevant products with a poor efficacy on tuber blight are not recommended (such as mancozeb). It is also possible to add a specific Alternaria product (Amistar, Signum) to a late blight fungicide. The site specific experiences determine which strategy is carried out.

Efficient strategy in combination with a reduced environmental impact of fungicides

In such a strategy all elements of IPM will have to include:

- Prevention: healthy seed, reduction of primary sources, use of resistant varieties
- Crop measures: N-fertlisation, scouting for earl infection
- DSS: integrate all relevant information such as weather, variety resistance, plant growth, fungicide characteristics, disease pressure
- Fungicides: fungicide choice, dose rates, environmental profile

- Application technology: drift reduction

National programs to reduce Pesticide Impact

The aim of the Umbrella Plan (financed by the Ministry of agriculture), which was launched in 2003, is to reduce the negative impact on the environment of the use of fungicides by 75% by 2012 using three strategies. First, to integrate all present and new research, and to focus all research on the aim of fungicide reduction. Second, to hand over the steering of all research to a board of representatives from the potato sector to ensure commitment to and application of the results of all short-term and long-term research. Third to combine the three parties – research, policy and potato sector – in one consortium to ensure that each party takes its responsibility for reaching the 2012 aim.

The reduction of input is measured by calculating the environmental impact using the environmental indicator for each individual fungicide. The environmental indicator is calculated by CLM (www.milieumeetlat.nl) using official registration data. The environmental points for fungicides registered in potatoes are presented on the Milieu-effect kaart 2007 Aardappelen. The institute LEI has monitored the environmental impact of fungicides used to control late blight in potato. They observed in relation to the reference period 1996-1998 a reduction of 97% of environmental impact per hectare in 2005. It is interesting to mention that compared to the reference period no reduction in kg active ingredient/ha or number of sprays is observed (Jager & Janssens, 2007)

6 Control strategies in Poland

Importance of late and early blight: occurrence, damage

Late blight is the important disease in potatoes. In Poland yield losses resulting from *P. infestans* infection are estimated in a range of 20-25% (Pietkiewicz 1989). In the years 1999–2003 the yield losses were higher and ranged from 22 to 57% (Kapsa 2004).

In the recent years earlier appearance of late blight on potato crops and an increase of infection pressure of *P. infestans* has been observed. The occurrence of *P. infestans* on potato plants at early plant growth stages points to possibility of existence of other infection sources such as infected seed tubers or volunteer plants and their increasing role in disease epidemiology. These changes have led to late blight epidemics developing earlier and more severely than previously and changes in the occurrence and development of first symptoms of *P. infestans* infection on potato plants.

In the years 1997–2006, field studies were conducted at the Plant Breeding and Acclimatization Institute of Bonin with the emphasis on comparison of time of the occurrence and incidence level of late blight of potato. Late blight occurred the earliest at Bonin in 2001 (42 days after planting), latest in 2006 (111 days after planting). The time of occurrence of late blight depends upon rainfall in May and June.

High humidity required for pathogen development needs to be correlated not only with appropriate temperature but the character of pathogen growth and host plants as well. The first LB infections developing on plant stems were found to be as stem late blight. This form of LB was recognized on 80.5% potato fields in 1997 and 29.4% in 2006 around Poland.

Early blight is an increasing problem in Poland. Observations carried out in the years 1998-2006, revealed that early blight occurrence on potato crop is common in most production areas. Inspections confirm early blight occurrence on 86,0% observed fields. Under Polish climatic conditions early blight occurs earlier than late blight on potato crops. In Poland, early blight occurs usually at the end of May or the beginning of June**.** Harmfulness of early blight is estimated differently depending from the year. In Polish climatic conditions there were recorded high regional losses caused by the early blight, however, most related to cultivars with recognized susceptibility to this disease. Based on Polish experience In field experiments crop losses due to early blight infection ranged from 6 to 45%.

Size of potato area and fungicide input in Poland

	Acreage (ths.ha) 2005 / 2006	**Yield (t/ha) 2005**	**Costs fungicides (€/ha) 2005**	**Active ingredient (kg/ha)**	**Number sprays/ha**
Ware	± 558,5 / 564,9				
Seed	4,7 / 5,3				
Starch	± 25,0 / 27,0	22.0-25.0			5-7
Total	588,2 / 597,2	17.6 / 15.0			2-17

Potato protection strategies against late blight in Poland

- The most often the first chemical treatment applied - when late blight symptoms are observed is in the region or in the potato field.
- **Simplified recommendations - referring to beginning of chemical control when plants meet between rows or in rows - the most popular.**
- Intensive protection based on phonological phases of a given crop that comprises routine fungicidal applications starting at evaluated risk of disease occurrence, sometimes when plants are 10-15 cm.
- Sustainable protection based on pathogen monitoring, forecasting the risk of LB appearance and decision support systems (NegFry, Dacom) – only in a few production farms.

Best Practices (important control measures that could potentially contribute to a reduction of the environmental input).

- **Primary inoculum sources**: A number of measures to reduce the primary inoculum sources (seed, dumps, volunteers, early crops) are part of the control strategy.

- **Resistance of varieties**: field trials are carried out to estimate resistance of new registered varieties for P. infestans infection and their reaction for fungicide protection (annually about 40 varieties). In 2008, recommendations based on these results will be published. The recommendations to reduce fungicide input in resistant cultivars were validated and demonstrated in experimental trials in the years 2001-2003 and presented on conference in Zakopane in 2007.

- **Fertilization**: use N according to recommendations for each variety.

- **Decision Support Systems:** wide education for farmers is implemented by research workers from IHAR Bonin (lectures, trainings, instructions, articles in popular agriculture journals).
  NegFry is developed in field experiments in a few agricultural institutes (IHAR – Bonin, IUNG – Pulawy, IOR – Poznań) and fields of Protection Services since 2001, after cooperation in project with DIAS. The model supplies information about the optimum time to spray and the type of fungicide to use. A starting date of the protection is accessible for all farmers on Internet (http://www.dss.iung.pulawy.pl), based on nearest synoptic weather station data and calculated by NegFry.

- **Fungicides:** Fungicides play a crucial role in the integrated control of late blight. In order to optimize the use of fungicides it is important to know the effectiveness and type of activity of the active ingredients to control blight. Each year efficacy of new fungicides and fungicide programs are assessed in field trials in 4 different localizations. The results of these trials are used in discussions with farmers and comparisons are made between the trial results and their spraying schedules regarding efficacy, costs and environmental side-effects.

- **Alternaria**: Control of Alternaria is only relevant in the beginning of the growing season. Control can be achieved by using late blight fungicides with a side – effect on Alternaria look for tab.). In that way we control both: early and late blight. It is not possible to advise farmers to control early blight only in Polish farmer mentality with specific Alternaria products.

Efficient strategy in combination with a reduced environmental impact of fungicides

In such a strategy all elements of IPM will have to include:

- Prevention: healthy seed, reduction of primary sources, use of resistant varieties
- Crop measures: N-fertilization, scouting for earl infection
- DSS: integrate all relevant information such as weather, variety resistance, plant growth, fungicide characteristics, disease pressure
- Fungicides: fungicide choice, dose rates, environmental profile
- Application technology: drift reduction

National programs to reduce Pesticide Impact

At present no national plan to reduce the impact of pesticides exists in Poland.

7 Fungicides registered for control late and early blight

Fungicides registered (October 2007) for **late blight** and highest label dose rate (NR = not registered, RNM = registered but not on market)

Products	NL	DK	I	PL	F
benthiavalicarb + **mancozeb**	Valbon 2 kg/ha	NR	NR	Valbon 72 WG - 1,6 kg/ha	NR
chlorothalonil	Daconil 3,5 l/ha	NR	NR	Bravo 500 SC, Clortosip 500 SC - 3,0 l/ha	Daconil Fix 2l/ha Dorimat 3l/ha
chlorothalonil + Zn	NR	NR	NR	Bravo Plus 500 SC, Gwarant 500 SC – 3,0 l/ha	NR
copper	NR	NR	FLOWBRIX 2,5-3 l/ha	Mag 50 WP – 2,5 kg/ha Cuproxat 345 SC -5.0 l/ha, Champion 50 WP -3,0 kg/ha, Cuproflow 375 SC -3,5 l/ha Nordox 75 WG – 1,0 kg/ha	Copper 5 kg/ha
cyazofamid	Ranman 0,2 l/ha	Ranman 0,2 l/ha	Ranman 0,2 l/ha	NR	Ranman 0.2 l/ha
maneb	Maneb 2,0 kg/ha		NR	NR	Maneb 2,0 kg/ha
mancozeb	Mancozeb 2,25 kg/ha	Dithane NT, Tridex 2,0 kg/ha	NR	Dithane Neo Tec 75 WG, Manconex 80 WP, Sancozeb 80 WP, Pennfluid 420 SC – 3,0 kg,l /ha Indofil 80 WP - 2,0 kg/ha	Mancozeb 1,6 kg ai/ha
metiram	Aviso DF 3,0 kg/ha	NR	NR	Polyram 70 WG 1,8 kg/ha	NR
propineb	NR	NR	NR	Antracol 70 WG -1,8 kg/ha	NR
captan	NR	NR	NR	Merpan 50 WP – 3,5 kg/ha	NR
folpet - N	NR	NR	NR	Folpan 80 WG – 2,0 kg/ha	NR
famoxadone+**cymox**	Tanos 0,6 kg/ha	NR	NR	Tanos 50 WG - 0,7 kg/ha	*Equation Pro*

anil					*0.4 kg/ha*
fluazinam	Shirlan 0,4 l/ha	Shirlan 0,4 l/ha	Shirlan 0,3-0,4 l/ha	Altima 500 SC - 0,4 l/ha	*Shirlan 0,4 l/ha*
zoxamide + **mancozeb**	Unikat 1,8 kg/ha	Electis 1,8 kg/ha	NR	Unikat 75 WG - 2,0 kg/ha	*Adério 1.8 kg/ha*
cymoxanil solo	Curzate 60 DF 0,2 kg/ha	NR	400 g/ha	NR	*NR*
cymoxanil+ **mancozeb, metiram** or **copper**	Curzate M 2,5 kg/ha Aviso DF 3,0 kg/ha	NR	NR	Curzate M 72,5 WP, WG, Ekonom MC 72,5 WP, Helm Cymi 72,5 WP, Toska 72,5 WP – 2,0 kg/ha Curzate Cu 49,5 WP - 3,0 kg/ha	*Rémiltine pépite 2.5 kg/ha*
dimethomorph + **mancozeb**	Acrobat 2,0 kg/ha	Acrobat 2,0 kg/ha	NR	Acrobat MZ 69 WG - 2,0 kg/ha	*Acrobat M DG 2.0 kg/ha*
fenamidone + **mancozeb**	Sereno 1,5 kg/ha	Sereno 1,5 kg/ha	Sereno 1,5 kg/ha	Pyton 60 WG - 1,25 kg/ha	*Séréno 1.25 kg/ha*
benalaxyl + **mancozeb** [3]	NR	NR	2,5 kg/ha	Galben M 73 WG - 2,0 kg/ha	*Trecatol 2.5 kg/ha*
metalaxyl-M + **mancozeb** or **fluazinam** [3]	Fubol Gold 2,5 kg/ha	Ridomil Gold 68 MZ 2,0 k/ha (only one application after G.S. 60)	2,5 kg/ha	Ridomil Gold MZ 68 WG – 2,5 kg/ha	Eperon pépite 2.5 kg/ha Epok 0.4 l/ha
propamocarb-HCl solo	NR	NR	NR	Spinaker 607 SL – 3,0 l/ha	*NR*
propamocarb-HCl+**fluopicolide**	Infinito 1,6 l/ha	NR	NR	Infinito 687,5 SC - 1,6 l/ha	*NR*
propamocarb-HCl + **mancozeb** or +**chlorothalonil**	Tattoo C 2,7 l/ha	Tattoo M(with mancoceb) 4,0 l/ha	NR	Tattoo C 750 SC – 2,5 l/ha	Tattoo C 2.7 l/ha
propamocarb-HCl+ fenamidone	RNM	Tyfon 2,0 l/ha	NR	Pyton Consento 450 SC – 2,0 l/ha	NR

Fungicides registered (October 2007) for **early blight** and highest label dose rate (NR =not registered for control of early blight)

Products	**NL**	**DK**	**I**	**PL**	**F**
mancozeb	NR	NR	NR		Mancozeb 1.6 kg a.i./ha
zoxamide+**mancozeb**	NR	NR	NR		Adério 1.8 kg/ha
chlorothalonil	NR	NR	ORTOFLO 3 l/Ha		NR
copper sulfate	NR	NR	BIORAM FLO 350 ml/hl		NR
azoxystrobin	Amistar 0,25 l/ha	Amistar 0,25 l/ha	NR		NR
pyraclostrobin + boscalid	Signum 0,2 kg/ha	NR	NR		NR

8 The most important seed, ware and starch varieties

Area of the 5-10 most grown potato varieties (ware, seed, starch) and their resistance level to blight (foliage, tuber)

Ware potatoes (between brackets resistance in canopy and tubers respectively as mentioned in the National Variety lists)

	NL (2006)	F (2006)	DK (2007)	PL (2004)	Italy
1	Bintje (3, 4½) >7000 ha	Bintje (3,3)	Sava (4½,8) 4.500 ha	Vineta (2, 4)	Junior, Konsul, Carrera, Imola, Kuroda, Cosmos, Escort - Emilia Romagna, 7018 Ha
2	Agria (5½, 7½) 5000-6000 ha	Charlotte (6,6)	Saturna (4½, 6½) 3000 ha	Satina (3, 5)	Alcmaria, Arielle, Berber, Inova, Konsul (Reg. Campania)
3	Fontane (4½, 6½) 4000 - 5000 ha	Monalisa (6,5)	Ditta (5½, 7) 1.500 ha	Denar (3, 4)	
4	Innovator (8,7) 3500 ha	Agata (4,8)	Folva (3½, 4) 1500 ha	Lord (3, 4)	
5	Lady Olympia (3, 5) 3000-3750 ha	Amandine (4,4)	Bintje (2½, 2½) 1000 ha	Irga (2, 4)	
6	Premiere (2½, 5) 2500-3000 ha	Caesar (5,8)		Velox (2, 3)	
7	Ramos (3½, 7) 2900 ha	Marabel (-,-)		Bryza (4, 4)	
8	Asterix (5, 8½) 2300 ha	Nicola (4,6)		Sante (4, 4)	
9		Saturna (5,7)			

Seed potatoes

	NL (2006)	F (2006)	DK (2007)	PL (2006)
1	Spunta (5, 4½) 4817 ha	Bintje (3,3) 1398 ha	Spunta 701 ha	Vineta (2, 4) 559,9 ha
2	Bintje (3, 4½) 2802 ha	Spunta (5,5) 1079 ha	Kennebec (6½, 6½) 448 ha	Satina (3, 5) 325,3 ha
3	Seresta (7, 8) 2687 ha	Charlotte (6,6) 825ha	Sava (4½, 8) 426 ha	Innovator (3, 4) 293,3 ha
4	Agria (5½, 7½) 1984 ha	Kaptah-V (5,7) 710ha	Saturna (4½, 6½) 380 ha	Pasat (5, 4½) 286,4 ha
5	Desiree (5,7½) 1743 ha	Monalisa (6,5) 535 ha	Kuras (8, 7½) 304 ha	Saturna (3, 4½) 186,6 ha
6	Kondor (4½, 7½) 984 ha	Agata (4,8) 458 ha	Folva (3½, 4) 205 ha	Rumpel (5, 5) 165,3 ha
7	Agata (4, ?) 939 ha	Amyla (5,-) 437 ha	Bintje (2½, 2½) 177 ha	Jasia (6, 4) 154,6 ha
8	MonaLisa (4,6) 855 ha	Amandine (4,4) 404 ha	Oleva (4½, 8) 177 ha	Ikar (5½, 4) 117,3 ha

Starch potatoes

	NL (2005)	F (2006)	DK (2007)	PL (2006)
1	Seresta (7, 8) 23220 ha	Kaptah-V (5,7)	Kuras (8, 7½) 9.000 ha	Pasat (5, 4½)
2	Mercator (8,7½) 5358 ha	Amyla (5,-)	Kardal (7½, 7½) 4.000 ha	Rumpel (5, 5)
3	Festien (8,9) 2679 ha	Kardal (8,-)	Oleva (4½, 8) 2.000 ha	Jasia (6, 4)
4	Katinka (6½,9) 2223 ha	Elkana (5,-)		Ikar (5½, 4)
5	Karnico (8,6½) 1786 ha	Producent (-,-)		Dorota (3, 4)
6		Epona (4,4)		Monsun (5, 5)
7		Hinga (8,3)		Umiak (6½, 4.5)
8		Fausta (-,-)		
9		Centaure (5,-)		

9 Discussion & recommendations

The state of the art of late & early blight control strategies was surveyed in Denmark, France, Italy, The Netherlands and Poland. In this survey information was used from the European network of integrated control (www.euroblight.net). 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. The extent in which these different elements are used in practice is different for the countries studied. The use of resistant varieties in Poland is a much more important part of the strategy compared to the other countries. In The Netherlands a lot of emphasis has been laid on the prevention of primary inoculum sources in the Masterplan Phytophthora. Also the way in which the environmental impact of the fungicide input is measured is different.

In the end report of the Potato case “Analysis of the integrated control strategies” the importance of all Best practices will be analysed and their contribution to a reduction of the environmental impact of fungicides will be discussed. In that report also recommendations will be given for the use of Best Practices in other European potato growing regions.

10 References

10.1 Denmark

10.1.1 Websites

www.planteinfo.dk
www.lr.dk
www.euroblight.net
www.Eucablight.org

10.1.2 Papers/brochures (in Danish)

Bødker, L. 2007. Skimmelbekæmpelse i kartofler nær rækkelukning, PlanteNyt nr.: 399 – 2007

Bødker, L. 2007. Oversigt over Landsforsøgene, kartofler. Dansk Landbrugsrådgivning, Landscentret s. 305-319

Anon, 2007. Forebyg mod kartoffelskimmel nu! KartoffelNyt nr. 9

Jens Grønbech Hansen, Bent J. Nielsen og Hans Hansen (2007) Status vedrørende beslutningsstøtte for skimmelbekæmpelse. Plantekongres 2007. Dansk Landbrugsrådgivning og Danmarks JordbrugsForskning, 333-334.

Hansen, J.G., Thysen, I., Nielsen, B.J., Bødker, L. & Hansen, H.H., 2003. Udvikling af Skimmelstyring for bekæmpelse af kartoffelskimmel. 20. Danske Planteværnskonference. Korn, kartofler, skadedyr, miljø og postere. DJF rapport 89. P. 7-24.

Hansen, J.G., 2003. Hvornår er det skimmelvejr? Følg med i under hvilke vejrforhold der er størst risiko for vækst i skimmel i kartofler. Kartoffelnyt 49, 3 pp. http://www.kartoffelafgiftsfonden.dk/Kartoffelnyt/2003Nr2/Kartoffelnyt_frame49.htm 2003 F

Nielsen, B. J. 2004. Bekæmpelse af kartoffelskimmel (*Phytophthora infestans*). Pesticidafprøvning 2004. Landbrugsafgrøder. Danmarks JordbrugsForskning Rapport, Markbrug, nr. 112, 95-107.

Nielsen, B. J. 2005. Bekæmpelse af kartoffelskimmel (*Phytophthora infestans*). Pesticidafprøvning 2005. Landbrugsafgrøder. Danmarks JordbrugsForskning Rapport, Markbrug, nr. 118, 77-91

Nielsen, B. J. 2006. Bekæmpelse af kartoffelskimmel (*Phytophthora infestans*) og kartoffelkbladplet (*Alternaria solani* & *A. alternata*). Pesticidafprøvning 2006. Landbrugsafgrøder. Danmarks JordbrugsForskning Rapport, Markbrug, nr. 129, 73-8

10.1.3 Papers/brochures (in English)

L. R. Cooke, H.T.A.M. Schepers, A. Hermansen, R.A. Bain, N.J. Bradshaw, D.S. Shaw,
Evenhuis, G.J.T. Kessel, J.G.N. Wander, B. Andersson, J.G. Hansen, A. Hannukkala, R Nærstad, B.J.Nielsen. Epidemiology and integrated control of potato late blight in Europe. Chapter in Book “Potato disease management” (in press) (Word-version available)

Jensen, Allan Leck ; Boll, Peter Sandal ; Thysen, Iver ; Pathak, Bikash Kumar 2000. Pl@nteInfo - A webbased system for personalised decision support in crop management. Computers and Electronics in Agriculture. Vol. 25, 271-294

Hansen. J.G., Nielsen, B.J., Bødker, L., Andersson, B., Yuen, J., Wiik, L., Hermansen, A., Nærstad, R., Le, V.H., Brurberg, M.B., Hannukkala, A. & Lehtinen, A. 2006. Blight management in the Nordic countries. In: Schepers, H.T.A.M.& Westerdijk, C.E. (eds.): Proceedings of the Ninth Workshop on the European Network for Development of an Integrated Control Strategy of Potato Late Blight. Tallinn, Estonia, 19th – 23rd Oct. 2005. Applied Plant Research, AGV Research Unit, Wageningen, PPO-Special Report no 11, March 2006, 39-52.

Hansen, J.G., Lassen, P., Koppel, M., Valskyte, A., Turka, I. & Kapsa, J., 2003. Web-blight - regional late blight monitoring and variety resistance information on Internet. Journal of Plant Protection Research 43(3), 263-273.

Hansen, J. G. , Nielsen B., Bødker, L., Andersson B., Yuen, J., Wiik, L,. Hermansen, A., Nærstad, R. , Le, V.H., Brurberg, M.B. ,Hannukkala, A. & Lehtinen, A. 2005a. Studies on the new Nordic population of Phytophthora infestans to improve late blight forecasting and control. EAPR, Bilbao 15-22 July 2005.

Hansen, J.G., Andersson, B.,, Yuen, J. 2005b. Late blight modelling within the NorPhyt project. 9th International Workshop on Plant Disease Epidemiology. Plant Disease Epidemiology : Facing 21st Century Challenges. Rennes, France (Poster)

Jensen, PK 2008. Influence of volume rate and nozzle angling on control of potato late blight with flat fan, pre-orifice and air induction nozzles. Aspects of Applied Biology, International Advances in Pesticide Application 2008, pp-pp.

Jensen, PK & Nielsen BJ 2008. Potato late blight control using Hardi Twin air-assistance or Danfoil Airsprayer. Aspects of Applied Biology, International Advances in Pesticide Application 2008, pp-pp.

Nielsen B. J. 2004. Control strategies against potato late blight using weekly model with fixed intervals but adjusted fungicide dose. Proceedings of the eight workshop of an European network for the development of an integrated control strategy of potato late blight. Jersey, 31 March– 4 April 2004. H.T.A.M. Schepers and C.E. Westerdijk, editors. PPO-Special Report no. 10 (2004), 233-235.

10.2 France

(no references provided)

10.3 Italy

10.3.1 Websites

http://www.ermesagricoltura.it/wcm/ermesagricoltura/fitosanitario/avversita/peronospora_patata_pomodoro/pag_modelli_ipi_misp.htm

http://www.ipm.ucdavis.edu/DISEASE/DATABASE/tomatolateblight.html

http://vegdis.cas.psu.edu/03Diseases/D107.html

http://www.fao.org/ag/Agp/agpc/doc/services/pbn/pbn-160.htm

http://www.actahort.org/books/695/695_46.htm

http://www.potato2008.org/en/events/index.html

http://www.ce-pa.it/

http://www.imof.na.cnr.it/promipa/mipa99.html

http://www.unapa.it/portale/costnazionale.asp

http://www.ministerosalute.it/alimenti/sicurezza/sicApprofondimento.jsp?lang=italiano&label=pro&id=378

http://www.patataprimaticcia.it/wcms/

10.3.2. Papers/brochures (in Italian)

Ponti I., Cavanni P., Mazzini F. & Libè A. (1985). Verifica di criteri previsionali per la peronospora del pomodoro. Informatore Fitopatologico 35 (3), 13-21.

Cavanni P., Ponti I. & M.Marinelli (1990). Modello previsionale per la peronospora del pomodoro". Informatore Fitopatologico 40 (6), 17-25.

Bugiani R., Govoni P., & Cavanni P. (1995). Peronospora del pomodoro: Il sistema integrato di previsione utilizzato in Emilia Romagna" - Atti del convegno "Moderni Indirizzi nella Protezione del Pomodoro dalle Malattie". Rome, 11-13/9/1995; PETRIA Vol.5, Suppl.1, 18-19 .

Bugiani R., Govoni P., & Cobelli, L. (1999). Esperienze nell´utilizzo del modello previsionale IPI per la peronospora della patata e del pomodoro in Emilia-Romagna. Frustula Entomologica, Spec. num. XXII (XXXV).

10.3.3. Papers/brochures (in English)

Bugiani R., Cavanni P., & Ponti, I. 1993. An advisory service for the occurrence of

Phytophthora infestans on tomato in Emilia-Romagna region. Bulletin OEPP/EPPO 23: 607-613.

Govoni P. & Bugiani R. (1993). Further evaluation of the Advisory Service for the prediction of tomato late blight occurrence in Emilia Romagna region in 1993. Proceedings of the Workshop on Computer-based DSS on Crop Protection, Parma, Italy, 23-26 Novembre 1993. SP-Report, Danish Inst. *Plant and Soil Sci*., 7, 163-171 .

Bugiani R., Govoni P. & Cobelli L. (1996). Comparison of different prediction criteria for the first ocurrence of potato late blight in northern Italy. Proceedings of the 1st Workshop on the European network for development of an integrated control strategy of potato late blight - Lelystad, The Netherland 30 September - 3 October 1996; Erno Bouma & Huub Schepers (eds.), Special PAV - Report 1 69-78 .

Bugiani R., Govoni P. & Cobelli L. (1997). First large scale application of I.P.I. model for potato late blight prediction in the Po Valley. Proceedings of the 2nd Workshop on the European network for development of an integrated control strategy of potato late blight - Carlow, Ireland 24 September - 27 September 1997. Erno Bouma & Huub Schepers (eds.), PAV - Spec. Rep. 3, 188-199 .

Bugiani R., Cobelli L. & Govoni, P. (1999) . Possibility of a combined use of IPI and MISP forecasting models for late blight warnings. Proceedings of the 3rd Workshop on the European network for development of an integrated control strategy of potato late blight - Uppsala, Sweden, 9-13 September 1998; Erno Bouma & Huub Schepers (eds.), PAV - Special Report 5 258-270 .

Camele, I., Marcone, C. & Rana, G.L. (2005). Detection and characterization of *phytophthora* species infecting tomato in southern italy by dna-based methods. Acta Horticulturae (ISHS) 695, 373-378.

Storti E, Pelucchini D, Tegli S, Scala A, 1988. A potential defense mechanism of Tomato against the late blight disease is suppressed by germinating sporangia-derived substances from *Phytophthora infestans*. *Journal of Phytopathology*, 121: 275-282.

10.4 The Netherlands

10.4.1 Websites

www.dacom.nl
www.opticrop.nl
www.kennisakker.nl
www.euroblight.net
www.milieumeetlat.nl
www.eucablight.org

10.4.2 Papers/brochures (in Dutch)

Jaarrond bestrijdingsstrategie 2007. Nieuwsbrief Masterplan Phytophthora april 2007 (PDF available)

Phytophthora: de aardappelziekte. Brochure Masterplan Phytophthora, mei 2002 (only paper version available)

Sterke eigenschappen middelen goed benutten. Boerderij 2 maart 2004, p. 10-11 (PDF available)

De aardappelziekte, overzichtsartikel op www.kennisakker.nl (HTML-version available)

Milieu effect kaart 2007 aardappelen (PDF available)

Jager, J.H. & S.R.M. Janssens. Monitoring (Environmental impact) Masterplan Phytophthora. Project report January 2007 (Word-version available).

10.4.3 Papers/brochures (in English)

L. R. Cooke, H.T.A.M. Schepers, A. Hermansen, R.A. Bain, N.J. Bradshaw, D.S. Shaw,
A. Evenhuis, G.J.T. Kessel, J.G.N. Wander, B. Andersson, J.G. Hansen, A. Hannukkala, R Nærstad, B.J.Nielsen. Epidemiology and integrated control of potato late blight in Europe. Chapter in Book "Potato disease management" (in press) (Word-version available)

Effectiveness of fungicides products. Bologna 2007 (PDF available)

Schepers, H.T.A.M. & W. Nugteren. Prophy: a computerised expertsystem for control of late blight in potatoes in The Netherlands. Abstracts XIII International Plant Protection Congress, 2-7 July 1995, p.948.

Schepers, H.T.A.M. & M.A.T. van Soesbergen, Factors affecting the occurrence and control of tuber blight. In: Phytophthora 150, L.J. Dowley, E. Bannon, L.R. Cooke, T. Keane & E.O'Sullivan (eds). Proceedings of EAPR Pathology Section Conference, Dublin 1995: 171-176.

Bus, C.B., Ridder, J.K. & H.T.A.M. Schepers. Experimenting with lower doses of fungicides to prevent late blight in potato cultivars of different susceptibility in The Netherlands. In: Phytophthora 150, L.J. Dowley, E. Bannon, L.R. Cooke, T. Keane & E.O'Sullivan (eds). Proceedings of EAPR Pathology Section Conference, Dublin 1995: 351-356.

Ridder, J.K., Bus, C.B. & H.T.A.M. Schepers.Experimenting with a decision support system against late blight in potatoes (Prophy) in The Netherlands. In: Phytophthora 150, L.J. Dowley, E. Bannon, L.R. Cooke, T. Keane & E.O'Sullivan (eds). Proceedings of EAPR Pathology Section Conference, Dublin 1995: 214-219.

Schepers, H.T.A.M., Rainfastness of fungicides used to control Phytophthora infestans (abstract poster), In: Phytophthora 150, L.J. Dowley, E. Bannon, L.R. Cooke, T. Keane & E.O'Sullivan (eds). Proceedings of EAPR Pathology Section Conference, Dublin 1995: 374-375.

Schepers, H.T.A.M. Influence of simulated rain on the biological effect of fluazinam and maneb/fentinacetate on *Phytophthora infestans* in potato. Abstracts of conference papers, posters and demonstrations. 13th Triennial Conference of the EAPR 1996, p. 460-461.

Schepers, H.T.A.M., E. Bouma & C.B. Bus. State of the art of *Phytophthora infestans* control in Europe. Proceedings of the Workshop on the European network for development of an integrated control strategy of potato late blight. PAV-Special Report no. 1 January 1997: p. 7- 11.

Schepers, H.T.A.M., E. Bouma, C.B. Bus & J.K. Ridder. Recent experiences with control of *Phytophthora infestans* in the Netherlands. Proceedings of the Workshop on the European network for development of an integrated control strategy of potato late blight. PAV-Special Report no. 1 January 1997: p. 44-51.

Schepers, H.T.A.M. Effect of rain on efficacy of fungicide deposits on potato against *Phytophthora infestans*. Potato Research 39 (1996): 541-550.

Evenhuis, A., H.T.A.M. Schepers, C.B. Bus & W. Stegeman. Synergy of cymoxanil and mancozeb when used to control potato late blight. Potato Research 39 (1996): 551-559.

Genet, J.L., H. Schepers, R.J. Power & R.A. Hamlen. Curzate M action in controlling *Phytophthora infestans* . Phytopathology 86, No. 11 (Supplement), 1996: p. S31 (abstract).

H.T.A.M. Schepers & E. Bouma. The Multi-Year Crop Protection Plan in The Netherlands: fungicides to control late blight in potatoes. Proceedings of the First Transnational Conference on biological, integrated and supervised controls, 21-23 January 1998, Lille, p. 57-58.

Schepers, H.T.A.M. The development and control of *Phytophthora infestans* in Europe in 1997. Proceedings of the Workshop on the European network for development of an integrated control strategy of potato blight, Carlow 1997, PAV-Special Report no. 3, January 1998: 7-10.

Schepers, H.T.A.M. Report of the discussions of the subgroup potato late blight fungicides. Proceedings of the Workshop on the European network for development of an integrated control strategy of potato blight, Carlow 1997, PAV-Special Report no. 3, January 1998: 15-22.

Schepers, H.T.A.M. Epidemiological parameters in decision support systems for *Phytophthora infestans*. Proceedings of the Workshop on the European network for development of an integrated control strategy of potato blight, Carlow 1997, PAV-Special Report no. 3, January 1998: 30-36.

Evenhuis, A., Schepers, H.T.A.M., Bus, C.B. & W.L.M. Stegeman. Rainfastness of mancozeb and Curzate M on potato leaves. Proceedings of the Workshop on the European network for development of an integrated control strategy of potato blight, Carlow 1997, PAV-Special Report no. 3, January 1998: 218-225.

H.T.A.M. Schepers & E. Bouma. The concerted action entitled “European network for development of an integrated control strategy of potato late blight”. Proceedings of 1er colloque transnational sur les luttes biologique, integree et raisonnee, 21-23 Janvier 1998, Lille, p. 311-315.

H.T.A.M. Schepers, The European Network for Development of an Integrated Control Strategy of Potato Late Blight. GILB Conference: Late blight; a threat to global food security, 16-19 Maart, Quito, Ecuador. Poster Abstracts p. 23.

H.T.A.M. Schepers. The development and control of P. infestans in Europe in 1998. Proceedings of the Workshop on the European network for development of an integrated control strategy of potato late blight, Uppsala, Sweden, 9-13 september 1998. p. 10-16.

H.T.A.M. Schepers. Compilation of questionnaires on practical characteristics of fungicides to control potato late blight. Proceedings of the Workshop on the European network for development of an integrated control strategy of potato late blight, Uppsala, Sweden, 9-13 september 1998. p. 60-65.

Schepers, H.T.A.M. Decision Support Systems for control of late blight in potato in Europe: their history, achievements and possibilities. Proceedings of the Global Initiative on Late Blight Conference, March 16-19, 1999, Quito, Ecuador, p. 82-83.

Schepers, H.T.A.M. The European Network for development of an Integrated Control Strategy of Potato Late Blight. Proceedings of the Global Initiative on Late Blight Conference, March 16-19, 1999, Quito, Ecuador, p. 131 (poster abstract).

Schepers, H.T.A.M. The development and control of *Phytophthora infestans* in Europe in 1999. Proceedings of the Workshop for development of an integrated control strategy of potato late blight, 29 September- 2 October 1999, Oostende, Belgium. PAV-Special Report no. 6, February 2000, p. 10-18.

Schepers, H.T.A.M, J. Dogterom & J.P. Kloos. The Masterplan Phytophthora: a nationwide approach to late blight. Proceedings of the Workshop for development of an integrated control strategy of potato late blight, 29 September- 2 October 1999, Oostende, Belgium. PAV-Special Report no. 6, February 2000, p. 131-136.

Kessel, G.J.T., L.J. Turkensteen, H.T.A.M. Schepers & W.G. Flier. Quantification of oospores in leaf tissues from a field survey in The Netherlands. Abstracts of presented papers at the Nordic-Baltic seminar Bäckaskog, Sweden, 3-6 October 2000.

H.T.A.M. Schepers. Persistence of the protectant efficacy of potato late blight fungicides. Med. Fac. Landbouww. Univ. Gent, 65/2b, 2000, p. 789-798.

H.T.A.M. Schepers. The development and control of Phytophthora infestans in Europe in 2000. PAV-Special Report no. 7, february 2001, p. 9-18.

N.J. Bradshaw & H.T.A.M. Schepers. Experiences with RH-117281 (zoxamide) – a new fungicide for control of potato blight. PAV-Special Report no. 7, february 2001, p. 173-184.

H.G. Spits & H.T.A.M. Schepers. Efficacy of fungicides against Phytophthora infestans on a developing growing point of potato plants. PAV-Special Report no. 7, february 2001, p. 255-260.

H.T.A.M. Schepers & R. Meier. Effect of an organosilicone adjuvant on the biological efficacy of fungicides applied with low-drift air induction nozzles in potato and onion. Proceedings of International Symposium on Adjuvants for Agrochemicals ISAA 2001 (editor H. de Ruiter), 13-17 August 2001, Amsterdam: p. 245-250.

H.T.A.M. Schepers. The development and control of *P. infestans* in Europe in 2001. Proceedings of 6th potato late blight workshop, Edinburgh 26-30 September 2001. PPO-Special Report No. 8 (PPO 304), April 2002, p. 9-20.

G.J.T. Kessel, L.J. Turkensteen, H.T.A.M. Schepers, P.J. van Bekkum & W.G. Flier. *P. infestans* oospores in The Netherlands: occurrence and effects of cultivars and fungicides. Proceedings of 6th potato late blight workshop, Edinburgh 26-30 September 2001. PPO-Special Report No. 8 (PPO 304), April 2002, p. 203-209.

H.G. Spits & H.T.A.M. Schepers. Protection of new growth against *P. infestans* in fungicide schedules with spray intervals of 4 and 7 days. . Proceedings of 6th potato late blight workshop, Edinburgh 26-30 September 2001. PPO-Special Report No. 8 (PPO 304), April 2002, p. 217-223.

G.J.T. Kessel, L.J. Turkensteen, H.T.A.M. Schepers, P.J. van Bekkum & W.G. Flier. *P. infestans* oospores in The Netherlands: occurrence and effects of cultivars and fungicides. Abstract of papers and posters 15th Triennial Conference of the EAPR, Hamburg, 14-19 July 2002.

H.T.A.M. Schepers. Potato late blight IPM in the industrialized countries. Abstracts of papers and posters GILB'02 Conference: late blight: managing the global threat. Hamburg, 11-13 July 2002.

Schepers, H.T.A.M. Avances en Sistemas de Apoyo para la Toma de Decisiones en el Control de *P. infestans* en Europa. Memorias del Taller Internacional Complementando la Resistencia al Tizon (*P. infestans*) en los Andes, Febrero 13-16, 2001, Cochabamba, Bolivia, p. 145-150.

Schepers, H.T.A.M. La Red Europea para el Manejo Integrado del Tizon Tardio. Memorias del Taller Internacional Complementando la Resistencia al Tizon (*P. infestans*) en los Andes, Febrero 13-16, 2001, Cochabamba, Bolivia, p. 163-168.

Schepers, H.T.A.M. Potato late blight IPM in the industrialized countries. Proceedings of the Global Initiative on Late Blight Conference, Hamburg, Germany, 11-13 July 2002: p. 89-92.

10.5 Poland

10.5.1 Websites

http://www.dss.iung.pulawy.pl
www.euroblight.net
www.eucablight.org

10.5.2 Papers/brochures (in English)

Kapsa J. 2002. Varietal resistance of potatoes to late blight and chemical protection strategy. J. Plant Prot.Res. Vol.42, No.2: 101-107.

Hansen J.G., Lassen P., Koppel M., Valskyte A., Turka I., Kapsa J. 2003. Web-Blight - regional late blight monitoring and variety resistance information on Internet. J. Plant Prot.Res. Vol.43, No 3: 263-273.

Kapsa J. 2003. Usefulness of fungicides with various modes of actions in the protection of potato crops. J. Plant Prot.Res. Vol. 43, No 2: 191-198.

Kapsa J., Osowski J., Bernat E. 2003. NegFry – decision support system for late blight control in potato crops – results of validation trials in north Poland. J. Plant Prot.Res. Vol.43, No 2: 171-179.

Kapsa J., Hansen J.G. 2004. Establishment of a monitoring network for potato late blight (Phytophthora infestans) in Poland. Plant Breed. Seed Sci. 50: 63-70.

Kapsa J., Osowski J. 2004. Occurrence of early blight (Alternaria ssp.) at potato crops and results of its chemical control in Polish experiences. Special Report no.10 (2004) Proc.8th Workshop of an European network for development of an integrated control strategy of potato late blight. Jersey, England-France,31st March-4th April 2004. Eds. C.E.Westerdijk & H.T.A.M. Schepers, Applied Plant Research Wageningen: 101-107

Hansen J.G., Koppel M., Valskyte A., Turka I., Kapsa J. 2005. Evaluation of foliar resistance in potato to Phytophthora infestans based on an international field trial netrwork. Plant Pathology 54: 169-179.

Kapsa J. 2007. Effect of climatic conditions on infection pressure of Phytophthora infestans and harmfulness of the pathogen to potato crops. J. Plant Prot.Res. - in print

10.5.3 Papers/Brochure (in Polish)

Kapsa J. 2000. Zaraza ziemniaka – stare i nowe problemy. IHAR Oddz.Bonin: 35s. 4 fot.

Kapsa J. 2001. Zaraza (*Phytophthora infestans* /Mont./ de Bary) występująca na łodygach ziemniaka. Monogr. i Rozpr. Nauk. 11. IHAR Radzików 108 pp., 30 tabl. kolor.

Kapsa J. 2002. Możliwości ograniczania dawek fungicydów przez dodatek Insolu 7 w ochronie plantacji ziemniaka przed *Phytophthora infestans* (Mont.) de Bary. Zeszyty Naukowe Akademii Rolniczej w Krakowie nr 387, seria Sesja Naukowa z.82: 75-79.

Kapsa J. 2002. Zastosowanie systemów decyzyjnych w ochronie plantacji ziemniaka przed zarazą. Progress Plant Protection – Postępy w Ochronie Roślin 42 (1): 317-323.

Kapsa J. 2004. Problem of early blight (*Alternaria* ssp.) at potato crops in Poland and results of chemical protection. J. Plant Prot.Res. 44 (3): 215-222.

Kapsa J. 2004. Zmiany stanu zagrożenia i ochrony plantacji ziemniaka przed zarazą (*P.infestans*) w Polsce na tle krajów europejskich. Prog. Plant Protection /Post. Ochr. Roślin/ 44: 129–137.

Kapsa J. 2004. Zmiany stanu zagrożenia i ochrony plantacji ziemniaka przed zarazą (*P.infestans*) w Polsce na tle krajów europejskich. Progress Plant Protection (Postępy w Ochronie Roślin) 44 (1): 129-137.

Kapsa J., Bernat E., Kasprzak M. 2005. Przydatność systemu decyzyjnego NegFry w ochronie ziemniaka przed zarazą w różnych warunkach meteorologicznych. Biul IHAR 237/238: 177-186

Kapsa J., Gawińska-Urbanowicz H. 2004. Możliwości monitorowania występowania pierwszych infekcji zarazy (*Phytophthora infestans*) w uprawach ziemniaka. Biul. IHAR 232: 307-313.

Kapsa J., Korbas M. 2006. Choroby ziemniaka i ich zwalczanie. (W:) Program ochrony ziemniaków na rok 2006. Wyd. Plantpress Kraków: 7-18 (całość 51).

Kapsa J., Kraska A. 2005. Ogólnopolski, internetowy system monitorowania występowania zarazy na plantacjach ziemniaka. Progress Plant Protection (Postępy w Ochronie Roślin) 45 (1): 218-226.

Kapsa J., Osowski J. 2002. Wprowadzanie i ocena systemu decyzyjnego NegFry w strategii przed zarazą ziemniaka w warunkach polskich. Biul. IHAR 223/224: 351-359.
Odmiany ziemniaka znajdujące się w rejestrze w Polsce w 2007 roku. Produkcja ziemniaka, ogólna charakterystyka doboru odmian i odporność odmian na choroby. Materiały szkoleniowe. IHAR Młochów 2007.

Pietkiewicz J.B. 1989. Zwalczanie zarazy ziemniaka. Instrukcja upowszechnieniowa 1/89. Instytut Ziemniaka, Bonin, 20 ss. + 15 tab.

Wolny S., Horoszkiewicz-Janka J., Sikora H., Kapsa J., Zaliwski A., Nieróbca A, Kozyra J., Domardzki K. 2004. Wyniki prac badawczych i adaptacyjnych nad polskim internetowym systemem wspomagania decyzji w ochronie roślin w 2003 roku. Progress Plant Protection (Postępy w Ochronie Roślin) 44 (1): 513-522.

Zaliwski A.S., Kozyra J. 2006 NegFry – system wspomagania decyzji w zwalczaniu zarazy ziemniaka. http://www.dss.iung.pulawy.pl/Documents/ior/negfry. HTML-version available .

Example of brochures in popular agriculture journals

Kapsa J. 2007. Quo vadis polski ziemniaku? Rolnik Dzierżawca 4: 88-91
Kapsa J. 2007. Poprawić wysokość plonu ziemniaka i jego zdrowotność. Agro Serwis 6 (357): 16.
Kapsa J. 2007. Jak pokonać zarazę. Agrotechnika 5: 22-27
Kapsa J. 2007. Zaraza ziemniaka nadal groźna ? Bayer Kurier
Kapsa J. 2007. Zaraza światowy problem. Farmer 11: 28-30
Kapsa J. 2007. Zaraza ziemniaka wciąż groźna. Nowoczesna Uprawa
Kapsa J. 2007. Zaraza na plantacjach ziemniaka nadal groźna. Agroserwis 11: 2-3.

10.5.4 Publications breeding potato

Zarzycka, H., R. Lebecka, S. Sobkowiak. 2001. The role of *Phytophthora infestans* oospores in primary infection of potato foliage in Poland. Plant Breeding and Seed Science 45: 65-76.

Zarzycka H., Sobkowiak S., Lebecka R. 2001. Zmiany w strukturze populacji *Phytophthora infestans* w Polsce i ich wpływ na stabilność odporności ziemniaka na tego patogena. Progress in Plant Protection - Postępy w Ochronie Roślin 41: 240-248.

Zarzycka H., S. Sobkowiak, R. Lebecka, B. Tatarowska, 2002: Kształtowanie się fenotypowej struktury populacji *Phytophthora infestans* w Polsce w ciągu 15-lecia 1987-2001. Acta Agrobotanica 55: 389-400.

Zimnoch-Guzowska, E., R. Lebecka, A. Kryszczuk, U. Maciejewska, A. Szczerbakowa, B. Wielgat 2003. Resistance to *Phytophthora infestans* in somatic hybrids of *Solanum nigrum* L. and diploid potato. Theor Appl Genet 107: 43-48.

Sobkowiak S., Zarzycka H., Lebecka R., Zimnoch-Guzowska E. 2004. Wpływ koncentracji inokulum i terminów oceny odporności na ekspresję agresywności i wirulencji *Phytophthora infestans* w stosunku do ziemniaka. Biuletyn IHAR 233: 317-331.

Śliwka, J., H. Jakuczun, R. Lebecka, W. Marczewski, C. Gebhardt, and · E. Zimnoch-Guzowska. 2006. The novel, major locus *Rpi-phu1* for late blight resistance maps to potato chromosome IX and is not correlated with long vegetation period. Theor Appl Genet 113:685–695.

Śliwka, J, S. Sobkowiak, R. Lebecka, J. Avendaño-Córcoles, and E. Zimnoch-Guzowska. 2006. Mating type, virulence, aggressiveness and metalaxyl resistance of isolates of *Phytophthora infestans* in Poland. Potato Res. 49: 155-166.

Lebecka, R., S. Sobkowiak, and E. Zimnoch-Guzowska. 2006. Resistance of potato tubers to a highly aggressive isolate of *Phytophthora infestans* in relation to tuber age. Potato Res 49: 99-107.

Śliwka, J, H. Jakuczun, R. Lebecka,W. Marczewski, C. Gebhardt, E. Zimnoch-Guzowska. 2007. Tagging QTLs for late blight resistance and plant maturity from diploid wild relatives in a cultivated potato (*Solanum tuberosum*) background. Theor Appl Genet 115: 101–112.

Zarzycka H., R. Lebecka, S. Sobkowiak, 2000: Odporność Polskich odmian ziemniaka na *Phytophthora infestans* na tle struktury lokalnych populacji tego patogena. XI Sesja Naukowa Instytutu Ochrony Roślin. Poznań, 24-25 luty 2000: 43.

Zarzycka H., R. Lebecka, S. Sobkowiak, 2000: The stability of resistance against local populations of *Phytophthora infestans* in Polish potato cultivars. Breeding Research for Resistance to Pathogens and for Quality Traits. EAPR Section: Breeding and Varietal Assessment, EUCARPIA Section: Potatoes, Warsaw, Poland, July 3-7, 2000: 28.

Zarzycka H., R. Lebecka, S. Sobkowiak, 2000: The stability of resistance against local populations of Phytophthora infestans in Polish potato cultivars. Report of the joint meeting of the Potato Section and the section Breeding and varietal assessment of the EAPR, 3-7 July, 2000, Warsaw (Poland), Potato Res. 43: 418.

Sobkowiak S., E. Zimnoch-Guzowska, H. Zarzycka, R. Lebecka, 2001: Wpływ terminów oceny na zmienność wirulencji i agresywności wybranych izolatów *Phytophthora infestans*. Konferencja Ochrona Ziemniaka, 19-20 kwietnia 2001 Bonin: 144-149.

Sobkowiak S., Zarzycka H., Lebecka R., Zimnoch-Guzowska E. 2001. Wpływ terminów oceny na zmienność wirulencji i agresywności wybranych izolatów *Phytophthora infestans.* Mat. konf.: Ochrona Ziemniaka, 19-20.04.2001, Kołobrzeg: 144-149.

Lebecka R., Sobkowiak S., Zimnoch-Guzowska E. 2004. Maturity of potato tubers and their resistance to *Phytophthora infestans*. (In:) Abstracts of the workshop "Towards integration of late blight control in European potato production, breeding achievements and pathogen knowledge", 14-18 January 2004, Falenty, Poland: 28.

Lebecka R., Sobkowiak S., Zimnoch-Guzowska E. 2004: Resistance of potato tubers to *Phytophthora infestans* and its maturity. (In:) Abstracts, EAPR Pathology Section Meeting, 11-16 July 2004, Lille, Francja (materiały bez numeracji stron).

Śliwka J., Jakuczun H., Lebecka R., Marczewski W., Zimnoch-Guzowska E., *Gebhardt C*. 2004. Mapping loci controlling resistance to *Phytophthora infestans* in two diploid potato families. (In:) Abstracts of the 1st Solanaceae Genome Workshop 2004, 19-22 September 2004, Wageningen, The Netherlands: 148.

Śliwka J., Jakuczun H., Lebecka R., Zimnoch-Guzowska E., *Gebhardt C*. 2004. Chromosomal localization of genes responsible for resistance to *Phytophthora infestans* in two diploid potato populations. (In:) Abstracts, EAPR Pathology Section Meeting, 11-16 July 2004, Lille, Francja (materiały bez numeracji stron).

Śliwka J., Jakuczun H., Lebecka R., Zimnoch-Guzowska E., *Gebhardt C.* 2004. Chromosomal localization of genes responsible for resistance to *Phytophthora infestans* in two diploid potato populations. (In:) Abstracts of the workshop "Towards integration of late blight control in European potato production, breeding achievements and pathogen knowledge", 14-18 January 2004, Falenty, Poland: 19.

Śliwka J., Jakuczun H., Lebecka R., Zimnoch-Guzowska E., *Gebhardt C*. 2004. Chromosomal localization of genes responsible for resistance to *Phytophthora infestans* in two diploid potato populations. (In:) Materials of the NorFA course "Oomycetes – molecular characterization and plant-pathogen interactions", 19-26 June 2004, Ås, Norway (materiały bez numeracji stron).

Lebecka R., Sobkowiak S., Zimnoch-Guzowska E.: Związek między odpornością bulw ziemniaka na *Phytophthora infestans* a ich dojrzałością. Materiały konferencyjne „Nasiennictwo i ochrona ziemniaka", konferencja zorg. przez ZNiOZ IHAR Bonin, 4-5 marca, 2004 Kołobrzeg.

Lebecka, R. 2005. Resistance of *Solanum nigrum* to *Phytophthora infestans*. 16th Triennial Conference of the EAPR, Abstracts of Papers and Posters: 622-623, July 17-22, Bilbao, Basque Country.

Lebecka, R. Reaction of *Solanum nigrum* to *Phytophthora infestans* in whole plant and detached leaf assay, Late Blight Workshop Jõgeva Plant Breeding Institute, 19-23.10.2005, Tallinn, Estonia (plakat, bez streszczenia).

Lebecka, R. Odporność mieszańców somatycznych [*Solanum nigrum* (+) *S. tuberosum*](+) *S. tuberosum* na *Phytophthora infestans* „Mieszańce oddalone roślin uprawnych" Połączone Warsztaty Naukowe, 18 – 21 października 2005, Inowrocław, str: 84-85.

Śliwka, J., R. Lebecka, S. Sobkowiak, E. Zimnoch-Guzowska. 2006. Eucablight – europejska baza danych. *Phytophthora infestans* – badania populacyjne i odporność ziemniaka. Materiały konferencyjne „Nasiennictwo i ochrona ziemniaka", konferencja zorg. przez ZNiOZ IHAR Bonin, 30-31 marca, 2006 Kołobrzeg.

Sobkowiak, S. i R. Lebecka. 2006. Charakterystyka izolatów *Phytophthora infestans* pod względem odporności na metalaksyl. Materiały konferencyjne „Nasiennictwo i ochrona ziemniaka", konferencja zorg. przez ZNiOZ IHAR Bonin, 30-31 marca, 2006 Kołobrzeg.

Lebecka, R., J. Śliwka, S. Sobkowiak, E. Zimnoch-Guzowska. 2006. Zmienność fenotypowa i genetyczna populacji *Phytophthora infestans* w Polsce i Europie. Konferencja Naukowa „Nauka dla hodowli roślin uprawnych". Zakopane, 29.01-2.02.2007. Streszczenia, str. 53.

Polish newspaper Top Agrar: Lebecka R. 2007. Jak nie stonka, to zaraza. Top Agrar Polska 5: 84-86.