EAPR2011

ABSTRACTS

The 18th Triennial Conference of the European Association for Potato Research

July 24-29, 2011

Oulu, Finland

Abstracts of the 18th Triennial Conference of the European Association for Potato Research.

J. Santala and J.P.T. Valkonen (eds.)

Helsinki, Finland

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EAPR2011 programme at a glance

<table>
<tr><th>Sunday
July 24</th><th>Monday
July 25</th><th>Tuesday
July 26</th><th>Wednesday
July 27</th><th>Thursday
July 28</th><th>Friday
July 29</th></tr>
<tr><td rowspan="2"></td><td>09:30
Opening session</td><td>09:00
Concurrent sessions no. 4-7</td><td rowspan="5">08:30 – 17:45

Excursions

<u>Buses depart from the conference venue (city theatre) at 08:30</u>

At return, buses will drive via the hotels.</td><td>09:00
Concurrent sessions no. 12-14</td><td>09:00
Concurrent sessions no. 18-20</td></tr>
<tr><td>11:00
Plenary talks no. 1-3</td><td>11:15
Poster session I</td><td>11:30
Poster session II</td><td>10:40
Plenary talks no. 12-13</td></tr>
<tr><td rowspan="2">12:00 -18
Registration at the conference venue (Oulu City theatre)</td><td rowspan="2">12:30
Lunch</td><td>12:30
Workshops ”Organic potato production” and “Tuber blemishes”</td><td rowspan="2">12:30
Discussion session “GM/Biotech applications”</td><td rowspan="2">12:00

Closure of EAPR2011</td></tr>
<tr><td>14:00
Concurrent sessions no. 1-3</td><td>Lunch (available 13:00-15:00)</td></tr>
<tr><td rowspan="2">16:00 - 18
Extraordinary meeting of the Council of EAPR</td><td rowspan="2">16:30
Plenary talks no. 4-6</td><td>15:00
Meetings of the EAPR sections</td><td>15:00
Concurrent sessions no. 15-17</td><td rowspan="4"></td></tr>
<tr><td>16:00
Plenary talks no. 7-9</td><td>17:30
Plenary talks no. 10-11</td></tr>
<tr><td></td><td rowspan="3">18:30–19:30
General meeting of EAPR</td><td rowspan="3">18:30-20:30
Concurrent sessions no. 8-11</td><td></td><td></td></tr>
<tr><td rowspan="3">19:00 - 21

Get-together</td><td>19:30 - 21

Reception of the City of Oulu</td><td rowspan="3">20:00

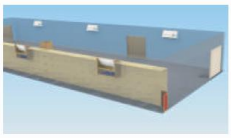
Conference dinner</td></tr>
<tr><td rowspan="2"></td><td>21 –
Roviantti at the market place</td></tr>
<tr><td></td></tr>
</table>

a-Lab Varastointijärjestelmät

Tuotteiden olosuhteiden seuranta sekä varastoinnin ratkaisut - istutuksesta kauppaan.

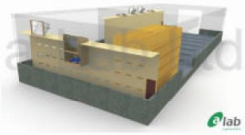
Kun varasto on kunnossa myös tuoteen laatu säilyy

Tuoretuotteiden myyntihinta riippuu niiden laadusta. Tuotteen laadun säilyminen varastoinnin aikana riippuu Ilmastointijärjestelmän laadusta. Hyvään Varastointitekniikkaan sijoittaminen kannattaa aina



Hyvä varasto säästää rahaa

Hyvin suunniteltu ja toteutettu ilmastointi ja varasto vähentää merkittävästi varastoinnin aikaisia painohäviöitä, kauppakunnostustappioita sekä säästää energiakustannuksissa



Kattava dokumentaatio vahvistaa kokonaislaatua

Laadukas ilmastointiautomatiikka myös tallentaa varastointiolosuhteet. Varasto-olosuhteiden dokumentointi on osa asiakkaiden arvostamasta kokonaislaadusta.

Varastointitekniikkaa kymmenien vuosien kokemuksella

Uudisprojekteissa a-Lab toimii järjestelmätoimittajana ja toimittaa laitteiden lisäksi asiantuntevan ilmastointisuunnittelun ja projektinhallinnan. Haluttaessa toteutamme koko projektin “avaimet käteen” - periaatteella.

Luotettavaa ilmastointi tekniikkaa Suomesta

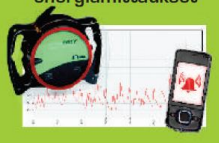
Hälyttävä varastovahti vahtii varaston lämpötiloja

Pienten ja jopa käsisäätöisten varastojen tuotteiden laadun säilyvyys paranee kun lämpötiloja tarkkaillaan ahkerasti. Automaattinen lämpötilojen valvonta ilmoittaa mikäli varastossa tapahtuu jotain huomion arvoista.

Meiltä myös

Kasvuolosuhdeseuranta

Varastovahdit, kuljetusseuranta, energiamittaukset



a-Lab Oy
Vaihde 0424 2521 • info@a-lab.fi • www.a-lab.fi

Welcome to EAPR2011!

Welcome to the 18th Triennial Conference of the European Association for Potato Research!

Research on potato continues vividly and corresponds to the demands of the society. This is evidenced by the progress made in many aspects of potato research since the latest EAPR conference held in Brasov, Romania, in 2008. Potato is not only one of the most important food crop plants but also serves as a model plant for biotechnological research since decades. The enhanced and economically accessible new genome sequencing techniques allow converting crop plants to model plants. This translational research is also true for potato. The genomes of two cultivated potato species have been determined, as well as the genome sequence of the late blight pathogen, *Phytophthora infestans*, and many bacterial pathogens of potato. The data open novel possibilities to plant breeding and plant protection. Some ground-breaking news will be reported during the conference.

The nutritional value of potato is exceptional but not always realised. New compounds beneficial for human health continue to be discovered in potato. The native potato species cultivated in South America are gaining particular interest in this respect. Potato continues to correspond successfully to the increasing demand of food in the developing world where potato cultivation is getting more and more common. Progress in all these areas of research will be reported in oral presentations and posters.

Consumers in the industrialized world demand 'greener' solutions in agriculture. They are concerned about the environment and consequences of the climate change. These demands represent a challenge to which the potato producers, trade and industry need to correspond, which in turn requires research outputs from potato scientists. 'Carbon footprint' of potato production appears often in discussions. In this respect, table potatoes that represent a local commodity are usually doing well in comparison to many other products. How these issues are addressed scientifically will be an interesting area approached in the scientific programme of EAPR2011.

The potato sector in Finland joined the forces to make the local arrangements for the EAPR2011 conference. Many organisations and companies have played a crucial role in facilitating the arrangements financially and by other means. I would like to express my gratitude to them on behalf of the conference organisers and participants.

I hope that you'll enjoy the scientific news, useful information, good company of colleagues and the nightless nights during the EAPR2011 in Oulu!

Jari Valkonen
President of EAPR

EAPR2011 ORGANISERS on behalf of EAPR

Scientific committee:

Mehmet. E. Caliskan, Mustafa Kemal University, Turkey
Sorin Chiru, Research and Development Institute for Potato and Sugar beet, Romania
Louise R. Cooke, Agri-Food and Biosciences Institute, Northern Ireland, UK
Adrian Cunnington, AHDB Potato Council, Sutton Bridge Crop Storage Research, UK
Serge Duvauchelle, Ministere de l'Agiculture et de la Peche, France
Jean-Pierre Goffart, Centre Wallon de Recherches, Agronomiques-CRA-W, Belgium
Norbert U. Haase, Federal Research Centre for Nutrition and Food, Germany
Asko Hannukkala, MTT AgriFood Research Finland
Anton J. Haverkort, Plant Research Institute, WUR, The Netherlands
Katrin Kotkas, Estonian Research Institute of Agriculture, Estonia
Carl Spetz, Bioforsk, Norway
Mike Storey, AHDB Potato Council, UK
Paul Struik, Wageningen UR Crop and Weed Ecology/Crop Physiology, The Netherlands
Jari P.T. Valkonen, University of Helsinki, Finland
Herman J. van Eck, Wageningen University, The Netherlands
Romke Wustman, Applied Plant Research, WUR, The Netherlands

Local organizing committee:

Kirsi Heinonen, Ministry for Agriculture and Forestry
Antti Hintikka, Northern Seed Potato
Lauri Juola, Finnish Seed Potato Centre
Lea Hiltunen, MTT AgriFood Research Finland
Mirja Kemppainen, MTT AgriFood Research Finland
Hanna Kortemaa, Finnish Food Safety Authority Evira
Paavo Kuisma, Potato Research Institute
Antti Lavonen, Finnish Farmers' Union
Timo Lehtiniemi, Centre for Economic Development, Transport and the Environment
Mari Leppilampi, Business Oulu
Anu Markus, MTT AgriFood Research Finland
Heikki Markus, Finpom
Vesa Nuolioja, ProAgria Oulu
Ossi Paakki, Finnamyl
Tuula Palmen, BusinessOulu
JP Palohuhta, Finnish Seed Potato Centre
Helena Pikkarainen, Congress Oulu (Business Oulu)
Eero Pisilä, Profood
Riku Räätäri, Shaman Spirits
Johanna Santala, University of Helsinki
Asko Seppänen, Perunaseppä Oy
Marko Sulonen, Congress Oulu
Jussi Tuomisto, Finnish Potato Association
Jari Valkonen, University of Helsinki
Elina Virtanen, MTT AgriFood Research Finland

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Table of Contents

1. General information

Registration and conference assistants

Registration and information desks are situated in the lobby of the city theatre (conference venue).

Registration and information desks are operated by Congress Oulu and will be open as follows:

Sunday July 24 12:00 – 18:00

Monday July 25 08:00 – 16:00

Tuesday July 26 08:00 – 16:00

Thursday July 28 08:00 – 16:00

Friday July 29 08:00 – 12:30

Information desk will be manned by conference assistants also after closure of registration until the end of the programme.

Conference assistants are in your service and wear shirts with EAPR2011 colours and the logo. Please feel free to consult them.

Instructions for speakers

Speakers and chairpersons should ensure that oral presentations will be kept in time according to the following time allocations:

Plenary talks: 30 min for presentation; 10 min for questions and discussion

Concurrent sessions: 20 min for presentation, 10 min for questions and discussion. Please note that some people may wish to move to another session during the last minutes of discussion time.

Files and formats: Please bring your talk on a memory stick as a PC-compatible Powerpoint presentation file. Speakers are requested to bring the file to the Presentation Collection Point in the lobby of the conference venue latest two hours before the respective session. Assistants will transfer the file to a computer (PC) in the designated lecture room. There is no possibility to use your own computer for the presentation.

Instructions for poster presenters

The dimensions of poster boards are 147 cm (height) and 147 cm (width). Posters will be fixed to the board with pins provided by organisers.

Poster boards are numbered according to the list of posters. If you experience difficulties in finding the board for your poster, please consult the conference assistants.

The posters will be displayed in two sessions. Posters no. 1 - 65 will be at display in session I (Tuesday July 26). Posters no. 66 - 131 will be displayed in session II (Thursday July 28).

Posters for session I can be placed on to the poster boards on Sunday afternoon (July 24) or during Monday. The posters must be removed before the end of the scientific programme on Tuesday.

Posters for session II will be placed on to the poster boards during Thursday morning before 10 am. Please remember to remove the poster on Friday morning before departure.

Coffee breaks and lunch

Coffee and lunch included in the registration fee are served in foyer and restaurant of the theatre.

Notices from organisers

Notices will be displayed in a large monitor situated in the staircase to the foyer and can be observed from the foyer. It will display any changes in the programme and other useful information.

Notice board

There will be a notice board where you can display job announcements or other pertinent information for other conference delegates. The notice board will be situated in the foyer.

Internet connection

There is a free wireless internet connection (PanOulu) that can be used in the conference venue.

Departure on Friday July 29

Please bring and deposit your luggage to the lobby of the conference venue in the morning if you'll leave for the airport directly after closure of the conference.

Buses will depart from the conference venue to the airport at 12:30. You'll reach the flights departing after 2 pm. If your flight will depart earlier, take a taxi or consult the Information desk for another transport arrangement.

3. Social Programme

SUNDAY, July 24

Get-together reception

For all participants of EAPR2011 and the accompanying persons.

Time: 19:00 – 21
Place: Oulu Museum of Art (Oulun taidemuseo)
Address: Kasarmintie 7 (follow the Isokatu street northwards from the city centre)

For your convenience, conference assistants carrying the EAPR2011 sign will be available in the lobby of the hotel Radisson Blu and Hotel Scandic at 18:35 and will walk with you to the Oulu Museum of Art. They will pass also via Holiday Inn and Sokos Hotel Arina, so you may wait in the lobby at 18:40 to join these guided groups.

WEDNESDAY, July 27

Reception offered by the city of Oulu

"Wine and salads" reception hosted by Mr. Matti Pennanen, the Mayor of Oulu.
For all participants of EAPR2011 and the accompanying persons.

Time: 19:30 – 21
Place: The City Hall (Kaupungintalo)
Address: Kirkkokatu 2a

Roviantti – the event of delicious food

The recommended place to continue the evening with other conference delegates, Finnish potato professionals (farmers, companies), and people spending their holidays/free time having a pint of beer and probing various delicious foods prepared by the local restaurants in the summer evening. No entrance free.

Time: Open until 1:00 am
Place: Piknik Areena at the market place (Kauppatori) next to the conference venue

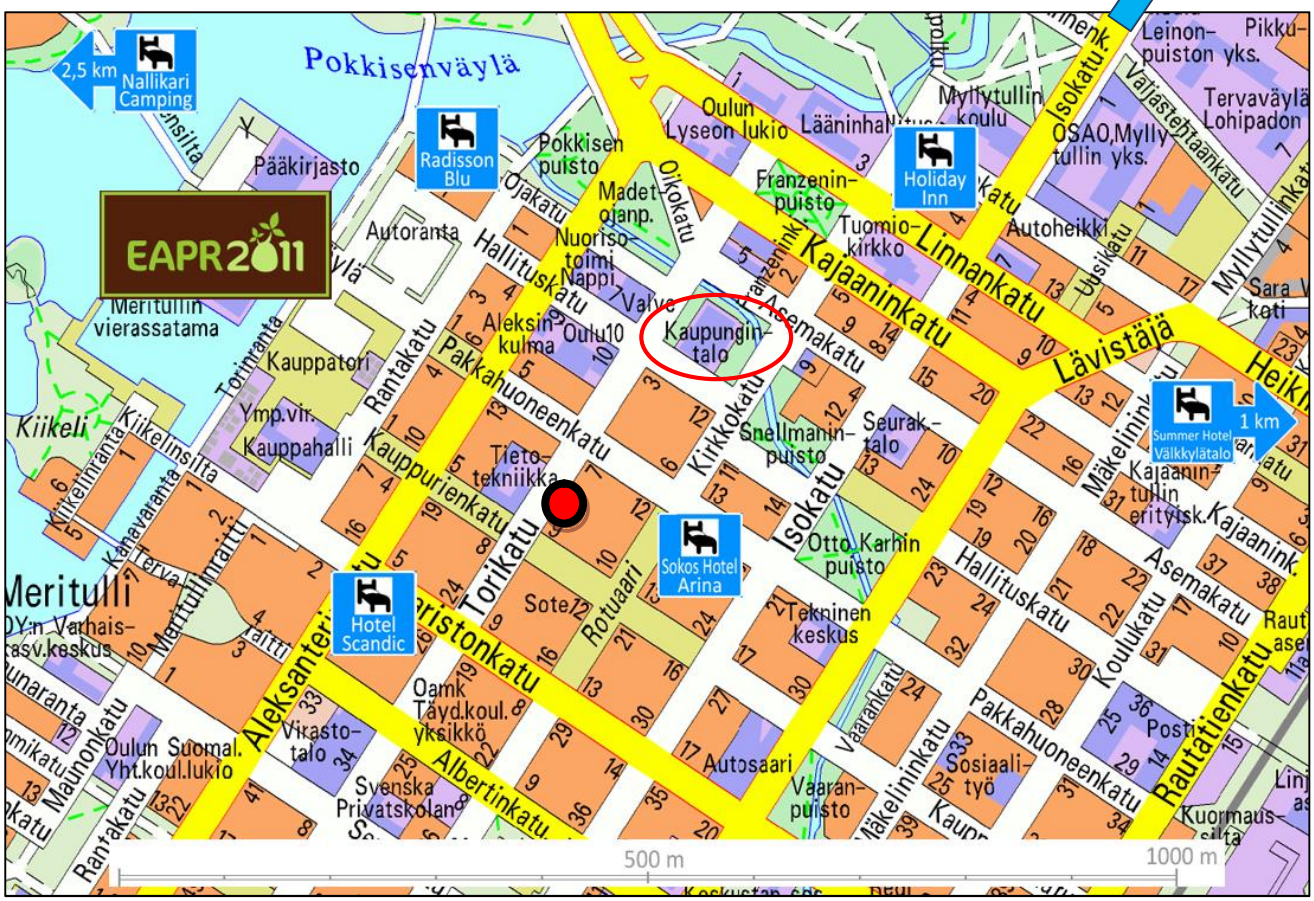
THURSDAY, July 28

Note! During the lunch break at 13:30-14 a few representatives of EAPR compete in making potato dishes in Piknik Areena. Come and experience a unique France-Netherlands contest!

Conference dinner

Time: 20:00 – 24
Place: Holiday Inn Oulu
Address: Kirkkokatu 3

Get-together
(ca. 600 m from Holiday Inn)



Bus stop Toripakka P

Accompanying persons' programme

In addition to the get-together reception, excursion day and conference dinner, there will be special programme for accompanying persons.

The tours will depart from the city theatre (conference venue).

Short Tour: Something old, something new, a little bit of blue

Tuesday, July 26, at 9:00-12:00

This walk takes you from the old monumental centre to the new one. The guide will tell you about the persons and events of the past, show you where the long narrow boats full of tar barrels landed and lead you to the old storehouses and to the market hall guarded by the statue of a policeman. You will be revealed the humorous stories behind this figure loved by everyone.

Coffee and tea will be served during the tour. The tour will be guided in English.

Long Tour: A day in the Stone Age

Thursday, July 28, at 9:00 -16

A tour to Kierikki Stone Age Centre departs at 9.00. During the guided tour, the group will explore the dwellings of the Stone Age people and have a chance to practice ancient archery and other activities and tasks.

Kierikki Stone Age Centre is an archaeological centre situated north-east of Oulu on an archaeological site of a former Stone Age settlement, which was inhabited as far back as 7000 years ago. Lunch will be enjoyed at the main building.

The tour continues to KulttuuriKauppila, local art home. KulttuuriKauppila is a dream of three artists of a new kind of an art home. There are an atelier and an exhibition house for the local artists and the old school building functions as the artist residence. Coffee and tea will be served during the visit. The tour will end at 16.00.

WORKSHOPS

Round-table discussion on the nomenclature and assessment of tuber blemishes

Time: Tuesday July 26, at 12:30

Convener: Karima Bouchek-Mechiche, INRA, France

Potato tubers may be affected by a large range of blemishes leading to rejections or downgrading. Among these blemishes, several have been studied in detail (common and netted scab, powdery scab, black scurf, black dot and silver scurf), the causal agents are well-known and there is a general consensus about usage of symptom terminology.

However, several other frequently observed blemishes have a less clear origin and are cited in the literature with variable terminologies and are sometimes attributed to known pathogens following field observations rather than based on scientific evidence (Koch' postulates).

Indeed, the nomenclature of tuber blemishes needs rationalisation. The objectives of the proposed round-table discussion are to approach this problem through an action committee with the contribution of experts from different countries and organizations, including seed potato, ware potato, processing potato experts, researchers, people working in extension, breeders, etc.

Besides working on a consensus classification of tuber blemishes, this round-table discussion would provide a good opportunity to share knowledge on the importance, nomenclature, assessment, and control of such tuber blemishes.

Proposed contents:

1. Introduction to the subject (K. Bouchek and collaborators)

2. An overview of the situation in another European country

3. A "tour around the table" to understand how the problem is tackled in different countries (France, UK, Finland, The Netherlands, Switzerland, Germany, Belgium and elsewhere), focusing on the following items:

- Economic incidences of such blemishes?

- Are there research programs carried on these blemishes (biology, symptomatology, epidemiology, control management, detection)

- Tuber blemishes versus seed certification process?

- Tuber blemishes versus varietal assessment?

4. How to rationalise the current national nomenclatures into a widely consensual version?

5. Listing topics of interest that could initiate working groups or collaborative research?

Please note that the round-table discussion will be focused on the matter of consensus nomenclature of tuber blemishes. Participants are more than welcome to submit abstracts for oral presentations or posters on blemishes and related topics in the framework of the general EAPR meeting and they will be discussed in the normal oral and poster sessions.

Organic potato production

Time: Tuesday July 26, at 12:30

Convener: Thorsten Haase, University of Kassel, Germany

Outline:

Organic potato cultivation in Europe is predominantly nitrogen-limited and defoliation of the crop canopy caused by late blight may further reduce tuber yield. The latter may lead to considerably lower yields compared to conventional potato crops and possibly lower N use efficiency. Previous research suggested that choice of cultivar, pre-sprouting, and application of copper fungicides are the most promising measures at hand to reduce yield losses associated with late blight. With a pending ban of copper or very strict limitations already in effect in some countries of the European Union, further sophisticated agronomic measures must be developed to increase productivity of organic potato cultivation.

In the workshop, the state of the art of research will be outlined, to be followed by a common discussion of future challenges in research and potential collaborations.

Discussion session about GM/biotech applications

Convener: Melvyn F. Askew, Honorary Member of EAPR

Time: Thursday, July 28, at 12:30

Outline:

Where might genetic engineering fit into potato production, and having identified any opportunities, what might be the pros and cons of any introduction?

Areas for discussion:

• weed control in the potato - could herbicide tolerant varieties of potato help?

• late blight in potato - introducing blight resistant or tolerant varieties through biotech applications?

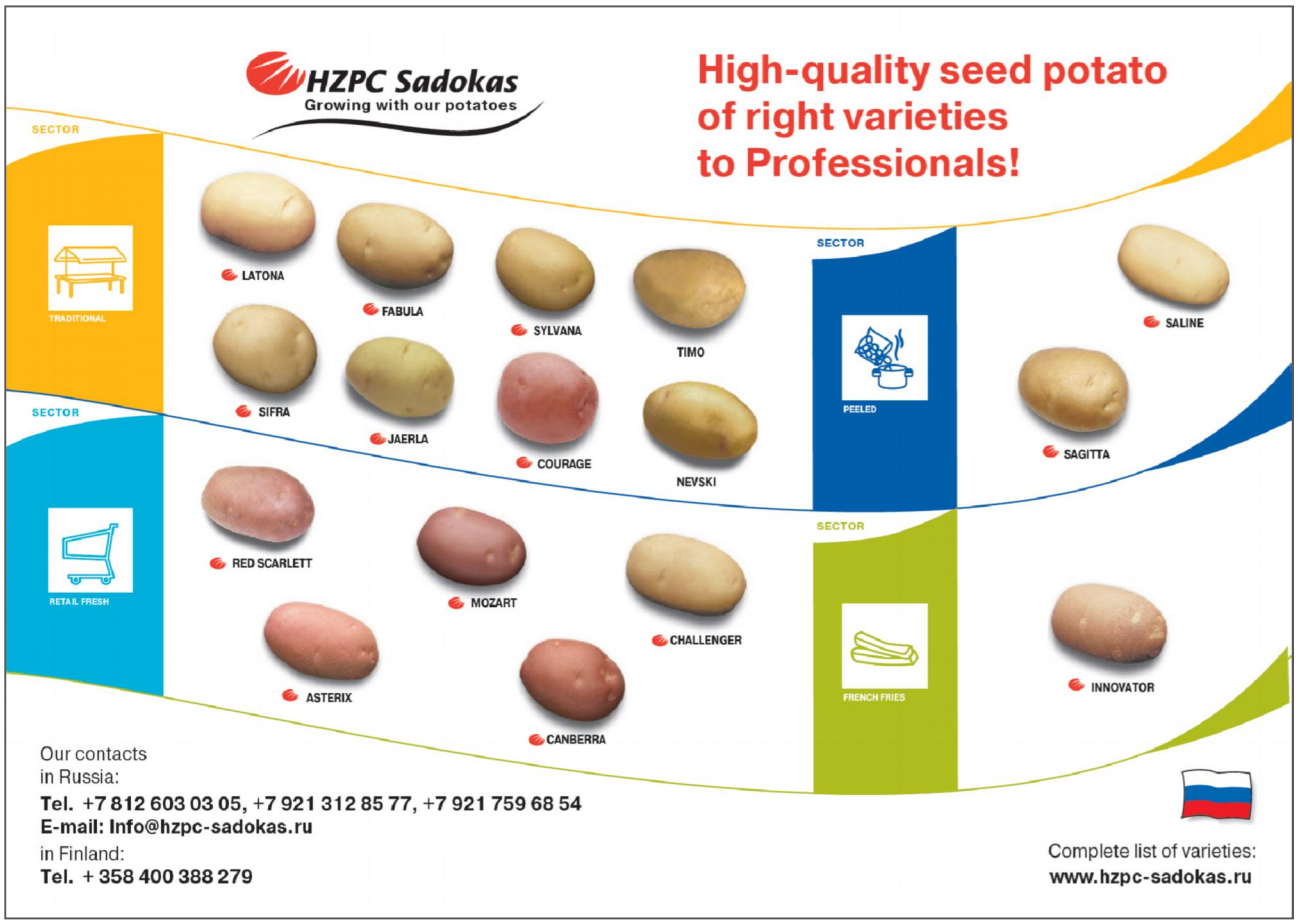
• potato storage - could antisense technologies (amongst others) assist in storage of potatoes crops?

• improved potato quality for human or industrial use - could GM technologies bring in new genetic traits?

• adaption to climate change - could traits introduced by GM technology assist in overcoming temperature, drought stress etc that will occur with climate change?

• public opinion and biotech – implications on potato consumption?

A short scene setter item (5 min) will be presented for each topic. Each topic will be dealt one by one, and the discussion will move on to the next topic.


HZPC Sadokas
Growing with our potatoes
High-quality seed potato of right varieties to Professionals!
SECTOR
TRADITIONAL
SECTOR
RETAIL FRESH
SECTOR
PEELED
SECTOR
FRENCH FRIES
LATONA
FABULA
SYLVANA
TIMO
SALINE
SIFRA
JAERLA
COURAGE
NEVSKI
SAGITTA
RED SCARLETT
MOZART
CHALLENGER
ASTERIX
CANBERRA
INNOVATOR
Our contacts
in Russia:
Tel. +7 812 603 03 05, +7 921 312 85 77, +7 921 759 68 54
E-mail: Info@hzpc-sadokas.ru
in Finland:
Tel. + 358 400 388 279
Complete list of varieties:
www.hzpc-sadokas.ru

Programme

SUNDAY, July 24

12:00 – 18:00 **Registration**

Registration desk will be open at the conference venue (Oulu City Theatre) on Sunday afternoon and daily during the conference.

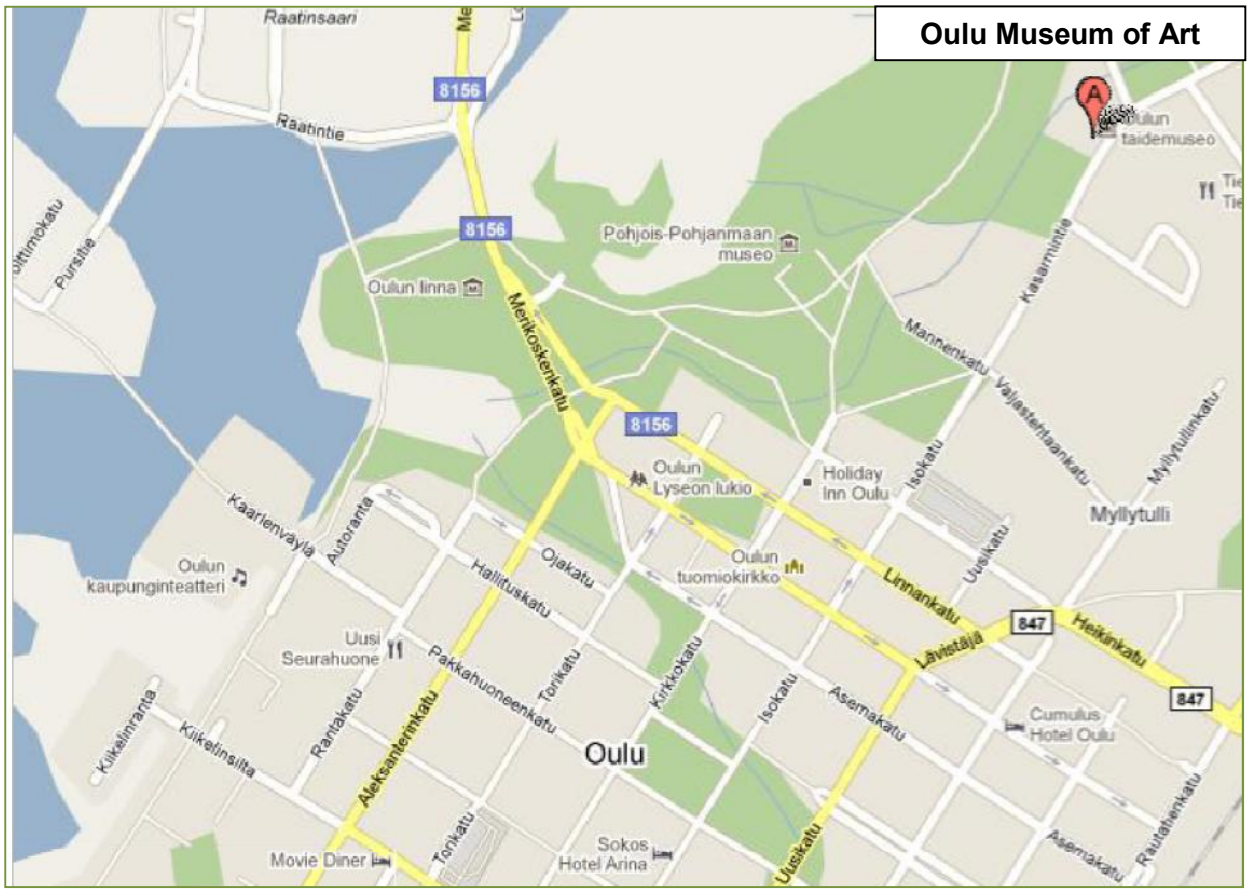
16:00 **Extraordinary meeting of the Council of EAPR**

17:00 **Joint meeting of the EAPR Council, Section chairpersons and Country representatives of EAPR**

19:00 - 21 **Get-together**

For all participants of EAPR2011 and the accompanying persons

Place: Oulu Museum of Art (Oulun taidemuseo)
Address: Kasarmintie 7 (follow the **Isokatu** street to north from the city centre)



MONDAY, July 25

	Hall "Lake" Suuri näyttämö		
9:30	**Opening of EAPR2011** **Leila Helaakoski,** Centre for Economic Development, Transport and the Environment **Martti Eirola,** Ministry for Foreign Affairs of Finland **Jari Valkonen**, European Association for Potato Research		
	Chair: Jari Valkonen		
10:30	Plenary 1: Using and sustaining potato biodiversity for health and income generation (M. Bonierbale)		
11:10	Plenary 2: Current potato production and research and development efforts in Africa (W. Wagoire)		
11:50	Plenary 3: Agronomic options to reduce the carbon footprint of potato (A. Haverkort)		
12:30-14:00	Lunch		
	Hall "Lake" Suuri näyttämö	**Hall "Field" Pikisali**	**Hall "Forest" Pieni näyttämö**
	Session 1 **Chair: Waldemar Marczewski**	**Session 2** **Chair: Mehmet Caliskan**	**Session 3** **Chair: Ian Toth**
14:00	Accerelated breeding in potato using marker assisted selection: strategy, prospects and challenges (Dalton)	Multiplication Factors in Potato (*Solanum tuberosum* L.) (Struik)	Spreading of new *Dickeya* spp. (*Erwinia chrysanthemi*) causing blackleg and soft rot of potato in Europe (Pirhonen)
14:30	Evaluation and application of molecular markers within the Australian potato breeding program (Slater)	Seed Potato Production in Algeria using Hydroponics (Chang)	To the question on of potato protection system from diseases (Andrianov)
15:00	Molecular Marker Assisted Selection (MAS) application in a small breeding company (Lopez)	Tubering Characteristics Of Local Potato (*Solanum tuberosum* L) Genotypes (Arslanoglu)	Towards a better understanding of potato cyst nematode distribution on a national scale (Goeminne)
15:30	Genetic analysis in a highly heterozygous diploid potato cross segregating for many commercially relevant traits (Bryan)	The Sprout/Seed-Potato (S/S-P) Technology: An update on attempts to transfer this affordable minituber production system (Caram)	Using massively parallel sequencing to investigate soil microbial populations and disease (Peters)
16:00	Coffee		
	Chair: Richard Visser		
16:30	Plenary 4: Genomics leads to new discoveries and practical solutions to disease control for the bacterial potato pathogens *Pectobacterium* and *Dickeya* (I. Toth)		
17:10	Plenary 5: Molecular arms' race between viruses and potato plants (J. Valkonen)		
17:50	Plenary 6: A new paradigm in potato breeding (P. Lindhout)		
18:30 – 19:30	General Meeting of EAPR (Hall "Lake")		

TUESDAY, July 26

	Hall "Lake" **Suuri näyttämö**	**Hall "Field"** **Pikisali**	**Hall "Forest"** **Pieni näyttämö**	**Hall "Winter"** **Vinttikamari**
	Session 4 **Chair: Paul Struik**	**Session 5** **Chair: Mike Storey**	**Session 6** **Chair: Romke Wustman**	**Session 7** **Chair: Herman v. Eck**
9:00	Identification and exploitation of candidate genes for adaptation to abiotic stresses in potato (Ritter)	Physiological aspects of plant development and yielding of potatoes growing under organic system (Zarzynska)	Gas exchange and water use efficiency in potato as related to the level of drought tolerance (Boguszewska)	Markers assisted selection for late blight resistance in tetraploid potato (Marhadour)
9:30	Screening of potato cultivars against heat stress using cell membrane stability, growth and yield parameters (Caliskan)	Nitrogen use efficiency and N crop status of selected potato cultivars under organic farming conditions (Haase)	Irrigation of early potato during the day (Andrianov)	Molecular markers for high-throughput selection of late blight resistant potato (Trognitz)
10:00	QTL analysis for root length and dry weight in a diploid potato population (Iwama)	Benchmarking on organic potato production and the quality and the sensory profile of selected varieties (Böhm)	Early potato irrigation regime (Andrianov)	Using Resistance Gene enrichment and Next Generation Sequencing to clone late blight resistance genes (Verweij)
10:30	Potato plant development under conditions of temperature decreasing - in the context of climate change (Rykaczewska)	Performance of newly bred potato varieties under organic and conventional experimental conditions (Hebeisen)	Climatic condition in Poland and the requirement of irrigation in potato cultivation (Nowacki)	Production of blight resistant potato using Ensifer adhaerens OV14: A novel transformation platform to facilitate technology transfer from potato genome initiatives (Mullins)
11:00	Coffee			
11:15	**Poster session 1**			
12:30-14:00	Hall "Field": Workshop "Organic potato production"		Hall "Forest": Workshop "Tuber blemishes"	
13:00-15:00	Lunch			
15:00-15:50	Section "Breeding" Section"Utilization" (VIP cabinet)	Section "Physiology"	Section "Virology"	Section "Pathology"
	Chair: Ewa Zimnoch-Guzowska			
16:00	Plenary 7: Potential and limitations of plant virus epidemiology: lessons from the *Potato virus Y* pathosystem (T. Döring)			
16:40	Plenary 8: The role of traditional potato breeding in scientific potato improvement (C. Brown)			
17:20	Plenary 9: Molecular diagnostics for disease resistance and tuber quality traits: concept, achievements and perspectives (C. Gebhardt)			
18:00	Special report: The use of potato starch in a paper mill (S.E. Bruun, Chemigate Co.)			
18:20	Coffee			

	Session 8 **Chair:** **Kazuo Watanabe**	**Session 9** **Chair:** **Serge Duvauchelle**	**Session 10** **Chair:** **Asko Hannukkala**	**Session 11** **Chair: Hannele Lindqvist-Kreuze**
18:45	20 years with protoplast fusion in potato breeding - results and perspectives (Schwarzfischer)	Effect of growing season length on response to seed aging (Thornton)	Can an alternative host increase the problems with late blight in potato? (Grönberg)	Diversity analysis of potato landraces in the CGN genebank by means of SNPs (Hoekstra)
19:15	A new look at the problem of inter-EBN interspecific crosses in potato (Yermishin)	Tuber yield and some nutritional traits in early potatoes as affected by growing season, genotype and harvest time (Ierna)	Functions of Phosphorous Acid for Late Blight Control in Potatoes (Wang-Pruski)	Genomic in situ hybridization (GISH) analysis of the North and Central American hexaploid wild potato species (Gavrilenko)
19:45	Consequences of autopolyploidization in potato: putting omics tools to work (Aversano)	Subsoiling in starch potato: Higher yields of starch potatoes and improved water management (Ekelöf)		Illustration of the diversity of genebank accessions of cultivated potato using simple sequence repeat markers (Diekmann)
20:15 - 20:45	Advances in in-vitro conservation of potato germplasm in India (Gopal)	The Relationship Between Yield And Above Ground Parts Of Some Potato Genotype (Arslanoglu)		A microsatellite and morphological assessment of the VIR cultivated potato collection (Gavrilenko)

WEDNESDAY, July 27

1. EXCURSIONS (08:30 – 17:30)

All excursions will head to the High Grade Seed Potato Production zone in Tyrnävä and Liminka, south from Oulu, however, programmes will be varied. **Buses for all excursions will depart at 08:30 from the conference venue (Oulu City Theatre)** and return 17:30.

Excursion 1 - Seed potato production, cultivars and related research

Programme: A joint exhibition organized by the seed potato companies (in-doors) followed by a visit to field trials related to seed potato research. After lunch, visit to the campus of University of Oulu and the Center for Internet Excellence (CIE) , MTT AgriFood Research Centre and the Finnish Food Safety Authority Evira, respectively, and a small sight-seeing tour in Oulu on the way back to the hotels.

Excursion 2 - Research and seed potato production, with some cultural aspects related to the HG region

A small sight-seeing tour in Oulu on the way to the campus of University of Oulu and the Center for Internet Excellence (CIE), MTT AgriFood Research Centre and the Finnish Food Safety Authority Evira, respectively. Visit to the high school and library of Tyrnävä (HG zone). After lunch, visit to Shaman Spirits (alcohol production from potato) and potato field experiments.

Excursion 3 – Table potato production and potato industry, with some cultural aspects related to the HG region

Visit to a table potato farm, followed by a visit to the Profood potato processing plant. After lunch, visit to the high school and library of Tyrnävä, followed by a sight-seeing tour in Oulu on the way back to the hotels.

Excursion 4 – New technologies and applications utilizing potatoes

A small sight-seeing tour in Oulu and a visit to the Stora Enso paper factory, followed by a visit to a table potato farm. After lunch, a joint exhibition organized by the seed potato companies and a visit to Shaman Spirits (alcohol production from potato).

2. SOCIAL PROGRAMME IN THE EVENING (19:30 –)

Social programme in the evening

Reception offered by the city of Oulu

Time: 19:30 – 21 (be there at 19:15, please)
Place: The City Hall (Kaupungintalo)
Address: Kirkkokatu 2a

Roviantti – the event of delicious food

Time: Open until 1:00 am
Place: Piknik Areena at the market place (Kauppatori) next to the conference venue

THURSDAY, July 28

	Hall "Lake" Suuri näyttämö	Hall "Field" Pikisali	Hall "Forest" Pieni näyttämö
	Session 12 **Chair: Dan Milbourne**	**Session 13** **Chair: Elina Virtanen**	**Session 14** **Chair: Norbert Haase**
9:00	Rationale for modern resistance breeding in potato (Zimnoch-Guzowska)	Mycorrhiza: biological tools for promoting ecosystem services in potato production (Mercy)	Towards a clonal collection of wild *Solanum* species: tagging wild *Solanum* R genes, genomes and species (Rogozina)
9:30	Results and perspectives of potato breeding for resistance to diseases (Simakov)	Assessing the sustainability of potato production in South Africa (Steyn)	Natural and EMS-induced variants of invertase PAIN1 (Wolters)
10:00	Adequate sample size and replication in potato experiments (MacKerron)	New system of potato protection from Colorado potato beetle (Andrianov)	Regulation of steroidal glycoalkaloids in potato (Ginzberg)
10:30	Development of molecular markers to assist selection for high levels of resistance to potato leafroll virus (PLRV) from *S. tuberosum* ssp. *andigena* (Lindqvist-Kreuze)	Managing the intercropping period for controlling soil borne diseases of potato due to *Streptomyces* spp. and *Rhizoctonia solani* (Bouchek-Mechiche)	SNP and haplotype identification from targeted next-generation re-sequencing in a set of 83 potato cultivars. (van Eck)
11:00	Coffee		
11:30	**Poster session 2**		
12:30		Discussion session about GM/biotech applications (Hall "Field")	
13:30-15:00	Lunch		
	Session 15 **Chair: Anton Haverkort**	**Session 16** **Chair: Paavo Kuisma**	**Session 17** **Chair: Sorin Chiru**
15:00	Strategies to produce cisgenic transformants in potato (Zhu)	The effect of carbon dioxide atmosphere on tuber quality characteristics in potato storage (Harper)	SPOT-5 satellite multi-spectral data potential for assessing potato crop nitrogen status at a specific field scale (Goffart)
15:30	Intragenic tools for genetic enhancement of potato (Conner)	Energy use in potato stores in Great Britain (Cunnington)	Predecessors and fertilizer of an early potato (Adrianov)
16:00	Captured - The NB-LRRome of Sarpo Mira (Jupe)	Improvement of air distribution in forced air letterbox ventilation systems (Wulf)	Managing processing quality of high yielding potato varieties by potassium fertilisation (Demeulemeester)
16:30	Genetic diversity analyses in wild potatoes via multiplex fluorescent microsatellite fingerprints (Dehmer)	Mint oil: a new natural sprout suppressant opportunity (Martin)	Root vertical distribution and water absorption ability in Konyu potato cultivars with drought tolerance (Deguchi)
17:00	Coffee		
	Chair: Louise Cooke		
17:30	Plenary 10: Physiological and genetics determinants of *Streptomyces scabies* pathogenicity (S. Lerat)		
18:10	Plenary 11: Drought and salt stress tolerances in wild species and transgenic potatoes (K. Watanabe)		
20:00	Conference dinner		

FRIDAY, July 29

	Hall "Lake" Suuri näyttämö	**Hall "Field"** Pikisali	**Hall "Forest"** Pieni näyttämö
	Session 18 **Chair: Katrin Kotkas**	**Session 19** **Chair: Carl Spetz**	**Session 20** **Chair: Jean-Pierre Goffart**
9:00	Challenges and Accomplishments of the U.S. Northwest Potato Variety Development Program (Pavek)	The treatment with essential oils a potential enemy for potato virus Y in *Solanum tuberosum* and *Nicotiana tabacum* (Badarau)	Studies on the antioxidant capacity of potato tubers (Haase N.)
9:25	Early maturing potato for sustainable intensification in cereal based systems in India (Kadian)	Spread of *Potato mop-top virus* in Sweden (Kvarnheden)	Potato tuber composition and its contribution to blackspot susceptibility (Pawelzik)
9:50		*Potato Virus Y* (PVY) strains spread and symptoms on plants and progeny tubers of potato cultivars (Dupuis)	Characterisation of Hungarian potato varieties for total glycoalcaloid content in relation to seasonal changes (Polgar)
10:15	Coffee		
	Chair: Christiane Gebhardt		
10:40	Plenary 12: *Phytophthora infestans* effectors in late blight disease development, and exploitation for disease control (S. Whisson)		
11:20	Plenary 13: Updates and outcomes from the Potato Genome Sequencing Project (R. Visser)		
12:00	Closure of the conference		
12:30	Departure		

ABSTRACTS

Plenary sessions

Plenary 1

Using and Sustaining Potato Biodiversity for Health and Income Generation

Merideth Bonierbale, Centro Internacional de la Papa (CIP), Apartado 1558, Lima 12, Perú
Gabriela Burgos, Centro Internacional de la Papa (CIP), Apartado 1558, Lima 12, Perú
Walter Amoros, Centro Internacional de la Papa (CIP), Apartado 1558, Lima 12, Perú
Elisa Salas, Centro Internacional de la Papa (CIP), Apartado 1558, Lima 12, Perú
Stef de Haan, Centro Internacional de la Papa (CIP), Apartado 1558, Lima 12, Perú
Maria Scurrah, Grupo Yanapai, Jr. Atahualpa 297, Concepción, Junín, Perú
Ladislao Palomino, Instituto Nacional de Investigación y Extensión Agraria (INIEA), Av. Micaela Bastidas 3010 Wanchac, Cusco, Perú

Micronutrient deficiency is a widespread health problem in the developing world. With HarvestPlus, CIP has undertaken biofortification of potato as a food-based strategy to combat micronutrient malnutrition, targeting Fe, Zn and ascorbic acid, as a promoter of mineral bioavailability. A food system perspective on malnutrition an ongoing research in the Andes has given a finer perspective on the potential role of potato in achieving food security. In situ conservation of potato genetic resources is largely a consequence of infraspecific diversity in Andean food systems. Dietary intake studies have shown that native and improved varieties are highly complementary in different periods of the year with regards to caloric, and micronutrient intake. Traditional freeze-drying of potato allows for long term storage and the resulting chuño plays a vital role in food security retaining, vital minerals such as Ca and Fe. Meanwhile, biodoverse landrace type potatoes are finding new markets for their appealing pigments and culinary uses and their higher content of antioxidants such as phenolic acids, carotenoids, anthocyanins and ascorbic acid . Ranges of variation, extent of GxE, retention, and concentrations of anti nutrients and promoters of bioavailability have been examined. In vitro assays show that consumption of yellow-fleshed potatoes may enhance the bioavailability of Fe from other sources in the diet. Nutritional value of cooked and processed potatoes varies with genotype and preparation method. Boiling reduced the concentrations of violaxanthin and antheraxanthin but not those of lutein and zeaxanthine, showing deep yellow fleshed varieties to be a significant source of these important carotenoids. Participatory selection with farmers, NGOs, universities and schools among other stakeholders builds on end-user perceptions, preferences and demand for distinctiveness. Recent experiences in the central and southern Andes have shown that although farmers select candidate varieties for decentralized official release they often maintain multi-clone portfolios to satisfy demand for diversity and confront environmental variability. Evaluation of the stability of nutritional value complements participatory evaluation to identify more nutritious clones and variety mixtures for incorporation into traditional and modern production and food systems. Curiously, Andean landrace potatoes also present outstanding chip quality. The identification of novel processed products with added value has heightened awareness of biodiversity and stimulated investment in the production and marketing of native potatoes known until recently primarily as subsistence crops.

Plenary 2

Towards Sustainable Potato Production in East and Central Africa

William W. Wagoire, Research and Development Institute, Buginyanya Zonal Agricultural, P.O. Box 1356, 1234, Mbale, UGANDA,

Potato, *Solanum tuberosum,* originally known to be a temperate crop, is now cultivated in most of the East and Central African countries (ECA) for provision of food and income. Potato yields in the ECA is on the average 9 t/ha which is far below the 40 t/ha that are realised by the larger producers in Africa - Egypt, Algeria, South Africa and Morocco. Potato cultivation in the ECA is usually in the high altitude areas and is by small scale farmers who produce mainly for subsistence and sell off only the excess. This leads to the potato production system that is characterised by low in puts and yet there are constraints of diseases and pests, unavailability of affordable adequate quality planting materials and poor marketing systems. Thus, the challenges faced by farmers and the potato sub-sector stakeholders at large can be summed into:

- How to embrace the available technologies when they have limited resources
- How to improve infrastructural and technical capacities for mitigation of the production constraints

In the ECA, the above alluded to constraints and the inherent challenges have culminated into the low utilisation of quality seed ranking high among the factors that hamper production. Seed production is by large mainly the informal seed system that avails only about 1 % requirement of quality seed. This informal seed system is continually being supported by the formal one that is benefiting from the current advances in technology. Consequently, in the ECA countries, potato research and development revolves around enhancing the utilisation of quality seed potato. The National Agricultural Research Systems (NARS), International Potato Centre (CIP) and other development partners, in a complimentary manner, have committed substantial resources to improvement of the seed potato systems. To this endeavour, the potato research and development in most of ECA countries revolves around:

- Development and promotion of technologies for enhancing utilization of quality seed potato
- Development of disease and pest resistant potato varieties with desired culinary characteristics
- Training farmers in application of available potato production technologies
- Improving seed production, storage and quality control capacity, laboratory and associated facilities.
- On-Farm research and dissemination of crop management measures.

This paper highlights areas where progress has been made and brings out some of the success stories.

Plenary 3

Calculation of carbon footprint of potato production

Anton J. Haverkort, Plant Research, Wageningen University, pobox 616, 6700 PA, Wageningen, NETHERLANDS,

The level of carbon-dioxide (CO2) in the air in the northern hemisphere was 315 parts per million in 1958 and currently it is 390 and continues to rise. It serves as a greenhouse gas as do methane (from cows and rice production) and nitrous oxide gases from bacterial soil live. Especially these gases contribute to the greenhouse effect as they are 300 times more effective than carbon dioxide. A reduction of greenhouse gas emission by agriculture could be a substantial means of mitigating its effect on climate change.
A new tool to calculate the CO2 emitted in the production of crops or animals in agriculture is the Cool farm Tool (CFT) developed by dr. Jon Hillier at the University of Aberdeen commissioned by Unilever. The CFT-Potato is potato specific. It needs the site and country as some countries have a high emission level of electricity used for pumping and cooling where mainly coal is used whereas e.g. France has a low level as here nuclear energy is used. The tool asks if soil is sandy, medium or heavy as heavier soils require more energy to plough and to harvest. Soil organic matter, humidity and acidity are reported as they influence nitrogenous fertilizer break down to volatile compounds and high organic matter soils lose soil carbon. Fertilizers – total amounts and type - are noted as well as the sources of potassium, phosphorus and calcium, manure and slurry and the number of applications of herbicides, insecticides and fungicides. The Tool then sums up all the embedded energy to produce the chemicals and how much CO2-equivalents of nitrous oxygen is emitted. Next all operations are recorded such as plowing, ridging, destining, spraying, spreading, irrigation, on farm transport of materials and tubers and harvesting. The Tool then calculates – based on ASABE data - how much diesel and electricity is used and converts it into kg CO2. Finally the tool asks whether the product is washed, graded, loaded into a store and stored with ventilation and refrigeration and about the use (number and dose) of sprout suppressant. The original Tool did not contain information nor questions about irrigation, grading, storage and sprout control. So we collected data from various operations and came up with easy questions such as how many millimeter did you apply in total and for how many weeks did you store and how many degrees was the potato in the store cooler than the average outside temperature. From our data we know how much electricity it costs to irrigate one mm, or to cool potatoes down per degree for one week. We also changed some figures the ASABE data base clearly underestimated such as for sub-soiling and harvesting.
Finally the grower has to fill in the yield and the seed rate and the Tool calculates the CO2 emission associated with the production of one ton of potato, usually a few hundred kilograms. The tool is helpful in benchmarking different growing systems such as tropical highlands or temperate climates, dryland or irrigated farming, organic or current, low or high input production and stored or transported. Policymakers of governments and companies my use it to take decisions and develop strategies such as Walkers Crisps in the United Kingdom to reduce the CO2 foot print. For individual growers at specific fields the tool as yet needs to be tested and possibly be fine tuned further.

Plenary 4

Genomics leads to new discoveries and practical solutions to disease control for the bacterial potato pathogens *Pectobacterium* and *Dickeya*

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In 2004 we published the genome sequence of Erwinia carotovora subsp. atroseptica (now Pectobacterium atrosepticum_Pba). From the sequence it became clear that Pba contained many genes that were previously undiscovered in this group of pathogens but that potentially code for new pathogenicity determinants as well as factors involved in plant colonization when not causing disease. Our work since then has involved the use of a number of functional genomics methods to discover what we can about the ways in which this pathogen interacts with plants and causes disease, and how it has acquired the means to do this. Many of the putative pathogenicity genes have been tested and shown to be directly involved in disease. Information from these studies has allowed us to identify potato genes involved in resistance and this knowledge, in turn, was used to make a transgenic potato plant that was fully resistant to the pathogen. We have also identified genes within the genome of Pba involved in attachment to, and colonization of, the roots of many different plant types, including both crops and weeds. This knowledge is being used to determine the presence of alternative host plants in the environment and their potential role for spreading the pathogen to and between potato crops. Recently, we sequence 16 strains of Dickeya species and used this information to develop a new method of primer selection on a multi-genome scale. These primers are now available for use in molecular diagnostics of the soft rot potato pathogens D. dianthicola, ‘D. solani’ and other Dickeya species (formerly Erwinia chrysanthemi).

Plenary 5

Molecular arms race between viruses and potato plants

Jari P.T. Valkonen, Department of Agricultural Sciences, University of Helsinki, Latokartanonkaari 5-7, PO Box 27, FI-00014, Helsinki, FINLAND,

Viruses are considered to be the most dangerous pathogens of potato due to the ease by which they are transmitted to new crops in seed tubers and the heavy yield losses they cause. Viruses cannot be controlled by chemical treatments during the growing season. Transmission of viruses is also difficult to control in the field. Success in control of the persistently transmitted *Potato leaf roll virus* (PLRV) can be met by killing the vector aphids with insecticides, and some control of non-persistently transmitted viruses such as *Potato virus Y* (PVY) can be achieved using mulching during the early growth stage of potato plants. Due to these limitations, use of virus-resistant potato cultivars remains as the main approach to control potato viruses in the field. Breeders have introduced a number of dominant, virus or virus strain specific resistance (*R*) genes to cultivars. Locations of *R* genes against PLRV, PVY and potato viruses A (PVA), M (PVM) S (PVS) and X (PVX) have been mapped on potato chromosomes. DNA marker assisted selection of these genes and resistances is now possible in breeding programmes. The gene *Rx* for extreme resistance to PVX has been isolated. There are also other types of virus resistance which have been exploited less in breeding of potato than other crops of Solanaceae. They include recessive resistance based on mutated genes encoding the translation initiation factor 4E or its isoform. Recently, a proteinase inhibitor has been shown to confer resistance to systemic movement of PVA in potato plants. However, viruses have evolved various means of evade or suppress antiviral defense in their host plants. Mutations in viral proteins allow virus to evade recognition by the *R* genes. Active suppression of RNA silencing, the basal antiviral defence mechanism of plants, is used by all viruses. Current knowledge of this "arms' race", as relevant to resistance breeding and virus diagnostics, will be discussed.

Plenary 6

A new paradigm in potato breeding

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Progress in potato breeding is very slow. Century old varieties like Russet Burbank and Bintje are still cultivated, due to the lack of genetic improvement because of the tetraploid inheritance and obligatory out-breeding. Therefore, genetic gains cannot be fixed and the number of meiotic recombination events is limited. Furthermore, vegetative propagation is prone to the spread of diseases and subsequent yield losses.
Alternatively, genetic improvement based on F_1 hybrid seed breeding would overcome these constraints. This approach has long been considered unrealistic, as this requires self-compatible and vigorous homozygous inbred lines, which has never been achieved before, due to severe inbreeding depression and self-incompatibility in diploid germplasm.
Recently, Phumichai et al., (2005) reported about the *Sli* gene originating from *S. chacoense* that inhibits incompatibility in diploid potato. This allowed repeated selfings to generate homozygous genotypes. However, the homozygous clones showed low agronomic performance as tuber quality and yield were low indeed. In our opinion, the combination of a wide diploid germplasm with much allelic variation and this *Sli* gene are the basis for a breeding programme aimed at selecting for inbreeding tolerance.
Therefore, we made crosses with the *Sli* donor with diploid elite germplasm that has been generated during the last thirty years at Wageningen University. This collection has been enriched with important traits for potato breeding, such as disease resistance, tuber quality and yield. Genetic analyses with a set of hundred SNP-markers, well spread over the potato genome, showed a rich reservoir of genetic variation in this collection.
Several offspring populations were generated, like F_3, BC_1 and BC_2, and analysed for segregation of SNP markers. Most of the markers segregated according to a single locus, though distorted segregations frequently occurred. This is probably due to alleles with reduced fitness, while absolute lethal genes were not identified. The best F_3 lines were more than 90% homozygous and some individual plants showed tuber yield close to the diploid controls. This paves the way towards F_1 hybrid breeding.
Finally, we started a practical breeding programme aimed at developing commercial F_1 hybrids. Numerous F_2 and BC_1 plants, from crosses described above, were tested in the field. The majority of the plants showed weak plant performance, sterility, self-incompatibility or weak tuber quality. However, some dozens self-compatible plants were selected with good agronomic and tuber characteristics. These were crossed with other elite diploid clones in order to develop a series of inbred lines with good agronomic performance that are the basis for F_1 hybrid breeding programmes for various markets.
F1 hybrid potato breeding will lead to a paradigm shift as the consequences for breeding, propagation, farming, processing and consumption are unprecedented.

Plenary 7

Potential and limitations of plant virus epidemiology: lessons from the Potato virus Y pathosystem

Thomas F. Döring, Crop research, Organic Research Centre, UK, Elm Farm, RG20 0HR, Hamstead Marshall, UK,

Plant disease epidemiology provides powerful tools to identify key factors in virus epidemics of agricultural crops. When successful, epidemiological approaches can help to decide which the most appropriate strategic options are in plant protection. A recent example is the successful identification of PVY vectors in a high grade seed potato production area in Northern Finland through epidemiological modelling. Here, the black bean aphid unambiguously emerged as the main vector of PVY from the joint analysis of vector, virus and plant growth data. In addition, modelling allowed the timing of the main virus transmission activity to be identified as the early part of the growing season, shortly after emergence of the potato crop.
However, pathosystems are not always as straightforward as this case. In fact, the notorious complexity of plant virus pathosystems, with multiple interactions between virus, vector, plant and environment, makes them often impenetrable even for advanced epidemiological models. In addition, several other dynamic factors often make plant virus pathosystems near-unpredictable. These include the rapid evolution of new virus strains, the constant turn-over of crop varieties, the climate-change driven shifts in geographical distributions of vector species, the evolution of vectors in response to insecticide treatments, or changes in agricultural management, as for example in the use of crop rotations or management of non-cropped areas.
This dynamic complexity questions the universal validity of employing mechanistic epidemiological models that attempt to identify key factors in plant disease epidemics for designing specific management responses. Indeed, more complex pathosystems require more data to be gathered before epidemiological models can make accurate predictions, with consequences for the costs of such approaches. In addition, the transferability of epidemiology-based insights from one region to another is frustratingly low in ever-changing environments.
I therefore argue that a complementary approach is needed that acknowledges the indeterministic nature of complex and evolving pathosystems. Such an approach is the use of diversity (e.g. of treatments or varieties), employing functionally complementary elements that can jointly buffer against environmental changes. Genetic diversity of crops and diversity of management options provides insurance against plant disease outbreaks even though the underlying mechanics of the pathosystem are not fully understood (nor ever fully understandable). It is predicted that not only for plant virus control, but for a much wider range of plant production problems, the strategy of combining deterministic and diversity-based approaches will provide the most potent and most sustainable solutions.

Plenary 8

The role of traditional potato breeding in scientific potato improvement

Charles R. Brown, USDA/ARS, USA, 24106 N. Bunn Rd., 99350, Prosser, USA,

Traditional breeding of potato, as it has been practiced for over a hundred years, has produced thousands of new varieties worldwide. With the advent of biotechnology it has appeared at various times and places that a sexual breeding might become a rarity. However, even with the tremendous array of molecular information and tools that have arisen, the need to carry this out in the context of a traditional program has not really diminished. With certain exceptions, the best commercial opportunities seem to arise from mostly non-GMO progeny of crosses. This dynamic comes about partly due to the lack of inbred line breeding methodology. A breeder cannot perform cycles of recurrent selection without placing materials in the field for selection for type, yield, and minimal storability and processability. In addtion breeding is not a one-way process. The breeder does not simply implant genetically variable potato and thereby make an impression on an unchanging environment. For those who have selected for disease and pest resistance an assessment of intensity and stability of response is often an open-ended and puzzling course of study. Disease and pest nurseries vary between years and may change in virulence specificities when faced with a new host resistance strategy. The disease/pest response may change rapidly or slowly, requiring multiple isolation of newly appearing strains. The truth is that most deep genetic knowledge starts with preliminary low technology observations of variation that are most economically observed in field plantings. All new varieties are compromises in performance of numerous traits. Although the pyramiding of traits appears to be manageable especially with molecular markers and accumulation of genes in transgenic schemes, multiple trait combinations are still coming about as a result of traditional breeding which is often the culmination of many decades and several careers of crossing and screening. A breeder's mind and intuition has something important to contribute in the midst of gene chips and genome sequences
This paper highlights areas where progress has been made and brings out some of the success stories.

Plenary 9

Molecular diagnostics for complex disease resistance and tuber quality traits: concept, achievements and perspectives

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Claude Urbany, Max Planck Institute for Plant Breeding Research, Köln, GERMANY,
Li Li, Max Planck Institute for Plant Breeding Research, GERMANY, Köln, GERMANY,
Benjamin Stich, Max Planck Institute for Plant Breeding Research, Köln, GERMANY,
Joao Paulo, Biometris, Wageningen University, Wageningen, NETHERLANDS,
Astrid Draffehn, Max Planck Institute for Plant Breeding Research, Köln, GERMANY,

Most agronomic characters that are relevant for potato cultivation and its use as food, feed and starch source are complex, meaning that they are controlled by multiple genetic and environmental factors. Knowing the genes and their allelic variants that underlay agronomic traits allows the development of molecular diagnostic tools for selecting improved potato cultivars. Diagnostic DNA-based markers are either derived directly from polymorphisms in genes causal for a trait of interest or are in linkage disequilibrium with those genes. They can be used to identify superior genotypes among parents and progeny in breeding programs (Precision Breeding). Diagnostic markers can be identified by combining QTL (quantitative trait locus) mapping, candidate gene mapping and association mapping using functional and positional candidate genes as markers. This approach was successfully used to identify loci, which contribute to the natural variation in modern breeding populations of the following traits: field resistance to late blight not compromised by late maturity (Pajerowska-Mukhtar et al. 2009, Genetics 181: 1115-1127), resistance to the root cyst nematode *Globodera pallida* (Sattarzadeh et al. 2006, Mol Breed 18:301-312), tuber starch content, yield, chip color (Li et al. 2008, Theor Appl Genet 116:1167-1181) and susceptibility to bruising (Urbany et al. 2011, BMC Genomics 12:7). Statistical epistasis between candidate loci was found for tuber starch content and starch yield (Li et al. 2010, Theor Appl Genet 121:1303-1310). In collaboration with breeders, DNA-markers associated with field resistance to late blight or tuber quality traits are currently evaluated for their diagnostic power in marker-assisted selection experiments. Allele mining and comparative sequencing of candidate gene alleles revealed an amazing degree of molecular diversity in potato, which is explained by its reproductive system (Draffehn et al. 2010, BMC Plant Biol. 10: 271). In the future, whole genome association mapping based on SNP (Single Nucleotide Polymorphism) genotyping methods in combination with the annotated potato genome sequence (Potato Genome Sequencing Consortium) will allow the identification of additional genes controlling important agronomic traits in potato, provided that accurate phenotyping is combined with genome wide genotyping. This will further facilitate molecular diagnosis, selection and combination of superior alleles in potato.

Plenary 10

Physiological and genetics determinants of *Streptomyces scabies* pathogenicity

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Streptomyces scabies is the main causal agent of common scab, a disease characterized by corky lesions on potato tubers and several root crops. It was shown that thaxtomin A, a phytotoxin produced by the pathogen is essential for pathogenicity. The genes responsible for thaxtomin biosynthesis are located on a large pathogenicity island in the bacterial genome. The mechanism of action of this toxin has yet to be elucidated, but it was shown that thaxtomin A inhibited cellulose synthesis. Thaxtomin A also induces, at least in some plant species, both a genetically controlled cell death and the biosynthesis of phytoalexins. *S. scabies* can produce thaxtomin A *in planta* but also *in vitro* when the culture media contain suberin and cellobiose. Suberin is a complex plant polymer composed of both polyaliphatic and polyphenolic domains. This biopolymer protects tubers against microbial infection. *S. scabies* can overcome this physical barrier by producing extracellular esterases that degrade suberin. *S. scabies* proteins that are differentially expressed in the presence of suberin are associated with energy metabolism, stress adaptation, carbon acquisition and possibly with virulence. In the presence of suberin, *S. scabies* underwent physiological changes that included membrane and cell wall modifications. Cellobiose, the other plant compound responsible for thaxtomin A biosynthesis, is the main degradation product of cellulose. Since *S. scabies* cannot grow on cellulose as the only carbon source, one can question how the pathogenic bacteria will be in contact with cellobiose during pathogenesis. Recent evidence reveals that enzymes degrading cellulose are produced by *S. scabies* when suberin is present in the bacterial environment.

Plenary 11

Drought and Salt Stress Tolerances in Wild species and Transgenic Potatoes

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Many wild relatives of potato can cope with drought stress conditions in their habitats. Forty four accessions of wild species were chosen from drought habitats with GIS information. These individual seeds were evaluated on solidified MS media with 0.04 g/mL of mannitol previous determination of an appropriate mannitol concentration. Germination percentage, root and shoot length were considered as response indicators. Based on the phenotypic evaluation, seedlings from S. *chillonanum*, S. *jamesii* and S. *okadae* were selected as potential drought tolerant. Examination has been made on whether those wild species would have alternative stress responses and corresponding genetic systems over cultivated potato germplasm.

Transgenic potatoes were also studied with their transgene functions and also tested whether a diversity of gene actions occur with different stress tolerance inducing genes.

Previously our *AtDREB1A* transgenic potato lines exhibited high survival rates under freezing or salinity stress conditions. However, the practical performance and mechanism of the enhanced abiotic stress tolerance should be elucidated further. To select available transgenic lines, we also measured growth profiles under non-stress conditions in our evaluation of transgenic lines and confirmed productivity. Additionally, we performed microarray analyses to clarify the abiotic stress tolerance mechanism controlled by *AtDREB1A*. Two transgenic lines displayed stable tuber production under high salinity stress conditions. We identified five significant genes that were induced by abiotic stress and *AtDREB1A* in potato; the reported homologs in *Arabidopsis* are downstream of the *AtDREB1A* gene. Our results suggest that the *AtDREB1A* gene acts as a transcriptional factor against abiotic stress in potato, and that potato may have mechanisms in abiotic stress tolerance controlled by a native transcriptional factor similar to *AtDREB1A*. We believe that our findings will lead to the identification of *AtDREB1A* orthologs in potato and will effectively improve potato cultivars for abiotic stress tolerance through biotechnology.

Further challenges would be comparing more details of the stress responses between cultivated and wild species, in order to examine whether effective germplasm enhancement could be carried out from wild species on the drought and salt stress tolerances.

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Plenary 12

Phytophthora infestans effectors in late blight disease development, and exploitation for disease control

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Over 160 years since the first late blight epidemics in Europe, *Phytophthora infestans* is still considered to be the most damaging disease of potato. Management of the disease may be through application of agrichemicals, or through deployment of resistance in potato cultivars. Historically, the latter strategy has not been highly successful, influenced in part by a failure to consider variability in 'elicitors' of resistance in *P. infestans* populations. As a consequence, pathogen strains able to overcome the resistances have been selected and increased in prevalence. Resistance to *P. infestans* is mediated through the recognition of pathogen proteins, termed avirulence effectors. In *P. infestans*, all identified avirulence effectors to date are secreted modular proteins that contain a conserved RXLR peptide motif, and a divergent protein domain that is recognised by the resistance proteins. These effectors are delivered inside potato cells where they are either recognised or exert their virulence function. At least nine genes encoding avirulence proteins have been isolated from *P. infestans* and forms that are not recognised by the cognate potato resistance genes have been identified. We are exploiting the knowledge of RXLR effectors to predict and identify potentially durable resistance by using an integrated approach of effector allele sequencing, gene expression profiling, cell biology, gene silencing in *P. infestans*, and screening in cultivated and wild potato species. The utility of this strategy, using avirulence effectors PiAvr3a and PiAvr2 as examples, will be presented.

P. infestans also produces a broad spectrum of additional secreted proteins, many of which may aid infection. As pathogen proteins that are exposed to plant cells, these potentially may act to trigger resistance, either as broad spectrum pathogen associated molecular patterns (PAMPs) or as specific effectors of resistance, or may offer alternative targets for novel agrichemical development. We have silenced a diverse selection of these candidate secreted effectors and demonstrated effects on late blight disease development. Results from these studies are aiding a deeper understanding of *P. infestans* disease development and identifying potential pathogen weaknesses for exploitation in future control measures.

Plenary 13

Updates and outcomes from the Potato Genome Sequencing Project

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With the availability of the draft sequence of potato new possibilities offer themselves to researchers in the potato field. The recently completed genome sequence gave us a first view into the number of potential genes in the potato genome and because of the partial sequencing of three haplotypes also a glimpse into differences between different haplotypes. We now also have a better view as to what makes the potato. More importantly the sequence will enable us to target in a more directed way the traits of interest and importance thus bringing precision potato breeding within reach. Genome wide association studies are now possible and the quest for the determining alleles for different traits will enter a new phase. Having linking pins for most regions of the genome will put more emphasis on the accuracy and throughput level of phenotyping. In combination with the availability of transcript, protein and metabolite datasets this will give new leads for quality traits in potato as well as possibilities for predicting performance in different environments and under different stress conditions. Some examples of this will be presented.

ABSTRACTS

Concurrent sessions

Session 1

Accerelated breeding in potato using marker assisted selection: strategy, prospects and challenges

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Most potato breeding programmes aimed at commercial cultivar develoment follow the same basic breeding scheme which typically takes up to 15 years to produce a variety. The breeding scheme comprises of two phases, a single round of crossing and over a decade of recurrent phenotypic selection and advanced trialling to produce a new variety. The goal of potato breeding programmes is to produce high-yielding, uniform varieties that possess a combination of disease resistance and tuber quality traits. Significantly however, the implementation of such a breeding scheme makes production of varieties that combine all these traits extremely difficult to achieve. Over the last decade, DNA-based molecular markers which allow diagnosis for the presence or absence of the genetic components of traits without the need for laborious multiplication and testing have gradually become available for several disease resistances and quality characteristics, hence, raising the possibility of accerelated breeding programmes. Therefore, a small scale experimental breeding programme was developed to investigate the potential for the routine deployment of marker-assisted selection (MAS) as part of the potato breeding programme at Oak Park and to rapidly pyramid and multiplex multiple traits into a single individual over three successive annual rounds of crossing.

Session 1

Evaluation and application of molecular markers within the Australian potato breeding program

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Current Australian commercial cultivars suffer from a number of production and quality issues. Commercial cultivar development within Australia currently uses a conventional potato breeding strategy, relying on outcrossing and screening of a large number of derived lines to identify improved cultivars. Implementation of marker-assisted selection (MAS) is highly desirable to increase the efficiency in identification of improved cultivars. Implementation of MAS will be conducted when MAS is more efficient or cost-effective than traditional screening techniques. Within the Australian breeding program the initial targets for MAS have been disease resistances. There are several diseases of concern within the Australian potato industry, potato cyst nematode *G. rostochiensis* Ro1 (PCN) and potato virus Y (PVY) pose the greatest threat and development of cultivars resistant to both PCN and PVY is therefore a high priority. Screening of 264 parental cultivars with the TG689 marker linked to *H1*-mediated PCN resistance identified 98% congruence, but also a loss of association between the marker and resistance gene in 5 cultivars. Evaluation of an alternative marker, 57R, more closely linked to the *H1* resistance gene revealed 100% congruence between phenotype and genotype data for the same 264 cultivars, suggesting 57R is a more diagnostic marker for predicting PCN resistance than TG689, which will be confirmed with further efforts. In parallel, over 550 parental lines were genotyped for PVY resistance with two molecular markers, RYSC3 and STM0003, linked with the resistance genes Ry_{adg} and Ry_{sto}. Only 5 cultivars were identified as resistant through genotyping efforts, however, phenotype screening in the glasshouse identified an additional 2 cultivars with putative PVY resistance attributed to other sources of resistance. To implement genotyping in the most efficient manner traditional agarose based PCN and PVY markers have been converted to fluorescently labelled markers resolved on capillary electrophoresis platforms in multiplexed formats and have been screened across second and third generation breeding lines where appropriate, based on existing pedigree knowledge of the parental lines. This represents the first use of MAS in Australian potato breeding. A combination of MAS and traditional screening will enable the earlier identification of superior cultivars for the Australian potato industry.

Session 1

Molecular Marker Assisted Selection (MAS) application in a small breeding company

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The main objective of any breeding program is to obtain new cultivars with improved characteristics such us high yield, quality traits and resistance to biotic and abiotic stresses. With the arrival of molecular markers, a promising new way appeared in plant breeding. To date, many markers linked to useful traits have been found and "easy-to-use" PCR based markers have been described. Currently, the potato map is one of the most highly saturated maps with different molecular markers, offering several opportunities to potato breeders. However, the reality is that, despite all its advantages, the application of MAS in a real breeding program is not so straightforward and needs good planning, qualified personnel and equipment investment.

A practical case of MAS for pathogen resistance applied to the breeding programme in a SME shows the advantages and disadvantages in the use of molecular markers. Resistance selection to some of the most important potato pathogens, like potato viruses or nematodes, is now possible in an easy and fast way applying molecular markers. The calculation of the allele dosage of the resistance gene of each progenitor based of the segregation ratios of the markers in the progenies is also possible using MAS. This allows the breeder to choose the best parents for his breeding lines. The costs of applying this kind of technology, compared with classical breeding tools have also been calculated.

Session 1

Genetic analysis in a highly heterozygous diploid potato cross segregating for many commercially relevant traits

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To ensure that modern potato breeding becomes more efficient in meeting changing needs, there is a strong requirement to develop effective links between modern molecular genetics and the improvement of potato (*Solanum tuberosum* L.). Conventional potato breeding relies on multiple rounds of phenotypic selection for desirable traits, rather than exploiting genotypic information. Typical potato breeding programmes result in many clones being discarded at an early stage leaving relatively small numbers of clones from which to select genotypes possessing critical traits (e.g. disease resistance and processing qualities).
Recent progress has been made in mapping and developing markers diagnostic for simply inherited traits. For marker assisted breeding to become economically viable, it will be important to develop many valuable markers that can be used simultaneously to carry out multi-trait analysis on breeding material. The potato genome will be an invaluable tool in the development of new markers and in the identification of genes involved in potato traits.
The population chosen for this study is the '06H1' cross, a highly heterozygous cross between two F_1 hybrid clones each from a diploid Group Tuberosum x Group Phureja cross. This cross segregates for several important traits. To date, two years of field trialling have taken place and an extensive amount of phenotypic data has been collected on 22 traits (e.g. sprouting, dormancy, tuber quality characters, yield, emergence and maturity) with broad sense heritabilities ranging from 0.55 to 0.88. Field trialling will continue over the next few years building on the existing data but specifically targeting markers associated with the control of tuber initiation, for which there is little genetic understanding.

Single nucleotide polymorphisms (SNPs) are highly abundant in the potato genome and are highly informative co-dominant markers. A 10,000 SNP platform has been generated through the SolCAP project, derived from transcript sequences from three US potato cultivars. These SNPs have been chosen to maximise coverage of the potato genome (~650Mb of 850Mb genome anchored). We have screened 190 clones of the 06H1 population using the SolCAP SNP panel (~3600 polymorphic loci) and a linkage map is under construction. Quantitative trait locus analysis will be performed using the map and the phenotypic data. The objective is to identify informative markers linked to many commercially valuable traits with an aim to use these markers in sets of diploid and tetraploid crosses from commercial potato breeding programmes.

Session 2

Multiplication Factors in Potato (Solanum tuberosum L.)

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Compared with most other crops, potato has a very low rate of multiplication during seed production. Seed potatoes are expensive as it takes many cycles to scale up the available seed lot of a new variety. Moreover, a large proportion of the total potato area is required for seed tuber production. The potato plant, however, is extremely versatile in its methods for rapid multiplication. Most buds can form a new shoot thus creating more buds, whereas each bud has the potential to form a tuber. Especially for the early phases of a seed production system, when increasing the total number of propagules is more important than their individual vigour, many different methods of multiplication have been designed. Propagules can vary in origin, type of organ or tissue, size, and vigour. They can include protoplasts, pollen, meristems, root tips, shoot tips, sprouts or sprout cuttings, (apical, stem, and nodal) cuttings, microtubers, minitubers, cut or whole seed tubers, true botanical seed, etc.

The type of propagule best used depends on the phase of the seed system in which one wants to use the propagules, but having a maximum multiplication factor (often also in the shortest possible time when more cycles of reproduction can take place) creating a type of propagule with a well-defined, minimum level of vigour is always essential.

Effective propagation of potato is actually propagation of active meristems followed by differentiation into a structure with enough vigour to be used as starting material for a next phase. Propagation can therefore consist of proliferation of a meristem into multi-meristem structures but also of simply cutting a single, large tuber into several seed pieces, each with at least one eye. Proliferation is influenced by the activity of a single meristem (e.g., by continuous production of new nodes each with its own auxiliary bud) or by branching thus increasing the number of active meristems. Our knowledge of shoot branching has increased tremendously over the last few years and it is interesting that many of the physiological factors determining branching also play a key role in the different processes associated with tuberization and subsequent tuber formation, including creating eyes.

Actually the most determinant factor in increasing the multiplication factor is the demand put on the type of propagule desired. The use of propagules demands certain robustness and creating that robustness requires differentiation which is often at the expense of further proliferation. During the differentiation phase, competition for resources becomes relevant. Apical dominance, hierarchical relationships, carbon and nitrogen assimilation, internal sugar and hormone signalling, internal communication within the propagule or plant, and plant organization all play a significant role in determining how this competition will affect multiplication. Proper manipulation of the key factors will allow us to reduce the impact of the factors thus pushing the multiplication factor to extremely high values under protected conditions.

The paper will unravel the key factors in rapid multiplication through different types of propagules, highlight their similarity in physiological terms and identify genetic variation in the expression of these factors.

Session 2

Seed Potato Production in Algeria using Hydroponics

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Crop demand in Algeria has continued to rise with a expanding volume of imports. Potato is one of the major staple food crops grown in Algeria for local consumption of 50 kg per year per capita. The area cultivated with potatoes about 90,000 ha producing about 2.0 million tons, with an average of 22.5 tons per ha. The lack of production technique and system of quality seed is a major constraint for growing potatoes in Algeria. The potato seed needs were met around 230,000 tons during the year 2005 and 100,000 tons were imported. For these reasons Algeria spends about 70 million dollars annually to import seed. Recently, Algeria has been achieved positive results in establishing quality seed potato production system through the implementation of the "Korea-Algeria Seed Potato Project (2007-2009)". During the project, Korea successfully transferred hydroponic technology and experience to Algeria in basic seed production by training and consulting. The details of the cooperative project between the two countries will be discussed.

Session 2

Tubering Characteristics Of Local Potato (Solanum tuberosum L) Genotypes

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Yield potential, secondary growth, tuber greening before harvest, growth cracking, hollow heart, internal rust spot, stolon attachment, length of stolon, tuber number per plant, tuber uniformity and tuber size considered as tubering characteristics by International Board for Plant Genetics Resources (IPBGR). These characters are just some of important features used to identify genetic material. In this research was used total 146 potato genotypes as material. The genotypes were taken according to stratified sampling system from 58 villages in high altitudes of province of Artvin and Rize located in the Eastern Black Sea Region of Turkey and were grown under Samsun ecological condition in 2006. Some morphological and agronomical characteristics of the genotypes published (Arslanoglu et al., 2011, African journal of Biotech., 10(6):922-932). Some of tubering characteristics of genotypes were given in this paper and their frequency distributions were calculated. According to tuber yield potential (g/plant) of genotypes varied between 12g and 2736.5g/plant. Two genotypes were very high tuber yield (scale 9) according to IPBGR scale. Most of genotypes yielded medium level (scale 5). Tubers per plant ranged from 1 to 31 tuber. Secondary growth was shown very low tendency in 22 potato genotypes, low tendency in 10 genotypes and very high tendency in 2 genotypes. Secondary growth wasn't observed in the other genotypes. Growth cracking varied between very high (scale 1) and very low (scale 9) in 74 genotypes. It wasn't observed in other genotypes. 10 genotypes was tendency to tuber greening before harvest according to scale 1-9. The tuber uniformity was very vaiable (scale 1) of 3 genotypes, variable (scale 3) of 4 genotypes, medium(scale 5) of 52 genotypes, very uniform (scale 9) of 21 genotypes, tubers of other genotypes were found uniform (scale 7). Tuber size of genotypes were determined medium (scale 5). Hollow heart tendency showed only one genotype (scale 9) in all genotypes and in the tuber of 3 genotypes (scale 9) found internal rust spot. As a result, 73 genotypes were selected taking into account all of characterization properties to be used in the future breeding researches.

Keywords: potato, local genotype, characterization, tuber yield

Session 2

The Sprout/Seed-Potato (S/S-P) Technology: An update on attempts to transfer this affordable minituber production system to developing nations.

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The Sprout/Seed-Potato technology (S/SP) has been an alternative, low cost system for large scale, high-grade minituber/seed-potato production. The sprouts (apical) used as seed source (propagating material) are by-product, usually detached and discarded from high-grade tuber/seed-potato stocks (imported or national). Advantages for the S/SP, as compared to plantlets and microtubers (laboratory dependents), are: low cost to obtain and transport sprouts; a less risk of soil borne spread, with similar minituber yield performance, under insect proof screen-houses. **In Brazil,** over the past 15-yrs, the S/SP has been proving to be an alternative, affordable and effective system of producing high-grade minituber/seed-potato lots for small potato producer . Since 2006, attempted have been made to transfer and evaluate the S/SP as an alternative system aiming to improve the seed-potato (minituber) production in developing countries: China, Mozambique and Benin (Souza-Dias et al., 2008, Abstracts of the 17th Trienial Conf. EAPR, Brasov, RO, p. 184-187; Caram Souza-Dias, et al., 2010. 14th EAPR-Virology Sct. Mtn, Hamar, Norway, Biofork FOKUS 5(5):16). **In China**, a cooperative S/SP research project is underway (Gomes, C. 2009. Diário Oficial ESP, IV-119-4, 08/01/2009). Last October, 2010, a first import permitted shipment of sprouts, as seed source, was successfully delivered (5-day delivery via FEDex-express), composed of 100 sprouts of each Brazilian APTA-IAC genotypes: Clone 2.5/ARVitoria, cv. 6090/IAC-IbituAçu, cv 5986/IAC-Itararé and cv. IAC-AracyRuiva.
Upon arrival, sprouts were taken into a greenhouse and planted in pots containing substrate. Although evaluations are underway on plant emergence, healthiness, minituber (number, size, weight, shape, dormancy) and further field tuber/seed-potato production, a renewal of the import permit for shipping the sprouts this year has already been. **In Mozambique**, last December 2010, after a first presentation of the S/SP to potato researchers, extensionists, and producers, in Maputo and Lichinga, an import permit was issued and experimental shipment of sprouts have been prepared (same IAC cvs. as sent to China). **In Benin**, a first visiting on the potato areas has taken place; sprouts from Germany potato cv. Granola has been permitted for the S/SP evaluations. The interest and expectation demonstrated by potato experts and producers toward success of the S/SP tech. will be discussed based on its potential for enhancing potato production, via supply (export-import) of a more accessible high-grade seed-potato product to their small potato producers.

Session 3

Spreading of new *Dickeya* spp. (*Erwinia chrysanthemi*) causing blackleg and soft rot of potato in Europe

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Soft rot enterobacteria are plant pathogens that cause rotting of numerous plants including potato. These bacteria cause blackleg (rotting of potato stems) in the field and soft rot of tubers during storage. In the temperate climates blackleg is caused mainly by *Pectobacterium atrosepticum*, while *P. carotovorum* mostly causes rotting of potato tubers. However, new variants of *P. carotovorum* and new species *P. wasabiae* have been identified from potatoes in Europe and elsewhere. Pathogens in the genus *Dickeya* (former *E. chrysanthemi*) cause blackleg and soft rot on potato especially in warm and tropical climates. Bacteria in the *Dickeya* genus can be divided into seven species, several of which can cause diseases on potato in various parts of the world. During the last decade the economical losses caused by potato blackleg and soft rot have increased. To understand the reason for this change, the bacterial populations present in diseased potato have been analysed in several countries including Finland. In several European countries a new clade of *Dickeya* has been identified. It is anticipated, but not yet proven, that is it a new bacterial species that has moved from ornamentals into potato in Holland. The species name *Dickeya solani* has been suggested. The characteristics of this pathogen are different when compared to the previously predominant pathogen *P. atrosepticum*. *D. solani* has higher growth optimum and is thus favoured by hot weather, it can apparently cause disease by lowed bacterial loading, it has an improved ability to invade undamaged roots in the soil and it causes higher levels of blackleg in the field. Apparently the introduction of the new *Dickeya* species as well the other, yet uncharacterised *Pectobacterium* variants and species into the potato cultivation chain is the reason for the increased damages and economical losses both in seed potato and ware potato cultivation.

Session 3

To the question on of potato protection system from diseases

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Abstract
On the basis of generalization and analysis of scientific results of long term multifactor field experiences and laboratory researches using mathematical methods, innovative biologized system of early potato protection from the main diseases for soil-climatic and organizational-economic conditions of the Republic of Bashkortostan was developed.

Introduction
Integrated plant protection system in the Russian Federation is not spread as its main aim has not been realized yet. Necessity of further thorough scientific researches of plant protection theory and practice is defined.

Materials and methods
In the experimental farm of the Bashkir State Agrarian University two factor field experiment on improvement of biologized potato protection system from diseases was established in 2009-2010. For research aims the super elite variety Nevsky was used. All observations, estimations and analyses were carried out using generally accepted methods. The experiment scheme is given in the Table 1.

Results and discussion
Leaf square in the experiment on the period of "blossoming+20 days" reached 57,9 thousands m^2/ha. The peak potato yield was under tuber treatment with Maxim 0,2 l/t and seedling treatment with Ridomil Gold MC 2,5 kg/ha; Tanos 0,6 kg/ha; Bravo 2,5 l/ha and rated fertilizer doze to 30 t/ha of tubers (33,8 t/ha). Dry matter content increases to 22-28%, starch content increases to 33-39%, ascorbic acid increases to 30-39,5%, nitrate content decreases to 40-46%, marketable value increases to 47-62% comparing with the control variant. Almost all diseases had extent and degree of development about 0% including the control plots.
Biological activity of biologized protection system of potato plantings from alternaria blight was very high (up to 35%). Development degree of alternaria blight to the time of harvesting was only 2-3 points. It means that all protection operations were highly effective. Such high potato productivity was achieved due to antiresistant strategy of fungicide use.

Conclusion
Thus, the analyses of our research work and the experience of leading potato growers of the Republic of Bashkortostan allows to make the following main conclusions:
1. Application in complex mixtures of the latest biologized fungicides of new generation mathematically reliably increases tuber yield and quality of potato.
2. Biologized early potato protection from diseases may be used with a great success when forecasts of epiphythoty fungi diseases are absent.

Session 3

Towards a better understanding of potato cyst nematode distribution on a national scale

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In order to understand the distribution of the population of the potato cyst nematodes *Globodera rostochiensis* and *G. pallida*, we developed a method to estimate the relative importance of three basic distribution channels of potato cyst nematodes: seed potatoes, machinery and soil tare. This quantification is a baseline for the evaluation of the effects of control measures for potato cyst nematode (PCN) on a national scale.

The baseline is determined by the surface planted with potatoes, the area infested with PCN, the proportion of resistant potato cultivars and the distribution of cysts trough different channels. The relative importance of the potato cyst distribution channels is determined by the frequency with which these channels are used, as well as the agricultural and other practices applied. We calculated the numbers of parcels per crop type planted with seed potatoes of a certain origin and their degree of infestation. We estimated all machinery operations in each type of crop and their characteristics: number of parcels, number of infested parcels, amount of soil distributed. Per evacuation scenario and per product transaction of potatoes we estimated the volume of soil tare, the incidence and the level of the infestation in the soil tare, and the destination of the soil tare.
Combination of the data leads to an estimation per year of the number of infested fields and soil removed, the total amount of cysts moved, the amount of cysts per infestation, the number of infestations in the same field, in another field of the same farmer and in a field of another farmer.

We concluded that within a region, the main causes of spread are machinery and soil tare. The most important spread occurs within the field itself and in the fields of the same farmer. Soil tare causes heavier infestations in one spot. Machinery disperses less cysts, but the infestation is in multiple spots. Fields of other farmers can be infested by seed (little importance), machinery (subcontractors) and soil tare. For long distance dispersion of cysts, soil tare appears to be the most important vector. Soil tare is easily transported over longer distances via trade and processing industry when soil tare is returned to farmers. It seems practically impossible to exclude infestation of soil tare with soil from other farmers. Therefore, it is recommended to investigate the cost/benefit of disinfection techniques , e.g. inundation of soil, at the level of the processors. Machinery of long distance subcontractors, as well as seed potatoes, are also possible vectors of cysts between regions, but the number of cysts is smaller than with soil tare.

Session 3

Using massively parallel sequencing to investigate soil microbial populations and disease

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Robust quantitative molecular diagnostic tools and soil DNA extraction techniques have recently been developed that enable detection and quantification of soil-borne inoculum for target pathogens such as *Colletotrichum coccodes* (black dot) and *Rhizoctonia solani* AG3 (stem canker and black scurf) (Peters *et al*. 2011, Potato Res. **54**: 94-95). These tests should allow the relationship between levels of soil inoculum and disease to be determined. In some pathogens, where the understanding of diagnostics and epidemiology is good, there may be an established link between inoculum level and disease. However, with some pathogens, the relationship between inoculum levels in soil and disease is not so straightforward. It might be that, for diagnostic tools to be effective in predicting risk of disease, it is essential that we understand how soil-borne pathogens interact with other soil microbial organisms. For example, we know that effective irrigation management can control common scab (Elphinstone *et al*. 2009, PCL Report 2009/9). A study using massively parallel DNA sequencing (MPS) to identify broad taxa of bacteria in soils, found that some groups of microorganisms were more prevalent in irrigated soils where scab levels were low, and that these are likely to constitute the link between irrigation and scab control. Evidence suggests that these microorganisms could be suppressing pathogenic *Streptomyces*. We will present data showing how MPS has been used to show a link between soil microbial populations and disease using *Streptomyces* species and *Spongospora subterranea* (powdery scab) as examples.

Session 4

Identification and exploitation of candidate genes for adaptation to abiotic stresses in potato.

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The effects of global climate change involving large climatic variations and prolonged heat, cold, or drought periods are likely to threaten most crop species. It is necessary to develop new cultivars which are adapted to these threats. Most of the actually cultivated potato species are not adapted, but large germplasm resources in form of *Solanum* wild species or native potato species exist which carry important genes for resistance or tolerance to different abiotic stresses. The aim of this study was to detect candidate genes for tolerance to different abiotic stresses using different molecular tools and to develop molecular markers for marker assisted selection in molecular breeding.
We have evaluated in commercial potato varieties, breeding lines, native pòtato species and different wild species accessions the adaptation to different abiotic stresses (heat, coldness, drought) by means of greenhouse trials and bioassays. Susceptible and tolerant accessions to abiotic stresses were determined by evaluating chlorophyll fluorescence, chlorophyll content, electrical conductivity and hydric potential in stresses and unstressed plants. From these accessions mRNA was extracted before and after applying severe stress conditions and converted into ds-cDNA using standard methodology. The differential cDNA-AFLP technique was applied to perform comparative transcriptome profiling. Using various primer combinations several differentially displayed transcripts were identified in the accessions. These bands were isolated cloned and sequenced. Sequence analyses revealed interesting homologies with known genes involved in stress response and tolerance, confirming the efficiency of the approach.
On the other hand water use efficiency in terms of yield losses under stress conditions were analysed in the SHxRH reference population of potato and QTL analyses were performed with these data. Several QTL were detected and integrated into the available map. Also differentially displayed TDFs were located on the map using *in silico* mapping techniques.
On the other hand known candidate genes for abiotic stress tolerance in other crop species were used to identify the potato homologs which were integrated into the map through in silico mapping. Co-location analyses between candidate genes and QTLs were performed and revealed some interesting associations.

Session 4

Screening of potato cultivars against heat stress using cell membrane stability, growth and yield parameters

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The potato is a cool season crop with an optimal growth temperature between 17 ºC and 21 ºC. The higher temperatures than the optimum significantly affect several physiological processes related with yield and quality formation. The effect of global warming has been perceived more in recent years. Therefore, the studies on alleviating of negative effects of global warming on crops have been increased all over the world. It is estimated that potato yield and production will also be significantly affected by global warming in most of the current potato growing areas. Hence the studies on improvement of adapted potato cultivars to higher temperature have a great importance. The selection or breeding of heat tolerant potato cultivars is one of the most feasible approaches to cope with global warming. Heat tolerant potato cultivars is also very important to get high yield in Mediterranean-type environments due to supra-optimal temperatures during growing period.
This study was conducted to determine changes in growth and yield parameters of potato cultivars under high temperature and applicability of Cell Membran Stability (CMS) method to determine heat tolerance level of potato cultivars. Fifty potato cultivars having different origin and maturity period were used in the experiments. Seed tubers of each cultivar were planted into black polyethylene bags (26 cm diameter, 40 cm height) in an open area. After emergence of shoots, half of the bags transferred to the greenhouse, which has higher growth temperature comparing to open area. Other half kept in the open area until harvest. The growth temperature was higher 3-6 ºC during night, and 6-12 ºC during day time under greenhouse during entire growth period. Vegetative growth traits of such as plant height, stem diameter, haulm dry weight significantly increased when cultivars grown under high temperature. However, some yield components such as number of tubers per plant, mean tuber weight, tuber dry matter content, biological yield per plant, harvest index and leaf photosynthesis rate significantly decreased when cultivars exposed to high growth temperature. Mean tuber yield values of potato cultivars decreased 54% under high temperature comparing to yield of cultivars grown in open area, while decreasing in yield reached to 89% in some cultivars.

The potato cultivars showed significant variation in respect to electrolyte leakage amounts and CMS values. The Spearman rank correlation coefficients showed that CMS values of cultivars grown in both environment were highly correlated with stress indices. Hence it was concluded that CMS method can be used a reliable selection criteria to identify heat tolerant or susceptible potato genotypes.

Session 4

QTL analysis for root length and dry weight in a diploid potato population

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Improvement of root traits is important for breeding drought tolerant genotypes. However, measurement of root traits in field trials is laborious and time consuming. It is indispensable to develop new methods for efficient identification of genotypic differences in root traits. In the present study, we measured root length and dry weight (DW) in a diploid mapping population with plants grown in pots for two years, and analyzed QTL (Quantitative Trait Loci) for these root traits. In addition, root traits of selected genotypes were measured in the field to test the relation in root traits between plants grown in pots and in the field. Leaf senescence dates in the field were recorded in all genotypes to assess a possible relation of root traits with plant maturity.
MATERIALS AND METHODS: In the pot experiment, 101 genotypes of the CxE mapping population including parents were grown in pots (4.5 liter) containing volcanic ash soil and expanded vermiculite with four replications per genotype from April to July in 2009 and 2010 in Hokkaido University. The pots were located at an open-air place and irrigated daily when there was no rainfall. At 35 days after sprouting (DAS), underground parts were washed with running water and separated into roots, tubers and stolons. Aboveground parts were separated into stems and leaves. Root length was measured with WinRHIZO, and thereafter DW of each organ was recorded. In the field experiment, root DW was measured at 35 DAS in 2010 for eight genotypes of the CxE population with different root DW in the pot experiment in 2009. Dates of leaf senescence in the field were recorded based on visual observation of leaf color for all genotypes of the CxE population in 2009. The data were analyzed with SPSS and JoinMap.
RESULTS AND DISCUSSION: Root traits in the pot experiment showed highly significant genotypic differences and high heritability values in each year. The correlations between two years were high and the interactions between genotypes and years were negligible. Both root traits showed significant positive correlations with total plant DW and the ratio of root DW to total DW, and negative correlations with tuber DW and the ratio of tuber DW to total DW. All of the traits showed QTLs with high LOD scores almost at the same position on Chromosome 5. Root DW in the pot experiment showed a highly significant correlation with root DW in the field experiment in 2010. In addition, the genotypic differences in plant maturity in the field experiment of 2009 correlated significantly with root traits in the pot experiments in 2009 and 2010. The QTL detected for plant maturity was very closely positioned to QTLs for root traits on Chromosome 5. The present results indicate that the most important genetic factor controlling root traits is located on the top part of Chromosome 5. In order to be able to use maker assisted selection for root traits further research is required to elucidate whether the plant maturity QTL and the root trait QTL are really overlapping or not. To this end, a larger population needs to be fine mapped.

Session 4

Potato plant development under conditions of temperature decreasing - in the context of climate change

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Recently there has been increasing interest in summer–autumn potato cultivation with temperature decreasing, not only with a view to exporting seed potatoes to countries where potatoes are grown more than once a year, but also in response to climate change. The Intergovernmental Panel on Climate Change (Climate change synthesis report 2007; Olesen et al. 2007, Climatic Change 81,123-143) suggests, for agriculture in general, to introduce some adaptation techniques, such as adjustment of planting dates, crop variety and relocate crops. The aim of this work was to determine the influence of gradually decreasing temperatures during the summer-autumn growing period on potato plant development and the yields of chosen potato cultivars.
The experiment was conducted over two years under controlled conditions. During the two growing seasons, spring-summer and summer-autumn, the influences of rising and falling temperatures on potato plant development and yield were investigated. Both growing seasons, the spring-summer and the summer-autumn, lasted by 16 weeks. The rate of increase in temperature was established on the basis of the natural daily soil temperature at a depth of 10 cm, averaged over the previous 10 growing periods in the experimental field in Jadwisin (central Poland). The study period was divided into pentades (periods of five days) and the temperature applied to the first growth chamber was based on a regression analysis of these records. The values of the falling temperatures were the inversion of the rising ones and they were applied to the second growth chamber. The pot experiment was done with four cultivars. The seed tubers were pre-sprouted for both series over 5 weeks and then planted in a standardized peat-sand soil. After planting, the pots were placed in two growth chambers. At 60 days after planting plant structure was analysed. The analysis of final yield was done at 110 days after planting. The second series of this investigation, covered the summer-autumn growing period, was a repetition of the first series. The statistical analysis of the results was done using the ANOVA.
The significant influences of the growing period and the temperature system on yield and most of the plant traits were confirmed. The growing period had a stronger effect, than the temperature, on the number of stems, the leaf area, final yield and the average mass per tuber. However, the temperature regime had the greater effect on stem length, and on mass and number of tubers at 60 DAP, and on number of tubers in the final yield. The analyses of variance also showed significant interactions between most of the factors tested and cultivar. The response of the potato cultivars tested, to temperature decreasing was connected with the rate of physiological aging of mother tubers.

Session 5

Physiological aspects of plant development and yielding of potatoes growing under organic system

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The average yield of potatoes growing under organic system is about 20-40 % lower than under conventional. There are a few reasons effected these differences. Mains of them are: problems with late blight and Colorado beetle control, nitrogen and potassium supply, weed control etc. These factors also influence on development of potato plant and finally the level of yielding and tuber size distribution.

Aim

The aim of the experiment was to assess physiological differences of plant development during vegetation period between potato cultivars growing under conventional and organic crop production system and their influence on tuber yield.

Material and methods

The experiment was carried out in the years; 2009-2010 on the sandy loam soil under two crop production systems: conventional and organic. The same 4 cultivars of different earliness were tested: Milek – very early, Owacja- early, Tajfun- mid early and Ursus – late. Cultivars were chosen according to the highest resistant to *Phytophthora infestans*. During vegetation period following measurements were done: height of plants, stem number, fresh and dry matter of leaves and stems, assimilation area, LAI, the degree of interception of photosynthetically active radiation PAR and SPAD index. After harvest the total yield and tuber size distribution was assessed.

Results

The significant differences concerning 2 crop production systems related to following features: assimilation area, LAI index, stem fresh mass, dry matter of leaves, degree of PAR interception and SPAD index and tuber yield. There were no differences concerning to: height of plant, stem number, total above ground fresh mass. Cultivars differentiated of most tested characters. For most features the differences between years were found too. In organic system plants had about 60 g smaller mass of stems, about 0.8 smaller LAI index and about 1 % smaller leaves dry matter. Also SPAD index and degree of PAR interception was lower. For organic system the SPAD index was 33, 3 but for conventional 37,1 (average for cultivars). In organic system plants earlier got yellow and mature. The highest index was reached for late cultivar Ursus and the lowest for very early cultivar Milek. Average degree of PAR interception was 73,7 % for organic system and 83,6 % for conventional one. In organic system plants have reached the highest degree of PAR interception later than in conventional. The highest degree of PAR interception was noticed for cultivar Ursus and the lowest for cultivar Milek. These differences influenced on tuber yield and tuber size distribution. Under organic system the tuber yield was from 20 to 40% lower than in conventional. There were significant differences between cultivars too. The highest yield was reached for cultivar Ursus and the lowest for cultivar Milek. In conventional crop production system tubers were bigger than in organic.

Session 5

Nitrogen use efficiency and N crop status of selected potato cultivars under organic farming conditions

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Organic potato cultivation in Western Europe is predominantly nitrogen-limited. The aim of our study was therefore to examine if a range of currently widely used and new cultivars differs in terms of the efficiency with which they utilize the limited plant-available N, expressed as either N harvest index or N use efficiency determined at the time of maximum dry mater accumulation. Another objective was to examine a range of methods/parameters representing crop nitrogen status (whole canopy [stems and leaves] and tuber N uptake, nitrate in stem sap; chlorophyll [YARA-N-Sensor], total N and nitrate in the youngest-fully-developed leaf) under well-defined available N supply conditions.A field experiment with eighteen different potato cultivars with four field replications was conducted on Haplic Luvisol over two subsequent years (2009 and 2010) at the Hessische Staatsdomäne Frankenhausen, the experimental organically managed farm of the University of Kassel. The above mentioned parameters were assessed in the field and the laboratory, respectively at four successive dates (60, 70, 80 and 90 days after planting). Finally, total dry as well as total and size-graded fresh matter tuber yields were assessed at mature crop harvest.
Results show that even at a rather low N supply, as determined in the experiments (37 and 83 kg NO_3-N at crop emergence in 2009 and 2010, respectively), cultivars can be differentiated in terms of N utilization and efficiency as well as crop N status. The differences yield in N utilization (N removal by tubers 90 days after planting) between cultivars yielding the same tuber dry matter could be explained by differences in tuber N concentration (% in DM). Besides, results suggest that both leaf (youngest fully-expanded leaf) chlorophyll (Yara-N-Sensor) and N concentration in leaf DM (Dumas) used as an indicator of N status, vary genotype-specifically. A cross-check of values received with both methods gave R^2 of 0.67 (2009) and 0.46 (2010) which suggests reliability of the easy-to–handle field measurements obtained by Yara-N-Sensor. However, different slopes of the linear regression in the two years suggest a certain vulnerability of Yara-N-values to climatic conditions affecting leaf thickness and thereby measured values. Nitrate concentration assessed with the semi-quantitative method Nitracheck (in 2010, only) showed good correlation (R^2 of 0.83) with tuber nitrate concentration measured analytically in the laboratory. Hence, Nitracheck testing may serve as an indicator of table potato inner tuber quality and be used instead of the time-consuming and expensive laboratory method.

Session 5

Benchmarking on organic potato production and the quality and the sensory profile of selected varieties

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During the years 2007 to 2009 the potato cultivation was checked on 282 organically managed potato fields with the three waxy varieties Princess, Nicola and Ditta in Nor-thern and Southern Germany. For this, cultivation and quality data were collected and fed in a web-based Benchmarking data base. At the harvest samples ratings were accomplished to the outside quality as well as the starch and nitrate content and the sensory quality were measured. The different levels of nitrate and starch contents were often attributed to the length of the growth period and thus to the occurrence of *P. infestans*. The sensory analysis showed different sensory profiles for the three va-rieties, whereby Princess showed the strongest bitterness and the lowest sweetness; Nicola, however, the most pronounced taste of sweetness and chestnut. In the case of an early haulm dying, as in 2007, showed a more pronounced taste of bitterness, which was associated with lower starch and higher nitrate levels. Using multiple regression models, relationships between production parameters and the parameters collected on yield, quality and sensory evaluation were carried out. The Benchmarking data base serves each farmer for the direct and anonymous comparison of its operational result with its colleagues.

Session 5

Performance of newly bred potato varieties under organic and conventional experimental conditions

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In Switzerland the production area of potatoes was in 2009 11'295 hectares. Organic potatoes were cultivated on 420 ha. Marketable yields of organic potatoes were in general lower than conventional ones and uncertain, thus market supply cannot be assured. Varieties appropriate to organic conditions may be one key for improving yield stability. Since 1997 the Swiss Agricultural Research Stations (Agroscope) investigate within varietal testing the suitability of new varieties under organic conditions. In the past several new late blight tolerant varieties were identified and recommended, but received small practical importance. The organic potato production did not expand as expected. An evaluation of recent data should reveal if new varieties contains beneficial characteristics for the cultivation under organic conditions.
Our comparison is based on results of agricultural and processing trials within the varietal assessment. The suitability of 22 new varieties for fresh consumption was investigated from 2002 to 2007. The trials were performed at 7 locations per year; two of them cultivated organically. 28 new processing varieties were grown from 2003 to 2010 at 6 to 7 sites per year, one of them an organic site. We use four standard varieties. Organic sites differed between each other in soils conditions, nutrient and water availability as well as late blight management. Conventional sites were well distributed from West to East.
External and internal tuber quality was investigated by scoring 100 tubers per site. Tubers were CIPC treated after harvest and stored at 8°C until May. Frying suitability were tested at two or three times during the storage period. Visual scoring of crisps was done by using IBVL colour cards. Reducing sugar contents were analyzed in parallel to frying experiments.
Combining all new varieties for fresh consumption the average marketable tuber yield under organic conditions reached 65 % of the conventional one (244 dt/ha (n=68) versus 369 dt/ha (n=145)). The average proportion of marketable yield was with 68 % significantly lower under organic conditions compared to 78 % under conventional conditions. With a relative yield of 68 % new varieties for processing yielded under organic conditions slightly higher than fresh consumption varieties. Annual and sites specific differences influenced yields in both experimental series. Average tuber number per plant of new fresh consumption varieties was with 12 (n=79) lower under organic compared to conventional managed sites (13,7; n=133). Crisps prepared from raw material of new processing varieties from the organic site were slightly brighter than crisps from other locations due to reduced sugar contents in tubers. This indicates that organic raw material from appropriated varieties fulfils quality requirements for processing. Results of external and internal tuber quality will be presented.
The data showed that new varieties like Jelly, Biogold and Challenger with their good agronomic and processing profile are suitable for Switzerland conditions. They have the potential to replace the varieties Charlotte, Agria and Ditta.

Session 6

Gas exchange and water use efficiency in potato as related to the level of drought tolerance

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Water limitation is the most adverse environmental factor having a profound impact on agricultural and ecological systems. Depending on the kind and timing of drought during season, reduced leaf area may affect photosynthetic productivity more than inhibition of photosynthesis itself. Nevertheless, maintenance of photosynthesis intensity under water deficit and recovery of photosynthetic activity after drought relief is a key element of plant drought tolerance defined in terms of its effects on yield.
Potato plant (*Solanum tuberosum* L) is well known as a highly sensitive to soil drought and extracts less of the available water from the soil in comparison with other crops (Schlafleitner et al. 2007). Under drought photosynthetic activity decreases and CO_2 assimilation is reduced more in susceptible genotypes, while resistant genotypes can continue photosynthesis (Pinheiro and Chaves 2011). Therefore, the aim of the present experiment was to estimate differences in gas exchange and water use efficiency between two potato cultivars differing in dehydration susceptibility in agricultural terms (Cekin, susceptible and Tajfun, resistant cultivar), diploid genotype and wild genotype *Solanum ruiz-ceballosi* .
The experiments were carried out in pots in vegetation hall in which half of the plants have been submitted to soil drought by cessation of watering for three weeks. Drought was applied to potato plants two weeks after tuberisation initiation. Then the normal watering conditions were restored and maintain till the end of the experiment (full maturity of plants). Following parameters were measured: net photosynthesis, transpiration, intracellular concentration of CO_2, stomatal conductance and water use efficiency.
There were no significant differences between well watered cultivars (Cekin and Tajfun) in net CO_2 assimilation, but the intensity of photosynthesis of diploid genotype was significantly lower and lowest in wild genotype. Similarly, transpiration rate was similar in both cultivars but it was about two times lower in diploid potato, whereas in wild genotype the rate of transpiration was only one fourth of that noted for cultivated potato genotypes. As a consequence, water use efficiency (WUE) was similar for both cultivar and diploid potato and lowest for wild potato.
Under severe soil drought (leaf RWC about 50%), photosynthesis dropped to about 3-10% of that noted for well watered controls of both cultivars and diploid potato, whereas it was still about 60% of that noted for well watered wild potato. WUE for drought resistant Tajfun cultivar was the highest and only about 30% lower than in well watered control plants and increased practically twice for wild potato. It is interesting to note that in wild potato the intracellular concentration of CO_2 remained on the control level.

Session 6

Irrigation of early potato during the day

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Abstract
In the conditions of unstable and insufficient humidification the most rational use of irrigation water is between 7 and 11 a.m. The difference in yield between morning and night watering and between day and night watering is essential – 6.6% and 5.1% respectively. Besides, during day watering water losses amount to 20%; during night watering fungal diseases, its degree and distribution increase (on 0,5 … 0,7 points).

Introduction
The first peak of potato photosynthesis intensity happen during morning hours. The intensive elffux of plastic substances and its transformation into storage compounds in tubers. It's possible to make a suggestion about different reactions of potato plants on the time of watering during the day.

Materials and methods
A three-factor experiment on defining the optimal time of iffigation during the day was carried out on Red Scarlet variety potato in experimental training farm 'Milovskoe' in 2000-2011. All the observations, calculations and analysis were carried out according to the generally accepted methodology. The scheme of the three-factor experiment is in Table 1.

Results and discussion
The maximum leaf surface was formed during the "flowering+20 days" period. Irrigation between 7 and 11 a.m. increases twice leaf surface reaching 54.5 thousands m^2/ha with rated dose to 40 t/ha of tubers. The least of water consumption coefficient (96,2 m^3/t) was in this variant. This variant case is characterized by with much bigger yield of tubers. The difference in yield between morning and night watering and between day and night watering is essential – 6.6% and 5.1% respectively. This caused by the better biomorphological indexes plants of early potato. The developed root system and assimilatory leaf surface not only loke a separate plant but also as agrophytocenosis as a whole allow to use applied fertilizers and solar radiation most effectively. Besides, during day watering water losses amount to 20%; during night watering fungal diseases, its degree and distribution increase (on 0,5 … 0,7 points). The maximum yield on August, 7 was achieved by irrigation from 7 to 11 a.m. and the rated dose of fertilizers to 40 t/ha of tubers. In this case there was the biggest gathering of dry matte (10 t per ha) and starch (6.8 t per ha).

Conclusion
Thus, the analysis of the carried-out scientific research and the experience of leading potato growers of Bashkortostan Republic allow making the following main conclusions:
1. Application of full mineral fertilizer to produce 40 t per ha makes irrigation water use better.
2. Potato irrigation is necessary to apply from 7 to 11 a.m.

Session 6

Early potato irrigation regime

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On the basis of generalization and the analysis of multifactor field experiments and laboratory researches on sprinkling and fertilizer of early potatoes using of mathematical methods the irrigation optimum regime for soil-climatic and organizational - economic conditions of Republic Bashkortostan were made.

Introduction

If the soil is missing thinly fluid and available moisture necessary for plants, this results in keeping potato growth and development. That's why both getting high quality potato tubers and cost price decreasing are determined mostly by the soil moisture regime efficiency of the calculated layer during the calculated period.

Materials and methods

Polyfactorial field experiments to determine an optimal irrigation regime for the Red Scarlett potato variety were carried out in 2008-2009 in Alekseevsky state farm. The scheme of the two-factorial experiment included the following: A-Factor – an irrigation regime with the pre-irrigation level in percentage of MWC (minimum water capacity) according to different periods. (I. Planting-sprouting + 10days; II. sprouting+ 14 days– flowering + 20days; III. flowering + 20days – harvesting). 1. Without watering control; 2. 70 - 80 - 70; 3. 70 - 80 - 80; 4. 80 - 80 - 80; 5. 80 – 85 – 80. B-Factor. Fertilizer dose. 1. Without fertilizer control; 2. Rated dose to 20 t/ha of tubers. 3. Rated dose to 25 t/ha of tubers; 4. Rated dose to 30 t/ha of tubers; 5. Rated dose to 40 t/ha of tubers. The final harvesting in September 3.

Pre-harvesting potato vine cutting was held 10 days before harvesting. Potato was harvested with the help of a potato digger; tubers were picked up by hand with the usage of the broadcast harvesting method. In accordance with common techniques observations, estimations and analysis were held. The figure below reflects the experiment scheme.

Results and discussion

The maximum leaf surface was formed during the period "flowering+20 days". Irrigation increases twice leaf surface reaching 98,8 and 95.0 thousands m^2/ha in 80-85-80 and 80-80-80% variants of MWC and with the calculated fertilizer dose for 40 t/ha.

A consumptive use factor is an important plant efficiency mark of potato usage. Its minimum (92,8 and 65,18 m^3/t) was in the 80-85-80% variant of MWC) and with the calculated fertilizer dose for 40 t/ha tubers.

The maximum yield (74,9 t/ha) of tubers in the final harvesting 03.09 (Figure 1) was reached under the irrigation regime 80-85-80% of MWC and rated fertilizer dose to 40 t/ha of tubers. The maximum of dry matter (15,3t/h) and starch was got when using in this.

Conclusion

Thus, the analyses of the research carried out and the experience of leading potato growers of the Republic of Bashkortostan allow to make the following main conclusions:

1. Having studied all the experiment's marks sprinkling proved to be the best method. To get 40 tons of tubers from a hectare pre-irrigation of the calculated soil layer (40-50-60 cm) during the 80 - 85 - 80% MWC periods and mineral fertilizer application were used while sprinkling.
2. Potato irrigation is necessary every year.

Session 6

Climatic condition in Poland and the requirement of irrigation in potato cultivation

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Introduction
Irrigation of potato production in Poland is not widely distributed agro-technique treatment. It has been estimated that, in all country, irrigation takes place only 1% of overall area of potato cultivation. It is 40 -50 thousand hectares every year. It is an element of new cultivation technique which stabilizes and improves yield quality. Irrigation is mainly used in table and processing potato production. Farms using accurate agro-technique but without irrigation they are able to achieve yielding on a level of 35-40 ton per hectare is in years with average rainfall level. The factor limiting common using of irrigation in potato production is relation between irrigation costs and the increasing value of yield.

Materials and methods
Based on meteorological dates from Institute of Meteorology and Water Management the analyses of rainfall level and distribution during vegetation period in last 25 years were carried out. Taking into account water demands of potato plants in different phenological phase's necessity analyse of supplement irrigation and analyse of yield losses, due to drought stress, were carried out. On a base of carrying field experiment irrigation costs level and its influence on the yield value were estimated.
Results
Geographical location of Poland causes that climatic condition has intermediate character. During vegetation period it is May- September alternate influence of continental and oceanic climate makes that rainfall distribution is differentiate in years. Rainfall sum not exceeding 300mm, causing deep water deficit, occurs very rarely (less than 10%). In Poland dominating years in which rainfall sum of vegetation period are estimated from 350 to 400 mm. In 30% cases rainfall level exceeds the value of 400mm which provide relative water comfort for cultivation of wide range of potato varieties. There are also years with excessive rainfall. Unfavourable phenomena in Poland is chronically occurring and increasing heterogeneous rainfall distribution not corresponding to water demands of potato plants in different phenological phases.

Economical analyse showed that in Poland sprinkle irrigation is reasonable for common using. High investment costs and necessity of yearly emplacing this type of installation during planting without certainty of its using makes that this method might be not common used in the future in Poland.

Session 7

Markers assisted selection for late blight resistance in tetraploid potato

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At the beginning of the 2000^{ies}, three of the French breeding companies decided to start a research program with the aim to evaluate molecular markers interest for late blight resistance. Segregating families were built using pre-breeding material delivered by Inra after several years of agronomic selection among genotypes obtained from the CIP in the 80ies.
Segregating populations were evaluated for *Phytophthora infestans* (*Pi*) resistance under natural field conditions of contamination in Ploudaniel, France. One first population (K2 family, 150 genotypes) was evaluated between 2005 and 2008. K2.1 second population (248 genotypes) obtained by sib-crossing one resistant genotype and a susceptible one from the K2 family, was also field evaluated for *Pi* resistance in 2009 and 2010. The resistance was evaluated by scoring foliage destruction weekly which permitted the construction of a Disease Progress Curve for each plant, computing of Relative Area Under the Disease Progress Curve and other parameters.
142 markers were used in successive steps to genotype the K2 family. Linkage between markers and phenotypic values was determined performing a regression analysis followed by a multiple regression analysis.
Main significant markers were detected on chromosomes IV and IX in the K2 family. The Quantitative Resistance Locus (QRL) for rAUDPC located on chromosome IV was significant all years except in 2008 whereas the one located on chromosome IX was significant all years of evaluation. Percentage of variation explained using these markers varied between 20 and 51% depending on the year and the trait.
Promising markers were used to genotype K2.1 family: 1 located on chromosome IV and 2 located on chromosome IX. Both markers of chromosome IX were significantly linked to rAUDPC measured in 2009 and 2010. Marker of chromosome IV was not significant. However results of multiple regression analysis showed that the percentage of variation explained was very low (8% using two markers).
Despite the relatively low number of markers used, we could identify markers with an acceptable level of resistance explanation and stable during 4 years. The QRL detected on chromosomes IV and IX confirm the importance of these regions for late blight resistance as it has already been published. Concerning the sharp decrease in the percentage of variation explained by the markers from K2 to K2.1 families, some hypothesis can be made: loss of linkage between markers and resistance factors, loss of efficiency of resistance factors in front of natural evolution of the pathogen population, decrease of the power of detection due to the increase of marker dosage.
We now need to increase the number of markers relevant at the tetraploid level in each chromosomic region. In front of the rapidly evolving pathogen population (shift from A1 to A2 mating type) we also need to identify regions consistently involved in the resistance. The mapping populations have been conserved *in vitro*, and might be re evaluated if necessary.

Session 7

Molecular markers for high-throughput selection of late blight resistant potato

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Markers for two novel late blight resistance genes in potato were developed. The allele *RPi-tbrM1* is from the clonal selection MF-II, and allele *RPi-adgT1* is from the group andigena cultivar TPS67. Both parental cultivars are in simplex state for their respective resistance allele. An MF-II x TPS67, 171-progeny, tetraploid mapping population (MT) was generated. The late blight resistance was mapped in the MT cross population by a combination of chromosome arm landing and genome island hopping (surveying patches of genome sequence) to two hotspots of R genes, *Rpi-adgT1* on chromosome IV and *RPi-tbrM1* on chromosome XI. The rapid positioning of the two putative R gene loci on the genome was possible with the aid of COSII markers and the partial sequence of the *Solanum phureja* genome. An immanent inaccuracy of mapping the loci resulted from the limited *Solanum* genome sequence and the rarity of differential *P. infestans* strains, or effectors of resistance, for the discrimination of resistance phenotypes. The reduced size of the MT population was no limitation. The rapid and cost-efficient approach yielded molecular markers linked to the two resistances.
Allele specific markers for selection in high-throughput for late blight resistance were constructed. Two techniques; KASPar and high resolution melting, equally allowed for fast and cost efficient, one-step genotyping of large samples. The markers were tested for their accuracy and predictive power in both their own genetic background and in crosses with unrelated genotypes. The TPS67-specific resistance was rarely found in European potato genetic background. Therefore, the corresponding markers, C2_At1g60560_KASPar and C2_At1g60560-HRM-P can be recommended for use in selection among large cross progenies when introgressing *Rpi-adgT1* into European breeding stocks. In contrast, markers for *RPi-tbrM1* were frequently detected among European potato germplasm indicating a wide distribution of this locus and suggesting that it might be linked to R genes that are closely akin to *RPi-tbrM1* from MF-II. These markers were applied most effectively in negative selection schemes, by eliminating individuals devoid of the resistance marker allele.

Session 7

Using Resistance Gene enrichment and Next Generation Sequencing to clone late blight resistance genes

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Potato is the fourth ranked crop in world food production and despite the extensive use of agrochemicals, late blight, caused by the oomycete Phytophthora infestans, is responsible for substantial crop losses. In the past, late blight resistant genes (R genes) from Solanum demissum have been introgressed in cultivated potato but these were quickly overcome by new races of the pathogen. We are in the search of R genes, from wild Solanum species from all over the world, that confers resistance to this devastating disease. Once resistant plants have been found, a segregating population will be made, each individual will be tested for resistance and subsequently genomic DNA from all resistant plants and all susceptible plant are bulked.
In order quickly identify linked R genes we set up a pipeline involving Agilent Sureselect technology in which we enrich for R gene sequences, prior to Illumina GAII sequencing. We have used the publicly available doubled monoploid potato genome sequence http://www.potatogenome.net) to bioinformatically mine R gene sequences and create a so called R-genome that consists of 523 full length and partial R genes. From this, 48500 biolinylated 120-mer RNA baits were developed and designed (Agilent) that were used to extract R gene homologous sequences from the BR and BS genomic DNA samples, followed by paired end Illumina GAII sequencing.
Currently, we are following this approach to identify resistant genes from several wild Solanum species and the first analyses indicate that we substantially enriched for R gene sequences (~1000 fold). Using several bioinformatic programs we identity polymorphisms (SNPs) between the enriched BR and BS samples, from which we design markers to analyze the linkage to the R gene of interest.

Session 7

Production of blight resistant potato using Ensifer adhaerens OV14: A novel transformation platform to facilitate technology transfer from potato genome initiatives

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Agrobacterium tumefaciens-mediated transformation (ATMT) is the preferred technique for the genetic modification of potato. Yet, a major disadvantage of the technology remains the complexity of the patent landscape that surrounds ATMT which restricts its use for commercial applications. We previously investigated the potential of published non-*Agrobacterium* strains (Transbacter™) but the low transformation efficiencies attained coupled with the necessity for significant adjustments in transformation protocols underlined their unsuitability for potato research (Wendt et al. 2011, Transgenic Res., 20, 377-386). In response, we isolated a novel collection (n = 751) of plant-associated bacteria from the rhizosphere of a commercial crop and screened the population for the ability to (a) utilize *vir* genes for genetic transformation and (b) be substituted for *A. tumefaciens* in existing transformation protocols, without a prerequisite for protocol optimisations. Based on a sequential screening process, including plant transformation with the open-source vector pCAMBIA5105, we discovered a strain of the bacterium *Ensifer adhaerens* which was able to transform potato (mean transformation frequency 35.1% from three independent experiments) using a standard reporter gene-based transformation vector. This was achieved by including *E. adhaerens* OV14 as a direct substitute for *A. tumefaciens* into an existing transformation protocol that did not receive additional modification. Thereafter, *E. adhaerens* OV14 successfully transformed potato with the *S. bulbocastanum RB* gene, which conferred resistance to late blight disease on the transformed variety as demonstrated via genotypic and phenotypic analysis. The ability of *E. adhaerens* OV14 to achieve 'gene stacking' via transgenesis was also confirmed during this process with up to 4 transgenes transferred into the target genome. These data illustrate the potential of *Ensifer*-mediated transformation (EMT) as a novel platform for the generation of transgenic potato. Of significance, a*s E. adhaerens* OV14 is genetically distinct from A. tumefaciens, EMT bypasses existing patents governing the use of *A. tumefaciens*.

Session 8

20 years with protoplast fusion in potato breeding - results and perspectives

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Modern plant breeding technologies like somatic hybridisation and genetic engineering are more precise than conventional breeding by crossing because the genetic information of the progenies is predictable. Also there is no need for a long, laborious and expensive selection procedure to find the "right" plants. In case of somatic hybridisation two genomes get added by cell fusion. The genomes of the selected dihaploid fusion partners determine the genetic constitution of the resulting somatic hybrids. In regard to the traits dominant or intermediate inheritance is possible (Schwarzfischer *et al.* 2002, Vortr. Pflanzenzüchtg, 123-130).

We apply somatic hybridisation since 1990 for potato breeding in addition to other breeding methods and produced over 6000 somatic hybrids from 580 different fusion combinations. Nearly from all of 313 different genotypes protoplasts could be isolated and fused. Only 5 genotypes delivered very bad protoplast preparations. In addition, protoplasts from 84% of the genotypes could be regenerated. In mean, 5% of the regenerates were somatic hybrids. Most of them were grown in the greenhouse and in the field for evaluation of breeding traits. Resistance traits (Globodera rostochiensis Ro 1,2,3,4 or 5; Globodera pallida Pa3; Synchytrium endobioticum 1,2,6; Pectobacterium carotovorum; Phytophthora infestance; extreme resistance to PVY) were mainly inherited in a dominant matter. Also good chips quality after cold storage at 4°C was found in the hybrids if only one fusion partner had this special valuable trait. For quality traits like starch content, taste, tuber shape or flesh color we observed intermediate inheritance. Some important traits like yield are not predictable.

Somatic hybridisation offers the possibility to overcome sterility, sexual barriers (fusion combinations with wild species like Solanum bulbocastanum or Solanum acaule) and maternal inheritance. We will present some hybrids from combinations of genotypes with extreme resistance to PVY combined traditionally with cytoplasmic male sterility and genotypes with male fertility which are resistant to PVY and male fertile in order to organelle segregation.

In future, protoplast fusion is an ideal tool for pyramiding of resistances. After preselecting of important traits with marker assisted selection in dihaploid populations with markers to nematode resistances (*Gro1,4*: Gebhardt *et al*. 2006, Theor. Appl. Genet. 112, 1458-1464; *Pa3 HC*: Sattarzadeh *et al*. 2006, Mol. Breed. 18, 301-312) and extreme resistance to PVY (*Rysto*: Song and Schwarzfischer 2008, Am. J. Pot. Res. 85, 159-170) we add these resistances in order to get hybrids with resistance combinations which are not realised in registered cultivars until now.

Session 8

A new look at the problem of inter-EBN interspecific crosses in potato

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1EBN wild diploid potato species represent a rich source of disease resistance genes for breeding. However, they are practically uncrossable with cultivated potato, including dihaploids of *S. tuberosum* (2x, 2EBN). Problems in producing such interspecific hybrids are mainly associated with endosperm failure of developing seeds as a consequence of the difference in "effective" ploidy of parental species (EBN). In addition, prezygotic incompatibility barriers, which are displayed as pollen tube growth inhibition, are also typical for 1 EBN diploid wild potato species from Mexico in crosses with *S. tuberosum* dihaploids.

A new look at the problem of inter-EBN interspecific crosses in potato are presented in the paper and new approaches to its decision are offered. We hypothesized that mutation(s) resulting in arising 2 EBN species from 1 EBN ones are still available in genetic pool of 1 EBN species. This mutation(s) can be expressed in the same manner as mutations, associated with formation of unreduced gametes. Some quantity of mutant 1EBN (but of the typical ploidy - n) gametes can be available along with typical 0,5 EBN gametes in the pollen or among ovules of some accessions of 1 EBN species. The use of wild diploid species *S. verrucosum* (2x, 2EBN) as a female parent in crosses with 1EBN species makes it possible to reveal mutant 1EBN pollen grains owing to lack of prezygotic incompatibility (*S. verrucosum* does not contain pistillate S-RNAses). This can resulted in formation of plump viable hybrid seeds. 2 EBN diploid interspecific hybrids which may be simply involved into breeding by means of hybridization with 2 EBN *S. tuberosum* dihaploids can be harvested from these seeds.

In order to examine this hypothesis we crossed *S. verrucosum* as a female parent with different accessions (bulk of pollen) of 1EBN diploid potato species *S. pinnatisectum, S. polyadenium, S. bulbocastanum, S. commersonii* and *S. circaeifolium*. A range of accessions of *S. phureja* (2x, 2EBN) was used as "negative control". They were crossed as female parents with accessions of *S. commersonii* and *S. circaeifolium* not having prezygotic incompatibility with *S. phureja.* A clon of *S. phureja* IvP 35 was used for the purpose of "rescue pollination".

Crosses between South American species having different "effective" ploidy (2 EBN *S. phureja* and 1 EBN *S. commersonii, S. circaeifolium*) failed, as it was anticipated. The use of "rescue pollination" gave the opportunity to obtain hybrid seeds in crosses between *S. phureja* and *S. commersoni* (788 hybrid seeds from 43 pollinations, 18,3 seeds/pollination).

1034 hybrid seeds from 107 pollinations (9,7 seeds/pollination) were obtained in crosses between *S. verrucosum* and all used 1EBN wild diploid species. *S. bulbocastanum* had the best crossability with *S. verrucosum* (270 hybrid seeds were obtained, 20,8 seeds/pollination). Use of "rescue pollination" resulted in further increase the efficiency of hybridization between *S. verrucosum* and 1EBN diploid species (26,6 seeds/pollination).

Obtained hybrid seeds were plump and had high viability (germination was 47 - 88%). The majority of hybrids were possible to cross as females with *S. tuberosum* dihaploids: 2818 hybrid seeds were obtained (37,6 seeds/pollination).

Session 8

Consequences of autopolyploidization in potato: putting omics tools to work

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Polyploidization is a common feature in plant evolution. It is particularly widespread in the flowering plants, including many major crops, such as the potato. Studies on allopolyploids have contributed very much to gain insights into polyploidy-related processes. Extensive molecular and, to a lesser extent, phenotypic studies revealed structural and functional modifications due to restructuring of the transcriptome, metabolome and proteome. However, allopolyploids inherently change two parameters at once and do not allow separating the effects of changes in chromosome number versus hybrid formation. By contrast, autopolyploids have the advantage of restricting the changes to one parameter, namely chromosome number, ruling out whole genome alterations primarily connected with incompatible genomes. Considering the evolutionary significance and practical value of autopolyploidy and the scanty information present in the literature, this work aims at exploring genetic, epigenetic and transcriptomic changes at the early stages of autopolyploidy in two diploid potato species, *Solanum commersonii* and *S. bulbocastanum*. Moreover, we performed an in deep anatomical analysis of vessel characteristics of newly synthetized polyploids to detect possible associations with chromosome doubling. Genetic and epigenetic analysis revealed alterations at different extent due to polyploidization. Although the trend was an increase in methylation, various types of cytosine methylation changes occurred in the newly synthesized autopolyploids, which included both hypo- and hyper-methylation at CG and CHG sites. Polyploidy-related gene expression changes were investigated as well. The number of differentially expressed genes was 237. One hundred and thirty eight had a known function, and 10 of them showed a fold change of at least 1.5. Most of them encoded structural proteins involved in, among the others, abscisic acid, shikimate and fatty acid biosynthetic processes. Other differentially expressed genes were transcriptional factors, signal transduction, cation transport, and transcription regulator proteins. Lastly, several morpho-anatomical parameters were evaluated including the number, area and diameters of vessel lumen and thickness of vessel walls. In *S. commersonii* lamina were lower in 4x derivatives compared to their 2x progenitor. By contrast, in *S. bulbocastanum* the aforementioned parameters were generally similar between 4x clones and 2x progenitor. The results obtained are presented and discussed from the breeding and evolutionary standpoints.

Session 8

Advances in in-vitro conservation of potato germplasm in India

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Germpalsm constitute the basic raw material for improvement of a crop plant through breeding. In India, the potato germplasm collection is held at the Central Potato Research Institute, Shimla, which is the national institute for potato R&D. It has more than 3800 accessions belonging to cultivated as well nearly 100 wild species. This collection is being maintained in field as well as in *in-vitro* gene banks, and the wild species are conserved mainly as true seeds. In order to improve the efficiency of *in-vitro* conservation of potato germplasm under sub-tropic conditions a number of studies were undertaken.

The efficacy of minimal growth storage employing osmotic stress induced by mannitol *vis-á-vis* sorbitol for *in vitro* conservation of potato microplants at low (7±1^{o}C) temperature was studied. Two concentrations of sucrose (20 and 40 gl^{-1}) in combination with two concentrations (20 and 40 gl^{-1}) of either mannitol or sorbitol in Murashige and Skoog medium were tested. Microplant survival, microplant condition and root growth in three potato genotypes belonging to different maturity groups were studied till 18 months of *in- vitro* storage without subculturing. Best results were achieved with MS medium having 20 gl^{-1} sucrose plus 40 gl^{-1} sorbitol. After 18 months without sub-culturing, maximum survival (58.0%) coupled with a microplant condition good enough to provide suitable nodes for sub-culturing was observed with the use of this medium. In another study, in order to explore the possibility of *in-vitro* conservation at normal propagation temperature conservation of microplants at 24±1^{o}C was investigated. Growth was controlled by using different concentrations of sucrose (20, 40 and 60 gl^{-1}) alone or in combination with either mannitol (20 and 40 gl^{-1}) or sorbitol (20 and 40 gl^{-1}) in Murashige and Skoog medium. Maximum microplant survival (55.5–77.8%) after 12 months of storage was on medium supplemented with 20 gl^{-1} sucrose plus 40 gl^{-1} sorbitol. Microplants so conserved were in good to very good condition, without phenotypic abnormalities and had enough nodes for sub-culturing. This conservation approach at 24±1^{o} C can be an effective alternative to low temperature (6-8^{o}C) storage, especially in tropical and sub-tropical conditions, where the ambient temperatures in summer can reach 45-50 ^{o} C.

Use of microtubers was also explored for increasing the conservation period. Efforts to prolong the dormancy of the microtubers for this purpose by supplementing the medium with known dormancy promoting growth regulator abscisic acid was tried. ABA decreased both microtuber production and microtuber dormancy, whereas higher concentration (60-80 gl^{-1}) of sucrose promoted biomass production, microtuber production as well as microtuber dry matter content. Microtubers stored in diffused light had longer dormancy than those kept in continuous dark. Microtubers produced on media free of ABA, but having high concentration of sucrose plus N^{6} benzyladenine (44.38 µM) could be stored under diffused light at 6±1^{o} C for 12 months.

The results and protocols developed will be discussed.

Session 9

Effect of growing season length on response to seed aging

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Physiological age is known to be an important component of seed productivity. Recent studies have shown that physiological age can be manipulated by warming seed immediately after harvest to increase stem numbers. Research was needed under a range of growing season lengths to understand how this information can be applied to improve returns to seed, fresh pack and process growers. Aging of Russet Burbank and Ranger Russet seed during the 2006 to 2008 growing seasons was accomplished by holding at 13 to 32^{o}C to accrue a set number of degree days immediately after wound healing, followed by storage at 4^{o}C until planting. The trials were planted at 10 day intervals, but vine killed on the same date to provide a range of growing season lengths from 134 days at Parma, 124 days at Kimberly and 114 days at Aberdeen, ID USA. All sites produced similar stem numbers in each treatment. Seed aging treatments had no influence on total yield , however, stem number dramatically impacted tuber number and size in both Russet Burbank and Ranger Russet. Tuber number increased in a linear manner with increasing stem number. Ranger Russet produced a wider range of stem numbers and tuber numbers across the treatments than Russet Burbank, but exhibited a similar relationship between stem and tuber numbers. For Ranger Russet the effect of an increase of one stem per plant was a reduction of average tuber size by 27g at Aberdeen, 25g in Kimberly and 22g in Parma. Likewise, for Russet Burbank the effect of an increase in stem number on average tuber size was a reduction of 18g in Aberdeen, 16g in Kimberly and 10g in Parma. These trials indicate that it is possible to manipulate seed age and resulting tuber size profile as a tool to meet specific market requirements.

Session 9

Tuber yield and some nutritional traits in early potatoes as affected by growing season, genotype and harvest time

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In several Mediterranean countries and in southern Italy as well, potatoes are mainly grown in off-season cycles (winter-spring and summer-autumn) for early potato production. Cultivation is often realized twice a year (double cropping), utilizing in the two off-season crops the same cultivars, even if plants are subjected to very different climatic conditions. Consequently potato growers are involved in choosing of cultivars with good yield performance in off-season crops. Current researches suggested also that "early potato" can be considered, more than main crop potatoes an good source of antioxidant compounds in the human diet (Leo et al. 2008. J. Agric. Food Chem., 56, 4154-4163). . Likewise, there is no information concerning the potential effects of harvest time on these compounds in early potatoes.
The aim of this research was to asses tuber yield and some tubers nutritional traits such as dry matter, ascorbic acid and total phenolics content in early potatoes coming from two contrasting growing seasons (winter-spring and summer-autumn crops) as influenced by genotype and harvest time in Mediterranean environment. Genotypes included 3 recent genotypes suitable for early potato production (Bionica, Lady Christl and Soprano) in comparison with 3 check cultivars (Marabel, Nicola and Spunta). The harvest time was made at 102 and 120 days after planting in the winter-spring season and at 77 and 100 days after planting in the summer-autumn season.
The three new genotypes showed good adaptability to off-season crops both for yield performances and nutritional traits. Bionica was very interesting for winter spring crop, Lady Christl for double cropping, whereas Soprano for summer-autumn crop. AA content was very similar in the two growing seasons, whereas in the summer-autumn season much higher levels of total phenolics was found in all studied genotypes. After a delay of harvest time, phenolics content of tubers decreased in both growing seasons, whereas ascorbic acid content increased in winter-spring and decreased in summer-autumn.
An appropriate combination of genotype, growing season and harvest time gave good yield performances and tuber qualitative traits which may satisfy growers' and consumers' requirements. In terms of nutritional value, qualitative traits relates to high content in ascorbic acid and total phenolics can contribute to increase their uptake in our diet.

Session 9

Subsoiling in starch potato Higher yields of starch potatoes and improved water management

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Agricultural practices today include the use of heavy machinery, not only for seedbed preparation but also during growth and harvest of the crop. Heavy machines cause high pressure on the soil, which may lead to soil compaction (Hamza and Anderson 2005, Soil & Tillage Res, 82, 121-145). Compacted soils may reduce the root system and limit the area from which the plant can extract water and nutrient. Sandy soils, which often are used in potato production, seem to be especially susceptible to subsoil compaction. The soil compaction may reduce both yield and quality and also physically restrict the development of tubers (Westermann and Sojka 1996, Soil Sci. Soc. Am. J, 60, 1448-1453). Plant roots of most species can penetrate soils with pressure up to 2 to 3 MPa, but potato roots are more sensitive. Already at a pressure of 1 MPa the root growth is negatively affected (Stalham, Allen et al. 2007, J. Agric. Sci, 145, 295-312). The ideal soil for potato production is therefore deep, well-drained and loose.

In this experiment inter-row subsoiling at the depth of 55 cm has been tested as a strategy to loosen the soil after planting and thereby increase the yield in starch potato production. The effects of subsoiling were tested in three different irrigation regimes over three years from 2007-2009. A decrease in soil compaction could be seen in the subsoiled plots in the entire soil profile. At 30 to 40 cm depths subsoiling decreased the compaction from approximately 5 to 1 MPa compared to normal tillage. This resulted in a yield increase which shows that subsoiling can increase the starch potato yield in sandy soils where a compacted plough pan is present. This holds true for all years and all cultivars tested. The effect was greater in dry years and decreased with increasing irrigation intensity. However, the starch content of the tubers was not affected by subsoiling but the total starch yield increased with 0.86 ton/ha to 1.37 ton/ha, depending on year, cultivar and irrigation strategy.

Session 9

The Relationship Between Yield And Above Ground Parts Of Some Potato Genotype

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Tuber yield and physiological development of potato are effected by many factors as genetic structure, adaptabilty, climate and soil structure, cultural practices, etc. During tuber formation of potato, the development of above ground parts of potato and the amount of assimilation are positively correlated with amount of starch stored in tubers. In present study was to determine the relationship between tuber yield per plant and genotype, main stem number, plant height, leaf number per stem, number of leaflet, leaf area, number of stomata above and under of leaf. The fifty three local potato genotypes were used. The potato tubers were planted in randomized block desing with three replications on 1th April 2009, the experimental area of Agricultural Faculty of Ondokuz Mayis University under Samsun (41^{o} 31'N, 35^{o} 35'E) ecological condition, in Turkey. Planting was made at a distance of 0.70x 0.30 m. The datas were recorded from ten plants randomly selected in each genotype of each replication. Statistical analysis was performed using SPSS statistical package whereas analysis of correlation was made using to by Pearson' correlations. Among the genotypes were found significant differences ($p<0.01$) in terms of all properties. According to Pearson's, Tuber yield per plant was determined insignificant correlation with the leaf area, stomata number of above of leaf, while it was found significant ($p<0.01$) positive correlation with plant height (r^2=0.257**), main stem number (r^2= 0.244**), leaf number per stem (r^2=0.172**), number of leaflet (r^2=0.189**). Negative significant correlation (r^2=-0.319**) between tuber yield and stomata number of under of leaf was determined.

Keywords: potato, stomata, leaf number, tuber

Session 10

Can an alternative host increase the problems with late blight in potato?

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Potato late blight is a major disease in potato production throughout the world and is caused by the oomycete *Phytophthora infestans*. The host range of *P. infestans* is mainly restricted to the *Solanaceae* family, most importantly potato and tomato, but also includes other solanaceous species such as *Solanum physalifolium* (Hairy nightshade). The hairy nightshade is a new and increasing weed problem in vegetable cultivation in the south of Sweden. With the climate change and a rise in temperature the hairy nightshade could be an increasing problem also further north in Sweden. During summer 2010 one potato field with hairy nightshade present was sampled. Single lesion leaflets from both hosts were collected and characterised to determine phenotypic or genotypic population differentiation. Aggressiveness test were performed using isolates from both potato and nightshade and cross inoculating them on the two different hosts. The latent period, lesion growth and sporulation capacity was determined. In order to study the genotypic variation microsatellites were used. Seven SSR markers previously showing a very high variability in Swedish *P. infestans* samples were used.

The results showed no genotypic differentiation in the samples from the two hosts. However, a phenotypic variation between isolates from potatoes and nightshade was observed. The isolates sampled from nightshade were shown to be more aggressive on potato compared to the isolates found on potato.

Session 10

Functions of Phosphorous Acid for Late Blight Control in Potatoes

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Late blight, caused by *Phytophthora infestans* (Mont.) de Bary, is a devastating disease of potatoes that occurs worldwide and causes significant crop losses annually. Current disease management is strongly dependent on extensive use of protectant fungicides. Phosphonate chemicals containing phosphorous acid (PA) as an active ingredient can suppress late blight disease symptoms. Recent reports have shown that treating plants with phosphorous acid promoted resistance/tolerance against late blight infection
under field and laboratory conditions (Wang-Pruski et al. 2010,
Amer. J. Plant Sci. and Biotech. 4, 25-29). The related fungicide Confine has been registered in Canada for control of several diseases in potatoes, tomatoes and grapes. It possesses a very favorable environmental profile and therefore, can contribute to a sustainable disease management program. To this date, the defense mechanisms elicited by PA in plants are not clear, even though several scenarios have been proposed. Two French fry processing varieties, Russet Burbank and Shepody, were used to study the effect of various fungicide treatment regimes for control of late blight. A randomized complete block design was used with four treatments, each replicated four times. Leaf samples were collected before and after pathogen inoculation for biological analyses. Comparative proteomics and bioinformatics tools were adapted to identify proteins that responded to the PA treatment. Subsequent analyses of these proteins were performed using multiple reaction monitoring and real-time qRT-PCR methods. In addition, microscopic observations using SEM and TEM were also performed. The collective outcome of these studies demonstrated that PA controls disease development by inducing several defense pathways in plants against the pathogen, and by direct inhibition of the pathogen's life cycle. These findings will contribute to the development of new disease control strategies for potato production.

Session 10

Detached-Leaf Evaluations of Potato Clones for Resistance to Alternaria solani

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Early blight disease, caused by *Alternaria solani*, is a serious disease of potato foliage and tubers that occurs in most potato-growing regions world-wide. Developing new potato cultivars with resistance to early blight may reduce losses in the field and in storage, and lessen the need for fungicide applications. In this study, A total of 229 clones,derived from 13 different hybrid families were evaluated for resistance to *A. solani* in detached leaf tests. Fully developed leaflets were detached from the middle part of the 6- to 12-weekold field-grown potato plants. Three detached leaflets of each clone were inoculated with 5-mm agar plugs of 1-week-old colonies of *A. solani* grown on tomato juice agar medium. Treated leaflets were placed on moist, sterile filter paper in a 90 mm covered Petri dish. Another leaflets were inoculated as a control with plain agar plugs. Leaflets were incubated in moist chambers at 20±2 ºC for 7 days before measurements were taken. Significant differences were found among families, and within families ($P < 0.05$). Out of 229 clones,115 were highly resistant (not show any symptoms of infection). For instance, clones, A2/11 and A2/132 derived from MF-1 X TS-4 hybrid family were very suscebtible to *A solani*, while the clones A2/120, A2/179 and A2/109 were found highly resistant to the pathogen. Similarly, the clones A3/20,A3/303, A3/117, T3/36, and A3/55 derived from Serrana x TS-9 hybrid family were very suscebtible to *A solani* while the clones A3/4, A3/66, A3/74, and A3/284 were found highly resistant to the pathogen.
These results suggest that these potato clones are worthy of use in breeding for early blight resistance.

Key words: Potato clone, resistance, *Alternaria solani*, detached leaf

Session 10

Evaluation of potato clones for resistance to black scurf caused by Rhizoctonia solani AG-3 in field studies in Tokat-Turkey

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Black scurf and stem cancer of Potato is a serious disease commonly observed in most potato-producing areas of the world. Caused by Rhizoctonia solani AG-3 (teleomorph Thanatephorus cucumeris [Frank] Donk), this disease is favoured by the capacity of fungus to survive in soil as sclerotia and mycelium in plant debris for long periods, and environmental conditions of low soil temperature and high soil moisture. Management of the disease requires an integrated approach since no single tactic is totally effective. An effective control program combines cultural practices, fungicides, and resistance. The objective of the present study was to evaluate the reaction of potato clones (262 clones derived from 13 hybrid families) for resistance to *Rhizoctonia* black scurf in field experiments during the 2008 and 2009 growing seasons. Seed tubers of each clone were planted in a field with an history of black scurf. Experimental design was randomized block design with three replication. At harvest, the incidence of black scurf on tuber was determined. The incidence of black scurf differed significantly among clones in both years. Based on the results of present study, black scurf incidences of 54 clones out of 262 clones were changing between 10% and 74%. On the other hand 153 clones were found highly resistant to the pathogen (0% black scurf incidence).
Key words: Potato clone, resistance, *Rhizoctonia solani*, detached leaf, Black scurf

Session 11

Diversity analysis of potato landraces in the CGN genebank by means of SNPs

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The Centre for Genetic Resources the Netherlands (CGN) maintains about 750 accessions of potato landraces, which were collected between 1955 and 1994 in Latin America. Little is known about the diversity within this part of the potato collection. The amount of available passport data is limited, often only the origin country is known. Therefore it is more or less impossible to create a core collection for breeders, containing the maximum of variability in a limited set of accessions. In the framework of the EU project Bioexploit the diversity in this Andean cultivated material was analysed by means of 768 SNP's using the Illumina platform. In total 454 potato landraces as well as 19 accessions from 13 potato wild relatives were analysed, with mostly two genotypes per accession. The analysis was performed using Illumina's Golden Gate technology and the Genomestudio Genotyping Module v1.0.10 software, which has been developed for human (a diploid species) applications. Allele dosage was estimated using the R script fitTetra (Voorrips, Gort & Vosman, submitted).
The analysis of the results shows that diploid and tetraploid cultivated material can be clearly separated. The results confirm that modern (reference) varieties are closely related to tuberosum germplasm from Chile (Ames & Spooner 2008, Amer. J. Bot. 95:252–257). Using the genetic distances, the germplasm can be grouped, enabling the creation of a core collection for breeders and/or screening for quality and resistance traits. Furthermore, priorities for the maintenance of the germplasm can be set, avoiding the costly test on quarantine diseases followed by (true seed) multiplication of similar material by the genebank.

Session 11

Genomic in situ hybridization (GISH) analysis of the North and Central American hexaploid wild potato species

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About 70% of wild potato (*Solanum* L. section *Petota* Dumort) species are diploid, with the rest tetraploid, hexaploid, and a few rare triploid and pentaploid populations. Development of the genome concept for species of the section *Petota* has been based on the analysis of chromosome pairing in species and their hybrids, molecular markers, DNA sequences, and most recently on GISH for Mexican tetraploid species.

The North and Central American hexaploid species: *S. iopetalum*, *S. schenckii*, *S. hougsii*, *S. demissum* have been the subject of a numerous studies because they are characterized by multiple resistances to diseases and pest. In the taxonomic treatment of Hawkes (1990) all these hexaploid species belong to series *Demissa*. According to a five genome hypotheses of Matsubayashi (1991) all members of series *Demissa* are strict allopolyploids with genome formulae AADDD'D', and the diploid Mexican species *S. verrucosum* was suggested as the putative contributor of the A genome whereas donor(s) of the D genome(s) are unknown. Morphological and molecular data contradict this genome concept in that the North and Central American hexaploid *S. demissum* is closer to the South American polyploid species of series *Acaulia* than to the other members of series *D*emissa. DNA sequence data (Rodríguez and Spooner 2009) divide species of series *Demissa* in two groups having different genome origin: 1. the Acaulia group with *S. demissum* and *S. acaule* containing minor variants of genome A, and the 2. Iopetala group with the other species of series *Demissa* (*S. hougasii*, *S. iopetalum*, *S. schenckii*) as allohexaploids containing two component genomes (A, B) from North and Central American diploid species and the 3rd unidentified component genome derived from the possible genomic contribution of South and Central American species of series *Piurana* or *Conicibaccata*.

Our GISH analyses hybridized chromosomes of *S. demissum, S. hougasii*, *S. iopetalum and S. schenckii* with differentially labeled DNA of their putative progenitors - diploids:

1. AA genome *S.verrucosum, S. stenotomum;*
2. BB genome *S. ehrenbergii, S. jamesii, S. bulbocastanum*;
3. PP/A^pA^p genome *S. andreanum*, *S. pascoense*, *S. piurae*;

and tetraploids:

4. AABB genome *S. stoloniferum*;
5. AAA^aA^a genome *S. acaule*.

GISH data support *S. hougasii*, *S. iopetalum, S. schenckii* as strict allopolyploids, containing component genomes (A, B), and the third genome most likely related to PP.

However, the three genomes *S. demissum* (and two genomes *S. acaule*) are highly similar, most likely homologous or highly homologous to AA. Thus, GISH data support *S. demissum* as an autopolyploid rather than an allopolyploid.

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Session 11

Illustration of the diversity of genebank accessions of cultivated potato using simple sequence repeat markers

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The Gross Luesewitz potato collections (GLKS) preserve around 3200 cultivated potato accessions. They derive from more than 60 different countries and were bred during the last 250 years. The diversity in the cultivated material is expected to be very high and the potato collection can be seen as potential source for valuable agronomic traits like resistance genes. However, despite the old age of many of the potato accessions, they are suboptimally characterized from a molecular point of view. In recent years the interest in characterizing this collection via molecular technologies increased. One major genotyping study for a resistance trait exists using 600 genebank accessions (Gebhardt et al. 2004, Molecular Breeding 13, 93-102) as well as several smaller studies.

Main objective of the present study, partially funded by BMBF and Norika, was to evaluate the diversity within a subset of around 350 cultivated accessions using five SSR markers. For the analysis the origin and release date of the accessions as well as skin and flesh colour were considered. Among the 350 accessions analysed were also approximately 100 potential duplicates that have very similar names or a very similar genetic background. Preserving the Gross Luesewitz cultivated potato collection is very time consuming and costly. Hence it is not desirable to have duplicated accessions within the collection. Thus another aim of this study was to identify true duplicates and enable a more efficient maintenance of the cultivated potato collection.

Session 11

A microsatellite and morphological assessment of the VIR cultivated potato collection

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The potato collection of N.I.Vavilov Institute of Plant Industry (VIR) is one of the largest and oldest in the world, now numbering 8,680 accessions. This collection has historical and practical significance, as they formed the first potato germplasm collections, and their study led to early concepts on potato systematics, evolution, and breeding.
Despite its importance and size, there has never been a study of its molecular diversity, and there were many gaps in its passport data. The purpose of this study is to obtain morphological, ploidy, and microsatellite (SSR) data needed to set up a useful subset of the collection of cultivated potatoes and closely related wild species, and to use this subset to study cultivated potato taxonomy, phylogeny and diversity.
We assessed the current state of the VIR potato collection through new chromosome counts and morphological and nuclear microsatellite studies (19 nSSRs) of a subset of 295 landrace and related wild species accessions.
Our studies are concordant with other recent studies showing that many ploidy records are incorrect, based on assumptions of ploidy by taxonomic determinations rather than actual counts. Nuclear SSR data are also concordant in separating the wild from the cultivated species, the hybrid cultivated species S. curtilobum and S. juzepczukii into a separate group with S. acaule, and the remaining cultivated species into roughly two groups: 1) diploids and triploids, and 2) tetraploids. Within the tetraploids, the Chilean and Andean landraces are somewhat separated. The morphological results support close phenetic relationships only of S. juzepczukii and S. acaule, and intermix many of the other cultivated species.
The results obtained are very similar to other recent studies of cultivated species, and show the need to reclassify the collection of cultivated potatoes.

Session 12

Rationale for modern resistance breeding in potato

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Losses in production and storage of a potato crop are caused by several fungal, viral and bacterial diseases. Losses are calculated in billion of US dollars worldwide. In recent decades the several programs of Integrated Pest Managements have been developed to protect the crop. The resistance of cultivated varieties became more important component of the IPM system. On the one hand the chemical protection against late blight is an excellent example of an effective crop protection and on the other hand there is an increasing interest in the environment protection and limitation of chemicals use. The resistance breeding in potato has a nice history starting in the beginning of the last century. The breeding for resistance by utilization of wild *Solanum* species and primitive cultivated ones has been initiated in several centers in the world and the cultivars resistant to respective diseases have been developed. In the presentation the input of resistant cultivars in the world collection will be analyzed.
In Poland, in order to rationalize the breeding of resistant cultivars, the program of parental line breeding has been realized for over 50 years in the Mlochów Research Center IHAR -PIB. Recent progress in resistance breeding based on complementary studies on host, pathogen and their interaction. In the host studies, MAS (Marker Assisted Selection) approach is a promise to speed up a selection process. In last decade, the number of available PCR markers associated to resistance genes increased. Application of MAS along with search for new resistance sources – two important elements of the parental line breeding program, will be discussed.

Session 12

Results and perspectives of potato breeding for resistance to diseases

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Increasing the number of traits in the direction of which breeding of potato carrying out determines the necessity of using special parental lines created on prebreeding phase. In our work in the first phase for the parental genotypes creating interspecific hybrids and backcrosses containing the dominant genes Ry_{adg} (of one source), Ry_{chc} (of two sources) and Ry_{sto} (of three sources) were obtained. Polygenes controlling field resistance to *P. infestans* were introduced in lines by return crossings. For this purpose, cultivars with field resistance originated from *S. demissum* were used. Our breeding program which we are carrying out at present time for further increasing of the field resistance to *P. infestans* of parental lines and new varieties of potato is based on the selection of transgressive recombinants in the progeny of saturating crosses. From crosses of parental lines with high field resistance a new group of recombinants consisted of 40 genotypes has been allocated. In epiphytoty *P. infestans* of 2008 these genotypes were estimated on the resistance. At the level of 9 points there were 4 genotypes (10%), at the level of 8.5 points - 27 genotypes (67.5%), the level of 8 points - 9 genotypes (22.5%). Indicators of parent resistance were 7-7.5 points. Most of the recombinants were characterized by a high degree of stability of field resistance. During seven-day period of blight epiphytoty 52.5% genotypes reduced the level of resistance only by 0.5 points, 17.5% of genotypes – by 1 point, and 12.5% genotypes - by 1.5 points. There were allocated 7 recombinant genotypes (17.5%), which during that period did not change the level of resistance. For comparison, early varieties with R-genes reduced its level by 5 points (genotype R_1R_2 – from 8 to 3 points, genotype R_3 – from 6 to 1 point). Productivity of genotypes with high degree of stability of field resistance was lower (814-930 g/plant) in comparison with less stable (1150-1180 g/plant). The obtained data indicate the possibility of increasing the level of field resistance by crossing recombinants 8.5x8.5 and 8.5x9, which opens up great perspectives for this direction of potato breeding. As a result parental lines combining higher stability of field resistance (8-9 points) with extreme resistance to virus Y are selected.

For stage reduction prebreeding and increases of its productivity use DNA markers is expedient. STS (YES3-3A and YES3-3B) markers of gene Ry_{sto} (Song, Schwarzfischer, Am. J. Pot Res, 85:159-170 (2008), RAPD a marker of gene $Ry_{?hc}$ (Sato et all., Euphytica 149:367-372 (2006) and SCAR a marker of gene Ry_{adg} (Kasai et all., Genome 43:1-8 (2000) have been found in cultivars and the hybrids of our selection characterised by extreme resistance (immunodefence) to virus Y. It is established, that a backcross 128/6 and varieties origin from him are sources Ry_{adg}; backcrosses 88.16/20, 88.34/14 and varieties origin from his, contain $Ry_{?hc}$ and Ry_{sto} - in potato varieties origin from Hungary's hybrids and from Fanal. Results of the spent researches confirm possibility of application of different types DNA markers genes of resistance to virus Y in potato breeding.

Session 12

Adequate Sample Size and Replication in Potato Experiments

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How many replicates (***r***) (blocks) do you use in your experiments? What is the size (***z***) of your experimental unit (unit) –number of plants per sample? Do you examine earlier data to characterise the variation and choose these features rationally? This paper will consider the effect of ***z*** on the coefficient of variation (***CV***) of variates studied and the precision that can be obtained when low ***CV*** are matched with appropriate replication.

Also it will examine a 90% chance of finding true differences (***Д***) at probability P = 0.05. The size of ***Д*** that is detectable depends on ***r*** and the error variance of the measurements. Reducing the ***CV*** enhances the accuracy of the experiment.

Statistics – The effect of differing sizes ***z*** on ***CV*** was assessed by randomly sampling variates with replacement, or bootstrapping (Efron & Tibshirani 1993 *An Introduction to the Bootstrap*. Chapman & Hall, New York). The effect of ***z*** and ***r*** on the size of the true difference detectable was calculated following Cochran & Cox 1957 (Chap 2 in *Experimental Designs*, 2nd Edn. John Wiley & Sons, Inc., New York) and tabulated values for Student's t-test.

Plant Material – Apart from careful selection of the experimental material, the simplest way to reduce the ***CV*** of variates is to increase ***z***. The data was drawn from growth analysis experiments over three years, giving a range of variates in three cultivars each year and twelve harvests per year. Each harvest involved 3-plant samples (the experimental unit) from six plots in replicated Latin squares. The records of individual plants were kept separate and so various sizes of experimental unit could be created.

Sampling was done from early June, 14 days after emergence, at 7- and 14-day intervals until the end of the growing season in October. The cultivars examined were Maris Piper and Guardian (3 years), Pentland Dell (2 years) and Maris Bard (1 year).

These data allowed assessment of changes in the ***CV*** in each variate - between cultivars, through a growing season, and between seasons. They also allowed the change in ***CV*** with ***z*** to be examined and an optimum size to be chosen.

Results

Based on the original 3-plant units, the ***CV*** of Total DWt was roughly equal in all three cultivars and varied between 10% and 20% throughout the growing season.

As might be expected Tuber DWt was initially more variable but ***CV*** stabilized between 10 – 18% from late July, early August.

In a mirror image, ***CV*** of LAI was initially conservative with time and cultivar between 15 and 20% but, from early August, it increased hugely as the canopies began to senesce.

The level of ***CV*** of Total DWt and its small change over the season were consistent between years.

The time when the ***CV*** of Tuber FWt stabilized differed between years as did the time of tuber initiation but it settled to similar values in each year (10 – 20%).

The ***CV*** of Total DWt declines asymptotically over the range of 1- to 12-plant units with values of ***CV*** where n = 8 or 9 being close to the asymptote. The ***CV*** of other variates behave similarly.

Calculations of the minimum ***Д*** between means with a 90% chance of being found at P = 0.05 were made for a range of unit sizes and replications and for both a one-tailed and a two-tailed test. These can be re-arranged to show the number of replications and unit size needed for the same 90% chance of finding any given true difference in means.

Session 12

Development of molecular markers to assist selection for high levels of resistance to potato leafroll virus (PLRV) from S. tuberosum ssp. andigena

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Potato leafroll is an aphid- transmitted disease caused by potato leaf roll virus (PLRV). It is a widely spread disease that may cause severe yield losses (up to 90%) and in some cultivars quality reduction due to internal necrosis. A major gene inheritance of resistance to PLRV was demonstrated at CIP in a parthenogenic segregating population derived from a highly resistant landrace from *Solanum tuberosum* ssp. *andigena* (Velásquez et al., 2007, TAG 114:1051-1058). The gene named Rl_{adg} provides high levels of resistance to PLRV infection and multiplication. It has been genetically mapped to the upper arm of chromosome 5 in the tetraploid map developed for the highly resistance *andigena* cultivar LOP-868, and a linked AFLP marker "P13M34.453" at 0.5cM has been identified. Here we report the development of a molecular marker for assisted and expedite selection (MAS) based on the closely linked AFLP marker to be effectively used in the introgression and incorporation of this high level of PLRV resistance in breeding populations. The DNA sequence of the 453 bp size tightly linked marker turned out to be highly similar to the leucine rich repeat (LRR) part of the *R1* late blight resistance gene of *S. demissum*. Several reverse primers were designed on the DNA sequence of the AFLP fragment and used together with a forward degenerate primer targeting the phosphate-binding domain (the P loop, GM(P/G)(L/M)GKTTLA motif) of the NBS region, common to many *R* genes. Using touch down PCR a number of fragments were generated of which one had the same segregation pattern as the original AFLP fragment. The degenerate primer was converted into a specific primer, which together with one of the primers designed on the AFLP fragment yielded a marker of expected size and having an expected segregation pattern in the mapping progeny. This marker was named NBS-LRR789. We also tested a sample of cultivars with known levels of PLRV resistance and show that the marker NBS-LRR789 developed is useful for MAS.

Session 13

Mycorrhiza: biological tools for promoting ecosystem services in potato production

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In France, potato is one of the crops treated with the highest amount of pesticides and fertilizers (Butault *et al*, 2010, INRA ed. 90p.). Due to this, potato production is faced with, both, legislative (Dir. 2009/128/EC, French national plan ECOPHYTO 2018) and economical difficulties (fertilizer prices are volatile; *e.g.* they have risen more than 200% in 2007 – IFDC).
It is therefore necessary to develop innovative methods to reduce the use of chemicals. For this, we are exploring* the use of Arbuscular Mycorrhizal Fungi (AMF), known to act as biofertilizers, bioprotectors and biostimulators in sustainable agriculture systems (Gianinazzi *et al*, 2010, Mycorrhiza 8, 519-530), associated with an organic product, the Floravit known to enhance plant robustness and yield.
A Field experiment has been performed with the potato variety Allians, where commercial mycorrhizal fungi (Symbivit) and Floravit have been applied independently or together to the tubers at the plantation. In the case of Floravit, a second application has been performed on Potato shoots of 3 weeks-old plantlets. Both treatments (AMF and Floravit) are compatible and when applied together, the potato yield increased of 18%. Furthermore tubers show a highest level of resistance against insects. These results will be discussed in the context of the development of alternative methods for potato production.

*QUALIVIVANT project (FEDER N°: 1088-29000318): "Promotion de la culture de pomme de terre en utilisant des alternatives biologiques (microorganismes telluriques bénéfiques, associé à des produits dit « vert » DVP - Développement Végetal Process) afin de renforcer les défenses naturelles de cette plante, tout en préservant les qualités nutritionnelles et organoleptiques."

Session 13

Assessing the sustainability of potato production in South Africa

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Agricultural production draws resources from and emits substances into the environment, which can potentially jeopardise sustainability. Potato production in the Western Cape of South Africa occurs in an ecologically sensitive and vulnerable environment. The question how potato production can be sustained in such a sensitive area asks for a scientific approach to define sustainability, and to monitor and improve farming practices.

Principles related to the ecological impact of potato production were developed (nature conservation, water preservation, and minimization of chemical inputs and carbon dioxide emissions) and criteria were derived regarding land clearing, irrigation, emissions, and others. Sustainability indicators were thereafter defined to quantify the efficiency with which these resources are used, e.g. the proportion of land cleared for production, potato yields achieved, water use by the crop, amount of chemicals used (including the energy content they represent) and the energy needed for farm operations. In-depth interviews were conducted with farmers to obtain current indicator values achieved on each farm. These were then compared to model outcomes of two main sustainability indicators, namely land and water use efficiencies.

Land-use efficiency values varied least between farmers (36 to 58 Mg ha^{-1}), while the recorded water-use efficiency ranged between 3 and 9 g potato L^{-1} water. Phosphorus fertlilzer use efficiency varied most, between 98 and 995 g potato g^{-1} P applied. Model simulation results confirmed some of the trends revealed by the survey, e.g. growing potato in winter and cutting down on water levels have the potential to double water-use efficiency. We propose that indicator threshold norms be derived, based on knowledge of the physical and biological processes that determine resource availability, the observed variation among farmers and model outcomes.

Since indicator values, their ranges and ways of improving them are now known, it will help us to establish sustainability norms, which can provide a quantitative framework for assessing sustainability of potato production in the Western Cape Sandveld and other ecologically sensitive areas.

Session 13

New system of potato protection from Colorado potato beetle

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Abstract

On the basis of generalization and the analysis of scientific results of long term multifactor field experiments and laboratory researches using mathematical methods and the experience of potato growing farms innovative biologized system of potato protection from Colorado potato beetle for soil-climatic and organizational-economic conditions of Republic Bashkortostan was developed.

Introduction

To overcome the resistance of Colorado beetles to insecticides it is necessary to get over to antiresistant strategy of its usage. The treatment with potato insecticides can be made when the level of economic threshold of harmfulness (ETH) of Colorado beetles larvae. The ETH it is 26-28 larvae/plant. Under the deficiency of moisture it is 18-20 larvae per plant.

Materials and methods

In the experimental farm of the Bashkir State Agrarian University two factor field experiment on improvement of potato protection from Colorado beetles was established in 2009-2010. For research the super elite variety Nevsky was used. All observations, estimations and analyses were carried out using generally accepted methods. The experiment scheme is given in the Table 1. Treatment was of ETH was 20 larvae/plant.

Results and discussion

The maximum leaf square was formed when Bitoxibacillin was used and the rated fertilizer doze 58 thousands m^2/ha to 30 t/ha tubers in 2009 was applied. This variant case is characterized by with much bigger yield of tubers 35,5 t/ha in 2009 and 14,2 t/ha in 2010. Dry matter content increases to 22-28%, starch content increases to 33-39%, ascorbic acid increases to 30-39,5%, nitrate content decreases to 40-46%, marketable value increases to 47-62% comparing with the control variant by Bitoxibacillin use. In 2010 two treatments were made. Biological effectiveness reached to 94% for the first time and 99,6% for the second time.

Conclusion

Thus, the analyses of our research work and the experience of leading potato growers of the Republic of Bashkortostan allows to make the following main conclusions:

1. Application of all insecticides in studied combinations was effective. Appearance of resistant populations of Colorado beetles was not marked.
2. New system of potato protection from Colorado beetles on the base of antiresistant strategy for ecologically yield of tubers is effective. It is used on optimal in the Russia level of ETH pest.

Session 13

Managing The Intercropping Period For Controlling Soil Borne Diseases Of Potato Due To Streptomyces Spp. And Rhizoctonia Solani

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In France, the establishment of catch crops between two commercial crops is in full development because of the environmental and agronomical issues. Some of these crops could have a beneficial effect for controlling soil borne diseases. The main objectives of our research are 1) to compare *in vitro* the biofumigation potential of several catch crops against *R. solani* and *Streptomyces* spp., 2) to assess the efficacy of biofumigation in potato production system *and* 3) to study the effect of some factors on the biofumigation efficacy.
In vitro reduction of pathogens growth by volatiles released from several plants (brown mustard, rye, white mustard, radish, oat) were quantified on *Streptomyces* spp. and *R. solani* using a bioassay (Charron and Sams, 1999. J. Amer. Soc. Hort. Sci. 124, 462-467). *R. solani* is completely (inoculum = agar disc) or almost completely (inoculums = sclerotia) inhibited by *B. juncea* volatiles. For *Streptomyces*, inhibition of the bacterial growth by *B. juncea* volatiles depends on the inoculum density. The other tested plants were not effective in reducing fungal and bacterial growth with this methodology. *B. juncea* seems to be the good candidate for further studies in green house and field experiments.
Two field trials were conducted using a wheat–potato rotation carried out in 2007 and in 2009. Mustard was grown as a cover crop during the intercrop period before potato and then crushed and incorporated into the soil. A significant effect of biofumigation by *B. juncea* in reducing common scab and black scurf incidence and severity was only observed in the 2007 trial. The efficacy variation between the two experiments could be related to the soil contamination level and to the differences in mustard biomass produced.
In green house , the effects of residue rates (50, 25 and 0 g fresh crushed residue / L of soil) and inoculum densities (1 and 5 % v/v) of *R. solani* and *Stretomyces* spp. were tested. Incorporating high quantity of residues (50 g FCR / L of soil) reduced black scurf and stolon cankers incidence by 40 to 100% according to soil inoculum densities 5 and 1% v/v respectively. Halve the amount of incorporated residues leads to inefficient biofumigation on *R. solani*. Similar results were observed on *Streptomyces* spp.

In vitro study confirms the biofumigant potential of *B. juncea* on pathogens. Nevertheless, the field and the green house data showed that the expression of this potential depends on factors such as crop biomass and soil contamination level. These data may explain some of the previous field studies which reported variable results on the biofumigation. Further epidemiological studies are needed to understand the mechanisms of action of biofumigation on disease development. These epidemiological data are useful for constructing IPM strategies based on complementary methods including biofumigation.

Session 14

Towards a clonal collection of wild *Solanum* species: tagging wild Solanum R genes, genomes and species

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The most efficient and ecologically sustainable way to thwart the global threat of late blight (LB) is to breed new potato varieties manifesting durable resistance to a wide range of *Phytophthora infestans* races. Such an approach implies an expanded search for new *R* genes for LB resistance among wild *Solanum* species and potato hybrids incorporating wild *Solanum* germplasm. Robust and reliable DNA markers greatly facilitate mapping and isolation of new *R* genes and help identify and track them in the germplasm collections. New donors of LB resistance are developed using marker-assisted gene pyramiding by remote hybridization and trans- and cisgenesis (Hein et al. 2009, Potato Res. 52, 215-222; Park et al. 2009, Plant Breed. 128, 109-117).
Wild *Solanum* accessions in the germplasm collections are usually highly polymorphic as to LB resistance, apparently in part due to diverse profiles of *R* genes. We therefore check the response to LB in individual plants and maintain these clones as the initial material for breeding future donors of LB resistance. To this end, we develop SCAR markers of *R* genes and *Solanum* genomes as the tools to tag these sources and donors. New and already existing sources and donors of high LB resistance are also employed in allele-mining for new *R* genes and their functional characterization using the candidate-gene and *Avr-R* gene approaches (Gebhardt et al., 2007. Crop Sci., 47, 106-111; Lokossou et al., 2009. Mol. Plant-Micr. Inter., 22, 630–641; Vleeshouwers et al., 2008. PLoS ONE 3, e2875).Here we report evidence from coupled phytopathological and molecular screens of over 200 accessions of 21 *Solanum* species. Detached-leaf trials for LB resistance were run in St. Petersburg and Bol'shiye Vyazemy using two locally isolated highly aggressive complex races of *P. infestans* virulent to all 11 *R* genes of *S. demissum* and also a set of simple *P. infestans* races. Two independent assessments using complex races were in good agreement by the Spearman's rank correlation coefficient. Avr-profiling of the isolates employed in these assessments will help determine their specificity for particular *R* genes.
We developed and verified SCAR markers for the genes *R1, R3* of *S. demissum, RB/Rpi-blb1* of *S. bulbocastanum* and for the corresponding germplasms. The structural homologs of these genes found in North and South American species were verified by cloning and sequencing although we have not yet proved their function as LB resistance genes. The presence of these homologs was not associated with high LB resistance.
The study is supported by the ISTC-ARS-USDA project 3714p.

Session 14

Natural and EMS-induced variants of invertase PAIN1

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Cold-Induced Sweetening (CIS) of potatoes is the accumulation of reducing sugars glucose and fructose after storage at low temperature (4°C). CIS negatively influences frying and chipping quality. One of the enzymes important for CIS is invertase, which converts sucrose into glucose and fructose. There are several types of invertases, but only vacuolar invertase PAIN1 is expressed in tubers and induced by low temperature. We investigated natural variants of PAIN1 in 8 monoploid, 18 diploid and 171 tetraploid potato genotypes by direct sequencing of PCR products. This study resulted in the discovery of 16 different PAIN1 alleles, some of which with a very low allele frequency. Next generation sequencing (Illumina HiSeq 2000) of exonic sequences of PAIN1 of 83 tetraploid genotypes yielded additional SNPs. Moreover, specific tagSNPs allowing the unique identification of each haplotype could be deduced. No significant correlation between haplotypes and frying quality was observed in an association panel comprising 137 cultivars. The SNPs in PAIN1 exonic sequences resulted in 36 amino acid changes. Of these, 31 were predicted to be benign by the PolyPhen-2 software. Three were possibly damaging and two probably damaging. None of these amino acid changes were present in the 13 conserved domains of invertases as described by Ji et al. (J Mol Evol 2005,60:615-634). In addition to analysis of natural variants we induced variants by treatment of seeds of diploid self-fertile potato genotype G254 with EMS. High Resultion Melting (HRM) analysis of ca. 1800 M1 seedlings and subsequent sequencing of PCR products showing a deviating melting pattern resulted in the discovery of 15 SNPs and 11 amino acid changes. Seven of the amino acid changes were predicted to be benign, three probably damaging, and one resulted in a premature stop codon. One of the probably damaging amino acid changes involved a highly conserved negatively charged amino acid in the sucrose-binding pocket of the PAIN1 invertase, which was changed into an uncharged amino acid. This amino acid change may have a large effect on efficiency of sucrose binding and hydrolysis. The natural and EMS-induced variants of PAIN1 will be a good starting point for breeding of CIS-resistant cultivars.

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Session 14

Regulation of steroidal glycoalkaloids in potato

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Steroidal glycoalkaloids (SGAs) are toxic secondary metabolites whose total content must be regulated in tubers of commercial potato. SGA composition and level are genetically determined; however various environmental conditions and post-harvest management practices may increase their level. The SGA pathway branches from the mevalonic acid/isoprenoid pathway; however, only sketchy details are available on SGA specific genes. We previously showed a correlation between SGA level and the abundance of transcripts coding for HMG-CoA reductase 1 (*hmg1*) and squalene synthase 1 (*sqs1*) in potato tissues of genotypes varying in SGA content (Krits et al. 2007, Planta 227:143-150). Sequence comparison of *hmg1* and *sqs1* from *Solanum tuberosum* cv. Desirée (low SGA producer) and the wild potato *Solanum chacoense* Bitt. clone 8380-1 (high SGA producer) indicated genotype-specific amino acid substitutions that may affect enzyme efficiency in metabolism. Hence, to confirm the association of high SGA level with high expression of *hmg1* and *sqs1*, we transformed Desirée with gene expression constructs of either the *hmg1* or *sqs1* cDNA of *S. chacoense*. Most transgenic plants exhibited greater (20-100%) leaf SGA than untransformed controls, as determined by HPLC. Quantitative real-time PCR was used to determine relative steady-state transcript levels of isoprenoid-, steroid-, and SGA-related genes in leaves of the transgenic plants compared to non-transgenic controls. The data suggest coordinated regulation of isoprenoid metabolism and SGA secondary metabolism. cDNA-AFLP was used to isolate putative SGA sequences by comparing transgenics with altered SGA expression with non-transgenic controls.

Session 14

SNP and haplotype identification from targeted next-generation re-sequencing in a set of 83 potato cultivars.

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Cultivated potato germplasm is characterized by a large number of different alleles, often exceeding 10 alleles per locus. Cultivars are highly heterozygous with often 4 different alleles per locus. Genome wide association studies (GWAS) between marker loci and trait phenotypes have limited power, because binary marker data (0/1) are insufficient to unambiguously follow these many alleles. Binary markers just lump alleles in two groups depending on the distribution of the DNA polymorphism. Some SNP markers however uniquely tag a single specific allele, and with an allelic series of such TagSNPs it should be possible to achieve full classification or haplotyping of potato genotypes at any given locus.
Since the completion of a draft version of the potato genome sequence, which represents only one allele, our next goal is the identification of genome wide allelic diversity or haplotype diversity of cultivated potato germplasm. However, re-sequencing of entire genomes at read-depths that warrants the identification of all four alleles is too costly. Therefore we captured only 1.5 Mb of target sequence from the 840 Mb potato genome using an in solution hybridisation with a library of 55,000 120-mer RNA oligonucleotide baits. The 1.5 Mb of target sequence represents 800 candidate gene loci across the potato genome. With an Illumina HiSeq 2000 machine we paired-end sequenced the captured fraction of 83 barcoded potato cultivars and one monoploid in pools of 12 genotypes per lane. From the obtained sequences >33 Gb could be mapped to the DM reference genome. This translates to an average read depth of 40x coverage and allows not only SNP identification but also a prediction of the zygosity. Within a collection of >100,000 SNP calls a subset of TagSNP is being identified and used for GWAS and subsequent validation of the diagnostic value of specific alleles in marker assisted breeding programs. This research is supported by a grant of the Dutch Technology Foundation STW: WPB-7926.

Session 15

Strategies to produce cisgenic transformants in potato

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To prevent yield losses in potato from late blight (LB), chemical crop protection is used. So far, many major resistance genes from wild species have been introgressed into potato by multiple steps to improve disease resistance to LB. Cisgenesis, with cloned resistance genes from the species itself or from crossable species, is an attractive approach in this vegetatively propagated crop especially if stacking of *R* genes is the target. Because it is envisaged that multiple *R* genes can contribute to a more durable resistance against LB, it is important to obtain transformants with multiple stacked genes. One way is to make transformation with constructs containing several *R* genes; another way is to do the co-transformation with two or more vectors, each harboring one or more *R* genes; and the third way is via re-transformation with plants already containing one or more *R* genes. Results showed that transformation with two genes in one vector has a higher efficiency of double gene integration (69%), than that after co-transformations (23%). Vector backbone integration showed significant differences between both methods, 8% of transformants harbored backbone sequences after one vector transformation, whereas, this was 52% after co-transformations. Furthermore, around 30% of the transformants, which were PCR positive for the inserted *R* gene(s) produced from both strategies, showed absence of resistance in the disease test. This is much higher than that observed after using kanamycin resistance as a selection marker. Recently, 14 transformants harboring four *R* genes had been obtained after re-transformation of transformants containing already two *R* genes. Results about the different experiments will be presented.

Session 15

Intragenic tools for genetic enhancement of potato

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Intragenic strategies for the genetic modification of crops allow gene transfer without the introduction of foreign DNA. We have constructed a series of intragenic vectors and expression cassettes for gene transfer to potatoes using both *Agrobacterium*-mediated transformation and direct DNA uptake. Potato sequences have been identified with the functional equivalence of important vector components such as T-DNA borders and regions for site specific recombination. To guarantee that intragenic transformation events are restricted to the intended plant-derived T-DNA regions, we propose the induction in *Agrobacterium* of minicircles from T-DNA regions using site specific recombination. In this manner transformation events are derived from the T-DNA minicircle induced immediately prior to co-cultivation with plant tissues, rather than from the binary vector from which they are derived. The careful assembly of the minicircle region, using potato-derived sequences for site-specific recombination and one potato-derived T-DNA border, assures the absence of foreign DNA during plant transformation using intragenic approaches. To target the desired expression of potato genes, we have also constructed a series of potato expression cassettes. This involves the deletion of the coding region of specific genes to leave the 5' promoter and 3' terminator regions separated by a native restriction site(s) into which the coding regions of other potato genes can be cloned. The accurate design and construction of vectors and expression cassettes is necessary to avoid the inadvertent inclusion of nucleotide sequences of foreign origin. To date, we have constructed expression cassettes for foliage-specific gene expression using a chlorophyll a/b binding protein gene (*StLhca3*), tuber-specific gene expression using a granule-bound starch synthase gene (*StGBSSI*) or a patatin gene (*St patatin class I*), and constitutive gene expression using the ubiquitin-3 gene (*StUbi3*). Applications and issues surrounding the intragenic delivery of potato intragenes and cisgenes for the genetic enhancement of potato will be discussed.

Session 15

Captured - The NB-LRRome of Sarpo Mira

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The effort of the potato genome sequencing consortium (PGSC) has led to the full sequencing and annotation of the genome of a monoploid potato species from the *Solanum tuberosum* Group Phureja. The genome assembly comprises about 730 Mb (estimated genome size is ~840Mb) and annotation has revealed approximately 39,000 genes. Of those, we could identify 400 nucleotide binding leucine-rich repeat (NB-LRR) type disease resistance (*R*) genes with an average length of approximately 3 kb. Thus, 0.14% of the potato genome encodes NB-LRR type *R* genes, the NB-LRRome. Among these are 61 NB-LRR with an N-terminal toll/interleukin 1 receptor (TIR)-like domain, and 339 NB-LRR with an N-terminal coiled-coil (CC) domain. All identified genes are spread over the entire genome, and map to the 12 potato chromosomes, with two major clusters on chromosome 4 and chromosome 11, around the well described *R* genes *R2* and *R3a,* respectively. Several major potato diseases, including late blight, caused by *Phytophthora infestans*, as well as those caused by viruses and nematodes are controlled by NB-LRR genes, and some *R* genes have been introgressed into modern potato cultivars from wild species of potato.
We have developed and designed a NB-LRR enrichment library consisting of 48,500 biotinylated RNA baits using the Agilent SureSelect platform and assessed the enrichment efficacy on a segregating potato population that was derived from crossing cv. Sarpo Mira with cv. Maris Piper. Independent field and glasshouse trials have shown that the *S. tuberosum* cv. Sarpo Mira is highly resistant to a wide range of *P. infestans* isolates, including those derived from the more aggressive A2_blue13 genotype that is currently dominating European blight populations. Enrichment prior to Illumina paired-end sequencing of resistant and susceptible bulks has yielded 69,006,196 and 41,493,120 high quality sequencing reads respectively. Of these, approximately 88% of each bulk could be mapped using the Burrows-Wheeler-Aligner to scaffold sequences of the potato genome. More important, for each bulk 60% could be aligned to the extended bait library, which contains in addition to the bait *R* gene sequence, 1kb of flanking sequence to accommodate introns as well as promoter and terminator regions. On average 43,500 paired end reads map to each of the previously identified NB-LRR genes, and all genes are covered. If compared to the 0.14% NB-LRR genes expected from sequencing non-enriched libraries, the SureSelect technology has thus yielded 430-fold enrichment.
Analysis of the sequencing data is ongoing and we are currently designing markers to confirm NB-LRR polymorphisms that are unique to the resistant bulk and could underpin the resistance of cv. Sarpo Mira.

Session 15

Genetic diversity analyses in wild potatoes via multiplex fluorescent microsatellite fingerprints

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Wild, tuber-bearing *Solanum* species as genetic resources of cultivated potato constitute an important gene reservoir for resistances to diseases or pests or valuable agronomic traits. In a BMBF funded project aiming at the development of molecular markers for alleles confering resistance to potato wart (*Synchytrium endobioticum* (Schilb.) Perc.), wild potato accessions from the IPK Genebank were examined in order to assess the degree of variability within and between accessions, as well as that within species (where applicable).
Based on earlier publications on the presence of potato wart resistance, twelve wild species from nine taxonomic series of tuber-bearing potatoes were selected. After tuber production from appr. 800 individual genotypes coming from 82 genebank accessions, resistance against *Synchytrium* race 18 was tested at JKI Kleinmachnow. Leaf material of all individuals was harvested and genomic DNA extracted. SSR analyses were conducted in order to elucidate the applicability and power of resolution of microsatellite markers from different sources of cultivated potato. 14 SSRs were employed in four multiplex PCRs and separated as two combined 6- or 8-plexes on an automated fragment analysis system using fluorescence labeling.
The evaluation of the generated banding patterns sheds a light on the degree of diversity within accessions - e.g. mainly low levels in selfers like *S. acaule* or *S. demissum* vs. higher levels in outcrossers like *S. sparsipilum* or *S. trifidum* - and also between accessions and species, respectively. In combination with resistance data for the respective genotypes, this diversity assessment provides a basis for the planned identification of novel resistance alleles against potato wart.

Session 16

The effect of carbon dioxide atmosphere on tuber quality characteristics in potato storage

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A study was carried out between 2007-2010 with a two-fold aim:

1. Understand the range of carbon dioxide levels found in potato stores over a storage season. Potato stores, generally typical of those in general use for pre-pack storage, were periodically assessed for carbon dioxide levels over one season and in a subsequent season continuously monitored for carbon dioxide. Levels found in almost all the stores evaluated were generally below 1% and, in most cases, below 0.5%. However, in one notable case levels of carbon dioxide ≥1.5% were found for the majority of one season with a maximum of > 4%, a level that is life-threatening for humans. Tubers exposed to a range of commercial store carbon dioxide levels were monitored for changes to quality attributes and these results are reported.

2. Define the effects of carbon dioxide atmosphere on taste and texture attributes of stored potato tubers.
To define the effects of carbon dioxide and ethylene on taste and texture attributes, tubers of cultivars Maris Piper, Marfona and Estima were exposed to different levels of carbon dioxide atmosphere from ambient to 6%. To understand the potential interactions between carbon dioxide and ethylene used for sprout suppression adversely affecting tuber quality, the trials were carried out with and without ethylene at 10 ppm. Two periods of 37 day treatment, each relating to early and late stages within a storage season, were undertaken. Following the treatments, cooked tubers were assessed by a trained taste panel against a wide range of taste and texture attributes and their results are reported.

Session 16

Energy use in potato stores in Great Britain

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Energy use in potato stores (largely through the use of electricity) is the most significant running cost and, mirroring increases in the price of oil, has risen sharply within the last 5 years. There is also an increased focus on the carbon footprint of storage operations with key markets now taking a close interest in optimising carbon use efficiency. This is putting storage under ever-increasing pressure to be cost-effective and any margins for inefficiency which might have been tolerated only a few years ago are being constantly degraded.

A three year study of energy usage in 33 industry stores was carried out by Farm Energy and Sutton Bridge Crop Storage Research to assess the levels and efficiencies of use. This revealed a wide range of performance across the industry, with stores commonly showing as much as a three fold difference in their comparative use of energy per tonne of crop stored.

It was noted that very few of the stores were using positive ventilation so it is likely that significant gains in efficiencies are available across the industry as a whole. In addition, factors like air leakage from stores have seldom been taken into account adequately and there is likely to be further scope for efficiency improvements in this regard as well.

Preliminary results from this work suggest:
1) There is huge potential to improve the efficiency of energy use in potato storage through adoption of new construction processes, enhancement of existing buildings and uptake of better environmental control systems.
2) Management processes need to be reviewed thoroughly if significant gains are to be made since, in this assessment, poor practices were often to blame for high energy use, more so than poor hardware and equipment.
3) There needs to stronger financial encouragement for potato growers and store managers to adopt new, low carbon technologies to ensure the long-term sustainability of potato storage operations in Great Britain.

Session 16

Improvement of air distribution in forced air letterbox ventilation systems

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Against the space ventilation the forced air letterbox ventilation system enables a more effective drying and cooling of potatoes. In most cases the air distribution takes place by a pressure wall and air outlets in each layer of solid sided boxes. The air escapes the pressure wall and passes through the slatted box bottom of up to 10-12 boxes in several rows, while piling high is up to 6 boxes. In practise, an insufficient air distribution was ascertained at the air outlets of the pressure wall, which led to higher storage losses of the potatoes in some boxes. Reduction of the cross sections of the air outlets in order to increase the static pressure in the wall and an additional air brake in the bottom of the pressure wall improved the vertical and horizontal air distribution in this letterbox ventilation system.

Session 16

Mint oil: a new natural sprout suppressant opportunity

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Since a long time there is a wish to preserve potatoes from sprouting during storage by using compounds which could keep the different qualities of tubers and leave as low as possible the residues levels on these. During a large number of years progressive experiments contributed to obtain a good evaluation on the potential of mint oil in this purpose. After a first European registration on Annex I of the European Directive 91/414/EU by directive 2008/127/EU, the essential mint oil has received a Market Authorization (MA) in France in mid - October 2010. So this natural product is in this beginning of 2011 the second sprout suppressant after CIPC that is allowed in France for applications during the storage period. Regarding its profile and official European listing, the product can also be used in organic farming systems.
The registration is done for the essential oil in its entity but L-Carvone, the optical isomer of D-Carvone contained in essential oil of carvi, is the main active ingredient (minimum content 550 g/l) which gives the efficacy of the product. Its effect is a quick necrosis of sprouts in growth, from a white bud stage till a more developed size.
The experiments were carried on different cultivars (Bintje, Nicola, Monalisa …), characterized by short to long dormancy, with repeated thermo-fogging applications which contribute to a good distribution in the store. The high volatility of the product promotes also the evaporation of the fog inside the building which gives a profit for a homogenous distribution of the vapour in the storage even if this is not a reason for not respecting sufficiently appropriate advices to have correct air distribution in the store as for bulk or box stores. This quick evaporation of the compound is also the origin of a rapid loss of concentration in the following days after the application which explains the necessity for having a rigorous agenda in the frequency of the applications. However, this seems possible to be managed in relation with the sprouting pressure mainly due to the variety and the temperature of the store. Complementary study done in anti-sprouting strategy combining application of maleic hydrazide on the foliage of the crop during the vegetation phase and mint oil during storage showed a slowdown of the sprouting activity which could grant a more flexible action in the mint oil treatment frequency in storage, especially for long term storage (June).
Regarding quality aspects, the culinary tests done on tubers treated during the whole storage period with mint oil showed that no effect is expected on their taste and their behaviour after vapour cooking or frying preparations. On other point, the diseases involved in the deterioration of the skin finish, silver scurf and black dot, have known a reduction in a limited proportion of their development.
However, further improvement in the use of the product seems still necessary in order to work at the optimal dose for preserving a too high increase in the cost of the chemical protection against sprouting.

Session 17

SPOT-5 satellite multi-spectral data potential for assessing potato crop nitrogen status at a specific field scale

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A useful decision support system for the management of split fertilizer nitrogen (N) applications was developed in Belgium for potato (*Solanum tuberosum*). It combines the total N recommendation based on the field-predictive balance-sheet method with in-season Crop Nitrogen Status (CNS) monitoring through handheld Chlorophyll Meter (CM) readings. Using a zero-N reference plot (10 x 20 m) in supposed homogeneous field areas, relative CM threshold value helps decision-making on the need for and timing of supplemental N to improve previous recommendation.
The potential of Earth observation and crop light reflectance to monitor CNS was investigated in a study in the 2008 and 2009 growing seasons on plots of different sizes (from 30 x 30 m to 100 x 100 m) fertilized with differing mineral N rates. From mid-June to the beginning of August, reflectance data were acquired once from SPOT-5 satellite multi-spectral (MS) imagery (10 m pixel resolution in red, green, near-infrared and short-wave infrared bands) and weekly from ground-based near remote sensing with a handheld radiometer, together with weekly CM readings.
From the analysis of the satellite images, the red and near-infrared bands and several derived Vegetation Indices (VIs), discriminated well the nitrogen rates, particularly the zero-N reference plots as did the CM readings. The digital number (DN) data between pixels of the same N plot varied little (cv < 5%), but variations between similar N plots in different fields were high. The discrimination between the smallest acceptable N plots area, according to the SPOT-5 satellite MS imagery spatial resolution (10m) and therefore based on a single-pixel DN data, was also quite good. There were very good correlations (r^2> 0.80) between several VIs calculated from SPOT-5 satellite multi-spectral Top-of-Canopy reflectance data (derived from DN data) and ground-based radiometer data, mainly including G and NIR wavebands. Relationship between CNS measured from the crop (yield or N uptake) and CM or SPOT-5 will also be presented.

Session 17

Predecessors and fertilizer of an early potato

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Abstract
Clean fallow is one of the main measures of control of drought and weeds, and enrichment of soil with microorganisms and mobile forms of nutrients of Russia. It is recommended to apply 30-60 t/ha of manure, and incorporate straw and other local organic fertilizers in fallow to prevent loss of soil fertility at multiple soil cultivations.

Introduction
The search of optimum predecessors and efficient fertilizing plan of early potato is an actual problem of agricultural science. As compared with other crops early potato responds to green manure most of all. With preceding green manure crops early potato makes good use of farmyard manure and mineral fertilizers. The aim of our research is to study the effectiveness of biological melioration methods in agrotechnology of early potato.

Materials and methods
Field experiments were carried out in 2001-2002 in AC "Ashkadar" in the Republic of Bashkortostan. The soil types on experimental plots are typical medium deep, medium humus, clay loamy chernozem formed on diluvium limestone clay. Concentration of labile phosphorus is low, concentration of potassium is medium, ph 6,0-6,4. The scheme of the two-factor experiment is in Table 1. The size of record plot is 105 m^2. Planting of Nevskii variety: May, 9. Final harvesting: August, 15.

Results and discussion
The results of our research work: early potato responds to soil fertility level change and crop variation with improvement of bush habitus indices, increase in total biomass, yielding capacity and tuber quality (Tables 1).
Maximum leaf area was achieved in 5 variant and 6 variant. Maximum tuber yield and marketability value was formed in 5 variant. The best tuber quality was achieved in 4 variant.

Conclusion
Thus, the analysis of the carried-out scientific research and the experience of leading potato growers of Bashkortostan Republic allow making the following main conclusions:
1. The use of sweet clover and straw as biological ameliorants has positive influence on formation dynamics of early potato yield.
2. The application of green-manure crop of sweet clover under early potato increases yield and tuber quality.

Session 17

Managing processing quality of high yielding potato varieties by potassium fertilisation

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In Belgium the use of potatoes for processing has risen to more than 3 million tonnes in 2010. In spite of some agronomic disadvantages Bintje remains the most grown cultivar. The past years some alternative, high yielding cultivars have proved themselves, for example cvs. Asterix, Fontane and Innovator. Besides the potential of a high yield, these cultivars also have high dry matter content. On one hand this characteristic is favourable to obtain a good processing quality, but it also implies an increasing risk on black spot and consequently more risk on refusal for processing purposes.
This abstracts describes the research on the influence of potassium fertilisation on yield, dry matter content, black spot susceptibility and fry colour for the cultivars Asterix and Fontane carried out in 2004-2006 on (sandy) loam soils. We compared the effect of different forms of potassium fertilizers applied shortly before planting and during the growing season in randomized block design (split-plot).
Potassium fertilization resulted only in a small yield increase, which could be correlated with the moderate to high K content of the soil. No negative impact on yield was observed from the chloride form applied shortly before planting or during the growing season.
The trials showed that the form of potassium plays a major role on the industrial quality, especially on dry matter content and black spot susceptibility. An additional dressing with potassium chloride in June had a clear impact on both parameters.
Potassium fertilizers had a positive influence on fry colour, but the impact of the form was rather limited, with a small benefit for potassium chloride. After 5 months of conservation these differences became even less pronounced.
Although black spot susceptibility decreased clearly, only a limited effect on the K content of the tubers was observed. This implicates that only a minor part of the applied K fertilizers was exported from the field at harvest.
The technique of applying additional potassium in June proved to reduce the risk on high black spot appearance, but should be reserved for those varieties with high dry matter content and high black spot susceptibility. Meanwhile this modus operandi is also applied in practice on other industrial varieties, like for instance Innovator.

Session 17

Root vertical distribution and water absorption ability in Konyu potato cultivars with drought tolerance

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Potato (*Solanum tuberosum* L.) is very sensitive to drought because of its shallow and sparse root system. To improve drought tolerance of potato, we bred four cultivars with large root mass and registered them as Konyu-1 to Konyu-4 in 2007. In our previous report, we showed their high potential of drought tolerance and tuber yield in relation to shoot characters, such as leaf to stem ratio and number of branches (Deguchi et al. 2010, Potato Res. 53, 331-340). In the present study, we investigated root vertical distribution of Konyu varieties and its contribution to water absorption throughout the soil profile in the comparison to Konafubuki of commercial variety with small root mass.

MATERIALS AND METHODS: Konyu-1, Konyu-2, Konyu-4 and a check variety Konafubuki (a parent of Konyu cultivars) were cultivated in irrigated and droughted fields for 3 years (2008-2010). In the middle of June, after ridging of rows, two poly-shelters (each 6.3×25 m) were set up in the droughted field to prevent rainfall. At the same time, furrow-irrigation tubes were set up in the irrigated field to maintain the matric potential of soil water (MPS) at 20 cm soil depth above -60 kPa. In early August (S2: maximum shoot growth stage of Konyu-4 and Konafubuki) and in late August (S3: maximum shoot growth stage of Konyu-1 and Konyu-2), root dry weight (RDW) was measured in the soil layers of 20, 60 and 100 cm depths by core sampling method. The MPS was measured with MPS-1 (Decagon Device, USA) in the soil layers of 60 and 100cm depths for Konyu-1 and Konafubuki in 2008 (no reprication) and 2009 (three replications), and of 20, 60 and 100cm depths for every 4 cultivars (four replications) in 2010.

RESULTS AND DISCUSSION: Over 3 years, Konyu cultivars showed higher RDW than Konafubuki at 60cm and 100cm soil depths even at S2. Thereafter, RDW of 60cm and 100cm soil depths increased in Konyu cultivars, but not in Konafubuki. Consequently, the differences in RDW between Konyu cultivars and Konafubuki became larger at S3. The varietal difference in root growth at the deeper soils could not fully attribute to the difference in plant maturity, because the difference in RDW was found even between Konyu-4 and Konafubuki of the same maturity class. Considering water absorption of roots, Konyu-1 showed lower MPS than Konafubuki at 60cm and 100cm soil depths over three years. The magnitude and the starting date of difference varied between years and between soil depths. In 2010, when we measured MPS at 20 cm soil depth, Konafubuki showed the lowest MPS at 20 cm soil depth among 4 cultivars. In addition, we found the difference in MPS between Konyu cultivars. The lowest MPS was recorded in Konyu-1 at 100 cm soil depth, while in Konyu-2 at 60 cm soil depth. These results indicate that water absorption of potato plants is dependent on root vertical distribution, and therefore a cultivar with superior root distribution in deeper soil depth is able to absorp water from deeper soil depth and results in drought tolerant, such as Konyu cultivars.

Session 18

Challenges and Accomplishments of the U.S. Northwest Potato Variety Development Program

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Since its inception in 1984, the Northwest Potato Variety Development Program (Tri-State) has released over 37 commercial potato varieties. The Tri-State program has been an outstanding example of cooperative federal, state, and industry research as envisioned by writers of the original United States Farm Bill. Involved entities include the USDA/ARS, Washington State University, University of Idaho, Oregon State University, Potato Variety Management Institute (PVMI) and regional industry organizations. In 2005 the state potato commissions of Washington, Oregon, and Idaho launched PVMI as a nonprofit corporation responsible for PVP licensing and royalty collection on Tri-State potato varieties and to improve industry involvement and new variety acceptance. The Tri-State program is critical in serving an area that produces over half of all U.S. potatoes and the majority of potato exports. The objectives are to develop, release and commercialize new potato varieties that will directly benefit all segments of the U.S. Northwest potato industry and indirectly benefit all U.S. producing regions. Identifying low-input varieties with improved production efficiency, high yields and quality, and resistance to disease and stress is a priority of the program. Challenges are common and include resistance to change (new variety acceptance) by the Quick Service Restaurants (QSRs), growers, and industry, reduced funding, variety competition, ignorance of the consumer and news services, anti-potato diets, researcher retirements, and lack of experienced replacement personnel.

Despite challenges, the effect of the Tri-State program on the U.S. Northwest potato industry has been substantial. The fresh market and processing industries have incorporated many Tri-State varieties into their businesses. Ranger Russet, Alturas, Western Russet, Premier Russet, and Umatilla Russet are examples of russet cultivars released from the Tri-State program that have greatly benefited the Northwest potato industry, being the 3nd, 4th, 6th 7thand 8th most widely grown cultivars in Idaho in 2010, respectively (NASS, Crop Production, December, 2010), and accounted for 18% of the planted acreage in Idaho in 2010. Umatilla Russet, Ranger Russet, Alturas, and Premier Russet were the 2rd, 4th, 5th, and 7th most widely grown cultivars in WA in 2010, respectively, accounted for 38% of total acreage. In OR, these cultivars ranked 5th, 2nd, 7th, and 11th, respectively, and accounted for 31% of total acreage. Ranger Russet, Umatilla Russet, Alturas, Premier Russet, and Western Russet were also the 3rd, 5th, 7th, 9th, and 17th most widely grown potato varieties in the U.S. in 2010, with Tri-State varieties representing about 20% of the fall crop nationally. Varieties recently released by the program are now produced on over 115,000 acres in the Pacific Northwest with value to growers estimated at approximately $415 million.

Session 18

Early maturing potato for sustainable intensification in cereal based systems in India

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A major aim of the present study is to develop early maturing potato varieties that are heat tolerant and late blight resistant to improve food security and livelihoods of resource-poor farmers in the sub-tropical lowlands of Asia through diversification of cereal-based cropping systems. Further research is being carried out to increase potato processing from its current level of about 5% to 20% by 2020 to help improve farmer
incomes and address risks associated with occasional overproduction of the crop. Nine CIP-bred clones and three commercial varieties were planted about 20 days before normal planting time under short days of autumn in the hot semiarid agro-ecoregion (Sehgal et al. 1990, Agro-ecological Regions of India, NBBS Publ.24, 25-26), of Gujarat India in 2009 and 2010. The crop was dehaulmed 80 days after planting. Maximum day and minimum night temperatures ranged from 35 - 28^{0}C and 20 - 10^{0}C. The maximum
temperature of 35 ^{0}C was recorded at planting time. Four CIP clones 388972.22, 301029.18, 393708.31 and 397065.28 significantly higher marketable and total yield between 49-53 t/ha and 51-56 t/ha, respectively compared to three varieties Kufri Lauvkar, Kufri Surya and Kufri Badshah 33-45 t/ha and 35-47t/ha, respectively under warmer climate. The first 3 CIP clones were also found suitable for processing. Two of
the four elite clones 301029.18 and 393708.31 were moderately resistant to late blight under field conditions in the highlands under long days. The four CIP elite clones selected based on two successive years' performance will be introduced too the All India Coordinated Research Project for region specific multilocation adaptability testing and to release superior clones as varieties for sub-tropical lowlands.

Keywords: Sub-tropical, lowlands, elite clones, early maturing, processing attributes, adaptability.

Session 18

Study on Breeding of Potato clones adaptable to Central-North intersectional region of Turkey

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Potato breeding studies are new ,although potato has been produced for years in Turkey. But in recent years, studies on developing new cultivars were gained acceleration in Turkey. Potato cultivars growth in Turkey were mainly imported from overseas. This study was aimed at development of new potato cultivar and has been performed since 2007. Beginning materyals of the study were real seeds of 13 hybrid families (Serrana x 104.12LB, MF-1 x TS-4, Serrana x TS-9, Granola x TS-2, Serrana x DTO-33, Serrana x LT-7, Serrana x TS-4, Serrana x TPS-113, Serrana x TPS-67, MF-1 x LT-7, Pentland Crown x TS-2, Granola x Huincul, and Achrina x LT-7) originating from CIP. In the first year of the study about 20.000 seedling belonging to 13 hybrid families were produced. Then seedling were planted in the field and seed tubers were produced. Clone selection has been continued by use of clonal selection method. The following yield and tuber parameters were used in clonal selection studies; tuber yield/per hill, nubref of tuber/per hill, average tuber weight, tuber shape, peel smoothness, tuber dry matter content, peel and internal colour of tuber. Detailed quality characteristics of the clones have been evaluated since 2010. In this study, Marfona, Marabel,Agata,Agria,Hermes,Slaney,Layd Claire and Granola varieties were used as standart. In 2011 growing periot, clonal selection experiments have been carried on with 60 clones at three different locations (Artova location with 1200 m atitude, Kazova location with 640 m altitude, and Niksar location with 339 m altitude) in Tokat-Turkey.
Key words: Potato, Solanum tuberosum, Clonal selection, Development of cultivars

Session 19

The treatment with essential oils a potential enemy for potato virus Y in Solanum tuberosum and Nicotiana tabacum

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The improvement of techniques used for pathogens control, the choice of new opportunities, methods, players, natural resources represent several requirements for obtaining health and safety food. Potato virus Y (PVY) (*Potyviride*) is one of the most dangerous potato viruses. Efforts to control PVY are essential for potatoes producers. Being very susceptible to potyvirus infection, usually, *Nicotiana tabacum (*family *Solanaceae)* is used like test plant for potato virus Y. Phenolic compounds and constituents of *Rosmarinus officinalis, Thymus serpyllum, Lavandula officinalis* plants (Family *Lamiaceae,* order *Lamiales)* have antioxidant activity(Bedoux G. et al. 2010, Journal of EcoAgroTurism,6:83-91). Antioxidants such as rosmarinic acid, chlorogenic acid, poliphenols presents in essential oils extracted from *Lamiaceae* family plants and many other compounds like hydrogen peroxide, ascorbic acid are implicated in processus signaling against stress.The effects of treatments with essential oils from *Rosmarinus officinalis* (for potato) and from *Thymus serpyllum, Lavandula officinalis (*for tobacco) (dilution 1/100; 1/1000) on pigments content, minituber yield (potato) and on antiviral activity (tobacco) were evaluated after virus mechanical inoculation. The oils treatments of positive potato plants significantly reduced the number of tubers, enhancing their weights, while leaf pigment content also increased. Concerning the antiviral effect of the *Thymus serpyllum* and *Lavandula officinalis* oils, all the treated tobacco plants presented after PVY infection values of absorbances at 405nm signifficantly lower than the untreated and inoculated controls. Without oils treatments, PVY inoculated plants suffered significant reductions in leaf weight compared to uninfected controls and to plants treated with essential oils. It has been suggested that a physiological balance of antioxidant components is necessary in order to obtain protection to generalized stress; however, antioxidants are not always accessible to some of the sites where they are most needed in times of stress. Our results agree with this idea since the oil injections and ascorbic acid/ H_2O_2 treatments induced significant anti-stress effects only in the tubers from positive plants. These researches presented potential benefits of *Rosmarinus officinalis* oils in enhancing the potato yield and quality of tubers and of treatments with *Thymus serpyllum, Lavandula officinalis* oils on the *Nicotiana tabacum* plant immunity. So, the reduction of biocide usage is possible using natural compounds.

Session 19

Spread of Potato mop-top virus in Sweden

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Spraing are necrotic symptoms of brown arcs and circles in the flesh and surface of potato tubers. It is caused by infection of the RNA-viruses *Potato mop-top virus* (PMTV) or *Tobacco rattle virus* (TRV). Spraing has become a severe problem for potato production in Scandinavia, mostly because of qualitative losses. Many of the Swedish ware potato cultivars and all crisp cultivars are sensitive to spraing caused by PMTV, showing symptoms when infected. PMTV is transmitted by zoospores of the soil-borne protoctist *Spongospora subterranea*, which itself is a pathogen causing powdery scab on potato tubers. Infection by *S. subterranea* is enhanced by cool temperature and high moisture, which are needed for motility of zoospores. The zoospores can acquire virions of PMTV when *S. subterranea* develops in virus-infected host cells. To determine the present distribution of PMTV in Sweden, potato tubers and soil from several locations throughout Sweden were tested for PMTV using bait plants, enzyme-linked immunosorbent assay (ELISA), reverse-transcription polymerase chain reaction (RT-PCR) and real-time RT-PCR. The results showed a spread of PMTV further north compared to the previous inventory for PMTV in Sweden that was carried out during 1987-1991. PMTV isolates from different parts of Sweden were selected for partial genome sequencing. These sequences are analysed together with PMTV sequences available in GenBank and generated by the NKJ-project: ”Mop-top: Enhanced control of *Potato mop-top virus* in the Nordic and Baltic Region” which is a collaboration between Sweden, Norway, Denmark, Finland, Russia, Estonia, Latvia, Lithuania, Poland and Germany (Santala et al. 2010, Ann Appl Biol 157: 163-178). Sequence analyses revealed a high sequence identity among Swedish PMTV isolates (96-100%). Phylogenetic analyses showed that the Swedish PMTV isolates were closely related to all other available PMTV isolates and that there was no specific geographic grouping. This suggests that PMTV has been recently introduced into Sweden and that it is mostly spreading through seed potatoes. It was possible to transmit a PMTV isolate in a soil sample from 1991 to bait plants. This shows that the spores of *S. subterranea* can be dormant with the virus for at least 15 years and then produce zoospores infecting host plants with PMTV.

Session 19

Potato Virus Y (PVY) strains spread and symptoms on plants and progeny tubers of potato cultivars

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Potato Virus Y (PVY) is a Potyvirus transmitted by aphids in potato fields. Isolates of PVY are commonly divided into three main strains: the common or ordinary strain (PVYO), the stipple streak strain (PVYC) and the veinal necrosis strain (PVYN). In the last two decades, two new variants of PVY were reported, namely PVYNTN and PVYW (or Wilga type). PVYNTN is the causal agent of potato tuber necrotic ringspot disease (PTNRD). The first objective of this study was to explore the spread potential of identified PVY strains in different potato cultivars. The second objective was to observe the corresponding symptoms expression on plants and progeny tubers. In 2005, 2006 and 2007, two parallel specific sets of field experiments were carried out in Changins, Switzerland (430m above sea level). In the first set of experiments, 100 healthy tubers of 6 potato varieties were exposed to 4% infection of two strains of PVYNTN and respectively one strain of PVYO, PVYN and PVYW. The percentage of infected plants (ELISA testing on progeny tubers) and the impact of PTNRD on the progeny tubers was observed for each replication. In a second set of experiments, a similar set of PVY strains have been tested. For each strain, 10 to 25 infected tubers of the cultivar Nicola were planted. Yield, development of field symptoms and necrotic ringspot on progeny tubers were observed for each replication. As a general result of strains virulence, there was a significant interaction between variety and PVY strain regarding virus spread. Furthermore, the necrotic ringspots expression from primary infected plants was low. As a consequence, the trial did not permit to differentiate the impact of the PVY strains on PTRND symptoms. Finally, all the cultivars gave the same response to PTRND except Nicola. This cultivar was highly affected by the disease, even for primary infected plants. As specific results of the PVY strains evaluation, it was clear that yield of plants infected by PVYN strain was not affected and that the symptoms in the field were difficult to localize. The abundant harvest was highly affected by PTRND and showed numerous necroses on tubers. The PVYO strain presented one of the lowest spread. As for the PVYN strain, symptoms of secondary infected plants were scarce in the field and high on progeny tubers, but yield was more affected. The response of PVYNTN strains varied from one strain to another. It varied from low to high spread, from low to high symptom expression on secondary infected plants and on progeny tubers. The lowest yield obtained with infected plants was due to a PVYNTN strain. The others strains of the same variant always affected yield. Lastly, the spread of PVYW was high and symptoms of secondary infected plants were visible. Yield was affected but progeny tubers presented few necrotic ringspots. It is concluded that PVY spread can vary function of the variant and strain. Necrotic ringspots are scarce on primary infected plants except for highly susceptible cultivars like Nicola. And finally, the virulence of PVY strains on secondary infected plants can vary within the same variant.

Session 20

Studies on the antioxidant capacity of potato tubers

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Potatoes are part of the daily diet in many countries and there is still an increase in developing countries, where malnutrition is often one of the major challenges. Among others, the daily antioxidant input should be high to get benefits of its health promoting functionality, which will reduce the incidence of degenerative diseases like cancer and arteriosclerosis. Principally, a diet with antioxidant rich food will result in a high antioxidant level in the blood.
Potato tubers contain several compounds with an antioxidant status. Next to vitamin C also other substances, e.g. flavonoids, carotinoids, and several phenolic compounds are involved, but our knowledge about potato antioxidants is still low. Details of natural variation are important when new cultivars are chosen for processing or when breeders design new crossing experiments, whereas changes during preparation and / or processing are more relevant to consumers.
A set of modern German potato cultivars was analyzed according to its antioxidant behaviour using two different laboratory procedures (FRAP <iron reducing> and ORAC >oxygen reducing>). Results were expressed as trolox equivalents (TE). Effects of growing sites, long term storage, and growing seasons were included. Furthermore, a set of cultivars with coloured flesh was analyzed in order to classify the data of yellow fleshed potatoes.
Cultivars were different in its antioxidant level, growing sites as well. Long term storage increased the concentration of antioxidants.
A comparison between two temperature regimes during storage (+4 and +8°C without any application of anti-sprouting chemicals) in a set of three cultivars, which have been stored for five months, pointed out an increase of the antioxidant capacity (AC) between 20% (4°C storage) and 30% (8°C storage), respectively. Absolutely, values after the long term storage were about 6.5 and 7.3 µmol TE g^{-1} fresh weight (FW), respectively.
A set of 8 cultivars was analyzed to estimate the influence of the boiling process upon the antioxidant capacity (AC). The absolute antioxidant level was between 2 and 5 µmol TE g^{-1} FW. In five cultivars, antioxidant reduction was between 2 and 40%, but in three cultivars an increase of AC was detected (between 2 and 20%). Most of investigated blue fleshed cultivars (5 of 6) showed an increase of antioxidants.
Deep fat frying resulted in a dramatic change of the physico-chemical behaviour of the potato stripes. A reduction of about 15% of AC was measured between raw potatoes and par fried French fries (on a fresh weight basis). Finishing resulted in an increase of about 70% of AC. Frying time at finishing had a significant influence, too.
Methodology had an influence, too. Both principles tested (HAT and EC), presented by ORAC and FRAP resulted specific concentrations not directly linked.
Conclusion: Potatoes offer a substantial contribution of antioxidants to the daily requirement. In future, updated breeding and preparation techniques may enhance the level of the antioxidant capacity even further.

Session 20

Potato tuber composition and its contribution to blackspot susceptibility

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Blackspot in potato tubers is an internal grey-black or blue-black discoloration beneath the tuber surface in the cortical parenchyma. It occurs after mechanical impact on the tuber. The discoloration is caused by polyphenol oxidase (PP0) catalyzing in the presence of oxygen the conversion of primarily tyrosine into melanin. Several external factors, as site and growing conditions, tuber maturity at harvest and storage conditions may influence the susceptibility of tubers to blackspot bruising. Moreover, the cultivar and its composition are important factors affecting blackspot occurrence. The susceptibility of tubers to blackspot bruising depends also on tissue mechanical properties, which are influenced by tuber specific gravity. Specific gravity is generally assumed as cultivar attribute and it is strongly correlated with the dry matter content of potato tubers. The term dry matter refers to all substances of the potato tuber, except water. The aim of the study was to examine for eight cultivars the relationship between specific gravity of the tubers, their dry matter composition (starch and cell wall substances) and their susceptibility to blackspot bruise. Eight cultivars of table potatoes as Adretta, Afra, Gala, Granola, Lolita, Marabel, Nicola and Renate were grown near Dethlingen, Germany with conventional farming methods during three vegetation periods and stored for five and eight months, respectively. After harvest, tubers with a diameter of 40 – 50 mm were selected and divided into six groups of specific gravity from <1.055 to >1.095 kg L^{-1}, with 0.01 increments. Susceptibility of the tubers to blackspot bruise, here expressed as Blackspot index (BSI) was determined. The analyzed dry matter components included starch, pectin, non-pectin components and cell wall material.
The results indicated that the specific gravity of tubers ranged between <1.055 to > 1.095 kg L^{-1} independent of given cultivars. Within all cultivars tested, as specific gravity increased, the BSI increased. Tubers of various specific gravities revealed no significant different accumulation of dry cell wall material and pectin or non- pectin (celluloses, hemicelluloses) substances. Results indicated also that neither cell wall thickness nor cell wall firmness was attributed to tuber blackspot bruise. However, only the starch content was significant different between the classes of specific gravity, indicating its importance for the tuber susceptibility to blackspot bruise.

Session 20

Characterisation of Hungarian potato varieties for total glycoalcaloid content in relation to seasonal changes.

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A strict resistance breeding programme to combine exotic potato species' resistance genes with desirable agricultural and quality traits of cultivated potato is under way at Keszthely since 1960. In the last 20 years unique varieties having complex resistance against major potato pathogens and pests were released out of the program. The resistance genes of these varieties for potato virus Y, X, A, S and PLRV, nematodes, late blight, common scab and wart originates from *Solanum* species like S. *demissum*, *S. andigenum*, *S. vernei*, *S. stoloniferum*, S. acaule, *S. hougasii*. From the human nutrition point of view utilisation of exotic potato species can negatively affect the total glycoalkaloid level (TGA) of tubers.
In this study we determined the TGA level (□-solanine and □-chaconine) of 8 Keszthely bred variety (Balatoni rózsa, Hópehely, Katica, Lorett, Luca XL, Rioja, Vénusz Gold and White Lady) by HPLC (Tömösközi-Farkas et al. 2006, Chromatographia, Vol. 63, S 115-118.). As a control, pathogen susceptible variety, Desirée generally accepted as having pure *S. tuberosum* background was used. Examined tubers were produced under field conditions using conventional techniques. Harvested, undamaged tubers were stored in dark at 18 oC for one moth before measuring the TGA content. Experiment was carried out during four years, 2004, 2005, 2009 and 2010 to estimate the potential effect of seasonal differences.
Results showed that pathogen resistant varieties except Hópehely had higher level of average TGA content (1,54 mg TGA 100 g-1 fresh weight) than of pathogen susceptible control Desirée (0.23 mg). Amongst resistant genotypes the lowest TGA content was detected in Hópehely (0.21 mg), while the highest was recorded for Lorett (4,07 mg). Comparing the results of four years, it was found that the TGA content was influenced not only by genetic but by environmental factors too. Significant differences were found between years for all the varieties. Considering the variety averages the highest TGA level was detected in 2004 while the lowest in 2010, 2,79 and 0.19 mg 100 g-l respectively.
The results demonstrate that use of wild *Solanum* species' germplasm as the source of resistance genes can elevate the TGA content of genotypes bearing complex resistance traits. However by a rigorous selection procedure the combination of wide range of resistances with preferred agricultural characters and high quality traits can be successful without the necessary increase of TGA content over safety limit. The TGA content of the examined varieties in all the cases was far below the allowable limit of the Official Food Regulations (18 mg 100 g-1 fresh weight).

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ABSTRACTS

Poster sessions

1

Main source of stem blight infections and possibilities of reducing symptoms

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Early stem blight leads to high late blight infection pressure that can result in severe losses of quality and yield. The main cause for early stem blight is the latent infestation of seed tubers with *Phytophthora infestans*. From 2007 to 2010 a total of 41 batches of certified seed tubers from all over Europe were tested for latent infections, 9 from organic and 32 from conventional production. DNA was extracted from the samples and PCR diagnosis used to identify infestation rates present. In 2007 the 5 tested batches showed infection rates from 2 to 37%. One charge was free of infection and the mean infection rate was 11.2%. The 6 batches tested in 2008 were all latently infected ranging from 2 to 23 % with a mean rate of 12.7%. In 2009 2 batches were not infected and rates ranged from 2 to 38% with a mean of 9.2%. Of the 23 tested batches in 2010 7 were without infection the others ranging from 2 to 43 %, mean rate 7.1%. Results of 4 years of experimentation show infection rates from 2% up to 43% while 10 out of 41 batches were free of *P. infestans*. The overall average infestation rate was 8.7%. Infection rates found in seed tubers from organic production were 19.5%, 14.0% and 2.0% in the years 2007 to 2009, compared to conventional production with 5.7%, 12.0% and 10.6% in corresponding years. There is no significant difference over these 3 years. In 2010, rates of 23.9% for organic and 3.5% for conventional production were found. And looking at mean infestation rates from all 4 years, organic 18.3% and conventional production 6.1%, there is a significant difference between both kinds of production. The data from 2007 to 2010 show a certain variability of infection rates due to differing initial infestation levels and weather conditions during the growing season. With high soil humidity the fungus expands into the stem or sporulates on the infested tuber and passes the disease on to neighbouring plants and also the disease can be transmitted directly to new daughter tubers. So a high initial infection rate can lead to high rates in newly produced tubers. Because of the high risk of using infected seed tubers control measures are highly recommended. In conventional potato farming infections can be controlled by means of systemic fungicides that spread into the plant tissue and can reduce the growth of the fungus within the plant. In organic farming the treatment of seed tubers with copper is a possibility to reduce primary infections. However, protective fungicides, used 7 to 14 days before fist symptoms appear, in conventional production prove to be more efficient. Our experiments from 2008 and 2009 show that fungicides can reduce stem blight by up to 100% compared to treating seed tubers with copper in organic farming with an effect of up to 71%. Calculated mean for the 7 field experiments are 70% effect for systemic fungicides and 37% for copper treatment. The more important it is in organic farming to have infection free seed tubers available as controlling late blight is more difficult and less effective than in conventional production.

2

Identification Of Commercial Cultivars, Breeding Materials And Other Solanum Germplasm Adapted To Different Abiotic Stresses.

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Abiotic stresses caused by climate change represent a critical limitation and a mayor threat for sustainable agriculture and food security. It is necessary to develop new cultivars with tolerance to abiotic stresses by exploiting the existing biodiversity of species. The aim of this study was to characterize and identify commercial potato varieties, breeding lines, native pòtato species and useful wild species which are adapted to the threats of climate change.
For this purpose we are evaluating in these materials the adaptation to different abiotic stresses (heat, coldness, drought) by means of greenhouse trials and bioassays under more controlled conditions. Different indirect parameters such as chlorophyll fluorescence, chlorophyll content, electrical conductivity and differential carbon isotope absorption have been evaluated in these materials.
Initially bioassays were performed to evaluate tolerance to heat, drought and coldness using native potato species belonging to different *Solanum* species and evaluating chlorophyll fluorescence (coldness), electric conductivity (heat) and the hydric potential (drought) under stressed and unstressed conditions. According to the results of these evaluations in all cases several accessions from different species were detected with elevated tolerance levels.
An extended drought assay was performed in 2010 in the greenhouse with 250 commercial cultivars, breeding lines and other Solanum germplasm. Accessions were cultivated in two blocks, one block was irrigated 100% and the other block had only 50% irrigation. A cold tolerance assay was performed in 2011 with 150 accessions which were cultivated in two greenhouses; one was at 20ºC and the other at 8-15ºC.
In both greenhouse trials biomass and tuber yield was compared under stressed and unstressed conditions. In general biomass and yield reductions occurred under stress conditions. However, certain cultivars and accessions showed good adaptation to these stresses. Dry matter content in stressed tubers was on average somewhat higher than in the unstressed material. Only partial correlations with the indirect parameters were found.

3

Field infection of partially late-blight-resistant potato cultivars and R-gene differentials by the Northern Ireland Phytophthora infestans population, 2009-2010

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In 2009 and 2010, single R-gene differentials (R0 to R11, plus R1234 in 2010) and selected cultivars with partial late blight resistance (Bionica, Sárpo Mira and Setanta) were planted at AFBI Crossnacreevy (2009, 3 June, 3 plants/plot; 2010, 23 July, 1-2 plants/plot). The R9 differential failed to grow in either year. The plants were exposed to natural late-blight infection from nearby potato crops and trials. Plants were checked regularly for symptoms of blight and when these were seen, samples were collected.

In 2009, lesions were first observed on 22 July (R3, R4, R5), 27 July (R0, R1, R2, R10) and 30 July (R6, R7, R11, Setanta). Lesions on Sárpo Mira and Bionica (17 August) only sporulated when sampled leaves were incubated under high humidity. Sporangia were observed on 3 September on freshly collected Mira leaves, but on Bionica only a few sporangia developed after prolonged incubation. Sporulating lesions were never seen on R8 in the field, but after the plants were harvested on 12 October, sporulation developed on incubated leaves. In 2010, lesions were first observed 16 August (R1), 23 August (R0, R2, R4, R5, R1234) and 31 August (R3, R6, R7, R10, R11, Setanta). Lesions on R8, Bionica and Mira seen on 13 September only sporulated after incubation of detached leaves under high humidity.

In 2009, isolates from all differentials except R8 and from all cultivars except Bionica were tested for mating type and phenylamide resistance. Of the 17 tested, 15 were phenylamide-resistant A2, while two (from R1) were A1 (one phenylamide-resistant, one -sensitive). All A2 isolates were genotype 13_A2 (Blue 13). In 2010, 15 isolates from all differentials (except R5, R8) and from Mira all proved to be phenylamide-resistant A2.

The current predominantly A2 *Phytophthora infestans* population in Northern Ireland readily overcomes all R-genes except R8 (R9 not tested). Of the partially resistant cultivars, Setanta was readily infected (but exhibits tuber resistance), while Bionica and Mira were only infected late season. Bionica reacted hypersensitively, its leaves developing many sharp-edged lesions; the production of a few sporangia on incubated, detached leaves showed that *P. infestans* was associated with these. In the field, Mira developed a few lesions with limited sporulation and retained green foliage to the end of the growing season: its resistance proved effective against the newer *P. infestans* population.

4

Improving the appearance of specialty potato cultivars

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Skin quality and appearance are major factors in consumer acceptance of specialty potato cultivars. Enhancing skin color may also improve nutrient content as many of the compounds responsible for skin color also have health promoting properties. A cooperative research project was begun in 2009 to evaluate a number of in-season and post-harvest management practices as methods to improve skin color and maintain appearance of specialty potatoes during storage. Field trials were established at the Parma Research and Extension Center on a silt loam soil (pH ~ 7.9) using common red (Red Lasoda, Terrarosa), purple (All Blue, Purple Pelisse) and yellow-skinned (Yukon Gem, Bintje) cultivars. Skin color and visual appearance were evaluated immediately after harvest, and again after 3 to 6 months storage at 7.2^{o}C. In-season management practices evaluated included foliar applications of growth regulators (2,4-D, NAA, LPE, 1-MCP and Ethephon), and date of vine kill. Post-harvest practices evaluated included curing duration and holding temperature, as well as application of vegetable waxes. Both 2,4-D and Ethephon significantly improved skin color of red-skinned cultivars compared to the non-treated control and other growth regulators at harvest, as well as after storage. Growth regulators had no influence on color of purple or yellow-skinned cultivars. Vine kill date significantly impacted tuber size and appearance. In particular, All Blue exhibited faded color and graying following the later vine kill treatment. Curing duration and storage temperature had little impact of skin color or appearance, but some commercial vegetable waxes significantly improved both color and appearance.

5

New potato varieties research in Lithuania

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Potato breeding and seed production in Lithuania is carried out at Voke Branch of Lithuanian Institute of Agriculture. It was started in 1958. Potato breeding work involved Lithuanian potato varieties, cultivars from collection, hybrids. Potato crosses were done at the autotetraploid level in the glasshouse and potato variety collection field. Up to two million hybrids were tested in the trial fields. The key objective was to select the varieties immune to wart disease, cyst nematodes, with high resistance to other diseases, with exellent agronomic and cooking qualities, suitable for processing industry. As the result of breeding work five new cultivars were produced: VB Venta, VB Rasa, VB Liepa, Goda and VB Aista. They all are immune to the worst potato disease - wart (*Synchtrium endobioticum* Schilb.). Most of them resistant to a local patotype of nematodes (*Globodera rostochiensis* Woll.). Other advantages such as good yield, suitability for processing industry, excellent cooking qualities, good taste or attractive shape were the main items in producing Lithuanian potato cultivars as well.
Potato seed production from meristem tissue at biotechnologie laboratory is carried dut in Voke branch of Lithuanian Research Centre for Agriculture and Forestry. It is the centre for potato seed production in Lithuania.

6

Early blight resistance in potato germplasm

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Alternaria solani is the causal agent of early blight of potato (*Solanum tuberosum* L.) and it also causes disease on tomato (*Lycopersicon esculentum* Mill.), and other members of the *Solanum* family. Disease symptoms are characteristic dark brown to black lesions with concentric rings. Early blight on potatoes causes yield losses in most growing regions of the world and if left uncontrolled the disease can be very destructive. In Tajikistan it is the most important potato disease.

Presently, fungicide application is the main control practice adopted worldwide but environmental and social concerns require a substantial reduction in fungicide usage. Therefore, more efforts to breed for improved resistance to this disease would be eligible.

In this study we have measured the level of resistance in potato germplasm (cultivars as well as breeding lines) in greenhouse trials. Methods for inoculation were optimized and resistance at different plant development stage and leaf positions was assessed. In addition some field scorings of the same germplasm has been performed. A poor correlation was found between detached leaf assays and whole plant assays in the greenhouse. Therefore, we screened the material by inoculation of intact plants. Cultivars and breeding lines differed significantly in resistance and we also found that lower leaves, i.e older leaves, were more susceptible than middle or upper leaves. The latest results of the studies will be presented.

7

The study of mini-tubers production potential in potato different cultivars micro-tuber under greenhouse conditions

This research was conducted to evaluate mini-tubers production potential in potato different cultivars micro-tuber under greenhouse conditions in Ardabil Agricultural and Natural Resources Research Station during 2010. Micro-tubers less than 1g of eight potato cultivars (Satina, Caesar, Marfona, Luta, Agria, Markies, Hermes and Savalan) were cultured on completely randomized design with three replications. The micro-tubers were planted in Biolan and Punch bed planting to volume ratio of 1:1 in plastic pots 10×10 cm. Analysis of variance from measured traits showed that between potato cultivars in all of traits had significant difference. The maximum of mini-tuber number per m^2 related to Agria, Satina and Savalan cultivars; mini-tuber weight per m^2 and mini-tuber size average related to Savalan cultivar; mini-tuber number and weight bigger than 10 g related to Savalan and Satina cultivars; mini-tuber number and weight between 7-10 g related to Agria and Satina cultivars were. Mini-tuber weight per m^2 with mini-tuber size average and mini-tuber number and weight bigger than 10 g relationship positive and significant.

8

The impact of foliar fertilizers containing selenium on the yield indicators and concentration of selenium in potatoes

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A small-plot field experiment initiated in 2010 examined the impact of a foliar application of selenium at the rate of 200 and 400 g.ha^{-1} together with a foliar fertilizer containing NK at the rate of 5 l.ha^{-1}. The content of nitrogen and potassium in the solution was 1,5 % N (NO^{3-} form) and 5 % K. The fertilizer was applied on the beginning of tuberisation. The experiment included two selected varieties – an early Karin and semi-early Red Anna. Samples for growth, yield and chemical analysis were taken 96 days after planting and 33 days after the fertilizer had been applied.
The results show a statistically significant influence of the applied NK fertilizer on all examined indicators. The variant of NK + 200 g Se realized a higher yield than the control variant but the difference was not statistically significant. The variant of NK + 400 g Se however did not reach the yield level of the control variant (14 % depression). The influence of the variety was only confirmed with the yield of tubers and total weight of organic matter. The influence of a variety on the number of tubers under one plant was not significant. The content of selenium was significantly influenced by the variant of fertilising. The highest content was in tubers from variant NK+200g Se (0.43 mg.kg^{-1} Se in dry matter). It was approximately two times higher content than the content of selenium in tubers from control variant. Significant difference between varieties was not found.

9

Improved methods for detection and control of Potato virus Y (PVY) in potatoes

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Potato virus Y (Potyvirus: Potyviridae) (PVY), particularly the PVY^{NTN} strain (associated with the potato tuber necrotic ring spot disease) brings new challenges to the Australian potato industry, including the impact on interstate and international trade of seed potatoes.
Field work completed in recent years demonstrated that current sampling strategies of collecting fully expanded leaves from field grown plants reliably detect *Potato leafroll virus* (PLRV), *Tomato spotted wilt virus* (TSWV) and *Potato Virus S* (PVS) by ELISA. However, the ELISA test was less reliable in detecting PVY in potato leaves collected from the field, particularly towards the end of the growing season. These results indicate a need to certify seed potatoes based on post harvest tuber testing. Currently the "grow-on ELISA" test is the most widely used post harvest tuber test for seed potato certification in Australia. This test however is time consuming and as such is not widely adopted by industry.

The development of real time polymerase chain reaction (RT-PCR) method for the detection of potato viruses that can be carried out directly on tubers has been reported. Our results indicate that the direct RT-PCR test on infected tubers is more sensitive than the grow-on ELISA test for the detection of PVY, PLRV, TSWV and PVS.

It has become apparent that adjustment to current practices in potato seed certification and virus disease management is needed to limit the spread of PVY. A multidisciplinary management strategy is required to control PVY in Australian potato production and to be effective requires the determination of key epidemiological data within a potato district such as alternate weed hosts and aphid species that can transmit the virus. A number of cultural practices that can assist control of PVY, including the possibility to isolate seed potato fields, alternate planting times, use of the mineral oils, removal of virus sources, aphids flight forecasting and early haulm killing will be assessed.

Our future study will identify more effective management strategies for PVY management which will be demonstrated to industry.

10

Productivity of Potato Plants Raised through different Multiplication Methods and Grown under Field conditions

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A plant multiplication technique developed in Estonia involves multiplying plantlets in plastic rolls filled with peat before transplanting them to the field, where the first generation of seed tubers will be grown. Four possible multiplication methods of potato plants were compared from the aspect of obtaining optimal-sized, disease-free seed tubers. Plants grown from tip- and stem-cuttings and truncated plants were compared with *in vitro* micro-plants cultivation in plastic rolls. Two local late-maturing potato varieties, Ants and Vigri, were used in the study. Greenhouse and field trials were carried out during the growing seasons of 2005, 2006 and 2007 in Saku (59.3□N, 24.7□E).
The objective of this work was to compare the dynamics of the formation of leaf area index, number of tubers per plant, average weight of a tuber, tubers mass per plant, total plant dry mass, also tuber dry mass, of field grown potato plants, produced by different multiplication methods in comparison with *in vitro* micro-plants.
The results of the statistical analysis, using together the data of three years and two varieties, revealed significant impact of the multiplication method on leaf area index, number of tubers per plant, average weight of a tuber, tubers mass per plant, total plant dry mass and tuber dry mass.
It appeared that plants multiplied *in vitro* had smaller leaf area index, more tubers and smaller average tuber mass than plants multiplied by plastic rolls multiplication methods. Increase in the number of tubers failed to compensate for the decrease in average tuber mass. In the case of *in vitro* multiplication method, tuber mass per plant remained significantly lower both in terms of fresh and dry mass, as well as the total plant dry mass, when compared to others multiplication methods. All described plastic rolls multiplication methods achieve quite similar tuber fresh yields and seed production potential compared to *in vitro* method.
For receiving the first generation of tubers, the mass multiplication of plants in plastic rolls and further cultivation of plants in the field is easier, cheaper and more energy- and material-conserving compared to the common *in vitro* multiplication followed by the growing of micro- or minitubers *in vitro* or in greenhouse.
From the result of this study we conclude that plants multiplied in plastic rolls achieve quite similar productivity and seed potential compared to the plants multiplied by the *in vitro* micro cuttings, but require differentiation in the harvest time. However, all described multiplication methods proved to be suitable for seed production.

11

Distribution of Potato Viruses and Symptoms of virus-infected Plants of different Varieties in Estonia

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The potato viruses are still a great problem despite of the fact that the diagnosis of viruses and virus resistance breeding together with rapid methods of eradication and multiplication of plants has been improved.
In Estonia basically 6 potato viruses are known, tested and evaluated. Those are PVX, PVS, PVM, PVY, PVA and PLRV. During the last years in the potato production fields the plants with complicated disease symptoms were seen. It is known that the symptoms of the same virus infection can vary. The process of a disease can give a different image in every plant-virus combination and also it could have differences in every variety. Therefore it is difficult to estimate the virus infection visually before the virus infection is not analysed and compared with visual symptoms. The visual evaluation is also complicated as the same similar as virus infection symptoms can be impacted by other influence factors as climate conditions, insufficient nutrients, usage of plant or weed protection chemicals, bacterial or fungus diseases and also injures caused by insects.
The aim of the research was to correlate different visual virus infection symptoms and the test results of different varieties. For all the tested plants the detailed description of 9 visual symptoms on 9 point evaluation scale was compiled. Altogether, 200 plants from 66 varieties, 69 injured and 131 from visually not evaluated injured plants were visually assessed and leaf samples tested by ELISA for existence of PVX, PVS, PVM, PVY, PVA and PLRV.
At most, 38% plants were infected by separately PVY or PVY mixed with PVM. 10 plants were infected separately by PVM and 2 plants with PVS. Viruses PVA, PVS and PLRV were not found. The PVY caused different symptoms on different varieties; necrosis and hanging dead leaves were most frequently found. The occurrence of symptoms depended on infection type – primary or latent infection. In the case of the field planted with meristem plants, the plants of 41 varieties were visually evaluated symptoms but only one plant infected on PVY was found. Before planting the plants were testes on 6 viruses and PSTV and resulted as diseases free plants. Therefore we can be sure the symptoms have environmental impact.
The results indicated that the potato virus PVY started to spread in our potato production fields and caused different symptoms on different varieties. Same results have been announced by many researchers and the problems caused by PVY are world-wide and therefore more investigations are needed (T. F. Döring, *et a*l., 2006).

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12

Somaclonal Variation in Potato Meristem Culture and the Affeting Factors

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The aim of our experiments was to investigate the effect of thermotherapy, growth hormones on variability of potato meristem clones. The results showed that meristem clones differed on the yield, number and weight of tubers and light blight resistance. The research provided new information about the effect of thermotherapy and growth hormone. For the first time we have detected deviation from true-to-type morphological characteristics.

The field trials were conducted in the test field of the Department of Plant Biotechnology EVIKA of ERIA in North-Estonia and in the Jõgeva Plant Breeding Institute (JPB) in Mid-Estonia. In the trials the first generation meristem tubers were used for the first year trials and in the following year the second-generation tubers were respectively used. The trials were set in random block-placement in 4 replications, 20 tubers per plot.

In our research we studied the agronomic traits and morphological characteristics of the meristem clones of the new potato variety “Reet” of Jõgeva PBI. And also we studied the influence of thermotherapy duration 0, 16, 42, 56 days and some growth hormones to the variation of meristem clones.

In this experiment the meristem clones were created from the meristem cuts, operated from the plants of the meristem clone 364 (“mother” clone), which was created earlier, tested and selected in field tests as the best meristem clone this variety. It is clearly indicated that among the tested 20 meristem clones statistically no successors exceeded the yield of “mother” clone. For example, the total yield of the meristem clone 7184 was two times lower as it was of the “mother” meristem clone. The yield difference up to 20.2 t ha $^{-1}$ (Rosenberg *et al* 2010).

By the visual evaluation, between the numbers 7181 to 7189 the meristem clones had different appearances in both years and in both locations, compared to the plants of the other meristem clones. The plants were higher, the stems were finer and the pigmented leaves were narrow and the flowering period started later. Those meristem clones were more late blight resistant and had longer growing period. The tubers were bigger, but fewer per plant and the stolons were longer compared to the tubers of other meristem clones. At same time the shape and colour of tubers were true-to-type. The data indicate that the weight of tubers was influenced by the duration of the thermotherapy. The longer period of the thermotherapy resulted in higher tuber weight. In the case without (0 days) thermotherapy and of 42 days, the average weight of tubers was equal.

The first time not true to-type in morphological characteristics of clones was detected. We have reason to presume that such kind of deviation was affected by the longer period of thermotherapy and higher concentration of growth hormone in the medium.

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13

How to assess the physiological vigour of potato mother tubers ?

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The vigour of potato mother tubers determines their productivity. However there are three types of vigour: genetic, physiological and ecological. This classification of vigour indicates its distinct sources, but all these forms cannot be separated, and ultimately lead to the physiological realization of the genetic programme in a changing environment. Low vigour of seed potatoes may be connected with the lack of possibility to ensure storage at a low temperature. The response of individual cultivars, however, is diverse and is not closely related to the length of the dormancy period or the length of the growing season (Reust and Munster 1975, Rev. Suisse Agric.7: 185-187). This means that the early cultivars are not always characterized by a rapid rate of physiological aging of tubers, or the late cultivars by a slow rate of this process. Before carrying out relevant studies it is not known what the vigour of mother tubers of each cultivar at a different physiological age will be.
In Poland, the physiological vigour of potato mother tubers of the new cultivars is determined by the method of accelerated aging (AA). (Rykaczewska 2010, Potato Res. 53: 325-329) The method we used is a result of the research work conducted in previous years (Rykaczewska 2003, Fragm. Agron. 3: 65-74). In the autumn of each year, just after harvest, certified seeds of the cultivars were divided into three batches, and then one of them was placed in a storage chamber under conditions optimal for seed potato storage (control), whereas the other batches were subjected to conditions of accelerated aging in the light, and in darkness. In the spring the mother tubers of tested cultivars are planted in the experimental field. The field trials are set up in a randomized complete block design with four replicates. Harvesting is performed when the crop cycle was completed. Yield and then the relative yield in relation to the control is determined. The decrease in yield caused by the AA treatments is used as a measure of the vigour of the mother tubers. The application of a 9-point scale according to the established methodology does not refer to the absolute yield, but to the relative yield, so that the method becomes universal. By means of this method it is possible to characterize one cultivar only or several cultivars at the same time.The results obtained show that the national gene pool contains currently more potato cultivars with a slow rate of physiological aging of tubers than it did in the 1980s . Most of the potato cultivars registered recently in the Polish directory of cultivars are characterized by their high physiological vigour. Cultivars with high vigour of mother tubers, despite having been subjected to accelerated aging in darkness, can be successfully used on farms that do not have modern storage facilities and may also be useful for exporting to countries with warmer climates. Seed potatoes of cultivars with high vigour after exposure to accelerated aging in the light can be pre-sprouted for a longer period without fear of a significant loss in their yielding potential.

14

Defence responses in potato after treatment with BABA - Can induced resistance contribute in late blight control

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Late blight, caused by the oomycete *Phytophthora infestans,* is a very serious disease of potato. Every year late blight leads to large problems for potato growers in many parts of the world. Today late blight control in susceptible and moderately resistant cultivars highly depends on frequent use of fungicides. Potato cultivars with introduced R-genes exist, but the oomycete can rapidly evolve and overcome those. In the future it is of great importance to find sustainable and sound integrated control methods that can reduce the need for fungicides.
Induced resistance (IR) may be a part of a control strategy if it is combined with other methods. BABA (DL-beta-amino butyric acid) is an inducing agent that has been shown to reduce potato late blight also under field conditions. BABA treatment seems to a high degree activate the defence through the jasmonic acid pathway if the pathogen is a necrotroph or the salicylic acid pathway if the pathogen is a biotroph. However this is not always the case and exactly how BABA induced resistance works still remains unclear and the course of events seems to vary also between different pathosystems.
In this project we have investigated how treatment with BABA affect various defence responses in potato at different stages of infection. Recently revealed results from our conducted secretome and phenol analysis as well as microscopy examinations will be presented.
Our greenhouse and field trials suggest that late blight can be controlled with a lower amount of fungicides if IR is applied. The level of protection by IR appears to depend on cultivar. Combining the choice of partially resistant cultivars with IR may significantly reduce the amount of fungicides necessary for efficient late blight control.

15

Use of EGES® to assess and improve energy demand, energy production and global warming potential of crop successions including potatoes

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Context and objectives: Further to a study which aims at bringing up to date energy consumption (EC) and greenhouse gas (GHG) emissions of vegetable and animal productions chains*, the web tool EGES® (free website) have been developed to enable crop producers to assess the environmental performances of their own plots from the point of view of their EC and GHG emissions.
* Ges" tim, a guide for assessing the energy impacts and GHG emissions due to agricultural activities in France - 2009.
Methods: EGES® is based on Life Cycle Assessment (LCA) methodology. It takes into account EC and GHG emissions from field but also from inputs, using references specific to France. As fertilisation, tillage, weed are managed on the whole crop succession and not only on one crop, it is more pertinent to use EGES® to assess crop successions and not to focus on one crop. Hence, it has been used to assess energy balance (EB) and GHG emissions of a crop succession, including potato, representative of Northern France, and to identify ways of improvement.
Results and Discussion: Results show that the EB is highly positive with an EC of 18.8 GJ/ha and an energy production of 190 GJ/ha. The GHG emissions are among 3 t éq CO2/ha. Fertilisation represents the highest part of EC and GHG emissions (resp. 62% and 65%). Different ways of improvement are assessed. For instance the seeding of cover crop with cruciferous and leguminous before potato crop instead of cruciferous cover crop leads to decrease respectively of 5% and 10% the EC and GHG emissions of potato crop. To do some comparison, the functional unit of hectare is not sufficient; we will also express results per units of production (eg. fresh matter, dry matter) to take into account the production level of the different alternatives.
Conclusions: For the first time, a tool has been developed to give instant results about EC and GHG emissions of crop succession and to invite users to try out alternatives. Easy to use and based on recent references, it helps producers to get ready for future measures aiming to reduce dependency to fossil energy and GHG emissions. In the near future, we will work to extend our approach to other environmental impacts as eutrophication, acidification …

16

Productive response of potato to water supply in Mediterranean basin and determination of water deficit thresholds

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Growing awareness of climate evolution and the increasing agreement on the magnitude of the expected changes are shifting the attention from understanding and forecasting global changes to the study of practical options of adapting to the changing climate.
In the Mediterranean basin, characterised by limited water resources, climate models concur in forecasting an increase in temperatures (approximately 2 °C in maximum summer temperatures) and a reduction in rainfall (up to 30% in some seasons),with a foreseeable impact on yield crops. With reference to the potato during the heat-free period of the year, yields will diminish as the suitable period becomes shorter; with a higher evaporative demand, the resource water will be used less efficiently. Intensive researches on water requirements, yield response of potato crops to water and water use efficiency, have been carried out in the Mediterranean area. With the aim of identifying optimal cultivars for the pedo-climatic conditions determined by future climate, it would be useful to determine the yield response of various cultivars to water deficit.
The aim of the present work was to evaluate the yield response of various potato cultivars to water deficit and to determine threshold values of soil water availability, from the results of field experiments reported by scientific literature. Ten potato cultivars (among the most widely grown in the Mediterranean) were examined, comparing non-irrigated treatments with trials that supplied a different fraction (33, 66 and 100%) of potential evapotranspiration (ETp), calculated from evapotranspiration of class A evaporimeter and crop coefficients.
The response to water deficit was evaluated by analysing the variations in relative yield (Yr) as a function of relative soil water deficit (1-p). Yr is the percentage ratio between the yield obtained in each treatment and the yield obtained in the fully irrigated one (100% of ETp); and 1-p is the relative water deficit, where p is the fraction of the water available in the soil in the layer explored by the roots. For each cultivar, the threshold values of relative water deficit were determined, namely the level of 1-p above which the relative yield drops appreciably. Threshold values of each cultivar were determined with an optimisation procedure, fitting to the experimental data set the two lines that minimised the difference between estimated and measured Yr.

The work was undertaken in the frame of the project “Scenari di adattamento dell’agricoltura italiana ai cambiamenti climatici - AGROSCENARI“.

17

Important agronomic measures and cultivar traits in Swedish organic potato production

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To identify the most important agronomic measures and cultivar traits in Swedish organic potato production, the effects of soil parameters, cultivar, year and geographical location on potato characteristics were investigated using multivariate analyses on data from a series of field trials carried out in Sweden.

In total, 21 trials were conducted during a 7-year period at five sites located throughout Sweden to compare cultivars with respect to yield, resistance to late blight, earliness and cooking quality. Fertiliser in the form of farm manure or biological residues was applied in amounts equivalent to 70-100 kg NO_3^--N. A randomised complete block design was used, with 4 replicates and 6-8 cultivars per trial. Plant emergence and flowering were assessed and number of stems per plant. The physiopathological conditions in plots were assessed once a week. Multivariate analyses were performed on the dataset obtained to evaluate the importance of different traits, the effect of soil variables, cultivar, year of trial and geographical coordinates on six potato growth and yield characteristics.

Soil parameters, including fertility level, had strong effects on potato characteristics explaining 53% of total variation. Variables related to duration of haulm growth were other dominant factors in variation. N fertilisation had little effect on yield and a negative impact on emergence. N availability is difficult to predict if the N is applied as organic-N, as is the case in organic cultivation systems. In the present trials, the fertiliser was applied in spring before planting. This may have resulted in high soil mineralisation of the N applied, increasing plant-available N to a level where N was no longer the main yield-limiting factor. P and K fertilisation increased yield. Lack of K is reported to be a constraint in organic potato production, as few organic fertilisers are rich in K. The strong correlation between yield and K and P fertilisation indicates that these nutrients were the most restricted and potentially yield-limiting. The multivariate analysis also indicated a relationship between yield and number of days between planting and emergence. Measures that promote fast emergence, e.g. soil preparation or presprouting, should therefore be beneficial for organic tuber yield. The most important cultivar trait in achieving acceptable yield levels was long-lasting foliage, a characteristic of cultivars resistant to late blight. We recommend cv. Cicero and cv. Sarpo Mira specifically for use in organic potato production.

18

Monitoring programme for Dickeya solani in Northern Ireland

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The blackleg-causing bacterium *Dickeya solani* has recently emerged as a major threat to potato production in Northern Europe and Israel, and has now been detected throughout the UK . A 3-year monitoring programme was begun in the summer of 2010 to screen for the disease in Northern Ireland, with the aim of determining whether the bacterium is present and whether a nil tolerance policy towards the disease would be suitable. The first part of the programme focused on a field survey carried out in the summer of 2010 in which 61 blackleg-affected plants from separate field inspections were characterized. *D. solani* was detected in one farm of potatoes grown from imported English seed of Dutch origin. Restrictions were put in place and no further outbreaks have been detected. The remainder of the programme targeted high-risk potatoes imported for processing and as seed, as well as a range of tuber samples of home origin and water samples from irrigation supplies and processing plants. To date, over 150 tuber samples, 20 river water samples and 10 waste water samples have been tested for the disease and were all negative for *D. solani*.

19

The detection of glycoalkaloid (a-solanine and a-chaconine) content in tubers of potato varieties, grown in organic and conventional farming systems

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Approximately 95 % of the total glycoalkaloids present in potatoes are accounted for α-solanine (S) and α-chaconine (C), both of which are structurally similar, being different glycosylated forms of aglycone, solanidine. The total glycoalkaloids content above 20 mg 100 g fresh weight is considered unsuitable for human consumption because of toxicity. Beside several factors, influencing level of glycoalkoloids in potato tubers, the genotype and environment are among the most important. The aim of study was to evaluate the impact of genotype and farming system on glycoalkaloids content in tubers.
Therefore a simple, sensitive, precise and specificliquid chromatography-mass spectrometry (LC-MS) method was developed and validated for the determination of glycoalkaloids in tubers. Reversed-phase chromatography, coupled to an electrospray ionization source, was used to separate and ionize S and C. Singly protonated molecular ions for each glycoalkaloid were detected by single-ion recording (SIR) *m/z 853* and *m/z 869* for C and S, respectively. Sample preparation involved liquid-liquid extraction and solid-phase extraction. The separation was carried out on *Waters XTerra C18* (150x2.1 mm I.D) with a mobile phase composed of 0.1% formic acid in water (A) and 0.1% formic acid in acetonitrile (B) in gradient mode at a flow rate of 0.2 ml min^{-1}. The developed method was validated in terms of accuracy, precision, specificity, system suitability, linearity, limit of detection and quantification. The determined validation parameters are in the commonly acceptable ranges for that kind of analysis. Twenty potato varieties were grown in organic (OF) and conventional (CF) fields in 2010. The crop supplying with nutritions was better in CF than OF due to soil composition and applied fertilisation. The beginning of growing period was wet and cool. However July and August were extremely hot with heavy rainfalls. Too high temperature during tuber development caused physiological damages and disorders. The tuber yield and glycoalkaloids were evaluated.
The average tuber yield of potato varieties in CF was 39.8 t ha^{-1}, but in OF – 18.2 t ha^{-1}. The significant influence of farming systems and varieties on tuber yield was determined ($p<0.01$). The S content in tubers of varieties varied from <0.1 to 3.2 mg 100 g^{-1} (average 0.69 mg 100 g^{-1}) in OF and from <0.1 to 5.3 mg 100 g^{-1} in CF (average 0.73 mg 100 g-1). The C content ranged from <0.1 to 3.2 mg 100 g^{-1} in OF (average 0.87 mg 100 g-1) and from <0.1 to 4.8 mg 100 g^{-1} in CF (average 0.91 mg 100 g-1). The influence of farming system on S and C content was not significant ($p>0.05$). The influence of genotype on S content was significant ($p=0.003$) and on C content not significant ($p>0.05$). The total glycoalkaloids level in tubers did not exceed 20 mg 100 g^{-1}.
The study has been carried out within EU EF Latvia co-financed project Nr. 2009/0218/1dp/1.1.1.2.0/09/APIA/VIAA/009

20

The effects of pre-planting treatments of seed tubers by a temperature drop on the productivity and quality of potato

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One of the most widespread and dangerous parasite of potato plant - potato cyst-forming nematode (PCN) *Globodera rostochiensis* Woll. - causes considerable damage in potato cultivation and reduces potato crop productivity by 30-80% depending on cultivar susceptibility, nematode population density in the soil and conditions for plant growth. Traditional PCN management includes prevention of the nematode establishment in potato fields due to quarantine regulations, crop rotations, resistant cultivars and soil amendments. The new effective management practice for potato growing and protection from nematode infestation has been suggested and covered by patent ? 2345515 in the Russian Federation . Potato tubers (*Solanum tuberosum* L.) of susceptible to *G. rostochiensis* cultivar Nevsky were obtained from the Governmental Agricultural Research Station (Republic of Karelia, Russia). Tubers were exposed at room temperature in an illuminated room for 2 weeks for sprouting and then treated with a temperature drop from 23°C to 5°C for 2 h, every 24 h for 6 days before planting. Then treated and non-treated tubers were planted in field plots infested with PCN (15 cysts per 100 g soil).
Pre-planting treatments of seed tubers by a temperature drop increased plant tolerance to low ambient temperatures, halved nematode infestation, increased crop productivity by 54% and improved yield quality by increasing the vitamin C content by 14% and starch content by 6% compared to control.
The work was executed under the financial support of the Ministry of Education and Science of the RF (project ? P1299).

21

CO2-gas exchange of potato cultivars in the north-west of Russia

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Plants of 6 potato cultivars were grown in pots with damp sand in the growth chamber under the temperature of day/night 20/18°C and luminescent lamps with irradiation of 100 W/m^2 and photoperiod 14 h out of minitubers - invigorated seed material, that was got by the method of apical meristem. Plants were watered regularly with a complete Knop nutrient solution (?? 5,6). ??$_2$-gas exchange were measured at the stage of 3-4 leaves.
It has been shown that the potential maximum of net-photosynthesis of potato cultivars was 10,5-13,3 mg ?O_2/g dry weight per hour. The range of temperature optimum of net-photosynthesis included temperature from 6,5° to 35,0°C, with maximum in 16,5-24,0°C and illumination of 420-500 W/m^2 for all cultivars. The maximum of net-photosynthesis was shift to the range of lower illumination in condition of low temperatures. Among the studied cultivars Pushkinec was characterized as the most light- and temperature-requiring, cultivar Nevsky - as the less light-requiring but high temperature-requiring and cultivars Elisaveta and Latona were the least light and temperature-requiring. Temperature curve of net-photosynthesis of these cultivars have the most flat-topped character that can tell about their high plasticity to this environment factor.
In conclusion, potato varieties cultivated in the certain region, are differing in their ecolophysioligical characteristics that is necessary to take into the account for their growing.

22

Cross-adaptation of potato plants to temperature drop and nematode invasion

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The phenomenon of cross-adaptation is widespread in plants. Plants are often exposed simultaneously to several environmental stresses. For example, cold temperature often combined with nematode invasion of plants in the North. One of the most significant pest of potato plant is potato cyst-forming nematode (PCN) *Globodera rostochiensis* Woll. The mechanisms of plant response to combination of these two factors remain unknown. The aim of the study was to investigate a potato plant responses to short-term temperature drop combined with PCN invasion. Potato plants of susceptible to *Globodera rostochiensis* potato cultivar Nevsky were grown at 23ºC with 12-photoperiod during 14 days in climatic chamber and they exposed to short temperature drop from 23 to 5ºC for 2 h at the end of the night for 6 days (DROP treatment) and at 23ºC (control). Then plants were infected by PCN and remained under optimal growth conditions (23ºC) for 2 months. Cold resistance (LT_{50}) and expression of the nematode resistance genes and COR gene (PCR in real time) has been analyzed. We showed that short term temperature drop pretreatment enhanced chilling tolerance and resistance to phytonematode invasion in potato plants. Expression of nematode resistance *H1* gene and COR gene of *?i7* take place in plants treated by short term temperature drops.
The work was executed under the financial support of the Ministry of Education and Science of the RF (project ? P1299) and by the Russian Foundation for Basic Research (project N 10-04-00097_a).

23

Comparison of fungicide efficacy on potato late blight in the Czech Republic during 2008 – 2010

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Fungicide control of potato late blight is still the most important element of integrated late blight management in intensive potato growing. For fungicide selection and sequence in a spraying program it is necessary to know efficacy of these products on foliar and tuber blight.
In the exact field trials, performed in the central potato production region during 2008 – 2010, efficacy of selected fungicides was evaluated. The trials were established in four replications with variety Ditta (medium early, susceptible to foliar and tuber blight). Plots sized of 22,5 m² involved 4 rows of 7,5 m length, spacing of plants was 0,75 x 0,3 m (100 plants/plot). Six treatments were done in 7 – 14 day intervals based on weather progress. The application was always initiated based on negative prognosis after achieving critical number of 150. All fungicides were applied at registered rates with water volume of 600 l/ha.
The trials evaluated foliage infection in week intervals, potato yield and tuber infection 8 weeks after the harvest.
All three trial years were characterized by strong infection pressure of the disease and suitable conditions for tuber infection; however, they differed in epidemic onset. Tubers were infected relatively early and most of them decayed in the soil prior to harvest. Yield differences between untreated control and fungicide variants were 16 – 136 %.
The highest mean efficacy on foliar late blight, which was expressed in significant increase of tuber yield, was recorded for fungicides Revus (mandipropamid), Infinito (fluopicolide + propamocarb – hydrochloride), Casoar (chlorothalonil + propamocarb – hydrochloride), Ranman (cyazofamid) and Consento (fenamidone + propamocarb – hydrochloride). Considering older active ingredients favourable results were also determined in fluazinam and dimethomorph. The lowest efficacy was recorded for copper-containing fungicides and further for zoxamide, mancozeb and benalaxyl. In phenylamides (metalaxyl – M, benalaxyl) reduction in efficacy was apparent during application season due to development of pathogen resistance.
The highest suppression of tuber blight provided Infinito (fluopicolide + propamocarb – hydrochloride), Ranman (cyazofamid) and Altima (fluazinam).
The trials showed high efficacy of fungicidal active ingredients of new generation. Obtained results could be used for compilation of suitable and effective application programs within the integrated late blight management.

24

Effect of temperature drop on plant development, cold resistance and nematode invasion in potato hybrids

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Plants are routinely subjected to different abiotic and biotic stresses. Abiotic stresses such as cold, drought and salinity reduce average yield for most major plants by more than 50% and the estimated yield loss caused by pathogens is typically around 10-20%. Among biotic stresses in potato, parasite invasion is one of the most serious diseases of potato. In particular, in the North where nematode invasion are often combined with low temperature, one of the most widespread and dangerous parasite of potato plant is potato cyst-forming nematode (PCN) *Globodera rostochiensis* Woll. - root endoparasite that causes considerable damage in potato cultivation. The aim of the study was to investigate the effect of temperature drop treatment on potato plant cold resistance and invasion with potato cyst-forming nematode. Experiments were conducted in the growth chambers in the Institute of Biology Karelian Research Centre RAS with somatic hybrids SH9A (freezing intermediate) and two S1 hybrids 1020 and 2022 classified as freezing tolerant and freezing sensitive genotypes. Plants were proliferated from stem cuttings, and grown for about 7 weeks in the growth chambers with a photoperiod of 16 h at a PPFD of 122 $\mu mol \cdot s^{-1} \cdot m^{-2}$ and temperature of 23°C . Then part of plants were growing for 6 days at constant temperature of 23°C (control) and other plants were subject to temperature drop from 23 to 5°C for 2 h at the end of the night (DROP treatment). At the end of experiment plants were infested by potato cyst-forming nematode (10 cysts per plant). Subsequent growth conditions were optimal. Cold resistance (LT_{50} method) and cyst infestation (Seinhorst's method) were estimated. Temperature drop enhanced cold resistance in all potato genotypes in compare with control. High level of cold resistance was combined with high tolerance to PCN only in freezing sensitive genotype (2022). There were no plant infestation by PCN in control and DROP-treated plants of freezing tolerant hybrid (1020) and freezing intermediate (SH9A) hybrids. The developmental rate was increased in infected control plants. The possible mechanisms are to be discussed.
Study was supported by joint project of the Academy of Finland and the Russian Academy of Sciences (project N 5) and by the Russian Ministry of Education and Science of the RF (project N P1299).

25

Assessment of phenotypic stability of resistance to Phytophthora infestans in potato cultivars.

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Phenotypic stability of resistance to *Phytophthora infestans* was tested for 22 potato cultivars. The genotype by environment interaction was analysed using multiplicative model of analysis of variance. The potato cultivars were tested in four experiments in Southeastern part of Poland over a four years. Tested cultivars differed in level of resistance came from various countries: Poland (9 cvs.), Russia (5 cvs.), Germany (1 cv.), Netherlands (6 cvs.) and Hungary (1 cv.). Seven of them (Alpha, Bintje, Gloria, Escort, Eersteling, Robijn, Sarpo Mira) form a group of Eucablight standard cultivars (www.eucablight.org).

The cultivars were planted each year at the beginning of April and were grown on 6-hill plots in two replications without protection against late blight. The tested cultivars were exposed to the natural infection with *P. infestans*. Each plot was surrounded by plants of susceptible cultivar, which served as infector. The development of late blight in foliage was evaluated by determine percentage of infected leaf area at weekly intervals (James 1971) and the relative area under the disease progress curve (rAUDPC) for each cultivar was calculated (Fry 1978).

The analysis of variance of rAUDPC values for 22 cultivars in four environments indicated significant (at $P<0.01$) influence of cultivar, environment, and G×E interaction. The first two canonical variables (V1 and V2) of the AMMI analyses together explained 96.8% of the interaction effects.

Detailed analysis of variance identified cultivars with stable and unstable expression of response to late blight. For stable cultivars G×E interaction was insignificant, while for unstable this parameter was significant. Significant effect of G×E interaction was not explained by regression of interaction effects on environmental effects, but deviations from regression were insignificant for 11 cultivars and significant for another 11 ones. Significant deviations from regression characterize unstable and unpredictable response to the late blight infection.

Evaluation of stability of resistance to late blight of potato cultivars is an important source of information for breeders and potato producers about variability of the pathogen and durability of cultivar resistance. The knowledge about stability of the cultivars allows to minimize the use of fungicides against late blight.

26

Temperature drop at early stages of ontogenesis as an effective tool to increase potato plant resistance to obligate parasite invasion

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An effect of temperature drop on the formation of resistance to potato cyst-forming nematode (*Globodera rostochiensis* Woll.) invasion was estimated on potato plants (*Solanum tuberosum* L.) cv. Nevsky treated with a temperature drop (from 23°C to 5°C for 2 h, every 24 h for 6 days before planting) at early stages of ontogenesis (pre-sprouted mini and elite tubers or seedlings). Plant infestation was carried out by inputting cysts (10-50 cysts per plant) into the soil nearly roots after ending of temperature drop treatment. After 3 moths the number of nematode females developed on the plant roots was estimated. Cold resistance was evaluated just after ending of temperature drop treatment and 2 weeks later.
It has been established that temperature drop increased plant cold resistance (2,9°C as compared with control), from one hand, and decreased plant infestation by parasitic nematode, from other hand. Under low level of infestation (10 cysts per plant) nematode population was 3-folds lower in growth chamber experiments with potato seedlings. Under field conditions using higher levels of infestation (25-50 cysts per plant) the nematode numbers decreased twice. Besides that a positive effect of temperature drop on plant development and productivity was observed. Preliminary short-term temperature treatment stimulated plant development, increased weights of plant aboveground part and tubers under nematode invasion conditions. Control infested plants were characterized by decrease in values of these parameters. Weight of root system after temperature drop was lower independently the invasion factor.
Thus, the same effect of temperature drop on the formation of plant resistance to potato cyst-forming nematode invasion was established regardless of the stages of ontogenesis, when plants were treated by temperature drop.
The work was executed under the financial support of the Ministry of Education and Science of the RF (project ? P1299).

27

Determination of Abscisic acid in potato by Competitive Elisa

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Abscisic acid (ABA) is an important plant hormone related with adaptation to environmental constraints, it is a second messenger on signaling to response a variety stress, it may switch in pathways that are not yet fully understood. ABA plays an important role in plant growth and development. Variation in ABA levels were reported for stress phenomena like salinity, relative humidity, osmotic root stress which relate to leaf ABA content, relationship between ABA level and water use efficiency seems to depend on experimental conditions. Potato is the most consumed crop around the world, is susceptible to water stress because it regulates water deficit by chemical signals like ABA and it yield depends on water availability. ABA molecule is an unstable sesquiterpene, it has been determinated by GC and LC-MS/MS, this expensive methods do not allow analyze a large number of samples. RIA and ELISA were developed, an inmunosensor too (Li et al. 2008. Anal Bioanal Chem. 391:2869-2874), Some ELISA were used to determine ABA (Kholova, et al. 2010. J.Exp.Bot. 61(5):1431–1440). We developed an indirect competitive ELISA, our optimal model is $y=2.127e^{11.31x}$ with an R^2:0.99 and 0.02 error, we tested Potato plants (*cv*. Unica), the ABA extraction was made with ethyl acetate. Then Elisa plates were coated with ABA-BSA, then ABA standards or samples and Mac 252 antibody were incubated. Next, added Anti-rat-AP and finally developed with P-NPP. After testing variants of antibodies, coating and substrate ratios. The best conditions were coating with 90 ng/ml of ABA-BSA, the ratio of MAC252 was 1/40000 and Anti-rat-AP was 1/4000, 2 mg/ml of substrate for developing was after 3 hours. In that way we tested potato samples from PRD treatments, the amount of free ABA increases at 60% watered period, at initial production of ABA plants with partial watered treatment showed bigger amounts of expected ABA than normal watered plants. We standardized our protocol overheating problems with directly detection using an indirect ELISA, we realized that ABA is an unstable molecule that is really sensible to light and high temperature, samples showed a relationship between stress and drought conditions, according with Kholova *et al*. 2010, the amount of ABA depends strictly on the treatment and conditions of each plant. Our assay has a very low cost in contrast with commercial kits, being cheaper for testing large number of samples.

28

Efficacy of selected insecticides on Colorado potato beetle (Leptinotarsa decemlineata (Say, 1824)) in the Czech Republic during 2009-2010

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Colorado potato beetle is one of the most important potato pests worldwide and in the Czech Republic, as well. In recent years, its importance has been still increasing due to suitable conditions for overwintering and subsequent population development.

During 2009 and 2010 exact field trials with insecticides were established in the early potato production region in agricultural enterprise in Žabcice, belonging to Mendel University. The fields are of plane character with above sea level of 179 – 184 m. This locality is ranked among the warmest ones in the Czech Republic, with annual mean temperature of 9,2 °C. Long-term annual rainfall amount from 1961 - 1990 is 480 mm, i.e. combined with high temperatures the locality belongs to very dry regions of the Czech Republic. Field trials were laid down in a randomized complete block design with controls involved in the blocks. Eight treatments were established in 4 replications on plots with area of 30 m^2. In exact field trials variety Rosara was planted in spacing of 75 x 30 cm. The way of establishment was longitudinal. Water volume was 400 l/ha for all treatments. The evaluations were done directly before application, 1-2 days and 7-8 days after application. On all evaluation dates, LI – LIV larvae, imago, % defoliation, egg colonies and predator distribution were counted. The results of insecticide efficacy on LI – LIV larvae were assessed using statistical method by Henderson-Tilton.

In trials the best results were recorded for Biscaya 240 OD containing a.i. thiacloprid, that provided efficacy 96,5 % on first and 99,0 % on second evaluation date. Very high efficacy (94 %) on second evaluation date was also recorded for Actara (thiamethoxam). Mospilan 20 SP containing a.i. acetamiprid from the same group of neonicotinoids similar as both previous insecticides, relatively quickly losses its good initial efficacy (efficacy reduction from 85,8 to 66,5 %). SpinTor with a.i. spinosad is a very good alternative for antiresistance strategy, where mean efficacy from trial years achieves up to 92 %. Decis Flow 2,5 based on pyrethroids with a.i. delthametrin showed very low efficacy (9,2 and 19,2 % on the first and the second evaluation date) and occurrence of resistant population to this group of substances. A slightly better result was found in Nurelle D with mixture of active ingredients from the group of pyrethroids and organophosphates (approx. 31 % on both evaluation dates).

Biopreparate for ecological growing NeemAzal-T/S based on a.i. azadirachtin showed decreased efficacy on larval mortality; however, leaf defoliation was significantly reduced or even stopped after NeemAzal-T/S application. It demonstrates mechanism of insecticide effect especially based on principle of *L. decemlineata* larval and beetle feeding inhibition.

The trials showed high efficacy of several insecticides and simultaneously the necessity to apply antiresistance strategy, since *L. decemlineata* is characterized by high flexibility, very quick adaptation to chemical substances and quick selection of resistant individuals.

29

Effect of soil cultivation depth in potato growing on soil physical characteristics and potato yield compared to selected crops.

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During 2008 – 2010 an effect of two soil cultivation depths (shallow cultivation to 100 mm, medium ploughing to 200 mm) in potato growing was studied on selected soil physical characteristics and potato yield. Porosity and soil structure state were evaluated. The trial also involved other selected crops – winter wheat, spring barley, peas and poppy. All selected crops incl. potatoes were grown after the same preceding crop – spring wheat. Conventional tillage systems, like the mouldboard ploughing, showed a significant reduction of porosity both in surface layer (0 – 100 mm) and at the lower cultivation depth (400 – 500 mm). (Pagliai et al., 2004, Soil and Tillage Research, 79, 2, 131 -143). However, on average of studied years it was found that soil porosity was more influenced by grown crop than soil cultivation. Potatoes positively acted from this view, soil porosity was significantly increased compared to growing of other crops. The different effects of the various alternate crops appear to be related to their different abilities in promoting soil structure formation and soil structure stabilisation (Chan et al., 1996, Soil and Tillage Research, 37, 2-3, 113-125). Soil structure state was evaluated using structure coefficient, indicating portion of agronomic important soil aggregates (0,25 – 10 mm) and agronomic less important soil aggregates (< 0,25 mm and > 10 mm). Soil structure coefficient was higher in potatoes compared to other crops. In wheat and peas the soil structure coefficient was higher in the variant of ploughing, in other crops shallow soil cultivation was more favourable. Crop yields differed in individual trial years. On average of years higher yield was determined in potatoes in the system of shallow soil cultivation, whereas barley, wheat and peas indicated more favourable response to the variant of ploughing as regard as yield. For poppy any yield differences between variants of soil cultivation were not recorded.

Keywords: soil cultivation, soil structure coefficient, porosity, yield, potatoes

30

Effect of stress conditions due to plant herbicide injury on potato yield and selected quality parameters

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Current potato growing technology in specialized agricultural enterprises is based on pre-planting field de-stoning. A de-stoning unit consists of furrower (which forms two furrows 1,8 m wide), clod and stone separator (which sieves soil from a furrow and place stones and clods into interrow) and two-row planter. The technology excludes subsequent mechanical operation used for weed removal from the plot. Weed management measures are therefore limited to herbicide application. In most cases only three active ingredients (metribuzin and linuron in mixture with clomazone) are used for a pre-emergent application. A post-emergent application is often necessary, for which two active ingredients are used – previously mentioned metribuzin and rimsulfuron. In metribuzin high varietal sensitivity exists. For almost one third of variety range metribuzin cannot be used after emergence, one third of varieties express no symptoms of injury and one third is characterized by strong interaction of metribuzin effect and weather conditions after the application. We cannot certainly conclude that application does not cause crop injury.
For stress due to a partial defoliation and assimilation apparatus damage more causes could exist. In addition to herbicide injury, the most frequent cause is frost damage in early vegetation stages or hail injury later in the season. Wille et al. (1992) studied response of yield and changes in potato quality to simulated hail damage. Damage simulated during early phases of tuber growth resulted in minor yield losses (below 5 %) at low defoliation level, but severe losses at higher levels with proportional loss of tuber quality. Defoliation toward the end of the season was manifested by much lower reduction in potato yield and quality. Langner (1995) found that at complete defoliation yield loss does not exceed 60 % in any case. Love et al. (1993) verified a model to predict yield loss due to metribuzin injury. The best model was linear-log one.
The aim of our study was to determine an effect of stress due to herbicide crop damage on potato yielding and qualitative parameters. Two varieties (very early Rosara and medium late Samantana) were used for the study on trial plots of PRI H. Brod in Valecov during 2004 – 2009. Tuber yield, starch and dry matter yield, dry matter and starch content, cooking quality, nitrate and glycoalkaloid content were evaluated. The results show that due to stress conditions after herbicide injury potato yield was 13,2 % (Rosara) and 22,7 % (Samantana) reduced at average of the years. It was reflected in dry matter and starch yield; however, dry matter and starch content were not affected. The same is true for cooking quality, incl. taste of cooked potatoes. On contrary, stress conditions resulted in substantial increase of nitrate (by 8,9 and 30,7 %), glycoalkaloid solanine (19,0 and 23,6 %) and chaconine (12,8 and 38,5 %) content.

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31

Interactions between Streptomyces strains and control of potato common scab by enhancing soil suppressiveness

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Common scab is one of the most important soil-borne diseases of potato in many potato production areas of the world. It is caused by a number of *Streptomyces* species. In Finland the causal agents are *Streptomyces scabies* (Thaxter) Lambert & Loria and *S. turgidiscabies* Takeuchi (Hiltunen *et al*. 2009. J. Appl. Microbiol. 106,199-212). The scab-causing *Streptomyces* spp. are well-adapted, successful plant pathogens that survive in soil also as saprophytes. Suppressiveness against common scab pathogens can develop naturally in potato fields due to antagonistic microorganisms including non-pathogenic *Streptomyces* strains (Lorang *et al*. 1995. Phytopathology 85, 261-268; Liu *et al*. 1996. Can. J. Microbiol. 42, 487-502) and reduce the severity of the disease. We have studied interactions between pathogenic and non-pathogenic *Streptomyces* strains, and possibilities to control potato common scab by enhancing the development of suppressiveness in soil. Non-pathogenic and pathogenic *Streptomyces* strains were tested for their ability to grow and interfere with the growth of each other at different pH (5.5, 6.5 or 8.0) *in vitro* on glucose yeast malt extract agar. Pathogenic strains of *S. turgidiscabies* were antagonistic to pathogenic *S. scabies in vitro* indicating that these two species may be competing for the same ecological niche (Hiltunen *et al*. 2009). In addition, strains of *S. turgidiscabies* tolerated lower pH than those of *S. scabies* and were highly virulent on potato. These findings, together with the fact that *S. scabies* and *S. turgidiscabies* co-occur in the same fields and in the same tuber lesions in Finland , suggest that *S. turgidiscabies* is a major problem in potato production in Finland . The possibility to enhance development of soil suppressiveness to common scab was investigated in long-term field experiments in two different locations. Tuber dressing applications of a non-pathogenic *Streptomyces* strain (272) isolated from a scab lesion or a commercially available strain (K61) of *S. griseoviridis* were repeated annually. Both strains reduced the incidence and severity of common scab indicating effective antagonistic action against pathogenic *Streptomyces* spp. under field conditions. However, several years' results are required to confirm the build up of suppressiveness in soil.

32

Effective ways of mineral nitrogen fertilizer applications and their effect on nitrogen use by potatoes, yield and potato quality.

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In field trials during 2008 – 2010 various variants of mineral N fertilizer applications were evaluated in potatoes under conditions of de-stoning technology. Broadcast application of ammonium sulphate prior to planting was compared to local application at potato planting. Furthermore, use of locally applied mineral nitrogen fertilizers containing nitrification and urease inhibitors was verified. In these variants the effect on potato yield, quality and nitrogen use by potato plants was studied. For retention of more rain water, the shape of a ridge was modified, forming an infiltration groove on the top. Year had the highest effect on crop development and tuber yield. Local application of ammonium sulphate positively affected tuber yield in all years compared to broadcast application. For fertilizers containing nitrification and urease inhibitors, especially Alzon, positive effects were also recorded. Nitrogen use by plants from applied fertilizers was dependent on year, with the highest use in 2009 and lowest one in drier year 2008. Modification in the shape of a ridge had a positive impact on potato yield and nitrogen use from fertilizers in drier year 2008. In moister years 2009 and 2010 this effect was not confirmed.

Keywords: potato fertilization, local application of nitrogen fertilizers, nitrification and urease inhibitor-containing fertilizers, nitrogen use, potato yield

33

Exploitation of Genetic Resources to Develop Potatoes with Durable Resistance to Late Blight (Phytophthora infestans)

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Foliage and tuber blight caused by *Phytophthora infestans* (*P.i.*) is the most serious disease of potato worldwide. Annual losses caused by this pathogen amount to 900 million EUR within the EU (Haverkort et al. 2008). Thus, pre-breeding to improve resistance to potato late blight constitutes an important task. In the past, breeding for late-blight resistance relied on single dominant, pathotype-specific genes (R-genes R1 to R11) which have not proved durable (Fry & Goodwin, 1997). An alternative strategy is breeding for race non-specific resistance which acts quantitatively and incompletely.
JKI breeding clones used in the present study have been developed *via* conventional crosses to the wild species of *Solanum demissum*, *S. stoloniferum*, and *S. okadae* as resistance donors, followed by backcrosses to cultivated potato cultivars.
Quantitative resistance of foliage blight was assessed as Area Under Disease Progress Curve (AUDPC) and as Relative Area Under Disease Progress Curve (rAUDPC) (Hansen et al. 2005). Compared to highly susceptible varieties, JKI breeding clones showed significantly higher degrees of quantitative *P.i.* resistance in the field. Some of these clones did not display any leaf attack in the field over three years. Most of the clones which proved resistant in the field test displayed good resistance in a detached-leaf assay, too.
Most of the clones with a high level of resistance against foliage blight in the field trial displayed moderate susceptibility in the tuber test. The varieties and some highly susceptible clones showed higher degrees of susceptibility against tuber attack. Leaf and tuber-blight resistance indices were not correlated in these trials and confirmed that foliage *vs*. tuber blight have to be considered as different diseases.
Notably, besides an improved resistance to *P.i.*, most of these clones expressed acceptable levels with regard to starch content, suitability for chips production, or table quality, thus demonstrating that race non-specific *P.i.* resistance may be combined with genetic backgrounds relevant to breeding practice *via* backcross programmes. In contrast, it was difficult to identify late-blight resistant clones with good suitability for crisp production.

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34

The effect of relationship between variety planting density upon production dynamics and culinary qualities of potato tubers turn into baby potatoes

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Baby potatoes are a new product on Romanian potato market. There has been studied the influence of technological parameters (variety and planting density) upon production dynamics and culinary qualities of: ZAMOLXIS, GAZORE, DESIREE, SANTE, ROSARA and ROCLAS grown at three planting distances (ranging from 15 to 20 and 25 cm), in order to establish a fresh raw material conveyer for baby potatoes turning into account.
During 2007- 2010, potato tubers with 20-30 mm diameter were harvested on dynamic from crops placed on non-irrigated Brasov's chernozem soil. Each plant was analyzed (development of aerial part, tuber number, weight) through individual measures. Culinary qualities were also tested.
Planting tubers at 15 cm, we were able to obtained a significantly higher yields of baby potatoes, given to higher intervals, due to meaningfully tubers achieved from the surface unit. At this thickness, varieties were differentiated through tubers yields level with diameter of 20-30 mm and period of achieving these yields, knowing that tubers number, formation and growing dynamic is primarily a tubering characteristic (The European Cultivated Potato Database).
It was noted GAZORE variety with 5.3 - 6.8 t / ha yields, achieved between June 21- July 31, due to high number of tubers (48-66 tubers / sqm). From total yield, production rate of potatoes in "baby"size ranged between 24.6 and 67.2 %. On ZAMOLXIS variety tubers yields with diameter of 20-30 mm, about 4-5 t / ha (40-50 tubers / sqm) were achieved at the end of June - early July and on ROCLAS variety- throughout July. The production of baby potatoes from these varieties share about 25 - 50 % from total yield.
On the last two decades of July, SANTÉ and DESIREÉ varieties achieved yields of 2.4 - 5 t / ha, the average number of formed tubers being about 27-40 tubers/sqm. During this period, from total yield "baby" yields varies between 76-38%, then suddenly drops below 10% due to intense growth. On DESIREÉ variety, there has been observed the occurrence of a new wave of tubers after dry periods followed by rains.
Throughout vegetation period, ROSARA variety was characterized by baby production levels less than 2.5 t / ha. On July, the number of tubers with diameter of 20-30 mm was less than 30 tubers / sqm and the production rate less than 20 % of total yield.
From all varieties "baby potatoes" harvested in July were culinary classified as grade A, which means that they are tasteful, look very pleasant, appearance is not impaired during cooking and are suitable for most culinary products (boiled potatoes, salads, garnish, soups, etc.).
Planting density is an important piece from technology in obtaining high yields from this assortment. GAZORE and ZAMOLXIS varieties responded extremely positive to this technological measure especially if harvested on late June.
The analyzed varieties can be considered a conveyer production stagger over time, to ensure constant row material for "baby potatoes" product.

35

Effect of potato minitubers size on the growth parameters and yield of cv Spunta for potato seed production in Cyprus

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The usual means of propagation for potato crops throughout the world is the vegetative seed tuber, which may be planted whole, as in most of Europe, or after cutting into pieces, as in North America and Cyprus. Seed tubers can be infected with numerous virus diseases and can carry many fungus diseases which may affect ware crop growth and the health of the progeny tubers. The availability of an annual supply of healthy tubers is an essential requirement for effective potato production.

Micropropagation multiplication steps are speeded up using *in vitro* plantlets, microtubers or minitubers (Ranalli, 1997, Potato Research 40: 439-453). *In vitro* plantlets are produced from either single node cuttings or from multiple stem nodes. Taking single node cuttings from *in vitro* plantlets and growing them in tuberizing medium routinely produces microtubers (4-10 mm). Minitubers (5-20 mm) are produced *in vivo*. Minitubers can be obtained from *in vitro* plantlets or microtubers and plants raised from both propagates can be subjected to a destructive harvest or to repeated harvest (Lommen and Struik, 1992, Netherlands J. of Agr. Sci. 40: 342-349).

In Cyprus about one fifth of the seed planted in autumn and spring crops is produced locally. It appears that under Cyprus conditions the best approach to produce part of the requirements of seed potatoes was a single multiplication of imported stocks (certified or foundation seed). Locally produced seed performs equally satisfactorily as imported seed. Ware crops grown from local seed were as healthy as crops grown from imported seed (Vakis, 1980, Technical Bulletin 34. Agr. Res. Institute, Nicosia, Cyprus).

Minitubers of <5, >5-10, >10-20 and >20-40 g grown from miniplants in pots in a nethouse, were planted in 2008 in the field for the production of basic seed. The planting distance was 75 cm between the rows and 20 cm in the row. Before planting the tubers were kept at 2°C for 6 months. The minitubers were planted on 17/01/2009 and the lifting was done on 30/04/09. The experimental design was a RCBD with four replications. The plots were irrigated when it was necessary with mini sprinklers of 200 l/h. The tubers harvested were separated to the classed 0-10, 10-28, 28-35, 35-55, and >55 mm.

The emergence was affected by the minituber size. Forty-eight days after planting the emergence reached 90% in the three heavier classes of the minitubers and only 70% for the minitubers <5 g. One hundred and six days after planting the soil cover was 80, 60, 58 and 50% and the LAI was 2.9, 1.7, 1.4 and 1.3 for the minitubers <5, >5-10, >10-20 and >20-40 g, respectively.

The plants grown from minitubers >20 g gave significantly higher yield and number of tubers from the other three seed classes. There was no difference between the two middle classes while the smaller tubers gave the lowest yield. The mean tuber weight was 28, 34, 44 and 44 g for the tuber sizes <5, >5-10, >10-20 and >20-40 g, respectively. No differences were found between the minituber sizes planted in the categories of 0-10 and >55 mm of the harvested tubers. The smaller minituber size (0-5 g) gave higher percentage of tubers on the classes from 10-35 mm and lower on the tuber size 35-55 mm of the tuber yield.

36

Skin blemish diseases (scab and scurf) in Norwegian potato production: A survey of pathogens involved and studies on control measures

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Skin blemish diseases in potatoes are caused by different pathogens including *Streptomyces* spp.(common scab), *Spongospora subterranea* (powdery scab), *Helminthosporium solani* (silver scurf), *Rhizoctonia solani* (black scurf), *Polyscytalum pustulans* (skin spot) and *Colletotrichum coccodes* (black dot). Root- lesion nematodes (*Pratylenchus spp.)* are also involved, as symptoms in potatoes caused by root-lesion nematodes vary from scabby to sunken lesions. The main objective of the project "Improved potato quality by reduced skin blemish diseases (scab and scurf) in Norwegian potato production" (2008-2012) is to develop and implement methods for reduction of these diseases.

A survey of incidence of scab and scurf after the growing seasons 2008 and 2009 was carried out on 241 potato lots representing different cultivars and regions. *H. solani* was present in all lots. *P. pustulans* and *R. solani* (mycelium) was found in 80 % of the lots while *Streptomyces* spp. and *C. coccodes* was present in 50 - 70 % of the lots. *S. subterranea* was found in 25-50 % of the lots. *Pratylenchus* spp. was present in 60 % of examined subsamples with common scab symptoms. The relationship between root lesion nematodes and *Streptomyces* need further studies. *S. europaeiscabiei* and *S. turgidiscabies* was the only pathogenic *Streptomyces* spp. isolated from common scab lesions.

In growth chamber experiments *S. turgidiscabies* and *S. europaeiscabiei* was inoculated separately in pots at the time of planting. Different soil humidity levels were maintained during the period of tuber initiation. *S. turgidiscabies* caused more common scab in humid soil than *S. europaeiscabiei* in one of two experiments.

Field experiments using different fertilizer strategies and soil compaction did not show any significant effect on the incidence of common scab or other skin blemish diseases.

Experiments with different post harvest strategies showed that dry conditions during the first phase after harvest reduced the incidence of *H. solani* significantly. A quick lowering of the temperature also partly restricted the development of this pathogen. The incidence of *R. solani* increased when the crop was left in soil for 22 days after haulm killing compared to 11 days after haulm killing or harvest on green haulm. These effects confirm results from experiments carried out in other countries.

Real-time PCR assays, developed at SCRI, was used to study the relationship between the levels of scab and scurf pathogens in the seed and soil and potential disease risk in different farmer's fields, and these data will be presented.

37

Efficacy of straw mulch, insecticides, mineral oil, and birch extract in controlling Potato virus Y in Finnish seed potato production

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Potato virus Y (PVY) is transmitted non-persistently by winged aphids and causes major losses in potato production. Mulching with straw shows a high potential against virus spread in vegetables (Summers *et* al., 2005, Calif. Agric. 59: 90-94), lupins (Jones, 1994, Ann. Appl. Biol., 124: 45-58), and potatoes, especially when the vector flight peaks in the early growing season (Saucke & Döring, 2004, Ann. Appl. Biol. 144: 347–355). The effect of straw mulch has been explained by a reduction of the visual detectability of young plants for aphids.
Vector flight soon after emergence of potato plants determines PVY transmission in the Tyrnävä-Liminka area (64°46’58N, 25°32’35E) in northern Finland, one of the five European High Grade (HG) seed potato production zones. Efficacy of straw mulch in controlling PVY in potato crops was tested in field experiments in 2009-2010 and compared to other potential methods, such as insecticide applications, treatments with mineral oil and birch extract. Barley straw was applied by hand at 6 t ha^{-1} before potato emergence in June. Insecticide treatments included 3-5 foliar spray applications of esfenvalerate at 15 g/ha, a combination of taufluvalinate at 60 g/ha and thiacloprid at 60 g/ha and a tuber dressing application of thiamethoxam at 4.9 g/100kg of seed. Mineral oil (Sunoco 11 E/3) was used as 1.5 % solution, and birch extract (Charcoal Finland Ltd) was used as 1.5 % (2009) or 3% solution (2010). The initial PVY infection level of the seed potatoes in cv. Asterix was 4.5 %. PVY incidence in the yield was assessed by testing progeny tubers using DAS-ELISA. Statistical analyses were performed by ANOVA followed by Scheffe"s test.
No differences were observed between the two years ($p = 0.6$; df = 1), so data was pooled across years. The mean PVY incidence in the progeny tubers in the untreated control was 37 %. Mean PVY reduction by straw mulch and mineral oil was 60.3% ($p < 0.001$; df = 6) and 50.9% ($p = 0.007$; df = 6), respectively. None of the other treatments reduced PVY significantly. Yield was not affected by any of the treatments.
To our knowlegde this is the first study comparing the effect of straw mulch to other treatments applied in attempt to control PVY in potatoes in previous studies. Results underline inefficiency of the methods that aim to control the aphid vectors by killing them with insecticides as means to prevent transmission of the non-persistently transmitted viruses such as PVY (Perring *et* al., 1999, Annu. Rev. Entomol. 44: 457–81). Straw mulch ermerges as a promising PVY managing tool in HG seed potato production areas and should be experimented further.

38

Concentration of some macro- and micronutrients in potato tubers differing in their blackspot susceptibility

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Black spot bruising lead to the formation of grey-black or blue-black discoloration which is the undesired formation beneath the periderm of the tuber after being exposed to mechanical impact. Finally, this discoloration leads to severe economical losses for farmer and consumer. Among other factors, concentrations of macro nutrients, especially of potassium, may influence the susceptibility of tubers to blackspot. However, other macro- and micronutrients have different physiological functions in the tuber metabolism and can contribute directly or indirectly to the black spot susceptibility. The aim of the present study was to evaluate the concentrations of potassium, calcium, phosphorus, magnesium, boron, iron and selenium in eight potato cultivars with different black spot susceptibility. The tubers were grown in sandy soil at the Potato Research Station Dethlingen at adequate nutrient supply during two vegetation periods. Tubers were harvested two weeks before the usual harvest time (pre-harvest) and at usual harvest time (main harvest). To get comparable results, tubers with a diameter of 40 – 50 mm were used and separated into five to six groups according to their specific gravity. Susceptibility of the tubers to black spot bruise, here expressed as Blackspot index (BSI), was also determined.
The results indicated that the time of harvest determined the specific gravity and the BSI of the tubers. However, the harvest time influenced only slightly the concentrations of the studied macro- and micronutrients. The comparison of the obtained data with references revealed that in the present study the tubers did not suffer from any nutrient deficiency. Thus, the concentrations of the tuber nutrients did not correlated with the BSI. The results underline the importance of a balanced fertilization to minimize black spot susceptibility.

39

The Effects of Different Growth Regulators on Growth, Tuber Yield and Quality of Early Crop Potato

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Potato is a very important crop for Turkey with annual production of 4,4 million tonnes on 143.000 ha production area. The potato crop is grown almost in whole country. The majority of production is realized during summer season as main crop in the Middle Anatolia region while it also grown as early crop during winter and summer months in the coastal Mediterranean and Aegean regions. Seed potatoes are also grown in the Middle Anatolia region.
Both the earliness and tuber yield are very important traits in early potato production while multiplication rate and tuber yield are the main targets in potato production. The time of tuber initiation (earliness) and the number and growth of tubers (tuber yield) are all affected by hormonal changes within the crop during growth cycle. This study was aimed to determine the exogenous application of gibberellic acid (GA_3) and chlormequat chlorine (CCC) on earliness, multiplication rate, tuber yield and quality under early crop production conditions.
The field experiment planted at the farmer fields in Imamoglu district of Adana on 11th January 2011. Three potato cultivars (early Orla, medium early Banba and medium late Slaney) used in the experiment. The field experiment laid out in split-split plot design with three potato cultivars as main plot, four GA_3 doses (0, 50, 100, 150 mg/L) as sub plots, and two CCC doses (0 and 2 g/L) as sub-sub plots. Three replications used in the experiment. Seed tubers immersed into GA_3 solutions for 30 minutes one day before planting for GA_3 treatments. According to the emergence time, there is no difference recorded between GA_3 doses of 50, 100, 150 mg/L.
GA_3 applied Orla plants emerged 45 days, GA_3 applied Banba plants emerged 47 days and GA_3 applied Slaney plants emerged 48 days after plantation. GA_3 doses 50, 100 and 150 mg/L emerged earlier than dose of GA_3 0 mg/l, which are 9 days for Orla, 17 days for Banba and 22 days for Slaney. CCC doses sprayed to the haulms of potato cultivars with equal doses at tuber initiation stage and two weeks later. Above mentioned observations will be maintained during the growing period and harvest measurements will be accomplished.

40

Involvement of ferritin isoform gene expression in iron storage in potato tubers contrasting in iron content.

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Iron deficiency is the most important micronutrient deficiency in the world especially in developing countries where more than 50% of the anemias are thought to be due to iron deficiency. Medicinal solutions are poorly efficient for these populations due to the high cost of the pharmaceutical products and to their isolation in many cases. Therefore, a more widely spread and cost effective solution such as crop biofortification represents a powerful strategy against malnutrition. Potato is considered as an important staple food and constitutes, among others, a good source of potassium and vitamin C, but remains less valuable as a source of iron. Thus, It is crucial to highlight mechanisms leading to higher iron content in tubers. Ferritins are known to be one of the main components of the iron transport and storage in plant. In potato, until now, the involvement of ferritins in tuber iron accumulation has not been well described. The present work aimed to study ferritin gene expression in tubers with low and high iron content.
Firstly, a panel taken from the CIP collection was evaluated for the iron content in tubers. From this wide panel, cultivars with high (21.5 to 27 mg.kg DW^{-1}) and low iron (10.5 to 14 mg.kg DW^{-1}) contents were retained. Secondly, using an *in silico* approach, three different ferritin isoforms were isolated from the EST databases and from each isoform, specific qPCR primers were designed. All the ferritin isoforms were expressed in the tubers and principal component analysis performed on tuber iron content and relative expression results displayed a strong correlation between iron content and one of the ferritin isoforms. Further experiments will be performed in order to validate this first result into a larger panel and additional iron uptake, transport and storage-related genes such as IRT or NRAMP transporters will be included.

41

Constitutive defence in a potato breeding clone

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Traditional breeding for resistance against *Phytophthora infestans* has generated several resistant cultivars but mostly with R-gene based resistance. The ability of *P. infestans* to infect plants involves sophisticated manipulation of the defence systems in plants and in most cases the pathogen has overcome R-gene resistance. Therefore new resistance sources with different modes of action that can be combined are needed to counteract the fast evolution of this pathogen. With the goal to understand mechanisms of resistance to *P. infestans* we analyzed the defence responses in three potato clones.
Two clones of potato, Sarpo Mira and SW93-1015, exhibited strong resistance against *P. infestans* in field trials, whole plant assays and detached leaf assays. These two clones exhibited differences in the defence responses at phenotypic and molecular level. SW93-1015 developed very limited amount of hypersensitive response (HR) related lesions at both macroscopic and microscopic level. Interestingly, this clone also had constitutive H_2O_2 production and pathogenesis related (PR) protein secretion. SW93-1015 can therefore be characterized as a weak cpr mutant without spontaneous HR lesions and this type of resistance could be predicted to be relatively durable. Proteomics analysis of the apoplast revealed putative protein candidates for defence that are differently expressed in the resistant clones. In a breeding program it can be useful to include fairly simple molecular analysis to detect different types of resistance.

42

A lateral flow immunoassay Sss AgriStrip as a tool for specific and rapid detection of Spongospora subterranean on potato tubers

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Most seed certification schemes have a low tolerance for powdery scab to minimize the risk of introduction and spread of the disease. However, visual inspection of tubers risks misidentification of scab symptoms as it is sometimes difficult to distinguish lesions caused by either *S. subterranea* or *Streptomyces* spp. It is important to avoid such risk because the two pathogens differ in their biology and epidemiology. Several sensitive and specific methods are available for the detection of *S*ss on tubers: PCR, ELISA, and real-time PCR. Although these diagnostic tools are very useful, they require technical knowledge, are time consuming, and need specific protocols and lab equipment. This makes them inappropriate for routine detection during the certification process where inspection of potato lots for blemish diseases is done at the place of production or storage or at border inspection points. These tools are also not adapted for large-scale scoring of potato tubers during field experiments. To avoid these problems, a rapid and lab-independent one-step test tool, the "*Sss* AgriStrip", has been developed (BIOREBA, Switzerland). It is based on lateral flow immunochromatography using monoclonal antibodies which are specific to resting spores of *Sss*. We assessed its accuracy and sensitivity in the routine diagnostics of *Sss* using tubers showing different types of symptoms (typical and atypical=suspicious lesions) and compared with other methods. In addition to *Sss* analyses, specific tools were used in samples detected free of *S*ss for investigating the presence of *Streptomyces* spp.
The *Sss* AgriStrip is as sensitive as the DAS-ELISA with a detection limit between 1 and 10 sporosori per ml buffer. Results of the *Sss* AgriStrip were highly consistent with the lab-based diagnostic methods (DAS-ELISA, PCR , real-time PCR, and microscopy).
Sss was detected with all diagnostic methods in all tubers with typical symptoms but only in a few lots with tubers showing atypical lesions. The appearance of these atypical lesions was similar: a diffuse brown necrotic tissue under the periderm and the absence of the visible dark brown *Sss* spore-balls. The *Sss*-DNA content was generally lower in the atypical diffuse necrotic lesions than in typical ones.
Streptomyces spp. were identified as the causes of most of the atypical lesions negative to the presence of *Sss* through isolation, pathogenicity tests, and amplification of *txt*AB genes, the pathogenicity determinant in *Streptomyces* species.
This data demonstrates the simplicity, robustness and sensitivity of *Sss* AgriStrip, which makes it ideally suited for rapid detection of *Sss*. This test will substantially increases the accuracy of inspection procedures and field scoring based on visual assessment. Indeed, *Sss* AgriStrip will help to prevent the spread of *Sss* to soils free from the pathogen or to avoid rejection of lots with tolerable levels of common scab.

43

Ion exchange substrates in potato breeding

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The ion exchange substrates (IES) represent a new type of nutrient media for plant growing [1]. They are a mixture of the synthetic (natural) cation and anion exchangers saturated with all the necessary biogenic macro- and microelements. They have definite composition, high contents of nutrients in an osmotically inactive form, high fertility, practical sterility, favorable physical properties. Thus the IES seem to be a perspective nutrient medium for potato breeding.
The aim of the present work was to study the influence of the different IES on the multiplication of the "in vitro" obtained potato plants: taking root process "in vivo" (during 30 days) and then minituber formation at greenhouse conditions (3 months, peat soil) of the different potatoes cultivars. Also the influence of some growth regulators added to IES on cuttings adaptation, biometrical properties of plants, clone mass and biochemical composition of the tubers has been investigated.
The following IES have been applied.
1. The substrates on the base of the nutrient MS, Ernst, Knudson solutions with different pH values and different microelements contenta;
2. A series of substrates with the incremental potassium content with keeping the other elements ratios constant;
3 - 5. The same study with respect to the Na^+, NO_3^-, Cl^- - ions;
6. Substrates with different forms of iron (inorganic and in DETAPA-complex);
7. The substrates with an additive of the natural zeolite cliniptilolite (Tedzami , Georgia) saturated with the Mg^{2+}, K^+, NH_4^+ ions.

Results

i) The plants ingrained "in vivo" on the IES were much stronger in comparison to control plants on the standard agar-agar MS medium "in vitro";
ii) During greenhouse period the experimental plants gave the tubers yield 2.5 - 6 times higher than in control variant;
iii) It was revealed that the optimal range of the substrate pH values should be 5.9 -6.9;
iv) There were obtained the optimal concentrations intervals for nutrients investigated;
v) The growth regulators added to IES accelerated the plant growth at low concentrations but depressed the productivity while regulators concentrations increased;
vi) The best results in referring to tuber productivity gave the IES with the clinoptilolite additive;
viii) The "aftereffect" phenomenon has been noticed. Plants after the IES technology developed the following 2,3 years in field conditions more quickly and gave higher yield then the standard plants on agar-agar solution;
ix) The cost of all resources for production of 1000 mini tubers on the base of IES technology was established to be at least two times lower then in traditional technologies: basic agar-agar technology "in vitro", hydroponics "in vivo", mini tubers "in vitro" [2].

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44

Multiplex detection of potato viruses with Luminex xMAP technology

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DAS ELISA, or some indirect forms (e.g. TAS ELISA) are employed for the detection of individual viruses, requiring running of a number of assays in parallel for each particular virus. Multiplex microsphere immunoassay (MIA), based on the Luminex xMAP technology, was successfully applied to multiplex screening in a number of fields. The first results were published also with triplex detection of potato viruses (Bergervoet et al. 2008, Journal of Virological Methods 149, 63-68).
In this study the specificity and sensitivity of xMAP technology for multiplex detection of all six main potato viruses with that of standard DAS ELISA.
Commercially available antibodies (Abs), (Prime Diagnostics, Wageningen, The Netherlands) and their AP conjugates were used for ELISA. From the same Abs the conjugates with paramagnetic beads (Luminex Bio Sciences, Austin, USA) and biotin respectively, were prepared for MIA, and Streptavidin –RPE (Primediagnostics) were used as fluorescent dye. The same leaf extracts were in parallel prepared for ELISA. Magnetic support and wash procedure with blocking agents (milk powder) were applied in MIA experiments. Signal intensity (A405) of ELISA and the same at MIA procedure measured in calibrated AtheNA Luminex 200 Analyser (Biomedica) was expressed as MFI. Three times above the mean of healthy samples absorbance in ELISA and twice the fluorescence of virus-free controls in MIA were considered positive. The optimised concentration of individual antibodies, reagents and MIA procedure were adjusted in preliminary experiments. With three isolates of each virus, unambiguously positive detections and differentiation of all PVY, PLRV, PVX, PVM and PVS isolates were proved in MIA, exceeding in optimised procedure 8.8 , 3.6, 41.8, 38.3 and 74.2 times, respectively, the threshold values. PVA displayed the value in average 1.6 times higher only, indicating low virus concentration at some isolates and necessary improvement of antibody activity.

Using potato plantlets maintained in *in vitro*, the reactivity of individual PVY, PLRV, PVA, PVX and PVM isolates were compared in detail. The results revealed that :

- all the 18 isolates of PVY, belonging to the O/C and N serotypes, were unambiguously recognised both by ELISA and MIA procedure
- out of 59 PLRV isolates only 53 were positive in ELISA and all 59 PLRV isolates were detected by MIA
- out of 27 PVA isolates 25 were positive in ELISA and 22 isolates only displayed higher fluorescence (MFI) than twice the healthy control in MIA, owing to higher background readings
- out of 39 PVM and 27 PVX isolates, all ones at both viruses were positive in ELISA as well as in MIA
- in 64 samples of different above mentioned viruses which were simultaneously contaminated with PVS, all were recognised by MIA and all confirmed by additional PVS specific ELISA.

The MIA assay is fully comparable with commonly accepted DAS ELISA as to the specificity as well as sensitivity. It is possible to consider the MIA method as alternative diagnostic procedure, offering also some advantages especially in the field of complexity.

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45

Elemental sulphur for control of potato common scab

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Keywords: soil reaction, varieties, precrops

INTRODUCTION

Common scab incited by Streptomyces *scabies* is widely distributed across the world and causes marketable losses in potato production due to worse quality. Soil reaction and moisture are the most important factors affecting scab infection. Cultivars differ in susceptibility, but it is partial resistanc, and none of cultivars is immune (Loria, R. Plant Dis. 81, 1997, 836-846). Irrigation potato crop is the best way to tackle common scab at critical development stage of potato but no irrigation devices are available in Estonia. Soil pH over 5,2 and higher soil temperatures are conductive to common scab and infection pressure may be very high (Agrios, G. 2005. Plant Pathology. 5th edition. Elsevier, 952 pp).

MATERIAL AND METHODS

The field trials carried out in 2009 and 2010 at the Experimental Station of the Estonian Research Institute of Agriculture. Disease infection with common scab was assessed after harvest. Soil pH varied between 5,9-7,4. Scab rating was based on visual estimation. Each sample comprised 100 tubers. Nine potato varieties were grown in field trial. Infection scoring were split into four groups: 1) 5-15%, 2) 16-30%, 3) 31-45%, 4) over 45% tuber surface covered by scab lesions. To study the problem a field trial with following precrops was established: barley, barley with undersown red clover, pea, spring wheat, rape, oilrape and potato.

RESULTS

Elemental sulphur (trademark *Brimstone*) reduced infection on neutral and alkaline soil by decreasing pH by 0,6-1,4 units. *Brimstone* reduced infection by 50% under dry warm soil conditions and under less conducive conditions, elementhal sulphur applied 100 kg per ha protected tubers from scab infection entirely. Disease was more intensive in 2010 when was warm and dry soil the critical period of susceptibility to scab increasing the incidence of the disease.

Precrops (red clover) have an important role to control of common scab. In the assessment results of soil phytosanitary properties level appeared the interval between crop rotation reduces soil contamination. By the right choice of precrops it will be possible to reduce the infection of potato yield with soil-inhabiting pathogens and to ensure better health of potato plants.

46

Nomenclature of potato blemishes needs rationalization

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Potato tubers may be affected by a large range of blemishes leading to rejections or downgrading of potatoes, resulting to economical losses for farmers. Among these blemishes, several are well-studied (common and netted scab, powdery scab, black scurf, black dot and silver scurf), with clearly identified causal pathogens and in general an agreed symptom terminology, we referred to them as typical blemishes. However, a number of other frequently occurring blemishes have less clear origins, these are cited in the literature with variable terminologies and are sometimes loosely attributed to known pathogens following field experience rather than by scientific demonstration (Koch' postulates), we referred to them as atypical blemishes.
Morphological descriptions and pictures of atypical blemishes have been published in several books. The lesions are distributed on the tuber surface as more or less big patches of various aspects: shallow, irregular, scaly, crackled or rough. However, the names attributed to the blemishes and their possible causes differ from one author to another, and the most striking examples are:
- Polygonal framework on the tuber periderm, several names were cited (elephant hide, turtleback, scabby lesion or rhizoscab). *R. solani* and *Streptomyces* spp. were generally cited as responsible of this symptom. Otherwise, some authors suggest that polygonal lesions could be due to unfavourable environmental conditions; i.e high temperature, high organic matter content, high soil moisture or fertilization.
- Corky spots, they are similar to polygonal lesions, but form little corky patches instead of large corky plates. It is also named rhizoscab because it suggests that *R. solani* might be responsible for this blemish.
- Corky cracks and tuber cracks, they are quoted as physiological reactions to growth stress, either abiotic (fluctuation of soil moisture, herbicide) or biotic (*R. solani*).
- Star-like corky lesion with or without halo, are attributed by some authors to tobacco necrosis virus (TNV), but by others to *R. solani* or *Streptomyces* spp.
At this point, and because no complete Koch's postulate has been scientifically fulfilled for all the cited atypical blemishes, it is impossible to draw any conclusion about the causing agents.
After reviewing the literature on this subject, we noticed a lack of knowledge on biology and symptomathology of atypical potato blemishes. It is obvious that clarification of the nomenclature is necessary to avoid ambiguities and misunderstandings among people working on potato projects, whether they are scientists or extension agents. The rationalization of the nomenclature of potato blemishes will be useful for future researches, establishing standards for seed certification, and improving cultivars evaluation.

47

Stewardship of Chlorpropham (CIPC) in Great Britain

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Chlorpropham (CIPC) is the main sprout suppressant used in Great Britain and about 1.8 million tonne of the stored potato crop (4.05 million tonne) is treated (Garthwaite *et al*, 2010. Pesticide Usage Survey. Report no 227).

In 2007 survey data was considered by the UK Advisory Committee on Pesticides (ACP) that indicated occasional residues were above the CIPC MRL of 10mg/kg. Several factors were identified as possible causes and there was a need to establish the most significant of these so that the risk of further exceedances could be minimised. In response to the government request a Potato Industry CIPC Stewardship Group was established, and in January 2008 a 5-point Action Plan was implemented.

The Action Plan documents the role of the Stewardship Group which is made up of representatives from the CIPC manufacturers/approval holders, fogging contractors, research and advisory organisations, trade associations for the processing (PPA) and fresh market (FPSA) sectors and the Red Tractor Crop Assurance scheme.

Substantial progress has been made since 2008. Cross industry communications have raised awareness of the 36g a.i. per tonne application limit for crops destined for fresh market use and the 63.75g a.i. per tonne stewardship level for processing crops. An Industry Code of Best Practice for Application of CIPC has been published that consolidates recommendations on e.g. store layout and fogging treatments.

Information from research projects conducted by Glasgow University and Sutton Bridge Crop Storage Research has led to new recommendations on the use of slow speed ventilation fans when applying CIPC to assist with its distribution and lower variability of residues in bulk stores. Further research is evaluating application and management practices in box stores and examining the potential use of CIPC vapour for sprout suppression. Alternative approaches to sprout suppression are also under investigation in order to help reduce industry reliance on CIPC

Alongside the research and knowledge transfer activities of the Stewardship Group, a complementary suite of controls have been developed to provide assurance for the industry and consumers that the different elements of the management process are monitored. These include a) operator competency certification for use of specific fogging machinery (NPTC), b) a national equipment testing scheme for fogging machines (NSTS) to ensure e.g. correct calibration and operating temperature monitoring and c) a new professional development module (BASIS) for potato crop storage. The different control elements for best practice have been incorporated within the Red Tractor Scheme to provide an independent audit for assurance purposes

Industry performance in reducing the risk of CIPC MRL exceedance is being monitored by government through their own residue monitoring schemes and also by industry with its own comprehensive package of residue assessments. These are collated and made available to the government regulators, to provide further assurance for consumers.

The 5-point Action Plan submitted was envisaged to continue until the end of 2012 and all members of the Potato Industry CIPC Stewardship Group are committed to its full delivery.

48

Impact of Haulm killing on Potato Virus Y (PVY) spread

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Potato Virus Y (PVY) is a Potyvirus transmitted by aphids in potato fields. Haulm killing is a major cultural practice used to stop tuber growth in order to advance tuber maturation, control tuber size and starch content and induce proper skin set. Haulm killing has an indirect phytosanitary effect by reducing crop exposure to diseases and pests. When haulm killing is carried out, crop is old and potato plants are known to have a mature plant resistance to PVY infections. Nevertheless, this resistance is not absolute and a risk of transmission still exists. The first objective of this experiment is to evaluate the risk of PVY transmission after haulm killing. The second objective is to compare the efficiency of different herbicides and cropping techniques in reducing PVY spread. In 2003, 2004 and 2005, field experiments were carried out in Changins, Switzerland (430m above sea level) in high PVY pressure conditions but without inoculation. During those three years of experiment, two herbicides were compared, one with a quick contact effect on plant desiccation (Dinoseb) and the other with a longer term effect on desiccation and presenting limited translocation (Carfentrazone-ethy). Those herbicides were tested on four different potato cultivars in association with haulm topping. Different haulm killing techniques combining haulm topping and herbicides applications for different periods of time were compared. The first technique involved complete haulm killing (herbicide+topping) compared to complete haul killing carried out five days earlier. The second technique involved haulm topping five days prior to the herbicide application. After haulm killing, one part of the field trial was covered with a polymer web which was removed just before harvest. This polymer web was used to avoid aphids contact with potato plants and prevent any virus transmission. This device will allow evaluation of virus transmission after haulm killing comparing the infection percentage of the protected and unprotected part of the field. Percentage of infected plants was recorded by ELISA testing on progeny tubers. Results suggest there was no significant difference in virus transmission when using Dinoseb or Carfentrazone-ethyl. This could be explained by the fact that, whatever the haulm killing technique, the transmission of PVY after haul killing is low. This low transmission have been highlighted by the use of polymer covers. Early haulm topping or early haulm killing did not allow to reduce significantly the virus transmission. One possible explanation is the fact that the five days period was not sufficient to significantly reduce crop exposure to aphid pressure particularly for mature plants less susceptible to PVY. All in all, haulm killing management procedures seems to have a limited impact on PVY spread. This is likely to be because haulm killing is carried out when potato crops show a high degree of mature plant resistance to PVY.

49

Can spatial meteorological data improve disease forecasting and crop management?

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Reliable meteorological data are necessary in agriculture for precise crop management and also to input in Decision Support Systems (DSS) used to evaluate the risk of pests or diseases or for water management. However, fields can be far from meteorological stations (in France, the average distance between stations has been evaluated to be around one every 30 km). Thus forecasting models and crop management can be unsuitable for fields located far from met. stations.
An alternative to expensive and time-consuming individual met.stations is the use of innovative technologies to generate met.data at high spatial resolutions (at the scale of 1 km²) with the combination of existing meteorological data from worldwide and national networks and new technologies such as high resolution atmospheric simulations (to generate observation and prevision grid weather data) , geostatistics and spatial data analysis (to integrate optimally grid dat with the weather stations data) and a network of weather stations if a very high resolution is needed. Radar data can be added to improve the rainfall evaluation which is a key factor for diseases and irrigation.
The main objective of the research project called SIMPATIC (*Spatialisation de l'Information Météorologique Pour l'Amélioration des TechnIques Culturales*) -involving an innovative SME CAP2020 and its partners with various French technical institutes- is to study the interest of such spatial bioclimatic data to support different DSS and to improve the reliability of crop management at the scale of the agricultural field.
The general scheme and preliminary results will be presented on this project which concerns different crops and 2 geographic area (Beauce, at the South of the Paris Basin, on (seed) potato and cereals; South-East on tomato and vineyard) and on various aspects of crop management (disease risk evaluation, e.g. potato late blight, and water management for irrigation).

50

The effect of different ruponics quantities on the effectiveness of growing potato in 2010

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Keywords: commercial yield, nitrates, number of tubers per plant, starch content, tuber weight, yield

There is a growing interest in agriculture in solutions of natural origin which are stimulating the plant nutrition. The aim of this study was to investigate the influence of liquid solution biohumus Ruponics the growth and development of the potato plant.
Ruponics (Humistar) is a liquid solution of biohumus which promotes the growth of different agricultural crops. Ruponics is a natural complex of ecologically pure and safe nutrients, humic and growth-promoting substances. Ruponics has a beneficial effect on growth, metabolism and photosynthesis, and increases the yields of agricultural crops.
In trials conducted in 2010, we examined the opportunities for growing potato using different amounts of Ruponics and the effect on potato yield and its quality. The potato varieties used were 'Laura' (middle-maturing) and 'Ants' (late). The following variants were used: – 1. R25 – Ruponics (25 l ha^{-1}) was sprayed on the soil surface before planting the tubers, 2. R25+25 – Ruponics was sprayed on the surface of soil (25 l ha^{-1}) before planting the tubers and then three times during the growth period on the surface of leaves (25 l ha^{-1}) and 3. R0 – without Ruponics.
Significant results are presented as average of two varieties.

1. The Ruponics had a statistically significant positive effect on the total yields. The use of Ruponics increased the average yields by 4.1-6.6 t ha^{-1}.
2. The Ruponics had also a statistically significant positive effect on the commercial yields. Ruponics increased the average commercial yields by 3.3-5.9 t ha^{-1}.
3. The use of Ruponics increased the weight of tubers per plant. The average increase of weight per plant was 77.6-125.0 grams.
4. The Ruponics had a positive effect on the average number of tubers per plant. The average increase in variant R25 was 3.0 tubers per plant which was statistically significant and R25+25 had an increase of 1.4 tubers per plant.
5. The use of Ruponics had no statistical influence on tubers starch content, but a positive increasing tendency on tubers starch content was observed. Ruponics increased starch content in tubers by 0.1-0.2%.
6. The use of Ruponics had no statistical influence on tubers nitrate content, but there was a decreasing tendency on tubers nitrate content. Ruponics decreased tuber nitrate content by 7.5-13.7 mg kg^{-1}.

Because of the extreme weather conditions in 2010 the potato yields remained lower than usual. In an intensive tuber formulation period the temperatures were very high and at the same time precipitation was significantly lower than the average of many years. Therefore the formation and growth of tubers were inhibited and because of the growing conditions plants suffered under the stress. In order to stay alive plants had to save their resources at the expense of tuber formation.

51

Comparison of dry matter and harvest index in potato plants grown under Conventional, Integrated and Organic production systems

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Many of the agronomical and physiological crop characteristics can be affected by the production systems. In order to the comparison of production systems on the potato shoot dry matter, tuber dry matter , total dry matter, harvest index, and tuber yield, a field experiment was conducted in a randomized complete-block design with four replications in Iran. Treatments were consisted of the conventional, integrated and organic production systems, which had differences in the nutrient management, pests and diseases management, and weed management. Potatoes of Agria variety were planted in the field on the 24th May 2010. At the end of growth season shoot dry matter, tuber dry matter, total dry matter, harvest index and tuber yield were recorded.
Results showed that, tuber yield was affected significantly by the production systems. In this experiment the organic yield was about 54% of the conventional system. In the same way, results of the tuber dry matter, showed significant differences among the production systems. The tuber dry matter in the conventional system was 66% higher than in the organic production system. There were no significant differences in the tuber yield and tuber dry matter between the integrated system and other production systems. Furthermore, the shoot dry matter and total dry matter were affected very significantly by treatments. The organic total dry matter and shoot dry matter were about 57% and 50% of the conventional system respectively. Also, total dry matter and shoot dry matter in the integrated system were 29% and 44%, respectively, lower than in the conventional production system. The higher amount of tuber dry matter, shoot dry matter, total dry matter, and tuber yield in this experiment were 113.5 g per plant, 63.04 g per plant, 176.29 g per plant, and 30.33 ton ha^{-1} respectively, which were obtained by the conventional system. In this trial, the Harvest Index was not affected by production systems.

52

Evaluation of simulated hail damage on marketable tuber yield of potato Agria cultivar in Ardabil region

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This study was conducted to evaluate simulated hail damage through plants aerial destruction at growth different stages of potato Agria cultivar to quantify the marketable tuber yield reduction in Ardabil Agriculture and Natural Resources Research Station during 2010. Experiment design used Factorial based on randomized complete block design with four replications and two factors. The first factor includes six levels of plants aerial destruction percent (0, 20, 40, 60, 80 and 100 percent) and the second factor included five levels of plant growth stages (2, 5, 8, 11 and 15 weeks after the growing). Analysis of variance data showed between levels of plants aerial destruction percentage and time and the interaction between them in terms of marketable tuber yield were significant difference. In early stages of vegetative growth (2 weeks after growing) was minimal marketable yield reduction percent. Occurrence of damage in the tuberization and bulking stages (5, 8 and 11 weeks after growing) was severely reduced marketable tuber yield. Again, in the late stages of tuber bulking (14 weeks after growing) was less reduction percent of marketable tuber yield. Reduction percent of marketable tuber yield in the percentage and time of damage occur was calculated through the regression.

Key words: Potato, Damage, Yield, Regression

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53

Recent Developments of Potato Storage in Turkey

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The purposes of potato storage in Turkey are not to damage of potato tubers, to make the demand for market regular and to preserve seed potato till it is sowed. A proportion of potato produced in Turkey is alloted for seed whereas a considerable amount of it is sold in the field or is sold as soon as it is reaped. For this reason, potato storage is made by merchants excluding seed potato. Today while the loss of seed poato, about 580 thousand tons today, in storage was 15-20% thirty years ago, preserving both seed potato and cooking potato has reduced the losses of storage to 6% due to new establisments. In Turkey, storage techniques are basically divided into two: traditional and modern storage. If we want to look into them in detail: a) Home warehouses, b) Storage in pits dug in the soil, c) Storage in roofed silos in the soil, d) Storage in silos without roof in the soil, e) Depots that have natural air flow, f) Frigorific depots, g) Storage in natural caves and building stables.

Keywords Potato • Storage • Turkey

54

Evaluation of reactions potato cultivars to potassium humate consumption under drought condition in Tabriz region, IRAN

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This study was conducted to evaluate potassium humate effect in tolerance to water deficit of potato different cultivars. Experiment design used Spilt Plot Factorial based on randomized complete block design with three replications and three factors during 2009 and 2010. Factor A includes five potato cultivars (Agria, Satina, Savalan, Markis and Caeser), Factor B included two levels of drought stress (irrigation after 70 mm evaporation from basin class A pan as control and irrigation after 140 mm evaporation from basin class A pan as stress conditions) and Factor C includes two levels potassium humate (consumption and non-consumption of potassium humate). The results of combined analysis of data from experiments two years showed that drought stress reduced all traits in all cultivars. The most reduced of plant height in Markies cultivar, leaf area, relative water content, chlorophyll content index, shoot dry weight and marketable tuber yield in Agria cultivar, cell membrane stability and marketable tuber number in Satina cultivar was obtained. Satina cultivar had high marketable tuber yield under non-stress condition with 54.6 t ha-1 and Markeis cultivar in stress condition with 34.9 t ha-1. Application of potassium humste inceresed marketabil tuber yield in Agria, Satina, Savalan, Markeis and Caeser cultivars about 20.83, 18.50, 57, 26.11 and 43.45 percent under non-stress condition and 63.59, 47.6, 107, 36.96 and 70.5 percent under stress condition.

Key words: Potato, Potassium humate, Drought stress, Marketable Tuber yield

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55

An overview on potato production and protection in Tunisia and the possibilities of collaborative projects (bilateral or as a network)

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Considered as a strategic crop since 1994, potato represents about 20% of vegetable crop production. The per capita consumption of potatoes increased markedly during the last years and reached actually about 32 kg. Plantations covered a mean area of 24500 ha annually for the last five years and reached 25000 ha since 2008. Potatoes are mainly grown in autumn, winter and spring crops allowing a continuous supply of markets with fresh ware potatoes from November to June. The spring crop is the most important with a potential yield of 30-40 tons/ha while autumn and winter crops yield up to 20-30 tons/ha.
All seed potato required for autumn and winter seasons are produced through a certified seed program while imported seeds are used for spring crop. Spunta is the most used cultivar followed by , Atlas, Safrane and Nicola.
As other countries in the Mediterranean Basin, many diseases and insects affect the potato crop in Tunisia. Pests importance and impact vary according to local microclimate conditions and production techniques. While some pests concern mainly the crop cycle as the late blight, black scurf, nematodes and viruses, other are particularly harmful during the storage phase such as the potato tuber moth, wet and dry rots. Many IPM programs were conducted to limit the most important threats such as the late blight and the potato tuber moth.
The Tunisian potential for potato production and exchange could be developed in the framework of partnerships with European potato sector. Such projects would aim to a permanent experience and data exchange to improve IPM methods which could lead to a better yield and product quality. Besides, a network on germplasm exchanges and evaluation would provide a more efficient approach in breeding programs at the national and regional level.

56

Molecular characterization of resistance to potato wart in tetraploid potato populations

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Potato wart is caused by the fungus *Synchytrium endobioticum*, which is subject to quarantine regulations due to the production of long persisting spores in the soil and the lack of effective chemical control measures. The selection of resistant cultivars using the standard bioassay according to Glynne-Lemmerzahl is a very time-consuming and laborious task. The selection of *Synchytrium*-resistant genotypes could be facilitated by using molecular markers closely linked with the respective resistance genes.
We present results of the molecular characterization of 92 tetraploid progenies originating from a cross between Saturna (resistant race 1) and Panda (resistant races 1, 2, 6, 18). Resistance tests were performed with *S. endobioticum* races 1, 2, 6 and 18 on 10-20 eye pieces per genotype and race based on the method of Glynne-Lemmerzahl. A genetic linkage map was constructed using AFLP (Amplified Fragment Length Polymorphism) and microsatellite markers. The construction of the genetic map and the QTL analysis were performed with the software TetraploidMap (Hackett et al. 2007, J. Hered. 98, 727-729). In the single-marker regression as well as in the QTL analysis a high proportion of the phenotypic variation was explained by the known resistance locus *Sen1* on chromosome XI (Hehl et al. 1999, Theor. Appl. Genet. 98, 370-386). In contrast, resistance against potato wart races 2, 6 and 18 was inherited by multiple loci explaining minor to moderate proportions of the phenotypic variation. However, genotypes combining multiple positive alleles have a remarkable lower disease severity compared to those possessing no or few positive alleles. Another tetraploid potato population with Ulme as donor for complete resistance serves on the one hand for the validation of molecular markers associated with potato wart resistance identified in the population Saturna x Panda and on the other hand for the mapping of new resistance loci. Furthermore, comparisons of genetic maps and QTL positions of the two populations will reveal if the same or different genomic regions are responsible for resistance. Molecular markers of interesting genomic regions might be converted into STS (Sequence Tagged Site) markers for marker-assisted selection.

57

Field evaluation of plant material for allele mining and association mapping

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Keywords: QUEST project, potato starch, sbe alleles, allele mining, association mapping

Introduction

Potato starch is a mixture of amylose and amylopectin with unique physical properties, ideally suited for different technical applications. Modification of the degree or length of branching or the degree of phosphorylation of these carbohydrates influences the physicochemical features of starch. Various starch branching enzymes (SBE) are involved in the modification of the starch polymers. From 2010 QUEST Consortium develops a PLANT-KBBE project which aims at breeding for plants with different *sbe*-allele dosages through the generation and/or identification of *sbe*-alleles with reduced or null activity. New breeding tools as Tilling, Allele Mining and Association Mapping will be applied.

Materials & Methods

Propagation of plant material for Allele Mining and Association Mapping is a joint effort of Neiker and Appacale. A germplasm collection of 400 accessions, made up of a common set of 50 genotypes for both partners plus 175 other accessions for each partner, was agreed. This collection included commercial potato cultivars, breeding clones, native species, wild species and wild-tuberosum hybrids. Each participant performed a field trial with 175 genotypes, core set included, under ware potato conditions and a Petersen design. Emergence, coverage, plant habitus, plant aspect, flowering and maturity have been evaluated during the growing period; tuber shape, size, uniformity, skin colour, flesh colour, depth of eyes, breeder's preference, total yield and number of tubers at harvest; and dry matter content, starch, amylose and amylopectin content afterwards. Also, 50 accessions of wild Solanum species and interspecific hybrids were grown separately in the greenhouse by each partner, since they usually not tuberize under field conditions. Tuber yield, tuber number, starch and amylose content were determined.

Results

Mean yield was 909 g/plant in Neiker's field and 1255 g/plant at Appacale's although variation was very large in both cases. Mean starch content was 16.2% and 13.0% and percentage of amylose 20.6% and 18.3%, respectively. Due to Petersen design corrected values were calculated for all traits depending on the performance of control varieties in Appacale's data. There were not significant differences between performances of the controls in the blocks in Neiker's data, so no adjustments were made. Correlations between traits at both locations were low but always significant and higher with the adjusted values than with the unadjusted ones. Based on these findings relative performance factors were defined to adjust the values of both partners and make them comparable. The combined yield, starch and amylose value of the genotypes, using these adjustment factors, were calculated and are the basis for further research and association mapping.

58

Late blight and root-knot nematode resistance introgression assisted by molecular markers

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Abstract
Disease resistance is a priority for any breeding programme since many pathogens are still hard to control without the use of pesticides, which represent a risk for the public health and the environment. *Phytophthora infestans* (Mont.) de Bary, which causes late blight, is economically speaking the most important disease of potato. Although late blight has been the focus of several studies and huge progress has been made regarding the knowledge of the pathogen and the disease, durable resistance is still an objective to achieve. On the other hand, relative success has been obtained in breeding programmes for cyst nematodes (*Globodera* spp.) resistance, another extremely harmful potato pathogen, and a wide range of resistant varieties are available. Nevertheless, this success has had, as side effect, an increase of other pathogens, mainly root-knot nematodes (*Meloidogyne* spp), due to the lack of competitors and the decrease in the use of pesticides (Draaistra, 2006).
The goal of this work is to obtain potato varieties with combined resistances to *P. infenstans* and to *Meloidogyne* spp. by exploiting the natural biodiversity available in wild species. The approaches/tools used to reach this objective are somatic hybridization by protoplast electrofusion to introgress the resistances, combined with the use of molecular markers for the selection of resistances.
Individuals from seven different accessions of the wild species *S. bulbocastanum, S.stoloniferum* and *S. papita* have been tested for late blight resistance by deteach leaf assay and resistant ones have been selected. Also, amplification protocols of markers indicating the presence of late blight (*Rpi-blb 1, Rpi-blb 2, Rpi-blb 3*) and root-knoot nematode (*Rmc1*) resistance genes have been implemented. Protoplast fusions between wild resistant individuals and tuberosum diplohaploids from the Germplasm Bank of the company have been carried out. Several calli have been obtained and they are regenerating plants. Hybridism will be checked by SSRs markers and hybrid individuals will be also screened with resistance markers. Hybrid resistant genotypes will be used to carry out backcrosses with commercial varieties in order to remove undesirable characters remaining from the wild species and thus to breed new resistant varieties. Afterwards, backcrosses will be selected again by molecular markers and used, if necessary, for further backcrosses.

59

Detection of candidate resistance genes for Phytophthora infestans by differential cDNA-AFLP and microarrays

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Potato (*Solanum tuberosum L.*) is the most important food crop after rice, wheat and maize. In many places the most important factor limiting crop production is late blight, caused by the oomycete *Phytophthora infestans* (*Mont. de Bary*). Fungicides represent the usual control method for this disease. However they are too expensive and dangerous for human health and the environment. The introduction of molecular breeding based on candidate genes for resistance can be a key strategy for controlling the disease in potato.
In this study we have identified new putative resistance genes against *P. infestans* using two different molecular tools, microarray analyses and differential cDNA-AFLP. Several cDNAs with a relevant biological meaning were detected.
These were analysed in five different genetic backgrounds: in the UHD reference map of potato (SH x RH) and in four other progenies involving different resistant *Solanum* wild species as parents. In the case of the UHD map specific primers were designed for promising cDNAs obtained by these two techniques. In several cases segregating amplification products were obtained, which could be used for linkage mapping and integration of these markers into the UHD map. However, nowadays also extensive sequence data are available in potato and the detected candidate genes could be located directly in the genome through *in silico* mapping techniques, independent from the availability of segregating amplification products. Some of the integrated cDNAs were found to be co-located with published QTLs for Phytophthora resistance, validating in this way their potential role for explaining a particular QTL.
With respect to the other progenies which were previously characterized for resistance levels to *P. infestans*, simple t-Tests were performed which revealed in some cases significant differences in resistance levels for the two marker classes (presence or absence) of a candidate gene, in part in different genetic backgrounds.

60

Expression and purification of recombinant Potato virus M structural and nonstructural proteins for antibodies production

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With the development of molecular biology techniques cloning and expressing of plant viral genes coding for structural and non-structural proteins has become an important strategy for obtaining large amounts of antigens with uniform concentration and stable properties.
We report here the strategy for production of polyclonal antibodies against recombinant proteins of Potato virus M (PVM).
Vector pET-45b(+) containing 6x His-tag sequence was used for expression of PVM structural (coat protein) and nonstructural proteins (triple gene block protein 1- TGBp1). In expression system set up from pET-45b(+) vector and *E. coli* Rosetta-gami 2(DE3) cells the high level of CP and TGBp1 was obtained. Expression conditions were optimized and after purification by simple fractionation using centrifugation through the saccharose cushion or by excision from SDS gels, the His-tagged PVM proteins are used for immunization of rabbits.
The recombinant viral non-structural proteins expressed in bacterial cells have great potential as a source of antigens for raising specific antibodies. The detection based on non-structural proteins could be profitable when combined with other detection methods. Additionally, the benefit of obtaining antibodies against recombinant PVM antigens for us was their possible application in functional studies of the fate of these proteins in infected plant and its role in the viral life cycle.
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61

Molecular characterization of Potato virus M isolates from the Czech Republic

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Potato virus M (PVM), a member of the genus *Carlavirus* is one of the most common viruses of potato. PVM has been reported from the United States and some parts of Europe. Carlaviruses like PVM have not been as extensively characterized as plant viruses of other genera. There are only a limited number of complete genome sequences of PVM available in GenBank.
PVM has filamentous particles comprising multiple coat protein subunits and a monopartite plus-sense single stranded RNA of approximately 8.5 kb. The 5´end of PVM RNA possesses a cap structure and the 3´end is polyadenylated. The genome organization was shown to contain six major open reading frames (ORFs). These are divided into three clusters separated by small intergenic regions. The first cluster from the 5´end is represented by a continuous ORF1 coding for a 223 kDa protein that contains methyl transferase, helicase and polymerase domains. The second cluster comprises ORFs 2, 3 and 4 coding for three proteins so called „triple gene block"-proteins (TGBp). These proteins are mainly involved in cell-to-cell movement. The third gene cluster, composed of ORFs 5 and 6, encodes a coat protein and a cystein-rich nucleic acid binding protein.
Detection and elimination of viruses in potato seed stock is very important for potato health and production worldwide. When new virus isolates or strains occur, the standard tests must be updated to provide the most efficacious detection possible. Potatoes infected with PVM are often infected with another carlavirus, mainly with Potato virus S. The simultanous infections of potatoes with more carlaviruses are dangerous, because it could lead to recombination events between similar sequences of related viruses and give rise to a new virus with new properties. Sequence analysis of PVM isolates and comparison of their sequences with other known carlaviruses are therefore important for production of new antibodies based on structural or nonstructural viral proteins.
We designed primers covering the whole PVM genome, amplified overlapping genomic fragments, sequenced them and the obtained sequences were arranged into a single contig. Genomic sequences of Czech PVM isolates were compared with each other, with sequences of other already sequenced PVM isolates and other related carlaviruses available in GenBank. We found notable differences between the Czech PVM isolates.
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62

SCAR markers of Solanum genomes A and B derived from FLORICAULA/LEAFY intron 2 polymorphisms

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Polymorphisms of *FLORICAULA*/*LEAFY* intron 2 (FLint2) are widely employed by molecular taxonomists (for review see Oh and Potter, Am. J. Bot. 2005, 92, 179–192). Smith and Baum (Am. J. Bot., 2006, 93, 1140-1153) were first to use FLint2 in the systematics of Solanaceae (Physaleae), while Tu et al. (Mol. Phylogenet. Evol., 2008, 49, 561-573) employed FLint2 polymorphisms to prove the monophyly of *Nolana* (Solanaceae). Earlier we reported manifest infra- and intraspecific polymorphisms of FLint2 in *S. demissum* and *S. tuberosum* ssp. *tuberosum* (Drobyazina and Khavkin, Acta Hort., 2007, 745, 411-419) and now evaluated FLint2 as a tool for phylogenetic reconstruction in the *Solanum* section *Petota*.
Using the primers within exons 2 and 3, we obtained FLint2 sequences from nine *Solanum* species containing genomes A, B and D as suggested by Matsubayashi et al., 1991 (cf. Rodriguez and Spooner, Syst. Bot., 2009, 34, 207-219). The intraspecific polymorphism varied from 73 to 100 % with most variable FLint2 sequences in polyploid *S. demissum* (genome AAD) and *S. stoloniferum* (genome AB) and practically identical sequences (94-100%) in diploid species, such as *S. verrucosum* (genome A) and *S. bulbocastanum* (genome B).
The phylogenetic analysis using Neighbor Joining (NJ) and Maximum Parsimony (MP) algorithms demonstrated that these FLint2 sequences fell into three clusters presumably corresponding to three *Solanum* genomes. The genome A cluster includes FLint2 sequences from *S. verrucosum* (A), *S. tuberosum* ssp. *tuberosum* (AA), and *S. microdontum* (A). One of two FLint2 variants from *S. stoloniferum* and one of three FLint2 variants from *S. demissum* apparently belong to genome A. The genome B cluster comprises FLint2 sequences from *S. pinnatisectum*, *S. bulbocastanum*, *S. cardiophyllum* and *S. ehrenbergii* and one of two FLint2 variants in *S. stoloniferum*. Two of three FLint2 variants from *S. demissum* clustered separately from other species and probably correspond to genome D.
We compared NJ and MP phylogenetic trees of *Solanum* section *Petota* produced from polymorphic sequences of FLint2 and two other single-copy nuclear genes with high intron content, *waxy* and *NIA* (Spooner et al., Crop Sci., 2008, 48, S27-S36; Rodriguez and Spooner, Syst. Bot., 2009, 34, 207-219). Six trees were mostly congruent regarding allopolyploidy of *tuberosum* genome AA and closely related *S. cardiophyllum* and *S. ehrenbergii* as the origin of genome B in *S. stoloniferum* (Pendinen et al., Genome, 2008, 51, 714-720).
FLint2 polymorphisms were used to develop SCAR markers discriminating between *Solanum* genomes A, B and D. Screening 17 *Solanum* species from three series with these markers produced results mostly consistent with the hypothetic pattern of *Solanum* genomes within section *Petota*; several exceptions invite further study.
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63

Molecular mapping of the Ny genes in potato cultivars

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In potato, there are two main types of resistance to PVY. The extreme resistance (ER) is determined by *Ry* genes which confer extremely high level of protection against all PVY strains. *Ny* genes are responsible for the hypersensitive resistance (HR). In 2008, we described the gene *Ny-1* in potato cultivar Rywal. Both common and necrotic PVY strains were localized when plants were grown at 20°C. At 28°C, symptomless infection appeared both in inoculated and noninoculated, upper leaves. In field trials, PVY was restricted to the inoculated leaves and PVY-free tubers were produced. Therefore, the gene *Ny-1* can be useful for potato breeding as the alternative donor of PVY resistance, efficacious in practice like extreme resistance *Ry* genes. The locus *Ny-1* mapped on potato chromosome IX (Szajko et al. 2008, TAG 116: 297-303). Here, we report map positions of HR genes against PVY in potato cultivars Albatros, Neptun, Romula and Sekwana.
Material: mapping F_1 populations Albatros × Accent, Neptun ×Accent, Sekwana × Accent, and Romula × Felka, strains PVY^{N}Bo and PVY^{N}W.
Methods: mechanical inoculation at 20 and 28°C, CAPS markers, mapping.
Results: cvs Neptun and Sekwana were produced in Polish breeding companies, whereas Albatros and Romula derived from German cultivar breeding programs. Expression of HR was temperature-dependent. HR was observed in the resistant parents at 20°C. When plants were grown at 28°C necrotic lesions were observed only in leaves of cv Romula. The 1:1 segregation ratios of hypersensitivity versus susceptibility in all four mapping populations indicated the presence of single HR genes in each of their resistant parents. These genes were mapped to the same region of potato chromosome IX and designated as *Ny-1A, Ny-1N, Ny-1R* and *Ny-1S* in cvs Albatros, Neptun, Romula and Sekwana, respectively.

64

Breeding of Double cropping potato with short dormancy for global climate change in Korea

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Potato cropping in Korea is differentiated into year-round production system because of the high consumer demands for fresh potatoes. Spring crop in low land is the main potato cropping season but autumn cropping areas have occupied about 20% of total acreage of potato in Korea.
Lately autumn cropping has grown by global climate change in Korea. Since 1960 Japanese potato varieties with short dormancy had been imported, autumn potatoes had been cultivated for food supply in Korea. Cv. Dejima imported from Japan has been main variety since 1978 but it is very susceptible to common scab by *Streptomyces scabies* and bacterial wilt by *Ralstonia solanasearum*. Since 1960, Common scab has been important disease and Bacterial wilt also increased by global warming in autumn potato production areas.
Generally, autumn potatoes are planted from mid August to early September and harvested from early November to early March. Cv. Dejima has been main autumn season"s variety but since 1999, new domestic double cropping potato varieties with short dormancy have been bred for autumn cropping in Korea. First Korean domestic double cropping potato variety "Chubaek" was released in 1999. It has short dormancy periods, early maturity and good common scab resistance. Now, it has occupied about 10% of total acreage of autumn season potato in Korea. Cv. Goun was released in 2006, and its tubers have high dry matter contents and low reducing sugar contents so it is suitable to potato chip processing. It also showed very good chip quality and light color after reconditioning after storage in low temperature. New potato variety ‘Saebong’ and ‘Bangul’ were bred in 2010, and they have also good chipping quality. Those dormancy periods are 50~60days after harvesting and short than cv. Goun. Those have so early maturity that it can be harvested about 90days after planting in spring season.
Double cropping of potatoes in Korea has many pathological problems such as common scab, late blight, bacterial wilt, tuber moth etc. But double cropping potato has been a good cash crop to farmers and those problems can be overcomes by potato breeding and development of new technology.
New double cropping potato varieties will be tested in other countries for their adaptation in tropical or short-day condition sooner or later. If a variety has a good results or possibility, it can contribute to improvement of food shortage and nutrition value of many people in developing countries

65

Use of plastid SSRs for the characterization of cultivated potato phylogeny

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Cultivated potato species have been derived from wild potatoes through domestication. Their taxonomy and evolution have been the subject of much debate. In the present study we screened cultivated species and their wild relatives with 13 plastid SSRs to see if they revealed insights into cultivated potato phylogeny. This preliminary study included 276 accessions; 179 accessions of all 7 recognized by Hawkes (1990) cultivated species and 97 accessions of 17 wild species (in series *Acaulia, Maglia, Megistacroloba*, *Tuberosa*, *Yungasensa*) proposed as wild progenitors of cultivated potatoes by various authors. These accessions were recently characterized using nuclear SSRs and morphology (Gavrilenko et al. 2010). All loci were polymorphic and identified a total of 75 alleles and 103 different haplotypes. Among these 103 haplotypes, only 24 were present in cultivated accessions, whereas 79 (mostly represented by the unique haplotypes) were present in wild accessions, reflecting decreasing in levels of genetic diversity through domestication. 156 of 179 cultivated accessions shared eight most frequent haplotypes. The most frequent haplotype 'I' (79 accessions) was present only in the following Andean cultivated species: *S.stenotomum*, *S.phureja, S.chaucha, S.curtilobum* and *S.tuberosum ssp.andigenum*. *S.curtilobum* shares common haplotypes with members of the Andigena Group, not with *S. juzepczukii*, although a close relationship between *S. curtilobum* and *S. juzepczukii* has been well documented previously using nuclear SSRs. Neighbor joining analysis revealed the close relationship between the plastid types of *S juzepczukii* and wild species of series *Acaulia*, reflecting an earlier hypothesis of maternal origin of *S.juzepczukii* from *S.acaule*. Part of 4x cultivated potatoes (mostly presented by ssp.*tuberosum*) and two accessions of *S.tarijense* formed the distinct group of 26 accessions supported by high bootstrap value.
We are continuing this study with a wider subset and plastid SSRs.
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66

Wart (Synchytrium endobioticum) resistance in cultivated potato species

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Potato wart (*Synchytrium endobioticum*) is an obligate chytrid fungus parasite. It is included in the list of the quarantine objects in 55 countries. At the end of the nineteenth century, the disease spread outside of its original range in the Andeans of South America. More than 40 pathotypes of the fungus exist, but the most widely distributed is pathotype 1. Three dominant genes, or one dominant and two complementary genes are effective against pathotype 1 (D1). It was shown that one dominant gene *Sen1* on chromosome XI determined resistance to pathotype 1 (D1) of *S. endobioticum*.

The aim of our study was to characterize wart resistance of a recently published experimental subset (Gavrilenko et al., 2010) from the VIR cultivated potato collection and to determine whether this resistance is associated with traditional cultivated species taxonomy, with ploidy, with geographic distance, or with molecular markers linked to the gene *Sen1* and to select new sources of wart resistance.

We used population of *S. endobioticum* that was determined to be the most pathogenic of pathotype 1 with 20 potato differentials. We used this population of *S. endobioticum*to screen 90 landrace accessions of *S. phureja* (2x), *S. stenotomum* (2x), *S. tuberosum* ssp. *andigenum* (4x), *S. tuberosum* ssp. *tuberosum* (4x). Resistance scoring was evaluated according to OEPP/EPPO (2004) that uses a 5-score scale. We also screened them with SCAR-marker *NL25* (Gebhardt et al, 2006), which is linked to a gene *Sen_1*.

Of the 90 tested landrace accessions, 39 were extremely resistant (score 1), and 25 were resistant (score 2), and three were extremely susceptible (score 5), distributed among all analyzed cultivated species. There was no correlation of wart resistance to cultivated species taxonomy, ploidy, or geographic distance. Only two accessions of ssp. *andigenum* and five accessions of ssp. *tuberosum* of the above four taxa possessed by the diagnostic fragment *NL25*-1400 bp. Six of them were resistant (scores 1 or 2), however accession of ssp. *tuberosum* k-3407 was assigned to the group of score 3. Thus, among landraces we did not observe correlation between the absence/presence of the diagnostic fragment *NL25*-1400 bp and the level of resistance to potato wart.

Whereas a strong relationship was observed in modern potato varieties between the presence of diagnostic component *NL 25*-1400 bp and the resistance to pathotype 1 (D1) of *S. endobioticum*
The marker diagnostic allele *NL25*-1400 bp was detected in all 84 resistant varieties, whereas this fragment was not identified in susceptible varieties (Antonova et al in press).

However, within the diversity of landraces, our work shows a lack of predictive associations of wart resistance and cultivated species taxonomy, ploidy, geographic distance, or the selective utility of the *NL25* marker.

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67

HCpro proteins of PVA and PVY interact with translation initiation factors eIF(iso)4E and eIF4E of their host plants

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Potato virus A (PVA) and *Potato virus Y* (PVY) belong to genus *Potyvirus* (family *Potyviridae*) that is the largest and economically the most destructive group of plant RNA viruses. An efficient barrier to viral infection is provided by naturally host resistance genes. The majority of those acting against potyviruses are recessive, suggesting that they are mutated forms of genes needed by the virus for infection. Many of them have been found to encode eukaryotic translation initiation factor eIF4E or the isoform eIF(iso)4E. They interact with viral genome-linked protein (VPg) of potyviruses. Here we show that also the HCpro protein of PVA and PVY interacts with both eIF4E and eIF(iso)4E. A bimolecular fluorescence complementation assay on leaves of *Nicotiana benthamiana* showed that HCpro from three potyviruses (PVA, PVY, and *Tobacco etch virus*) interacted with the eIF(iso)4E and eIF4E of tobacco (*Nicotiana tabacum*) and potato (*Solanum tuberosum*). In PVA-infected cells, interactions between HCpro and eIF(iso)4E were confined to round-shaped structures that co-localized with membrane-anchored viral 6K2-protein induced replication vesicles of the virus. A putative 4E-binding motif was found in the C-terminal region of HCpro. Mutations in the motif debilitated interactions of HCpro with translation initiation factors, and the virulence of PVA in plants was impaired. These results revealed novel, biologically significant potyvirus-host interactions and their control mechanism involving host proteins known to play a crucial role in the success of potyviral infection. The mechanisms by which the mutations in genes for translation initiation factors compromise virus infection are not yet known. This may be because only interactions between the translation initiation factors and VPg have been described. It is anticipated that future studies considering the multifunctional HCpro as an interaction partner for translation initiation factors will uncover important novel mechanisms by which the translation initiation factors confer resistance to potyviruses

68

The effective method of potato pathogens routine diagnostics

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Potato is commonly infected by various fungal, bacterial, viral diseases and nematodes. With high occurrence rates, these infections can cause serious crop losses of up to 50%. Furthermore, viral infection and the resulting decrease in starch content has a negative impact on both on the crop nutritional value and on its utility for industrial processing; some viruses cause internal tuber necrosis. It is obvious that the development of modern control techniques for pathogen detection and identification is an important practical need for the elite potato seed production.
The PCR based methods play an ever growing role in pathogen diagnostics, since they allow the accurate detection and identification of target species and strains based on nucleotide sequences specific for their genomes. In contrast to the traditional ELISA technique, which requires at least 0.1 ng of a pathogen-specific protein, PCR is efficient with as few as 10 DNA or cDNA copies of the target gene. The technique of fluorescent amplification-based specific hybridization (FLASH–PCR, the technique mainly analogous to Fluorescence End Point, FEP), based on determining PCR results by fluorescence intensity, was developed to improve the cost-efficiency of diagnostic laboratories by employing original economical high quality equipment and to eliminate the risk of the working zone contamination.
In the present work, we have developed a FLASH–PCR-based diagnostic system for detection of eight major potato viral pathogens: potato viruses A, Y, X, M, S, PLRV, PMTV, PSTV, and causative agents potato ring rot (*Clavibacter michiganensis* subsp. *sepedonicus*), potato brown rot (*Ralstonia solanacearum*), pale and golden potato cyst nematodes (*Globodera pallida* and *G. rostochiensis*). Potato actin mRNA was used to monitor the quality of RNA isolation and cDNA synthesis. Since the high sensitivity and specificity of PCR-based diagnostics are essentially secured by the optimal primer choice, the primer design was a most important procedure. After the primer pairs had been optimized, we designed hybridization probes, so called molecular beacons. As the reaction specificity is determined by the primers, the probes need not necessarily discriminate between related species, which makes it possible to search the complete sequence between the primers to optimize the probe structure.
Based on these results, a protocol has been elaborated and the production of the test systems approved by the Institute for Potato Farming, Institute for Plant Quarantine of the Ministry of Agriculture of the Russian Federation, Research and Development Center for Potato Breeding and Horticulture of the Belarus National Academy of Sciences, and in some seed production stations, is organized. The developed test systems are manufactured by Agrodiagnostica LTD (Moscow, Russia).

69

Breeding and functional characterisation of potato clones with high carotenoid content

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In recent years, potato genetic improvement has been increasingly aimed at breeding "biofortified" potatoes, with an enhanced accumulation of secondary compounds valuable for human health and nutrition. Among these, carotenoids have raised a great interest, especially for the existence in both cultivated and wild germplasm of a wide variation, allowing introgression of the high carotenoid trait into elite cultivars. Moreover, the detailed knowledge of the carotenoid biosynthetic pathway in several organisms, has led to the possibility to manipulate carotenoid content through the development of transgenic potato varieties.
At our Center, deep yellow-fleshed clones were developed by conventional breeding programs trough cross combinations between tetraploid clones *high yielding* x *high carotenoid* content. The examinated potato clones were characterised for the amount of total carotenoids by a preliminary screening based on spectrophotometrical determination and were tested, in field conditions, for yield performance by comparing them with commercial high-carotenoid cultivars; besides, a transgenic cv. (genetically modified potato), obtained by Diretto et al. (2007, PLoS iss. 4, e350) was tested for total carotenoid amount and compared with the described clone in controlled environment.
Further analysis on tubers obtained, carried out by LC-MS, demonstrated that one of our new clones (ISCI 5/03-1), tested in field trials in 2009 and 2010, showed a total carotenoid content of 100,79 µg/gr of dry weight (d.w.), and that the highest contribution was due to violaxanthin, lutein and other xanthophylls. The overall amount of carotenoids in ISCI 5/03-1 was only slightly lower than the one recorded for transgenic one (120,00 µg/gr. d.w.); ISCI 5/03-1 has good yield, smooth skin, oval and highly regular shape, and a high percent of 45-70 size.
In 2010, ISCI 5/03-1 was both crossed with a white-fleshed variety, and self-pollinated. TPS obtained was sown in a greenhouse for minitubers production from seedlings. For each single new clone 3-4 minitubers have been sown in open field conditions, under screenhouse for full growth cycle and for both detailed qualitative and quantitative HPLC analysis of carotenoid profiles, and evaluation by qRT-PCR of the expression levels of the genes of the biosynthesis/degradation pathways. This functional genomics analysis has been carried out for 6 of the key enzymes of the carotenoid pathway, at different developmental stages.
In addition, the F1 progenies (both from ISCI 5/03-1 selfing and ISCI 5/03-1 x white-fleshed potato cross) were tested for segregation of the *bch* CAPS marker developed by Brown et al. (2005, Am.J. of Potato Res. 83: 365-372), to check the suitability of this marker in tetraploid crosses.

70

The use of the molecular markers in selection of tetraploid potatoes resistant to different diseases and Globodera rostochiensis.

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Potato (Solanum tuberosum) is one of the major food sources in the world. Diseases and pests of the potato can cause large yield looses. The most effective and environmentally safe method of crop protection is the cultivation of resistant cultivars.
The phenotypic evaluation of resistances is an expensive and time consuming process. In some cases, this process can be more effective if DNA markers are used for selection of resistant forms (MAS marker assisted selection). Molecular markers linked to the loci of interest can be used in potato breeding at early stages of potato breeding scheme, which leads to rapid reduction of individuals under selection in next steps. Many resistance genes were already mapped along with the specific marker assays developed.
MAS for several resistance genes is already applied in the tetraploid parental lines breeding programme performed in Mlochów Research Centre IHAR-PIB. Potato clones are tested for their resistance to Potato Virus Y, Phytophthora infestans and Globodera rostochiensis.
The potato virus Y (PVY) is one of the most important viruses affecting potato production. The Ry-fsto gene for extreme resistance to PVY confer extremely high level of protection against all strains of PVY. Marker $GP122_{718}$ (CAPS), linked to Ry-fsto gene, proved to be very effective in selection of genotypes extremely resistant to PVY. 641 clones were tested, 403 of them were $GP122_{718}$-positive and 51 were recombinants.
Beside the resistance to the viruses, the resistance to the late blight, caused by the Phytophthora infestans, is important in the cultivated potato. The Rpi-phu1 gene is a novel resistance gene introduced to tetraploid breeding pool from an interspecific hybrid between S. stenotomum and S. phureja, and conferring a high level of resistance to P. infestans. Marker GP94, linked to this gene is used to select resistant genotypes. 841 clones were tested, 430 of them were GP94-positive and 48 were recombinants.
Globodera rostochiensis (Potato Golden Nematode - PGN) is one of the most problematic potato pests and is included in the list of quarantine pathogens in many countries. Breeding for resistance to PGN is a one of the major aims of potato breeding programmes. For selection of resistant clones, marker TG689 (De Jong, unpublished) is used. This marker is tightly linked to the H1 gene, commonly found in resistant cultivars and conferred resistance to Globodera rostochiensis pathotypes Ro1 and Ro4. 347 clones were tested, 261 of them were TG689-positive and 23 were recombinants.
For the group of advanced breeding lines CAPS markers GP283 and GP250 linked to the Rm gene (confering resistance to PVM) were applied conferring phenotypic evaluation of PVM resistance.

71

Mapping of the late blight resistance of potato cultivar Sárpo Mira

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The most destructive disease of cultivatedpotato (*Solanum tuberosum*), late blight, is caused by the oomycete *Phytophthora infestans*. This pathogen is famous for the severe epidemics of the potato crops in Ireland in the 1840s. Nowadays, despite using of fungicides against late blight, it is still responsible for substantial crop losses. One of the alternative ways of late blight control is cultivating highly resistant potato varieties possessing late blight resistant genes (*R* genes). It is important that the resistance provided by the *R* genes should be effective and durable.
Sárpo Mira (SM) is a Hungarian variety, which represents the highest resistance class. Due to its agricultural traits, it has become popular only in organic agriculture and allotment gardens. Unknown location of Sárpo Mira's resistance gene is also an impediment in using it in breeding programs supported with selection based on molecular markers.SM was crossed with susceptible variety Maris Piper (MP) by John Bradshaw and Alison Lees from SCRI, UK, who kindly shared the progeny with us. Two parental clones and 142 F1 individuals segregating for resistance were grown in a greenhouse in Mlochów. The inheritance of resistance was tested by detached leaflet test (with three *P. infestans* isolates: MP324, MP618 and MP650) in years 2009-2010. Tests were done on two dates, each time two replications x three leaflets per genotype. The leaflets were inoculated by 30 µl droplet of inoculum i.e. zoospore and sporangia suspension with concentration 50 sporangia/µl. After seven days of incubation in conditions supportive for disease development, leaflets were scored in a 1-9 scale, where 9 was the most resistant. A genotype was considered resistant (possessing the *R* gene), when its mean resistant score was ≥7. The progeny segregated for resistance in two clear classes of highly resistance and susceptible ones suggesting the presence of an *R* gene, named *Rpi-srp1*. However, the presence of quantitative resistance was also observed. The results obtained with the three *P. infestans* isolates were correlated with each other (Pearson's correlation coefficient MP324 - MP618: $r = 0.91$, $p < 0.001$, MP324 - MP650 $r = 0.93$, $p < 0.001$, MP618 - MP650 $r = 0.95$, $p < 0.001$). We plan to test the resistance of the SM x MP population also in 2011.
Linkage analysis using molecular markers from well-established resistance hot spot on chromosome XI was performed in a mapping population SM x MP. So far, five markers were found to be linked with the phenotypic resistance results. These five markers can be later potentially useful in marker-assisted selection of the resistant individuals carrying *Rpi-srp1* and should be viewed as the starting point for marker assisted gene pyramiding.
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72

Production and characterization of potato somatic hybrids between Solanum michoacanum (Bitter.) Rydb. resistant to Phytophthora infestans and S. tuberosum L.

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The objective of this work was to produce interspecific somatic hybrids resistant to *Phytophthora infestans* (Mont.) de Bary by means of protoplast fusion of the wild potato species *Solanum michoacanum* (2*x*, 1EBN, source of resistance) and *S. tuberosum* (2*x*, 2EBN; 4*x*, 4EBN). *S. michoacanum* is reproductively isolated from *S. tuberosum* and cannot be crossed directly with potato. In cooperation with Julius Kühn Institute, Germany , somatic hybrids were produced by protoplast electrofusion of two accessions of*S. michoacanum,* with three diploid clones of S. *tuberosum* and the cultivar Rywal, which were susceptible to late blight. For eight parent combinations viable calluses and shoots were achieved. In total, 1482 plants were produced from which 815 were preserved *in vitro*. One *in vitro* copy was preserved for each plant, second copy was planted in pot and propagated in the greenhouse. In total, 764 plants grown in the greenhouse were characterized for their phenotypic traits, like vigour, habit, shape of leaves, flowering and tuberization. The ploidy level of 402 plants was estimated by counting the chloroplast number in guard cells. Pollen fertility of 512 forms was evaluated based on percent of regularly shaped and stained by lactofuchsine pollen grains. Simultaneously, 490 plants were tested for resistance to foliage blight using the detached leaflet assay (scale 1-9, 9 = the most resistant). The hybrid nature was identified for 228 plants. It was confirmed by SSR, CAPS and RAPD markers. Two somatic hybrids were resistant to foliage blight (score 7). The presence of the *Rpi-mch1* gene (chromosome VII) was tested using C2_At1g53670 marker linked to this gene among seven susceptible to *P. infestans* somatic hybrids originated from 99-12/8 parent. One of them had the marker. In addition, 116 4*x* forms from autofusion, morphologically similar to *S. michoacanum* and resistant to *P. infestans* were obtained. They might be used in alternative approach (4*x*- 4*x* sexual crosses) to introgress the resistance to *P. infestans* into *S. tuberosum* background.

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73

The expression pattern analysis of the late blight resistance gene Rpi-phu1.

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Phytophthora infestans is the most dangerous pathogen of potato worldwide. Costs that late blight disease brings about, including yield loss and chemical protection, amount to 6 billion USD annually. Since the first half of the twentieth century, when eleven resistance genes (*R1-11*) from *Solanum demissum* were discovered, a lot of new R-genes have been identified. Searching for new resistance genes covered a number of wild species of the *Solanum* genus (*S. bulbocastanum, S. brachistotricum, S. microdontum, S. pinnatisectum, S. papita, S. polytrichon*, *S. stoloniferum, S. mochiquense, S. berthaultii, S. paucissectum, S. caripense*). Among them there was also the *S. phureja*, in which the *Rpi-phu1* gene was identified and mapped on potato chromosome IX. Analysis of the gene sequence revealed that is identical to a sequence of *Rpi-vnt1* gene from *S. venturii.* So far, only one *P. infestans* isolate from Ecuador is known to be able to overcome the *Rpi-phu1* resistance. The *Rpi-phu1* gene was transferred into cultivated potato gene pool using a series of interspecific crosses, first at the diploid, and then tetraploid level. The aim of the ongoing experiments is to investigate expression pattern of the *Rpi-phu1* gene in the non-infected and infected plants with different isolates of *P. infestans*. Based on known gene sequence, ten pairs of PCR primers were designed. After tests, phu6 marker was chosen as the one giving specific PCR product and was applied for further investigations. Optimalisation of the real-time PCR reaction using phu6 marker for *Rpi-phu1* gene and α-tubulin as a reference gene was performed. The poster presents the preliminary results of the experiments where *Rpi-phu1* plants (04-IX-21 – clone of potato) and susceptible plants of cv. Craigs Royal were inoculated with *P. infestans* isolates (MP324, MP828, MP1162). Before inoculation and 1, 3, 5 days after inoculation samples were taken from all plants. RNA was isolated using a kit, DNase I treated, then reverse transcription was performed. Relative expression of *Rpi-phu1* was measured in three biological and three technical replications. The expression level of the *Rpi-phu1* gene changed after contact with pathogen, dropping down first day after inoculation, then increasing third day and decreasing fifth day to similar level as first day. We plan to investigate the expression pattern of *Rpi-phu1* gene depending on genotype and age of plants, day length, and genotype of pathogen.
The research is founded by Polish NCBiR grant LIDER/06/82/L-1/09/NCBiR/2010.

74

The transgenic potato with coat protein PVY gene as a new initial material for potato breeding

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Transgenic potato lines of cv. Belorusky 3 (B3) with coat protein (CP) gene of potato virus Y (PVY) strain N were obtained in Moscow Bioengeneering Centre by agrobacterial transformation of internodal stem segments with 4 cassettes of expression: ? – p35SPLYCP (8 lines); ? - p35SPLYCPdelATG (8 lines); ? – ?35SX28YCP (7 lines); D - ?35SX28YCPdelATG (10 lines). They expressed foreign RNA and (or) protein. According to the results of field testing the sources of resistance to PVY have been selected among transgenic potato lines with CP PVY gene. Transgenic sources with CP PVY gene showed different resistance to PVY (hypersensitivity and immunity to Y-virus). Among seven transgenic sources of resistance to PVY two transgenic lines b7, c12 were immunity to PVY.24 reciprocal crossings between the transgenic potato lines ?1, ?3, ?4, ?9, ?12, b7 and cvs. Kapris and Arhideya were made. The sexual progeny was obtained for 5 crossings only.
Among sexual progeny from crossings have been selected hybrids with phenotypic occurrence of reporter gene nptII (resistance to antibiotic kanamycin on the selective medium).
For the analysis of inheritance of a target trait (resistance to PVY) kanamycin-resistant sexual progeny from transgenic PVY resistance sources were infected by mechanical inoculation of PVY during 2 years. Vegetative progeny of the infected hybrids have been analyzed on the stability of target gene's occurrence in field. Differences of crossing combinations were revealed as the final result (the amount of resistant hybrids with the stability occurrence of target trail at vegetative reproduction). It's connected with different resistance of partners and initial transgene forms. Finally 131 kanamycin-resistant hybrids with stable occurrence of a target trail «stability to PVY» were obtained.

75

Involve of interspecific somatic hybrids in potato breeding

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The interspecific somatic potato hybrids: SB – S. tuberosum, 4x (78563-76) + S. bulbocastanum; DL – S. tuberosum, 2x (LDH) + S. bulbocastanum; 2D – (S. tuberosum × S. chacoense) (86-6, 2x) + S. etuberosum; 4D – 86-6, 2x + (S. etuberosum × S. brevidens) were obtained between incompatible initial parents. In the begining they had different growth abnormalities. It is necessary 3-4 years of vegetable propagation for stabilization their phenotype and genotype. Seed berries and offsprings were also obtained after 3-4 years of vegetable propagation of somatic hybrids. The first backcross is the most difficult step in involving the somatic hybrids into potato breeding. We used high fertile pollinators and maximally possible amount of formed buds. The use of generative progeny from free pollination as a female parent is more successful for somatic hybrids DL and 2D in crosses with tetraploid potato.Four initial parental lines were obtained from 31 BC2 combinations of somatic hybrids SB. They form the yield of ware tubers from 990 to 1385 kg/bush with starch content from 16.3 to 22.0 % and they are crossed with S. tuberosum, 4x. The resistance to PVY (high resistance and immunity) and to foliage and tuber late blight was successfully transferred from Mexican wild S. bulbocastanum by means of somatic hybridization. Genomes of parental lines carry the RB gene from S. bulbocastanum. The BC3 offspring had from 46 to 92 % genotypes, resistant to inoculation by Phytophthora infestans.
The desired character of wild nontuberous species of series ETUBEROSA is resistance to viruses. The genotypes with high resistance to PVY, PLVR have been selected in the third and fourth sexual progenies of somatic hybrids of combinations 2D and 4D with nontuberous wild parents. Resistance to PVY and PLVR was estimated in the test with grafting of analyzed genotype onto tomato plants contaminated by PVY or the potato plants contaminated by PLVR. Symptoms of diseases on wilding and alive grafts were described in 28-35 days after grafting. At the same time the plants of graft and wilding were tested by ELISA.

76

PVY resistance screening and marker evaluation across Australian germplasm

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Potato virus Y (PVY) incidence has dramatically increased in Australia over the past decade, requiring urgent development of locally adapted PVY resistant cultivars. The identification and implementation of marker assisted breeding for PVY resistance can deliver cultivars that have broad resistance based on combining known and/or novel alleles in a reduced timeframe. There are several sources of PVY resistance, with the most commonly introgressed resistance genes from *S. tuberosum* ssp. *andigena* (Ry_{adg}) and *S. stoloniferum* (Ry_{sto}). The RYSC3 SCAR marker linked with the Ry_{adg} resistance gene was fluorescently labelled and screened across 555 Australian parental cultivars and breeding lines using an ABI3730xl capillary electrophoresis platform along with the TG689 marker as an internal control. Three cultivars amplified the requisite 320bp amplicon linked to PVY resistance. The STM0003 SSR marker linked to the Ry_{sto}, resistance gene was also screened across the same germplasm. Only 2 cultivars amplified the requisite 125bp amplicon linked to Ry_{sto}-mediated PVY resistance. In parallel, parental cultivars were phenotypically screened for PVY resistance. A range of cultivars has been chosen to be challenged with PVY^N and PVY^O inoculum from ELISA positive infected tissues. Plants amplifying the requisite resistant amplicon from either RYSC3 or STM0003 have been identified as being phenotypically resistant to either PVY inoculum. A subset of cultivars has been identified as putatively phenotypically resistant but lacked the resistant marker amplicons. These cultivars will undergo further challenges to confirm the observed phenotype and may represent novel sources of resistance to be used in future breeding cycles.

77

Evaluation of a more diagnostic molecular marker tightly linked to PCN resistance

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Potato cyst nematode (PCN) is a major problem in potato growing regions throughout the world. Australia has had limited incidences of infection from a single pathotype, *G. rostochiensis* Ro1, which is currently managed by stringent quarantine and regulatory procedures. The use of resistant cultivars is also being promoted as a management tool and so it is highly desirable that new cultivars are resistant. The *H1* resistance gene from *S. tuberosum ssp. andigena* conferring resistance to pathotypes Ro1 and Ro4 of *G. rostochiensis* has been extensively introgressed into potato cultivars. The SCAR marker, TG689, closely linked to the *H1* resistance gene (http://s2.generationcp.org/gcp-tmm/web/) has been evaluated by several researchers across tetraploid cultivars and breeding lines, however, all reported a loss of linkage between TG689 and *H1*-inferred resistant phenotypes in a small number of clones (Biryukova *et al.* 2008, Russ. Agr. Sci. 34, 365-368; Milczarek *et al*. 2011, Am. J. Potato Res. online first). Australian parental cultivars have also been evaluated with TG689, with a loss of association between phenotype and genotype observed in ~2% of cultivars (Schultz *et al.* 2010, Potato Res. 53 247-8). A recent publication by Finkers-Tomczak *et al*. (2011, TAG. 122, 595-608) generated sequence data across the *H1* locus and produced flanking SCAR markers, 110L and 57R. In an attempt to identify a more diagnostic PCN resistance marker, both 57R and 110L were screened across a small family and subset of cultivars. Spurious results were obtained for 110L while 57R displayed 100% congruence between phenotypic and genotypic data. The 57R marker was further tested across 264 parental cultivars, including the cultivars which displayed loss of linkage with the TG689 marker. There was 100% congruence between presence of the 450bp band and resistant phenotype. The 57R marker appears to more diagnostic for predicting PCN resistance than TG689 for application to marker-assisted breeding.

78

Identification and characterization of Streptomyces species causing common scab in Norway

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Common scab is a serious disease of potatoes reducing the crop value and causing yield losses. The disease is caused by soil-borne, gram-positive, filamentous bacteria of the genus *Streptomyces*. Relatively few of the several hundred species in the genus are plant-pathogenic. The plant pathogenic species are a relatively diverse group. It is important to determine the scab causing species in order to implement the appropriate control strategies. Plant pathogenicity in the genus is based on production of the phytotoxin thaxtomin which has an impact on cellulose biosynthesis. *Streptomyces scabies*, *S. turgidiscabies, S. acidiscabies* and *S. europaeiscabiei* are among the most well known common scab causing pathogens worldwide.

Our survey was conducted to clarify which *Streptomyces* species causing common scab in Norway. Bacteria were isolated from scab lesions on tubers sampled in two years from different locations in 15 counties of Norway spanning ~1400 km from south to north. Symptoms on tubers were diverse, ranging from superficial to deep-pitted lesions, and in some cases raised lesions. After DNA extraction from pure cultures, the primer pair txtAB1/txtAB2 was used to detect putative pathogenic strains and probable non-pathogenic strains.

Pathogenicity of selected strains was tested on radish seedlings and potato. The ability of the bacterial strains to infect potato or radish was consistent with the presence of the *txtAB* operon, the pathogenicity determinant.

Microarray-based comparative hybridization was conducted to identify a selection of the pathogenic strains of *Streptomyces* obtained from potato scab lesions and to compare genetic differences between them. Species determination was done by PCR based on the variable regions in the 16S rRNA gene.

The Norwegian strains of *Streptomyces* were assigned to *S. europaeiscabiei* (70 %) and *S. turgidiscabies* (30 %) based on the 16s rRNA gene and microarray analysis. Surprisingly, *S. scabies* was not found in Norway in our survey.

79

Cryopreservation of potato landraces from VIR collection

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Presently VIR holds the oldest and one of biggest potato collection consisting of approximately 8700 accessions including cultivated and wild species. One of the most important part of the collection are landraces representing native cultivated species collected by VIR expeditions.
The most actual task today is developing safety duplicates for the large field-maintained collection of cultivated potato species. At present about 250 potato accessions of cultivated species are preserved under *in vitro* conditions. Recently we've initiated cryoconservation program for this *in vitro* material.
For cryopreserved we used of 15 accessions of Andean potato landraces (*S.tuberosum ssp. andigenum*) and 5 accessions of Chilean landraces (*S.tuberosum ssp. tuberosum*). Apical and axillary buds have been cryopreserved by droplet-vitrification method (Panis *et al.*, 2005).3 repetitions for each type of explant were executed from the frozen material with 20 buds per repetition to examine survival and regeneration rate.
Regeneration rate after cryopreservation (8 weeks) was varied from 15% to 86% depend on genotype, 11 accessions had regeneration rate higher than 50%. In most accessions (14 of 20) regeneration rate of apical buds was comparable with axillary buds. For 6 accessions regeneration rate of apical buds was significantly ($p \leq 0,05$) higher than in axillary buds. There are no significant differences in regeneration rate between *S. tuberosum ssp. andigenum* and *S. tuberosum ssp. tuberosum*.
We showed that application of protocol of Panis et al (2005) is promising for cryopreservation of diverse tetraploid potato landraces of *S. tuberosum*, although the survival and regeneration rate was significantly affected by genotype. The regeneration of plants from apical buds was statistically higher than from axillary buds only in 6 of 20 accessions. In the most cases differences in regeneration rate between these two types of explants were not significant statistically. These results support the using of axillary buds of potato microplants in practical routine genebank cryopreservation.

80

Endogenous reference gene selection for qRT-PCR analysis of potato tubers under cold stress

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Potato tubers stored at temperatures below 9-10ºC concentrate high amounts of reducing sugars which result in dark-brown-coloured fries and chips which is unacceptable to consumers. Gene expression analysis is increasingly important in many fields of biological research, with real-time reverse transcription PCR (RT-PCR) becoming the method of choice for high-throughput and accurate expression profiling of selected genes. To ensure a robust normalization strategy it is necessary to use a reference gene that has been shown specifically to be stable expressed under relevant experimental conditions and in different tissues of an organism. In addition, an endogenous control should also be expressed at roughly the same level as the target under study. In the present work we used real-time qRT-PCR to examine the expression of the six housekeeping genes, ß-tubulin, cyclophilin actin, elongation factor 1-α (ef1α), 18S rRNA, adenine phosphoribosyl transferase (aprt) and cytoplasmatic ribosomal protein L2, in tuber-tissues of six commercial potato varieties. These varieties were exposed to cold, at 4ºC and 11ºC, during different periods (harvest time, one and three months after harvest), in order to assess their value as neutral controls in expression studies. Several algorithms have been used to identify the best reference genes under our experimental conditions, which allow for easy systematic validation: Bestkeeper (Pfaffl *et a*l., 2004), geNorm (Vandersompele *et al*., 2002) and Normfinder (Andersen *et al*., 2004). PCR efficiency for each housekeeping gene was determined by measuring serial dilutions of cDNA (1:5) and results between 87 and 104 percent were obtained. Both, geNorm and Normfinder identified the same genes as the most stable one differing in their ranking order. All six genes reach high expression stability with low M-values, below the default limit of M=1.5 in geNorm analysis. Normfinder analysis showed that the four most stable expressed reference genes are identical to the ones previously determined using geNorm. Bestkeeper software analysis which is based on Ct-values and displayed as the standard deviation and coefficient of variance, results different from the others for the most stable endogenous reference gene.

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81

Variability of characters in early generations of potato

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Alternative potato selection methods in early generations have been developed in recent years in which the first steps are speeded up using different computer programs (Chiru et. al.2008, Alap 08,181-182). Despite these it is still a high risk to loose a lot of valuable genotypes mostly because of visual selection limits.The success of a breeding program depends on: genetic variability; efficiency of methods; the experience of breeder (Rousselle et al.1996, La pomme de terre, 125-129).
In order to increase the chance to identify a new "good" genotype, a high level of variability must be achieved by suitable genitors.
This paper presents results of study on variability of traits in 4 tetraploid combinations in parents and 3 standards varieties on 2 locations (Brasov, Mc.Ciuc) during 2 years and also the correlations between traits .
Data concerning 9 traits: height of the main stem(MSH), number of stems(NS), size of plant(PS), foliar index(FI), tuber yield/hill(TYH), marketable yield(MY), number of marketable tubers(NMT), tuber yield/ha(TYHa) and general appearance(GA) were recorded at the flowering and harvesting time according to the previous experiments (Chiru et al.1998, Ph. D.,100-121).
The measurements were done in trials designed as a replicated system and parameters: genetic(G), phenotypic(F), environment(E), variance(V) and contributions (%G;E;GE), interactions, heritability(h^2) and genetic coefficient(GCV%) were calculated by ANOVA and MSTAT programs.
The genetic contribution in phenotypic expression within 9 traits is much higher for genitors and standards when compare with hybrid combinations. The bigger difference was recorded for MY where G=3,7% for combinations and G=63% for genitors. Inside combinations the limits of genetic contribution were between 3.7% for MY to 16,5% for PS. The environment contribution is dominant in combinations and it has values E=46, 2 % for NMT up to E=77.9 for MSH. Regarding the GE effect we have got values: GE=14,5% for MSH and 48,2% for NMT.
The values of heritability coefficients (h^2) for all characters analyzed gave us the following ranks:
genitors 1)MY(0,63); 2)MSH 3)PS; 4)TYHa; 5)TYH; 6)FI; 7)NMT; 8)NS(0.04)
combinations 1)PS(0,17); 2)NS; 3)THY; 4)TYHa; 5)GA; 6)MSH; 7)FI; 8)NMT; 9)MY(0,04)
The values for genetic contribution and heritability coefficients determined for combination showed us a higher effect of E and GE in phenotypic expression of characters studied, related to diverse genetic structure, heterogeneity of genotypes and the strong influence of years and locations. We could assume the results as a background in considering the sources to be used in getting a genetic progress in breeding activity.We have found the main next correlations between PS and: MSH(r=0.66**); NS(r=0.74**);TYH(r=0,62**).FI and MSH(r=0,64**);NS(r=0,51*)TYH(r=0,74**); MY(r=0,72**) .Both PS and FI should be considered as synthetic characters which can be used for representing in a correct way the inner compounds.Based on our results we can suggest that for a new "good" genotype the screening has to lead the breeder to these values of characters:NS(5-7); MSH(60-70cm); FI(2-2,5); NMT(10-15) and TYH(1000-1200g).

82

Cryopreservation of potato (Solanum tuberosum) germplasm

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In recent years, cryopreservation has become the most promising choice for long-term storage of germplasm in minimal space and maintenance requirements. Cryopreserved material is stored at ultra-low temperature where all metabolic processes are stopped and thus can theoretically be stored for an unlimited period. At present, cryopreservation procedures are available for about 200 plant species. However, species- or cultivar-specificity is still a major problem affecting survival and regeneration of cryostored material. During cryopreservation plant germplasm is exposed to various extreme stress conditions. In addition, recovery procedures may result in somatic variation, thus, the thorough assessment of genetic fidelity of cryostored material is necessary.

In the present study potato varieties preserved and maintained by micropropagation in slow growth conditions for already more than 30 years are used. The general aim of the present study is to develop the cryopreservation protocol for their safe storage. In addition, the genetic fidelity during cryostorage will be evaluated.

83

A strategy to retain the most relevant Marker-Trait associations from a Genome Wide Association Study (GWAS)

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A genome-wide association study (GWAS) was conducted using two association mapping panels. The first panel contained 205 historical and contemporary potato cultivars that were phe notyped in field trials at several locations in 2006, 2008, 2009 and 2010. The second panel consisted of 299 potato cultivars and combined five times 38 recent breeds obtained from five Dutch potato breeding companies and 109 reference cultivars from the first panel. Phenotypic data for the second panel were retrieved from the breeders" records taken during clonal selection programs at the individual breeding companies for multiple years and locations. All genotypes were analysed with 41 AFLP™ primer combinations yielding 3364 AFLP polymorphisms, as well as with 384 Illumina Goldengate™ SNP markers. All genotypes were scored for 49 agro-morphological and quality traits. The association analysis yielded vast amounts of significant Marker-Trait association. In order to design a strategy to retain the smallest set of markers maximally explaining the genetic variance of the trait, the impact was examined of various thresholds and criteria to narrow down this number of associations. It appeared that all criteria had severe trade-offs, implying that false positives could not be selected against, without losing putatively valuable markers.
This research is financially supported by a grant from the Centre for Biosystems Genomics (CBSG)

84

Molecular markering and mapping of a potato late blight resistance gene

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Cultivated potato due to its significant role in human nutrition is the third the most important food crop worldwide. One of its most dangerous disease resulting numerous environmental and food-safety problems is late blight caused by P. infestans. The aims of this study were the development of molecular markers for the S. demissum R 5 gene based resistance of Hungarian potato variety, White Lady. From previous publications it is presumed that R 5 gene is an allelic version of gene R 3 that maps to chromosome XI.

For the molecular studies we have created a segregating population by crossing resistant White Lady with susceptible breeding line S440. With 175 randomly selected F1 genotypes an artificial infection based late blight resistance test was made by the use of late blight isolate H12/10.

For markering and simultaneously to construct a genetic linkage map we applied 38 SCoT (Start codon Targeted Polymorphism), 13 SSR (Simple Sequence Repeat), 15 ISSR (Inter Simple Sequence Repeat) and 129 own designed Intron targeting as well as more than 400 RAPD (Random Amplified Polymorphic DNA) primers. For the Intron targeting method primer pairs were designed from known sequences of potato genes published in public data bases. Some published anchor markers mapped to the chromosome XI were also investigated. PCR reactions were optimized on he machine Eppendorf 384, received bands were separated in 1,5 % agarose gel, stained with ethidium-bromide. Results were documented with GeneGenius. The range and distance of the received bands were defined by the programs TetraploidMap and JoinMap.

Based on the artificial infection tests, the ratio of resistant and susceptible genotypes was found to be 1:1. This proves that the examined resistance gene R 5 is in one copy in White Lady. However the results refer that beside to the gene R 5 some minor genes plays role in the resistance reaction too.

Up to now by using the five above mentioned markering techniques we could identify 100 polymorphic band in White Lady and 129 in line S440. These bands were matched on the linkage map. Till now during the analysis we have got 18 linkage groups in White Lady and 12 in S440. Based on our available results the R 5 resistance gene is neither in linkage to specific markers to chromosome XI, nor to markers linked to resistance gene R 3.

This work was financed by the Hungarian research grant OTKA K 76485.

85

Distribution, detection and genetic variability of Potato mop-top virus

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Potato mop-top virus (PMTV, genus *Pomovirus*) induces necrotic spraing symptoms in potato tubers and causes severe quality problems in potato production in the Nordic countries. However, occurrence of PMTV in other countries in the Baltic Sea region has not been known. Therefore, a joint research programme (MOP-TOP, 2005-2008) was carried out to study distribution of PMTV in the Baltic Sea region and to consider methods and practices which could prevent PMTV from spreading to new areas. In Finland, long-term field trials revealed a high incidence of symptomless PMTV infections in many potato cultivars emphasizing the insufficiency of visual inspections in PMTV detection. Surveys using harmonized virus-specific detection procedures revealed that the non-Nordic countries of Baltic Sea region are mainly free of PMTV whereas the potato growing areas of the Nordic countries are widely contaminated.
Genetic variability of PMTV in Finland was also studied and two distinguishable types of RNA2 and RNA3 were detected, each showing only little genetic variability. Sequencing and restrictotype analysis of PCR amplicons from tubers indicated that the majority of PMTV isolates comprised RNA2-II and RNA3-B. However, a few tubers were infected with both types of RNA2 (I and II) and one type of RNA3, one type of RNA2 and both types of RNA3 (A and B), or both types of both RNAs. No specific type of RNA2 or RNA3 or their combination was associated with tuber symptoms or lack of symptoms. PMTV could be detected also in sprouts of tubers, but not potato shoots and leaves.

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86

Potato variety identification using SSR in France and Switzerland

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Six years ago, we published a set of 5 SSR markers usable to identify 286 potato varieties (Moisan-Thiéry et al., 2005). The database has been increased and now more than 500 potato varieties have been genotyped. In 2010 a ring test was organized by the GNIS SOC. It included for the first time a laboratory from Switzerland and an additional French site was also included increasing the total number of participants to six.
Samples of 5 tubers for 10 varieties were collected in the reference potato collection *i.e.* nucleus stock for micropropagation and seed potato inspection by an official inspector in July 2010. Eight samples were coded and sent to each laboratory with the aim to identify the varieties using the common set of markers. However, participants had the possibility to use additional markers and the system of revelation of their choice. Before the ring test, comparison of results obtained in Switzerland on a sequencing system and in France on silver staining system on the same markers showed that most of the allelic profiles were comparable in both systems.
Three laboratories identified precisely the 8 varieties received. One laboratory identified 7 of the samples but proposed 2 varieties for one sample. One laboratory identified 7 of the samples and the remaining one was unknown. The last laboratory identified 6 varieties and 2 samples remained unknown.
None of the samples were misidentified. The lack of identification was due to the absence of the reference profiles in the database of the labs concerned. These results reinforce the need of a common database shared by the users and updated regularly. The development of an informatics tool is in progress in France in a project partly funded by the French Ministry of Agriculture and led by the FN3PT. In addition, the set of markers is currently updated and we plan to make the experiments necessary to fit the French standard AFNOR V03-45 which international extension is currently under discussion.

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87

Tyrosine phosphorylation of PMTV TGBp3 is essential for virus cell-to-cell movement

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Potato mop-top virus (PMTV, genus *Pomovirus*) induces necrotic spraing symptoms in potato tubers, which constitutes an important quality problem in potato production in the Nordic countries. Although some potato cultivars develop symptoms at low propensity, no cultivar grown in Nordic countries is highly resistant to PMTV. Also, the lack of appropriate breeding material prevents breeding for PMTV resistance. More profound understanding of the PMTV infection mechanisms may assist in identificating potential sources of resistance.
To cause symptoms in a plant, virus needs to move from the initially infected cell to adjacent cells and other parts of the plant. For PMTV, however, it is sufficient to spread inside a potato tuber. PMTV encodes three movement associated proteins from an overlapping triple gene block (TGB). Previously it has been shown that PMTV TGBp3 enables TGBp2 assisted movement of TGBp1-viral RNA complex to and through plasmodesmata into neighbouring cells. In our study we found that TGBp3 is tyrosine-phosphorylated by plant protein kinase activity. First, we utilized a bioinformatic approach to map the potentially phosphorylated tyrosine residues in TGBp3. Tyrosine phosphorylation of TGBp3 was totally lost when the two sites predicted for tyrosine phosphorylation were substituted by site-directed mutagenesis. Secondly, PMTV mutants containing substitutions in one or both of these tyrosine phosphorylation sites were not able to infect plants systemically. More detailed analysis revealed that substitution in one of the phosphorylation sites rendered the virus uninfectious. Substitution in the other site restricted the virus infection to single cells, i.e. inhibited cell-to-cell movement. Yeast two hybrid assay indicated that the TGBp3 mutation inhibiting cell-to-cell movement of PMTV enhanced interaction between TGBp3 and TGBp2. We propose that tyrosine phosphorylation of PMTV TGBp3 regulates the virus cell-to-cell movement possibly via control of the interactions with TGBp2. In the future, recognition of the plant kinase responsible for this phosphorylation can provide new strategies for breeders to develop PMTV resistant potato cultivars.

88

A Quantitative Trait Loci (QTL) Study of Maturity-Corrected Resistance to Late Blight [Phytophthora infestans (Mont.) de Bary] in Tetraploid Potato (Solanum tuberosum L.)

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Breeding for durable resistance against *Phytophthora infestans* (Mont.) de Bary is difficult because of the high versatility and aggressiveness of this polycyclic pathogen and strong association between race-non-specific resistance and late foliage maturity. There are a high number of QTL for quantitative late-blight resistance in mostly diploid populations, which originated from crosses between S. *tuberosum* and wild *Solanum* species. QTL are repeatedly detected on chromosomes III, IV, V, and VI (Bradshaw et al. 2004).
A QTL study of the resistance to foliage blight was performed on a tetraploid mapping population taking into account the maturity of the individual clones. A full-sib population of 302 tetraploid clones derived from a cross between the tetraploid blight-resistant breeding clone GL-93.7015.04 of the JKI pre-breeding programme with the susceptible potato cultivar Delikat was used in this study. Phenotyping of these clones was done by reading the percent of the leaf area infested with *P. infestans* in field trials over a period of three years. The fields were not treated with fungicides and there were two replications at one location in each year. Artificial inoculation ensured a high repeatability. An experiment treated with fungicides was run in parallel to determine time of maturity of each clone. To eliminate the influence of maturity a maturity-corrected resistance parameter was calculated and used as phenotypic trait in the QTL-study. For genotyping SSR-, AFLP-, SCAR- and CAPS-markers were used. A single-allele test was applied using the Mann-Whitney test. AFLP genotyping was done using eight primer combinations yielding 58 informative markers. A preliminary grouping of the markers was done using cluster analysis in R with (1-r) as the distance measure and “average linkage” as the clustering method. Using the software TetraploidMap (Hackett & Luo 2003) two QTL for maturity-corrected resistance to foliage blight were mapped on linkage groups IV and XI, respectively. The sequences of these markers are available for use in potato breeding programmes.

This project was funded by the InnoNet programme of the German Ministry of Economics and Technology (BMWi).

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89

Utilization of resistance genes in potato breeding in Slovenia

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It has been a long tradition of potato breeding at the Agricultural Institute of Slovenia. First varieties were approved in 1962 and became leading varieties in Slovenia. Most of them have been destroyed by Potato virus Y^{NTN} strain at the end of previous century. A new potato breeding programme started in 1993, when first crossings for new to Potato virus Y resistant varieties were made. Mass selection against potato virus Y was performed after artificial inoculation at the seedling stage, which was followed by selection for important qualitative and quantitative traits in next 10 field generations. Extreme resistance against potato virus Y was successfully introduced in all new potato varieties. Resistances to Potato leafroll virus, potato wart (*Synchytrium endobioticum* (Schilberszky) Percival – pathotype D1, to two species of potato cyst nematodes (*Globodera rostochiensis* – pathotypes Ro1-Ro5 and *Globodera pallida* – pathotypes Pa2, Pa3) have been introduced in some varieties. *R* genes resistant to late blight on leaves originated from *Solanum demissum* have been successfully introduced in the programme since 1998 with two new resistant varieties. *R* gene from *Solanum bulbocastanum* has been introduced into breeding programme in 2008. So far six new varieties Pšata, Bistra, KIS Sora, KIS Mirna, KIS Kokra and KIS Sotla had been bred since. Pšata is early maincrop variety with high yield and numerous medium sized creamy fleshed tubers and excellent consumption quality. Bistra is late high yielding variety with numerous white flesh tubers for boiling and baking, suitable for organic production. KIS Sora is excellent multipurpose salad type high yielding late variety with medium sized creamy flesh tubers suitable for cold storages. KIS Mirna is early maincrop white flesh variety suitable for light sandy soils. KIS Kokra is early maincrop variety with light yellow flesh, resistant to late blight on leaves, suitable for organic production. KIS Sotla is excellent maincrop variety for deep fertile soils. We expect three new varieties in next three years, one of them tolerant to drought stress.

90

Characterization of Somatic Hybrids between Solanum Species S. tarnii and Cultivated Potato and their BC Progenies using Molecular Markers and Genomic in situ Hybridization (GISH)

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Selected somatic hybrids between Genebank-accession GLKS 32870 of *Solanum* species of the series *Pinnatisecta* (genome BB): *Solanum tarnii* Hawkes et Hjerting and a commercial cultivar Delikat were successfully backcrossed with cultivated potato. Parental clones, somatic hybrids and selected genotypes of the BC_1-BC_3 progenies were analyzed using molecular markers and GISH. Using 164 chromosome-specific SSR, STS- and CAPS markers the transmission of chromosomes of the wild species *S. tarnii*, into backcross generations was analyzed. As a result 32 chromosome specific markers (19 nSSRs and 13 SCAR) were selected which revealed polymorphism between the corresponding chromosomal segments of parental lines of the cultivars Delikat, Sonate and *S. tarnii*. The chromosomal constitution of 84 BC_2 hybrids was analyzed using selected DNA markers. From 2 to 11 alien chromosome-specific fragments of *S. tarnii* were detected in BC_2 clones. Most of the BC_2 clones (>60 %) had 5-7 alien chromosomes from *S. tarnii*. Recently, 86 BC_3 clones are analyzed using eight informative markers.
The GISH- analysis revealed that a number of selected fertile somatic hybrids *S. tarnii* (+) cv. Delikat had the expected genome composition (AAAABB) of 48 chromosomes of the cultivar and 24 of the wild species. Correspondingly the BC_1 clones, derived from the crosses between hexaploid somatic hybrids and tetraploid potato cultivars (AAAA) had the expected 5x ploidy level, confirmed by flow cytometry, and the expected genome composition, confirmed by GISH, with 48 chromosomes of potato and 12 of *S. tarnii* (AAAAB). Three BC_2 clones, which originated from crossing a pentaploid BC_1 clone with a potato cultivar had 48 potato chromosomes and 2-5 alien chromosomes of *S. tarnii*.
The organelle DNA composition of 52 somatic hybrids of *S. tarnii* (+) cv. Delikat was analyzed using PCR amplification of specific regions of chloroplast and mitochondrial genomes. The cytoplasmic genomes of 50 hybrids had a novel genetic configuration. Thirty of the *S. tarnii* (+) cv. Delikat hybrids inherited the chloroplast DNA of cultivated potato and 20 had plastids of *S. tarnii*. In two somatic hybrids chloroplast DNA from both parental species were identified. Forty seven of the hybrids had mixed parental mitochondria and five inherited the mitochondrial DNA of the wild species. These results demonstrate the compatibility of mitochondrial and chloroplast genomes of different *Solanum* species and the absence of nuclear-cytoplasmic incompatibility in interspecific somatic potato hybrids.

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91

Development of a genetic map from a potato dihaploid population to study the relationships between late blight resistance genes and plant architectural genes

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Plant architecture and plant dynamics of growth are important factors affecting pathogen development in the case of aerial diseases. Concerning potato, several studies showed that plant or canopy architecture had strong effects on the development of foliar late blight disease. Indeed, levels of partial resistance are significantly and positively correlated with plant maturity. This association results from the colocalization of resistance and lateness QTLs (Visker et al 2005, Euphytica, 143, 189-199). The understanding of the relationship between partial resistance and plant growth is therefore an important issue to orientate the construction of resistant ideotypes. The UMR APBV team is involved in a project named ARCHIDEMIO, funded by ANR Systerra, which aims at identifying the relative part of intrinsic resistance, architectural traits and growth characteristics in the late blight partial resistance in order to combine genetic resistance components with favorable architectural alleles in ideotypes.
A dihaploid population including 251 genotypes was obtained by crossing a tetraploid late blight resistant genotype 92T.118.5 with the parthenogenesis inductor *S. phureja* IVP48. The resistant parent combines monogenic and partial resistance. The evaluation of the progeny for late blight resistance in field conditions and for different architectural traits (plant height, leaf number, foliage coverage, length/width ratio of the leaflets, leaflet number, stem number) showed that these traits are segregating in the population. This population will be used to determine, among the genetic components that are involved in late blight resistance, those which result from intrinsic resistance only and those which colocalize with maturity and/or plant architectural QTLs.
Therefore, a genetic map of the tetraploid resistant parent is being constructed by using SSR markers. A set of 90 SSR markers, evenly distributed in the potato genome, is first being tested in order to select the markers that show more than 2 different alleles in the tetraploid parent and that segregate in the dihaploid population. The results of this polymorphism test and the first results of the genetic map will be presented in this poster.

92

Distinct resistance profiles against Phytophthora infestans in potato transformed with the RB gene from Solanum bulbocastanum.

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The late blight pathogen *P. infestans* continues to be the major biotic constraint in potato production worldwide. Current strategies to control this devastating disease include stacking of broad spectrum resistance genes isolated from wild potato relatives through transgenesis. At CIP the *RB, Rpi-Blb2* and the *Rpi-vnt1* gene are being considered for stacking to generate durable resistance in potato. To be able to predict durability of a gene stack, it is essential to understand the spectrum and level of resistance provided by each individual gene to the different *P. infestans* isolates present in a given environment. The current study examined the response of eight transgenic potato lines containing the *RB* gene to five *P. infestans* isolates from Peru. Results showed that all lines were fully susceptible to an isolate originally collected from a somatic hybrid of *S. bulbocastanum* and *S. tuberosum*, indicating resistance breaking isolates of *P. infestans* are present in Peru. Lines ranged from fully susceptible to fully resistant to the remaining isolates, but unexpectedly exhibited different resistance spectra against different isolates. Resistance was correlated to the level of gene expression prior to infection as well as the level of induction of gene expression after inoculation. Results of screening for the RB effector in *P. infestans* isolates used in the challenge as well as other isolates from Peru are also presented.

93

Diploid potato hybrids as sources of tolerance to blackspot bruising.

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The purpose of our study was to determine tolerance to blackspot bruise of chosen 31 interspecific diploid hybrids and 10 potato cultivars. Diploid clones possess different leading traits: usefulness for direct consumption, usefulness for chip processing, high starch content, resistance to soft rot and to late blight. Among cultivars seven were table and three starch forms. The tolerance level to blackspot bruise was evaluated in two consecutive years 2009-2010, using method according to Domanski et al. (2007). Bruising tests were performed in mid February in two replications, on 10 tubers tested. Before evaluation tubers were stored by 5 months at 5- 10 °C and then incubated for 12h at 11°C . Blackspot bruise reaction in tubers was induced by impacts in hexagon plywood drum followed by incubation of tubers at 20ºC for 72 hours. Evaluation of blackspot bruises was performed directly after peeling of tubers. The mean surface of blackspot bruises was evaluated for each tuber separately (scale 1-9, where 1= 80% surface of tuber covered by bruises, 9 tubers without bruises). Additionally, starch content was determined by underwater weight according Lunden (1956).
Variability of blackspot bruise reaction among diploid clones and cultivars was observed . Diploid clones and cultivars useful for direct consumption were high resistant to blackspot bruise. The most susceptible were diploid clones and cultivars with high starch content and diploids resistant to late blight.
Analysis of variance (ANOVA) of 41 genotypes showed significant effect of genotypes, years and interaction between this factors on blackspot bruising resistance. Genotypes had the largest influence on resistance to bruising, explaining 84.85% of variance (α= 0.05). The effect of years was weak, but significant (1.39%). Interaction between genotypes and years was significant and explained next 12.75% of variance. Broad-sense heritability was determined as moderately high (H_b= 0.74).
The reproducibility of the tests between years and the relationships between blackspot bruise and starch content were evaluated by linear Pearson's correlation coefficients. The mean blackspot bruise resistance was significantly correlated between two years of testing. Correlation coefficients at $p< 0.05$ were: r= 0.74 for all 41 genotypes; r= 0.73 for 31 diploid clones and, r= 0.85 for 10 cultivars. Significant correlations were also found between blackspot bruise resistance and starch content: in 2009 r= -0.53 ($p< 0.05$) and 2010 r= -0.79 ($p< 0.05$).
In addition the content of phenolic compounds in tested tubers before and after treatment is analyzing.

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94

Genetic analysis of Rhizoctonia solani associated with black scurf and superficial blemishes on potato tubers in France

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As part of a survey on tuber superficial blemishes in different ecological areas in France , a large collection of isolates of *Rhizoctonia solani* has been characterized at the molecular level to understand phylogenetic interactions. 73 French isolates were compared to a sample of 31 isolates from other European and over-seas countries. Three phylogenetic trees were built up based on the sequences of the internal transcribed spacer (ITS) regions and on the gene tef-1α. Total DNA fingerprinting was established by amplified fragment length polymorphism (AFLP).

The determination of the anastomosis groups (AGs) of *R. solani* based on the sequencing of the ITS region showed 3 different groups: 60 isolates as AG 3, 8 as AG 2-1 and 5 as AG 5.
This grouping was confirmed by the sequencing of the gene tef-1α used for the first time in an analysis of the genetic diversity of *R. solani*. About 42 % of the ITS sequences and 73 % of the gene tef-1α sequences contained polymorphic sites where several nucleotides are possible, suggesting that the cells of *R. solani* isolates contain several copies of ITS and gene tef-1α within the same nucleus or between different nuclei. Phylogenetic trees showed a greater genetic diversity within AGs in tef-1α sequences than in ITS sequences.
The AFLP analyses showed an even greater diversity among the isolates demonstrating that the French population of *R. solani* isolated from potatoes were not clonaly structured. Moreover, there was no relationship between the geographical origins of the isolates nor with the potato cultivar from which they were isolated and their genetic diversity.

Though the *R. solani* isolates were not previously characterized biologically, the sequence analysis of the rDNA-ITS region gave a useful indication of the AG's distribution within the studied population. Most of the 73 isolates were isolated from sclerotia potentially belonging to AG 3, that correlates with the majority (86 %) of AG 3 identified by the ITS analysis. This observed contribution confirmed previous data for the other AG 2-1 (11 %) and AG 5 (4 %),.
The important and under evaluated genetic diversity within the potato's AGs and the lack of population structure suggest potential genetic recombination associated with clonality leading to a constant evolution within *R. solani*. This may contribute to the understanding of superficial blemishes and the improvement of measures in order to control the pathogen successfully from seed tuber planting to harvest of the newly formed tubers.

95

Potato (Solanum tuberosum L) genetic resources – essential source of genotypical diversity for breeding of innovative potato varieties

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The crop varieties, containing appropriate amount of essential for health substances, are important source for healthy food. Potato is one of the crops which contains a number of substantial vitamins which are essential for human's health
Objective of the study is maintenance and evaluation of genetic diversity in Latvia potato genetic resources with aim to select parent genotypes for breeding varieties with elevated content of important vitamins.
Latvia potato genetic resources consists of varieties bred in Latvia by breeders, local varieties – genotypes with unknown origin introduced in Latvia by growers and breeding clones outstanding by specific traits. Collection of local genetic resources has been maintained at State Priekuli Plant Breeding Institute both in field (ex situ) and in in vitro collections. Latvia potato genetic resources consist of 82 accessions in field collection with duplicates in in vitro.
Maintenance in field collection is managed according to methodology worked out for evaluation, description and conservation of Latvian potato genetic resources. Annually the collection is planted in plots with the size of 4.2 m2, 16 tubers of each accession are planted per plot. After harvesting 70 tubers are used for further tests and for storing until the next season.
The method of in vitro conservation of potato germplasm determines maintenance of each accession as a shoot cultures in 4 duplicates. This method is known as a very reproducible of conserving a genetically stable germplasm collection. In vitro collection has been maintained in a growth chamber at + 200 C with a photoperiod 16h/8h and subcultered every two months.
59 potato accessions were evaluated and described using 80 descriptors worked out on 2006 on base of UPOV and IBPGR descriptors.
During the description of Latvia potato genetic resources (2007-2009) besides genotypes characterization, determination of vitamin content as an important trait has been done. 39 accessions were tested for ascorbic acid (vitamin C) content on 2007-2009 and there were carried out tests for thiamine (vitamin B1) and riboflavin (vitamin B2) content on 2007-2008. Differences among genotypes were found and average ratio ranged as follows:
Vitamin C from 12.64 to 34.90 mg 100 g-1
Vitamin B1 from 0.09 to 0.22 mg 100 g-1
Vitamin B2 from 0.04 to 0.15 mg 100 g-1
Higher vitamin content is essential for selection of parent genotypes for breeding.

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96

In silico integration of genetic, physical and sequence maps in potato using BAC sequence tags

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Whole Genome Profiling (WGP) is a recently developed novel approach for BAC library skim sequencing, which can be used for de novo physical map construction of genomes and whole genome sequence scaffolding (1, 2). We have applied WGP to 86016 BAC clones of the diploid potato genotype RH89-039-16 (RH), and we report on a novel application of these short (26 bp) sequence tags in genomics research. BLAST alignments with WGP tags from RH physical map BAC contigs against a pre-release of the Solanum phureja 'DM' genome sequence (Beijing Genomics Institute, Shenzhen, China) allowed a full integration of the RH physical and genetic maps with the available DM sequence and genetic maps. As such, approximately 1300 AFLP^{TM} markers from genotype RH could be transferred to the DM genome, without the need for additional marker sequencing or progeny genotyping. In reverse, previously unanchored RH physical map BAC contigs can now be assigned to chromosome locations, from their WGP alignments to the DM genome. These two integrated potato genomes form a firm basis for future fundamental and applied research in potato.

(1) Van Oeveren et al. (2011) Sequence-based physical mapping of complex genomes by whole genome profiling. Genome Research 21:618-625.
(2) http://www.keygene.com/services/services_molecular_WGP.php

97

Organ specification and transcriptional control of metabolic routes revealed by expression profiling of source – sink tissues in a segregating potato population.

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With the completion of genome sequences belonging to some of the major crop plants, new challenges arise to utilize this data for crop improvement and increase food security. Here we describe the identification of expression QTLs (eQTLs) in a segregating potato population and query the genome sequence to differentiate between cis- and trans-acting QTLs and source-sink tissue relationships. Potato is a highly heterozygous outbreeder, posing difficulties in standard QTL analysis. We have implemented a modified version of the *R/qtl* program, to allow high-throughput QTL analysis suitable for outcrossing species. Both leaf and tuber samples were included and screened for conserved and tissue dependent QTLs. Overlapping QTLs present in both tissues are predominantly cis-acting whilst for tissue specific QTLs, the percentage of trans-acting QTLs increases. Identification of regulatory networks based on differential expression unique to either source or sink tissues reveals candidate genes which can be targeted for future haplotyping and development of genetic markers.

98

Understanding the genetical basis of developmental traits in potato using multi-environment field trials

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Genotype and QTL by environment interactions play an important role in the expression of complex traits involved in plant development under field conditions.
The use of QTL mapping strategies taking into account environmental factors, helps to understand the genetical basis of developmental processes which occur during the growing season. In this study, developmental traits such as flowering, haulm senescence and plant height were evaluated under different day length regimes using ~200 genotypes from a diploid backcross potato population. The field experiments were carried out under short (Ethiopia), long (The Netherlands) and very long (Finland) day-length conditions and the traits were evaluated in time series during the growing season to have a better understanding of potato development under contrasting environments. Temperature and photoperiod, two of the main environmental factors controlling plant development, were used to transform the time axis from days after planting into photo-thermal units in each environment facilitating the comparability across locations. The phenotypic data were used in a smoothed generalized linear model previously described (Hurtado et al. 2011) to characterize the curve trajectory of flowering, senescence and plant height in terms of onset, progression rate, inflection point and end. These characteristics were used to study genotype by environment interactions at different development stages of the population and they were the input traits for a multi-environment QTL analysis enhancing the power of QTL detection. A multi-trait linkage analysis was also performed in each location to understand the genetic basis of trait correlations and co-location of QTLs when it was present.

Hurtado Lopez P, Schnabel S, Zaban A, Veteläinen M, Virtanen E, Eilers P, van Eeuwijk F, Visser RGF, Maliepaard C (2011) Dynamics of senescence-related QTL in Potato. Euphytica submitted.

99

Overcoming self-incompatibility and inbreeding depression in diploid potato enables an F1 hybrid breeding system

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Genetic gains cannot be fixed in potato due to obligatory out-breeding. Furthermore, clonal reproduction deprives breeders meiotic recombination events, and promotes the spread of diseases. Overcoming inbreeding depression using diploid self-compatible clones, should enable to replace the current method of out-breeding and clonal propagation into an F1 hybrid system with true seeds. This idea is not new, but has long been considered unrealistic. Severe inbreeding depression and self-incompatibility in diploid germplasm has hitherto blocked the development of inbred lines. Back-crossing with a homozygous progenitor with the *Sli* gene (Hosaka and Hanneman (1998) Euphytica 103:265-271), which inhibits gametophytic self-incompatibility (GSI), gave self-compatible offspring from elite material from our diploid breeding program. We demonstrate that homozygous fixation of donor alleles is possible, with simultaneous improvement of tuber shape and tuber size grading of the recipient inbred line. These results provide proof of principle for F1 hybrid potato breeding.

100

Nitrogenous and Phosphorus Fertilizer Requirement of Potato in the Conditions of Bafra and CarsambaPlains in Turkey

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Potato is used up quite a lot of in our country as in the world. Potato has a lot of carbohydrate. On the other hand starch and alcohol industry has been increasing gradually. Therefore the economic importance of potato has been increasing, too. Potato is grown up almost all over Turkey.
Up to now researches show that potato gives well answer to the fertilizer. Fertilizer can make increase the produce up to the certain level.
The research was carried out on Kizilirmak and Yesilirmak Delta. At the research area, Alluvial soil is medium level in organic matter content and it is less in the lime content ($CaCO_3$) and phosphorus content and it is well in potassium content and the reaction is neutral (pH=7.8) and drainage is in good condition.
The annual precipitation is about 700-800 mm and average temperature is 13-14^0 at Kizilirmak and Yesilirmak Delta. The first frost is in November and the last frost is in April. Various plants are planted on Bafra and Çarsamba plains.
The research was put into practice according to the Latin Square (4x4) test method. At the research, both phosphorus fertilizer level and nitrogenous fertilizer level have been determined as 0-7.5-15.0-22.50.
Potato wants good cultivated soil. At the end of the research, the total records were analysed with regression analysis method.
The nitrogenous fertilizer has influence upon the yield of potato as follows;

Kind of Potato	Suggested Fertilizer Dose	The Conjunction Between Fertilizer and The Crop
Sarikiz (Domestic)	16 kg/da N	$Y=956.7+10.32X-0.27^2$
Fina	22 kg/da N	$Y=1205.8+80.71X-1.79X^2$
Frigga	22 kg/da N	$Y=1306.9+66.31X-1.62X^2$

The following function shows that the conjunction between the Fertilizer and the yield of potato.

Kind of Potato	Suggested Fertilizer Dose	The Conjunction Between Fertilizer and The Crop
Sarikiz (Domestic)	19 kg/da P_2O_5	$Y=889.1+24.33X-0.67X^2$
Fina	17 kg/da P_2O_5	$Y=1342.5+66.47X-2.0X^2$
Frigga	16 kg/da P_2O_5	$Y=1407.1+52.77X-1.59X^2$

Above the suggested fertilizer doses increase the current yield high and provide the most economical yield.

101

Our Experiences on Promoting of Potato Foods

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In Estonia 20…25 years ago people ate potatoes 2 times more and the potato growing area was up to 6 times larger as it is nowadays. At the present, products from wheat and other corns have been more widely consumed. Children prefer to eat contrary to home made potato foods potato ships and French fries.
We have started to promote potato foods on fairs and in any other possible public get-togethers. We promote varieties suitable for usage for special dishes. For example for the baked potato most suitable are an old variety "Agrie Zeltanie" bred in Latvia, variety "Maret" bred in Estonia, a very old variety "Väike verev" and a land-race "Endla".
Commonly children do not like to eat potatoes, but well-prepared baked potatoes from selected varieties, are acceptable. Particularly the long potato slices, alike as French fries, are the most favourable. An interesting and approved fact is that a baked food prepared of many potato varieties, including "Blue Congo", carrots, celery, leek, zucchini, and others vegetables is well liked by many people.
In 2008, the Year of Potato, for promoting of potato the booklet "Potato - Nice, Good and Useful" was published. In the booklet researchers, children, politics and potato growers write about the potato. There are lot of pictures on potatoes and 'potato people'. We emphasise the usefulness of potato as human food and expostulations that eating potatoes can increase the body weight problems. Also, we have been promoting potato dishes and cooking with potato in TV and on radio programmes, in journals or special issues.
Such kind of activities has started affecting the potato eating habits and many young people have discovered the usefulness and diversity of potato. More and more people have started to prepare potato dishes at home and grow potatoes in their own gardens. In big supermarkets the choice of potato varieties is not so wide. Therefore potato plants in gardens are nice to look at and can offer interesting past time activities.
We suggest older people to pre-peel tubers for younger family members, who are working or students who also have no time for cooking homemade food. It is pleasant to take already peeled potatoes for boiling or baking from the freezer. Also, the games, how to plant and harvest tubers, are very popular.
The interest in varieties as the genetic resources and varieties with coloured flesh tubers is increasing. In our EVIKA test field we have been testing meristem clones of variety "Blue Congo" for more than 20 years. We have prepared and demonstrated the usage of that variety for making different salads, baked, boiled, mashed potatoes and even making French fries. At first people are afraid of the coloured flesh and think that some chemicals have been used, but after tasting they are pleased with the taste and are willing to use this variety in the future. Also, dark-yellow flesh potatoes are appreciated, both because of the colour and the possible source of the antioxidants. The varieties have been accepted as a part of functional diet.
Our results show that the promotion of usefulness of eating potatoes and disperse of potato foods are the keys for larger usage of potato as a healthy food source.

102

NIRS assisted breeding of root and tuber crops to improve carbohydrate profile

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Root and tuber crops provide a substantial part of the overall human nutrition worldwide. With respect to hidden malnutrition (a lack in vitamin and mineral supply in the diet) in developing countries, biofortified root and tuber crops may help improving health status when eaten at higher amounts. Today, available cultivars and clones are often not adapted to local climates and local disease pressure in developing countries.
The International Potato Center (CIP) has designed a worldwide quality analysis strategy: The near-infrared spectroscopy technique (NIRS) has been chosen to assist local breeding activities in developing countries in Africa, Latin America and it is also planned in Asia,). A NIRS network with master NIRS instrument at CIP's Quality and Nutrition Laboratory (https://research.cip.cgiar.org/confluence/display/cipqnl/Home) in Lima, Peru, serves so called satellite NIRS instruments at local breeding stations in 3 African countries (Uganda, Mozambique, Ghana). These satellite NIRS instruments have access to the NIRS models developed at CIP's Quality and Nutrition Laboratory and can apply this technique in their breeding progress.
In a project between CIP and Max Rubner-Institut (MRI), Detmold, Germany, a set of 480 freeze dried and milled root and tuber samples was analyzed according to starch and amylose content (energy and processing quality). Before the chemical reference analyses all 480 samples were scanned twice by NIRS at MRI and at CIP. Samples were grown on two different climate regions in Peru at least to include some environmental variation. All models developed were suitable to predict starch concentration and amylose proportion on a scanning level. Enlargement of the given data sets may still improve the accuracy of the prediction models.
Starch concentration in native potato samples was predictable with $R^2 = 0.90$. The same level was reached for modern potato cultivars ($R^2 = 0.90$). Sweetpotato samples ($R^2 = 0.96$) and yambeans ($R^2 = 0.97$) offered a wider range of individual values and, as a consequence, the prediction models were even better than the potato models. The same was to amylose, the most linear portion of starch with R^2 between 0.42 (native potatoes), 0.51 (modern potatoes), 0.83 (sweetpotatoes), and 0.88 (yambeans).
NIRS assisted breeding focused on starch and amylose is possible. CIP will include and maintain the new NIRS models in its NIRS network. One important application will be the non-sweet orange fleshed sweetpotato (high starch, high b-carotene, low sugars) for West African preferences.

103

Effects of ultrasonication on the processing quality of potato slices

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In order to meet the demand of the consumer, one of the most important considerations in the potato processing industry is the production of light-colored chips. Many studies have shown that the Maillard reaction is responsible for the color development of processed tubers. The reaction occurs between the aldehyde groups of reducing sugars and the free amino groups of amino acids which take place during frying. Moreover, the tendency of acrylamide formation, as a potential carcinogen, is determined also by the content of these components. Many attempts have been made to minimize the content of Maillard reaction contributors. Blanching, immersing in acid or NaCl solution and additional treatments before and during processing have been studied (Pedreschi et al. 2007, J. Food Eng. 79, 786-793; Pedreschi et al. 2010, Food Bioprocess Technol. 3, 917-921). Ultrasonication can be regarded as an alternative pre-treatment option due to its leaching effects. Leaching occurs by rapidly formed, grown and collapsed numerous tiny bubbles which generated by high frequency throughout the liquid (de Castro and Capote, 2007. Analytical Application of Ultrsound. Elsevier). The objective of the present research is to investigate the effects of ultrasonication, as a preliminary step for potato chips production, on the content of reducing sugars, sucrose and asparagine. Potato tubers cvs. Nicola (waxy), Laura (mainly waxy) and Golden Wonder (mealy) were used as raw material of chips production. The tubers were grown from April to September 2010 in the research field station of the University of Goettingen. Slices of 1.25 mm thickness were cut from the pith part of the tubers and rinsed immediately. Ultrasonication was applied at 35 kHz frequency at 25 and 50°C for 10, 20 and 30 minutes, respectively. The concentration of the reducing sugars fructose and glucose as well as of sucrose and asparagine of all slices were determined by HPLC. Our first results show that the effects of ultrasonication decreasing the content of reducing sugars depends probably on the initial content of these compounds in the tubers. Only in slices of cv. Laura the content of reducing sugars was decreased depending on the duration of treatment, whereas in cvs. Nicola and Golden Wonder no significant effects on the reducing sugars, sucrose and asparagine were found. In order to validate these findings, investigation of the ultrasonication effect needs to be studied on the stored tubers.

104

The transgene coding a key enzyme of glycolytic pathway helps to decrease the sugar content in potato tubers

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Cold-stored potato tubers gradually accumulate reducing sugars. One proposed reason for this phenomenon is a cold-induced blocking of glycolysis. This problem can be solved by introduction and expression of the bacterial gene *Lbpfk* coding for cold-tolerant phospho-fructokinase. The identical gene was introduced into four Czech potato cultivars and the transgenic plants were subjected to field trials. The data concerning the sugar content in cold-stored tubers minimally from two seasons were obtained for cultivars Kamýk, Vladan, and C70/2. The tubers were stored for four months and the analysis of reducing sugar content and frying colour of chips was performed three times during that period. The results differ for each transgenic line and also for different years of cultivation. The greatest differences in reducing sugar content between untransformed and transgenic plants were found for cultivar Vladan, where some transgenic lines retained the lowered amount of glucose and fructose for all three years. Transgenic lines of cultivar Kamýk, which contained roughly the same sugar level in nontransgenic tubers after the harvest, did not show such remarkable results in average, but some lines in initial field trials gave also substantially lower values in reducing sugar content. The transgenic lines from cultivar C70/2 were obtained as the last ones and the data from two seasons were evaluated. Although this cultivar has the sugar content lower than Kamýk and Vladan, the effect of transgenosis has not been as effective as in cultivar Vladan probably due to different genetic background. The sugar values were substantially higher for tubers from the second season in comparison to Vladan transgenic lines despite that some lines retained for both seasons low sugar content. Two out of sixteen lines showed after prolonged cold-storage and subsequent reconditioning in both seasons lower sugar levels than nontransgenic controls, whereas all Vladan transgenic lines but one retained in both seasons the lower values. Some transgenic lines derived from all three cultivars compared to the nontransgenic plants provided lighter coloured chips, too.

105

Effect of Steaming and Drying Conditions on the Quality of the Dehydrated Powder in Color-fleshed Potatoes

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Recently, "Hongyoung" and "Jayoung" potatoes that have the red or purple color in skin and flesh were developed in Korea. Generally, it has been well known that the color of skin and flesh is due to an accumulation of anthocyanin that exhibit many functional properties for human health. In our recent study, we could find that extracts of two color-fleshed potatoes showed the antimutagenic effect and cytotoxity to human cancer cell lines. As functional properties of color-fleshed potatoes are widely introduced to consumers, it will be considered that the demand for the processing to various food materials including powder increase. This study was carried out to investigate the effect of steaming and drying conditions on the quality of the powders in color-fleshed potatoes. Two color-fleshed and one white-fleshed of "Superior" were exmined and different steaming times before drying and three different drying methods such as freeze drying, room condition drying and hot air drying were treated. The quality factors such as anthocyanin content, moisture and hardness of powder were investigated. As a result of determining of Hunter"s value, powder color was well maintained after drying process by freeze drying for "Jayoung" and room condition drying for "Hongyoung". The freeze drying method also showed the highest content of anthocyanin in all cultivars as compared with other methods. The optimum hardness of powder was obtained in the steaming treatment for about 20 minuntes before drying for all cultivars. Based on these results, our findings suggest that powders obtained from color-fleshed potatoes are able to be used for functional food materials.

Key words: color-fleshed potato, anthocyanin, powder, functional

106

Effect of CIPC and S(+) Carvone on sprout inhibition and quality of potato tubers Turing storage

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A major component of managing potato quality in storage is effective sprout inhibition. Many chemical compounds are known to inhibit sprouting (Afek et al. 2000). CIPC is the most commonly used to provent sprouting of tubers in many countries. Ii has been known since 1969 that naturally occurring volatile substances like pule gone and carvone inhibit sprouting (Oosterhaven et al. 1995).
The aim of the experiment was to investigate reaction of three potato cultivars on CIPC and S (+) carvone during storage.
Material and methods
In 2009-2010 the potato tubers of cultivars Asterix, Gracja, Jelly were stored at 8^{o}C and treated CIPC and S (+) carvone. The essessement were carried out in four terms (January, February, April). Mass and length of sprout, reducing and total sugars, dry matter, colour of chips and crips on darkening of tuber flesh were determined.
Results
The sprout control of potato treatments of CIPC was very good. The potatoes were still suppressed of unloading time (April). The potates treated of S (+) carvone were suppressed like CIPC, only variety Asterix had small sprouts in April.
The dry matter content in potatoes increased during storage due to water losses (transpiration). Signifficantly highest positive effect was obtained in potato tubers treated with both sprout inhibitors.
Reducing and total sugar content was lower in all treated tubers comparing with stored at 8^{o}C without sprout inhibitors. No difference in darkening of tuber flesh was found between CIPC, S (+) carvone and control (8^{o}C).
CIPC treatment resulted lighter fry color than controls and S (+) carvone, but the differences were not signifficant.

Conclusion

Sprout inhibitor treatments (CIPC, S (+) carvone) affected the contents of dry matter, reducing and total sugars.
S (+) carvone and CIPC inhibited sprout growth during storage period (7 months).

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107

Polyphenol content and profile of 17 potato cultivars grown in Luxembourg

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Potato is known to be a good source of carbohydrates, proteins, dietary fiber, minerals, and vitamins, and also contains important amounts of polyphenols. *In vitro* studies indicate that polyphenols may reduce inflammation, cancer risk, cardiovascular diseases, and diabetes. In order to generate a greater awareness by the food industry and the consumer that potatoes can act as "functional food" due to their antioxidant compounds, more studies on the polyphenolic composition of potatoes have to be conducted (Camire *et al*. 2009, Crit. Rev. Food Sci. Nutr. 49, 823-840).
The polyphenolic profile of 17 potato cultivars (*Solanum tuberosum* L.) grown in Luxembourg was established by high-performance liquid chromatography coupled with tandem mass spectrometry (HPLC-MS/MS) and ultra-performance liquid chromatography coupled with a diode array detector (UPLC-DAD). In addition, the total phenolic content was determined by the Folin-Ciocalteau assay. For these purposes, the raw potato tubers were separated into three sections: skin (approx. 2 mm), outer flesh (approx. 1 cm), and inner flesh.
In all investigated cultivars, the content of the UPLC-quantified polyphenols (11 compounds) was decreasing from the skin via the outer flesh to the inner flesh. Differences in the total polyphenolic content between the cultivars were also observed. Cultivars with the highest polyphenol contents in the flesh were Vitelotte and Luminella, whereas Charlotte and Primura were those with the lowest contents. In contrast to these results, the Folin-Ciocalteau assay revealed no significant differences between the outer and the inner flesh of the potatoes, which indicates that the profile of the polyphenols changes between the sections but not the total amount. Total phenolic amounts in the flesh of yellow and white fleshed cultivars were between 0.38 □ 0.02 mg/g dry weight gallic acid equivalents (DW, GAE) (Lady Rosetta) and 1.68 □ 0.17 mg/g DW GAE (Ukama). The purple fleshed cultivar Vitelotte contained 5.40 □ 0.20 mg/g DW GAE.
Concerning the profile, 5-chlorogenic acid was the major polyphenol in potatoes. Additionally, phenolic acids (caffeic acid, ferulic acid, *p*-coumaric acid, and vanillic acid), the flavanol catechin, as well as the flavonols rutin and kaempferol-3-*O*-rutinoside were identified.
In conclusion, potatoes contribute to the daily intake of polyphenols and their consumption thereby may have positive effects on the human health.

108

Screening native potato genetic resources for health-promoting compounds

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Potato contains compounds with high bioactivity, most of them located in the tuber skin. Bioactive compounds enhance human health and can be useful components for food industry. Genetic resources of potato are rich, including more than 200 tuberizing species. The Native Potato Species (NPS) including *Solanum ajanhuiri*, *S. chaucha*, *S. juzepczukii*, *S. curtilobum*, *S. phureja*, *S. stenotomum*, *S. st.* ssp. *goniocalyx*, *S. tuberosum* ssp. *andigenum* and *S. tub.* ssp. *tuberosum* are consumed in the Andes of South America. In Europe, very few potato products are available made of species other than *S. tuberosum* ssp. *tuberosum*. The NPS materials are of intrinsic value because of their heterogeneous genetic background, which also offers plasticity under environmental changes. In addition, diversity of the traditionally grown materials offers new opportunities for development of novel products, which may have potential as special food products. The germplasm collections of VIR (N.I. Vavilov Institute of Plant Industry) represent the first botanic and scientific collection made of potatoes and include 8,680 accessions. It has tremendous practical importance, serving as the base for Russian potato breeding efforts. The NPS research material for the present study derived from VIR was represented by a recently developed subset of accessions, which was characterized by phenetic morphology analysis, chromosome number counts and nuclear SSR markers (Gavrilenko et al. 2010. Genet. Resour. Crop Evol. 57:1151-1164). Fifty-two accessions of *S. stenotomum*, *S. phureja*, *S. tuberosum* ssp. *andigenum* and *S. tuberosum* subsp. *tuberosum* were selected based on their skin and flesh colour and an ability to form tubers under the long-day conditions. Plants were grown in the Experimental Field of the Pushkin Research Station of VIR. Tubers from four plants per accession were harvested, pealed, and flesh and skin samples were separated, then sliced and pretreated by lyophilization. Bioactive compounds which are potentially health-promoting are under analyses. During the present project, the main activities will be carried out in terms of qualitative and quantitative analyses of glycoalkaloids, carotenoids, and phenolic acids. Also protein analyses including certain peptides will be made. Some genotypes of NPS collection may show inhibition of the angiotensin converting enzyme I (ACE), a biochemical factor which has an effect on hypertension. The project is financially supported by Tekes, MTT, University of Helsinki, and Finnish industry.

109

Potential for enhancing dietary fibres of potatoes through breeding

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Potato is an important staple food in the world. Its nutritive value is directly related to tuber dry matter which is, quantitatively, predominantly composed of carbohydrates. Improvement in nutritional value of carbohydrates can therefore have significant impact because of the high intake of potatoes in many diets. Carbohydrates-related characteristics of potatoes such as the glycemic index and dietary fibre have received increasing attention from nutritionists. Evidence from this and other studies suggest breeding potential for enhancing the carbohydrate profiles and nutritive value of potatoes. Evaluation of a wide range of germplasm grown in different locations across Canada highlighted genetic variability in advanced breeding clones for starch and dietary fibre profiles, as well as an influence of the environment. Some negative associations were noted between carbohydrates profiles and other traits of interest, as well as significant genotype x environment interactions. Improvement in carbohydrate characteristics of interest also requires rapid screening methods to practise selection over a number of vegetative generations for clones with desirable traits. We have demonstrated that near infrared spectroscopy (NIRS) can provide a rapid and cost-effective method for some dietary fibre components. Breeding offers tremendous potential for positioning potatoes as a significant source of dietary fibres and to improve its nutritional profile.

KEY WORDS: Potato fibre, carbohydrates, nutrition, breeding, genetics

110

Influence of cold storage on some chemical compounds in early potato tubers

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In several Mediterranean countries and in southern Italy as well, potatoes are not grown in the usual cycle (spring-summer) owing to the high temperatures and to the considerable demand for water, but are mainly grown in off-season cycles: winter-spring (planting from December to January and harvesting from March to early June) and summer-autumn (planting in early September and harvesting from November to the end of January) for early potato production. In early potato crops tubers are harvested before their complete ripening, presenting characteristics of "freshness", such as peel very thin and clear that can be removed easily and low dry matter content. Thanks to these characteristics, early potato tubers are mainly destined for fresh market. A suitable method of storage could extend their calendar of commercialization, with economical implications.
Different studies has been conducted on the effects of cold storage on potato tubers cropped in spring-summer crop, wherease researches about this topic are lacking for early potato tubers. The aim of this work was the evaluation of cold storage duration (0, 3, 6, 12 and 24 weeks at 4 ± 1 °C) on citric acid, ascorbic acid, total phenolic acids amounts and dry matter content in four genotypes (Arinda, Ditta, ISCI 4F88, Marabel) suitable for early production. Cold storage of early potato tubers resulted in a reduction of citric acid, ascorbic acid, total phenolic acids amounts and dry tuber weight, following different trends in relation to genotypes and duration of storage.

111

Crossing of potato (Solanum tuberosum l.) in Tajikistan

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Potato tubers as a valuable food product for most people in the world are considered “second bread”. Agricultural environment of mountainous areas of Tajikistan situated at an altitude of more than 1800 meters above sea level make it possible to grow good and quality harvest of potato. Under these cool mountainous conditions potato plants are of little affection, have intensive bloom and formation a lot of berries and botanic seeds.

We the pollen vitality was analyzed in July and August months. As a material for research 62 clones and varieties of potato that were given by the International Centre of Potato Investigation (CIP & CGIAR) in the network of plant gene pool investigation in the republics of Central Asia and the Caucasus were served.

Thus by means of the above methodology for the first time in our republic we have estimated pollen grain fertility of potato varieties and species. According to our researches pollen grain fertility of potato clones and grades in highland environment of our republic is genotypic ally specific. Most of the examined clones and grades have more than 80-97 per cent of fertile (vital) pollen grains. At the same time it is necessary to note that pollen grain fertility of some potato grades makes only 5-10 per cent. Among potato varieties cultivated in the mountainous area ?ardinal variety had the low per cent of fertile pollen grains – 26, 5%. The new perspective Dusti variety had the greatest per cent of those – 95, 2%.

We, also was crossing of different of potato varieties for obtaining first hybrids generation. As a result of crossings we was received 6 kg of hybrid berries, which seeds as necessary breeding materials for potato selection in the future.

112

Population characterization of Phytophthora infestans in Michigan during 2008 to 2010

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Isolates of *Phytophthora infestans* characterized as the new genotype US-22 collected from potatoes and tomatoes from 2008-10 in Michigan, USA differed in pathogenicity after cross-inoculation studies over the two crops and in other characteristics. The appearance of this new clonal lineage, which started in tomato plants was sudden and has displaced the US-8 clonal lineage in Michigan at least in potato crops. This study focused on the analysis of *P. infestans* isolates obtained during 2008 to 2010 in Michigan, and compared them to reference isolates. Characterization included mating type, GPI allelozymes, virulence, resistance to mefenoxam, mitochondrial DNA haplotype (mtDNA) and DNA fingerprinting based on simple sequence repeats (SSR). Most of the isolates were mating type A2, 100/122 GPI profile and Ia mtDNA haplotype. These characteristics were attributed to a new clonal lineage US-22, recently found in the US. Resistance to Mefenoxam (EC_{50}) ranged from <0.1 – 91 µg/mL, where most of the isolates were classified as intermediate. Race composition and tuber pathogenicity were also variable among isolates, but those obtained from tomato were less pathogenic in tubers than those obtained from potato. To further characterize the population, SSR were used and revealed different genotypes within the US-22 designation from isolates collected from tomato and potato. Despite the different virulence races observed, the genotypic diversity observed was low. The continuous tracking of changes within *P. infestans* population could yield evidence of genetic shifting due to introduction of new genotypes to the region or due to variability generated by management, environmental conditions and cultivars.

113

Comparative and phylogenetic study of the *Ditylenchus destructor* and *D. dipsaci* populations

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The Ditylenchus genus constitutes from about 80 nematode species with a very wide host species spectrum, including lower and higher plant species. Among them are potatoes, carrots, garlic, onion or chicory. The most serious nematode species are: *Ditylenchus dipsaci,* with the host range over 400 host species, that is on EPPO quarantine list, and hence it subject to control and limitation procedures, and *D. destructor* with over 70 host species, but potato is the main one. *D. destructor* is considered by EPPO as quarantine pest subject to control and eradication on potatoes and some plant's seeds. These nematodes are widely distributed, with the highest occurrence in temperate regions. However, data concerning their variability and the phylogeny is rather scarce and not very much of DNA sequences that can be used for comparative study are available in the databases. In our study we have gathered several populations of both *D. dispsaci* and *D. destructor* nematodes, infecting crops in Poland, and we have carried out the analyses of their rDNA sequences spanning both ITS1 and ITS2 regions. DNA sequencing results obtained for Polish populations were compared with those from populations belonging to the those isolated in other European as well as Asiatic and American countries, that are deposited in the GenBank database. The results indicate that there is not a clear distinction between European and non-European populations of both *Ditylenchus* species. Some of the European populations, including Polish ones are grouped together with other European populations, but there are also some that are clustered together with populations of studied *Ditylenchus* species of USA or Chinese origin.

114

Determination of classification parameters of potatoes by using image processing and artificial neural networks

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Quality is one of the important factors in the marketing of agricultural products. Grading machines have a great importance in quality control systems. The most efficient method in the present grading machines is image processing. In this study, the classification of potatoes in terms of size by using image processing techniques and artificial neural network was aimed. Before the classification process, potatoes that have malformation and deformation in the outer surface were detected by using Otsu method and morphological processes. These potatoes were kept outside the classification. Later on, potatoes without any anomaly were classified in terms of their sizes. The system was trained with pictures of small, middle and large-sized potatoes by using multi-layered artificial neural networks. In this study, Matlab software was used for the use of image processing and artificial neural networks. By using image processing techniques and artificial neural networks, classification accomplishments of potatoes were studies.

Keywords: Artificial neural networks, image processing, potato grading, defects detection

115

HIP2, a potato microtubule (+)-end-associated protein interacting with potyviral HCpro

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Plant microtubulus (MT) cytoskeleton exists as a self-organizing array beneath plasma membrane in interphase (non-dividing) cells. Functions of this cortical array involve guiding synthesis of cell wall, which restricts and directs elongation of cells and plant organs. MT array is subject to sudden changes of dynamic nature, responding to external stresses. Several viruses have interactions with MTs or microtubule-associated proteins, but the meaning of these interactions is not well known for plant pathogenic viruses. For example, some viral movement proteins that are able to open plasmodesmata for virus cell-to-cell movement in plant tissues, localize to MTs.
Potato virus A (PVA) belongs to the genus *Potyvirus* (family *Potyviridae*), the largest group of plant viruses, and causes significant yield losses in potato. PVA is used as a model RNA-virus for studies on potyvirus-host interactions. A multifunctional potyviral protein, Helper-component proteinase (HCpro) is important for virus transmission to plants, replication, movement within the host plants, and suppression of the fundamental antiviral defence system, RNA silencing.
HCpro from PVA interacts with a potato protein HIP2 (Guo et al. 2003, MPMI 16, 405-410). A homolog of potato HIP2 in *Arabidopsis thaliana,* TOR1/SPR2, is a microtubulus (+)-end-associated protein necessary for cortical microtubule array dynamics in directional (=anisotropic) cell expansion (Yao et al. 2008, J Cell Sci 121, 2372-2381). The aim of this study is to characterize potato HIP2 and reveal the putative biological significance of the HCpro-HIP2 interaction in infected plants.
Potato HIP2 expressed under native SPR2-promoter complemented twisting phenotype of *Arabidopsis spr2*-mutant in transgenic plants, suggesting a functional homology between HIP2 and SPR2. Transiently expressed HIP2 tagged with red fluorescence protein localized to GFP-marked MTs *in planta*. In yeast two-hybrid system (YTHS) and bi-molecular fluorescence complementation (BiFC) analyses, HIP2 interacted with HCpro in yeast and plant cells, respectively. Importantly, the interaction took place during PVA-infection in leaves and aligned to cortical MTs. Within HCpro, the domain required for HIP2-interaction in YTHS was mapped to an area of 30 amino acids. Mutagenesis of the virus at the putative HIP2-interaction domain reduced virus accumulation in systemically infected leaves of potato. These data suggest that the microtubulus-interaction by HCpro might be beneficial for PVA.

116

Changes in growth after exposure to drought-induced on potato cultivars with polyethylene glycol

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In a world faced with climate shocks, energy and food crisis, potato remains a major growing culture for tuberization and on following decade is expected to be a solution for global food security. Water deficit reduced leaf number, plant height, tubers number, and affects final production. Tissue culture is an alternative for studding the plant tolerance mechanism to water stress *in vitro*. Polyethylene glycol is used to simulate plantlets stress *in vitro* and thus, were initiated researches concerning PEG"s influence on *in vitro* plantlets. The researches were performed on vitro-plants, belonging to Christian and Roclas varieties, for studying their tolerance to water stress. The experience was bi-factorial, type axb (2x5) with 10 variants, **a**-variety with two graduations, **b**-medium with 5 graduations. The researches were made both on a single layer of polyethylene glycol, and dual-layer (lower layer:MS and PEG, and the top layer:MS). For vessels with double layer, the second type of medium was added after solidification of the lower layer. There were used two concentrations of PEG (0006M;0012M). The influence of medium with different PEG concentrations upon the plantlets height and number of leaves/plantlets was dissimilar for these cultivars. On 4 tested mediums plantlets growing was inhibited, compared with control medium. On control medium, plantlets without PEG, had an average height of 12.53cm Christian and 10.33cm Roclas. Variant with MS basic medium and 0.012M PEG concentration, inhibited plant growth, plantlets from Roclas having 1.53cm comparative with 2.27cm to Christian variety. Variant with double layer (MS and 0.006MPEG+MS) have best results on plants height (Christian4.43cm, Roclas 4.27cm).On the case of Christian variety, the medium without PEG, determined 15.27 average number of leaves/plantlet, the lowest number was on 0.012MPEG variant with 2.27 average numbers.The highest number of leaves/plantlets, depending on PEG concentration and substrate type occurs in variant with double layer (average 0.006MPEG+ MS and MS), with values between 8.33-6.47 leaves/plantlets, with negative significant differences, statistically assured, given to control variant, with-6.94 and-6.93 leaves/plantlets (Christian,Roclas). Potato plantlets from Christian and Roclas varieties grown *in vitro*, (culture medium containing PEG on different proportions) in order to simulate water stress, showed plantlets and leaf formation growth inhibition given to control variant (MS medium without PEG), providing clews for selection the best varieties in drought conditions.

117

Towards the on-line estimation of dry matter and starch content of whole unpeeled potato tubers using NIR interactance

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Variation in raw material quality is a huge challenge for the potato industry, and a load of potato tubers is notoriously heterogeneous. For industrial processing, different raw material qualities should ideally be processed using different operation settings in order to obtain optimal product quality. Today, however, the raw material quality is only partly controlled and not always systematically monitored prior to processing, causing higher waste ratios and lower product qualities. Parameters such as the dry matter and starch content constitute two major characteristics of raw potato quality. Industrial evaluation of these parameters often comprises under-water weighing, which is only measuring a small part of the total volume of potato tubers. This introduces a source of error that can be costly for the producer and the farmer, since the payment is calculated on a dry matter basis. Near-Infrared spectroscopy (NIR) has previously been presented as a potential approach for estimation of dry matter and starch contents in rather homogeneous samples of potato mash and potato slices. Novel technology based on NIR interactance, on the other hand, allows increased sampling volumes enabling the use of NIR for measuring quality parameters in whole and intact potato tubers. In this study, thus, the feasibility of using NIR interactance for estimation of dry matter and starch content in whole unpeeled potato tubers was investigated. Sound and robust calibrations for dry matter using the NIR data were obtained, and the calibration performance exceeded results obtained using the under-water weighing approach. The NIR calibration for starch content, on the other hand, only showed modest results. This might likely be related to the low spectral resolution of the present NIR interactance system. The NIR interactance approach is a feasible tool for rapid estimation of dry matter in whole potato tubers. The measurements are rapid (spectral acquisition takes less than one second), and the instrumentation have capabilities for on-line monitoring.

118

Production of minitubers (prebasic material) using industrial substrates

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Industrial substrates offers an excellent alternative to reduce tuber contamination risk with soil pathogens and to eliminate the necessity of using chemical disinfectants, dangerous for human health and environment. It offers also opportunities for minituber production with higher quality. In this system were tested Ostara, Christian, Roclas varieties, comparatively with conventional technology for protected area (soil), using *in vitro* plantlets.The main objectives was to answer to the following questions:- which is the best culture substrate for highest number of minitubers? - what is the influence of substrate type and variety upon the number and size of minitubers? Using industrial substrates (expanded clay and perlite) we found positive influence upon the number of minitubers/plant, comparatively with classical crop in greenhouse, on the soil. A large number of minitubers/plant was obtained on expanded clay substrate (with an average of 7.60 minitubers/plant), followed by perlite substrate (7.03 mini-tubers/plant) comparatively with 5.13 mini-tubers/plant on soil substrate. The number of minitubers produced from each variety and substrate was: Ostara: 6.66 minitubers/plant on expanded clay, 6.35 minitubers/plant on perlite and 3.92 minitubers/plant on soil. Christian variety: 7.31 minitubers/plant on expanded clay, 8.29 minitubers on perlite and 6.20 minitubers on soil. Roclas: variety: 8.82 minitubers for expanded clay (maximum mean /variety /substrate); 6.45 minitubers on perlite and 5.16 minitubers on soil. Data concerning the number of minitubers produced per plant, calibration class, variety and substrate shows that most of minitubers belongs to 15-25 mm fraction. On this class, Ostara variety has 3.75 minitubers/plant on expanded clay, Christian 4.69 minitubers on perlit and Roclas 4.38 minitubers on clay. On the class 25-35 mm: Ostara has an average number of 2.79 mini-tubers/plant on expanded clay, Christian 1.60 minitubers on perlit, and Roclas 2.44 minitubers on expanded clay. The experimental results function of calibration class and substrate were: class <15 mm: 1.70 minitubers/plant on clay, 1.96 minitubers on perlite and 1.26 minitubers on soil; for class 15 -25 mm: 3.67 minitubers/plant on clay, 3.54 minitubers on perlite, and 2.68 minitubers on soil; for class 25-35mm: 2.19 minitubers/plant on clay, 1.36 minitubers on perlite and 1.06 minitubers on soil; the 35-45 mm size class, the values ??were below sub-unit for all three substrates. Using industrial substrate for minitubers production, comparatively with conventional technology, ensure possibilities for getting a larger number of potato minitubers.

119

The current PVY population affecting potatoes in Finland

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Potato virus Y (PVY) is one of the most common viruses in potato. It causes serious problems in the production and quality of potatoes. To investigate the PVY population in potatoes in Finland, we collected 21 PVY isolates from seed potatoes and seven additional isolates from other potato fields in 2006 and 2007. Biological, serological and molecular methods were applied to characterize the isolates. Results showed that the isolates fell into two strain groups (PVY^N and PVY^O) according to the responses on potato cultivars Pentland Crown (Ny:nc), P. Ivory (Ny:Nc), King Edward (ny:Nc) and *Nicotiana tabacum* cv. Samsun. Several isolates which caused necrosis on *N. tabacum* Samsun also induced necrotic blotches on locally and systemically infected leaves of P. Ivory and/or P. Crown which contains the *Ny* resistance gene specific to PVY^O, but the symptoms differed clearly from the necrotic local lesions and no systemic infection caused by PVY^O. Serological results were consistent with the biological assays with one exception: isolate 182-14 caused veinal necrosis on tobacco but was detected with a PVY^O–specific monoclonal antibody (Mab1129), which is similar to the PVY^{NW} strain group. The 5'- and 3'-proximal sequences of the PVY genome including 5'UTR, P1, HC-Pro, CP and 3'UTR were determined in the PVY isolates. Fourteen out of 21 isolates in seed potatoes and five out of seven isolates in other potato crops were found to contain recombination events within the CP encoding sequence, which has been previously reported in PVY^{NTN} strain group. Only the isolate 182-14 was found to contain a recombination event in the P1 encoding region. Phylogenetic analysis indicated that 182-14 has a PVY^N-like HC-Pro but PVY^O-like CP. The PVY^{NTN} isolate Nevski was characterized in detail by graft-inoculation to 31 potato cultivars. It infected most of the cultivars and produced tuber necrosis on cultivars Nicola and Annabelle. In conclusion, PVY^N strain group was the predominant one in seed potatoes in Finland and hence likely to be also most common in ware and industrial potato crops; only four isolates belonged to PVY^O strain group.

120

Prediction of storability and end-product quality of potatoes for different end-uses based on methods related to maturity and disease pressure

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The short and cool growing season in Norway often results in immature potatoes at harvest. This causes problems for the storability and end-product quality of potatoes for different end-uses. Immature potatoes are more susceptible to skinning injuries, weight loss and diseases. Immature potatoes also have higher respiration rates and sugar contents, which can reduce storability and processing quality of the potatoes.
Improved prediction of storability of potatoes is one of the goals in the project: *"Improved quality of Norwegian fruits, potatoes and vegetables after long and short-term storage"*. The project also includes prediction of storability of carrots and apples, as well as studies of short-term storage of minimally processed vegetables.
A study on the influence of different pre-harvest markers and their ability to predict storability and end-use quality of potatoes for different end-use purposes has been carried out in 2010. Two different varieties of potatoes ("Asterix" and "Saturna") with three different maturity-levels (obtained by using planting time, fertilizing (N) and pre-sprouting) were grown.
Samples were withdrawn for analysis three times in the last part of the growing season. The pre-harvest markers studied were haulm senescence/N-content in the plant and skin set, respiration, and contents of dry-matter and reducing sugars in the tubers.
The potato quality and storability was followed during the storage season, and potato tubers were sampled three times during storage. The quality and storability of the potatoes was measured by analysis of skin set, respiration, sugar content, frying quality and weight loss.

A study on postharvest diseases with main focus on *Fusarium* species is another part of the project. This includes a survey of *Fusarium* spp. currently causing dry rot problems in Norway and attempts to develop multiplex real-time PCR to detect *Fusarium* spp. and *Boeremia foveata* in potato samples.
Data from these studies are in progress and will be presented.

121

Determination of Classification Parameters of Potatoes by Using Image Processing and Artificial Neural Networks

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Quality is one of the important factors in the marketing of agricultural products. Grading machines have a great importance in quality control systems. The most efficient method in the present grading machines is image processing. In this study, the classification of potatoes in terms of size by using image processing techniques and artificial neural network was aimed. Before the classification process, potatoes that have malformation and deformation in the outer surface were detected by using Otsu method and morphological processes. These potatoes were kept outside the classification. Later on, potatoes without any anomaly were classified in terms of their sizes. The system was trained with pictures of small, middle and large-sized potatoes by using multi-layered artificial neural networks. In this study, Matlab software was used for the use of image processing and artificial neural networks. By using image processing techniques and artificial neural networks, classification accomplishments of potatoes were studies.

Keywords: Artificial neural networks, image processing, potato grading, defects detection

122

Characterize the tolerance of potato varieties to drought under field conditions

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Among biotic and abiotic factors that may impact the total tuber yield of potato, drought is considered to be a serious constraint of potato production and tuber quality. Up to now, rules of water management are adapted to each outlet, soil type and maturity (Irrinov®). But, the increase of water access restrictions is forcing the potato industry to identify some ways to reduce the crop water need. In Northern France, a program led aims to help producers to optimize the water management. Priority tasks concern both crop rotation and crop management. Among the solutions, to identify new varieties less sensitive to weather conditions and more effective in water use could be a good way to maintain the potato crop acreage in Northern France.

In this context, our objectives were to identify varieties which could be used as probe in selection trial for their particular response to drought and to identify key traits favoring the maintaining of marketable yield under drought. Ten potato varieties, differing in earliness and drought tolerance according to expert opinion, were tested in 6 trial sites in Northern France in 2009 and 2010. We examined stem height, main stems number per plant 50 days after emergence and above-ground growth kinetics (development and senescence rates, value and duration of maximal above-ground). Tuber yield by size classes and tuber number were measured at harvest and some quality criteria observed (common scab, physiological disorders, dry matter and nitrate content, fry color...).

Different seasonal rainfall and varying levels of irrigation between sites and years created a wide range of soil moisture levels. In 2009, moderate deficit was observed in drought treatment in all sites from early June and it became markedly stronger from late June, which corresponds to the beginning of the bulking stage. In 2010, strong deficit of water appeared more rapidly in all sites from late May, which corresponds to the initiation tuber stage.

In 2009, drought reduced the total tuber yield by 27% and losses varied between 19 and 35% according to varieties. By contrast, the reduction of tuber number per m² induced by drought was low and varied less between varieties. In 2010, reductions of tuber yield and tuber number per m² were higher with mean reduction of 34% and 16% respectively. Varieties ranking based on tuber yield mean losses in 2009 was consistent with that of 2010, except for one variety which had higher loss in 2010 than in 2009.

Nevertheless, the response of one variety can varied with the environment characteristics including the period or the intensity of drought. Up to now, these differences are difficult to interpret within multi-site trials due to the complexity of genotype x environment interactions. Characterizing the specific soil moisture levels in each trial and adapting a method developed on wheat and computed in DIAGVAR tool (Lecomte et al, 2010, Agron. Sustain. Dev. 30, 667 – 677) to the potato crop could allow taking into account the genotype x environment interaction to characterize the varietal response to drought.

123

Using the Wild Potato Species Solanum Bulbocastanum Dun. as Resistance resource in Potato Breeding

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A wide range of wild *Solanum* species are potential sources for resistance genes to late blight (*Rpi*) caused by the oomycete *Phytophthora infestans* (Mont.) de Bary. Introducing these genes into cultivated potato by introgressive breeding is one way to increase both the durability and the level of resistance to this devastating disease.
The diploid, self-incompatible wild potato species *Solanum bulbocastanum* is resistant to late blight but has not been widely exploited in breeding programmes mainly due to the difficulty of crossing it with cultivated potato. There are four different nucleotide-binding site leucine-rich repeat resistance genes, *Rpi-blb1= RB*, *Rpi-blb2, Rpi-blb3* and *Rpi-bt1*, in *S. bulbocastanum* (review, Lokossou et al. 2010).
Somatic hybrids between genotypes of the Genebank-accession GLKS-31741 of *S. bulbocastanum* (IPK Genebank, Gross Lüsewitz, Germany) and five German commercial potato cultivars were produced and characterized at both the molecular and cytological level, and in terms of morphology, agronomic traits and resistance to foliage blight. Selected hexaploid somatic hybrids were backcrossed (BC) with cultivated potato and BC progenies produced. Parental clones, somatic hybrids and BC progenies were assessed for resistance to foliage blight using detached leaf assays and in the field using an inoculum of *P. infestans* consisting of common races collected in the field. In BC_1 and BC_2 clones resistance to foliage blight segregated in the population. Selected hybrids and BC clones were evaluated in the field for tuber quality and tuber yield.
Molecular analysis using gene-specific primers confirmed the presence of the *Rpi-blb1* and *Rpi-blb3* genes of the accession used in somatic hybrids, which were resistant to foliage blight.
Recently, a set of five genotypes of five additional accessions of *S. bulbocastanum* were phenotyped and genotyped. Marker-assisted selection will be used to select progeny and used to pyramid different pathogen resistance genes in breeding material.

Reference
Lokossou et al. 2010, MPMI 23 (9), 1206-1216

124

Presentation of a new way of organizing reseach and development for potato production research and developement in Norway (preliminary title)

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125

Chlorpropham is more active when applied at warmer temperatures

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For many years chlorpropham (CIPC) has been the predominant sprout suppressant for use in potato stores in the processing sector, where crops are held at 7-10°C. In the fresh market, sprout control can be imperfect despite the use of refrigerated stores at 3-4°C, and attention has turned to the use of CIPC at these low temperatures. The work here describes the behaviour of CIPC, under cold storage conditions, with particular emphasis given to the application procedure and its consequences through the storage period.

When applied into low temperature potato stores, CIPC was found to be persistent over the storage duration, with negligible decline compared to application at warmer store temperatures (processing). The behaviour of CIPC applied at different store temperatures was investigated.

CIPC was applied, as a hot-fog, to crop during temperature pull down at the beginning of storage, when crop was at 10□C, 7□C or 3.5□C [10, 7, 3.5 Early]. For comparison, a late CIPC treatment was also included, applied at 3.5°C, once tuber sprout growth had initiated [3.5 Late]. Except for the period of temperature pull-down, all crops were held at 3.5°C (+/- 0.3°C) and unloaded after 8 months in store.

Crop treated at all temperatures and timings had similar deposits of CIPC after application (1.5-3mg kg^{-1}). However, the CIPC vapour concentration released during storage was greatest from tubers where CIPC treatment had occurred at 10□C. Similarly, the CIPC vapour concentration was higher following treatment at 7°C than at 3.5°C (Early or Late). The elevated vapour activity persisted for at least 7 months of storage, indicating a long-lasting effect of conditions at application on CIPC behaviour in storage.

In addition, the amount of CIPC redistributed onto samples of fresh, untreated crop, placed in boxes after applications, during the storage period was greater when application of CIPC had been conducted at warmer temperature.

Results suggest that store air or tuber temperature, at the time of application can have a pronounced effect on the behaviour of CIPC during long-term storage.

Preliminary results from this work suggest:

1) Greater CIPC vapour activity, and improved sprout control efficacy, can be obtained during storage at 3.5°C by applying CIPC at warmer temperatures during the initial pull-down period.
2) Redistribution of chemical takes place throughout the storage period, although not to the same extent as occurs in warmer processing stores.
3) The efficiency of CIPC usage in low-temperature stores can be improved by optimisation of the application stage.

126

Sv-lines an effective tool for introgression of 1EBN species germplasm into breeding

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127

Local breeding to increase potato resistance against late blight (Phytophthora infestans) and leaf miner (Liriomyza huidobrensis)

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In tropical countries, as well as in temperate regions of the world, potato is a crop of great economic importance. In Costa Rica more than 3000 ha of potatoes are grown annually. From the total production costs, up to 45% correspond with pest and disease control. Late blight (*Phytophthora infestans*) Mont. De Bary, and the leafminer (*Liriomyza huidobrensis*) Blanchard, are the most constraining biotic factors in potato production in Costa Rica. Their control has been based on the use of chemical fungicides and insecticides, leading to the selection of resistant populations and the consequent environmental impact of agrochemicals overuse. Genetic resistance is the best option for pest and disease control, and might reduce the costs of applying pesticides and their environmental impact. Potato breeding has allowed the development of varieties with high resistance or tolerance to many pests and diseases. However, in tropical countries, growing conditions are more favorable to biotic problems than those in countries where many potato varieties have been traditionally improved, so that the importation and evaluation of materials from other countries has been ineffective to reduce the negative impact of potato pests and diseases in our country. A local potato breeding program was initiated nearly a decade ago at the University of Costa Rica, which focuses on the evaluation and combination, through sexual crossings, of suitable progenitors for the production of hybrids with combined resistance to both late blight (horizontal resistance) and leafminer, and other important agronomic traits such as yield and desirable tuber traits. From the first crosses carried out, the program has generated 28 new clones that have been selected through several years of field evaluation in different potato growing regions of Costa Rica. These materials show a very high resistance to late blight and leaf miner, as well as high yielding, compared with the clones currently in use. In addition, the selected clones are characterized by high solids, and good processing quality, making them potential candidates to be released as new varieties in the coming years.
Key words: *Solanum tuberosum*, field evaluation, improved clones

128

Dissecting the genetics of abiotic stress tolerance in potato

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Drought and salinity tolerance are complex traits involving many genes that interact with the environment. These traits are generally difficult to breed for which is even more complicated in an outcrossing heterozygous, tetraploid crop like potato.
Our studies are aimed at unraveling the complex genetics of abiotic stress tolerance in potato by integrating extensive phenotyping strategies with ~omics techniques in mapping populations.
The diploid CxE potato mapping population was evaluated for drought and salt stress tolerance traits in the greenhouse. Effects on photosynthetic activity in the whole plant was monitored with a novel chlorophyll fluorescence technique. Ion contents were measured in shoots and roots. Salt stress tolerance was found to be correlated to K^+ concentration in roots, and Na^+ and K^+ concentrations in leaves. A number of QTLs for growth parameters in control, drought stressed and salt stressed conditions co-localize on chromosome 5, close to or at the locus that determines maturity in potato. QTLs for K^+ content in leaves and stems map at the same position.
Genome-wide transcriptome analysis of the drought-stressed potato population revealed over 24,000 expression QTLs (eQTLs). Interestingly, a disproportionately large number of trans-eQTLs (for which the expression of the gene does not map to the physical position of that gene) under drought conditions was present on chromosome 5, indicating the presence of a genetic factor initiating a genome-wide drought response at this region.

129

Tuber formation in progenies derived from two short-day dependent Mexican potato species resistant to Phytophthora infestans

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The Mexican species *Solanum guerreroense* Corr. and *S. neoantopoviczii* Buk. have been recognized as highly resistant to *Phytophthora infestans*. *Solanum guerreroense* can be considered as short day dependent due to its close relation to *S. demissum* Lindl. which is of this type. *Solanum neoantopoviczii* was also characterized by low ability to develop tubers during long daylight conditions. The goal of our evaluation was to select genotypes with combined resistance to *P. infestans* and ability to develop tubers under long day conditions. *Solanum guerreroense* hybrids were obtained in crosses with Black´s differential line *R5* (1), the Swedish cultivar Superb (2) and an accession of *S. andigenum* Juz. et Buk (3). A *S. neoantipoviczii* hybrid was obtained in crosses with a selection from the Russian cultivar Aurora (4). Evaluations for tuber formation ability in the F_1 hybrid populations were performed in PPBI and SLU (locations with long day conditions). In PPBI hybrid plants from (1), (3) and (4) were grown in pots. Plants from (2) and (3), studied at SLU, were grown in the field. Leaflet inoculation tests for resistance to *P. infestans* were performed at both locations.
Intra-population variation for tuber shape, tuber size and skin colour was observed in hybrid (1). Two of 30 plants failed to tuberize. Mean tuber weight for single plants within the population varied between 2.9g and 17.7g. Two plants possessed maximum single tuber weights of 53.3g and 55.4g. Tubers were obtained from all plants from hybrid (2). They were more morphologically uniform and possessed a higher tuber weight compared to (1). Average tuber weight within this population ranged from 2.9g to 24.5g. Single tuber weight in the superior genotypes reached 62.4 g and 76.5g. All hybrid progenies between *S. guerreroense* and *S. andigenum* (3) developed tubers of relatively small size in both locations. For plants grown in PPBI tuber weight was 4.2g on the average. Uniform, relatively large tubers, exceeding the average tuber weight of the wild parent were found in hybrids of *S. neoantipoviczii*×Aurora (4). In this population plants produced tubers with average weight from 17.2g to 31.1g. and the maximum tuber weight reached 24.8g and 35.1g. Analysis of Variance calculated using Minitab, showed significant differences between plants regarding tuber weight ($p=0.034$ for (3) and $p=0.001$ for (1), (2) and (4).
All progenies derived from *S. guerreroense* were completely resistant to *P. infestans*. The hybrids from *S. neoantipoviczii* segregated into resistant and susceptible plants according to the ratio 2:1. In summary foliar resistance to *P. infestans* was found in each of hybrids evaluated. Seedlings of hybrids (1), (2) and (4) formed tubers with sizes superior to the ones from the wild parents. Plants with combined tuber formation ability under long day conditions and high foliar resistance to *P. infestans* were found in these hybrid populations.

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130

Resistance to Phytophthora infestans in eleven interspecific potato hybrids

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Late blight caused by *Phytophthora infestans* is one of the major problems in potato production. Potato breeding can benefit from the use of resistance derived from wild species with different resistance background. Hybrids were obtained using accessions from wild species screened for resistance to *P. infestans* in previous evaluation supported by a CEEM (Cornell-Eastern Europe-Mexico) project. Accessions from the following species were used in crosses: *Solanum andigenum* Juz. et Buk. (adg), *S. berthaultii* Hawk. (ber), *S. guerreroense* Corr. (grr), *S. kurtzianum* Bitt. et Wittm. (ktz), *S. neoantipoviczii* Buk. (nan), *S. papita* Rydb. (pta), *S. ruiz-ceballosii* Card. (rcb), and the original hybrid *S. microdontum* x *S. tarijense* (mcd x tar). A breeding line from the breeding program at SLU (*S. tuberosum* L. 93-1015), and the Swedish cultivar Superb were included as well. Hybridizations and leaflet tests were performed at SLU. Inoculum with a concentration of 20000 zoospores/ml was prepared from an aggressive *P. infestans* isolate. Disease ratings were done according to a scale 1–9. Plants qualified as resistant when scored 7–9.
The parental accessions grr, rcb, ber, nan and pta were found to be highly resistant when using a standard inoculum concentration. Using higher concentration only grr and nan kept high resistance levels. *Solanum kurtzianum* parent was selected from population with low frequency of resistant seedlings. The hybrid progeny from mcd x tar had high predominance of resistant plants (3:1). The breeding line 93-1015 has shown extreme resistance in long-term field observations at SLU.
In the current evaluation, hybrids derived from grr and adg were completely resistant (9.0 on average) despite the susceptibility to *P. infestans* found earlier in adg. High resistance was also observed in the progeny of grr and cv. Superb (average 8.8). Hybrids obtained from reciprocal crosses between nan and pta were completely resistant. Resistance of pta hybrid derived from a cross with ktz scored an average resistance of 8.5. The strongly segregating progeny from (mcd x tar) x ktz showed resistance only in 1/5 of the plants. The progeny from ber x 93-1015 scored 5.7 on the average. Hybrid progenies obtained from crosses of nan with 1) rcb, 2) ber and 3) mcd x tar, respectively, differed in resistance. The highest degree of resistance, accompanied by a hypersensitivity reaction, was expressed in the first combination (nan x rcb) (average 8.6). The lowest resistance (average 6.0) was found in the strongly segregating progeny nan x ber. Regardless similar resistance levels of ber and rcb found in a previous evaluation the progeny from cross of nan and rcb differed in resistance compared to progeny from nan and ber. Apparently from these data rcb has an advantage as a parent compared to ber. The resistance of the third hybrid progeny (nan x (mcd x tar)) was on average 7.6.
Six hybrid combinations (grr x adg, grr x Superb, nan x pta, nan x rcb, pta x ktz, pta x nan) expressed very high resistance to *P. infestans* with average scores close to maximum. Fully resistant populations were derived from cross combinations with grr, nan and pta.

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131

Effects of Helper-Component Proteinase, the silencing suppressor of potyviruses, on systemic spread of different viruses and viral vector

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In plants, RNA silencing is specifically involved in multiple defence mechanisms against invading genetic elements, such as transgenes, transposons and particularly viral pathogens. To combat this defence mechanism, plant viruses produce silencing suppressor proteins (viral suppressors of RNA silencing [VSRS]). Various VSRSs appear to target different steps of the silencing pathway and therefore can be used as probes to study specific silencing-related phenomena and host-virus interactions. We have produced a set of transgenic Nicotiana benthamiana lines expressing different silencing suppressors including helper-component proteinase (HC-Pro) from Potato virus Y (PVY) (Siddiqui et al. 2008. Mol. Plant-Microbe Interact. 21: 178-187). HC-Pro is a very strong and one of the best described VSRSs. When expressed in transgenic plants, it can strongly enhance accumulation of the invading viruses (Pruss et al. 1997, Plant Cell 9: 859-868). To study the effects of HC-Pro on spread of heterologous viruses and/or a viral vectors, transgenic N. benthamiana plants, expressing HC-Pro, were either inoculated with a chimeric construct in which the ChlH gene is inserted into the Tobacco mosaic virus-30b vector (TMV-ChlH), or agro-infiltrated with GFP-tagged crucifer-strain of TMV (crTMV-GFP). The VIGS-induced silencing of ChlH gene causes reduced chlorophyll biosynthesis, which can readily be seen by specific (yellow/white) symptoms in the TMV-ChlH-infected leaves. On the other hand, epigenetic expression of Pectin Methyl Esterase (PME) enhances silencing, and when co-infiltrated with crTMV-GFP, it strongly reduces the spread of this virus in wild type N. benthamiana plants (Dorokhov et al. 2006. FEBS Lett. 580: 3872-3878). When HC-Pro transgenic plants were inoculated with TMV-ChlH construct, it prevented the ChlH silencing and enhanced the accumulation of the virus. However, different results were observed in the HC-Pro- expressing plants upon infiltration by the crTMV-GFP construct. Surprisingly, spread of this virus construct was reduced in HC-Pro-expressing plants, and the co-infiltration of the PME-expression cassette did not enhance the virus spread, or the GFP expression level. . These results suggest that besides the ability of HC-Pro in enhancing the accumulation of invading virus, it can also induce resistance to invading heterologous virus.

Author Index


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