

## REPORT

### **Report of the joint meeting of the Potato Section of EUCARPIA and the Section Breeding and varietal assessment of the EAPR, 3–7 July, 2000, Warsaw (Poland)**

The joint meeting of the Potato Section of EUCARPIA and the Section Breeding and varietal assessment of the EAPR was held in Warsaw (Poland) on July 3–7, 2000. The meeting was organised by the Plant Breeding and Acclimatization Institute (IHAR) and was focused on “Breeding research for resistance to pathogens and for quality traits”. During the six sessions of the meeting 34 oral presentations and 52 posters were presented.

The first scientific session was devoted to the topic: “How to breed for resistance to fungal and bacterial diseases?” and was introduced by a keynote lecture by Dr John Bradshaw, from the Scottish Crop Research Institute of Dundee. The four communications and the ten posters presented were centred on resistance to late blight and *Erwinia*.

The subject of the second session was “Is resistance to viruses an important task for European breeding?” that was opened by an invited lecture by Prof. Jari Valkonen of the University of Uppsala. The session consisted of six oral communications and seven posters.

The third session dealt with “Tuber quality - objectives in breeding and breeding research”. The opening lecture was given by Daniel Ellissèche from INRA of Ploudaniel, followed by five oral presentations and by 6 posters, covering different aspects of technological and nutritional quality of potato.

The fourth session was dedicated to “Achievements of biotechnology applicable at present in potato breeding”. Four oral presentations and seven posters on the utilisation of molecular techniques to assist potato breeding were preceded by a keynote lecture by Dr Christiane Gebhardt, of the Max-Planck Institute for Breeding Research of Cologne.

The fifth session was devoted to the topic: “Varietal assessment in Europe”. After an introductory lecture by Dr Julia Boris, from COBORU, four oral papers and ten posters were given.

The last session was dedicated to “Breeding - diploids, resources, methods” and included five communications and ten posters, discussing the use of diploid lines to introgress valuable genes from wild germplasm into cultivated potato.

On July 5, the participants to the meeting visited the Młochów Research Center of IHAR and on July 6, about 60 attendants took part in a whole day excursion to the Potato Breeding Station at Zamarte (IHAR) and to the Research Center of Cultivar Testing (COBORU) at Karzniczka.

The satellite meeting of Global Initiative on Late Blight (GILB) linkage groups was held on July 4.

About 108 participants from 21 countries have attended the meeting.

Organisation of the meeting was sponsored by EUCARPIA, GILB, McCain Poland and 3M Poland. In total 14 scientists from Eastern Europe attended the

meeting due to joint sponsoring of EAPR, EUCARPIA, GILB and Cornell - Eastern Europe - Mexico (CEEM) International Collaborative Project in Potato Late Blight Control.

The success of the meeting is owed by the high level of the presentations and of the discussions and by the excellent organisation ensured by our Polish colleagues.

Andrea Sonnino,  
Chairman Section Breeding and varietal assessment

J.E. Bradshaw, A.K. Lees & H.E. Stewart (SCRI, Dundee, UK): *How to breed potatoes for resistance to fungal and bacterial diseases*

The title is really short for 'how to breed potatoes which are very high yielding, have superb processing or table quality, and which also have adequate levels of durable resistance to fungal and bacterial diseases, as well as to other pests and diseases'. After a brief summary of worldwide priorities for resistance to fungi and bacteria, the pre-requisites for successful breeding are considered before giving examples from actual breeding programmes. First, one needs to consider the sources of resistance available in cultivated and wild species, as well as prospects for engineered resistance, paying due regard to the level of resistance required and likely durability of the resistance under consideration. Next, one needs to think about screening for disease resistance in terms of using the most appropriate isolates of the pathogen in reliable and repeatable tests. Then, finally, one needs to understand the inheritance of the resistance. The analytical techniques required will depend upon whether one is dealing with qualitative or quantitative resistance, but will include seeking molecular markers linked to the resistance genes of interest in order to practise marker assisted selection or to clone the resistance genes. With these pre-requisites in place, one can practise efficient breeding methods based on sound scientific principles, some examples of which will be given.

Diseases mentioned include late blight, *Verticillium* wilt, early blight, *Fusarium* wilt, wart, dry rot, black scurf and stem canker, common scab, powdery scab, gangrene, skinspot, silver scurf, black dot, blackleg and soft rot, bacterial wilt and bacterial ring rot.

B.R. Trognitz, M. Ghislain, M. Orrillo, L. Portál, P. Ramón, H. Pinedo, E. Pestana, R. Nelson & F. Trognitz (CIP, Lima, Peru): *Technology development of selection for quantitative late blight resistance assisted by molecular markers*

Race non-specific, quantitative resistance to late blight is preferred by many breeders, yet selection for it is expensive, as it can only be reliably estimated in multi-year, multi-location trialling. Therefore, we explore the potential of selection for quantitative trait loci (QTL) contributing to field resistance.

The objectives of our study include the detection of resistance QTLs in a diploid population segregating for resistance (denominated the PD population) and the design of molecular markers linked to these QTLs. The QTL markers for resistance in the PD population are tested for their ability to detect resistance in other populations descending from PD. Diploid and tetraploid progenies obtained in intercrosses of PD individuals and backcrosses to 4x potato have been obtained and they are evaluated for late blight resistance in the field. Molecular markers are tested for their cosegregation with resistance. For markers that reliably detect resistance we then design PCR primers that can be used in breeding programmes for large-scale screening of segregating materials.

Preliminary results indicate that the race non-specific resistance to late blight of the PD progeny is highly modified by the specific environment. Nevertheless, several QTLs have been detected that are stably expressed across environments, and marker-assisted selection for these QTLs should be possible.

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Resistance of potato tubers to late blight is important in both breeding and cultivar assessment programmes, but it is also one of the most difficult traits to assess in a repeatable and meaningful way. Therefore, a co-operative project (financially supported by the French Ministry of Agriculture and Fishery) between INRA and the French private potato breeders was set up to develop a satisfactory methodology to check genotypes for tuber blight behaviour.

Laboratory tests using artificial contaminations of tubers from a wide range of cultivars were not reliable enough, as the results depended heavily on harvest time and on inoculation and scoring procedures. The skin constitutes a major component of resistance, as inoculating young or wounded tubers increased the incidence of disease and the severity of symptoms.

In the field, tuber contamination was higher in all genotypes over the standard untreated non-irrigated procedure, when plots were partially protected by fungicides until tuber setting and received frequent water sprinkling. The best discrimination of genotypes was obtained from disease incidence at an early harvest date (late July instead of the usual mid September) and after an incubation period of 3 weeks just after harvest. Altogether, these results suggest that the modified field protocol is best suited to assess genotypes for tuber blight behaviour, although the choice of standard reference varieties, particularly for intermediate levels of resistance, needs to be validated.

L. Gergely (OMMI, Budapest, Hungary): *Foliar resistance of potato varieties to late blight (*Phytophthora infestans* (Mont.) de Bary)*

In Hungary, potato leafroll virus (PLRV) and potato virus Y mosaic (PVY) diseases are endemic, causing crop losses of 20–30% from year to year due to ecological conditions. Recently, potato late blight (*P. infestans*) has also caused serious losses in potatoes and tomatoes.

In the autumn of 1999 the foliar resistance of 50 potato varieties was assessed to late blight fungus. The resistance test was carried out in a walk-in plastic tunnel, because all field trials are treated with fungicides. 60 bud-cuttings from the tubers of each variety were made and planted into peat-beds in a 2 replicate randomized experiment, after breaking their dormancy by chemicals (GA3 + thiocarbamate). A mixture of 2 Hungarian *Phytophthora* isolates was used as an inoculum which was sprayed onto the foliage at the 10- to 14-leaf stage (30,000 sporangia/ml). The assessment of foliar resistance was performed on the 14<sup>th</sup>–18<sup>th</sup> day after inoculation by estimating the diseased leaf area compared to the whole foliage based on the sporulation caused by the fungus (infected area %).

Foliar infections of the genotypes tested ranged between 0–92.5%. Only 14% of the varieties showed high resistance in the foliage, but a further 16% performed as intermediate types whilst 70% was found to be highly susceptible. The highest resistance was expressed by varieties Vilma, Cupido, Cicero, Bettina and Innovator. The following varieties were found to be the most susceptible: Berber, Agata, Colette, Arosa, Red Star and Margarita.

K.M. Świeżyński, B. Flis & M.T. Sieczka (IHAR, Młochów, Poland): *Comparative results of the evaluation of foliage resistance to *Phytophthora infestans* in the potato using two different methods*

In 226 potato genotypes the foliage resistance to *P. infestans* has been evaluated using two methods: testing detached leaflets, collected from young, field grown plants and evaluation of resistance under high natural infection pressure. Each potato genotype was evaluated with both methods for two years and in each year its maturity was also determined. The genotypes tested were diploid and tetraploid clones, pre-selected for resistance to *P. infestans*, but differing in mean resistance level to this pathogen.

The results of both testing methods were positively, but not closely correlated. In both methods the interaction of genotype x year was found to be statistically significant. While the leaflet resistance was very weakly correlated with late maturity, the correlation between resistance to natural infection and late maturity was statistically highly significant with a mean absolute value of the correlation coefficient,  $r=0.555$ . In highly resistant genotypes most leaflets were highly resistant. In susceptible and partly resistant genotypes the leaflet reaction was more variable.

It is concluded that the evaluation of resistance under high natural infection pressure has the advantage of being a direct resistance estimation. However it is not

only laborious, but requires repeated evaluation (due to genotype  $\times$  year interaction) and to obtain a resistance estimation useful in breeding work, the effect of maturity must be excluded. The evaluation of resistance in detached leaflets is cheap and its results are only slightly dependent on maturity. It is very suitable for the identification of resistant genotypes. The separation of genotypes showing small differences in resistance requires repeated testing.

J.P.T. Valkonen (SLU, Uppsala, Sweden): *Resistance to viruses: an important task for European potato breeding*

Viruses are, for several reasons, dangerous pathogens of potato. They cause heavy yield losses, are transmitted to new crops via infected seed tubers, and their control in the field during the growing season is inefficient or impossible. The use of virus-free seed potatoes in industrial countries, enabled by specialized seed potato production schemes, has decreased the incidence of infections with some viruses. However, it has not decreased the importance of these viruses since re-infections through transmission from infected plants (mostly other potato crops) in the field occur frequently. New virus problems are appearing in some areas. In northern Europe, the soil-borne Potato mop-top virus causes qualitative damage on tubers and prevents infested fields from being used for certain types of potato production. Economic losses are substantial. It appears that these problems will be solved only with increased resistance to viruses in the potato crops. Breeding for virus resistance has been carried out in Europe for 60 years with good results. Effective genes for broad-spectrum (extreme) resistance to Potato virus Y, X, S and M have been identified and incorporated into a few potato cultivars. The positions of several virus resistance genes have been mapped on potato chromosomes. The molecular markers linked to the resistance genes can be developed further for easier applicability in conventional breeding programmes. A few virus resistance genes have been isolated and characterized. Breeding for virus resistance in potato can now be significantly enhanced using the molecular tools available, which is an important task for European potato breeding.

M.F.B. Dale & D.J. Robinson (SCRI, Dundee, UK): *Tobacco rattle virus in potatoes - effects of symptomless infection on plants and tubers*

Tobacco rattle virus (TRV) is known to establish systemic infection in some potato cultivars without the visible expression of the classicalspraing symptoms (arcs or lines of corky brown tissue) in the tuber flesh. Such potato cultivars can, however, suffer significant decreases in yield and quality attributes. A limited number of cultivars, systemically infected with M-type TRV, have been propagated over a 5 year period. Results of field trials comparing plots of uninfected and TRV-infected plants of the potato cultivars Wilja and King Edward indicated that the virus could

have a detrimental effect on a number of important attributes.

While material was growing in the field (during 1998), plant establishment and canopy development were retarded among the infected plants. Yields from the infected plants were substantially reduced, particularly in the cultivar Wilja, as was tuber size. There was also a significant increase in tuber number and in the degree of secondary growth.

The study also looked at a number of tuber quality attributes. Notable increases within the TRV-infected material were observed for after-cooking blackening, and chlorogenic acid and sucrose levels. These changes will be discussed in relation to general plant defense mechanisms.

The detrimental effects of such systemic infection with TRV (M-type) on tuber yield and quality, and also the clarification of the epidemiology of this soil-borne virus, have implications for breeding for resistance to the virus and also for the spread of the virus from site to site.

M. Chrzanowska (IHAR, Młochów, Poland): *Resistance to PVY in potato cultivars in the light of recent studies of PVY population in Poland*

PVY is the most important virus affecting potatoes in Europe. De Bokx in 1974 recognized three main strains of PVY: PVY<sup>C</sup> non transmitted by aphids, PVY<sup>o</sup> normal strain causing often severe symptoms on potatoes, and PVY<sup>N</sup> necrotic strain causing veinal necroses on tobacco.

At present three subgroups of PVY<sup>N</sup> are distinguished: PVY<sup>N</sup>, an old typical strain identified in Poland in 1974 as PVY<sup>N</sup> Ny, PVY<sup>NTN</sup>, a new severe strain able to induce a necrotic ringspot disease on tubers (found at first in Hungary, common in the South of Europe, identified in Poland in 1994) and PVY<sup>N</sup> Wi, a mild strain, widely spreading in Poland and described there already in 1991.

On the official List of Cultivars Registered in Poland there are 93 potato cultivars: 76 Polish and 17 foreign ones. Among these cultivars, 76 were inoculated with four strains of PVY: PVY<sup>o</sup>, PVY<sup>N</sup> Ny, PVY<sup>NTN</sup> and PVY<sup>N</sup> Wi. Extreme resistance to PVY was found in 16 Polish cultivars and in the cv. Santé. Most remaining cultivars are resistant to PVY<sup>o</sup> and to the old strain PVY<sup>N</sup> Ny, but susceptible to PVY<sup>N</sup> Wi and PVY<sup>NTN</sup>. In this group there is a close correlation between the reaction to PVY<sup>N</sup> Wi and PVY<sup>NTN</sup> ( $r=0.8^{**}$ ). Although PVY<sup>NTN</sup> was detected in Poland, it was never found to cause necrotic ringspot disease of tubers under field conditions. Therefore selection for resistance to PVY<sup>N</sup> Wi is likely to eliminate most selections susceptible to PVY<sup>NTN</sup>.

B. Flis & I. Wasilewicz-Flis (IHAR, Młochów, Poland): *Genetic determination of resistance to PVY and PLRV in parental lines bred at IHAR Młochów*

Parental line breeding at Młochów Research Center offers possibilities for introducing different traits into commercial breeding materials. Resistance to Potato Virus Y (PVY) and Potato Leaf Roll Virus (PLRV) are important characters present in our parental lines.

In the case of PVY, a gene coding for extreme resistance from *Solanum stoloniferum* was introduced into the breeding material. It was found that other genes may influence expression of this gene, and that in some genotypes extreme resistance is controlled by more than one gene.

The main source of resistance to PLRV in our genetic pool is the diploid clone DW.84-1457. A simple genetic mechanism determines its resistance, which originated from *S. tuberosum*. The question raised is if an inhibition of long distance virus transport may be considered as another type of resistance. To evaluate such an inhibiting effect, stem pieces of resistant plants were grafted between PLRV infected scions and healthy susceptible rootstocks. Some inhibiting effect of virus transport caused by the inserted stem sections was observed only in a primary infection. Among secondarily infected susceptible plants, grown from daughter tubers of infected rootstocks, significant differentiation of virus concentration was observed. These differences depended on the combination of the resistant stem section genotype and susceptible rootstock genotype, which were used in grafting. Anyhow, in all secondarily infected plants virus concentration was high enough to conclude that long distance PLRV transport is a passive process, which cannot be considered as a separate element of resistance in tested genotypes.

U. Darsow (BAZ, Groß Lüsewitz, Germany): *Virus resistance as problem in prebreeding of late blight resistance*

PLRV, PVY, PVX, PVM, PVS and PVA rank among the most important potato viruses in middle Europe. The virus diseases exercise an influence on late blight resistance of the potato. As a result, the effect on foliage resistance varies significantly from tuber resistance.

Most clones are highly susceptible to virus diseases, even those from wild species which are known as sources of virus resistance. Because of their long growing season, very late maturing late blight resistant species are especially prone to virus infections. As examples, 44% of clones of *Solanum stoloniferum* displayed severe mosaic or leaf roll in their third year of assessment and 85% of *S. demissum* plants were severely virus diseased in the fourth year. Fusions of *S. bulbocastanum* and *S. tuberosum* (2x) had severe mosaic in the fourth year. As a consequence, the main fraction of the potential sources of blight resistance has to be removed because of virus infections before assessment of important traits is finished and crossing can be started. Thus, parents with high virus resistance are of principal importance for a prebreeding

programme with wild potato species. However, using extremely PVY-resistant parents was not successful, although PVY was the most frequent virus. Rather, polygenically determined virus resistance for variety breeding was preferred.

In general, a high percentage of visible virus attack of first backcrosses (BC1, BC2) in the second and third year in the field cannot be avoided. We found a correlation between blight resistance and susceptibility to PVY. This correlation was overcome by backcrossing and intercrossing with the best virus resistant clones after three to four generations.

E. Turska & S. Wróbel (IHAR, Bonin, Poland): *The role of resistance of potato cultivars to viruses in seed potato production in Poland*

Introducing the principles of a market economy in 1989 became one of the reasons for a significant decrease of potato seed plantation area in Poland. In 1989 it was 74 thousand hectares, while in the last few years it has stayed in the range of 7.5 to 12 thousand hectares.

Also in 1989, due to the potato virus Y epidemic, there was a decrease in potato seed plantation areas of cultivars particularly susceptible to PVY, including three consumption cultivars (Mila, Atol, Bryza), which were grown in 30% of the whole seed plantation. In 1989, over 10% of seed areas were the starch cultivars with extreme resistance to PVY.

In recent years, there was an increased number of cultivars (from 60 to 93) recorded in the registry while also noticing significant changes in their assortment. About 90% are registered after the year 1989. The top positions in the ranking of potato seed plantation areas have the cultivars with high levels of virus resistance, particularly to PVY, and of high quality features such as taste, high level of starch etc. As those cultivars have significantly lower seed production costs, they are very well accepted by the market. The same tendencies are noticed with regard to both Polish as well as foreign cultivars. The cultivars extremely resistant to PVY did not have a significant role in seed production except for the cultivar Bzura, which is also characterized by a high resistance to late blight.

S. Horváth, I. Wolf & Z. Polgar (VE-GMK, Keszthely, Hungary): *The significance and results of breeding for resistance at Keszthely*

The results of countrywide virological surveys and experiments proved that the low Hungarian average yield is mainly caused by the virological degeneration of potato. In the case of susceptible foreign varieties the rate of virus infection can reach 60–80% while the yield loss can be 20–30% during one year's cultivation. In recent years, about 5–6% of growing area was planted with appropriate virological quality imported seed and about 10–15% with seed from its first year propagation. The seed used for the rest had practically 100% virus infection. Studying the available ways to



prevent virus infection we found that by their combined application one can decrease the rate of infection but effective changes on a country level can be realised only by cultivation of resistant varieties.

Based on a resistance breeding programme utilising wild species, seven varieties were released by our Department. These varieties have extreme resistance to PVY (systemic hypersensitivity in one case), even against the new NTN strain. All have a high level of field resistance to PLRV, PVX, PVA and common scab. Five varieties are resistant to *Globodera rostochiensis* Ro1, Ro4, while one is highly resistant to late blight. The varieties show nice tuber shape, shallow eyes, stable yielding ability and general table quality.

Virus infected plants have increased susceptibility to different environmental stresses, resulting in higher yield decreases. This is the main reason for the heavy fluctuation of average yields and has a significant influence on unpredictable market conditions. By the cultivation of virus resistant varieties however we could reach the ecological potential yield of 25–27 t/ha without major technical development. Based on the above, the current goal of our breeding programme is the preservation of reached resistances and the improvement of effectiveness of selection on processing quality. For this the creation of parental lines having PVY resistance genes in homo- or hetero multiplex format was started. In this later case alleles of PVY resistance genes are originating from different species (*Solanum stoloniferum*, *S. andigenum*, *S. hougasii* or *S. chacoense*). The new breeding programme is completed by a complex parental line evaluation system and in the longer term by the utilisation of different biotechnological techniques.

M.-C. Kerlan & D. Ellissèche (INRA, Ploudaniel, France): *Tuber quality: objectives in breeding and breeding research*

The potato is the fourth most important human food crop in the world, and it is used in various ways in the human diet. Therefore tuber quality encompasses many traits and objectives in breeding are to issue varieties well adapted to a given market.

Ware potatoes require a regular tuber shape, and an absence of external and internal defects. After cooking blackening is prohibitory for cooking quality while appreciation of texture and flavour is more consumer dependent, as illustrated by the inclination towards non sloughing French 'variétés à chair ferme' in some European countries. The processing industry specifically needs large sized tubers with a medium to high dry matter content and a low reducing sugar content.

Among those traits, many are complex and subject to the influence of environmental factors; genetic studies on their inheritance are sometimes contradictory. Some characteristics are precisely measured (dry matter content, sugar content) while others are visually (tuber aspect) or even subjectively (flavour) assessed.

Conventional breeding has mostly used the variability of quality traits which exists in *Solanum tuberosum*. Now, related species are more widely exploited so that

checking glycoalkaloid contents in the progenies is needed, according to the Novel Food Regulations. It may be assumed that biotechnology (embryo rescue, gene transfer as a way to study metabolic pathways, gene mapping) will play an increasing role in breeding.

New developments can be foreseen in breeding targeted to washable potatoes, cold storage ability and starch quality.

G.R. Mackay & D. Todd (SCRI, Dundee, UK): *A targeted and accelerated approach to breeding potatoes for processing*

Breeding improved cultivars of potatoes is complicated by the heterozygous, tetraploid status of *Solanum tuberosum* ssp. *tuberosum*, by the many diseases and pests to which the crop is prone, and a multiplicity of end user needs. In a large-scale breeding programme selecting cultivars can, therefore, require up to 12 years of routine testing, trialling and selection, before clones can be submitted to two years official (National List) trials. Hence, a minimum of 15 years can elapse from the sowing of seedlings in the glasshouse to the commercialisation of a named cultivar. Research into the efficiency of early generation selection and the development and application of progeny tests at SCRI has expedited the selection process by identifying superior crosses much earlier than hitherto.

The process can be further accelerated by applying early generation selection for traits of most importance to specific end user needs. In 1991, three thousand, one hundred seedlings, representing 43 progenies, were sown in our glasshouses. By focusing on (targeting) traits of specific interest to processors, and by the use of micropropagation to rapidly multiply superior clones, it was possible to submit three clones from this population to UK National List Trials in autumn 1996. In July 1999, cultivars Montrose, Golden Millennium and Harborough Harvest were admitted on to the UK National List, having been deemed of satisfactory value for cultivation and use by the statutory authorities. The procedures that achieved this successful Targeted and Accelerated approach to breeding potatoes for processing will be described and the application of similar approaches to breeding for other end uses discussed.

K. Olsson (Svalöf Weibull AB, Svalöv, Sweden): *Breeding for low glycoalkaloid levels in potato: implications for quality and resistance*

Glycoalkaloids,  $\alpha$ -solanine and  $\alpha$ -chaconine, are natural bitter and toxic substances in potato tubers causing gastrointestinal as well as neurological disturbances in man. The currently recommended upper limit for food safety is 200 mg/kg fresh weight. Genotypic as well as pre- and post harvest factors influence total glycoalkaloid levels.

In years with bad weather conditions, some potato clones which normally have glycoalkaloid levels well below the recommended level will unexpectedly accumulate

toxic levels. Laboratory methods of stressing tubers through exposure to light or mechanical wounding will unveil such field-sensitive material. Analyses of glycoalkaloid accumulation after induced stress in the laboratory thus markedly reduce the number of years needed in field trials.

Insect larvae like wireworms (*Agriotes obscurus*) cause severe quality defects. Varietal differences in wireworm injuries of the tubers are mainly due to differences in glycoalkaloid levels. The insects avoid bitter-tasting potatoes. Selection of clones with high glycoalkaloid levels in the peel but very low levels immediately under the peel will result in tubers with approved total levels and yet good resistance against insect larvae.

K. Zgórska & A. Frydecka-Mazurczyk (IHAR, Jadwisin, Poland): *Quality requirement of potatoes for processing and direct consumption*

The definition of quality depends on the intended use of the potatoes. The most important quality requirements for ware potatoes for human consumption are: external appearance, culinary value and cooking properties. Quality requirements for processing vary according to product and product group. Besides size and shape of tubers, essential factors are: dry matter or starch content, reducing sugar content and, in addition, any tendency of the raw and cooked potato to discolouration. A special problem for processing is the blackspot susceptibility of tubers.

The influence of genotype, climatic conditions during growing season and storage period on tuber compounds (dry matter, starch, sugar, vitamin C, raw and after cooking discolouration, blackspot susceptibility) and processing quality of 50 potato cultivars were examined. From the results of this study, the following conclusions can be drawn:

Dry matter, starch content, raw and after cooking discolouration depend first of all on the genetic characters. Reducing sugar and vitamin C content are influenced by genotype - environment interactions (climatic conditions, storage temperature and the length of storage period). The blackspot of tuber tissue depends on the genotype. High correlation coefficients were found between the blackspot index and the contents of dry matter, starch, phenolic compounds, and electrolyte efflux, enzymatic darkening, and periderm thickness, and point to the existence of a relationship between after-wounding blackspot incidence and biochemical and reological characters of tubers.

B. Putz & L. Weber (BAGKF, Detmold, Germany): *Rapid test procedures for quality assessments of potatoes*

Potato breeding covers several quality aspects. Often focus is given to farming and storage aspects whereas quality criteria of potato utilization are limited. The reason for this is the difficulty of testing breeding lines. To improve these facilities, several

rapid test procedures have been developed or have been optimised during the last few years. A short overview is given of the most important test procedures in relation to the specific utilization of the potatoes. Especially the potato processing industry should be taken into account, because the number of suitable varieties is still very limited.

Common test procedures for raw potato analyses will be described: estimation of dry matter content, nitrate content of tubers, glycoalkaloid content in potatoes, content of reducing sugars, and crude mash discolouration.

*Quality aspects of pretreated potatoes.* In many cases a linear correlation exists between raw potato quality (e.g. crude mash discolouration) and potato product quality. If not, a pretreatment is necessary. But with respect to technological facilities of modern potato processing upscaling often is limited. After cooking darkening leads to unfavourable potatoes and potato products (especially French fries and dehydrated potatoes). Registration is like crude mash discolouration, either visual or instrumental. Taste and texture of cooked potatoes can be determined by using a sensory panel. Next to it there will be described methods to determine the quality of: dehydrated and mashed potatoes, potato chips, and French fries.

Special test procedures of starch potatoes: amylose-amylopectin ratio, and phosphorus content of potato starch.

*Common test procedures in future.* Like cereal and oilseed breeding, potato breeding will also come in contact with chemometric techniques. The high water content of potatoes requires a special preparation. Also the hardware equipment must be optimised. But first results are available: protein content of potatoes (near infrared reflectance (NIR) of mashed or predried and ground potatoes), and dry matter and starch content (NIR and near infrared transmission (NIT) of crude mash).

C. Celis-Gamboa, H. van Eck, P. Struik, R. Visser & E. Jacobsen (Wageningen University, Wageningen, The Netherlands): *Towards the genetic dissection of tuber development*

Tuber formation is a complex but well coordinated sequence of morphological, physiological and molecular events including stolon initiation, elongation, swelling of the stolon tip and set, growth and maturation of tubers. In 1999, a diploid mapping population (N=250) was grown (2 plants/genotype) and harvested at eleven regular intervals from 29 to 140 days after planting to monitor the dynamics of the following traits: plant size; number of main stems and wild stems per plant; flowering stage and berry-set; vine maturity; number of new stolons, length, degree of branching and number of stolon tips showing swelling; size and number of tubers; number of resorbed tubers, weight by size category; specific gravity and yield. Large variation in the timing of stolon formation, stolon tip swelling, tuber setting, flowering and senescence was observed, but all clones followed highly similar sequences of trait development. The data show genotypic differences in the duration of the period between: a) stolon and tuber initiation; b) tuber setting to tuber growth. Stolon

formation ceased before tip swelling and flowering generally preceded maximum swelling, tuber set, and even maximum stolon formation. Single-trait, multi-trait and time-related QTL analysis with anonymous AFLPs and Candidate Genes should improve our understanding of the genetics and gene-expression involved in time-specific processes during tuber development, and their physiological consequences.

C. Gebhardt<sup>1</sup>, E. Tacke<sup>2</sup> & R. Schuchmann<sup>2</sup> (<sup>1</sup>MPI for Breeding Research, Cologne, Germany; <sup>2</sup>BIOPLANT, Ebstorf, Germany): *Achievements of biotechnology applicable at present in potato breeding*

Three areas of biotechnology are relevant for potato breeding: cell and tissue culture, genetic engineering and DNA markers. Cell and tissue culture techniques are being used for the generation of fusion hybrids which have currently a limited role in commercial breeding programmes. Sterile propagation of shoots and meristems for maintenance and fast multiplication of healthy cultivars is well established in practical potato breeding in industrialized countries. Genetic engineering has resulted in first transgenic varieties with resistance to viruses PVY and PLRV or with resistance to the Colorado beetle. These transgenic varieties are cultivated in the US, Canada and Japan but not yet in Europe due to the lack of public acceptance. More transgenic varieties with other properties - modified starch, for example - are in trial phase in Europe and elsewhere. DNA markers have application in cultivar identification and marker assisted selection. DNA fingerprinting is possible with RFLP, AFLP and SSR markers. Genetic factors controlling qualitative and quantitative resistance to pathogens or other agronomic traits have been mapped on potato molecular maps. Currently, however, DNA marker technology is not yet applied in commercial breeding programmes. Problems and perspectives of biotechnology in applied potato breeding programmes will be discussed.

W. Marczewski<sup>1</sup>, A. Talarczyk<sup>2</sup> & J. Hennig<sup>2</sup> (<sup>1</sup>IHAR, Młochów, Poland; <sup>2</sup>IBB PAN, Warszawa, Poland): *Development of SCAR markers linked to the Ns locus in diploid and tetraploid potatoes*

Potato Virus S (PVS) is considered to be one of the most important viruses for potato breeding. *Solanum tuberosum* ssp. *andigena* was found to be a source of the dominant *Ns* gene, which is responsible for the hypersensitive reaction of potato to PVS infection. A RAPD marker OPG17<sub>450</sub> linked to *Ns* (Marczewski et al., 1998, *Plant Breeding* 117, pp. 88–90) was used to develop SCAR (sequence-characterized amplified region) markers. After cloning and sequencing of OPG17<sub>448</sub> new PCR primers were designed to generate dominant (SCG17<sub>321</sub>) and codominant (SCG17<sub>448</sub>) markers. For SCG17<sub>448</sub> polymorphism between susceptible and resistant genotypes was recovered after digestion of the marker with the restriction enzyme *MunI*. The marker SCG17<sub>321</sub> can be used in marker-assisted selection for the *Ns*

locus derived from clone G-LKS 678147/60 in diploid potatoes. However, in tetraploid potatoes, only four out of 7 and three out of 11 resistant clones or cultivars derived respectively from G-LKS678147/60 and clone MPI 65118/3 could be identified with SCG17<sub>321</sub> and SCG17<sub>448</sub>.

H.J. van Eck (Wageningen University, Wageningen, The Netherlands): *The ultra high density map of potato and future applications*

An EU-financed collaborative effort by Wageningen University, INRA, SCRI and CIMA aims to develop a highly saturated molecular marker map of potato. With 400 AFLP primer combinations a diploid mapping population is being scanned for polymorphic AFLP markers. With 25–35 polymorphisms for each fingerprint a sufficient marker density should be reached to allow (1) physical mapping and map based cloning via the BAC landing approach and (2) SCAR marker development for marker assisted breeding.

Novel mapping software has been developed to evaluate the vast amount of data, and to assign markers to genetic intervals (bins) of one recombination unit length. This software (Combin) and some mapping results will be shown. Uneven distribution of AFLP markers along the genetic map is indicative for the ratio physical/genetic distance.

Conversion of AFLP markers into easily handled SCAR markers is essential for the utility of this project. Amplification products, excised from gel, cloned and sequenced allow the design of specific primers. The rate of successful re-amplification of the same locus and the level of polymorphism at the SCAR locus is being studied. DNA markers should result in improved efficiency of potato breeding efforts by marker assisted selection. However, application of DNA markers is limited to a few qualitative traits with monogenic inheritance. More efforts are required to develop suitable diploid mapping populations to identify important loci involved in quantitative traits.

J. Syller (IHAR, Młochów, Poland): *The effects of the interaction between Potato leafroll virus and Potato spindle tuber viroid in doubly infected plants on the viroid transmission by aphids and plant response*

Potato leafroll polerovirus (PLRV) and potato spindle tuber viroid (PSTVd) have common host plants, the potato being a major one. PLRV is readily transmitted by aphids, mainly by *Myzus persicae* Sulz., while it is not mechanically transmissible. PSTVd, unlike PLRV, is transmitted by foliar contact and true seed, but is not aphid-transmissible. However, in doubly infected plants, PSTVd can be encapsidated by the capsid protein of PLRV, the particles so formed being transmissible by *M. persicae*. In our studies, the aphids successfully transmitted PSTVd to potato and tomato cv. Rutgers plants from mixed infections, whereas the viroid was not transmitted from

plants infected with PSTVd alone. The efficiency of PSTVd transmission depended on the potato cultivar used as the source of inoculum or as the test plant, and ranged from 0% to 55%. In some cases, PLRV was found to act as a viroid carrier only, since the infection with PSTVd was detected in aphid-inoculated potato or tomato test plants, but the plants escaped the virus infection. The response of potato plants to the combined secondary infection with PSTVd and PLRV was strikingly more severe than those to infection with either pathogen alone. Also, serious disturbances in sprout emergence were indicative of the double infection.

T. Gavrilenko<sup>1</sup>, R. Thieme<sup>2</sup>, J. Larrka<sup>3</sup> & V.-M. Rokka<sup>3</sup> (<sup>1</sup>VIR, St.-Petersburg, Russia; <sup>2</sup>BAZ, Groß Lüsewitz, Germany; <sup>3</sup>MTT, Jokioinen, Finland): *Identification of the E- and A- parental genomes in interspecific somatic hybrids of potato and their progenies by genomic in situ hybridization*

Genomic in situ hybridization (GISH) was successfully applied to discriminate between parental genomes (E-genome and A-genome) in the somatic hybrids of both *Solanum etuberosum* (+) *S. tuberosum* and *S. brevidens* (+) *S. tuberosum*. GISH was also applied in the analysis of the transmission of the parental chromosomes to the sexual backcross progeny and to the haploid lines (somatohaploids) derived from the hybrids. In general, in both hybrid combinations, chromosomes of the E-genome were more frequently lost than chromosomes of the A-genome.

Prospects for introgression of alien genetic material from the E-genome of wild non-tuberosus *Solanum* species (*Etuberosa* series) into the A-genome of cultivated potato are discussed based on two strategies: subsequent backcross generations derived from sexual crosses between potato (+) *S. etuberosum* hybrids and tetraploid potato breeding lines, and second generation somatic hybrids derived from protoplast fusion between interspecific somatohaploids and dihaploid lines of cultivated potato.

J. Borys (COBORU, Słupia Wielka, Poland): *Some aspects of potato variety assessment in Europe*

In almost all European countries, a potato variety is included on national lists or the EC Agricultural Common Catalogue before its seed can be in trade. Varieties included in the EC Common Catalogue are usually freely marketable throughout the Community. Before registration, each new potato variety proves its Distinctness (D) from existing varieties, sufficient Uniformity (U) and Stability (S) in distinguishing characteristics. The variety must also possess required (respectable) value for cultivation and use (VCU). DUS testing is one of the necessary conditions to establish eligibility for Plant Breeders' Rights (PBR). In most European countries DUS testing of potato varieties is conducted for morphological characters closely following the UPOV guidelines. Within UPOV countries there is close cooperation

in work on harmonization and improvement of guidelines, new methods, techniques and statistical tools used for interpretation of DUS trials data. There is also cooperation among countries in DUS testing of potato varieties. Breeders are now more interested in granting rights on their potato varieties. More varieties are applied to the Community Plant Variety Office in Angers. The statutory potato variety testing for listing is done by independent authorities, organizations, research institutes sometimes in cooperation with other institutions and breeders. The VCU of potato varieties is established by evaluation of such characters as yield, quality characters and resistance to important diseases and pests. The methods proposed by EAPR are used in many countries as a standard. The test of cooking quality is an example going according to the scheme developed by the EAPR.

The EAPR Sections and their Working Groups, especially the Varietal Assessment Group, have worked on the methods of assessment for potato, resistance to potato diseases, and standardisation and harmonization of potato variety testing for many years. The changes in the political and economic systems in all countries, especially in the middle and eastern part of Europe have influenced legislative regulations, breeding, seed industry, potato production, system of marketing and, finally, the variety assessment for listing and PBR. The shortage of adequate government funding influences the size of the testing programme, and the way of carrying out trials and laboratory tests of potato varieties. In some countries there is organized or under organization a special system of post-registration testing. The registered potato varieties are tested in recommended list or descriptive list trials which are advisory for practice. Further international collaboration in variety research work and the exchange of results among the European countries would be very fruitful for harmonization of potato variety assessment in Europe.

R. Wustman (PAV, Lelystad, The Netherlands): *A survey of potato varietal assessment programmes in Europe*

The variation in levels of resistance to late blight (*Phytophthora infestans*) and PLRV (potato leafroll virus) in Western European National Cultivar Lists was shown. A survey held during 1994–96 revealed a wide spectrum of characteristics being recorded in national potato varietal assessment programmes in European countries. The characteristics were subdivided into three categories: agronomical characteristics, quality traits and disease resistances. All programmes assessed agronomical characteristics as foliage development, yield and maturity. Most programmes determined quality traits as cooking type and taste, but only a few programmes assessed for French fry and chipping quality. Susceptibility to common diseases such as late blight, common scab, PLRV and PVY was carried out in over 75%. Resistance to other diseases (i.e. dry rot, early blight) and pests (i.e. *Globodera* spp.) depended to a large extent on national importance.

Many disease resistance assessments were based on recording natural infection although controlled inoculation tests were done for more important diseases.



An important result of the survey was the absence of common methodologies for resistance assessment for major diseases. Although the potato industry has expanded considerably, national programmes still have to anticipate this process of internationalisation. The following four suggestions were made: 1) EAPR must aim at improving the reliability of cultivar testing; 2) testing procedures should be standardized; 3) conducting cultivar testing on a regional instead of on a national basis needs more consideration; and 4) exchanging information on specific characteristics must be explored.

K.M. Świeżyński, M. Chrzanowska, L. Domański & E. Zimnoch-Guzowska (IHAR, Młochów, Poland): *Resistance to Potato Virus Y and tuber resistance to Phytophthora infestans evaluated in potato varietal assessment of five European countries*

Results have been compared of varietal assessment of both these characters in France, Germany, Great Britain, The Netherlands and Poland. In total 75 varieties were available, evaluated in more than one country. All evaluations were expressed or could be transformed into 9-grade scale of increasing resistance. Some evaluations did differ considerably. This was due to two main reasons: countries differed in severity of evaluation and the relative resistance level ascribed to individual varieties depended on the country. Differences between countries in severity of evaluation could exceed two grades in resistance to PVY and three grades in tuber resistance to *P. infestans*. In the relative resistance ascribed to individual varieties the difference between countries were still larger, reaching up to 6 grades in evaluation of resistance to PVY and up to 8 grades in evaluation of tuber resistance to *P. infestans*. It is concluded that more consistent varietal assessment results from various countries could be obtained, if agreed common standard varieties were agreed and if more consistent evaluation methods were applied.

M.F.B. Dale<sup>1</sup>, G.R. Mackay<sup>1</sup>, J.E. Bradshaw<sup>1</sup>, D. Todd<sup>1</sup> & A. Murdoch<sup>2</sup> (<sup>1</sup>SCRI, Dundee, UK; <sup>2</sup>Gordon & Innes Ltd, Elgin, UK): *Stability of low temperature processing characteristics across a range of European environments*

Approximately 30% of potatoes in the European Union are processed. The processing industry is forecasting a 4–5% per annum expansion in the tonnage of potatoes processed over the next five years, this increase being predominantly in the frozen/chilled market. At low storage temperatures to prevent sprouting, tubers accumulate sugars, particularly the reducing sugars fructose and glucose, with levels being dependent on environmental and inherited factors. This low temperature sweetening is a major problem for the potato processing industry. When tubers with relatively high reducing sugar contents are processed, a Maillard reaction between the reducing sugars and certain amino acids occurs, resulting in unacceptably dark and bitter tasting products. Consequently, the processing industry relies on storage

over long periods at higher temperatures (c. 8–10 °C) to avoid this problem. Such storage conditions result in increased storage costs, disease problems and necessitates the use of chemical sprout suppressants. By extrapolation, an estimate of the overall costs to the European industry could be approximately 18 million Ecu per annum.

An EU-funded (CRAFT) 2-year research project is investigating a range of unique potato germplasm which exhibits the potential to process after c. 3 months storage at low temperatures. The project assesses the stability of important attributes including dry matters, reducing sugar levels and processing qualities over a range of diverse environments in Europe. Material is assessed post-harvest and following three months storage at 4 °C and at 10 °C. Results indicate a degree of interaction between the genotypes and the growing environments but that it is possible to select relatively stable genotypes with good processing qualities post-storage.

R. Ruiz de Arcaute, A. Carrasco & S. Isla (APPACALE S.A., Burgos, Spain): *Potato breeding in APPACALE S.A. - Castilla y León (Spain)*

At present, Castilla y León, an autonomous region in the north-centre of Spain, is one of the main potato producer areas in Spain. In the scope of ware potatoes, a slight acreage increase during the last 5 years combined with a rise of productivity per area unit, has led to the production of about 1,000,000 t in 1999. This is almost 30% of total potato production in Spain. Furthermore, the northern part of the region is now the principal area producing seed potato in Spain and has practically maintained a constant area of 2,800 ha for the last five years, which is 70% of the total area of Spanish seed potato production.

The importance of this crop and the great dependence in our country on imported seed potato and varieties have directed the work of APPACALE S.A. to the creation of new varieties. The company is owned by the most important cooperatives of seed potato production in the region and the local government Junta de Castilla y León. From 1993 APPACALE S.A. has made an important effort to modernize the breeding programme and now combines a conventional breeding system with the support of biotechnology in order to obtain varieties for the ware market or industrial processing (chips or frozen fries) with virus resistance, especially to PVY. An overall picture of the work will be presented.

B.Y. Anoshenko (IGC, Minsk, Belarus): *Local adjustment method for field experiments*

Spatial variation is caused by heterogeneous environmental factors, such as soil heterogeneity, uneven application of fertilisers, temperature, humidity, light, and interactions between neighbouring plots etc. An application of the local adjustment FIELD-method, which has sufficient precision for evaluating spatial heterogeneity, considerably increases the reliability of estimates in all kinds of experiments over a

wide interval of spatial heterogeneity. This is the case even with a small number of replications or with unsuccessful randomisation. It can be used not only for common quantitative characteristics but, also, for evaluation of resistance to diseases, expression of which depends on environmental factors (for example, late blight). Therefore, for all field experiments that have fulfilled the necessary requirements, the FIELD-method is recommended as an obligatory statistical procedure prior to data analysis. Adjustment of the data resulted in: (a) more accurate estimation of the mean value of individual clones, (b) more precise estimation of variances and deviation SS and MS from ANOVA, (c) more stringent analysis of progeny segregation, and (d) simplified selection of appropriate G×E analysis methods. Alternatively, the procedure can be used to estimate the spatial heterogeneity of experimental fields. A software application was developed for convenient computation of spatial adjustment in individual data sets. It may be requested via email for non-commercial use.

U. Darsow & H. Tiemann (BAZ, Groß Lüsewitz, Germany): *Dihaploid potato breeding for French fries after cold storage*

Breeding for processing potatoes to French fries includes a complex of traits: discolouration after frying, long oval tuber shape, large tuber size, a starch content of 16% or more, and at least an acceptable taste of tubers. Our efforts for this purpose have been intensified since 1991. The frying test for discolouration includes blanching of tissue rods, followed by frying in fat at 180 °C in two steps. Clones with suitable potato colour of scores 6–9 were stored at 4 °C for at least 4 months and tested directly from cold storage. A two-years experiment with >100 clones showed that between 4 and 9 months of storage at 4 °C there was little change in fry colouration. Thus, the shorter storage period has experimentally been applied since 1993.

At the beginning of the breeding programme the whole range from 1 to 9 for discolouration was encountered. Since 1995 genotypes with scores 1 to 3 (very brown to brown) were eliminated by preselection after harvest. Sources of processing quality were partly clones from variety breeding at the Institute for Potato Research, Groß Lüsewitz. As a result of widening the genetic basis of dihaploid breeding in the seventies genes for cold storage compatibility were introduced from *S. phureja* and *S. ehrenbergii*. Fries colouration of a clone varied over 3 to 4 years up to 4 scores with a standard deviation of 1.2 and lowest significant difference for clone comparison of 2.3 scores. The mean value of the parents correlated with that of single progeny clones with  $r=0.61$ . Between the mean value of fusion families and the mean of fusion partners correlation coefficient was  $r=0.87$ .

M. Bonierbale, E. Mihovilovich, L. Salazar & W. Amoros (CIP, Lima, Peru): *Breeding value for resistance to potato leaf roll virus in native and improved germplasm sources*

Potato leaf roll virus (PLRV) is a main cause of tuber seed degeneration and crop loss. While the availability of resistant varieties would be the most attractive option for control of this disease, the number of resistant selections is often small, considering the large amount of materials tested in programmes with this objective. Further, resistance to infection has been overcome under heavy aphid pressure, indicating that levels of resistance are not very high. Higher degrees of resistance, sufficient to reduce or prevent virus infection, have been reported in wild and cultivated relatives of potato, but these have not yet been fully exploited in applied breeding programmes. We report the results of a study of the potential of *S. tuberosum* ssp. *andigena*, and the integration of family and clonal screening methods, to enhance the efficiency of breeding for this trait in our programme. *Andigena* was found to be a valuable source of high levels of resistance; and the high heritability of resistance to infection observed indicates that progress in increasing the frequency of PLRV resistance in this population can be expected when selecting resistant genotypes. Complementary studies to determine the parental value of improved, resistant varieties/clones have also been conducted in contrasting agroecologies where viruses are primary production constraints, lending confidence to off-site selection in the context of a global breeding programme.

D. Levy, Y. Itzhak & E. Fogelman (The Volcani Center, Bet Dagan, Israel): *Breeding potatoes for Mediterranean climates*

In regions such as the Mediterranean region, the climate is semi-arid and arid in most areas, and major obstacles for potato production are the high temperatures and the limited availability of water. Temperatures over 35 °C during noon time are common in the spring and summer seasons, and when combined with mean night temperatures of ca. 20 °C, it is detrimental to the yield and the quality of most cultivated potatoes.

These limitations forced the potato production in the warm regions into the cooler winter season and dictated shorter growing periods, usually 80–120 days. This combination of cool short days, occasional cloudiness, limited water supply and shorter growing season, resulted in lower yield potential even when good growing practices were employed, including adequate irrigation and fertilization. Hence, there is an ongoing effort in the search for potatoes with improved adaptation to warm-dry climates. To achieve this goal, breeding should be conducted locally in the target areas, including the choice of parents and all the selection procedures.

In Israel, procedures for assessment of parental material and for the identification and selection of heat tolerant genotypes in seedling populations were developed and practised. In addition, sources for heat tolerance from primitive and wild *Solanum* should be identified and incorporated into the breeding material. In our case in

Israel, a cooperation was established through various projects with CIP, the Netherlands and the U.S. Wild types were incorporated into the research, a breeding programme was established, and heat tolerant clones were developed.

However, the incorporation of wild types could cause elevated glycoalkaloid content. Since the test of glycoalkaloids in tubers is laborious and expensive, molecular markers for this trait are sought to assist in selection of heat tolerant clones with low content of alkaloids in tubers. We also realised that leptin, a glycoalkaloid which occurs only in leaves, is a good candidate to be utilized as an insect repellent in the potato. So, in the process of developing better cultivars for warm climates, a reduction in the use of insecticides might be gained for the benefit of growers and consumers.

The richness of the genetic diversity of the potato provides for the development of varieties capable of growing in Alaska in the north as well as in the African Sahara.

The success of breeding varieties in India and South Africa and the development of local varieties demonstrates that such achievements can be obtained elsewhere in the world, and the potato can play an important role as a major staple food in diverse climatological regions.

A.P. Yermishin (IGC, Minsk, Belarus): *Development of potato genotypes at the diploid level, useful in breeding for disease resistance*

Dihaploids of *Solanum tuberosum* or other advanced cultivated diploid genotypes may be used to introduce desired genes from wild species. Such genotypes should have a good combination of agronomic characters, high fertility (as male and female parents), and the ability to produce fertile offspring. They should also possess the mutated genes for self-compatibility and the formation of  $2n$ -pollen (fs) or  $2n$ -eggs (os). A breeding programme for the production of such genotypes is in progress at the Institute of Genetics and Cytology in Minsk, Belarus. It includes: (1) the breeding of donors of fertility and self-compatibility, (2) the breeding of donors of meiotic mutations fs or os, resulting in  $2n$ -gamete formation, (3) the breeding of donors of fertility, self-compatibility and  $2n$ -gamete production on the basis of selected genotypes from the previous stages and (4) the breeding of genotypes on the basis of different initial *S. tuberosum* dihaploids and selected genotypes from stage (3) (backcrossing and selfing).

E. Zimnoch-Guzowska (IHAR, Młochów, Poland): *Research programme realised at Młochów Research Center, IHAR - general information related to the visit at Młochów*

The Plant Breeding and Acclimatization Institute (IHAR) is the largest agricultural research institute in Poland. In 1997 the Potato Research Institute was fused with IHAR. IHAR's research in plant breeding and seed production of Poland's main field crops is realised in six research centres and several experimental farms.

In the IHAR Młochów Center, in the Department of Potato Genetics and Parental Lines 4x and 2x parental lines are being developed for all Polish potato breeders. In their development, emphasis is placed on table and processing quality, starch content and resistance to viruses, *P. infestans*, nematodes and wart. More than 1,800 tuber samples of 4x parental lines have been provided to potato breeders during the past 30 years. Over 45% of the Polish advanced breeding clones have originated from this work leading to 32 released cultivars. At the IHAR Młochów Center combining abilities of potential parents for potato breeding programmes are evaluated. In the center, all Polish breeder's advanced selections are evaluated for virus resistance. An in vitro and field collection of potato germplasm (2x and 4x) of about 800 genotypes is maintained at Młochów. Studies on the biology of potato pathogens, including viruses, with special attention to their new pathotypes are being carried out. The variation in the *P. infestans* populations from various parts of Poland is being monitored. The potato pathogen collection of viruses and *P. infestans* is maintained at Młochów. Methods applicable for resistance breeding, including transgenic approach, are studied. Improvements in diagnostic tests and screening methods are an important part of germplasm evaluation and technology development. Preliminary studies are conducted on mapping and marker assisted selection (MAS) in potato and an application of PCR for diagnostics of pathogens. Training courses are organised for breeders, seed producers, seed inspectors and potato growers.

The research is realized in five laboratories by scientific staff comprising one Professor, one Associate Professor and seven researchers with a Ph.D. degree. Experiments are conducted in greenhouses (1600 m<sup>2</sup>), screenhouses, climatic chambers, 5 laboratories and ca 10 ha of experimental fields.

## POSTERS

A.J. Hilton, S.L. Linton, H.E. Stewart, M.J. Nicolson & A.K. Lees (SCRI, Dundee, UK): *Breeding for resistance to skin blemish diseases*

Silver scurf (*Helminthosporium solani*), black dot (*Colletotrichum coccodes*) and black scurf (*Rhizoctonia solani*) are important blemish diseases of potatoes. Symptoms caused by these diseases all result in deterioration of skin quality which is important to the fresh pre-pack market. Despite these diseases being common in the field and in storage, little information is available on host resistance.

Repeatable tests for identifying resistance to black dot and black scurf among commercial cultivars have been developed in the glasshouse using plants grown in a mixture of compost and inoculum. Plants were grown to maturity to allow for setting of tubers, before being harvested and visually assessed for disease (0–24 scale). Significant differences for disease severity between cultivars were observed following inoculation with black dot and black scurf. Severity of black dot varied from 1.6 (cv. Shelagh) up to 13.3 (cv. Estima), whilst black scurf severity varied from 0.4 (cv. Shelagh) up to 7.5 (cv. Marfona).

A test for resistance to silver scurf has been developed using tubers dipped in a spore suspension before being placed in a growth cabinet set at 15 °C and 90% relative humidity for 1 month and 80% humidity for a further month. After 3 months significant differences between cultivars in disease severity score (range 0–24), ranging from 4 (cv. Désirée) to 15 (cv. Estima) were seen.

These tests can now be used to understand the inheritance of resistance among cultivars of *Solanum tuberosum* and to find superior sources of resistance amongst wild species of potato.

G. Bebre & B. Kalnina (Priekuli Plant Breeding Station, Cesis, Latvia): *Different hybridization progenies resistance to late blight diversity evaluation in epidemic conditions*

*Phytophthora infestans* is an agent of the most feared disease of potatoes in Latvia. Late blight is the most dangerous disease especially in summers when weather is medium wet. From observations over many years *P. infestans* usually appears in the beginning of July. It is time when potatoes start to blossom. So early infection decreases potato yield significantly. Successful late blight control depends on a proper plant protection system and resistance of hybrids. One of the aims of potato breeding is to breed cultivars resistant to *P. infestans*.

The infection level of progenies was analysed from several crossing combinations in 1998. Wide epidemic development of *P. infestans* occurred in this year. The development of late blight was evaluated visually in field conditions every 10 days. The first symptoms of disease were found on 4th July in the field.

Different maturity and resistance to late blight crossing combinations were analysed. Combinations, where one of parents had been relatively resistant, had progenies with higher resistance (0–30% of damaged foliage). More resistant progenies had cross combination 91-96.2 × Quarta - 33.1%. This cross combination had the smallest amount of progenies sensitive to late blight - 30%. In crossings of early cultivars the level of resistance to *P. infestans* was very low. The largest amount of sensitive progenies was obtained from cross combination where one of parents was cv. Impala - from 93.6% till 94.7% of progenies. Better results occurred if early maturity cv. Ausonia had been used as parent.

A.A. Podgaetsky (Institute for Potato Research, Nemishaevo, Ukraine): *To create potato starting breeding material resistant to late blight*

Taking into account the absence of effective genes controlling foliage and tuber resistance to late blight in the genome of *S. tuberosum* varieties, it is considered necessary to introgress them from wild and sometimes from cultivated species. We developed the following scheme: studying the reaction norm of potato genotypes to growing under certain ecological-and-pathogen conditions in order to select forms

with high phenotypic expression of resistance to late blight; establishing the effectiveness of the genetic control of the character, selecting and creating resistance sources for subsequent forming of a germplasm collection; overcoming barriers to interspecific crossability, establishing genetic control of  $F_1$  resistance to late blight; determination of optimum schemes for primary hybrid involvement in subsequent crossing, selecting forms with effective genetic control of  $F_1$  resistance to late blight; selection of varieties and intervarietal hybrids ensuring successful fulfilment of crossings but not effecting negatively on late blight heredity; and ascertaining regularities of the main agronomic character heredity by multispecific hybrids backcrossing, selecting donors for resistance to late blight and other characters.

After artificial inoculation of 66 wild potato species with late blight, promising sources of resistance to tuber late blight were selected. It was established that the resistance to fungus penetration is a limiting constituent of the character. High expression (point 9) of resistance was found in *S. bulbocastanum* and *S. capsibaccatum*. Individual self-pollinated seedlings with analogous expression of the character were split off in some other species.

The following sources of resistance to late blight were created during the process of homozygotization: UK 27-41-11c2, UK 27-41-11c7, UK 27-41-21c4, UK 27-41-21c6, UK 27-41-21c9, UK 27-41-21c30, UK 27-41-21c32, UK 27-41-21c42, UK 27-29c1 of *S. demissum* species; UK 16-1, UK 16-5 - *S. bulbocastanum*; UK 100-3 - *S. antipoviczii*; UK 82-34, UK 82-22, UK 82-22-6-23c34 - *S. stoloniferum*.

Primary and secondary interspecific hybrids with very high expression of the character, which were not inferior to the starting species were obtained. New breeding material involving 4 to 6 species, including *S. bulbocastanum*, was created in the process of backcrossing the best of the hybrids. The best hybrids exceeded the best standard varieties in foliage and/or tuber resistance to late blight by 2–4 times. Multiple backcrosses with group resistance to 5 to 7 pathogens were selected. Some of them have high expression of other agronomic characters.

H. Zarzycka, R. Lebecka & S. Sobkowiak (IHAR, Młochów, Poland): *The stability of resistance against local populations of Phytophthora infestans in Polish potato cultivars*

The stability of resistance to *Phytophthora infestans* of 14 resistant potato cultivars planted in four naturally infected potato fields was assessed in 1998–1999. The local *P. infestans* populations were characterized with respect to virulence, race diversity, aggressiveness and mating type. We did not state differences with respect to virulence factors and level of aggressiveness among isolates collected at different dates, but the races were much more complex at the end than at the beginning of the vegetation period. The races of *P. infestans* were characterized by a high degree of diversity. The presence of oospores in naturally infected potato plants may be an indication that in all investigated plantations there is a high possibility of occurrence of a generative propagation of *P. infestans*.



The ranking of cultivars in relation to their resistance to *P. infestans* was similar in all the four plantations during the two-year experiment. In principle the infection of cultivars was related to the known level of their resistance. It is concluded that resistance to *P. infestans* of Polish potato cultivars in last two years was not overcome.

R. Lebecka (IHAR, Młochów, Poland): *Resistance to tuber soft rot (Erwinia carotovora ssp. atroseptica) in unselected potato progenies obtained from 4x-2x crosses*

Twenty four unselected tetraploid potato progenies derived from factorial crosses of eight 4x females with three 2x males (sources of resistance to soft rot bacteria), were evaluated in 1999 for tuber resistance to *Erwinia carotovora ssp. atroseptica* (Eca). Parental forms and three standards were evaluated together with the progenies. From 53 to 60 clones were evaluated in individual progenies.

Both GCA and SCA contributed to the inheritance of potato tuber resistance to Eca. Among the 11 tested parents three, the most resistant, were characterised by high GCA: DG 88-9, DG 94-112 and cv. Glada. Among 1394 clones from 4x-2x crosses, 318 showed a higher level of resistance than the most resistant cv. Glada and 116 combined good resistance with agronomic performance (yield of tubers at least 1000 g/plant, good shape of tubers and shallow eyes).

The narrow sense heritability for potato tuber resistance to soft rot was  $H^2_n = 0.29$ , based on regression of progeny on parents. The significance of the SCA variance implies that a considerable part of the heritable variation must have been due to non-additive effects and tuber resistance to soft rot of a progeny cannot be adequately predicted from its parents phenotypes. In such a case it is suggested to make preliminary progeny testing.

The evaluation for resistance to Eca will be repeated next year, as it is known that it is greatly influenced by environmental factors.

P. Petr & J. Pavlas (PRI, Havlickuv Brod, Czech Republic): *Testing of potato genotypes with field (horizontal) resistance against late blight (Phytophthora infestans)*

Field (horizontal) resistance to potato late blight (*Phytophthora infestans*) in potato genetic material at tetraploid level was evaluated. Based on the international co-operation of the Potato Research Institute Havlickuv Brod (Czech Republic) and International Potato Centre (CIP, Lima, Peru) true potato seeds were obtained from the South American region. In cross combinations obtained there was presupposition of high level of field resistance to late blight, because the same combinations were successfully tested in localities with the highest infection pressure (Rio Negro in Columbia and Toluca in Mexico). First, there was carried out testing of introduced cross combinations for quarantine diseases PSTVd (*Potato spindle tuber viroid*), APLV (*Andean potato latent virus*) and APMV (*Andean potato mottle virus*). The occurrence of these diseases was not detected. Field resistance to *P. infestans* was

evaluated using a field test. Clones were tested in plot non-treated with fungicides. For providing uniform and optimum infection pressure in the whole experimental plot, the late blight susceptible variety, Lukava, was used as spreader. Selected registered varieties were included in the trial as controls for comparison. At regular intervals during plant growth, the occurrence of foliage late blight was observed. Evaluation was carried out based on percentage leaf area infection using 9-point scale (1 - susceptibility to late blight, 9 - the highest resistance to late blight). As a further criterion for field (horizontal) resistance to *P. infestans* AUDPC values (Area Under the Disease Progress Curve) were measured. In the first testing year (1998), 387 tetraploid potato clones and 5 control varieties with different length of growing period were evaluated. Next year (1999), 533 clones and 19 control varieties (210 clones from previous period and 323 new ones) were evaluated. All clones originated from 71 different crosses. The most promising cross from the viewpoint of level of field resistance to late blight was 96.76 (39 32 14) with parentage 387415.7 × 389746.2, from which there were obtained 3 of the most resistant clones (96.76/4, 96.76/18 and 96.76/30). A further promising cross was 96.78 (39 31 1) with parentage 386209.10 × Libertas. Following two years of testing 90 clones were selected with the highest level of field resistance to late blight, which will be further studied. These clones were found to be well adapted to the long-day conditions of the Czech Republic, but they are susceptible to virus diseases. As most genotypes possess a longer vegetation period, it is required to utilize earlier breeding stock in hybridizations with them.

G. Zguromsky (BNDIB, Samokhvalovich, Belarus): *Screening for late blight resistance as a part of potato breeding programme*

Particularities of potato biology allow assessment of resistance to late blight at different stages of ontogenesis. Also it is possible to fulfil in vitro tests during interseasonal period.

In seedling generation, the greenhouse tests are preferable for preliminary selection of resistant genotypes. Artificial or natural conditions with high pressure of infection are recommended in later tuber generations. The most promising results were obtained to make artificial conditions for selecting blight resistant individuals by using sporangia of *Phytophthora infestans* cultivated on aseptic rye grain at density not less than  $2 \times 10^4$  conidia/ml.

Susceptibility of tubers to causal agent of *P. infestans* changed during ontogenesis. Optimal conditions for tuber inoculation and further selection of resistant clones appeared to be at the beginning of storage. A new screening technique based on the rate of leaf blight development for identification of genotypes with superior resistance is proposed.

V.G. Ivanyuk (BNDIB, Samokhvalovich, Belarus): *Pathotypes of fungi caused potato diseases and breeding resistant cultivars*

More than 60 species of fungi cause potato diseases in Belarus during vegetation and storage. The most dangerous of them are *Phytophthora infestans*, *Alternaria solani*, *Rhizoctonia solani*, *Geotrichum candidum* and *Fusarium* species.

The diversity of pathogens populations has been studied for 10–15 years. As a result 344 races and two mating types ( $A_1$ ,  $A_2$ ) of *P. infestans* were differentiated. The population of *R. solani* is represented by 3 anastomosis groups, *A. solani* - by 5 races. Dry rot is caused by 7 *Fusarium* species.

Effects of cultivated varieties and environment on qualitative and quantitative changes of pathogen populations were the most considerable. Intraspecific diversity of pathogens is to be used as a factor of assessment in breeding resistant cultivars.

I.M. Yashina & Y.A. Simakov (VNIIEKH, Korenevo, Russia): *Methodological aspects of potato breeding for field resistance to Phytophthora infestans*

The efficiency of screening for resistance to *P. infestans* was studied when two different methods of inoculation were applied. Nine hybrid populations were used for the study, each containing 1200–1300 seedlings. At the stage of 5–6 true leaves, two thirds of the seedlings were inoculated with the suspension of *P. infestans* zoospores; one third of them remained uninoculated and served as a control. In the first tuber reproduction the hybrids of both groups were assessed for their resistance by inoculation of detached leaves taken from the plants in the field.

It was found that in the group with inoculation the proportion of late maturing forms had increased (average 18.4% in comparison to the control), and alongside the high proportion of resistant forms (mark is  $\geq 7$ ) there remained 15–22% of susceptible genotypes. The average frequency of selection was the same in both groups, i.e. 11.7 and 11.9%.

In the second tuber reproduction the results of the selection in the group with inoculated seedlings appeared to be lower as compared to the control (0.22 and 0.94% of the initial number of seedlings, respectively). The average resistance of the selected hybrids was the same as that of the population.

Thus the method of inoculation of detached leaves is more effective for screening for the resistance to *P. infestans*. When seedlings are inoculated some valuable genotypes are eliminated and a large proportion of susceptible forms remains because of the age resistance. The method of inoculation of detached leaves can be used for the investigation of inheritance of field resistance to *P. infestans*.

While evaluating 14 hybrid populations it was established that this feature is controlled by polygenes with additive effect which is witnessed by transgressions for resistance and by direct correlation between the average level of resistance of the parental forms and that of the progeny ( $r=0.77$ ). Regular selection of transgressions can result in a significant rise in the level of resistance of the breeding material.

A. Kryszczuk<sup>1</sup>, M. Pakosińska<sup>1</sup>, R. Lebecka<sup>1</sup>, E. Zimnoch-Guzowska<sup>1</sup>, N. Zoteyeva<sup>2</sup> & M. Chrzanowska<sup>1</sup> (<sup>1</sup>IHAR, Młochów, Poland; <sup>2</sup>VIR, St.-Petersburg, Russia): *Resistance to PVX and PVY in 49 accessions of 15 wild Solanum species from the VIR potato collection in St. Petersburg*

As an element of the project "Collaborative Research with Russian Scientists to Enhance Potato Late Blight Resistance Mediated by Poland's Plant Breeding and Acclimatization Institute (IHAR)" 49 accessions of 15 wild *Solanum* species were tested for resistance to PVX and PVY at the Młochów Research Center, IHAR.

Thirty young seedlings per accession were inoculated with PVX<sup>o</sup> from cv. Osa using a spray gun. From 16 to 30 two-week old seedlings per accession were mechanically inoculated with three strains of PVY: PVY<sup>o</sup> LW, PVY<sup>N</sup> Wi, PVY<sup>NTN</sup> 12/94. Plants were tested serologically (ELISA) and external symptoms were evaluated till maturity.

Five accessions of *S. acaule* were fully resistant to PVX, and two accessions of *S. acaule* and *S. guerreroense* had about 60% resistant plants. All the remaining accessions were susceptible to PVX.

Four accessions of *S. stoloniferum* were extremely resistant to PVY. In all the accessions of *S. ajuscoense*, *S. chacoense*, *S. demissum*, *S. guerreroense*, *S. michoacanum*, *S. parodii*, *S. pinnatisectum* and *S. verrucosum* were found both resistant and susceptible plants to PVY<sup>o</sup> LW and PVY<sup>N</sup> Wi. The resistant plants usually expressed a necrotic reaction. When inoculated with PVY<sup>NTN</sup> all the plants of these species resistant to other strains of PVY were found to be susceptible. The remaining accessions were susceptible to the all strains of PVY: all accessions of *S. acaule*, *S. fendleri*, *S. papita*, *S. polytrichon*, *S. ruis-ceballosi*, *S. ujujense* and a part of accessions of *S. demissum*, *S. stoloniferum* and *S. pinnatisectum*.

M. Chrzanowska<sup>1</sup> & T. Doroszevska<sup>2</sup> (<sup>1</sup>IHAR, Młochów, Poland; <sup>2</sup>IUNG, Puławy, Poland): *The role of PVY strains collected from tobacco and potato in the evaluation of potato resistance to PVY*

Based on serological detection, cytological studies and on the reaction of three potato cultivars it was found that the tobacco strain PVY<sup>N</sup> I is related with PVY subgroup represented by PVY<sup>N</sup> Wi. The tobacco strain Y<sup>NZ</sup> is similar to PVY<sup>N</sup> Ny (but it infects potatoes very rarely) and the tobacco strain PVY<sup>N</sup> III belongs to PVY<sup>NTN</sup>. Three PVY isolates were collected in 1999 from tobacco: PVY<sup>N</sup> Gr (from the tobacco field near Grudziądz city), Y<sup>N</sup> Wa and Y<sup>N</sup> Ha. The last two isolates break the resistance to PVY in tobacco cultivars Wislica and Havesi.

The aim of studies is the characterisation of the reaction of potato cultivars to six PVY isolates collected from tobacco plants and to six isolates from potatoes (four Polish isolates: PVY<sup>o</sup> LW, PVY<sup>N</sup> Ny, PVY<sup>N</sup> Wi, PVY<sup>NTN</sup> 12/94 and two French isolates belonging to PVY<sup>N</sup> similar to the strain PVY<sup>N</sup> Wi).

Five cultivars differing in the level of resistance and in disease symptoms were

chosen for the studies: cv. Rywal (resistant with severe necrotic reaction), cvs Jagoda and Perkoz (moderately resistant with mosaic or chlorotic symptoms), cv. Vital (sensitive to PTNRD) and cv. Baszta extremely resistant to PVY.

External symptoms (local, systemic) were observed till maturity of plants. A serological test (ELISA) was made in 4<sup>th</sup> and 6<sup>th</sup> week after inoculation. Cv. Baszta expressed resistance to all the tested isolates of PVY. In the remaining cultivars reaction to PVY was strain dependent.

I. Wasilewicz-Flis, J. Syller & B. Flis (IHAR, Młochów, Poland): *Some aspects of the interactions between potato plants and Potato leafroll luteovirus (PLRV)*

At Młochów Research Center routine selection of potato clones resistant to potato leafroll virus (PLRV) is performed. It was found that final evaluation of resistance levels of potato clones may be influenced by several factors besides resistance itself.

Plants of six potato genotypes were inoculated with two different PLRV isolates (L7 and a new isolate designated "1457") by two methods (by aphids and grafting). The virus inoculum came from plants of three potato genotypes (diploid clone DW84-1457, cvs Osa and Sokół).

All those factors influenced evaluations of resistance. The method of inoculation affected our evaluations only in primary infection, since a significantly greater number of plants showed infection after inoculation by aphids than after grafting. The significant effect of virus donor on resistance evaluation was also observed. The highest number of infected plants occurred when plants of cv. Sokół were virus donor.

The proportions of plants infected with both isolates used were similar, but significance of specific virus × potato genotype interactions was found. Such type of interaction indicates the difference in the level of virulence of the PLRV isolates used in the study.

P. Felczak<sup>1</sup>, G. Garbaczewska<sup>1</sup> & M. Chrzanowska<sup>2</sup> (<sup>1</sup>SGGW, Warszawa, Poland; <sup>2</sup>IHAR, Młochów, Poland): *Cytological studies of PVY transport in potato plants inserted by grafting between tobacco plants*

The aim of the experiment was to determine pathways and forms of potato virus Y (PVY) transport in inserts of potato cultivars varying in resistance level to this virus grafted on tobacco plants.

Scions of tobacco plants of cv. Samsun infected with PVY<sup>N</sup> Wi were grafted with inserts of two potato cultivars: susceptible - Glada or resistant - Ania. The scions, inserts and new potato shoots were tested by ELISA. Presence of PVY was confirmed in tobacco infector plants and potato inserts but was not identified in new potato shoots of both cultivars tested.

PVY particles and cylindrical inclusions were found electron-microscopically in

parenchyma cells and vascular tissue (phloem and xylem) of infectors and inserts as well as in new shoots of potato cv. Glada. In new potato shoots of cv. Ania, extremely resistant to PVY, only internal necroses were found.

G. Garbaczewska<sup>1</sup>, M. Chouda<sup>1</sup> & T. Muchalski<sup>2</sup> (<sup>1</sup>SGGW, Warszawa, Poland; <sup>2</sup>IHAR, Młochów, Poland): *Cytological studies of TRV transport in potato plants inserted by grafting between tobacco plants*

The aim of the experiment was to determine pathways and forms of tobacco rattle virus (TRV) transport in potato inserts of cultivars varying in resistance level to this virus.

*Nicotiana tabacum* cv. Samsun plants were infected with TRV isolate PSG and they were grafted with inserts of potato plants: cv. Fala resistant or cv. Sokół susceptible to TRV. Healthy plants of *N. tabacum* made up the stocks.

Location of virus particles in cells of parenchyma and vascular tissue of the infector, insert and stock was investigated using cytological methods. The assay to explain in which form the viral factor is translocated in the plant will be discussed.

K. Treder & J. Lewosz (IHAR, Bonin, Poland): *Detection of PLRV and PVY in dormant potato tubers by cocktail and amplified ELISA assay*

Exact knowledge about the health status of potatoes is very important, especially for inspection of plants designated to gene bank, seed tubers indexation and determination of plant resistance against viruses. We observed that potato plants that have very low concentration of viral particles might be incorrectly qualified as virus free by DAS-ELISA. Cocktail-ELISA more properly determined health status of the same potato plants. Linked sap and conjugate incubation step makes Cocktail-ELISA faster than DAS-ELISA. Moreover results obtained suggest that this method could be used reliably to detect PLRV and PVY directly in tuber sap. Modification of Cocktail-ELISA by additional step of microplate blocking by gelatin and by using AmpliQ DKK 1452 (DAKO, Denmark) to amplify alkaline phosphatase activity makes the method 40-times more sensitive than DAS-ELISA. In this way it was possible to detect PLRV in 200-times diluted sap from dormant tubers. This kind of assessing the virus health status of potato plants seems to be faster and cheaper than presently used procedures because propagation of the plant in glasshouse might be omitted.

A.I. Uskov, V.P. Kniazeva & Y.A. Varitsev (VNIKKH, Korenevo, Russia): *Development of ELISA test-system for determining tobacco rattle virus (TRV)*

For the last decade the spread of viruses that earlier were not typical for potato production in Russia is progressing and becoming a problem, for example, tobacco rattle virus (TRV) spread with nematodes of 20 species of *Trichodorus*. TRV is widely spread all over the world. According to the data of Parasitology Institute of Russian Academy of Sciences in the Moscow area many varieties were infected by TRV from 20 up to 55%. In the 1980s, a large study on the aetiology and diagnostics of TRV was conducted in the All-Russia Potato Research Institute. The aim of our activity was to create the ELISA diagnostic test-system for determining TRV, using information material from the previous researches. With this purpose in 1997–1999 the following activity was conducted: the isolations of a virus in natural conditions were chosen; the accumulation of TRV on plants-stores was conducted; high-purified virus preparation was obtained; immunization of animals was conducted and antiserum obtained with specific titer - 1:512000 in indirect version of ELISA with conjugate protein A-phosphatase (the nonspecific titer was 1:1000); the specific antibodies were chosen which were conjugated with peroxidase of horse radish; the check of the test-system on preparations and vegetative material was conducted; the experimental sample of ELISA diagnostic set to TRV was prepared; the tests of a diagnostic set under production conditions were conducted.

As a result the test-system ELISA with sensitivity of TRV determination - 30 ng/ml was created. At testing of vegetative material the maximum dilution of plant extract giving the possibility to register the immune-chemical reaction reliably was 1:12800. Thus the background responses at testing of heterologous virus and juice of leaves of healthy plants of potato have low values ( $A_{450} < 0.05$ ), that allows us to make a conclusion about rather high specificity of obtained ELISA test-system.

I. Skrabule (Priekuli Plant Breeding Station, Cesis, Latvia): *Relationships of potato traits determining French fries quality*

The potato germplasm collection was investigated over three years (1996–1998) with the purpose to select suitable parents for developing potato clones adapted to local growing conditions and suitable for French fries production. French fries quality parameters: French fries colour (C), inside texture (T) and blackening after pre-cooking - blanching and pre-frying in oil 140 °C (BC) were assessed and relationships with glucose content in potato juice (G), dry matter content (D), small grain (<30 µm) content in starch (S), blackening of steamed potatoes after one hour (BS) were found. C showed a significant negative correlation with G in two years but not in the third. No correlation was found between T nor with D, neither S. T could not be predicted and selection of acceptable clones could not be done by these parameters. Assessment of BC correlated significantly with assessment of BS in the experiment years.

Significant positive correlations were found between French fries quality traits (C, T, BC), excluding the correlation coefficient between T and BC in 1997. No correlation was found between G and BS, and G and D. It seems that G could be used in selecting clones acceptable for French fries production with eligible colour. BS predicts suitability to French fries quality and this parameter could be used in selecting clones with eligible BC. Both traits could be selected independently.

A. Tsahkna (Jõgeva Plant Breeding Institute, Jõgeva alevik, Estonia): *Estimation of tuber quality (enzymatic and non-enzymatic darkening) in potato breeding*

Important quality indicators in potato breeding are enzymatic and non-enzymatic darkening. Non-enzymatic (mostly after cooking) darkening results from the formation of a coloured compound between ferro ions and chlorogenic acid. Enzymatic (polyphenoloxylase) darkening (mostly in raw potato) results from the content of tyrosine and ascorbic acid in tuber. Potato tubers with high content of tyrosin and low content of ascorbic acid show high susceptibility to darkening. Content of chlorogenic and ascorbic acid is influenced mostly by genotype.

The experiments with 15 potato varieties and clones were carried out during the storage periods of 1996–1999 at the Jõgeva Plant Breeding Institute. The aim of experiments was finding out which of the methods - visual evaluation or by content of chlorogenic and ascorbic acids - is the most suitable in potato breeding. The visual estimation of darkening of raw peeled potato tubers (enzymatic) and after cooking (non-enzymatic) were carried out in winter (3 months after harvesting) and in spring (in May) on a 9 points scale. Content of chlorogenic acid was determined by colorimetric method.

Reliable data of visual darkening could be obtained from the results of several years. Susceptibility to darkening is also influenced by weather conditions (drought, water stress). Determination of the content of chlorogenic and ascorbic acid as more expensive analyses could be recommended for use in the main and preliminary trials, where the number of clones is smaller.

A. Frydecka-Mazurczyk & K. Zgórska (IHAR, Jadwisin, Poland): *The influence of genotype on glycoalkaloid accumulation in potato tubers due to mechanical damage and light exposure*

Glycoalkaloids (TGA), natural components of plants in Solanaceae family are potentially toxic. High amounts of TGA in potato tubers can be dangerous for people and animals. The upper TGA limit for food safety is 200 mg/kg fresh weight. The tubers of 24 Polish and 23 West European cultivars were analysed for TGA content after 3 months dark storage conditions (8 °C) in store-house. Twenty tubers of every cultivar were damaged and placed for a week under 15 W fluorescent tubes (13  $\mu\text{mol m}^{-2} \text{sec}^{-1}$  - equivalent to light in supermarkets). The resulting level of TGA in potato



tubers can be expected in shops and supermarkets, because prior to distribution tubers are graded, brushed or washed, which poses a risk of bruising and damage, and once in the shop, they are exposed to light.

It was found that the content of glycoalkaloid in potato tubers depended on the cultivar and the increase of TGA content due to damage and light exposure was higher in varieties with a higher level of this compound, for example: Peppo, Albatros, Santana and Columbus (above 200 mg/kg FW). The smaller increase occurred in varieties with a low content of TGA: Polish - Irga, Grot, Baszta, Tokaj and West European - Satina, Ditta, Gloria, Victoria.

The main amount of TGA was observed in the periderm. Content of glycoalkaloids in the peel was 2 times higher than in the whole tubers and 5 times higher than in flesh.

L. Lovatti (CISA, Imola, Italy): *The cold sweetening of table potato varieties: a new tolerant breeding clone*

In Northern Italy, table potatoes are harvested during the hottest months of the year, July and August, and a small part of them is stored in ambient temperature until the month of September. The vast majority of table potatoes are stored in refrigerated environments at low static temperatures (+6–7 °C), in order to maintain the high level of washability of the skin, with the application of antisprout chemicals (CIPC) until April and the first ten days of May. An important part of the production is refrigerated without CIPC application at lower temperatures (+4–5 °C) in order to prevent sprouting of the tuber. With this temperatures the maximum period of storage is limited to the end of December due to the extent of sweetening and sprouting that limits consumer acceptability. In EU the use of CIPC is under revision (Directive 91/414), so in the future it is important to find new antisprout active ingredients which are more environmentally and human friendly. From a breeding point of view, it is possible to work with genotypes with long dormancy and low rate of reducing sugars (glucose and fructose) and saccharose production during storage at low temperatures (<7 °C). The CISA potato breeding programme has been active from 1983 (coordinated by CRPV and founded by MiPAF and Emilia-Romagna Region) and one of the main targets for table potato varieties is the improvement of the quality of tubers: skin finish, organoleptic attributes after cooking and storage behaviour (dormancy and cold sweetening). After two years of validation we have selected a new clone (MN 1305L46) with high quality characteristics and cold sweetening tolerance after storage at low temperature (+4 °C).

L. Domański & M. Domańska (IHAR, Młochów, Poland): *General and specific combining ability of potential potato 4x and 2x parents for some agronomic and quality traits*

Combining ability analysis is a useful tool for helping to make the choice of parents for breeding programmes. The purpose of the experiments conducted at Młochów in 1991–1996 was (1) to identify superior parents for breeding programme, (2) to recognise the structure of the variance between progenies of potential parents. The breeding value of 35 potential parents was evaluated in 4 factorial crossing programmes (NC II design). The parents consisted of 19 cultivars, 9 tetraploid parental lines, 5 tetraploid breeding lines and 2 diploid parental lines. Depending on the progeny experiment, from 30 to 80 unselected individuals per cross were evaluated. A completely randomised block design was applied in each experiment. Traits recorded included: tuber yield, mean tuber weight, tuber shape, regularity of tuber shape, eye depth, incidence of secondary growth, skin appearance, uniformity of flesh colour.

Based on tested pool of parents, general combining ability has been shown to be of greater importance in the inheritance of mean tuber weight, eye depth and skin appearance. In the case of tuber shape, regularity of tuber shape, and uniformity of flesh colour both components of combining ability, GCA and SCA, were significant.

There were identified several parents (Drop, Gesa, Marta, Mondial, Santé, Van Gogh) outstanding in GCA for tuber quality traits. Among parental lines with multiple resistance to viruses, the superior 4x parents were PW-309 and PW-341. Diploid parents DG.88-89 and DG.88-4556 were suitable for generation of clones with high chipping quality.

I. Kolyadko, O. Kolyadko, V. Makhanko & L. Kozlova (BNDIB, Samokhvalovich, Belarus): *Accumulation of dry matter and reducing sugars in varieties differing in maturity*

During the later stages of the potato breeding programme in Belarus advanced breeding lines are put in trials for different agronomic and quality traits at seven sites differing in climatic and soil conditions. Nine advanced selections and three standard varieties have been assessed for dry matter content (DMC) and reducing sugars content (RS) for two years. Differences, both between and within maturity classes, were recorded on assessed parameters ( $P < 0.01$ ). DMC was found to be quite a stable character depending mainly on genotype (58.76%); the effect of growing site and year was minimal (11.1 and 7.84%, respectively). Influence of environment on RS was predominant (36.97%).

Analyses carried out at four harvest dates from mid July to mid August showed that in first early and second early varieties a threefold decrease of RS was recorded. RS of maincrop varieties decreased more considerably (4–8-fold decrease).

On the basis of this research, two advanced clones have been selected on extremely

low stable RS and high DMC in first early and maincrop maturity classes.

L. Frusciante<sup>1</sup>, A. Sebastiano<sup>1</sup>, D. Carputo<sup>2</sup> & A. Barone<sup>2</sup> (<sup>1</sup>University of Naples, Portici, Italy; <sup>2</sup>CNR-IMOF, Portici, Italy): *Use of RFLPs, RAPDs and AFLPs to monitor the introgression of *Solanum commersonii* into cultivated gene pool*

*Solanum commersonii* (2n=2x=24, 1EBN) is a source of valuable traits lacking in cultivated *S. tuberosum* varieties (2n=4x=48, 4EBN). A breeding scheme involving ploidy manipulations was set up to overcome the EBN barriers existing between these species. In order to verify the occurrence of chromosome pairing and meiotic recombination between homeologous chromosomes, cytological and molecular studies were performed. Microsporogenesis analysis of BC<sub>1</sub> pentaploids provided evidence of multivalent pairing in many cells. Molecular analyses allowed the identification of *S. commersonii* specific RFLP, RAPD and AFLP markers. Twenty specific RFLPs, uniformly distributed throughout the potato genome, provided evidence for recombination on 5 out of 12 chromosomes. To monitor the extent of wild genome introgression into the cultivated background across different backcross generations, *S. commersonii*-specific RAPDs and AFLPs were used. Thirty-four specific RAPDs and 61 specific AFLPs were used to estimate the percentage of the wild genome still present in the backcross generations. RAPD and AFLP analyses were consistent, and mean values of specific markers found in the BC<sub>1</sub>, BC<sub>2</sub>, BC<sub>3</sub> were 90%, 75%, and 30%, respectively. Genotypes combining useful traits and low wild genome content were identified.

M.H. Madsen<sup>1</sup>, H.G. Kirk<sup>2</sup>, R. Labouriau<sup>1</sup>, K.K. Sørensen<sup>1</sup> & K. Tolstrup<sup>2</sup> (<sup>1</sup>DJF, Tjele, Denmark; <sup>2</sup>LKF, Vandel, Denmark): *Linkage studies of morphological and physiological traits in three populations of *Solanum* spp.*

The high level of heterozygosity in the tetraploid crop complicates potato breeding. The relatively narrow genetic background of cultivated *Solanum tuberosum* necessitates introgression of new resistance traits from wild *Solanum* spp. However, due to linkage drag of unwanted traits the process is estimated to take more than 25 years using traditional breeding methods. In an attempt to shorten this process we have initiated a project in which traditional breeding is compared to MAS (marker assisted selection). Preliminary results from this project will be presented.

The morphological characteristics of plants and tubers have been analysed in three dihaploid populations of *Solanum* (*S. tuberosum*<sub>1</sub> × *S. vernei*; (*S. tuberosum*<sub>2</sub> × *S. sparsipilum*) × *S. tuberosum*<sub>3</sub>; *S. tuberosum*<sub>3</sub> × (*S. tuberosum*<sub>2</sub> × *S. sparsipilum*)) grown on two locations. Linkage between these characteristics has been analysed. The results show a genotype × environmental interaction in most of the registered phenotypic traits. Furthermore we found no correlation between foliage and tuber traits. Correlation was found between skin type and anthocyanin colour of the

phelloderm in four of the six investigated genotype  $\times$  environment combinations. Apparently the correlation structure of the two reciprocal populations was different.

In one population (*S. tuberosum*<sub>1</sub>  $\times$  *S. vernei*) these morphological traits together with the phosphorylation level of the starch and resistance to *Globodera pallida* will be correlated with DNA markers (AFLP and SSR). For further information please visit our website at (<http://www.jbs.agrsci.dk/~rsl/Projects/Kskim/resist2000.html>).

A. Szczerbakowa<sup>1</sup>, U. Maciejewska<sup>1</sup>, B. Wielgat<sup>1</sup>, M. Gawroński<sup>2</sup>, A. Kryszczuk<sup>2</sup> & E. Zimnoch-Guzowska<sup>2</sup> (<sup>1</sup>IBB PAN, Warszawa, Poland; <sup>2</sup>IHAR, Młochów, Poland): *Somatic hybrids between hexaploid Solanum nigrum and diploid potato hybrid and their resistance to Phytophthora infestans*

Somatic hybrids between a non-tuberizing hexaploid wild species *Solanum nigrum* L. resistant to *Phytophthora infestans* (Mont.) de Bary and a susceptible diploid clone ZEL-1136 (hybrid with input of *S. tuberosum*, *S. chacoense* and *S. yungasense*) were regenerated from the mesophyll protoplasts after PEG-mediated fusion with an objective to introduce the late blight resistance into the cultivated potato. The somatic hybrids were easily identified by their intermediate morphology: *nigrum* leaf type and *tuberosum* flower type. Under greenhouse conditions some of the hybrids produced berries with underdeveloped seeds as well as tuber-like structures. The leaves of the sixteen selected somatic hybrids were assessed for their resistance to two highly aggressive isolates of *P. infestans*, MP 322 and US 8, with a broad virulence spectrum: 1,2,3,4,(5),6,7,(8),(9),10,11 (MP 322) and 1,2,3,4,6,7,10,11 (US 8). The resistance level was evaluated on a 1–9 grade scale (9=resistant). The isolates were able to overcome the high resistance of *S. nigrum* (mean scores 5.8 to 6.5) and of the resistant standard cvs Bzura and Meduza (3.3 and 6.8, respectively). Diploid parent ZEL-1136 was very susceptible to both isolates (mean scores 1.5 to 2.6). Several of the assessed somatic hybrids were found to be significantly more resistant to both isolates than the wild parent *S. nigrum*, with five hybrids being scored from 8.4 to 9.0. The genotypes assessed produced a variable response in leaflet tests, while in whole plant tests no symptoms of infection were developed either by the somatic hybrids or by the *S. nigrum* parent. The analysis of variance showed the significant effect of genotype, inoculum concentration and the date of testing on the registered variability of resistance reaction, while a genotype  $\times$  inoculum concentration interaction was found to be not significant. The results prove the successful transfer of the resistance to late blight from the wild *S. nigrum* into its somatic hybrids with ZEL-1136.

R. Thieme<sup>1</sup>, T. Thieme<sup>2</sup>, U. Heimbach<sup>3</sup> & T. Gavrilenko<sup>4</sup> (<sup>1</sup>BAZ, Gross Lüsewitz, Germany; <sup>2</sup>BTL, Sagerheide, Germany; <sup>3</sup>BBA, Braunschweig, Germany; <sup>4</sup>VIR, St. Petersburg, Russia): *Transfer of resistance from wild Solanum species to potato by somatic hybridisation*

Many wild species related to the potato *Solanum tuberosum* L. have resistances to major potato diseases. Due to sexual incompatibility much of this diversity remains difficult to access. For incorporation of desirable traits from wild *Solanum* species to the genepool of cultivated potato somatic hybridisation by protoplast fusion was used to produce interspecific somatic hybrids between potato and *S. etuberosum*, *S. bulbocastanum*, *S. pinnatisectum*, *S. berthaultii* and *S. tarnii*, respectively. Somatic hybrids were analysed by isozymes, microsatellites and genomic in situ hybridisation. Investigations on the expression of viral, fungal and bacterial resistance in both parental lines and selected interspecific somatic hybrids were carried out. BC progeny of hybrids between the potato virus Y (PVY) resistant wild species *Solanum etuberosum* and a dihaploid potato clone were produced. PVY transmission by mechanical inoculation and vectors to in vitro as well as greenhouse and field grown plants showed that eight of the somatic hybrids and seven genotypes of BC progeny had no or low virus infection together with normal plant habit. As an aspect of vector resistance the feeding behaviour of aphids on potato species and on interspecific somatic hybrids was studied.

Z. Polgar<sup>1</sup>, J.P. Helgeson<sup>2</sup>, S.M. Wielgus<sup>2</sup>, I. Wolf<sup>1</sup>, C. Pintér<sup>1</sup>, D. Dudits<sup>3</sup> & S. Horváth<sup>1</sup> (<sup>1</sup>VE-GMK, Keszthely, Hungary; <sup>2</sup>University of Wisconsin, Madison, USA; <sup>3</sup>BRC of HAS, Szeged, Hungary): *Breeding value of potato + Solanum brevidens somatic hybrids*

One hundred and fifty-six somatic hybrids between two Hungarian potato varieties and *S. brevidens* and their BC progenies were investigated for breeding value (plant vigour, tuber/haulm characteristics, fertility, reaction to PLRV, PVY and *E. carotovora*). Genetic background of resistance to bacterial soft rot was studied by RAPD analysis of three hexaploid hybrids.

Hybrids derived from the two fusion combinations differed significantly in their response to in vivo conditions. Due to abnormal chlorophyll development and subsequent retarded growth and sterility all hybrids with cv. Százszorszép proved to be useless. In the case of combination with cv. White Lady most of the plants grew, flowered and tuberized normally. All flowering clones were proved to be female and two to be male fertile in spite of the cytoplasmic effect of *S. stoloniferum*. All the hybrids and most of the BC progenies expressed the high level of resistance of parents against tested viruses. Experiments showed that *S. brevidens* hybrids inherit late maturity and sensitivity of tubers to environmental stresses. Tested BC genotypes generally had medium dry matter content with moderate quality. Male fertility was found in many cases giving a special importance to those genotypes in a

strict resistance breeding programme against PVY. For bacterial soft rot a continuous level of resistance was detected. Seven hybrids showed extreme resistance, however none of their BC1 progenies inherited the same level. RAPD analysis of three protoclonal lines revealed that DNA segments possibly involved in defence reaction are situated on different chromosomes, confirming the polygenic nature of this resistance and making it difficult to breed for.

As a consequence, desired traits of fusion parents could be successfully combined in somatic hybrids. However due to the wild characteristics of hybrids and polygenic inheritance it is obvious that a long backcrossing and a strict selection programme is needed to successfully utilise favourable characters of *S. brevidens*.

G.A. Yakovleva, I.A. Rodkina, T.V. Semanyuk & S.V. Monarkhovich (BNDIB, Samokhvalovich, Belarus): *Improvement of potato resistance to diseases and pests by genetic engineering*

Somatic hybridisation was used for transfer of resistance to late blight from the wild Mexican species *S. bulbocastanum* to *S. tuberosum*. The chlorophyll-deficient mutant of tetraploid *S. tuberosum* (78563-76) was used. Field somatic hybrids had intermediate phenotype and formed ware tubers. *S. bulbocastanum* under field conditions produced only microtubers 10–15 mm in diameter. All somatic hybrids were resistant to tuber and foliage late blight after artificial inoculation by a mix of some isolates of *Phytophthora infestans* in presence of A1 and A2 types of compatibility.

Transgenic plants of cv. Temp carrying a partly modified gene of *Bacillus thuringiensis* var. *tenebrionis*  $\delta$ -endotoxin and cv. Belorusky 3 with the coat protein gene (CP) from PVY were obtained in the Bioengineering Centre. We studied insecticidal activity to CPB in transgenic plants and their progeny from natural pollination and test crosses. The kanamycin-resistant seedlings from true seeds were used in bioassays. Samples which had higher mortality of larvae and also less percent of emerging imago compared to cv. Temp were revealed among transgenic plants and their sexual progeny. Samples which were free from PVY according to an ELISA test after the first and second inoculation during the long 4 year period of vegetative reproduction were revealed among transgenic plants with CP PVY.

L. Rakosy-Tican, C.M. Aurori, A. Aurori, G. Szekely, G. Cinege, M. Lenga & M. Imbuzan (Babes-Bolyai University, Cluj-Napoca, Romania): *In vitro culture of dihaploid potato lines and wild Solanum species resistant to Phytophthora infestans. The use of two marker gene systems for heterokaryon selection - a new proposed scheme*

In vitro cultures have been established for dihaploid potato lines and wild *Solanum* species resistant to *Phytophthora infestans*: *S. acaule*, *S. microdontum*, *S. pinnatisectum*

and *S. verrucosum*. Optimisation of in vitro dihaploid potato line micropropagation for efficient protoplast isolation was achieved on media supplemented with silver thiosulphate. Cell suspensions were initiated and studied for potato dihaploid line 687051/99 and embryogenic callus of *S. verrucosum*. Plants have been regenerated from mesophyll protoplast of dihaploid potato line. In order to achieve somatic hybridisation between dihaploid potato lines and wild *Solanum* species resistant to *Phytophthora infestans* a new selection scheme for the heterokaryons based on two marker genes (*gfp* and *nptII*) and protoplast inactivation is proposed. As a first step leaf disk transformation of dihaploid potato lines was achieved through cocultivation with *Agrobacterium tumefaciens* carrying the construct pHB2892. The transgenic plants exhibited resistance to kanamycin and the green fluorescence of GFP in all tissues and organs. The mean efficiency of transformation was 50%. The new selection scheme will be applied to study symmetric and asymmetric somatic hybridisation between wild *Solanum* species and dihaploid lines.

J. Borys & J. Kamasa (COBORU, Słupia Wielka, Poland): *Potato variety assessment in Poland*

In Poland, official variety assessment is the responsibility of the Research Centre for Cultivar Testing (COBORU) at Słupia Wielka. All activities connected with the handling of applications, fees, preparing the methods of testing, variety denomination, procedures, registration, maintenance of the Register of Cultivars (National List) and Plant Breeders' Rights Register are done in COBORU. According to Polish Seed Act of 1995 potato varieties are registered by COBORU on the base of the satisfactory results of Distinctness, Uniformity and Stability (DUS) and positive results of value for cultivation and use (VCU) trials. Listing of potato variety is a potato seed marketing requirement. The official statutory variety testing is carried out at the Experimental Stations for Cultivars Testing (SDOO) belonging to COBORU. The procedures of DUS testing are based on the UPOV guidelines (TG/23/5). Assessment of DUS is conducted on sprout morphology under light in a special cabinet and field trials at SDOO Lućmierz with two replications for 2 to 3 years. Fifty five different morphological characteristics are recorded (using a 1–9 scale) and assessed to determine distinctness between varieties, to check their uniformity and stability, and to describe tested potato variety.

VCU of new potato varieties is determined in 20 field trials carried out in incomplete blocks design for 4 groups of earliness (very early, early, medium early, medium late together with late). Each trial comprises plots containing 60 plants grown in four replicates. Seed material (for VCU trials) provided by the breeders is multiplied at SDOO Karżniczka situated in the North in good conditions for potato seed production. VCU trials for potato are conducted according to standard agronomy practices with the protection of plants against late blight. The agronomic value of the variety is evaluated by taking into account a range of characters like yield, structure of yield, starch content, yield of starch, resistance to bacterial and

fungal diseases, defects of tubers (tested in VCU trials) and the cooking quality characters, suitability for chips and crisping, and glycoalkaloid content (tested in laboratory). Resistance to virus diseases (minimum 5 for PVY and PLRV) and to potato wart disease are obligatory requirement for variety listing. Since 1999 the new system of post-registration potato variety testing has been organized all over the country.

J. Soyer<sup>1</sup>, M. Bozec<sup>2</sup> & D. Ellissèche<sup>2</sup> (<sup>1</sup>GEVES, Guyancourt Cedex, France; <sup>2</sup>INRA, Ploudaniel, France): *Regulations and methods of official potato varietal assessment in France*

As with other arable crops, potato varieties are submitted to a statutory assessment before being registered on the French National List, according to rules and methods which are published as an official document, revised and updated at regular intervals. GEVES (Groupement d'étude des variétés et des semences) is in charge of the experiments which are run over a 2 years period in the frame of a multilocal net. Varieties are sorted according to their group of maturity and category: "Consommation à chair ferme" (firm fleshed potatoes), "Consommation" (ware potatoes), "féculières" (starch potatoes).

About 30 traits are evaluated, among which are yield (or starch yield), quality (tuber traits, cooking quality...), specific utilization criteria (earliness of tuberization, frying colour) and behaviour to diseases and pests (late blight, common scab, virus, cyst nematodes).

Performances of each potato variety are translated into notes (1–9 scale) and/or bonus and penalties, which leads to a total of points then compared to a threshold value. Varieties reaching or overcoming the threshold value are the only ones recommended for the List by CTPS (Comité Technique Permanent de la Sélection).

B. Lutomirska & W. Mazurczyk (IHAR, Jadwisin, Poland): *Relationship between resistance to mechanical damage of tubers and dry matter, starch and potassium content in Polish cultivars*

Mechanical damage of tubers lowers the quality of table potatoes and potatoes for processing. Damage is caused by many factors, including susceptibility of a cultivar. The features which determining them comprise, among others, the chemical constitution of tubers.

Examinations carried out in the Potato Agronomy Section of Plant Breeding and Acclimatization Institute in Jadwisin in the years 1984–1996 aimed at defining interdependencies between the content of starch, dry matter and potassium in tubers and the resistance to mechanical damage of tubers of Polish potato cultivars. In all years the potatoes were grown in identical soil and agricultural conditions. The 100 tubers from each cultivar were sampled during the harvest. They were damaged in



laboratory sorting machine. Evaluation of damages was carried out after 72 hours and the W damage indices were calculated. The content of dry matter, starch and potassium was determined immediately after the harvest, in simultaneously taken samples.

According to the variance analysis, the content of evaluated components in tubers and W damage index depended to a great extent on cultivar and season. Results of a regression analysis indicated that the content of evaluated components in tubers did not have any effect on the total of tubers damage. However, a significant interdependence between the content of dry matter and starch and the internal damage of tubers was established. The regression indices amount respectively to 0.4820 and 0.4382, and the increase of starch content within the range from 14.0% to 20.0% by 1% generates increase of internal damage index ( $W_w$ ) by 0.96.

On the basis of effected examinations, the cultivars were divided into two groups: cultivars with significant increase of internal damage as a result of increase of dry matter and starch, and cultivars in case of which the correlation between alterations of the content of dry matter and starch in tubers and damage of tubers was not established. This group includes primarily cultivars which are less stable with respect to the content of dry matter and starch.

W. Mazurczyk & B. Lutomirska (IHAR, Jadwisin, Poland): *Evaluation of Polish potato cultivars for their potential of biomass production*

Potential yield ( $Y_p$ ) is the highest one which can be reached by a given cultivar grown with ample nutrients and soil water but in the absence of diseases, weeds, pests. Values of  $Y_p$  can change depending on year and growing region. Higher levels of  $Y_p$  allow a higher actual yield ( $Y_a$ ) to be reached. So the same value of  $Y_a$  does not necessarily mean the same efficiency of the available solar energy utilization by crops. Therefore not only the values of  $Y_a$  but also the ratio of  $Y_a/Y_p$  should be compared.

The values of  $Y_p$  were calculated according to the van der Zaag method (*Potato Research* (1984) 27: 51–73) for 41 table and 36 starch cultivars each grown for 3 or more years.  $Y_p$  were compared to actual yields ( $Y_a$ ) obtained in experimental fields in Jadwisin. All cultivars were grown without irrigation and chemical control of diseases in years 1975–1999.

Mean values of  $Y_a/Y_p$  were 0.51 for starch and 0.45 for table cultivars. Ranking of the best Polish cultivars according to their utilization of potential biomass production ( $Y_a/Y_p$ ) is the following: Bliza (0.63), Bzura (0.63), Bóbr (0.62), Ikar (0.60), Fauna (0.57), Stobrawa (0.57), Harpun (0.56), and 0.55 for Baszta, Ekra, Narew. The highest values of  $Y_a/Y_p$  were obtained by starch cultivars registered in 1985 and 1996 and by table cultivars registered in 1984, 1985, 1994 and 1996.

K. Mechtler (BFL, Vienna, Austria): *Austrian national list trials and variety registration in potato*

In 1999, the total area of potatoes amounted to 23,180 hectares, mainly in the regions "Wein- and Waldviertel" of Lower Austria (81%). The remaining area is distributed to Upper Austria (8%), Styria, Tyrol, Burgenland and Carinthia with a few hectares in the other federal states. The Federal Office and Research Centre for Agriculture at Vienna is concerned with coordination and carrying-out of national list trials and with registration of varieties. In 2000, 85 potato varieties are listed in Austria.

According to the seed act 1997 a variety will be registered after successful DUS- (distinctness, uniformity and stability) and VCU-testing (value for cultivation and use) and if there exists an appropriate variety denomination. DUS-tests are done for two years according to UPOV-guidelines including 50 traits. The VCU trial network is adapted to the spreading of potato production in agricultural practice with four trial sites in Lower, and two in Upper Austria as well as one each in Styria and Carinthia, the last two for potato varieties which are used mainly for human consumption. VCU-tests take three years at four to eight trial sites depending on maturity group and utilisation characteristics of the varieties in question. Therefore 3000 to 4000 tubers of each candidate are needed. The trials are designed as randomised complete blocks. Characters assessed are tuber yield in three classes of tuber size (small-medium-big), starch content and starch yield and ripening performance. Further, infection with *Phytophthora*, *Alternaria*, *Cercospora*, *Rhizoctonia*, *Synchytrium*, *Spongospora* and *Streptomyces* as well as resistance against nematodes and mechanical damage and the appearance of viruses and internal rust spot are investigated. Since potato production for human consumption takes more than fifty percent of the total acreage, cooking and frying quality and colouration of raw tuber flesh of varieties are of great importance in VCU-tests. Cooking tests include disintegration, consistency, mealiness, humidity, texture, colour, darkening, taste, solanin-taste and a classification for cooking types. Fry-tests for crisps and chips production follow the EAPR procedure.

The costs are 5000 ATS (363 €) for VCU-test and 3,927 ATS (285 €) for DUS-test each year with an application fee of 2000 ATS (145 €).

The results of a shifting three to six year testing period are published yearly for registered varieties in the Austrian Descriptive List for Varieties, which may be purchased from our institute. This information will also be available on the internet.

J. Rembeza & J. Chotkowski (IHAR, Bonin, Poland): *Seed potato production and varietal assessment in Poland*

In Poland, there are not any official data about percentage of particular varieties in potato area. For that purpose in 1997 and 1998, 568 farms were investigated (1004 potato plantation in the first year, 1045 in the second year).

The investigation showed large differences between planted potato varieties. The

most popular varieties were Bryza (15.4% in total potato area), Irga (11.8%) and Ibis (8%). In the west of Poland yellow flesh varieties are predominant, whereas in the east of Poland a large part (30% or even more than 50% in some regions) falls to white or cream flesh varieties.

The seed potato area in Poland compared with the total potato area is extraordinary low (less than 1%). Nevertheless the new varieties disseminate fast. In the investigated farms the varieties registered in the last 10 years occupied 21.5% and varieties registered in the last 15 years occupied 47.3% of potato area. However a large part of the area (10.2%) was occupied with varieties which had been rejected for 5 or more years from Polish register. There exists a weak correlation between popularity of varieties in seed area and in non-seed area (correlation coefficient 0.295).

In the investigated farms the most important factors differentiating potato yields were: seed potato class, amount of fertilizers and application of fungicides. The importance of varieties was much smaller.

K. Zarzyńska & A. Gluska (IHAR, Jadwisin, Poland): *Differentiation of Polish cultivars concerning physiological characteristics of tubers and plants*

Twenty-three middle-late and late cultivars have taken part in a long-term experiment. The following characteristics of tuber and plant were examined: dormancy, incubation period, initial growth of sprouts and roots, assimilation area, LAI index, etc.

All cultivars were divided into 3 statistically significant groups according to the value of their tested features. Differentiation of cultivars concerned the following characters: number of days from tuberization to the end of dormancy, number of days from the end of dormancy to air tuberization, number of roots per 1 sprout, number of eyes per tuber (of average size), stem number per plant (average seed size tuber), stem to eyes ratio, mass of foliage (full vegetation), assimilation area (full vegetation), and LAI (full vegetation).

H. Polzerová (PRI, Havlickuv Brod, Czech Republic): *Characterisation of registered potato varieties by molecular genetic techniques*

The contemporary list of registered potato varieties in the Czech Republic contains 91 genotypes including 30 of Czech origin. These varieties are described by using morphological and economical characters. These descriptions seem to be insufficient for precise and fast identification of unknown samples and it would be convenient to complement them by means of molecular genetic techniques. Unfortunately these techniques were not yet worked out in our country for utilisation in potato industry. The introduction of fingerprinting on the basis of DNA analysis would help to improve checking of variety authenticity and purity. It could positively influence

protection law of varieties in market for potato seed. It will make possible easier classification and management of genotypes in potato genebanks etc.

We have aimed at developing useful molecular markers for characterisation of potato varieties by means of RAPD analyses. The RAPD procedure was used to study genetic diversity of 30 potato (*Solanum tuberosum*) genotypes, representing mainly Czech potato cultivars. Genomic DNA was isolated with five methods and these techniques were compared. These DNA were used as template in RAPD amplification and no variations in the banding patterns were found between reactions made from various DNA extractions. Some variations between RAPD products were observed when different DNA polymerases were used. Therefore, it is necessary to focus on this problem during optimisation of RAPD procedure. Amplification with six decamer primers generated 66 DNA fragments, ranging in size from 178 bp to 1847 bp, of which 46 were polymorphic products. The similarities of RAPD profiles were estimated with the Jaccard's coefficient and then the data were processed by cluster analysis (UPGMA). Each genotype was identified and distinguished from the others. Our results indicate that RAPD technology is a rapid technique usable for identification of potato genotypes.

J. Pietrak (IHAR, Młochów, Poland): *Resistance to viruses in advanced Polish breeders selections and in foreign cultivars evaluated in Poland in statutory trials*

The resistance to potato viruses PVY and PLRV was evaluated in the years 1995–1999 at the Młochów Research Center, IHAR. The resistance was expressed on a 9-grade scale (9=resistant).

The Polish advanced breeders selections expressed a much higher level of resistance to PVY than foreign cultivars (7.5 compared to 5.4) and a slightly higher level of resistance to PLRV (6.4 compared to 6.2).

Out of 108 evaluated genotypes, 44 Polish cultivars and 16 foreign ones were registered in Poland in the years 1996–2000 as new cultivars. The registered cultivars of Polish origin were on average much more resistant to PVY when compared to those of foreign origin (7.5 versus 5.9); on the other hand they were slightly less resistant to PLRV (6.4 versus 6.6).

K. Rykaczewska (IHAR, Jadwisin, Poland): *Changes in dormancy duration of the tubers of cultivars registered in the last 45 years*

Physiological dormancy is required period of potato plant development. The purpose of analysis was the comparison of dormancy periods of cultivars registered during the last 45 years and ascertainment if there is any breeding advance in that respect. Altogether 123 cultivars were analysed on the basis of previously published and till now unpublished results. Years 1955–1999 were divided into nine 5-year periods. The share of cultivars characterized by a short, intermediate and long period of dormancy

in each period was estimated, with short dormancy meaning October or earlier, intermediate dormancy November, and long dormancy December or later. The percentage was transformed by Bliss's method for statistical calculations. Regression significance of participation of cultivars with short, intermediate and long lasting dormancy period in total number of registered cultivars during particular 5-year intervals was tested by test F of Snedecor. The results obtained show that the share of cultivars with a long dormancy period increased significantly in recent years and that there is a breeding advance in this respect.

M.J. De,Maine<sup>1</sup>, A.K. Lees<sup>1</sup>, D.D. Muir<sup>2</sup>, J.E. Bradshaw<sup>1</sup> & G.R. Mackay<sup>1</sup> (<sup>1</sup>SCRI, Dundee, UK; <sup>2</sup>HRI, Ayr, UK): *Long-day-adapted Phureja as a resource for potato breeding and genetic research*

A population of clones of the Andean cultivated diploid potato *Solanum tuberosum* Group Phureja, which is adapted to the long-day growing seasons of Western Europe, has been developed at the Scottish Crop Research Institute. Resistance to *Erwinia* (soft rot) was found in the population and a progeny was produced from two parents selected for the character. From the resultant progeny clones were selected combining resistance with good yield and other tuber characters. As *Erwinia* resistance is quite rare in Tuberosum, Phureja may prove to be of interest to potato breeders and geneticists as a source of germplasm for this character.

A study of sensory characters was carried out on cooked Phureja flesh using a panel of assessors. It showed that it was possible to distinguish between Phureja clones and established European Tuberosum cultivars on flavour, texture and flesh colour. This is in contrast to previous studies of Tuberosum potatoes which have found that flavour differences between cultivars are slight and vary from year to year and between growing sites. The differences between Tuberosum and Phureja were consistent and may provide the opportunity to study the chemical nature of the flavour differences and its genetic control in potato. Consumer studies have shown that the flavour of Phureja was preferred by most people who tasted it.

The potential of long-day adapted Phureja as a genetic resource for improving the soft rot resistance and flavour of Tuberosum potatoes is discussed.

J. Frček<sup>1</sup> & V. Voral<sup>2</sup> (<sup>1</sup>PRI, Havlickuv Brod, Czech Republic; <sup>2</sup>Potato Breeding Station, Kerkov, Czech Republic): *Utilization of TPS in temperate conditions of the Czech Republic*

In the framework of International collaboration between the Potato Research Institute (PRI) in Havlickuv Brod and the International Potato Centre (CIP) in Lima, TPS with field resistance to late blight (*Phytophthora infestans*) was tested for three years in temperate conditions of the Czech Republic. The project did not receive funding from the Ministry of Agriculture of the Czech Republic and so it was

financed from means of PRI. Based on decision of the State Phytosanitary Administration of the Czech Republic, there were carried out tests for health status in randomly chosen seeds from each sample with regard to possible occurrence of quarantine agents (PSTVd). Results showed that materials were pathogen-free. Next year, all seeds were sown in greenhouses of PRI. Seedlings were transplanted into pots with volume of 1 dm<sup>3</sup> soil and placed on growing beds in nethouse. After harvest, each seedling was analysed according to CIP descriptors for tuber skin colour (predominant, secondary and distribution of secondary colour of skin), tuber shape (general, unusual), depth of tuber eyes, and tuber flesh colour (predominant, secondary and distribution of secondary flesh colour). Tuber set per seedling and tuber weight was determined. For verification of performance of individual progenies in field conditions of the Czech Republic, a random selection of tubers (3×60) of each progeny was carried out. These tubers were planted into field conditions in spring at 0.75×1 m spacing, and a similar planting was performed under field conditions of the Kerkov Breeding Station. During vegetation period the usual cultural practices and screening for occurrence of viral and other diseases were carried out. In this vegetation period no symptom of infection was detected. These healthy materials flowered abundantly till harvest. The vegetation period had to be finished with mechanical haulm killing and every hill was harvested individually. After that, measurements were made of total tuber yield, number of tubers, occurrence of tuber late blight, misshapen tubers, common scab, cracks and stolons. Further, analyses were made of skin colour, tuber shape, depth of tuber eyes and tuber flesh colour. From these materials, some genotypes were selected as suitable for use in resistance breeding at PRI.

J. Pavlas (PRI, Havlickuv Brod, Czech Republic): *The transfer of resistance genes into potato using interspecific hybridisation at diploid level*

Hybridisations at the diploid level of *Solanum tuberosum* and interspecific hybrids and wild *Solanum* species (*S. incamayoense*, *S. vernei*, *S. pachytrium*, *S. sparsipilum*, *S. berthaultii*, *S. pinnatisectum*, *S. spegazzinii*, *S. microdontum*, *S. polyadenium*, *S. yungasense*, *S. gourlayi*) were done during research projects of National Agency for Agricultural Research of Czech Agricultural Department (EP0960996566 and EP9334) over the period 1996–1999. Morphological and resistance selection of progenies was done (morphological evaluation, resistance against *Fusarium* wilt, late blight, potato nematodes, wart, viruses, starch content in tubers). The best materials with suitable breeding characteristics were selected. The materials are available at the Potato Research Institute in Havlickuv Brod, Czech Republic.

N. Zoteyeva (VIR, St.-Petersburg, Russia): *Reconstruction of potato wild species collection of the N.I. Vavilov Institut of Plant Industry (VIR)*

The potato wild species collection of the N.I. Vavilov Institute of Plant Industry (VIR), St. Petersburg, Russia consists of about 2500 accessions. In the last decade the maintenance of the collection was difficult due to financial problems. Since 1998 the restoration of the collection from old true seeds has been conducted at IHAR - Młochów Research Center with financial support by CEEM, Cornell University, U.S.A.

In total, 305 accessions of 63 potato wild species have been sown since 1998, from which 87 accessions were collected as true seeds and 31 as tubers. During vegetation seasons the accessions were evaluated, besides various traits, for resistance to *Phytophthora infestans* in seedlings, detached leaflets and tuber slices. Tuber characterization within species resistant to *P. infestans* was also done.

Under artificial inoculation, the majority of accession populations segregated for resistance to *P. infestans*, giving resistant, moderately resistant and susceptible plants. The highest predominance of resistant plants was identified within populations of the following species: *S. demissum*, *S. guerreroense*, *S. stoloniferum*, *S. papita*, *S. polyadenium*, *S. polytrichon*, *S. cardiophyllum*, *S. microdontum*, *S. berthaultii*. The highest tuber resistance to *P. infestans* was in accessions of *S. pinnatisectum*.

Within species resistant to *P. infestans*, *S. cardiophyllum*, *S. polytrichon*, *S. demissum*, *S. stoloniferum*, *S. papita* and *S. berthaultii*, types were identified with several useful tuber characters: relatively large size and good shape, lack of anthocyanin, long dormancy period and no flesh darkening.

I. Wasilewicz-Flis, H. Jakuczun & M. Gawronski (IHAR, Młochów, Poland): *The collection of diploid hybrids*

The objective of the collection is to maintain valuable genotypes which can be utilised in traditional potato breeding as a source of desired characters. In the collection, genotypes are available resistant to potato viruses (PVX, PVM, PVY and PLRV), *Phytophthora infestans*, *Erwinia* spp., nematodes and wart. There are also donors of high starch content, table and chipping quality. Most of them are able to produce  $2n$  gametes.

The collection is maintained in field plots and in vitro cultures. In 2000, the field collection consists of 241 diploid clones. Most of them (182 clones) were obtained at IHAR Młochów in the course of breeding at the diploid level. These clones are complex interspecific hybrids and originate from several wild and primitive cultivated *Solanum* spp. and dihaploids of  $4x$  breeding lines and cultivars. Their ancestors include the following *Solanum* species: *S. tuberosum*, *S. chacoense*, *S. gourlayi*, *S. stoloniferum*, *S. acaule*, *S. demissum*, *S. phureja*, *S. yungasense*, *S. verrucosum*, *S. microdontum* and *S. acaule*.

The remaining 59 diploid clones were obtained from other Polish and foreign

research centres. The most valuable genotypes are introduced into in vitro cultures.

In 1999 the collection of clones was supplemented with 14 families, originated from Plant Introduction, Sturgeon Bay (U.S.A.) and from VIR, St. Petersburg (Russia). These families represent 7 *Solanum* species (*S. kurtzianum*, *S. ruis-cebalozii*, *S. pinnatisectum*, *S. michoacanum*, *S. chacoense*, *S. phureja* and *S. polyadenium*). They are expected to be a new source of quality and resistance characters, mainly low content of reducing sugars, resistance to PLRV and resistance to *Phytophthora infestans*.

E. Ratuszniak (WSP, Słupsk, Poland): *Pollen size variation inside the fertile pollen fraction of the potato wild species*

The wild potato species were donors of many important features for the cultivated potato, especially resistance to diseases. The crossing of tetraploid cultivars with the diploid wild species involves a problem of ploidy and fertility of recombinants. The possibility of forming unreduced pollen grains in diploid species could be linked with production of different sized pollen grains. The purpose of the conducted research was to describe the variation of fertile pollen grain size for 12 diploid wild species, both between species lines and within these lines.

In 1999, pollen from 65 plants representing 24 wild potato lines from the collection of the Plant Breeding and Acclimatization Institute, Młochów was analysed. The pollen specimens for microscopic research were stained with lactofenolfucine and a diagonal of stained pollen were measured in  $\mu\text{m}$ . Among all the 5762 pollen measured, the diagonals varied from 12.28 to 33.66  $\mu\text{m}$ . The mean value for all pollen was 20.28  $\mu\text{m}$ . The mean value for individual lines varied from 16.88 (*S. polyadenium*) to 22.32  $\mu\text{m}$  (*S. pinnatisectum*). The coefficient of variation scored for each plant was from 4.07% (*S. chacoense*) to 26.87% (*S. marinasense*). The score distribution analysis shows that for the majority of species and lines this distribution was normal or close to normal. In some cases the distribution for particular plants inside the same line was different (*S. marinasense* line K 18520 and line PI 310946).

The researched wild species are propagated from true seeds which means that each plant of any particular line could represent more or less a different genotype. If observed differences for pollen size distribution were connected with unreduced pollen grain production, it would be possible to carry on the line selection in the desired direction.

S.D. Kiru, V.P. Zdvizhkova & D.A. Bychkov (VIR, St.-Petersburg, Russia): *Search for genetic sources of tuber quality in Solanum andigenum Juz. et Buk.*

The cultivated South American polymorphic potato species *Solanum andigenum* Juz. et Buk. is a rich source of resistance to various diseases, pests and climatic stresses. However its quality characters were not sufficiently evaluated.



In the years 1997–1999, 165 samples of 38 forms of the VIR *S. andigenum* collection were evaluated. The following quality characters were determined: dry matter, starch and protein content; concentration of total and reducing sugars; starch grain size; moisture; cooking and processing quality (chipping, frying, mashing); tuber shape and flesh colour. The biochemical factors associated with cooking and cooking quality were evaluated according to the methods used in the VIR Department of Technological and Processing Evaluation.

The most promising *S. andigenum* forms were found among those originating from Columbia and Peru. The evaluation of F1 progeny from crossing selections of *S. andigenum* × *S. tuberosum* indicates, that the desired quality characters are inherited. From such hybrids were found 18 valuable clones which may be utilized in breeding programmes.

J. Draaistra, R. Hutten & H. van Eck (Wageningen University, Wageningen, The Netherlands): *Genetic analysis of S. chacoense derived resistance against Meloidogyne hapla and M. fallax*

*Meloidogyne* root-knot nematodes cause yield reduction and often tuber damage. Until now resistant varieties are not available. Janssen et al. (*Eur. J. Plant Path.* 102: 859–865, 1996) identified *Solanum chacoense* accessions resistant to *M. hapla* and *M. fallax*. A diploid mapping population (*S. tuberosum* × (*S. chacoense* × *S. tuberosum*)) of 261 individuals was analysed for resistance against *M. hapla* and *M. fallax*. The continuous distribution of the number of eggmasses, produced on offspring roots, indicates a quantitative inheritance of the resistance. The resistance against *M. hapla* segregated independently of the resistance against *M. fallax*. The heritability of the resistance against *M. hapla* and *M. fallax* was 53% and 17% respectively. An AFLP-map was constructed to identify genetic loci (QTLs) involved in the resistance. The poor heritability of *M. fallax* resistance, and consequently the failure to identify any major QTL is not easily explained, in view of the high level of resistance in the *chc* × *tbr* hybrid parent. Two major QTLs conferring resistance to *M. hapla* allowed classification of the offspring into four different groups having none, the first, the second or both QTLs. The efficiency of phenotypic selection in comparison with Marker Assisted Selection (MAS) demonstrated that phenotypic selection would have resulted in frequent loss of one of the QTLs.

J. Lewosz & A. Pilecka (IHAR, Bonin, Poland): *Pectinolytic enzymes of Erwinia carotovora triggered by some substances arising in potato tuber extract*

Interaction of plant tissues and pathogenic microorganisms is mediated by various chemical compounds already present or generated in plant cells as the result of mechanical or enzymic destruction of plant tissues. Several-fold increases in the production of pectate lyase or polygalacturonase have been observed when *Erwinia*

cells were grown in medium composed of potato tuber extract supplemented with some organic substances (organic acids, sugar acids, sugar alcohols, nucleotides). Some of these substances became active stimulators of one or several pectic izozymes only in the case of their addition to tuber extract processed in mild temperature. Preliminary data indicate the participation of tuber enzymes in the processing of some of these substances into factors that become able to affect multiplication rate and virulence of bacteria. Autoclaved extracts of the tubers were unable to convert added substances to active stimulators of pectic enzyme production by bacterial cells.

Perhaps the decompartmentalization of cell organelles under stress conditions (chilling, wounding, mechanical impact) may result in a similar conversion of some cell compounds into factors that can be recognized by bacteria and affect their virulence. Identification of the processes involved in formation of these compounds is in progress.

A. Pilecka & J. Lewosz (IHAR, Bonin, Poland): *Isolation and characterization of storage and defense proteins present in potato tubers of 80 cultivars*

Proteinase inhibitors of several families (ChI I; ChI II; cathepsin D inhibitors, Kunitz-type inhibitors and cystatin superfamily inhibitors) play a role as storage proteins in potato tubers and as defence factors against proteolytic enzymes of invading pests. Inhibitors of cysteine proteases might counteract cell apoptosis triggered by reactive oxygen species in the cellular response to environmental stresses such as: chilling, ozone, drought or pathogen attack.

Protease inhibitors were isolated from potato tuber sap by affinity chromatography on covalently bound trypsin to Sepahrose matrix. Mainly Kunitz-type inhibitors were entrapped to the affinity matrix and were subsequently released by elution of the chromatographic matrix by a solution at pH 1.5. Three groups of proteins (22, 23 and 24 kD) were separated by SDS-electrophoresis, 12 bands were separated by native polyacrylamide electrophoresis, and almost 40 bands were resolved by electrofocusing in pH range 3-10. Patterns of molecular forms of inhibitors in dormant tubers were specific and unique for each of the 80 cultivars studied. Electrophoretic patterns of isolated inhibitors were utilized as markers of identity and uniformity of potato cultivars.

The appearance of more acidic molecular forms of the inhibitors in stressed tubers may suggest elimination of highly reactive peroxides from cell space by binding to inhibitors.

V.E. Podlisskikh (IGC, Minsk, Belarus): *Genetic analysis of the meiotic abnormality fused spindles*

Segregation of the meiotic abnormality fused spindles (fs) leading to FDR 2n pollen production has been analysed in cross and self progenies of dihaploid potato.

Segregation was studied in different types of crosses (nofs  $\times$  fs, fs  $\times$  fs and nofs  $\times$  nofs). In  $F_1$  crosses, progenies segregating for fs according to distinct patterns and progenies not expressing fs were detected. Selfing and  $F_2$  crossing of fs producers and non-producers resulted in patterns of segregation indicative of possible polygenic control with two or more oligogenes for this characteristic. Single individuals of a progeny produced distinct numbers of meiotic cells expressing fs (0–95% of all cells). The largest numbers of fs cells were detected in progenies possessing high-fs (70–90% meiotic cells expressing fs) parents. High-fs parents produced almost exclusively fs progenies and they are therefore assumed to be homozygous for the main oligogenes. Non-fs parents exclusively producing progenies with normal meiosis were also detected. Dissection of the genetics of this abnormality is complicated due to reduced crossability between diploid potatoes, the quantitative expression of fs, and the possible heterozygosity of the parental genotypes used. The segregating material produced will be used for molecular-genetic analysis of the fs meiotic abnormality.

V. Kozlov (BNDIB, Samokhvalovich, Belarus): *Assessment of hybrid populations from  $4x \times 2x$  and  $2x \times 2x$  crosses on agronomic characters*

In a breeding programme for late blight resistance, the tetraploid varieties Lazurit, Yavar, Skarb, differing in maturity, and dihaploid clone 233/1 with female 2n gametes, were used as female parents. Agronomic characters of the tetraploid females were almost equal. An interspecific diploid clone (*S. phureja*  $\times$  *S. vernei*) was used as the male parent. Tetraploids selected from the progenies were assessed for yield, starch content and resistance to tuber blight. In  $4x \times 2x$  crosses the highest yielding offspring was obtained from population Skarb  $\times$  233/1 and this progeny considerably out-yielded tetraploid parental line. Yield in progenies derived from Yavar  $\times$  233/1 and Lazurit  $\times$  233/1 was moderate and low, respectively.

In screening for tuber blight resistance a lot of individuals with a high degree of resistance were found in hybrid families with varieties Lazurit  $\times$  233/1 and Skarb  $\times$  233/1. Results of tuber blight test with progeny of Yavar were not so promising and highly resistant clones were not detected at all.

The tetraploid progeny from the  $2x \times 2x$  cross was characterised by the maximal yield of tubers in the experiment. Starch content between and within all hybrid populations did not vary greatly. In  $4x \times 2x$  crosses yield and resistance to tuber blight in progeny depended on the choice of tetraploid female.