Agronomy Research **7**(1), 59-72, 2009

Research of technical crops (potato and flax) genetic resources in Lithuania

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Abstract. The research of potato accessions preserved in Lithuanian potato gene bank genetic diversity research was carried out at the Voke branch of Lithuanian Institute of Agriculture in years 1990–2006. Research was provided with potato collection covering 200 varieties and hybrids from the main potato origin and growing regions and selection material bred in Lithuania. Potato varieties varied in accordance of morphologic, physiologic, immunologic and farming features in the different maturity groups and between groups. Using transgenic hybridization method and working with genetic material of local potato collection were selected potato varieties of Lithuanian origin. The key objective was to select the varieties immune to wart disease, cyst nematodes, with high resistance to other diseases, with excellent agronomic and cooking qualities, suitable for the processing industry.

Over 1966–2006 years the collection of more than 350 flax breeding lines and varieties from different countries were investigated at the Upyte Research Station of the Lithuanian Institute of Agriculture. Therefore it is desirable for the new flax varieties to be highly adaptable, stabile yielding and high fiber quality under different growing conditions. The collection serves as a base while selecting flax varieties for hybridization. There have been chosen the varieties and breeding lines having the complex of qualities and positive characters. The varieties and breeding lines with positive characters were involved into the program of fiber flax breeding.

Key words: collection, breeding, technical crops, potato, fiber flax, varieties

INTRODUCTION

Since the previous times the most valuable worth was selected and conserved for future. The knowledge on sustainable use of plant genetic resources was passed from one generation to another.

The development of the Global System on Plant Genetic Resources began in 1983 with the establishment of the Commission on Plant Genetic Resources the objectives of which are to ensure the safe conservation, and promote the availability and sustainable use of plant genetic resources (Plant Genetic Resources, 2009).

For a long time potatoes and fibre flax were considered to be the main technical crops in Lithuania.

Cultivated potatoes are coming from the South America. From the old times in the Latin America countries were grown *Andigena* and *Tuberosa* potato species. Introduced to Europe and later to United States different *Solanum tuberosum L. ssp.*

Chilotanum and *S.andigenum* potato species seedlings from Chile were selected hybrid potato varieties which belong to *Solanum tuberosum L. ssp. Europaem Buk. Et Lechn*. subspecies. In the breeding work are also used wild species, such as *S.demissum, S.stoloniferum, S.acaule* and others. In many cultivars phenotype dominates *S.tuberosum* features and all selected cultivars are attached to this specie (Hijmans, 2001).

S.tuberosum and *S.andigenum* potato species are tetraploids (2n=48), so many features potatoes inherit at the tetrasomic level. *S.demissum* species of Mexico origin are aleloheksaploids (2n=72). They have resistance to the late blight *Phytophthora infestans (Mont.) de Bary.* It is widely used in Lithuanian potato breeding programs and due to this local potato cultivars have high resistance to the late blight. *S.andigenum* potatoes are donors for the resistance to the PVX virus and potato cyst nematode Ro1. Local potato cultivar 'Aista' has parents from these species hybrid crosses (Staniulis & Razukas, 2003).

Usually potatoes are bred using hybridization method. The most valuable in the breading work are paternal plants which have perfect quality features such as high yielding, earliness, resistance to diseases and pests, dry matter content amount and others transmission to their progeny. In the potato breeding process the most important are varieties and hybrids which belong or have progeny of nine systematic groups: *Comersoniana, Glabresantia, Acaulia, and Transa equaatorialia, Andigena, Tuberosa*, *Longipedicellata*, *Demissa* and *Pinnatisecta*. They give proper genetic diversity for the cultivated potato varieties (Lough et al., 2001).

Potato breeding and primary seed production from the meristem tissue programs in Lithuania are provided at Voke branch of Lithuanian Institute of Agriculture. Potato genetic resources gene bank is collected and sustained here. Research of over 200 potato varieties and hybrids selected all over the world is provided at the breeding department. Potato breeding is one of the main ways to get strong cultivars with good resistance to unfavourable climatic conditions, diseases and pests (Razukas, 2002; Razukas et al., 2003). High quality potato seed, good yielding varieties show are results of many years breading work (Razukas et al., 2001). One of the objectives of the present work was to study accessions of the potato collection, to select genetically valuable genotypes and introduce them into the breeding program (Chauvin et al., 2003, Asakaviciute et al., 2008).

In Lithuania and in all European countries it is quite important to secure a potato harvest in order to bring it to a summer market as soon as possible, when prices are higher (Bradshaw et al., 2006). The developing Lithuanian potato industry also needs potatoes suitable for chips production, because the main crop variety after a long storage time. From the agrotechnic point of view potatoes are also greatly valued because of their short growing period. In crop rotation, the field after potatoes can be sown with winter crops.

The Lithuanian potato breeding program's main research object was and in the near future will be early and maincrop, immune to wart and nematodes potatoes selection. Due to they high resistance to disease and pests all Lithuanian potato varieties are exhalent for growing in ecological farms.

Flax has been grown in Lithuania more than for four thousand years. Scientific fibre flax breeding has been carried out in Lithuania since 1922. Since 1922 to 2005 18 varieties of fiber flax have been bred in Lithuania. Since 1966 this work is carried out at the Upyte Research Station. Prof. D. Rudzinskas is the breeder of 'Dotnuvos ilguneliai I', 'Dotnuvos pluostiniai' and 'Dotnuvos ilguneliai II'. Prof. Z. Mackevicius has bred variety 'Vaizgantas'; A. Vycas has bred varieties 'Lietuvos 230', 'Zydriai', 'Lietuvos 392', 'Banga', 'Vega' and 'Viltis', K. Bacelis – 'Banga 2', 'Upyte', 'Upyte 2', 'Baltuciai', 'Vega 2', 'Alfa B', 'Kastyciai' and No. 1547-7-11 (Bacelis, 2001). Flax varieties 'Dotnuvos ilguneliai I' and 'Dotnuvos ilguneliai II' were disseminated in Lithuania till 1950. Variety 'Vaizgantas was disseminated in Lithuania in 1950-1977. The variety 'Upyte 2' has been included in National list of plant varieties in Lithuania and in Estonia in 1987, variety 'Baltuciai' – in Lithuanian (1991), Byelorussian (1992), and in Russian (1993) National list of plant varieties. The variety 'Vega 2' was included into National list of plant varieties in Lithuania in 1997 and in Latvian – since 2001, variety 'Kastyciai' – in Lithuanian National list of plant varieties since 2000. In 2004 this variety was included in the list of EC Common Catalogue of varieties of agricultural plant species.

Initial material for fiber flax breeding must be not only diverse and abundant but also must meet the key requirements under local conditions (Wlaswinkel, 1994; Rosenberg, 1995; Akin et al., 2002; Chikov et al., 2003; Jankauskiene et al., 2006). The flax collection is continuously replenished by local breeding lines and the samples of the latest varieties obtained from other research institutions. The tested varieties which more closely meet the requirements set for the direction of the breeding work are used for intervarietal crossings with a view to develop new initial material (Rolski & Heller, 1998; His et al., 2001; Fu et al., 2002; Couture et al., 2004).

Investigation and preservation of plant genetic resources become a very important task in many countries, representing a national value of each country (Bacelis & Jankauskiene, 2005).

The main objective of presented work was to envestigate fibre flax varieties, breeding lines and to develop high yielding new fibre flax varieties with a moderately long vegetative growth period, with a high fibre content and quality, lodging resistant and less susceptible to fungal diseases. Therefore it is desirable for the new varieties of flax to be highly adaptable stabile yielding and high quality of fibre under different growing conditions.

The investigation of genetic resources of potatoes and flax allows getting more knowledge about the diversity in the mentioned plant species, to preserve them, to establish various characters, to use valuable accessions in the breeding programs with aim to develop new varieties.

MATERIALS AND METHODS

Study of potato genetic resources collection

Research was performed with 200 potato cultivars and hybrids. Potato genetic material was collected from all over the world. Potato genetic resources collection trials were planted at Voke Branch of Lithuanian Institute of Agriculture breeding department during 1990–2006 years. Trials were performed on sandy loam on carbonaceous fluvial-glacial gravel eluviated soil (IDp), according to FAO-UNESCO classification Haplic Luvisols (LVh). All four varieties were tested and grown on soddy podzolic sandy loam soil in a crop rotation field of the breeding department grasses. The trial field was fertilized with organic manure - 50 t ha^{-1} and the mineral fertilizers 90 g kg^{-1} N, 90 g kg^{-1} P, 90 g kg^{-1} K. Tubers were planted by hands into the rows. All plots of the field were fully randomized, the number of replications in different years was up to four. The size of the plots was also different, but each plant feeding plot always was 0.7 x 0.35 m^2. In the first three years potatoes were harvested by hand, later with a potato digging machine. Tubers were stored in the underground potato storage at natural conditions: +1 to +2 0C and 80-90 % humidity in the winter season (Razukas et al., 2001).

Gene bank potato varieties and seedlings during vegetation period were tested for the resistance to diseases. The trials were set up in conformity with the local agricultural potato growing practices. One hundred plants, 25 plants from every plot i.e., were tested. The potato vine infection level was scored according to the attack: few plants with lesions, 1–2 lesions in a 10-m radius; 0.5-1-5 spots per plant; 1 – 5-10 spots per plant; 5 – about 50 spots per plant, or up to 1 in 10 leaflets lesions; 10 – about 10% of leaf area destroyed; up to 4 in 10 leaves destroyed; nearly every leaflet has lesions, plants still look normal; 25 – about 25% of leaf area destroyed; nearly every leaflet has lesions; plants remain normal; the field still looks green; 50 – about 50% of leaf destroyed; every plant with lesions; the field is still green but with brown spots; 75 – about 75% of leaf area destroyed; the field colour is between green and brown; 95 – only a few leaves left, but stems are still green; 100 – all leaves dead or dying. Late blight data obtained from the trial field were scored percentage: late blight spread was assessed, and the first early potato cultivar 'Venta' was used as control.

Potatoes plants features were registered according BBCH scale. It covers over 50 parameters. The main are beginning of sprouting, plant exuberance, flowering period, flowers colour, stems number, diseases development on the plant, beginning of foliage destruction, and end of vegetation period. Depending to the plant vegetation period potato varieties are divided to the five maturity groups: first early, second early, maincrop, late and last late. Plants foliage resistance to bacterial, fungal and viruses were determined visually during flowering period. Potato yield quality features such as total yield, marketing tubers yield, tubers number, tubers shape, eye depth, skin and flesh colour, dry matter amount, cookery and technological features.

Study of fiber flax genetic resources collection

The tests were conducted at the Upyte Research Station of the Lithuanian Institute of Agriculture over the period of 1966-2006. A flax-preceding crop was winter wheat and agricultural techniques were conventional. The trials were conducted on a sandy loam soil. Main agrochemical indices of the arable layer of soil: pH – 7.2–7.6; humus content – 2.8-3.9%, total nitrogen content – 0.11–0.13%, amount of available P_2O_5 – 140–183 mg kg^{-1} and K_2O – 116–180 mg kg^{-1}.

Over 350 flax varieties and breeding lines obtained from the N.I. Vavilov Institute of Plant Industry (St. Petersburg) and from the flax collection of the Russian Flax Research Institute (Torzok), etc., were used for testing. These varieties and breeding lines come all over the world: Poland, Czech, France, Germany, Hungary, Romania, Sweden, Austria, Belgium, Japan, China, Ukraine, Byelorussia, Russia, Canada, etc. Trials were conducted in several stages, i. e. every three years testing a new set of varieties and breeding lines. All the investigated varieties were compared to the standard varieties registered in Lithuania at that time, such as 'Svetoc' (1966-1971), 'VNIIL 17' (1972-1977), 'K-6' (1977-1984), 'Orsanskij 2' (1985-1995), 'Belinka' (since 1996). Flax was sown into the belt of 1 m wide with 10 cm interrows, in three replications, in the beginning of May. The plot size was 1 m^2 and seed rate was 22-25 millions germinable seeds per hectare. Flax crops were treated with insecticides and herbicides during a stand care stage.

During the vegetative growth period great attention was paled to lodging and disease resistance, plant height and duration of the vegetative growth period (Tejklova, 1995; Rozhmina & Zhuchenko, 1998). The phenological stages were fixed during the growth period of flax crops. On harvesting the qualitative (number of long fibre, firmness, flexibility, thinness) and quantitative (long fibre output and yield) parameters of the flax yield were determined. Flax plants were pulled up in the early yellow ripeness stage, threshed with a thresher of the 'Eddi' type, stems were soaked in heated water, and straw was broken with a flax brake SMT-200, fiber was hacked with combs No. 9 and No. 13. Quality number of long fibre was determined in the laboratory: flexibility by a device G-2, firmness by a device DK-60, fineness by counting separate fibres in the described fibre sample. Morphological analysis of plants was carried out; stem, linseed and fibre yield was calculated using dispersion analysis.

Resistance of varieties and breeding lines to rust (*Melampsora lini* Desm.) and to fusariose (*Fusarium spp.*) was determined in accordance with methodical instructions (Methodology for Technological Evaluation of Flax and Hemp Production, 1961). For the investigation of flax varieties susceptibility to the causal agents of fusarium, fungi of *Fusarium spp*. genus infectious background was formed in the following way: fusarium-affected flax stems cut into 1–1.5 cm length pieces were arranged at 30–40 g m^{-2} on the soil in wooden boxes (85 x 50 x 20 cm) and then covered by 3-4 cm soil layer. The soil in the boxes was kept moist. After 5-6 days flax was sown into the boxes at a depth of 1.5 cm, and 2.5 x 2.5 cm intervals. Sowing rate was 10-20 seeds, with 2-3 replications in the 3rd ten-day period of May. Two standard varieties were sown: one resistant to fusarium (I–7) and the other one – susceptible to fusarium – (Svetoc). During the vegetative growth period the flax was watered when the weather was dry. For the assessment of susceptibility to rust (*Melampsora lini* Desm.), flax varieties and breeding lines were sown in the experimental field in a 1 m wide band, with 20 cm interrow spacing at a rate of 100 seeds per row, with 1–3 replications. Flax was sown late – in the 2nd or 3rd ten-day period of June. At the "fir-tree" growth period stage the gaps between flax were placed with (40 g m^{-1}) stems (cut at 4–6 cm long segments) infected by *Melampsora lini* Desm. spores of winter stage. In dry weather the flax segments were watered. Until flowering nitrogen fertilizers (15 g m^{-2}) 2–3 times were applied to flax.

Statistical data analysis

The research data were processed using statistical analysis (unifactorical and two-factorial) for quantitative and qualitative parameters and the set of statistical data analysis software "Selekcija". The data of the experiments were treated according to this criterion using the software "ANOVA".

RESULTS AND DISCUSSION

Research of potato genetic resources diversity

One of the main cultivated plants crops features is vegetation period length. Potato vegetation period research leads for the better use of the plants potentiality in the concrete geography zone. Day length has straight influence to potato variety vegetation period and yielding. Potato varieties originated from South America depends to the short day (13–14 h) geographical zone (Bradshaw et al., 2006). So, all potato varieties in the potato gene bank collection are divided into five maturity groups. Provided trials data testify that first early maturity potato group form cover potato varieties which vegetation period from sprouting till foliage death extend 52–58 days in the South East part of Lithuania. To this maturity group were attached 49 varieties. Second early potato group covers potatoes, which vegetation period is 59–68 days. There are 62 varieties in this group. Maincrop maturity group's potato vegetation period is 69-75 days, and there are 42 varieties. There are 20 varieties in the late maturity group; it covers 76–85 days. Last late potatoes' vegetation period is 86–101 days, and 27 varieties are in this group.

Very important factor in potato breeding using hybrid cross method is flowering and berries production. Experiments data give results providing information that modern potato variety which digress greatly from progenitors produce less berries. During last ten years 120 varieties had stable flowering period and only 57 varieties and hybrids without special intervention nurtured seeds naturally in the field conditions. One of the main berries and seeds absence reasons is sterility. In some cases there was no flowering start because flowers don't evolve. They drop down at the size 0.5–1 cm. In other cases asserts fenotipical stamen sterility. It can be invoked by physiological occasions such as unfavorable meteorological conditions when, for example, air temperature during potato flowering period increases up till 25–30^{o}C. At the dry and hot climatic conditions anther sprouts have no possibilities accrue to ovary. Fenotipical sterility can be eliminated at wet and cool medium. In that condition potatoes flower well and produce seeds. Potato variety, which naturally has stamen sterility in the breeding practice, can be used as mother plant. Producing sterile varieties hybrid crosses with fertile, follows split to sterile and fertile. Varieties and hybrids which do not flower and produce berries working with classical breeding methods have no appliance. They can be used as gene donors working with protoplasts in the laboratory.

Lithuanian potato genetic collection is rich with light yellow tubers skin colour and flesh. 135 potato varieties have light yellow tubers skin colour, 112 varieties of them have light yellow flesh. Light yellow tubers colour and flesh dominates in potato tubers which are resistant to R_{o1} potato nematode patotype.

One of the main important factors is potato tubers shape, uniformity, and eye depth. Potato hybrids which produce in the breeding work bad shape and uniformity have no farming value. Jerusalem artichoke tubers shape in potato collection give wild species potatoes. Potato tubers shape degradation from uniform to irregular is found increasing population age. Older varieties have higher virus infection and their plant and tubers shape recede from cultural variety parameters. That can be discussed as entropy expression in the populations of cultural potatoes.

High attention is given to the natural potato resources to diseases and pests. Such disease as wart, also nematodes and viruses can be eliminated partially or fully in producing new potato varieties using genetic material which have high resistance or immune to one or another disease and pest. All potato varieties and hybrids stored in the gene bank are immune to the wart disease. Resistant to Ro1 potato nematode patotype in the gene bank collection are 75 varieties. Crossing varieties when both parent plants have resistance to this pest, progeny hybrids almost always are immune. When one of the parent's not immune progeny hybrids can be selected with negative or positive reaction.

Viruses and virus diseases cause great problems in potatoes. One of the main is potato tuber yield and quality decay. There are no potato varieties or hybrids which have full resistance to the number of viruses. All new selected potato varieties during their vegetation period get virus infection. So the main item in breeding work is use primary breeding material with tolerance to virus diseases. Virus infection development is fast in potato varieties which have no tolerance; it causes plant degradation, increases penetration possibility for fungal and bacterial infection to the plant. It leads to full death of the plant. In the plants which have tolerance to virus infection, viruses cause low injuries which at good growing conditions can't be registered. Typical such variety is 'Dietskosielskij'. In Lithuanian breeding program tolerant varieties from the gene bank are used. Tolerance to viruses in new breed varieties can be reached using classical breeding methods.

In Lithuania the most harmful potato disease is late blight *Phytophthora infestans*. Disease decreases plants leaf assimilation area and destroys fully potato foliage at potato tuberization. Virus infection influence potato yield and during storage period causes different rots. Fifteen years of testing of potato genetic collection gave conclusion that there was no variety with full resistance to *Phytophthora infestans*. First early, second early and maincrop maturity groups' potato varieties and hybrids have low resistance to the late blight. Comparatively late maturity potatoes such as 'Aistes', 'Vilnia', 'Kuras', 'Olev', 'Danve' had the highest resistance to the late blight.

Supreme potato yield in Lithuania produces maincrop varieties. There are no donors with the resistance to the late blight in this group. Breeding maincrop maturity potato varieties genetic material of early and late maturity groups is used. Special methods were used to prevent discrepancy of flowering time. Lithuanian potato gene bank research gave considerable data amount on which base were bred all Lithuanian potato varieties 'Aistes' (('Olympia' x 'Olev') x ('Severnaja' x 'Sagitta')), 'Aista' (N 263 x N 476-9), 'Goda' ('Ausonia' x 'Franci'), 'Liepa' (N 34/36 x 'Pirmunes'), 'Meta' ('Saggita' x 'Comtesa'), 'Mirta' ('Fryla' x No 17/6), 'Nida' ('Amaryl' x ('Sagitta' x 'Olev')), 'Pirmunes' ('Pepo' x VIR), 'Rasa' ('Cardinal' x Viola'), 'Voke' ('Majestic' x No 323), 'Vilnia' ('Sagitta' x 'Neringa'*)*, 'Vaiva' ('Hanibal' x 'Anosta'), 'Venta' ('Priekulu visagrie' x 'Pirmunes') (Table 1).

Selected Lithuanian potato varieties quality data are presented in the Fig. 1. All varieties depending to their genetic feature diversity produced high seed potato yield. Accordingly to their progeny, starch amount and dry matter was different. Shorter growing period potato varieties produced lower amount, when late varieties such as 'Vilnia' and 'Aista' had the highest starch and dry matter amount. Tubers number per potato plant depended to variety genetic features.

The variety 'Goda' produced the highest number of potato tubers. Early and maincrop varieties produced bigger size tubers than the late maturity varieties. This potato variety quality indicator depended on potato vegetation period. The biggest tubers were produced by varieties 'Venta', 'Nida' and 'Goda'. Varieties susceptibility to diseases was different and depended on their genetic progeny.

Table 1. The yield data and economic-biological characteristics of potato varieties (Voke branch, 2001–2006)

Variety	Morphology of tuber				Disease strengths/weaknesses			
	Shape	Color of skin	Color of flesh	Time of maturity	Nematode R_{01}	Wart	Late blight, leaf	Late blight, tuber
Aista	round	yellow	white	very late	+	+	+	+
Goda	round	yellow	yellow	early	+	+	-	+
Liepa	round	yellow	light yellow	early	+	+	-	+
Meta	round	yellow	yellow	very late	+	+	+	+
Mirta	round	yellow	light yellow	medium	+	+	-	+
Nida	short-oval	yellow	light yellow	medium	+	+	-	+
Rasa	oval	red	yellow	very late	+	+	-	+
Voke	oval	yellow	light yellow	early	-	+	-	+
Vilnia	oval	red	yellow	late	+	+	-	+
Vaiva	oval	red	yellow	early	+	+	-	+
Venta	round	yellow	light yellow	very early	-	+	-	+

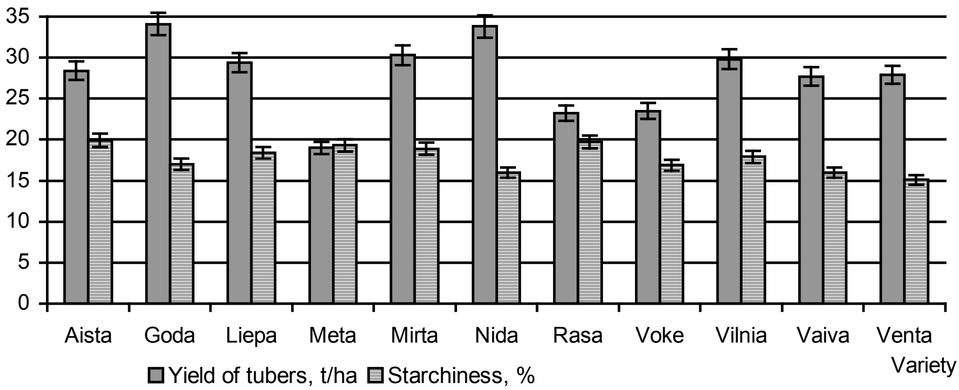

Fig. 1. Economical parameters characteristic of various Lithuanian potato varieties. Each value is the mean of three replicates ± standard error (Voke branch, 2001-2006).

Research of fiber flax genetic resources diversity

The collection serves as a base while selecting flax varieties for hybridisation. Combination power of different varieties of collection elucidated from the intervarietal crossings and some regularities of quantitative and qualitative characters inheritance. Different weather conditions over research years gave an opportunity to select lodging resistant (point 8-9) flax varieties such as: ‘Belinka’, ‘Raisa’, ‘Viola’, ‘Ninke’, ‘Evelina’, ‘Hera’, ‘Ilona’, ‘Escolina’, ‘Regina’, ‘Madonna’, ‘Fibra’, ‘Wiersum 7005-1’, etc. (NLD), ‘Sojuz’, ‘Torzokskij 4’, ‘L-1120’, ‘Krom’, ‘Smolenskij’, ‘Sokinskij’ (RUS), ‘Opaline’, ‘Aurore’, ‘Diane’, ‘Ariane’, ‘Hermes’, ‘Argos’, ‘Viking’ (FRA), ‘Laura’, ‘Elise’ (BEL), ‘Signal’, ‘Mogiliovskij 2’, ‘Prizyv 81’ (BLR) (Table 2, data only of some Lithuanian varieties are presented here). The best donors for developing resistance to lodging are varieties and breed lines: ‘L-1120’, ‘Torzokskij 4’, ‘Sokinskij’, ‘K-6’ (RUS), ‘Ariane’, ‘Viking’, ‘Argos’ (FRA), ‘Regina’, ‘Viera’, ‘Belinka’, ‘Hera’, ‘Fibra’, ‘Diana’ (NLD), ‘Laura’ (BEL) and other.

Table 2. The yield data and economic-biological characteristics of Lithuanian fibre flax varieties ‘Upyte 2’, ‘Baltuciai’, ‘Vega 2’ and ‘Kastyciai’ in the competitive variety trials (Upyte Research Station, 1966–2006)

Characteristic	Variety			
	Upyte 2	Baltuciai	Vega 2	Kastyciai
Long fibre content	19.7 ± 1.5	17.1 ± 0.4	15.1 ± 0.5	19.4 ± 1.4
Quality of fibre:				
Number	11.7 ± 0.3	10.8 ± 0.6	11.6 ± 0.5	12.0 ± 0.3
flexibility mm	43.5 ± 5.1	53.3 ± 0.9	53.8 ± 3.7	44.4 ± 1.7
firmness kgj	14.8 ± 1.9	14.3 ± 2.4	23.6 ± 2.6	22.3 ± 2.2
thinness unit	189 ± 21	195 ± 33	202 ± 10	271 ± 20
Plant height, cm	80.9 ± 6.1	69.2 ± 4.6	70,.8 ± 1.9	66.9 ± 2.9
Technical stem length, cm	69.4 ± 7.5	58.8 ± 3.9	61.1 ± 2.3	61.3 ± 2.8
Lodging resistance in points	4.7 ± 0.2	4.6 ± 0.2	4.6 ± 0.2	5.0
Growth period in days	97 ± 4	87 ± 2	83 ± 3	90 ± 6
1000 seed weight g	5.24 ± 0.27	4.70 ± 0.12	5.50 ± 0.14	5.32 ± 0.27

Fiber quality was higher (firm, flexible, fine and met the demand of textile) of the following varieties: ‘Banga’, ‘Vega’, ‘Vega 2’, ‘Vaizgantas’ (LTU), ‘Saldo’ (EST), ‘Aoyagi’ (JPN), ‘Orsanskij 2’, ‘Progress’, ‘Vita’, ‘Promenj’, ‘Vitebskij’ (BLR), ‘1288/12’, ‘806/3’, ‘Svetoc’, ‘Vasiliok’, ‘Viatic’, ‘Zaria’ (RUS), ‘Belinka’, ‘Natasja’, ‘Wiersum 7005-1’ (NLD), ‘Bertelin’, ‘Rastatter’, ‘Berthelsdorf 6484/60’ (DEU), ‘Zoria 87’ (UKR), etc.

The following varieties and breeding lines have high long fiber content (till 23 %): ‘Upyte 2’ (LTU), ‘Ariane’, ‘Viking’, ‘Argos’, ‘Hermes’, ‘Diane’ (FRA), ‘Viola’, ‘Raisa’ (NLD), ‘T-9’, ‘T-10’, G-1071-4, G-1071-6-2, ‘K-6’, ‘Lazurnyj’, ‘A-29’, ‘Aleksim’ (RUS), Zodinskij’, ‘Daskovskij’, ‘D-20’ (BLR), ‘Elise’ (BEL) and other. The best donors for developing of high fibration are ‘T-9’, ‘T-10’, Torzokskij 4’, G-1071-4, G-1071-6-2, ‘A-29’, ‘K-6’ (RUS), ‘Argos’, ‘Viking’, ‘Hermes’, ‘Ariane’, (FRA), ‘Upyte 2’ (LTU), ‘Zodinskij’, ‘D-20’ (BLR), etc.

Quality data of some selected Lithuanian fiber flax varieties are presented in the Fig. 2. ‘Severianin’, ‘1288/12’, ‘Rassvet’, ‘T-5’, ‘T-7’, ‘T-9’, ‘Slavnyj 82’, ‘Svetoc’, ‘Omega’, K-952, K-2848, K-6664, K-3584, K-3585, K-3617, K-3600 (RUS), ‘Baltuciai’ (LTU), Rod 781 (CZE), ‘Xesan 5’ (KOR), ‘Il de France’, ‘Tajga’ (FRA), and some other varieties and samples have a short growth period (70-90 days). The varieties and breeding lines ‘Svalof 0228’ (SWE), ‘Saldo’ (EST), ‘Aoyagi’ (JPN), ‘Ariane’, ‘Hermes’, ‘Diane’ (FRA), ‘VNIIL-11’, ‘VNIIL-19’, ‘L-1120’, ‘Torzokskij 4’, ‘K-6’, ‘Lazurnyj’ (RUS), ‘LD-147’ (UKR), ‘Berthelsdorf 6484/60’, ‘Bertelin’ (DEU), ‘Belinka’, ‘Madonna’, ‘Natasja’, ‘Ninke’, ‘Berber’, ‘Escolina’ (NLD), ‘Svapo’ (POL), ‘Laura’ (BEL), ‘Zodinskij’ (BLR) etc., have long growing period (90-100 days). The best donors for developing early or medium early varieties are flax varieties ‘1288/12’, ‘Slavnyj 82’, ‘Svetoc’, ‘Rassvet’, ‘Severianin’ (RUS), ‘Tajga’ (FRA), ‘Baltuciai’ (LTU), ‘Viola’, ‘Raisa’ (NLD), etc.

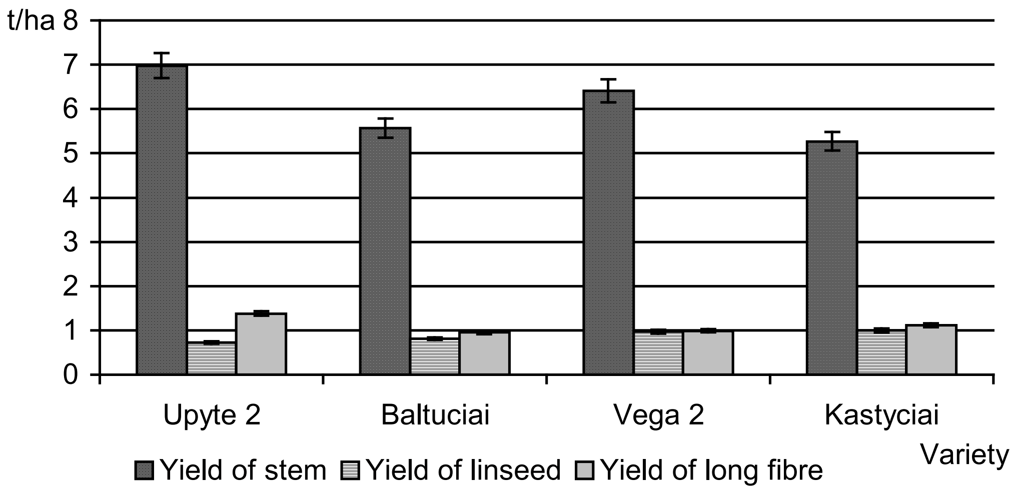

Fig. 2. Economical parameters of various fiber flax varieties of Lithuanian origin. Each value is the mean of three replicates ± standard error (Upyte Research Station, 1966-2006)

The longest stems (70-85 cm) amongst the tested varieties belonged to the varieties ‘Aoyagi’ (JPN), ‘Escolina’, ‘Evelina’, ‘Natasja’, ‘Ninke’, ‘Belinka’, ‘Ilona’ (NLD), ‘L-1120’, ‘Zaria’, ‘R-1’, ‘Stodoliscenskij’ ‘VNIIL-19’, ‘VNIIL-14’, ‘Torzokskij 4’, ‘C-6’, ‘Torzokskij 85’, ‘VNIIL-11’ (RUS), ‘Diane’, ‘Ariane’ (FRA), ‘Ariadna’, ‘Svapo’, (POL), ‘Upyte 2’, ‘Banga 2’ (LTU) and some other.

The varieties ‘Belinka’, ‘Ninke’, ‘Regina’, ‘Cebeco’, ‘Wiersum 7005-1’, ‘Escolina’ (NLD), ‘Torzokskij 4’, ‘VNIIL-11’, ‘VNIIL-19’, ‘L-1120’, ‘C-108’, ‘Krom’, ‘K-6’ (RUS), ‘Viking’, ‘Ariane’, ‘Hermes’, ‘Diane’ (FRA), ‘Zodinskij’, ‘Mogiliovskij 2’ (BLR), ‘Millenium’ (POL) and some other distinguished themselves by abundant stem (500-1000 g m^{-2}), seed (110-180 g m^{-2}) and long fiber (80-140 g m^{-2}) yield. Some varieties and breed lines ‘Belinka’, ‘Ninke’, ‘Regina’, ‘Escolina’ (NLD), ‘Torzokskij 4’, ‘VNIIL-11’, ‘Krom’, ‘VNIIL-19’ (RUS), ‘Viking’, ‘Ariane’, ‘Hermes’, ‘Diane’ (FRA), ‘Zodinskij’, ‘Mogiliovskij 2’ (BLR) have the complex of positive properties and characters and may be used in the flax intervarietal crossings.

The most resistant to flax rust were the varieties and breeding lines ‘T-13’, ‘Uspech’, ‘Torzokskij 4’, ‘Aoyagi’ (JPN), ‘Belorusskij 2’, ‘Rodnik’, ‘Daskovskij’ (BLR), ‘LCSD-207’, ‘Minerva’ (POL), ‘Astella’ (FRA), etc. The degree of disease severity fluctuated between 1.5-10%. The best donors for developing flax varieties resistant to rust are varieties ‘Uspech’, ‘Torzokskij 4’, (RUS), ‘Aoyagi’ (JPN), ‘Astella’ (FRA), etc.

Very resistant to fusariose were the varieties and samples ‘Dvina’ (BLR), ‘Aoyagi’ (JPN), ‘T-13’, ‘I-7’, ‘L-1120’, ‘VNIIL-3’, ‘Natasja’ (NLD), ‘Currong’, ‘Banner’ (AUS), ‘LD-147’ (UKR), ‘Daros I’, ‘Cascad’ (DEU), and some others, the degree of disease severity fluctuated between 0.5-12%. The best donors for developing fusariose resistant varieties are the varieties ‘I-7’, ‘T-13’ (RUS), ‘Dvina’ (BLR), ‘Aoyagi’ (JPN), ‘LD-147’ (UKR), ‘Natasja’ (NLD), etc.

The highest yields and resistance to lodging had varieties from the West European Region – from Netherlands and France. The varieties bred in Russia were most resistant to rust and fusariose diseases.

Multifunctionality and competitiveness design the future scenarios of the common agricultural policy in the EU. Multifunctionality comprises sustainable development, environmental conservation, and food safety, cultivation of plants more able to provide food, renewable materials, nutraceutical and functional dietary supplements. The integration between farms and agro-industry and the identification of a strategy to design improved plants with enhanced industrial end uses become relevant ((Plant Genetic Resources, 2009). In Lithuania, research on industrial crops dealt in particular with food and non-food species and scientific programs are based on an integrated and multidisciplinary approach including crop physiology, advanced plant breeding methods and crop management.

Technical crops can be attractive economically because they often provide a high unit value product. As well, they can offer employment opportunities through the nature of the processing associated with their production and utilisation. Some crops have always been grown for non-food purposes, for example flax for fibre. But recently the flax seeds find new application area for food, feeding, medicine, cosmetics, etc.

CONCLUSIONS

The following conclusions were drawn after the research of the genetic resources collections of potatoes and fibre flax varieties and breeding lines, conducted in Lithuania:

- Studies of potato gene bank gave significant data about every variety and hybrid. Splendiferous genetic material was used in the breeding work to produce local potato varieties and hybrid crosses for further breeding. Potato varieties were divided into five maturity groups: first early, second early, maincrop, late and last late. Potato varieties varied in accordance of morphologic, physiologic, immunologic and farming features in the groups and between groups. Dominant potato tubers skin and flesh color – light yellow, dominant tuber shape – round, oval round and oval long.
- All tested potato varieties are immune to wart disease, 75 varieties and hybrids have resistance genes to potato cyst nematode patotype R_{o1}. Virus resistant potato varieties as donors were not found. Tolerant to virus infection potato gene donors were only few. Late maturity potato varieties genetically have higher resistance to the late blight than early.
- All varietys are immune to the main quarantine object in Lithuania – wart disease. The potato varieties 'Goda', 'Liepa', 'Rasa' and 'Aista' are immune to the potato cyst nematode Globodera rostochiensis R_{O1} patotype. All varieties have good field resistance against the most wide spread diseases – black leg, viruses, common scab, rizoctonia and etc. Their foliage have a fair resistance and tubers a good resistance to late blight. Storage characteristics under controlled conditions are good.
- While breeding new fiber flax varieties, into hybridisation process it is necessary to involve specific genotypes having following value for cultivation or biological features: fibre content – 'Hermes', 'T-10', 'T-9', G-1071-6-2, etc; productivity – 'Belinka', 'Hermes', 'Fibra', 'L-1120', etc; lodging resistance – 'Fibra', 'Reina', 'Emmeraude', 'Silva', etc; flax rust resistance – 'L-1120', 'Uspech', 'Aoyagi', 'Belorusskij 2', etc; fusariose resistance – 'I-7', 'L-1120', 'VNIIL-3', 'Currong', etc.
- The varieties and breeding lines 'Ariane', 'Reina', 'Viking', 'Torzokskij 4', 'L-1120', 'Belinka', 'VNIIL-11', 'Datcha', 'VNIIL-19', 'Bertelin', 'Diane', 'C-108', and some other have a complex of good values for cultivation and biological features. They will be involved into fiber flax next years breeding programs.

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