INVESTIGATION AND USE OF THE LITHUANIAN FLAX GENETIC RESOURCES IN THE BREEDING PROGRAMS
LIETUVAS LINU ĢENĒTISKO RESURSU IZPĒTE UN IZMANTOŠANA AUDZĒŠANĀ

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Abstract. *The profusion, diversity and value of genetic resources significantly contribute to the success of flax breeding. Of special value are genotypes of local origin, highly adapted to the local climatic and soil conditions. Storage of genetic resources in Lithuania was started in 1994-1995. During the period 1995-1997 25 flax varieties and local accessions were studied at the Upytė Research Station of LIA. In 1998-2000 we tested 21 varieties and breeding lines, in 2001-2002 18 accessions, in 2003-2004 12 accessions. The best genotypes were included in flax breeding programs. About 50 genotypes have been transferred to the Gene Bank of the Lithuanian Institute of Agriculture after assessment for biological-agronomical characters following UPOV descriptors.*

Keywords*: accession, breeding, breeding lines, genetic resources, fibre flax, Gene bank, genotype, variety.*

Introduction

Collection, storage and investigation of plant genetic resources have become a very important task in many countries [1, 3, 5, 7, 8]. Many authors report that plant genetic resources have a national value for each country [2, 4, 5, 6, 7, 8, 10]. Different local varieties, accessions, and breeding lines serve as a solid basis for the development of new plant varieties [1, 3, 4, 10].

The aim of the present study was to collect and store fibre flax varieties created earlier and recently, different local accessions (landraces), valuable breeding lines as well as registered fibre flax varieties in our Republic and to assess those accessions as a fibre flax Gene Fund of Lithuania, describe them following the guidelines and criteria of international organizations, and to transfer the evaluated and described accessions to the Gene Bank stationed at the Lithuanian Institute of Agriculture.

Materials and methods

Collection and storage of flax genetic resources in Lithuania was started in 1994. The investigations were carried out in different stages: in 1995-1997, in 1998-2000, and in 2001-2002. In 2003-2004 12 accessions consisting of fibre flax varieties currently registered in our Republic and registered some time before were investigated.

The flax preceding crop was winter wheat. Conventional agricultural practices were applied. The trials were conducted on a sandy loam Endocalcari-Endohyphgleic Cambisol. The main agrochemical parameters of the arable soil layer were as follows: pH_{KCl} – 7.2-7.6, humus content - 1.64-2.24 %, total nitrogen content – 0.12-0.16 %, available P_2O_5 – 145-205 mg kg^{-1}, available K_2O – 140-185 mg kg^{-1}.

All the investigated varieties and local accessions were compared to the standard varieties registered in Lithuania at the time of the investigations (such as „Belinka", „Baltučiai" (1995-1997), „Ariane" (1998-2000 and 2001-2002), „Hermes" (2003-2004).

Flax was sown in a 1 m wide band with 10 cm interrows, in three replication at the beginning of May. The size of an experimental plot was 1 m^2 and the seed rate was 25 million viable seed per hectare. Flax crop was treated with insecticides and herbicides.

The phenological stages were recorded during the growing period [9]. During the growing season great attention was paid to flax lodging and disease resistance, plant height and length of the growing season. At harvesting flax fibre quantitative (fibre content) and qualitative parameters (fibre tenacity, flexibility, thinness) were determined [9]. For this flax plants were

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pulled up in the early yellow ripeness stage, threshed with a thresher of the "Eddi" type. Stems were soaked in hot water, straw was breaked with a scutching tool SMT-200. Flax fibre was hackled with combs Nb. 9 and Nb. 13. Quality of long fibre was determined in the laboratory: flexibility – by a device G-2, tenacity – by a device DK-60, fineness – by measuring individual fibres in a specific fibre sample [9]. The incidence of the diseases (*Fusarium* spp., *Septoria linicola*, *Colletotrichum lini*, *Plyspora lini* etc.) was estimated on the natural background in the field conditions [9].

Over experimental years (1995-2004) the weather conditions were diverse, which gave us a good chance to estimate the performance of the varieties and local accessions under various conditions.

Results and discussion

Storage of plant genetic resources in Lithuania was started in 1994-1995. In 1995-1997 25 flax varieties and local accessions were investigated at the Upytė Research station of the Lithuanian institute of Agriculture. In 1998-2000 the investigation of 21 varieties and breeding lines, in 2001-2002 – of 18 accessions, in 2003-2004 – of 12 accessions was carried out. The last 12 accessions will be tested for another year, and the data will be presented later. Tables 2 and 3 present the data of only some tested varieties.

Evaluation of Lithuanian flax Gene Fund during 1995-1997. Averaged data from three years, show that the highest seed yield (131-141 g m^{-2}) was produced by the varieties „Belinka", L-1120-1, K-5497 and „Vega 2", a little lower yield (121-127 g m^{-2}) was obtained from the following varieties: F-5-398-4, E-4-430-2, M-4-126-1, 777, K-5978, K-5583 (Table 1). High seed yield is a valuable character of a variety or of a local accession. It depends on the length of the growing season, crop resistance to lodging and diseases, and seed size.

The investigated varieties differed in plant height, too. The tallest plants (76-82 cm) were identified for the varieties F-5-398-4, „Upytė 2", „Vaizhgantas, 1890-32, E-4-430-2, „Orshanskij 2", „T-10", „L-1120", 1885-14, D-5-344-4. Varieties „Svetoch", „806/3", K-5978, K-5497 and K-5583 produced short plants (59-68 cm).

Varieties „Belinka", 1660-40, L-1120-1, „L-1120", K-5978, K-5497 and K-5583 are characterised by a long growing season (92 days), varieties „1288/12", „Svetoch" and „Baltuchai" by a short growing season (85-87 days).

Lodging resistance is a very important character of the variety, because it is very difficult to pull up lodged flax, and the lodged flax is of a rather poor quality [4, 9]. Averaged data from 1995-1997 suggest that the following varieties were selected as lodging resistant: „Upytė 2", „Belinka", „L-1120", L-1120-1, „Vega 2", „Baltuchai", D-5-344-4, M-4-126-1, E-4-430-2, F-5-398-4, K-5978, K-5497, 1885-14, 1890-32 and K-5583. Non-resistant to lodging (7.9 points) were flax varieties „Orshanskij 2" and „806/3".

The largest seed (1000 seed weight 6.46-5.55 g) was produced by accessions L-1120-1, 1885-14, „Upytė 2", „Vega 2" and „L-1120". Varieties „Vaizhgantas", „Banga" and breeding line Nb.1660-40 produced the smallest seed (1000 seed weight 4.78-4.52 g).

The chief quality parameters of flax fibre are tenacity, flexibility and divisibility (it shows fibre thinness). Averaged data from 1995-1997 show that the highest fibre tenacity (18-19 kg f) was identified for the accessions „Vaizhgantas", „806/3", 1660-40, and K-5583 (Table 2). Accessions „Vaizhgantas", „Vega 2", „Belinka", „Orshanskij 2", „806/3", „1288/12" and 777 were selected as possessing the highest fibre flexibility (40-45 mm), and accessions „Vaizhgantas", „Baltuchai", „Belinka", M-4-126-1, „806/3", K-5583 and „1288/12" – as having the thinnest fibre (divisibility of which was 230-330 units).

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Table 1.

Characteristics of some flax varieties and breeding lines investigated in 1995-1997

Accession	Country of origin	Linseed yield, g m^{-2}	1000 seed weight, g	Plant height, cm	Growing period, days	Lodging resistance, points
„Svetoch”	RUS	94	5,01	68	86	8,1
„Vaizhgantas”	LTU	112	4,52	79	91	8,2
„Upytė 2”	LTU	103	5,62	80	90	9,0
„Vega 2”	LTU	131	5,79	74	89	9,0
„Baltuchai” (stand.)	LTU	120	5,13	73	87	9,0
„Belinka” (stand.)	NLD	141	5,20	75	92	9,0
„Orshanskij 2”	BLR	118	4,89	77	90	7,9
D-5-344-4	LTU	113	5,34	76	91	9,0
M-4-126-1	LTU	122	5,00	75	91	9,0
E-4-430-2	LTU	122	5,08	78	90	9,0
„Banga 48”	LTU	115	5,09	75	89	8,6
„806/3”	RUS	114	4,80	68	89	7,9
„T-10”	RUS	121	5,10	77	88	8,1
„Banga”	LTU	112	4,63	71	88	8,2
1660-40	LTU	111	4,78	70	92	8,6
L-1120-1	LTU	139	6,46	75	92	9,0
„L-1120”	RUS	130	5,55	76	92	9,0
F-5-398-4	LTU	122	4,98	82	91	9,0
K-5978	LTU	126	4,88	61	92	9,0
K-5497	LTU	136	4,87	59	92	9,0
„1288/12”	RUS	100	5,00	75	85	8,2
777	LTU	124	5,20	73	89	8,2
1885-14	LTU	109	5,61	76	90	9
1890-32	LTU	105	4,95	79	90	9
K-5583	LTU	127	5,31	62	92	9

Evaluation of Lithuanian flax Gene Fund in 1998-2000. The highest seed yield (130-150 g m^{-2}) was produced by the accessions „Laura”, 0249-4, 1732-6 and 1959-7 (Table 3).

The tallest plants (70-77 cm) were obtained from the accessions 1959-7, 1953-20, „Ariane”, „Mogiliovskij 2”, 0917-10 and 1687-24-23. „Saldo”, and 01125-32 produced slightly shorter plants (66 cm).

Over the experimental period the varieties „Laura”, „Ariane” and 0861-42 were selected as late ripening, and the accessions 0917-10 and 1687-24-23 were medium late (growing period 98 days).

Varieties with complete resistance to lodging were not found among the accessions investigated in 1998-2000. The most resistant to lodging were plants of accessions „Laura”, „Ariane and 1547-11-7 – their lodging resistance was estimated as 8.0-8.3 points.

Accessions „Laura”, „Saldo” and 1547-11-7 produced the largest seed (1000 seed weight 5.30-5.38 g), accession 0861-42 – the smallest seed (1000 seed weight 4.53 g).

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Table 2.

Long fibre parameters of some flax accessions investigated in 1995-1997

Accession	Country of origin	Long fibre parameters		
		Flexibility, mm	Firmness, kg f	Divisibility, units
„Vaizhgantas”	LTU	44,9	18,5	232
„Vega 2”	LTU	41,9	16,1	225
„Baltuchai” (stand.)	LTU	32,0	15,3	245
„Belinka” (stand.)	NLD	42,0	14,3	325
„Orshanskij 2”	BLR	45,6	13,2	234
M-4-126-1	LTU	36,8	13,4	294
„806/3”	RUS	42,2	19,1	291
„1288/12”	RUS	40,7	15,0	269
1660-40	LTU	33,8	18,9	218
777	LTU	40,5	16,6	199
K-5583	LTU	35,5	18,5	241

Table 3.

Characteristics of some flax varieties and breeding lines investigated in 1998-2000

Accession	Country of origin	Linseed yield, g m^{-2}	1000 seed weight, g	Plant height, cm	Growth period, days	Lodging resistance, points
„Ariane” (stand.)	FRA	122	4,75	75	103	8,0
„Mogiliovskij 2”	BLR	124	4,64	73	100	6,7
„Laura”	NDL	141	538	70	104	8,3
„Saldo”	EST	121	5,30	66	102	4,7
01125-32	LTU	114	4,86	66	100	5,7
0249-4	LTU	139	4,99	69	99	6,5
0861-42	LTU	121	4,53	69	103	6,0
0917-10	LTU	128	4,72	71	98	5,0
1687-24-23	LTU	121	5,09	71	98	6,0
1732-6	LTU	146	4,60	69	99	5,0
1826-5	LTU	126	5,22	68	102	7,8
1547-11-7	LTU	121	5,32	69	102	8,0
1959-7	LTU	138	5,01	77	100	6,3
1953-20	LTU	125	4,71	77	100	6,0

Accessions „Ariane”, „Mogiliovskij 2”, 01125-32, 0249-4, 0861-42, 0917-10 and 1826-5 were distinguished themselves for high long fibre content – 26-28 %, and accessions „Laura”, „Saldo, 1687-24-23, 1732-6, 1959-7 and 1953-20 – for low fibre content (22-24 %) (Fig.1).

Fibre quality parameters of the investigated accessions were different (Table 4). The most flexible fibre (38.2-39.8 mm) was identified for accessions 1547-1-7, 1732-6 and 1959-7, and finest fibre (divisibility 240-260 units) – for accessions 1959-7, 1547-11-7 and 1687-24-23.

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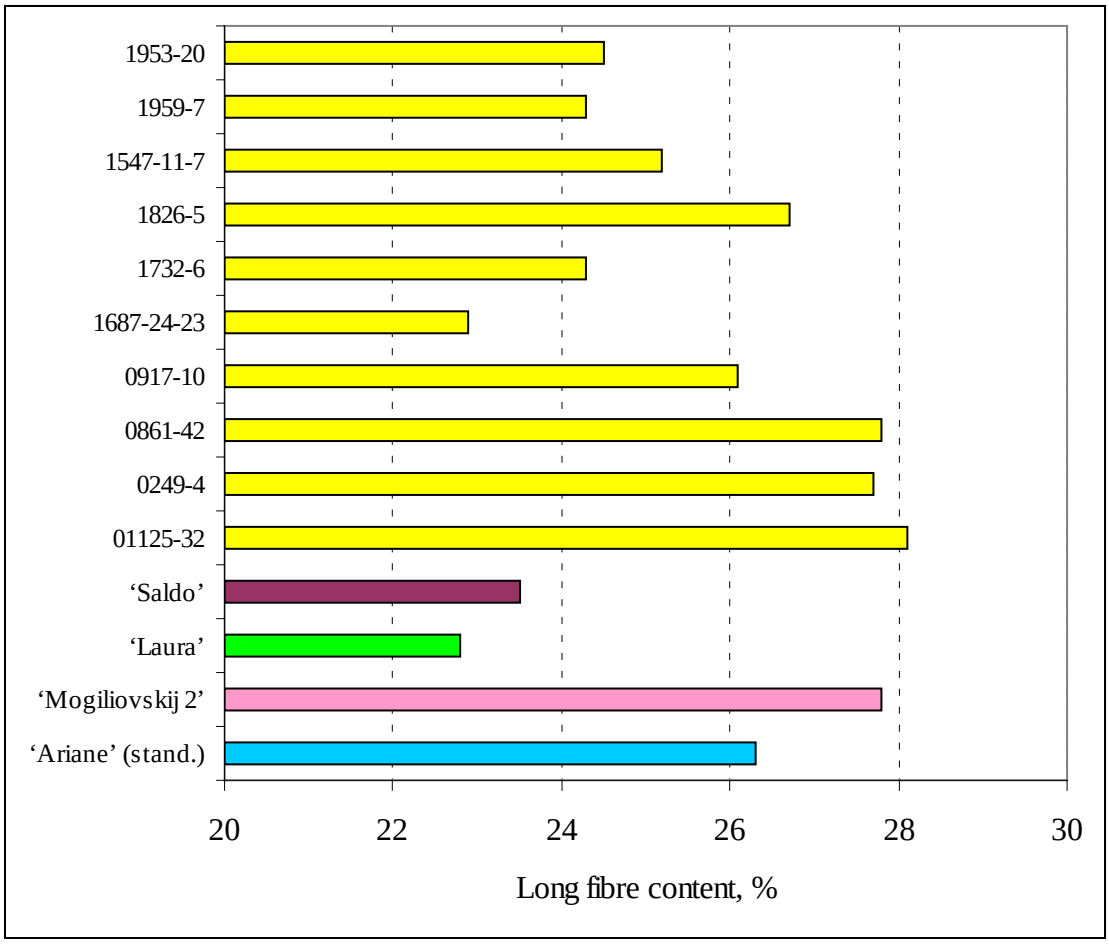

Fig. 1. **Long fibre content of accessions investigated in 1998-2000**

Table 4.

Long fibre parameters of some flax accessions investigated in 1998-2000

Accession	Country of origin	Long fibre parameters		
		Flexibility, mm	Tenacity, kg f	Divisibility, units
„Ariane" (stand.)	FRA	34,0	12,0	200
0249-4	LTU	34,1	11,6	210
0861-42	LTU	38,8	12,9	199
0917-10	LTU	35,5	11,5	228
1687-24-23	LTU	35,9	11,8	266
1732-6	LTU	39,8	11,1	225
1547-11-7	LTU	39,2	11,8	260
1959-7	LTU	39,2	10,2	243

Evaluation of Lithuanian flax Gene Fund in 2001-2002. Averaged data from 2 testing years revealed that the accessions „Alfa-B", 0877-5 and 1827-30 produced the highest seed yield (98-111 g m^{-2}) (Table 5). The lowest seed yield (98-111 g m^{-2}) was produced by the accessions 0964-12 and 1790-10. Flax stems of the accessions „Banga 2", „Ariane", 1790-10, 0964-12 were the tallest. Growth period of all tested accessions was very similar. Accessions „Ariane" and „Banga 2" had a little bit longer growing season period (90-92 days), and accession 01186-6 had the shortest growing season (86 days). In terms of lodging resistance, the most resistant (9 points) were accessions 1826-26, 1827-5, 1827-30 0877-5 01032-5 and 1790-10. The seed size was very similar for all investigated accessions. Accessions 1910-5, 1463-43, 0877-5 and „Banga 2" produced larger seeds (1000 seed weight 4.76-4.90 g).

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The highest fibre content (27.3-28.5 %) was obtained from the flax of accessions 1826-26, 1463-43, 01032-5, 1827-5 and 1827-30 (Fig. 2).
Averaged data from 2001-2002 indicate that flexible fibre (41-44 mm) was specific to the accessions „Alfa-B", 0964-12, 1827-30 and 1951-5 (Table 6). Accession „Alfa-B" also had the highest fibre tenacity (16.7 kg f). Fibre tenacity of the other investigated accessions was between 12-13 kg f. Fibre of accessions „Alfa-B", 0964-12, 1827-5, 1827-30 and 1951-5 was thin (divisibility 248-289 units).

Table 5.

Characteristics of some flax varieties and breeding lines investigated in 2001-2002

Accession	Country of origin	Linseed yield, g m^{-2}	1000 seed weight, g	Plant height, cm	Growth period, days	Lodging resistance, points
„Banga 2"	LTU	87	4,76	80	90	8,9
„Alfa-B"	LTU	98	4,33	71	87	8,8
0964-12	LTU	83	4,51	72	88	8,9
0877-5	LTU	111	4,87	67	87	9,0
01032-5	LTU	93	4,55	62	87	9,0
01186-6	LTU	90	4,28	69	86	8,8
01186-8	LTU	90	4,25	70	87	8,8
1463-43	LTU	88	4,78	70	87	8,3
1790-10	LTU	80	4,31	73	99	6,9
1826-26	LTU	91	4,48	68	87	9,0
1827-5	LTU	90	4,3	67	88	9,0
1827-30	LTU	104	4,68	66	89	9,0
1910-5	LTU	85	4,90	68	87	8,8
1951-5	LTU	91	4,36	67	88	8,8
„Ariane" (stand.)	FRA	88	4,70	75	92	9,0

Table 6.

Long fibre parameters of some flax accessions investigated in 2001-2002

Accession	Country of origin	Long fibre parameters		
		Flexibility, mm	Tenacity, kg f	Divisibility, units
„Ariane" (stand.)	FRA	35,7	12,6	146
„Alfa-B"	LTU	41,6	16,7	255
0964-12	LTU	43,4	12,6	261
1827-5	LTU	37,5	13,6	248
1827-30	LTU	42,9	12,4	251
1910-5	LTU	37,3	12,3	212
1951-5	LTU	44,2	13,7	289

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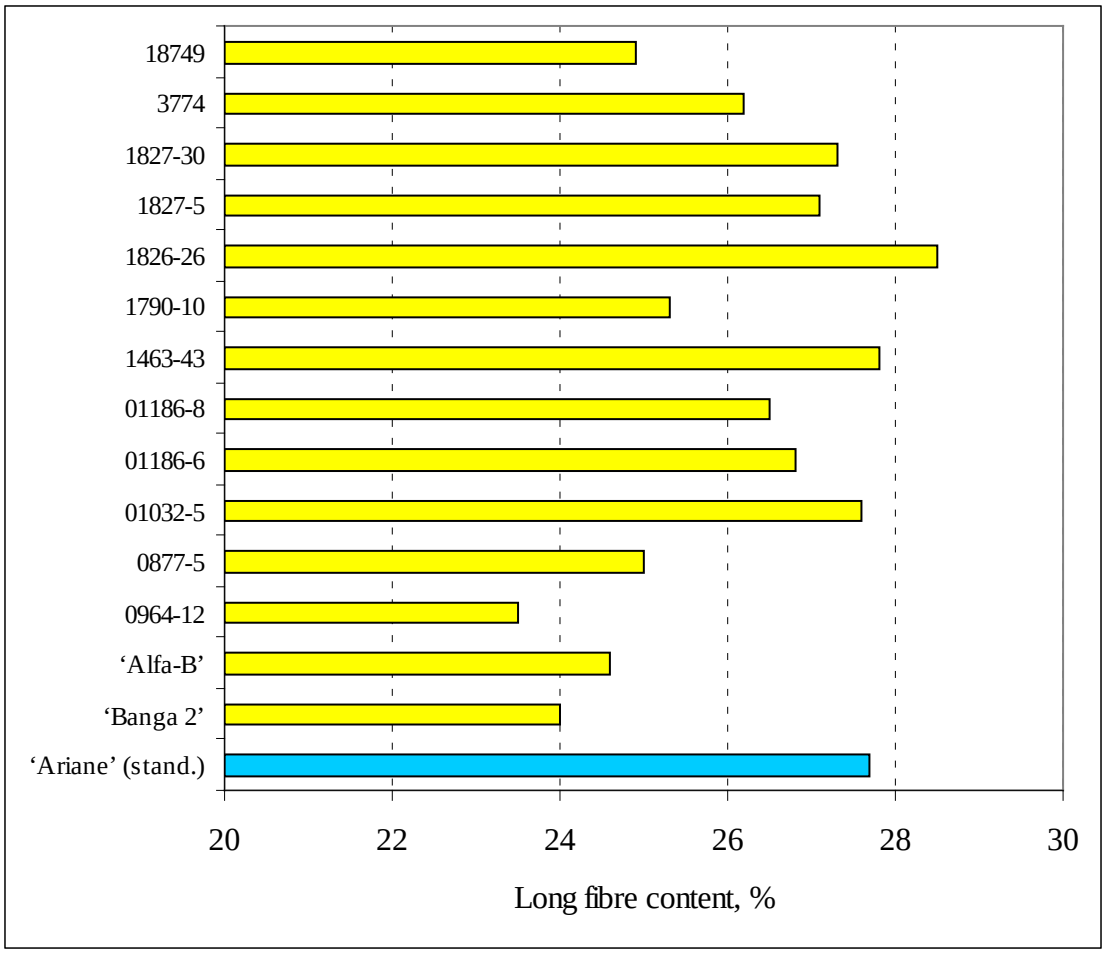

Fig. 2. **Long fibre content of accessions investigated in 2001-2002**

Conclusions

Based on flax accessions testing carried out at the Upytė Research Station of the Lithuanian Institute of Agriculture during the period 1995-2002, the following conclusions were drawn:

1. Storage of genetic resources in Lithuania was started in 1994.
2. In 1995-1997 25 flax varieties and local accessions were investigated, in 1998-2000 21 varieties and breeding lines, in 2001-2002 – 18 accessions. In 2003-2004 12 accessions were investigated and the investigation process will be continued for another year.
3. The main test parameters of flax Gene Fund were biologically and agronomically valuable characteristics such as seed productivity, long fibre content and quality, plant height, length of flax growing season, lodging resistance.
4. In total, 60 different flax genotypes were found to posses some valuable characters:
   - 4.1. Lodging resistance: „Upytė 2", „Baltuchai", „Belinka", D-5-344-4, M-4-126-1, E-4-430-2, L-1120-1, „L-1120", F-5-398-4, K-5978, K-5497, 1885-14, 1890-32, K-5583, 0877-5, 01032-5, 1826-26, 1827-5, 1827-30, „Ariane";
   - 4.2. Highest seed yield: „Vega 2", „Belinka", L-1120-1, „L-1120", K-5497, „Laura", 0249-4, 1732-6, 1959-7;
   - 4.3. Tallest plants: „Vaizhgantas", „Upytė 2", E-4-430-2, „L-1120", F-5-398-4, 1890-32, „Banga 2";
   - 4.4. Early maturity: „Svetoch", „Baltuchai", „1288/12", 0917-10, 1687-24-23, 01186-6;
   - 4.5. Late maturity: 1660-40, L-1120-1, „L-1120", K-5978, K-5497, K-5583, „Laura", 0861-42, „Ariane";
   - 4.6. Largest seed: „Vega 2", L-1120-1, 1885-14, „Upytė 2", „Laura", 0877-5;
   - 4.7. High fibre quality: „Vaizhgantas", „Vega 2", „Belinka", „Orshanskij 2", „806/3", „1288/12", „Alfa-B".

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5. After investigation and description of the flax accessions the seeds of the above-mentioned flax genotypes and description data were transferred to the Gene Bank of the Lithuanian Institute of Agriculture for long-term storage.

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