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Evaluation of the old Lithuanian flax cultivars included in the list of Lithuanian Traditional Crafts

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Abstract

The old Lithuanian fibre flax (*Linum usitatissimum* L.) cultivars 'Kondratavičiaus', 'Dotnuvos ilgūnėliai I', 'Dotnuvos ilgūnėliai II', and 'Vaižgantas', developed before World War II have been included in the list of Lithuanian Traditional Crafts. The seed accessions of these cultivars, obtained from various gene banks, were tested at the Upytė Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry in 2013–2015. The accessions of each cultivar were compared among themselves and with a modern fibre flax cultivar 'Kastyčiai' used as a standard. Due to the small quantity of available seed, the experimental plots 1 m^2 in size were sown manually in three replications. Flea-beetles were controlled by insecticides and weeds by the herbicide Glean (a.i. 750 g kg^{-1} chlorsulfuron in the form of a water dispersible granule). Flax was harvested at an early yellow ripening stage. Phenological phases, plant height, flower colour, stem, seed and long fibre yield, fibre content and quality (flexibility, strength and quality number), duration of vegetation period, resistance to lodging were investigated. The study showed the modern fibre flax cultivar 'Kastyčiai' to be superior to the old fibre flax accessions in terms of stem and long fibre yield and plant height. However, the old flax cultivars showed a better performance in terms of seed yield, duration of vegetation period as well as fibre quality parameters (particularly fibre flexibility) than the standard 'Kastyčiai'. The study showed that the accessions bearing the same cultivar name differed in the characteristics tested.

Key words: cultivars, fibre content, fibre flax, fibre flexibility, yield.

Introduction

Lithuanians should be proud of their achievements in flax growing in the first half of the 20th century. In 1928, the total flax production area in in Lithuania amounted to 90 thousand hectares. In 1933–1938, Lithuania was the third country in Europe (following USSR and Poland) according to the flax growing area. Over the 1926–1939, Lithuania annually exported around 50.3% of the total flax fibre produced and around 46.5% of the total flax seed produced. In 1927, the flax fibre exports amounted to 21 100 t, which accounted for 71.5% of the total fibre produced, and flax seed exports totalled 25 000 t, which accounted for 69.5% of the total seed produced. The sales of production yielded Lithuania 85.1 million Litas, or 32.6% of the total exports income (Flax trials…, 1942). Until the end of the 19th century farmers used their own local flax seed for sowing. In the 2nd and 4th decades of the 20th century, a local flax cultivar 'Kondratavičiaus' was the most popular among the flax growers (Vyšniauskaitė, Laniauskaitė, 1977). The plant height of the cultivar was 70–90 cm (Bačelis, 2001), it produced a satisfactory stem and fibre yield but low seed yield (Flax trials…, 1942). Records show that 'Kondratavičiaus' produced a stem yield of 2.67–3.01 t ha^{-1}, a seed yield of 0.31–0.49, and a fibre yield of 0.33–0.61 t ha^{-1} of (Bačelis, 2001).

Flax breeding work was started in 1922 at Dotnuva Plant Breeding Station and in 1942–1945 was transferred to Savitiškis Experimental Station. The first two fibre flax cultivars 'Dotnuvos pluoštiniai' and 'Dotnuvos ilgūnėliai I' were developed at Dotnuva Breeding Station (Ruzgas, 2009). The cultivar 'Dotnuvos ilgūnėliai I' was 83.9 cm in height, technical stem length was 70.9 cm, stem yield – 2.15–2.28 t ha^{-1}, seed yield – 0.42–0.52 t ha^{-1}, fibre yield – 0.26–0.34 t ha^{-1}, vegetation period – 79–86 days (Bačelis, 2001; Jankauskienė, 2014). As the improvement of the 'Dotnuvos ilgūnėliai I', the 'Dotnuvos ilgūnėliai II' was developed (Work conducted…, 1939; Ruzgas, 2009; Jankauskienė, Gruzdevienė, 2015). Average plant height was 82.2 cm, technical stem length – 72.3 cm, stem yield – 2.88–5.08 t ha^{-1}, seed yield – 0.44–0.78 t ha^{-1}, fibre yield – 0.44–0.87 t ha^{-1}, vegetation period – 78–88 days (Bačelis, 2001).

Later on, the cultivar 'Vaižgantas' was developed (Work conducted…, 1939; Ruzgas, 2009). This cultivar

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had a longer vegetation period (84–86 days), stem length (75–84 cm), average fibre yield (730–750 kg ha^{-1}) and seed yield (800 kg ha^{-1}) (Leistrumas, 1959). During the World War II, flax seed material suffered, was mixed, thus the cultivar 'Vaižgantas' was newly developed – purified by A. Vyčas. Plants of the improved cultivar 'Vaižgantas' were around 82 cm in height, technical stem length was 74 cm, stem yield – 3.02–5.49 t ha^{-1}, seed yield – 0.65–0.99 t ha^{-1}, fibre yield – 0.54–0.81 t ha^{-1}, vegetation period – 79–90 days (Bačelis, 2001).

After the restoration of independence in 1991, Lithuania started to take care of traditional handcrafts and national heritage. In this way, following the traditional crafts classification (signed by the minister of Ministry of Agriculture, order Nb. 3D-481, 1st of October, 2008) the oldest fibre flax cultivars, developed more than 50 years ago in Lithuania, 'Kondratavičiaus' (code 053AG18.01.01), 'Dotnuvos ilgūnėliai I' (code 053AG18.01.02), 'Dotnuvos ilgūnėliai II' (code 053AG18.01.03) and 'Vaižgantas' (code 053AG18.01.04), have been indicated as the traditional objects of Lithuanian National Heritage.

Thus the aim of the study was to find recovery and test the recovered accessions of the old Lithuanian flax cultivars, included in the list of Lithuanian Traditional Crafts. In the study, we made comparisons among the flax accessions bearing the same cultivar name and likened them to the modern flax cultivar 'Kastyčiai' used as the standard.

Materials and methods

Research was carried out at the Upytė Experimental Station of Lithuanian Research Centre for Agriculture and Forestry during 2013–2015.

Plant material. The local collection of fibre flax (*Linum usitatissimum* L.) at the Upytė Experimental Station had only one accession of the cultivar 'Vaižgantas'. The request for the old Lithuanian flax cultivars was sent to the gene banks all over Europe. After a few years of search, some requested accessions were received from Germany (Prof. Dr. A. Graner, head of Gene Bank, Leibniz-Institute of Plant Genetics and Crop Plant Research (IPK), Gaterslebeen) and Poland (Dr. Grazyna Silska, Institute of Natural Fibres, Poznan).

The names of the received accessions were not exactly corresponding to the original Lithuanian names of the old flax cultivars, but were similar (Table 1), and the Lithuanian origin of the accessions also helped to identify them as being the requested accessions.

As the received seed samples of the accessions were very small (a few grams), to collect the necessary amount for testing, we multiplied the seed for several years. In 2013, the required amount of seeds was available to start investigation. The modern cultivar 'Kastyčiai' used in flax breeding nurseries in Lithuania as a standard was used in our study as a reference.

Table 1. The denominations of old Lithuanian flax cultivars

Original denomination of old Lithuanian cultivar	Denomination of received accession	Denomination of accession used in the article
'Dotnuvos ilgūnėliai I'	Ilguniliai (LIN 2111)	Ilgūnėliai a
'Dotnuvos ilgūnėliai I'	Ilguneliai (LIN 952)	Ilgūnėliai b
'Dotnuvos ilgūnėliai II'	Ilguneliai II (LIN 1474)	Ilgūnėliai II
'Kondratavičiaus'	Kondratawiciaus	Kondratavičiaus a
'Kondratavičiaus'	Kondratoviciaus (LIN 2115)	Kondratavičiaus b
'Vaižgantas'	Vajzgantas (LIN 1982)	Vaižgantas a
'Vaižgantas'	Vaijzgantas (LIN 951)	Vaižgantas b
'Vaižgantas'	Vaižgantas (Upytė Experimental Station)	Vaižgantas c

Field experiments. Flax was grown on an *Eutri-Endohypogleyic Cambisol* (*CMg-n-w-eu*) (WRB, 2014). In the field rotation, flax followed winter wheat. Soil fertility varied over the experimental years: the content of available P_2O_5 in the soil plough layer was 116–242 mg kg^{-1}, available K_2O – 85–143 mg kg^{-1} (determined in A-L extraction), pH_{KCl} level – 6.8–7.7 (potentiometrically), humus content – 2.16–3.12% (by Tyurin method). Flax was sown manually in 1 m^2 plots with three replications. Sowing dates: 20 05 2013, 15 05 2014 and 11 05 2015. Flea-beetles were controlled by insecticides and weeds were exterminated by the herbicide Glean (a.i. 750 g kg^{-1} chlorsulfuron in the form of a water dispersible granule). Assessments of the main flax growing stages and lodging resistance before harvesting were carried out. Flax was harvested at an early yellow ripening stage.

Laboratory analyses. Dry flax was threshed, stems were retted in warm (33–37°C) water, then stems were broken up, fibre was hackled. Quality number of long fibre was determined in the laboratory, flexibility by a device G-2 (VNIIL – All-Russia Flax Research Institute), strength of fibre by a device DK-60 (CNII – Central Research Institute, Russia) (The methodology…, 1961).

The incidence of pasmo (*Septoria linicola* (Speg.) Garass) disease (%) on flax stems was calculated according to the following formula (Žemės ūkio augalų kenkėjai…, 2002):

$$B = (a \times 100) / A,$$

where B is incidence of the disease (%), a – number of infected plants, A – number of analysed plants.

The disease severity (%) was calculated according to the following formula (Žemės ūkio augalų kenkėjai…, 2002):

$$L_i = (\Sigma (a \times b) \times 100) / A \times K,$$

where L_i is disease severity (%); $\Sigma (a \times b)$ – the sum of product of disease severity (points from 0 to 4) (a) and number of diseased plants in corresponding scale group (b); A – number of analysed plants, K – the highest point in the score scale (i.e. 4).

Meteorological conditions. Thermal and moisture conditions during the crop growing season could be described by a widely used agrometeorological indicator – Selianinov's hydrothermal coefficient (HTC):

$$HTC = \Sigma p / 0.1 \Sigma t,$$

where Σp is total precipitation sum (mm) during the given period, the temperature of which is above 10°C; Σt – total sum of active temperatures (°C) of the same period. At HTC > 1.6 – the precipitation is excessive, HTC = 1.0...1.5 – optimal precipitation, HTC = 0.9 ... 0.8 – weak drought, HTC = 0.7 ... 0.6 – moderate drought (arid), HTC = 0.5 ... 0.4 – heavy drought, HTC < 0.4 – very heavy drought (Dirsė, Taparauskienė, 2010).

According to the HTC data presented in Figure, in May flax had sufficient moisture for germination and establishment. The weather conditions in June differed between the experimental years: in 2015, there was excess of rainfall, whereas, in 2014 there was a lack of rainfall. In July, moisture conditions were more favourable for flax and similar in all experimental years. In August, in 2014 there was excess of rainfall, while in 2015 it was quite dry.

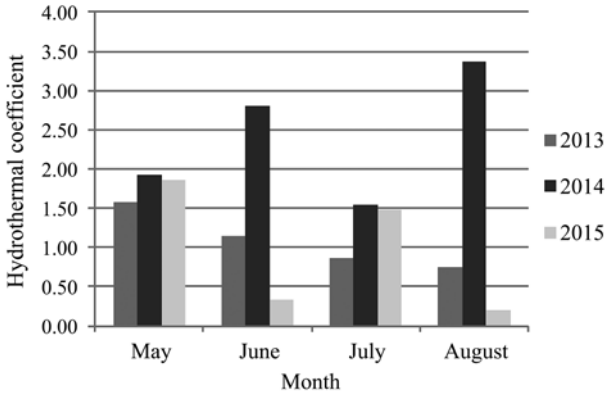

Figure. Hydrothermal coefficient during the flax growing season (2013–2015)

Statistical analysis. The experimental data were statistically processed by the analysis of variance (*ANOVA*) from the package *SELEKCIJA* (Tarakanovas, Raudonius, 2003).

Results and discussion

The accessions of all the tested old Lithuanian flax cultivars had significantly shorter vegetation period than the standard cultivar 'Kastyčiai' (Table 2). The accessions of 'Kondratavičiaus' a (8.4 points), 'Vaižgantas' a (7.8), 'Vaižgantas' b (8.0) and 'Vaižgantas' c (8.1) showed significantly lower resistance to lodging. None of the tested cultivars showed high resistance to lodging during the experimental period. The tested accessions of 'Ilgūnėliai' and 'Kondratavičiaus' were significantly shorter when measuring plant height in the field before harvesting. The accessions of 'Vaižgantas' were fairly tall. The plants of 'Ilgūnėliai' and 'Vaižgantas' accessions were more susceptible to pasmo disease. The most sensitive were accessions 'Ilgūnėliai' b (pasmo incidence was 23.6%), 'Ilgūnėliai II' (18.7%) and 'Vaižgantas' a, b and c (17.3–19.6%). Good resistance to pasmo disease was shown by both tested accessions of 'Kondratavičiaus'.

The data in Table 2 show that the accessions bearing the same cultivar name differed in the agrobiological characteristics. For example, 'Ilgūnėliai' a and b, 'Vaižgantas' a, b and c differed in the duration of vegetation period and plant height. The accessions of 'Kondratavičiaus' a and b had similar vegetation period and plant height.

In general, the old Lithuanian flax cultivars exhibited lower yielding capacity than the modern cultivar 'Kastyčiai' (Table 3).

Table 2. Agrobiological characteristics of the old Lithuanian flax cultivars (2013–2015)

Cultivar	Vegetation period, days	Resistance to lodging, points	Plant height in the field before harvesting cm	Pasmo incidence on stems before harvesting %	Pasmo severity on stems before harvesting %
Kastyčiai (standard)	89.0	8.8	81.5	12.4	3.1
Ilgūnėliai a	86.7*	8.9	55.7*	13.8	3.4
Ilgūnėliai b	85.0*	8.9	57.0*	23.6*	6.3*
Ilgūnėliai II	85.3*	8.9	57.9*	18.7*	5.7*
Kondratavičiaus a	86.7*	8.4*	65.4*	14.7	4.2
Kondratavičiaus b	86.3*	8.5	66.1*	13.8	3.4
Vaižgantas a	86.3*	7.8*	79.9	19.6*	5.3*
Vaižgantas b	86.3*	8.0*	81.3	17.3*	4.6*
Vaižgantas c	85.0*	8.1*	76.8	18.7*	5.2*
LSD_{05}	0.11	0.29	4.73	3.40	1.45

* – significant at 0.05 probability level

The accessions of 'Ilgūnėliai', 'Kondratavičiaus' a and 'Vaižgantas' c produced significantly lower stem yield. Because of the lack of rainfall during the rapid growth stage in 2015, all accessions, even the standard cultivar, produced a low stem yield. Some of the old Lithuanian flax cultivars showed good seed yielding capacity. According to the average data of 2013–2015, significantly higher seed yields (1.26–1.44 t ha^{-1}) were obtained from the accessions 'Ilgūnėliai' a, 'Kondratavičiaus' a and b. The year 2015 was unfavourable for good yields.

The old Lithuanian flax cultivars produced higher long fibre yield and content in the stems compared with the standard (Table 3). Of all the cultivars tested, the accessions of Vaižgantas (a, b and c) produced the highest fibre yield. The oldest cultivars produced the lowest fibre yield.

Over all testing years, fibre content in stems was very low. Even the standard cultivar 'Kastyčiai' had low fibre content. The fibre content in the stems of the old Lithuanian flax cultivars was below 11%.

Fibre flexibility of all the tested old Lithuanian flax cultivars was significantly higher (62.5–76.0 mm) that that of the standard cultivar 'Kastyčiai' (59.7 mm) (Table 4). The tested cultivars did not differ considerably

Table 3. Yielding capacity of the old Lithuanian flax cultivars (2013–2015)

Cultivar	Stem yield kg ha^{-1}	Seed yield kg ha^{-1}	Long fibre yield kg ha^{-1}	Long fibre content in stems %
Kastyčiai (standard)	6789	1070	892	13.1
Ilgūnėliai a	4277*	1440*	253*	6.6*
Ilgūnėliai b	3529*	1074	363*	11.0
Ilgūnėliai II	4464*	1242	341*	8.3*
Kondratavičiaus a	5556*	1358*	371*	7.5*
Kondratavičiaus b	5980	1263*	433*	7.3*
Vaižgantas a	6013	724*	641*	10.9
Vaižgantas b	6427	1004	643*	10.2*
Vaižgantas c	5410*	972	501*	10.4*
LSD_{05}	1154.3	184.3	238.3	2.67

* – significant at 0.05 probability level

Table 4. Characteristics of scutched fibre of the old Lithuanian flax cultivars (2013–2015)

Cultivar	Fibre flexibility mm	Fibre strength kg F	Quality number	The impression by touching
Kastyčiai (standard)	59.7	14.6	11.9	medium / soft
Ilgūnėliai a	67.2*	13.2	8.3*	medium / soft
Ilgūnėliai b	65.0*	13.9	8.3*	medium / soft
Ilgūnėliai II	62.5*	11.7*	7.9*	medium
Kondratavičiaus a	64.4*	12.0*	8.9*	soft
Kondratavičiaus b	72.7*	12.4*	9.6	soft
Vaižgantas a	76.0*	15.4	11.8	soft
Vaižgantas b	72.8*	15.2	11.4	soft
Vaižgantas c	64.8*	13.8	10.2*	medium / soft
LSD_{05}	4.74	1.87	1.08	–

* – significant at 0.05 probability level

in scutched fibre strength, only the accessions of 'Ilgūnėliai II', 'Kondratavičiaus' a and b had significantly lower fibre strength than the standard cultivar. Fibre quality number of 'Vaižgantas' a and b was similar to that of the standard cultivar. The other tested accessions had significantly lower fibre quality number. The best impression by touching fibre was exhibited by the accessions of cultivars 'Kondratavičiaus' a and b, 'Vaižgantas' a and b, whose fibre was very soft and pleasant to touch.

Morphological characteristics of the tested old Lithuanian flax cultivars are presented in Table 5. Only the accession 'Ilgūnėliai' b produced significantly more capsules per plant (on average 8.7). The accessions 'Ilgūnėliai' a, 'Ilgūnėliai II', 'Kondratavičiaus' a and b produced the largest seeds. The average one thousand seed weight 6.35 g is more characteristic of linseed than of fibre flax. Unfortunately, the accessions 'Ilgūnėliai' b, 'Vaižgantas' a and b had significantly lower 1000 weight. Differences were found between the accessions bearing the same cultivar name.

The length of panicle differed between the accessions but no significant differences were found. The

Table 5. Morphological characteristics of the old Lithuanian flax cultivars (2013–2015)

Cultivar	No. of capsules per plant	1000 seed weight g	Length of the panicle cm	Stem diameter mm	Total stem length cm	Technical stem length cm	Technical stem length %	Technical stem length:diameter
Kastyčiai (standard)	5.3	4.85	11.1	1.36	71.6	60.5	84.2	297
Ilgūnėliai a	4.1	4.89*	9.8	1.16*	51.4*	41.6*	82.1	239*
Ilgūnėliai b	8.7*	4.50*	12.8	1.26	49.8*	37.0*	75.7*	213*
Ilgūnėliai II	6.1	6.35*	10.3	1.34	54.2*	44.0*	81.4	221*
Kondratavičiaus a	4.7	5.60*	10.1	1.28	61.2*	51.2*	83.4	269
Kondratavičiaus b	5.5	5.44*	10.2	1.40	64.7*	54.5*	84.3	262
Vaižgantas a	4.5	4.34*	8.8	1.34	70.8	62.0	87.4	313
Vaižgantas b	4.6	4.51*	8.6	1.31	68.3	59.7	87.7	305
Vaižgantas c	3.8	4.71	8.1	1.30	65.0*	56.9	87.9	294
LSD_{05}	1.80	0.030	3.56	0.123	5.51	6.33	5.64	54.3

* – significant at 0.05 probability level

investigation of stem diameter did not show significant differences, except for the accession 'Ilgūnėliai' a, whose stems were thinner.

The oldest Lithuanian flax cultivars (accessions of 'Ilgūnėliai' and 'Kondratavičiaus') had the shortest total stem length. The later developed cultivar 'Vaižgantas' had longer stems. Thus it can be inferred that progress in terms of plant stem length increase has been achieved over the years of selection and breeding work. The same trend was observed for the length of technical stem part – the oldest Lithuanian flax cultivars had shorter technical stem part (only 37.0–54.5 cm). The accessions of 'Vaižgantas' had the longest technical stem part (87.4–87.9%).

Relational index of distribution of fibres in the stem is the ratio of technical stem length to stem diameter – the higher the ratio, the higher the fibre content and the better the fibre quality (Понажев, Медведева, 2011; Рожмина и др., 2011; Павлова и др., 2016). The optimal ratio of the technical stem length to stem diameter for fibre flax is between 400 and 700. In the study on flax collection resources Рожмина и др. (2011) found this ratio to be 550–685; however, they indicated that in unfavourable weather and growing conditions this index could be as low as 300. In our investigation, the ratio of technical stem length to stem diameter was rather low, and it was the lowest for the oldest cultivar (accessions of 'Ilgūnėliai').

Conclusions

1. The accessions of the old Lithuanian flax cultivars were inferior to the standard cultivar 'Kastyčiai' in terms of stem and fibre yield and superior to the standard in terms of seed yield and 1000 seed weight.

2. Fibre flexibility of all the tested old Lithuanian flax cultivars was significantly higher (62.5–76.0 mm) than that of the standard cultivar 'Kastyčiai' (59.7 mm).

3. The accessions of all the tested old Lithuanian flax cultivars had significantly shorter vegetation period than the standard cultivar.

4. The accessions of 'Vaižgantas' showed significantly lower resistance to lodging than those of the other old Lithuanian flax cultivars tested.

5. Both accessions of the cultivar 'Kondratavičiaus' exhibited high resistance to pasmo disease.

6. The newest fibre flax cultivars are more advanced, exhibit higher yielding capacity, higher resistance to lodging and diseases but poorer fibre quality, particularly flexibility, compared with the old cultivars tested.

7. The accessions of the tested old Lithuanian flax cultivars bearing the same name were found to differ in the tested characteristics. As a result, they should be conserved and stored as different accessions.

8. The accessions of 'Ilgūnėliai' a and b differed in the susceptibility to pasmo disease, stem yield, seed yield, long fibre yield and content, number of capsules per plant, 1000 seed weight, length of the panicle, technical stem length, ratio of technical stem length to diameter.

9. The accessions of 'Kondratavičiaus' a and b were quite similar and only slightly differed in stem, seed and long fibre yield, fibre flexibility, quality number, number of capsules per plant, stem length and diameter.

10. The accessions of 'Vaižgantas' a, b and c slightly differed in resistance to lodging, plant height, resistance to pasmo disease, seed yield, long fibre yield and quality, number of capsules per plant, total and technical stem length, ratio of technical stem length to diameter, but the differences were not always significant.

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Senųjų lietuviškų pluoštinių linų veislių, įtrauktų į tradicinių amatų sąrašą, įvertinimas

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Santrauka

Tradicinių amatų klasifikacijoje (patvirtintoje Lietuvos Respublikos žemės ūkio ministro 2008 m. rugsėjo 1 d. įsakymu Nr. 3D-481) kaip tradiciniai objektai yra įtrauktos ir senos, daugiau nei prieš 50 metų sukurtos lietuviškos linų veislės ‘Kondratavičiaus’ (kodas 053AG18.01.01), ‘Dotnuvos ilgūnėliai I’ (kodas 053AG18.01.02), ‘Dotnuvos ilgūnėliai II’ (kodas 053AG18.01.03) ir ‘Vaižgantas’ (kodas 053AG18.01.04). Iš Europos genų bankų gavus senųjų lietuviškų linų veislių sėklų, 2013–2015 m. jos buvo padaugintos ir tirtos LAMMC Upytės bandymų stotyje. Dėl nedidelio turimų sėklų kiekio keturių veislių skirtingų pavyzdžių linų sėklos buvo pasėtos 1 m^2 laukeliuose trimis pakartojimais, pasėliai prižiūrėti nuo spragių ir piktžolių, linai nurauti ankstyvosios geltonosios brandos tarpsniu. Stebėti ontogenezės tarpsniai, įvertintas augalų aukštis, žiedų spalva, derlingumo, pluošto kokybės rodikliai, atlikta augalų morfologinė analizė, įvertintas atsparumas išgulimui ir pasmai, to paties pavadinimo pavyzdžiai palyginti tarpusavyje ir su šiuolaikine pluoštinių linų veisle. Tyrimo duomenys parodė, jog standartinė pluoštinių linų veislė ‘Kastyčiai’ už senąsias lietuviškas linų veisles pranašesnė stiebelių, brukto pluošto derliumi, pluošto išeiga, tačiau senosios veislės buvo ankstyvesnės, užaugino daugiau sėklų, buvo geresnės pluošto kokybės (lankstumo). Tos pačios veislės skirtingų pavadinimų gautų pavyzdžių savybės taip pat skyrėsi, tad pavyzdžius būtina saugoti skirtingais pavadinimais.

Reikšminiai žodžiai: derlius, pluošto išeiga, pluošto lankstumas, pluoštiniai linai, veislės.