barības vielu trūkuma dēļ. Laika apstākļi 2005. gadā bija graudaugiem labvēlīgāki. 2006. un 2007. gadā graudu ražas un kvalitātes samazināšanos izraisīja sausums. Miežu un auzu graudu kvalitāte abās audzēšanas sistēmās bija līdzīga; kviešiem bioloģiskos apstākļos veidojās lielāki graudi. Proteīna saturs bioloģiskos apstākļos samazinājās, lielākais samazinājums novērots kviešiem.

THE NEW LITHUANIAN FIBRE FLAX VARIETY 'SNAIGIAI'

Jankauskienė Z., Bačelis K.
Upytė Research Station of the Lithuanian Institute of Agriculture, Lininink̨ų 3, Upytė, Panevėžys district, Lithuania, LT-38294, phone: +370 45 555 413, e-mail: soja@upyte.lzi.lt

Abstract
Fibre flax (*Linum usitatissimum* L.) is the most important source of natural fibres for textile production in many countries where cotton is not grown. For 4 thousand years flax has been serving Lithuanians as raw material for clothing, food, medicine and other purposes. Linen (fabric from flax fibre) is highly hygroscopic, has high air permeability and heat conductivity, does not cause allergic reactions and is helpful in treating a number of allergic disorders. Because of exlusive value of this plant and interest of growers and processors, fibre flax has been bred in Lithuania since 1922. During this period eighteen fibre flax varieties have been developed.
he new fibre flax variety 'Snaigiai' (breeding line No. 2243-13) has been bred using the method of intervarietal hybridization. This breeding line was tested in the control nursery in 2001-2002 and in the preliminary variety testing trials in 2003. In the competitive variety trials 'Snaigiai' was tested in 2004-2005. It is a white flowering, moderately ripening, and lodging resistant variety. The seeds are brown, 1000 seed weight is 5.53 g. It exhibits high fibre quality and is suitable for textile production. 'Snaigiai' was bred by Dr. K. Bačelis. Since 2005 initial variety testing has been done by Dr. Z. Jankauskienė. Since 2007 the variety has been tested for DUS and VCU.

Key words: breeding, fibre flax, fibre quality, variety, yield.

Introduction
Linum species belongs to the oldest arable crops. Even in ancient times fibre and oilseed were considered valuable agricultural products.
Flax (*Linum usitatissimumm* L.) cultivation is considered a traditional branch of agriculture in Lithuania. For 4 thousand years flax has been serving Lithuanians as raw material for clothing, food, medicine and other purposes. For three centuries (XVII-XIX) flax was the main source of income for Lithuanian people. During all the periods of Lithuanian State development flax cultivation was one of the key branches of the crop production economy (Bražukienė, 2001).
Fibre flax breeding has been carried out in Lithuania since 1922 (Bačelis, 1998). Fibre flax breeding in Lithuania was started at the Breeding Station in Dotnuva, then continued at the Savitiškis Research Station, and since 1965 has been done at the Upytė Research Station of the Lithuanian Institute of Agriculture. The first flax breeder was Prof. D. Rudzinskas. At the beginning, flax varieties were bred by the method of individual selection. In 1932 synthetic flax breeding was initiated by crossing selected varieties. Since 1971 physical and chemical mutagens have been applied in flax breeding. From 1922 to 2005 eighteen fibre flax varieties were developed in our country (Bačelis, 2001).
In the first stages of breeding initial material for crossing must be evaluated. It has to be diverse and abundant and has to meet key requirements under local conditions (Rosenberg, 1995). The tested varieties or breeding lines, mutants that best meet the requirements are necessitaled by for intervarietal hybridization with a view to developing novel breeding material.
The prime aim for fibre flax breeders is to increase fibre yield per hectare, but this characteristic has low heritability, and it is not easy to evaluate because it is largely influenced by the environment (Fouilloux, 1989). High fibre quality is one of the key requirements in fibre flax breeding for textile purposes (Хеллер и Рульский, 2002). But the quality is yet less heritable than fibre productivity. Moreover, there seems to be negative genetic correlation between fibre

productivity and quality (Fouilloux, 1989). Furthermore, the new flax varieties should be resistant to lodging and diseases (Bačelis and Gruzdevienė, 2001; Trouve, 1996; Крылова *и др*., 2002).
Therefore, it is not easy to breed fibre flax because in general, the important characteristics have poor heritability, are difficult to evaluate and need large quantity of seeds in field trials (Fouilloux, 1989; Keijzer and Metz, 1992).
Our aim is to develop novel high yielding fibre flax varieties, resistant to lodging, with a high fibre yield and quality, less susceptible to fungal diseases, with a moderately long vegetative growth period, well adapted to Lithuania's soil and climate conditions.
The hypothesis of the study is that the new variety will be high yielding, will have good fibre quality and will be less sensitive to lodging and diseases.

Materials and Methods

The flax breeding was conducted on a Eutri-Endohypogleyic Cambisol (Buivydaitė et al., 2001). Flax was sown after winter wheat. Conventional cultivation practices were used. Fibre flax breeding was carried out according to the following scheme: 1) nurseries of initial material (collection, hybrids, mutants), 2) breeding nursery, 3) hybrid nursery, 4) selection nursery, 5) control nursery, 6) preliminary variety trials, 7) competitive variety trials. In the nursery of initial material the varieties and accessions were sown in plots of 0.2-1.0 m^2, and in the breeding, selection and control nurseries – in the plots of 0.2-4.0 m^2. In the control nursery flax was sown with 4-5 replications. Initial and competitive variety trials involved 3-4 replications. The size of a record plot was 11.2 and 16.0 m^2, respectively. All field trials were conducted (with a few modifications) in compliance with the published methodology (Методические, 1978; Рогаш *и др*., 1987).
In the competitive and initial variety trials the plots were sown by the sowing machine SNL-16 at a seed rate of 25 million seed per hectare, 10 cm space between rows. In the other nurseries the plots were sown manually at a seeds rate of 22 million seeds per ha. Insecticides were sprayed against flax flea beetles and herbicides were used to control weeds.
During the vegetative growth period phenological observations were done, lodging resistance and fungal diseases on the natural background were assessed (Лошакова *и др*., 2002). Flax was pulled at the stage of early yellow ripeness, threshed by a MS thresher, the stems were retted in warm (33-37˚C) water, the stems were scutched by by a scutching tool SMT-200, fibre was hacked by combs number 9 and 13. The number of long fibre was determined in the laboratory, flexibility by the device G-2, the strength of fibre by the device DK-60 and thinness (divisibility) – following the special methodology by counting separate fibres in a fibre sample, the length of which is 1 cm, mass 10 mg. Long fibre rupture length (in km) was calculated using the formula (Методики, 1961):

$$RL = 0.1 * F + 0.2 * S + 0.013 * D + 2.1$$

Where: RL – Long fibre rupture length, km;
F – Long fibre flexibility, mm;
S – Long fibre strength, kg force;
D – Long fibre divisibility, units;
0.1; 0.2; 0.013 and 2.1 are constants.

Morphological analysis of plants was carried out. Stem, seed and fibre yield was evaluated using analysis of variance. For calculations we used the statistical software developed at the Lithuanian Institute of Agriculture (Tarakanovas and Raudonius, 2003).
Meteorological conditions during the period 1979-2005 were not favourable every year and had a marked effect on the yield. The years 1990, 1991, 1993, 1996, 1997 and 2000 were favourable for flax growing and a satisfactory seed and fibre yield was obtained in these years. In the years 1992, 1994 and 1999 hot and dry weather in June and July markedly a declining flax yield. In the year 1998 very abundant rainfall in July lodged the flax plants, which resulted in a marked deterioration of flax produce quality. In 2001 the weather conditions were adverse, especially in the second half of the growing season. Heavy rainfall lodged flax crops. The year 2002 was characterised by a shortage of moisture during the growing season. In 2003 because of the lack of rainfall in the first

half of the growing season, flax did not develop well, the end of the growing season was rainy and the flax stand was partially lodged.

Results and Discussion

The new fibre flax variety ‘Snaigiai’ (breeding line No. 224313) has been bred at the Upytė Research Station of the Lithuanian Institute of Agriculture using the method of intervarietal hybridization. In 1979 the female variety ‘T-10’ (of Russian origin) was crossed with flax variety ‘VNIIL-6’ (developed in Russia). After investigations on hybrids and selection nurseries, this breeding line was tested in the control nursery in 2001-2002 (Table 1).

Table 1. Some characteristics of the new fibre flax variety ‘Snaigiai’ (breeding line No. 2243-13) in the control nursery. Upytė, averaged data 2001-2002

Indices	‘Snaigiai’ (2243-13)	‘Ariane’ (standard)	‘Snaigiai’ (2243-13) compared to ‘Ariane’
Stem yield, t ha^{-1} (LSD_{05} 0.26)	4.75	4.63	102.6
Seed yield. t ha^{-1} (LSD_{05} 0.05)	0.58	0.53	109.4
Long fibre yield, t ha^{-1} (LSD_{05} 0.12)	0.65	0.61	106.6
Long fibre content, % (LSD_{05} 2.5)	14.0	13.3	105.7
Long fibre flexibility, mm	41.9	37.4	112.0
Long fibre strength, kg F	14.9	11.4	130.8
Plant height, cm	88.3	74.3	118.9
Growing period, days	89.5	89.5	100.0
Resistance to lodging, points (9=not lodged)	8.6	8.1	105.6

In the initial variety trials ‘Snaigiai’ was tested in 2003, in the competitive variety trials in 2004-2005 (the results are presented in Table 2).

Table 2. Some agrobiological characteristics of the new fibre flax variety ‘Snaigiai’. Upytė. competitive variety trials. Averaged data 2004-2005

Indices	‘Snaigiai’	‘Hermes’ (standard)	‘Belinka’ (standard)	‘Snaigiai’ compared to ‘Hermes’	‘Snaigiai’ compared to ‘Belinka’
Stem yield. t ha^{-1} (LSD_{05} 0.67)	6.30	5.85	-	107.7	-
Seed yield. t ha^{-1} (LSD_{05} 0.11)	0.61	0.74	-	82.4	-
Long fibre yield, t ha^{-1} (LSD_{05} 0.19)	1.65	1.57	-	105.1	-
Long fibre content, %	26.2	26.5	16.3	98.9	160.7
Long fibre flexibility, mm	46.6	38.1	42.5	122.3	109.7
Long fibre strength, kg F	13.9	15.6	14.1	89.1	98.6
Long fibre divisibility, units	283	248	246	114.1	115.5
Long fibre rupture length, km	13.2	12.3	12.4	107.3	106.5
Long fibre quality number	12.4	11.9	12.6	104.2	98.4
Plant height, cm	80.1	73.8	-	108.5	-
Technical stem length, cm	70.6	69.3	-	101.9	-
Number of capsules per plant	1.25	1.80	-	69.4	-
1000 seed weight, g	5.53	5.59	-	98.9	-
Growing period,. days	89	91	-	97.8	-
Resistance to lodging, points (9= not lodged)	8.90	8.95	-	99.4	-
Disease incidence on stems, %	12.8	37.0	-	34.6	-

Since 2007 the variety has been tested for DUS and VCU. K. Bačelis is the author of ‘Snaigiai’. Since 2005 competitive variety testing and initial seed multiplication have been carried out by Z. Jankauskienė.VCU results for the new fibre flax variety ‘Snaigiai’ in Pasvalys and Plungė State Variety Testing Stations in 2007 are presented in Tables 3 and 4.In the control nursery in 2001-2002 (Table 1), ‘Snaigiai’ produced slightly larger stem, seed and long fibre yield when compared to the standard variety ‘Ariane’. The plants of ‘Snaigiai’ were taller than those of ‘Ariane’. Flax

'Snaigiai' had slightly higher fibre content, more flexible and stronger fibre compared to 'Ariane' in the control nursery. The duration of the growing season for both varieties tested was the same.

Average data of 2 years of competitive trials in 2004-2005 (Table 2) showed that the new variety 'Snaigiai' had taller plants, higher stem and long fibre yield, more flexible and thinner fibre (higher divisibility data), a higher quality number and rupture length, compared to the standard variety 'Hermes'. Plants of 'Snaigiai' were more resistant to *Fusarium spp*. and *Colletotrichum lini*.

Fibre quality of the variety 'Belinka' is known as the standard of good quality, thus for the evaluation of fibre quality in our trials the variety 'Belinka' was chosen as a reference (standard) variety. Compared to the data of 'Belinka' (quality standard), a flax of the new variety 'Snaigiai' had higher fibre content, more flexible fibre, higher fibre divisibility and rupture length.

Investigations carried out at the LIA Upytė Research Station suggest that 'Snaigiai' is a white flowering, high fibre yielding, moderately late ripening, lodging resistant variety. Fibre quality is satisfactory and suitable for textile production. Seeds are brown, 1000 seed weight – 5.53 g.

VCU testing results for the new fibre flax variety 'Snaigiai' at the Plungė State Variety Testing Station (western part of Lithuania, region with higher rainfall) in 2007 (Table 3) showed that flax of this variety had lower stem yield, but due to higher long fibre content, the long fibre yield was higher compared to that of the standard variety 'Kastyčiai'.

Table 3. VCU testing results for the new fibre flax variety 'Snaigiai'.(Plungė. VCU trials, 2007)

Indices	'Snaigiai'	'Kastyčiai' (standard)	'Snaigiai' compared to 'Kastyčiai'
Stem yield, t ha^{-1} (LSD_{05} 0.30)	6.08	7.16	84.9
Long fibre yield, t ha^{-1} (LSD_{05} 0.06)	1.16	1.08	106.9
Long fibre content, % (LSD_{05} 2.37)	25.5	20.3	125.7
Long fibre flexibility, mm (LSD_{05} 2.08)	31.9	35.5	89.8
Long fibre strength, kg F (LSD_{05} 0.91)	13.5	12.7	105.7
Long fibre divisibility, units	194	181	107.6
Long fibre rupture length, km	10.54	10.50	99.7
Long fibre quality number (LSD_{05} 0.53)	11.0	10.9	101.1
Plant height, cm	75	76	98.7
Growing period, days	91	89	102.2
Resistance to lodging, points (9=not lodged)	9.0	9.0	100.0

The fibre of 'Snaigiai' was less flexible than that of 'Kastyčiai', but that of the new variety was firmer (by 5.7 %) and finer (by 7.6 %). Long fibre rupture length, quality number, plant height, and resistance to lodging were very similar for both varieties tested.

Table 4. VCU testing results for the new fibre flax variety 'Snaigiai'. (Pasvalys. VCU trials, 2007)

Indices	'Snaigiai'	'Kastyčiai' (standard)	'Snaigiai' compared to 'Kastyčiai'
Stem yield, t ha^{-1} (LSD_{05} 0.75)	7.55	6.18	122.2
Long fibre yield, t ha^{-1} (LSD_{05} 0.09)	1.12	1.05	106.5
Long fibre content, % (LSD_{05} 1.75)	20.9	23.9	87.6
Long fibre flexibility, mm (LSD_{05} 1.67)	30.6	25.2	121.4
Long fibre strength, kg F (LSD_{05} 1.36)	10.6	10.5	101.0
Long fibre divisibility, units	189	131	144.2
Long fibre rupture length, km	8.3	9.7	85.3
Long fibre quality number (LSD_{05} 0.64)	11.5	9.8	117.9
Plant height, cm	75	71	105.6
Growing period, days	71	75	94.7
Resistance to lodging, points (9=not lodged)	9.0	9.0	100.0

The trials in the Pasvalys State Variety Testing Station (north-east part of Lithuania) in 2007 (Table 4) showed that the new fibre flax variety 'Snaigiai' had a higher stem yield (by 22.2 %), but the content of long fibre in the stems was lower compared to that of the standard variety 'Kastyčiai'. The fibre of 'Snaigiai' was more flexible and thinner (higher divisibility data), and was evaluated under a higher quality number. The plants of 'Snaigiai' grew taller (by 4 cm), ripened 4 days earlier than the plants of the standard variety. Both varieties showed good results of lodging resistance.

The results in both State Variety Testing Stations could differ due to the different soil and climatic conditions. This confirms that flax yield and its quality are not stable and largely depend on the local conditions.
The new fibre flax variety 'Snaigiai' was found to be superior to different standard varieties.

Conclusions

In the control nursery in 2001-2002 'Snaigiai' (breeding line No. 2243-13), produced a slightly longer stem, more seed and long fibre yield compared to the standard variety 'Ariane'. The plants of 'Snaigiai' were taller, had slightly higher fibre content and more flexible and stronger fibre. The duration of the growing period for 'Snaigiai' and 'Ariane' was the same.
In the competitive variety trials the new fibre flax variety 'Snaigiai' had taller plants, longer stem and long fibre yield, more flexible and thinner fibre (higher divisibility data), a higher quality number and rupture length compared to the standard variety 'Hermes'. The plants of 'Snaigiai' were more resistant to *Fusarium spp*. and *Colletotrichum lini*. When compared to 'Belinka' (quality standard), flax of the new variety 'Snaigiai' had higher fibre content, more flexible fibre, better fibre divisibility and rupture length.
VCU tests in 2007 showed that in the Plungė region the new fibre flax variety 'Snaigiai' had a higher long fibre content and yield, stronger and finer fibre, and in Pasvalys region taller plants, longer stem and long fibre yield, more flexible and thinner fibre (higher divisibility data), and a higher quality number compared to the standard variety 'Kastyčiai'.
'Snaigiai' (breeding line No. 2018-8) is a white flowering, high fibre yielding, moderately late ripening, lodging resistant variety. Fibre quality is satisfactory and suitable for textile production. The seeds are brown, 1000 seed weight is approximately 5.53 g.

References

1. Bačelis K. (2001) 'Vega 2' and 'Kastyčiai' – the newest fibre flax cultivars. *Agriculture. Scientific articles*, 76, 127-133.
2. Bačelis K. (1998) Pluoštinių linų selekcija. In: *Augalų selekcija*. Vilnius, 97–105.
3. Bačelis K., Gruzdevienė E. (2001) Resistance of fibre flax varieties to *Colletotrichum lini* Manns et Boley. *Biologija*, 3, 4–9.
4. Bražukienė I. O. (2001) Pluoštinių linų auginimas Lietuvoje: istoriniai ir geografiniai aspektai. In: *Linų auginimas ir jš tyrimai. Flax cultivation and research*. Upytė, 116–124
5. Buivydaitė, V.V., Vaičys, M., Juodis, J. ir kt. (2001) *Lietuvos dirvožemių klasifikacija*. Vilnius. 76.
6. Fouilloux G. (1989) Breeding flax methods. In. *Flax: breeding and utilisation*. G. Marshal (ed.) Kluwer academic publishers. ECSC, EEC, EAEC, Brussels and Luxembourg, 14-25.
7. Keijzer P., Metz P. L. J. (1992) Breeding of flax for fibre production in Western Europe In.: *The biology and Processing of flax*. Sharma H.S.S., Van Sumere C.F. (eds.) M Public., Belfast, 33-66.
8. Rosenberg L. (1995) Flax collection – source of breeding for fibre quality. In: *Breeding for fiber and oil quality in flax*. St. Valery en Caux, France, 14-20.
9. Tarakanovas P., Raudonius S. (2003) *Agronominių tyrimų duomenų statistinė analizė taikant kompiuterines programas Anova, Stat, Split-Plot iš paketo SELEKCIJA ir IRRISTAT*. Akademija. 58.
10. Trouve J.P. (1996) L'amelioration variatale du lin textile face aux besoins des marches In: *Comptes rendus de e'academie d'agriculture de France*. France, 82 (8), 55-63.
11. Крылова Т.В., Лошакова Н.И., Кудрявцева Л.П. и др. (2002) Селекция льна-долгунца на груповую устойчивость к болезням In: *Селекция, семеноводство, агротехника, экономика и первичная обработка льна-долгунца*. Торжок, 30, 1, 35-39.
12. Лошакова Н.И., Крылова Т.В., Кудрявцева Л.П. (2000) *Методические указания по фитопатологической оценке устойчивости льна-долгунца к болезням*. Москва. 52.
13. *Методические указания по проведению полевых опытов со льном*-долгунцом (1978). Торжок. 72.
14. *Методики технологической оценки льна и конопли* (1961). Москва.182.
15. Рогаш А.Р., Марченков А.Н., Александрова Т.А. и др. (1987) *Методические указания по селекции льна-долгунца*. Торжок. 62.
16. Хеллер К., Рульский С. (2002) Биологический прогресс в селекции и агротехнике льна-долгунца. In: *Селекция, семеноводство, агротехника, экономика и первичная обработка льна-долгунца*. Торжок, 30, 1, 149-152.

JAUNA LIETUVAS ŠĶIEDRAS LINU ŠĶIRNE 'SNAIGAI'

Jankauskienė Z., Bačelis K.

Škiedras lini (*Linum usitatissimum* L.) ir nozīmīgākais dabīgo šķiedru nodrošinātājs tekstilrūpniecībā daudzās valstīs, kurās netiek audzēta kokvilna. Četrus tūkstošus gadu Lietuvā lini tika izmantoti apģērbam, pārtikai, medicīnai un citām vajadzībām. Lina audums (audums no linu šķidrām) ir izcili higroskopisks, tam piemīt gaisa caurlaidība un siltuma izolācija, tas neizraisa alerģiskas reakcijas un var tikt izmantots daudzu alerģisku traucējumu ārstēšanā. Tā kā augam piemīt izcila vērtība, kā arī balstoties uz audzētāju un pārstrādātāju ieinteresētību, šķiedras lini Lietuvā tiek selekcionēti kopš 1922. Astoņpadsmit šķidras linu šķirnes ir izveidotas kopš tā laika. Jaunā šķiedras linu šķirne 'Snaigiai' (līnija Nr. 2243-13) tika izveidota izmantojot starpšķirņu hibridizāciju. Selekcijas līnija tika pārbaudīta kontroles audzētavā 2001.-2002., iepriekšējā šķirņu pārbaudē – 2003.gadā. Salīdzinošajā šķirņu pārbaudē 'Snaigiai' tika pārbaudīta 2004.-2005. Tā ir baltziedu, vidēji agrīna, veldres izturīga šķirne. Sēklas ir brūnas, 1000 sēklu svars ir 5.53 g. Šķiedras kvalitāte ir augsta un ir piemērota tekstilrūpniecībai. Dr. K. Bačelis ir izveidojis šķirni 'Snaigiai'. Kopš 2005.gada šķirņu pārbaudi šķirnei veica Dr. Z. Jankauskienė. Kopš 2007. gada šķirne nodota AVS un SĪN pārbaudēm.

THE PATH ANALYSIS OF YIELD TRAITS IN SUNFLOWER (*Helianthus annuus* L)

Kaya Y., Evci G., Pekcan V., Gucer T., Durak S., Yilmaz M.I.
[1]Trakya Agricultural Research Institute, PO Box: 16, 22100 Edirne, TURKEY,
Phone: +90 284 2358182, Fax: +90 284 2358210, e-mail: yalcinkaya@ttae.gov.tr

Abstract
Plant breeders have always tried to know that which characters contribute more in the seed yield that is a quantitative character influenced highly from environment and their relationships. Path coefficient analysis helps the breeders to explain the direct and indirect effects; hence it has been extensively used in breeding works by various researchers. The research covering yield performance and the path analysis of hybrids in the trials at the National Sunflower Research Project was conducted in Edirne province, where has 20% of thesunflower production in Turkey. The totals of 2932 sunflower hybrids were tested in 118 trials in this research. The 1000 seed weight gave the highest contribution to breeding for higher yield, and head diameter and plant height followed it respectively regarding to contribution to seed yield based on path and simple correlation analysis both in dry and rainy growing seasons.

Key words: sunflower, hybrid, seed yield, yield traits, path analysis.

Introduction
Seed yield is a quantitative character, which is influenced more from climate and environmental factors in sunflower because of being controlled large number of genes. To increase the yield, the study of direct and indirect effects of yield components provides the basis for successful breeding program and hence the problem of yield increase can be more effectively tackled based on the performance of yield components and selection for closely related traits (Fehr, 1993). Head diameter, 1000 seed weight, plant height are valuable yield parameters to determine for yield improvement in the sunflower (Miller and Fick, 1997).
The use of simple correlation analysis could not fully explain the relationships among yield characteristics. Path coefficient analysis helps the breeder(s) to explain the direct and indirect effects for a more and complete determination of the impact of independent variable on dependent one among important yield traits (Singh and Chaudhary, 1979). Therefore, path coefficient analysis has extensively been used by many researchers (Kaya and Atakisi, 2003; Kaya *et al.*, 2003; Vidhyavathi, *et al.*, 2005; Göksoy and Turan, 2007). This research was conducted to determine the direct and indirect effects of yield traits on the sunflower yield by path analysis in conducted trials over many years in dry (1999-2001) and in rainy seasons (2002-05)) in Edirne, Turkey.