EFFECT OF ORGANIC AND CONVENTIONAL PRODUCTION ON YIELD AND THE QUALITY OF SPRING CEREALS

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Abstract
The situation in the agricultural sector has changed during the last years. The need to increase sustainability and protect the environment has become more relevant. Also organic farming is increasing in Estonia. The field trials were carried out at the Jõgeva Plant Breeding Institute to compare the grain yield and quality characteristics of spring wheat, barley and oat in organic and conventional conditions. Thirteen varieties of each cereal crop were tested during a three year period (2005-2007). The trial results showed that all the spring crops were able to produce comparatively high yields in organic conditions. The highest yielding in the organic trial was obtained by oat followed by barley and wheat. The yield decrease in spring wheat was the biggest (34%) in organic conditions compared to conventional conditions. Yield reduction was mostly the result of the shortage of plant nutrients. Weather conditions were more favourable for cereals in 2005. Drought caused a decrease in grain yield and quality in 2006 and 2007. The grain quality of barley and oats was similar in both cropping systems; wheat produced bigger kernels in the organic trial. Protein content in organic conditions decreased, wheat having the largest decrease

Key words: spring wheat, barley, oat, yield, quality, organic, conventional condition

Introduction
Cereals cultivated in organic conditions should produce sufficient yields without the use of mineral fertilizers and plant protection chemicals (pesticides). At the same time organic cultivation is oriented to high quality production. Yield usually takes priority in non-organic cultivation but will often have a lower priority in organic farming, relative to quality. Also, organic farming management is complex. In contrast to conventional systems, organic farmers rely mostly on preventive and adaptive management.

In Europe, Lammerts van Bueren (2003), Wolfe (2002) and Vogt-Kaute (2001) have tested and summarized the results of organic trials - organic plant breeding and crop production yield and yield stability, the efficiency of nutrient uptake, adaptation to organic inputs, quality characteristics etc.

In Estonia the following topics have been discussed during recent years. Sepp and his colleagues (2006) have tested the influence of organic crop rotation on yield and the quality and weediness of wheat and barley. Changes in the earthworm community in experimental plots of conventional and organic trials have been studied by Ivask and her group (2007). The comparison of spring cereals and their varieties in conventional and organic systems have not been carried out in Estonian conditions. The preliminary results of our trials about the yield and quality of spring cereals were published in 2007 (Tamm *et al.*, 2007).

A series of field trials comparing organic and conventional systems of the production of spring wheat, barley and oats was established in 2005 at the Jõgeva Plant Breeding Institute in Estonia. The objective of the study was the assessment of the suitability of different spring cereal crops and their varieties to organic cultivation.

Materials and Methods
The trials were conducted from 2005 to 2007 and included 13 spring wheat, barley and oat varieties. The following barley varieties were included: Anni, Elo, Viire, Leeni (Estonia), Tocada, Danuta, Barke, Annabell (Germany), Wikingett, Mette (Sweden), Zazjorski 85 (Belorussia), Inari (Finland) and new the Estonian breed 3280.14.1.4. The oat varieties Jaak, Villu (Estonia), Hecht, Revisor, Nelson, Jumbo, Freddy, Aragon (Germany), Vendela, Belinda, Birgitta, Freja (Sweden) and Celsia (The Netherlands) were used. From the spring wheat varieties the folloning were

selected Helle, Meri, Mooni (Finnish-Estonian collaboration), Vinjett, Tjalve, Zebra, SW Estrad (Sweden), Munk, Triso, Monsun (Germany), Manu, Mahti (Finland) and Baldus (The Netherlands). The experimental design was a randomized complete block with 4 replications. The organic and conventional trials were established on soddy-podzolic soil. The average P content was good, the level of K average, the rganic matter content medium and the pH slightly acid. The precrop in the organic trial was red clover in 2005 and 2006 and was followed by buckwheat in 2007. Mechanical weed control by repeated harrowing was carried out after germination and in the 3-4 leaves stage. The precrops in the conventional trials were potato and rapeseed. The fertilizer level $N_{70}P_{16}K_{29}$ was used for oats and $N_{90}P_{20}K_{38}$ for barley and wheat in the conventional trial. Weeds were controlled by herbicides. A seeding rate of 500 (barley) and 600 (wheat, oat) germinating seeds per m² was used. The yield, 1000 kernel weight, volume weight, protein content, the falling number for wheat and the husk content for oats was measured after harvest. The falling number was determined by the ICC standard method 107/1, oat grains were dehulled by hand and the hulls and groats weighed separately.
Weather conditions in all of the tested years were drier than average (Figure 1). The most favourable for yield formation were the weather conditions in 2005. The first half of the vegetation period was cool and early season precipitation favoured plant growth and development. Drought in July had some effect on plant growth but the yielding level was above average. The driest was the vegetation period in 2006, but the distribution of precipitation caused only small yield decrease compared to the previous year. Severe drought (only 10 mm during the 2 weeks before heading) and a higher than average temperature in June of 2007 resulted in significantly shorter plants and fewer spikelets (Keppart, 2008). Yield decrease was remarkable. Because of drier than average vegetation periods in all of the 3 years there was almost no lodging and comparatively low disease incidence. Data was analysed using the Agrobase computer package (Agrobase gen.II^{TM}, 2004).

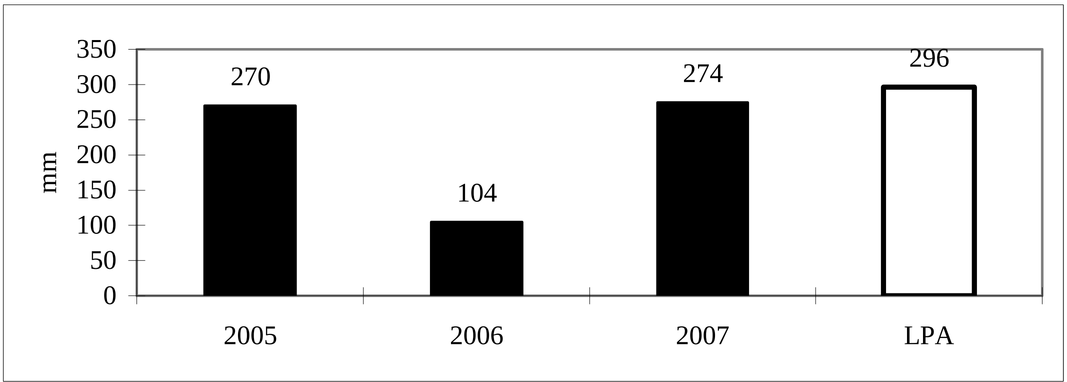
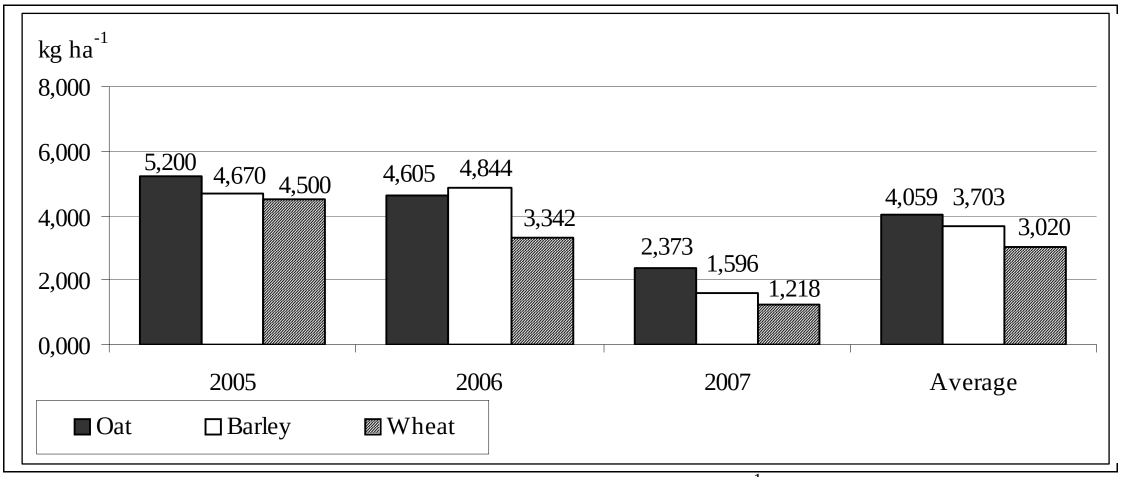


Figure 1. Precipitation (mm) of the vegetation period of 2005-2007 compared to LPA (long period average)

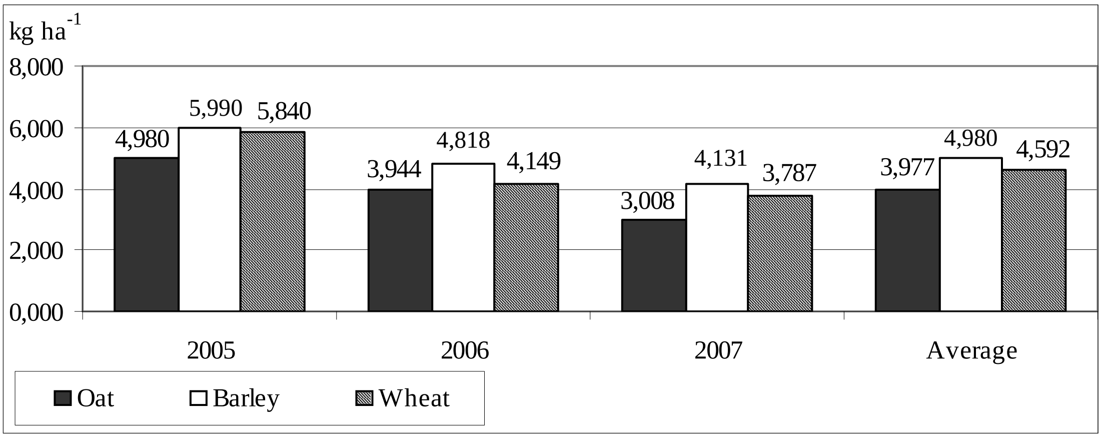
Results and Discussion

Grain yield. In the first trial year the yielding capacity of all the spring cereals in the organic trial was high extending to 4,500 kg ha^{-1} (Figure 2). Yields of oats and barley were despite the drought on average level also in 2006 respectively by 4,605 and 4,844 kg ha^{-1}. Spring wheat suffered the most, producing only 3,342 kg ha^{-1}. Heavy soil crust during germination, early drought before heading and an unsuitable precrop (buckwheat) in 2007 decreased the yields the most.
Similar to oganic trials in conventional conditions the yield were the highest in 2005 and the lowest in 2007 (Figure 3). The grain yield of the oat varieties in conventional trials was lower than that of barley and wheat during all the trial years.
In the conventional trial barely yield the highest average (4,980 kg ha^{-1}) followed by spring wheat (4,592 kg ha^{-1}) and oat (3,977 kg ha^{-1}). Oats were less influenced by the two management systems and there was no significant difference in the average yield of the organic and conventional trials. In organic conditions the grain yield of barley constituted 74 % and wheat 66 % of the conventional yield.



(LSD$_{0.05}$ for 2005= 155, 2006=162, 2007=113 and average= 97 kg ha^{-1})

Figure 2. The grain yields of spring cereals in organic conditions in 2005–2007



(LSD$_{0.05}$ for 2005=182, 2006=147, 2007=138 and average=97 kg ha^{-1})

Figure 3. The grain yields of spring cereals in conventional conditions in 2005–2007

The most of the varieties ranked similarly by grain yield in both growing conditions. The correlations between the grain yields of oat, barley and wheat varieties in organic and conventional trials were significant (Table 1).

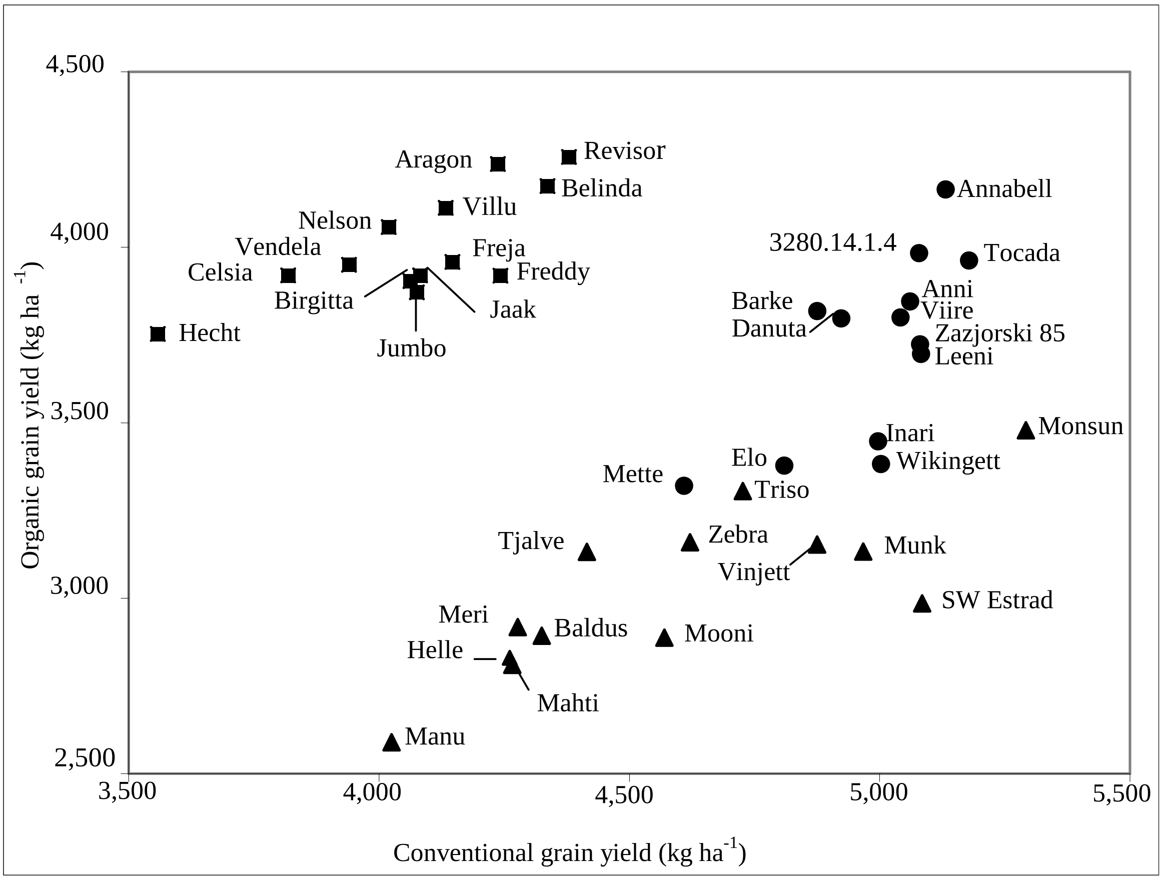
Table 1. The correlations between conventional and organic grain yield and quality characteristics of spring cereals

Characteristic	Oat	Barley	Wheat
Grain yield	0.76**	0.64*	0.80**
Thousand kernel weight	0.77**	0.93***	0.93***
Volume weight	0.85***	0.7*	0.71**
Protein content	0.76**	ns	0.88***
Husk content	0.81**	–	–
Falling number	–	–	0.7*

* – significant for P<0.05; ** – significant for P<0.01 *** – significant for P<0.001; ns – not significant

The highest yielding of the three years average in the organic trial were the oat varieties Belinda (4,336 kg ha^{-1}), Freddy (4,243 kg ha^{-1}), Aragon (4,238 kg ha^{-1}), Freja (4,147 kg ha^{-1}), Villu (4,133 kg ha^{-1}) and Jaak (4,082 kg ha^{-1}); the barley varieties Annabell (4,164 kg ha^{-1}), Tocada (3,942 kg

ha^{-1}), Anni (3,845 kg ha^{-1}), Barke (3,818 kg ha^{-1}) and Viire (3,800 kg ha^{-1}) and the spring wheat varieties Monsun (3,479 kg ha^{-1}), Triso(3,305 kg ha^{-1}), Zebra (3,153 kg ha^{-1}), Vinjett (3,153 kg ha^{-1}) and Munk (3,133 kg ha^{-1}).
While comparing the yields of the two management systems the varieties of the different spring cereals formed quite clear groups (Figure 4).



■ – oat; ▲– wheat; ● – barley

Figure 4. Comparison of organic and conventional grain yields of spring cereals ($LSD_{0.05}$=402)

The grain yield of the oat varieties in conventional management was lower on the average yield than the rest of the conventional trial and the reaction in the organic trial was the opposite – all the varieties outyielded the trial average. Most of the barley varieties had higher than average trial yields in conventional conditions and close to average or even a little above in the organic trials. Several spring wheat varieties produced higher than average yields in the conventional trial but all were lower than average in the organic trial. Under both management conditions increased grain yield was associated with late maturity. The correlation coefficient between the yield and the length of the growing period of wheat was 0.73 ($P<0.01$) in the organic and 0.79 ($P<0.01$) in the conventional trial. No significant correlation between the yield and the length of growing period of oats and barley was found.
Grain quality was higher in the same varieties in both management conditions. Significant positive correlations of quality characteristics between both management conditions were found except for barley protein content. No significant correlations were found between most of the tested traits in both systems. The only significant correlation was between yield and protein content of spring wheat in the organic and conventional trials, respectively –0.53 ($P<0.05$) and –0.82 ($P<0.01$). For oat and barley the correlation was not significant.
When comparing the management the conditions the quality characteristics of barley differed less than the others. For three years the average 1000 kernel weight was 46.6 g in both conditions.

Barley produced big kernels in organic conditions also in the low-yielding year 2007. Protein content was also similar – respectively 116 g kg^{-1} in the organic and 120 g kg^{-1} in the conventional trial. The results of volume weight followed the situation respectively by 684 and 685 g l^{-1}.

In organic fertility management, oats also behaved similarly to barley – there were no significant differences. The tested years average 1000 kernel weight was 34.6 g in organic and 34.4 g in conventional trials and the same for every years. Husk content was also comparable by 262 and 265 g kg^{-1} respectively. Average volume weight was somewhat lower in organic management by 470 g l^{-1} compared to that of conventional management (503 g l^{-1}). During the first two years, volume weight in the both management systems was equal. Significant differences in volume weight occurred in 2007, a year with an early drought, respectively 420 g l^{-1} in organic and 512 g l^{-1} in conventional trials. The average protein content was 120 g kg^{-1} in organic and 129 g kg^{-1} in conventional conditions. In 2005 and 2006 the content of protein was similar, but in 2007 significant differences occurred 117 in organic and 135 g kg^{-1} in conventional trials.

Table 2. The grain quality characteristics of spring cereals in conventional and organic conditions

Characteristic	Conventional conditions				Organic conditions			
	Oat	Barley	Wheat	$LSD_{0.05}$	Oat	Barley	Wheat	$LSD_{0.05}$
Thousand kernel weight, g	34,4	46.6	34.2	1.8	34.6	46.6	36.5	1.9
Volume weight, g l^{-1}	503	685	808	29	470	684	788	32
Protein content, g kg^{-1}	129	120	151	10	120	116	127	10
Husk content, g kg^{-1}	265	–	–	–	262	–	–	–
Falling number, s	–	–	296	–	–	–	285	–

Spring wheat reaction to different management systems was the most sensitive one. Average 1000 kernel weight was significantly bigger (36.5 g) in the organic trial compared to the conventional trial (34.2 g). Significant difference in volume weight was not measured. The biggest dissimilarity was found in protein content. It was significantly lower in the organic trial in all the tested years, being 127 g kg^{-1} and 151 g kg^{-1} respectively as the average. Spring wheat turned out to be the most sensitive to the shortage of nitrogen in the soil for the production of protein. Falling number values were not much influenced by the particular management system - 285 s in organic and 296 s in conventional trial.

During a year average oats showed the highest level of grain yield in organic conditions (4,059 kg ha^{-1}), followed by barley (3,703 kg ha^{-1}) and spring wheat (3,020 kg ha^{-1}). It has also been a common experience in Norway that oats generally perform better than wheat with lower nutrient availability (Loes *et al.*, 2007). The grain yield of oat turned out to be 25% higher compared to that of wheat in organic trial. Nutrient requirements of oat are less than those of wheat (Forsberg and Reeves, 1995). Oats outyielded barley and wheat in organic trials in 2005 and 2007, but their yield was 5% lower than barley in 2006. This could be explained by the better tillering capacity of barley. The results of 3 years of trials show that some varieties were found to produce comparatively higher yields and better quality in organic conditions. To get the best possible yields on a given site, growers use varieties that are adapted to that particular environment and to nutrient levels, which fluctuate with the seasons (Lammerts van Bueren, 2003).

The decrease of the protein content of spring wheat by 16% was observed in organic trials compared to conventional trials. Previous studies have shown that the yield and protein content of wheat produced under organic conditions are often 20-40% lower than those achieved in conventional conditions (Taylor and Cormack, 2002; Mäder *et al.*, 2002). This may partially be due to on insufficient nitrogen supply during the later growth stages (Taylor and Cormarck, 2002). Cultivation of wheat in organic conditions is a challenge for a grower but has great value because of it can br utilized in multiple ways (Pedersen *et al*., 2006).

Conclusion

The results of the trials indicate that on fertile soil and after a suitable precrop (red clover in our trial) all the spring cereals produced comparatively high yields with good quality in organic conditions. Unfavourable weather conditions and an unsuitable precrop caused a significant yield decrease. In terms of quality characteristics protein content and volume weight were the most influenced by the particular management system and the weather. In organic conditions the highest yielding was found in oats. In cultivating spring wheat high soil fertility is needed to produce a high yield with good quality.

Acknowledgements
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References

1. Agrobase generation II™ (2004) *User's manual.* Winnipeg, Manitoba, 250.
2. Løes A.-K., Henriksen T.M., Eltun R. (2007) N supply in stockless organic cereal production under northern temperate conditions. Undersown legumes, or whole season green manure? In: *3rd QLIF Congress: Improving Sustainability in Organic and Low Input Food Production Systems,* University of Hohenheim, Germany, March 20-23, 2007, 226-230.
3. Keppart L. (2008) Weather of growing seasons of 2006 and 2007 and influence to plant production. In: N*ew varieties of field crops, their characteristics and individuality of cultivation.* Jõgeva, 4-7. (In Estonian).
4. Mäder P., Fliebach A., Dubois D., Gunst L., Fried P., Niggli U. (2002) Soil Fertility and Biodiversity in Organic Farming. *Science 296*: 1694-1697.
5. Taylor B.R., Cormack W.F. (2002) Choices of species and varieties. In: *Organic cereals and Pulses.* Younie D., Taylor B., Welch J.P., Wilkinson J.M. (eds.) Lincoln: Chalcombe Publications, 9-28.
6. Forsberg R.A., Reeves D.L. (1995) Agronomy of oats. In: *The Oat Crop. Production and utilization*. Welch R.W. (ed.) London: Chapman & Hall, 221-251.
7. Lammerts van Bueren E.T., Hulcher M., Jongerden J., Haring M., Hoogendoorn J.D., van Mansvelt J.D., Ruivenkamp G.T.P. (1998) *Sustainable organic plant breeding:* http://www.ifgene.org/breed1.htm – accessed on 8.01.2008.
8. Ivask M., Sepp K., Kanger J. (2007) Changes of earthworm community in experimental plots of conventional and organic farming. *Agronomy 2007*, Kadaja J (ed.) Saku, 13-16. (In Estonian).
9. Pedersen L., Thorup-Kristensen K., Loges R. (2006) Wheat baking quality: The effect of catch crop strategies and species: http://orgprints.org/7575/01/Paper_forcongress2006LP.doc – accessed on 15.01.2008.
10. Sepp K., Kanger J., Pevzner J. (2006) Grain yield, quality and weediness of wheat and barley in organic crop rotation. *Agronomy 2006*, Nurmekivi H. (ed.), Jõgeva, 23-29 (in Estonian).
11. Tamm I., Tamm Ü., Ingver A. (2007) Comparison of grain yield and qualiy of spring cereals in organic and conventional conditions. *Agronomy 2007*, Kadaja J. (ed.) Saku, 57-60. (In Estonian).
12. Lammerts van Bueren E.T. (2003) Challenging new concepts and strategies for organic plant breeding and propagation*:* http://www.leafyvegetables.nl/download/04_017-022_Lammerts.pd – accessed on 7.01.2008.
13. Vogt-Kaute W. (2001) Crop breeding for organic agricultur*e:* http://www.ncl.ac.uk/tcoa/files/cropbreeding_orgagr.pdf – accessed on 10.01.2008
14. Wolfe M.S. (2002) Organic plant breeding. In: *Proceedings of the COR Conference.* Powell *et al*., (eds.), Aberystwyth, 303-305.

BIOLOĢISKĀS UN KONVENCIONĀLĀS AUDZĒŠANAS SISTĒMAS IETEKME UZ VASARĀJU GRAUDAUGU RAŽU UN KVALITĀTI

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Situācija lauksaimniecības sektorā pēdējo gadu laikā ir izmainījusies. Nozīmīgāka kļuvusi nepieciešamība palielināt ilgtspējību un aizsargāt vidi. Bioloģiskās lauksaimniecības platības Igaunijā palielinās.
Jogevas augu selekcijas institūtā tika iekārtoti lauka izmēģinājumi, lai salīdzinātu vasaras kviešu, miežu un auzu graudu ražu un kvalitātes pazīmes bioloģiskos un konvencionālos apstākļos. Katras graudaugu sugas 13 šķirnes tika pārbaudītas trīs gadu laikā (2005.-2007. g.). Izmēģinājumu rezultāti parādīja, ka visas vasarāju sugas bioloģiskos audzēšanas apstākļos spēja izveidot salīdzinoši augstas ražas. Ražīgākās bioloģiskajos izmēģinājumos bija auzas, tām sekoja mieži un kvieši. Lielākais ražas samazinājums (34%) bioloģiskos apstākļos salīdzinājumā ar konvencionālajiem apstākļiem bija vasaras kviešiem. Ražas samazinājums bija galvenokārt augu

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’

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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