YIELD AND ITS QUALITY PARAMETERS OF OAT CULTIVARS GROWN IN LATVIA

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Abstract

Oat (Avena sativa L.) is well known as a healthy food in the world, because of its unique biochemical structure. The aim of this study was evaluate 19 different husked oat cultivars by yield and quality parameters in three vegetation seasons. The obtained results showed significant differences among oat cultivars and growing season in all tested parameters, for example average yield in 2012 was 4.99 t ha-1, in 2013 – 5.81 t ha-1 and in 2014 – 7.74 t ha-1. Higher yielding ability showed foreign cultivars, but with better quality characterized Latvian breed cultivars.

Key words: *oat, yield, protein, lipids, β-glucan*

1. INTRODUCTION

Avena sativa (Linnaeus, 1753) or common oat is one of the cereal crops cultivated in temperate climate zones and distinct among the cereals due to its multifunctional characteristics and nutritional profile. It is used for animal as well as for human nutrition, but mostly 70% of produced oat yield is used for animal feed, however in total demand for oat has considerably decreased. In Latvia oat sown areas takes approximately 10.7% from all cereal occupied territories. The total demand for oat in the world has decreased, because of the comparatively low yields – 2.1 t ha^{-1}, while winter wheat achieves 4.2 t ha^{-1} in Latvia in 2013. It makes farmers to choose for good high yielding cereal crops for making business. At the first oat was used for medicine purposes 2000 BC in Egypt. Oat is a nutritious source of protein, carbohydrate, fiber, vitamins and minerals. And currently discussion on oat grain dietetic value and suitability to the production of functional food is more frequently mentioned in scientific literature (Biel et al., 2009). With the development of the techniques of intensive management over crop production demands to oat varieties have changed considerably. Oat breeders through hybridization and selection have improved yielding ability potential of oat varieties. Nowadays common oat can be as a raw material of functional food because of its biochemical composition of grain: protein, lipids, β-glucan, starch amount in grain (Wood, 1997). Grain yield, test weight and 1000 kernel weight are the most important economic traits mentioned by the oat consumers, because the end-product outcome is due to these traits (Sadiq Butt et al., 2008). Protein is the most important nutrient for humans and animals as well. The average protein content of small cereal grains covers a relatively narrow range (8 – 11 %) variations, however, are quite noticeable. The main part (approximately 40%) of kernel structural component is starch. Because of its unique properties, starch is important for the textural properties of many foods, in particular bread and other baked goods. It is located only in endosperm and is present in granular form. Oat contains relatively high amounts of lipids (approximately from 7 %) compared to other cereal grains (Sadiq Butt et al., 2008).Among the main compounds associated with health-promoting effects in cereals is dietary fiber that is found only in plant foods. It consists of both soluble and insoluble fiber. Both types are important for health in different ways (Manthey et al., 1999). Water-soluble fiber in cereals is composed of non-starchy polysaccharides such as β-glucan. Some of the oat constituents are valuable as ingredients or starting materials for several types of products (Brindzova et al., 2008). β-glucan is included in the soluble dietary fiber fractions of oat that participates in the glucoregulation and causes a decrease in serum cholesterol levels in humans (Wood, 2007). Comparing to other cereals, oat as well as barley endosperms have relatively higher β-glucan contents compare with other cereals (Queenan et al., 2007).

The aim of this study was to characterize the yielding and quality abilities of foreign and native husked oat cultivars grown in Latvia from 2012 till 2014.

2. MATERIALS AND METHODS

2.1. Cultivars

There were used 19 husked oat cultivars (int. al. 9 Latvian and 10 foreign origins) in this study to identify their yielding and quality potential. Investigated cultivars are listed in Table 1.

Table 1. List of Latvian and foreign origin husked oat cultivars

Latvian origin cultivars		Foreign origin cultivars	
No	Cultivar	No	Cultivar (origin country)
1	St.Dārta	1	Scorpion (PL)
2	Arta	2	Aveny (SE)
3	Māra	3	Freja (SE)
4	Laima	4	Kirovec (RU)
5	32659*	5	Duffy (DE)
6	32986*	6	Pergamon (PL)
7	32584*	7	Kerstin (SE)
8	33122*	8	Vendela (SE)
9	St.Līva	9	Corona (DE)
10	-	10	Rajtar (PL)

* Perspective breeding lines of State Stende Cereals Breeding Insistute

2.2. Field trials

Field trial and investigation were carried out at the State Stende Cereals Breeding Institute (SSCBI) in 2012, 2013 and 2014. The soil of the site was sod-podzolic, its parameters are performed in Table 2.

Table 2. Soil parameters 2012 – 2014, SSCBI

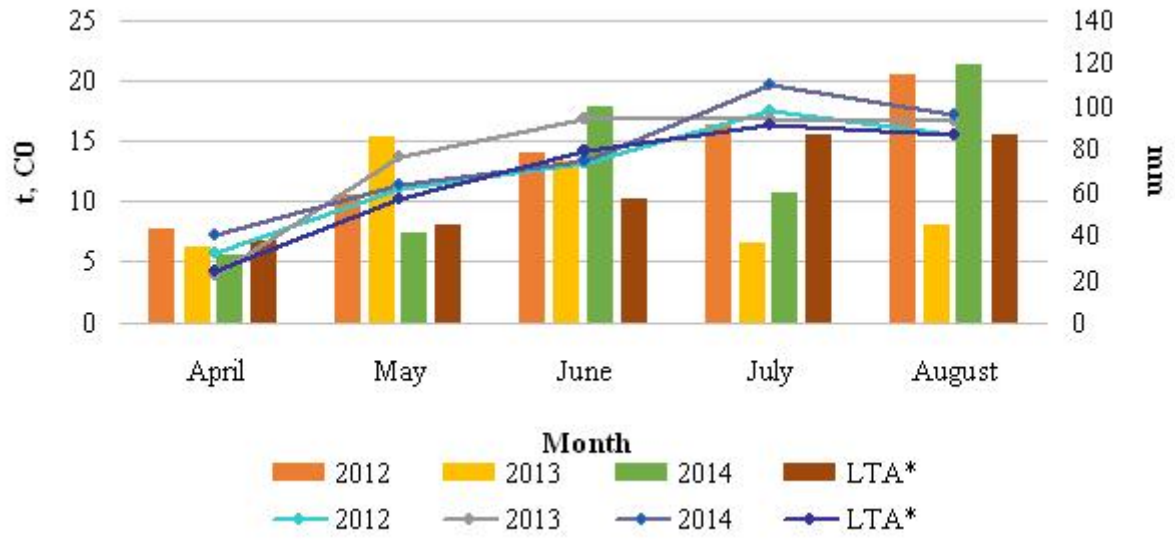
Parameter	2012	2013	2014
Humus content, g kg^{-1}	18	20	22
pH KCl	6.2	6.6	6.0
phosphorus (P), mg kg^{-1}	42	39	99
potassium (K) mg kg^{-1}	59	53	150
pre-crop	barley	barley	potatoes
Sowing date	28.04.	03.05.	22.04.
Harvesting date	09.08.	07.08	22.08.

All agro-technical operations were carried out at optimal terms according to the weather conditions during the vegetation period and depending on the plant development phases. Seed rate was 500 seeds per 1 m^2. Before cultivation of the soil a complex mineral fertilizer was applied: N – 51, P_2 – 30, K_2 –

42 kg ha^{-1}. Variants were arranged in four replications with plot size 10 m^2 in a randomized block design.

2.3. Meteorological conditions

Oat yield and quality is closely related to meteorological conditions during vegetation season. Yield parameters are influenced by temperature and amount of precipitation mostly during all vegetation period, but quality parameters are made after early milk stage. The temperature and moisture conditions provided grate oat field germination in 2014 and are represented in Figure 1. All studied years were different in both: temperature and precipitation limits.



* Long Term Average

Figure 1. Mean daily temperature (C°) and precipitation (mm), 2012 – 2014, SSCBI

2.4. Laboratory analyses

Mean samples from all replications (500 g) were taken for testing by Infratec Analyser 1241 (2005, FOSS) (test weight, protein, starch, lipid content, β-glucan) performed at the State Stende Cereals breeding institute. 1000 kernel weight was detected using standard method LVS EN ISO 520:2011.

2.5. Data statistics

The obtained results were statistically processed by MS Excel program package using the methods of descriptive statistics; arithmetic mean value and standard division were calculated for Latvian and foreign origin cultivars. Means comparison of both origin cultivars were carried out using t-test and the *p*-values less than 0.05 were considered to be statistically significant. ANOVA procedures were used for data analysis.

3. RESULTS AND DISCUSSION

Oat in Latvia has been widely studied as a raw material for human diet. For using oat meals in human nutrition, it is necessary to investigate its quality and thereby its suitability. The parameters, which have been usually studied, are yield from hectare, test weight and crude protein content, but these parameters does not describe oat nutritive and dietary value, which is important criterion, describing the quality of food. Oat differs from others cereals by balanced essential amino acid structure in protein, lipids with unsaturated fatty acids, easily available starch and comparatively high amount of β-glucan (Ryan et al., 2007). Plant breeders should pay attention to biochemical meters of cereals, while developing new oat varieties for food production until now. In Latvian oat breeding program the highest crude protein and crude lipid content are the selection criteria to evaluate breeding material (Zute et al., 2010).

3.1. Yield

Yield is the main character interesting for grain producers. It is necessary to achieve grater grain amount from a hectare, because higher yielding potential lowers growing costs. The significantly (p<0.05) highest yield were detected in year 2014 (Figure 2).

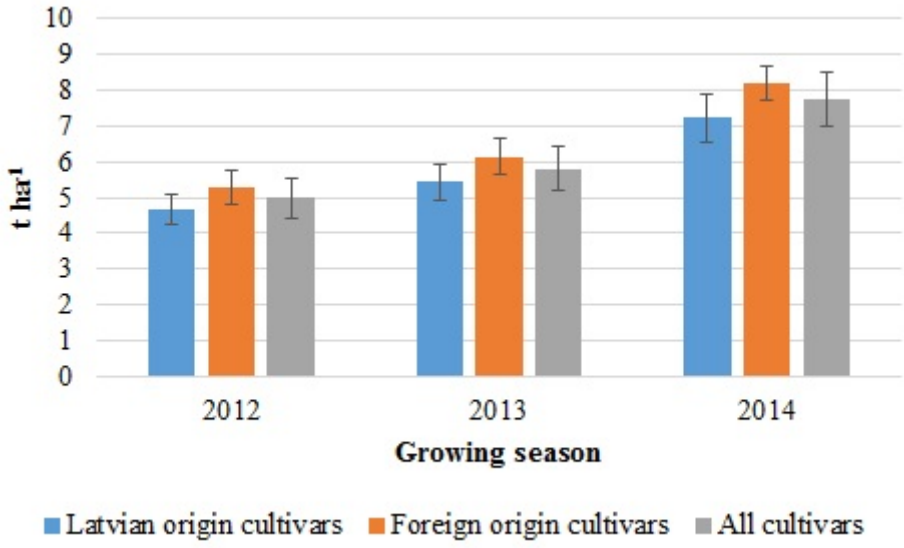


Figure 2. Yield of oat cultivars grown in Latvia, 2012 – 2014, SSCBI

First months of the year 2014 characterized with relatively low mean daily temperature and amount of precipitation. Oat comparing with other spring cereals can grow in lower temperatures, they are stressed when mean daily temperatures become too high. Precipitation of July was lower than long term average, but temperature exceeds even more than 30 C°. Drought and relatively high temperature did not lowered yield because of May moisture and low temperature. The significantly (p<0.05) highest yielding ability was detected for foreign origin cultivars, from 5.29 to 8.20 t ha^{-1}. Latvian varieties and perspective breeding lines showed lower yields, from 4.65 to 7.22 t ha^{-1}. Yields were detected so high because of the small plot size, at the commercial field yields would be lower. Latvian variety ‘Arta’ characterized with significantly (p<0.05) lower yield from all cultivars (from 3.85 to 6.23 t ha^{-1}). Highest yield was detected for varieties ‘Rajtar’, ‘Scorpion’ and ‘Aveny’ (accordingly 5.93 – 8.86 t ha^{-1}, 5.82 – 8.36 t ha^{-1} and 5.82 – 8.78 t ha^{-1}), from Latvian origin variety ‘Stendes Dārta’ and perspective breeding line ‘32986’ had the highest yields – 5.20 – 7.23 t ha^{-1} and 4.99 – 8.03 t ha^{-1}. Zute et al. (2010) reported husked oat yield about 5.02 t ha^{-1} between 1993 and 2009 years, which is lower than obtained in this study. Difference could be explained with meteorological conditions and variety choice.

3.2. 1000 kernel weight

1000 kernel weight is a parameter which characterizes kernel weight and ecological plasticity of cultivar; it is dependent on meteorology and genetic factors. The results showed that Latvian origin oat cultivars have lower 1000 kernel weight comparing with foreign oat cultivars, because yield and 1000 kernel weight is related parameters, but difference was not significant (p>0.05). Differences among genotypes and variation among years was significant (p<0.05). For Latvian origin cultivars 1000 kernel weight varied from 35.79 to 38.75 g, but foreign origin cultivars from 37.95 to 40.94 g. The highest 1000 kernel weight form Latvian origin cultivars was detected for breeding line '32986' (38.66 – 41.99 g), but foreign – 'Pergamon' (41.48 – 45.50 g).

3.3. Test weight

Grain test weight characterize grain kernel filling and for tested cultivars varied from 47.78 – 52.71 g L^{-1}. Test weight in 2013 was significantly (p<0.05) higher than other tested seasons, respectively 52.34 g L^{-1}. There was no significant difference (p>0.05) between foreign and Latvian origin cultivars (Figure 3). Variety 'Duffy' characterized with significantly (p<0.05) higher test weight (52.75 g L^{-1} in 2012, 54.70 g L^{-1} in 2013 and 50.68 g L^{-1} in 2014). Test weight is most commonly used to evaluate grain quality and its value was influenced by sowing year observed by Doehlert et al. (2004).

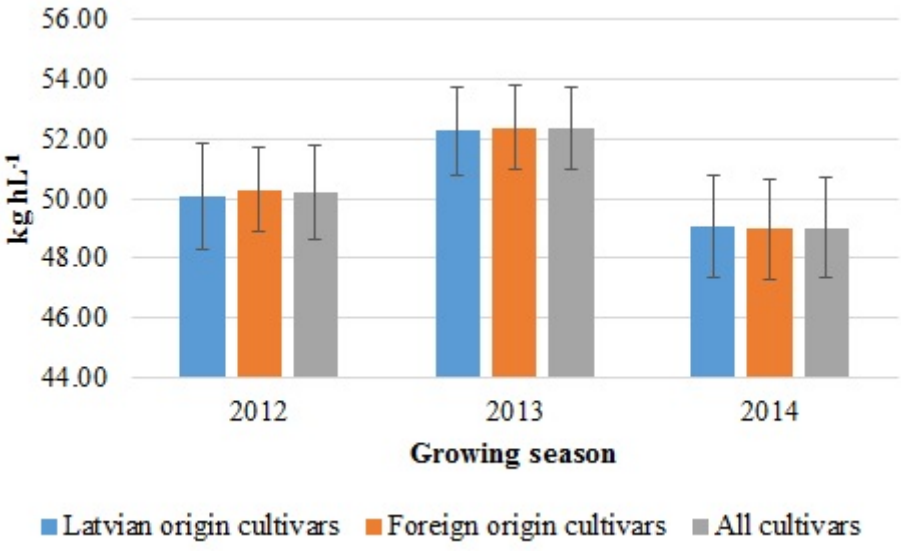


Figure 3. Test weight (g L^{-1}) of oat cultivars grown in Latvia, 2012 – 2014, SSCBI

3.4. Protein content

The noticeably highest quality parameters are for varieties which characterized with lowest yield and its parameters. Quality parameters develop after flowering, when grain filling begins. The significantly (p<0.05) lowest protein content was detected in year 2013 because of relatively low precipitation and low temperatures during grain filling. The highest protein content among Latvian oat cultivars was detected with the variety 'Arta' (119.50 g kg^{-1} in 2012) having the lowest yielding ability. In the literature, for husked oat, average protein content is reported as 115.0 g kg^{-1} (Biel et al., 2009). Protein content in oat grain is dependent on mostly agro-meteorological conditions: variety, nitrogen treatment, sowing date and weather conditions (Givens et al., 2003). That is the reason why significant differences were found among varieties and years. Significantly (p<0.05) highest protein content was detected for Latvian origin cultivars (97.75 to 105.72 g kg^{-1}) comparing with foreign (91.95 to 99.26 g kg^{-1}) (Figure 4).

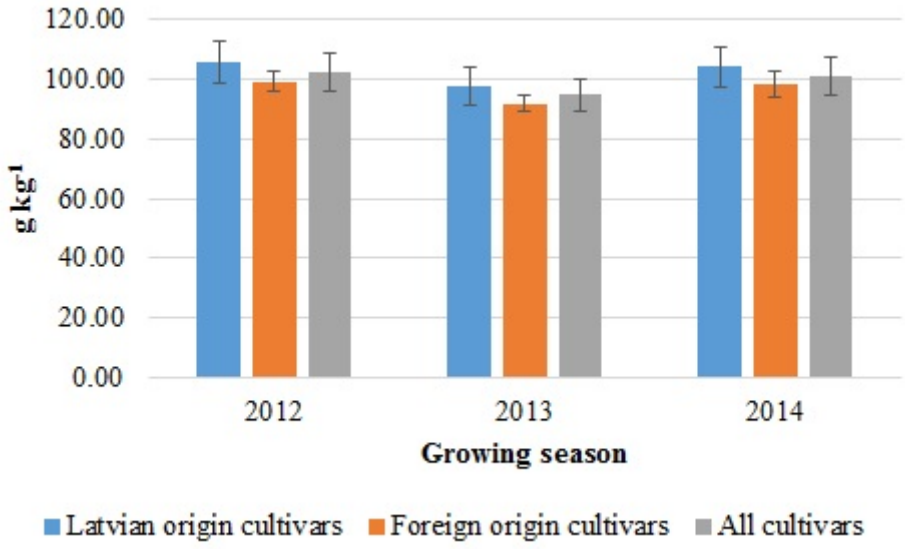


Figure 4. Protein content of oat cultivars grown in Latvia, 2012 – 2014, SSCBI

3.5. Starch content

Starch is the major storage carbohydrate of cereals and an important compound for human nutrition. Mean starch content given by Givens et al. (2003) was 400 g kg^{-1}. Mean starch content in this study was more than given in literature – 483.53 g kg^{-1} in 2012 till 487.64 in 2013 g kg^{-1}. Foreign origin cultivars characterized with significantly (p<0.05) higher starch content comparing with native once (Figure 5). Furthermore the highest values of starch were detected in 2013. As starch in grain is the storage substance for germination, year 2013 had been favorable and oat plant had enough nutrients for storage forming in grains. Starch content in oat grain is subjected to variety, nitrogen treatment and weather conditions. In this study, nitrogen treatment was the same in both years, but chosen varieties and meteorological conditions might affect starch contents according to our results.

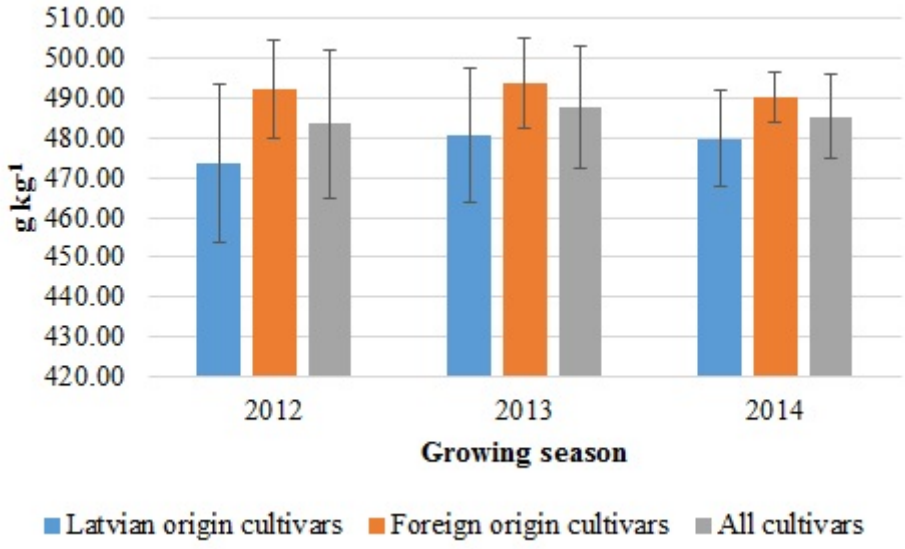


Figure 5. Starch content of oat cultivars grown in Latvia, 2012 – 2014, SSCBI

3.6. Lipid content

The lipid fraction of the oat grain determines in large measure its energy content and has a significant impact on nutrition (Zhou et al.,1999). Lipids in foods are an important nutritional factor and their profile may play a crucial role as concerns the stability of cereal products (Brindzova et al., 2008). Oat grain has soft kernel and lipid distributed throughout the seed, which makes the milling process more difficult than wheat and corn. To prevent from atmospheric oxidation, the oat is hydrothermally treated before processing (Sadiq Butt et al., 2008). The high lipid content is not desirable for food producers, but crucial component for human diet, because of consistence of vitamin E and fatty acids, which is located in lipids. Lipid content of selected cultivars varied from 47.58 – 62.58 g kg^{-1}. Lipid content of Latvian origin cultivars was significantly (p<0.05) higher than foreign origin (Figure 6). Significant (p<0.05) difference was observed among growing season as well. Lipid content in oat cultivars is strongly dependent on meteorological conditions of sowing year which was indicated by Givens et al. (2003) too.

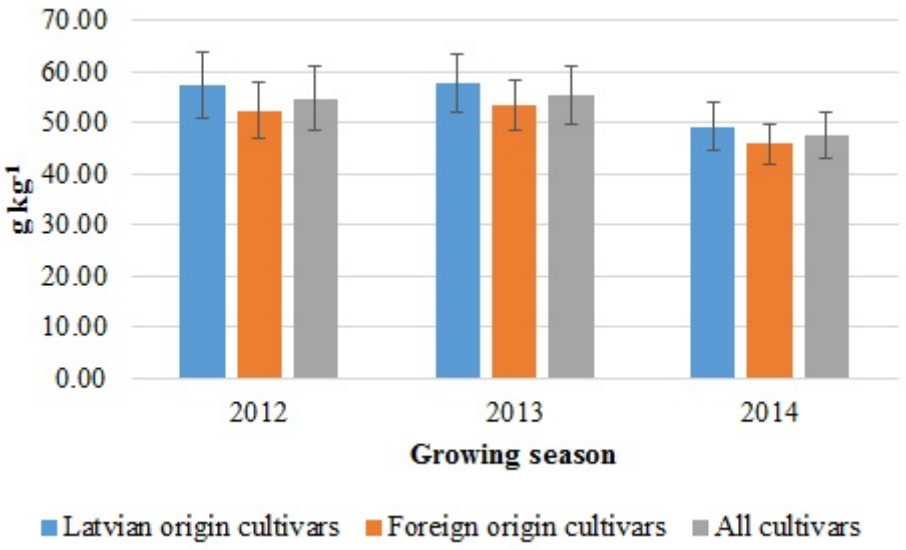


Figure 6. Lipid content of oat cultivars grown in Latvia, 2012 – 2014, SSCBI

3.7. β-glucan content

β-glucan, which is a soluble dietary fiber, is an important component of oat grain with health promoting effect. It could have beneficial role in gastrointestinal diseases, lowering of cholesterol level, promoting heart health, preventing diabetes and even cancer (Daou, Zhang, 2012). Latvian origin cultivars had significantly (p<0.05) higher β-glucan content, as shown in Figure 6. In the literature, β-glucan contents for oats were reported between 23 - 85 g kg^{-1}. Cultivars studied in this research demonstrated low results compared to data reported previously, respectively from 27.89 to 39.22 g kg^{-1}. Significant (p<0.05) differences were observed among cultivars and growing season as well (Figure 7).

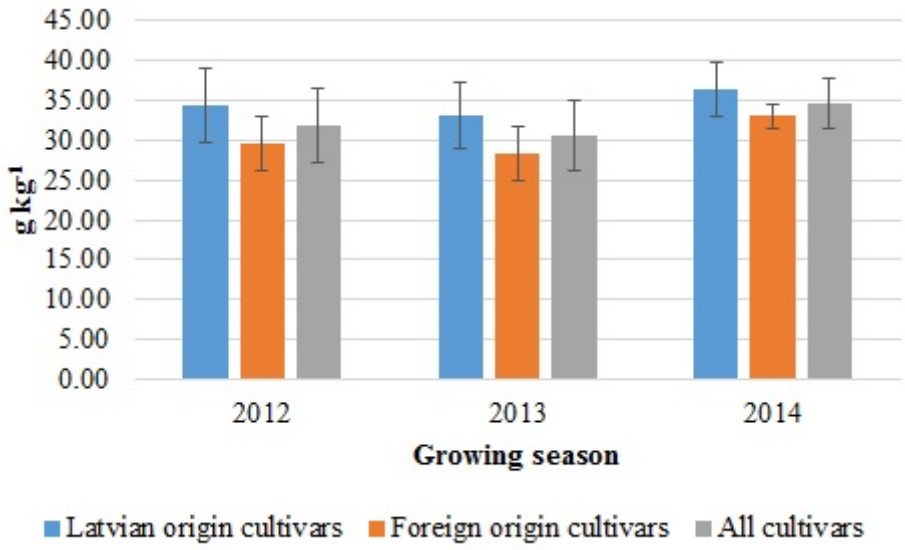


Figure 7. β-glucan content of oat cultivars grown in Latvia, 2012 – 2014, SSCBI

4. CONCLUSIONS

Latvian origin oat cultivars on average characterized with significantly ($p<0.05$) lower yield, test weight and 1000 kernel weight, but higher quality parameters comparing with foreign origin. Significant ($p<0.05$) differences were observed among tested cultivars and growing seasons as well. In result of described research we have found that the cultivars with highest yielding ability does not characterized with high quality parameters. These high-yielding cultivars with higher quality are acknowledged as perspective in oat breeding program and are possible to use as raw material for new oat varieties further.

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