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GRAIN YIELD AND ITS FORMING PARAMETERS VARIATIONS OF OAT CULTIVARS

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Common oat (*Avena sativa* L.) is one of the small cereal crops grown in temperate climate zone. The usage of this crop has been widely discussed nowadays. It is used for animal as well as human nutrition due to its unique biochemical composition. Oat sown area occupies only 10 % from all cereals sown area in Latvia lately because of the low oat yielding ability which is approximately two times lower comparing with winter wheat. For farmers it is economically advantageous to cultivate more productive crop like wheat although oat with its biochemical structure and ways of usage is unique among other cereals. The aim of this research was to compare 19 oat cultivars by their yield and productivity forming parameters (potential yield, test weight, 1000 kernel weight, plant height and weight, grain size and count in panicle) to demonstrate connections among them and influence of cultivar and growing year. Field trials were carried out at State Stende Cereals Breeding Institute in the years 2012, 2013 and 2014 which were different in their temperatures and precipitation limits. Statistically significant differences ($p<0.05$) were observed among tested cultivars and growing season as well. Correlation between yield and several productivity parameters were detected, but were strongly influenced by metrological conditions of growing year.

Key words: oat, cultivar, yield, productivity, variability.

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INTRODUCTION

Common oat (*Avena sativa* L.) is one of the major crops in temperate climate zones used both for human and animal nutrition (Sadiq Butt et. al. 2008). In Latvia oat sown areas ocupies approximately 10% from all cereal grown territories. The total demand for oat in the world has decreased, because of the comparatively low yields – 2.32 t ha^{-1}, while winter wheat achieves 3.95 t ha^{-1} in Latvia in 2013. But comparing grain dietetic value and suitability to the production of functional foods oat is more frequently mentioned in scientific literature. 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, they have developed oat varieties dwarfed in length and more resistant to lodging (Zute et al. 2010). On consumers' side lower

Table 1. Soil parameters and pre-crop 2012 – 2014, State Stende CBI

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	47
Potassium (K) mg kg^{-1}	59	53	63
Pre-crop	barley	barley	potatoes

standards are set forward regarding biochemical composition of grain: protein, lipids, β-glucan, starch amount in grain, though dietetic value of oats is just due to these traits (Wood 1997).

Grain yield, test weight and thousand kernel weight are the most important economic traits mentioned by the oat consumers, because the end-product outcome is due to these traits when processing oat grain. Grain productivity is dependent of agro-metrological conditions and individual variety potential (Zute et al. 2010).

The aim of this research was to compare 19 oat cultivars by their yield and productivity forming parameters (potential yield, test weight, 1000 kernel weight, plant height and weight, grain size and count in panicle) to demonstrate connections among them and influence of cultivar and growing year.

MATERIAL AND METHODS

Field trials

The field trials were carried out at State Stende Cereals Breeding Institute (State Stende CBI) using 19 oat genotypes (int. al. four perspective lines from Latvian breeding program – '32659', '32986', '32584' and '33122') from 2012 to 2014. 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 germinate able seeds per 1 m^2. Sowing dates and harvesting dates were dependent on meteorological conditions (sowing date – 28.04., 03.05., 22.04.; harvesting date – 09.08., 07.08., 22.08., according 2012, 2013, 2014). Variants were arranged in four replications with a plot size 10 m^2 in a randomized block design. The soil of the site was sod-podzolic, its parameters are given in Table 1.

Meteorology

Meteorological conditions in their mean daily temperature and precipitation amount of studied years differed from each other and long term average as well and are performed in Figure 1. The temperature and atmospheric precipitations provided perfect oat field germination in 2013. Precipitations exceeding long term average and sufficient mean daily temperatures in May and June provided good conditions for germination and tillering. But on the same period lower mean daily temperatures and high precipitations in 2014 and 2012, slowed oat growing and flowering, pollination was bothered. Low sum of precipitation and mean daily temperature close to long term average in 2013 in July and August ripened oat grains and gave excellent yield, while in 2014 mean daily temperature was higher than long term average and with the lack of precipitation in July caused stress for oat plants. The harvesting in 2012 and 2014 were delayed approximately by week because of heavy rainfalls at first two decades of August. Strong wind gusts in all studied years through all vegetation period provided perfect conditions for stem lodging.

Grain yield, grain yield components

Before harvesting there were taken bundle examples containing plants from 0.125 m^2 large areas from each cultivar and replication. All plants were counted and achieved amount of productive and unproductive tillers. 10 plants from each bundle were measured to receive plant and panicle height. Panicle was weighted and grains counted in it to receive grain count in panicle. Thousand kernel weight was detected by standard method LVS EN ISO 520:2011. Yield was measured from 10 m^2 plot in t ha^{-1}. Mean samples from all replications (0.5 kg) were taken for testing kernel size fractions by separator machine SORTIMAT. Cleaned sample of 100 g to be weighed on a balance accurate to 0.01 g and then placed onto the top sieve. The sieving period was set from 3 minutes, recommended by producers. There were used sieves with diameter 2.5 and 2.2 mm. With a weighed batch of 100 g the percentage proportion is then obtained by weighing the individual fractions.

Statistic analysis

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 each measured and calculated parameter. ANOVA procedures were used for data analysis. P-values less than 0.05 were considered to be statistically significant.

RESULTS AND DISCUSSION

Yield

Yield of studied cultivars were in the limits of 4.51 to 8.86 t ha^{-1} and was significantly ($p<0.05$) influenced by cultivar and year and are performed in Figure 2. The yield in 2012 and 2014 were significantly ($p<0.05$) lower comparting with yield observed in 2013. Cultivar 'Laima' were set as standard and yield of this cultivar varied from 5.45 to 7.79 t ha^{-1}. In 2012 for 10 cultivars ('Stendes Dārta', '32986', '32584', 'Corona', 'Pergamon', 'Scorpion', 'Aveny', 'Kerstin', 'Freja' and 'Rajtar') yield was significantly ($p<0.05$) higher comparing with standard. In 2013 there were only 6 cultivars ('Corona', 'Pergamon', 'Duffy', 'Scorpion', 'Aveny' and 'Rajtar') with significantly ($p<0.05$) higher yields comparing with 'Laima', but in 2014 already 12 cultivars ('32986', '32584', 'Kirovec', 'Corona', 'Pergamon', 'Vendela', '33122', 'Duffy', 'Scorpion', 'Aveny', 'Kerstin'

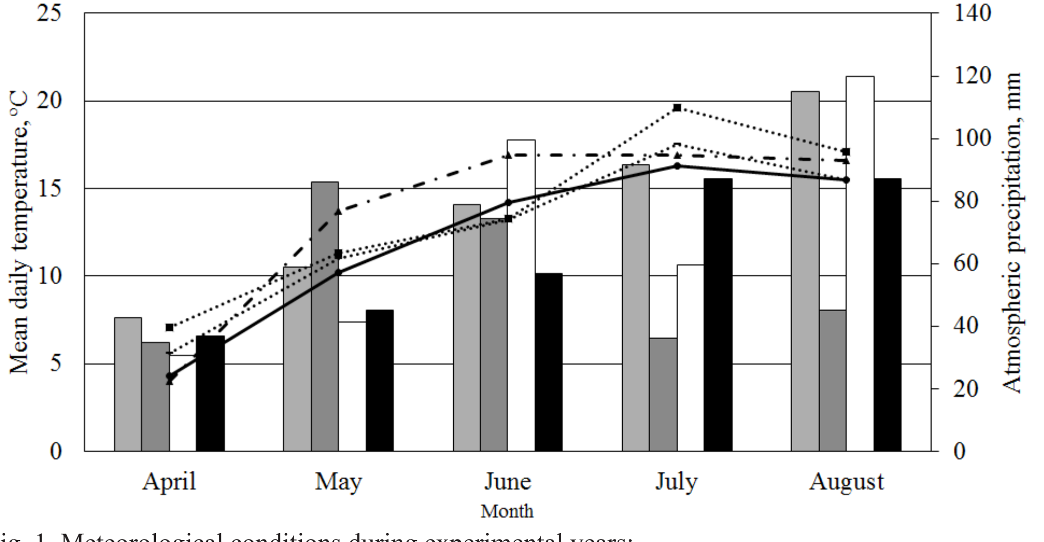

Fig. 1. Meteorological conditions during experimental years:
■ 2012, ■ 2013, □ 2014 ■ LTA, *LTA – Long term average value of temperature
2012, 2013, 2014 Long term average value of precipitation.

and 'Freja'). Significantly ($p<0.05$) highest yields were observed for cultivars 'Aveny' and 'Rajtar' in 2013 (respectively 8.78 and 8.86 t ha^{-1}). With significantly ($p<0.05$) lowest yield characterized cultivar 'Arta' in all tested years. Zute et al. (2010) established husked oat yield from year 1993 – 2009 about 5.02 t ha^{-1}.

Productivity parameters

At first we need to speak about plants and tillers per m^2, describing the productivity of oats (performed in Table 2). Martynial (2008) and Deiss et al., (2014) have mentioned that the number of productive tillers of cereals is dependent on environmental conditions at tiller initiation and the subsequent stages until flowering. According, Spasova et al., 2013, number of plants, productive and unproductive tillers could be dependent on fertilization, growing system and agrometeorological conditions. In this study fertilization and growing system was similar in all studied years, in that reason attention was paid to meteorology in first growing stages. Meteorological conditions in third decade of April and first and second decades of May were different in all studied years. In the year 2013 mean daily temperature and precipitation was close to long term average values in April last decade, but exceeded in May. In that way could be explained differences between 2012 and 2013 in number of plants and productive tillers per m^2. Number of plants per 1 m^2 significantly ($p<0.05$) highest was in 2012. But between number of plants in 2013 and 2014 significant differences were not observed. But metrological conditions in 2013 and 2014 were quite different. Lack of moisture in May of 2014 was replaced by high precipitations in June and that was the main difference between 2012 and 2014 influencing plant and tiller amount. Differences among cultivars were observed significant as well ($p<0.05$). Number of productive tillers is only one parameter influencing grain yield.

Grain size of cultivar and grain number per panicle could be very important describing oat grain yield. Cultivars with larger grains and more grains per panicle characterizes with higher yields. Differences in grain size were significant ($p<0.05$) among tested cultivars and growing season. It is found in literature that in hot and dry conditions at grain filling process content of smaller grains increases (Dolferus et al. 2011). Year 2014 characterizes with extremely high mean daily temperatures in July, but the highest small grain proportion was detected in 2012, when July was the coldest. In 2012 the number of plants was significantly higher and there were higher competition for nutrients in soil among separate plants increasing number

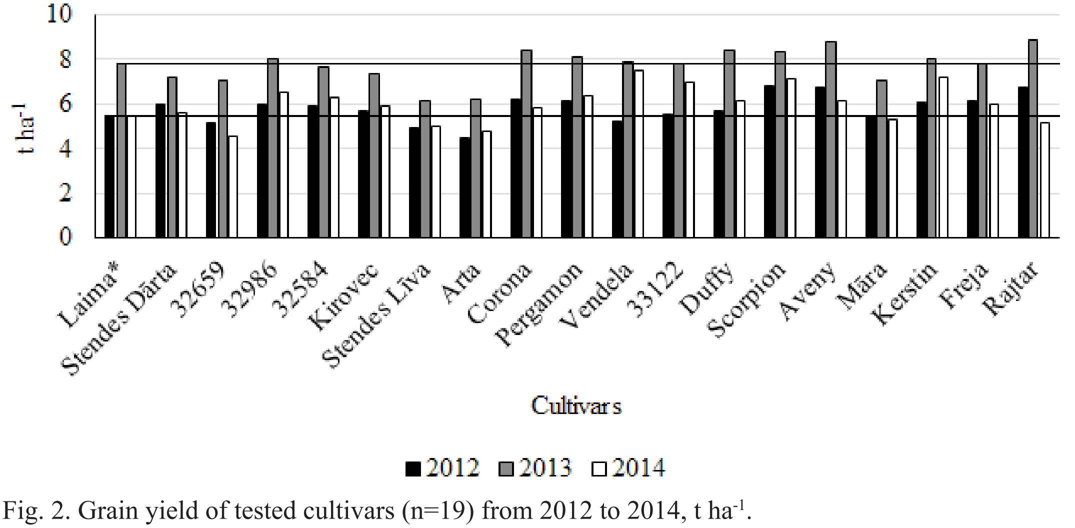

Fig. 2. Grain yield of tested cultivars (n=19) from 2012 to 2014, t ha^{-1}.

Table 2. Measured parameters of tested cultivars (n=19) from 2012 to 2014

Parameter	Year	Average by cultivars	LSD $_{0.05}$
Number of plants, per 1 m^2	2012	**469.37**	20.62
	2013	388.21	
	2014	380.32	
Number of productive tillers, per 1 m^2	2012	**453.37**	22.54
	2013	379.16	
	2014	**471.79**	
Number of unproductive tillers, per 1 m^2	2012	**198.63**	13.67
	2013	50.74	
	2014	59.47	
Plant height, cm	2012	108.56	1.86
	2013	105.63	
	2014	**111.01**	
Panicle length, cm	2012	**17.34**	0.33
	2013	16.10	
	2014	16.42	
Number of grains per panicle	2012	65.22	2.97
	2013	60.36	
	2014	**68.00**	
Thousand kernel weight, g	2012	36.98	0.32
	2013	**39.90**	
	2014	37.53	
Weight of one panicle, g	2012	**5.90**	0.34
	2013	5.31	
	2014	4.82	
Grain size >2.5 mm, %	2012	58.67	1.04
	2013	**61.68**	
	2014	58.17	
Grain size 2.2-2.5 mm, %	2012	30.96	0.89
	2013	33.30	
	2014	**34.85**	
Grain size <2.2 mm, %	2012	**10.36**	0.34
	2013	5.02	
	2014	6.99	

All tested parameters were significant between years and cultivars at the level of $p<0.05$.
* Abbreviators used in correlation test.

of unproductive tillers too. De Almera et. al. (2003) have found out that plant density does not influence oat grain yield similar our experiment when highest number of plants per m^2 in 2012 gave lower yields comparing with 2013, but in 2014 when plant density was similar to 2013 differences between yields were significant ($p<0.05$).

Correlative connections among yield and productivity parameters

Correlation among measured parameters (performed in Fig. 3) showed significant ($p<0.05$) linear negative correlation to yield and plant height in the years of 2012 and 2013 (r=-0.475 (2012); r=-761 (2013) > $r_{0.05}$=0.456), but in 2014 correlation was not significant (r=-0.376 < $r_{0.05}$=0.456). There is no literature describing that smaller sized cultivars characterizes with higher yield, but Berry et al. 2004 has mentioned that breeding programs use dwarf forms of wheat to increase lodging resistance and preserve high yields. In 2013 regression equation shows that in 57% of cases changes in yield could be explained by plant height. Decrease in plant height will increase oat grain yield. Such connection could be explained by the choice of cultivars, using larges amount of cultivars could give different results.

Significant ($p<0.05$) linear negative correlation of yield and grain size (2.2 – 2.0mm) was observed in all studied years (r=-0.529 (2012); r=-638 (2013); r=-522 (2014) > $r_{0.05}$=0.456). Impact of larger small grain fraction proportion is one of the main reasons decreasing yielding ability of oat cultivar.

There were observed significant correlations among several parameters, but they didn't remain between tested years, which could be explained with each year individuality in meteorological conditions, but it is not proved in scientific literature.

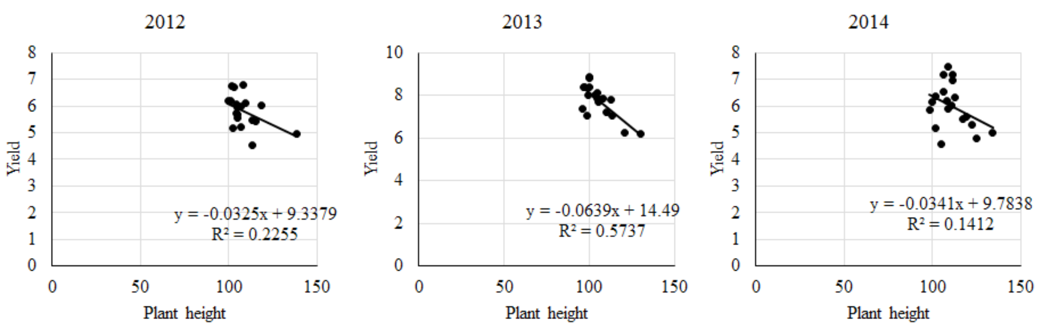

Fig.3. Effect of plant height on oat grain yield.

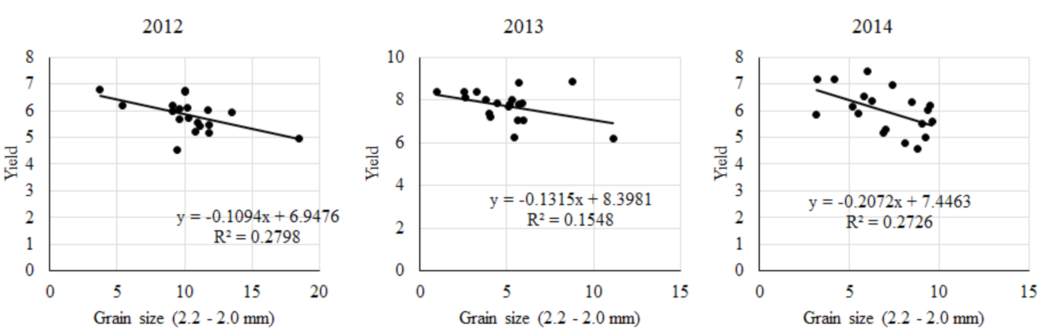

Fig. 4. Effect of grain size (2.2-2.0 mm) on oat grain yield.

CONCLUSIONS

Based on three year study, the following conclusions can be drawn: For all tested parameters there were observed significant ($p<0.05$) difference between years and tested cultivars. In the year 2013 and 2014 the growing conditions for oat in early growing stages were good for tillering. With higher yield characterized the year 2013, although few yield forming parameters were lower. Correlation analysis showed significant negative correlation between yield and plant height (r=-0.473 (2012); r=-757 (2013)) and linear negative correlation of yield and grain size (2.2 – 2.0mm) in all studied years (r=-0.529 (2012); r=-638 (2013); r=-522 (2014) > $r_{0.05}$=0.456).

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