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OAT GRAIN YIELD VARIATIONS ASSOCIATED WITH PRODUCTIVITY PARAMETERS AMONG OAT CULTIVARS GROWN IN LATVIA

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Abstract

Common oat (*Avena sativa* L.) is an important field crop cultivated in temperate climate zone for green fodder and grains production as well. Oat sown area occupies 62.4 thousand hectares that is only 10.7 % from all cereals sown area in Latvia. The low oat productivity which is approximately two times lower comparing with winter wheat is the main reason in cereal choice. 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 parameters to demonstrate connections among them. Field trials were carried out at State Stende Cereals Breading Institute in the years 2012 and 2013. These two years in Latvia were significantly different in their temperature limits and precipitation. Results showed that significantly higher ($p<0.01$) yield was observed in 2013 due to favourable meteorological conditions. Although most part of productivity parameters were significantly ($p<0.01$) lower in 2013, but kernel size uniformity test and proportion of productive and unproductive stems was significantly ($p<0.01$) higher for all investigated cultivars. It can be concluded that the main yield formers after two year field trials can be grain size and proportion of productive and unproductive stems, which are closely dependent on meteorological conditions.

Key words: *oat, meteorological conditions, yield, productivity*

Introduction

Avena sativa (Linnaeus, 1753) or common oat is one of the major crops cultivated in temperate climate zones. It is used both for human and animal nutrition although nowadays about 70% of the produced oat yield is used mostly for animal feed (Sadiq Butt et. al. 2008). 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. 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 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 parameters to demonstrate connections among them.

Materials and Methods

Field trial. The trial was carried out during 2012 – 2013 at State Stende Cereals Breeding Institute. 19 oat cultivars (int. al. four perspective lines from Latvian breeding program – ‘32659’, ‘32986’, ‘32584’ and ‘33122’) were used. The soil of the site was sod-podzolic, the humus content in 2012 and 2013 – 18 and 20 g kg^{-1}, the soil pH KCl – 6.2 and 6.6, the available for plants content of phosphorus P – 42 and 39 mg kg^{-1}, and that of potassium K – 59 and 53 mg kg^{-1}. The previous crop during both years of investigation was barley. All agronomic practices not specifically considered in this study were in accordance with the methods accepted for growing of this crop. Seed rate was 500 seeds per 1 m^2. Before cultivation of the soil a complex mineral fertilizer was applied: N – 51, P – 30, K – 42 kg ha^{-1}. Variants were arranged in four replications with a plot size 10 m^2 in a randomized block design. Sowing was completed on April 28 in 2012 and on May 3 in 2013.

Meteorology. The temperature and atmospheric precipitations provided perfect oat field germination in 2013 and 2012 and are represented in Figure 1. Precipitations exceeding long term average and sufficient mean daily temperatures in May and June provided good conditions for germination and tillering. 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 2012 harvesting was delayed approximately by ten days because of heavy rainfalls at first decade of August. However strong wind gusts in both years through all vegetation period provided perfect conditions for stem lodging.

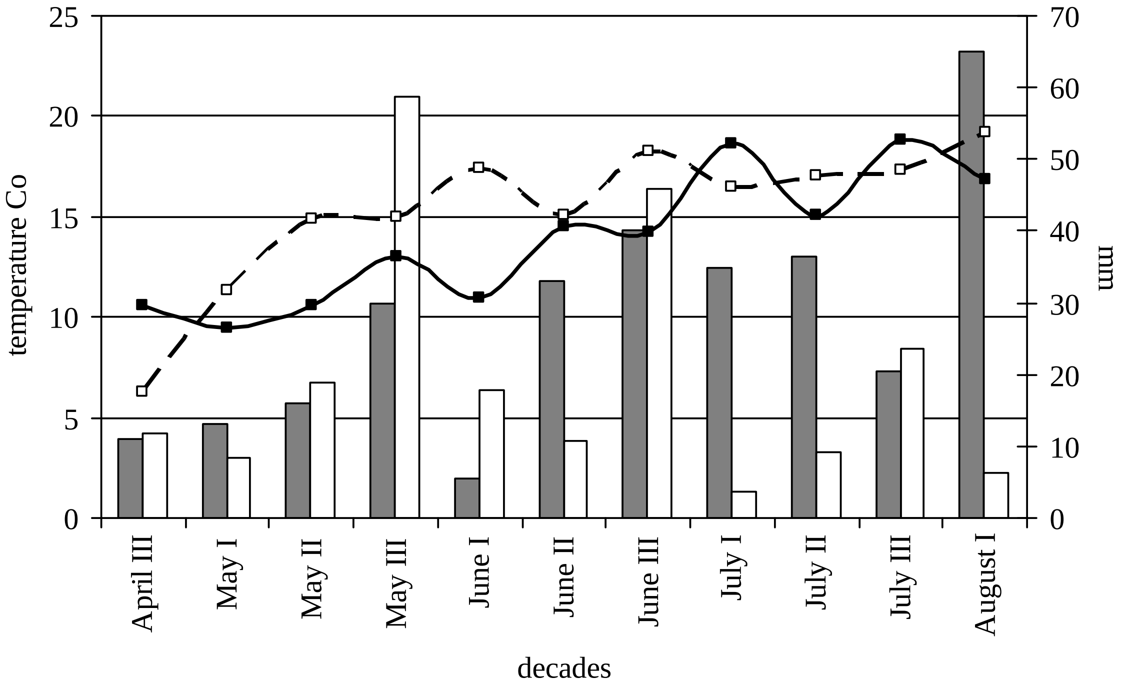

Figure 1. Meteorological data in the experimental period (Stende meteostation data, 2012, 2013)

■ – precipitation of 2012, mm; □ – precipitation of 2013, mm; –■– - mean daily temperature of 2012, °C; –□– - mean daily temperature of 2013, °C.

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}. The value of potential yield was calculated by formula:

$$R = \frac{V \times G \times M}{100000},$$

where R – potential yield t ha^{-1};
V – number of panicles per 1 m^2;
G – number of grains per 1 panicle;
M – thousand kernel weight.

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

When processing the results, at first we need to speak about plants and tillers per m^2, describing the productivity of studied oats. Martynial (2008) and Deiss et. al., (2014) mentioned that productive tiller number 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 both years, in that reason attention was paid to meteorology in first growing stages tillering. Meteorological conditions in third decade of April and first and second decades of May in 2012 were favorable for oat germination. April and May were warm and wet, but comparing with year 2013 when soil was drier and temperatures lower. In that reason using similar seed rate – 500 seeds per 1 m^2 in both years; plants per m^2 in 2013 was only 82.7% of plant amount of 2012. As well as because of remarkable changes of atmospheric precipitation in 2012; the number of unproductive tillers was four times larger than in 2013 performed in Table 1.

Differences between years were observed significant for all tested cultivars at the level of $p<0.01$. Also differences among cultivars were significant as well ($p<0.01$). With largest number of plants per m^2 characterized cultivar ‘Rajar’ in 2012 (564 plants per m^2), but in 2013 it was ‘Aveny’ – 470 plants per m^2.

Number of productive tillers is only one parameter influencing grain yield. Calculated potential yield was grater comparing with actual yield in both years. It is correct, because potential yield is showing potential of cultivar, but can be affected by many conditions, including meteorology, losses during harvesting and agrotechnology. Although potential yield calculated in 2013 lower comparing with 2012, opposite actual yield represented in Table 2.

Table 1. Measured parameters of tested cultivars (n=19) in 2012 and 2013

Parameter	Year	Average by cultivars	LSD $_{0.05}$
Yield, t ha^{-1} (*R*)*	2012	5.81	0.14
	2013	7.74	
Potential yield, t ha^{-1}	2012	10.86	0.43
	2013	9.07	
Number of plants, per 1 m^2	2012	473	15.03
	2013	391	
Number of productive tillers, per 1 m^2 (*PT*)	2012	460	17.20
	2013	381	
Number of unproductive tillers, per 1 m^2 (*UT*)	2012	204	11.10
	2013	50	
Plant height, cm (*PH*)	2012	109	1.64
	2013	106	
Panicle length, cm (*PL*)	2012	17	0.34
	2013	16	
Number of grains per panicle (*NGP*)	2012	65	2.85
	2013	60	
Thousand kernel weight, g (*KW*)	2012	36.98	0.33
	2013	39.91	
Weight of one panicle, g (*PW*)	2012	5.90	0.40
	2013	5.31	
Grain size >2.5 mm, %	2012	55.21	1.03
	2013	59.50	
Grain size 2.2-2.5 mm, %	2012	33.25	0.80
	2013	35.69	
Grain size <2.2 mm, %	2012	11.55	0.36
	2013	4.81	

All tested parameters were significant between years and cultivars at the level of $p<0.01$.
* Abbreviators used in correlation test.

Differences between years were observed significant as well as among tested cultivars at the level of $p<0.01$. The highest yield was observed for cultivars ‘Scorpion’ and ‘Rajtar’ (respectively 6.81 t ha^{-1} (2012) and 8.86 t ha^{-1} (2013)).

Table 2. Yield and potential yield of tested cultivars (n=19) in 2012 and 2013, t ha^{-1}

Cultivar	Yield		Potential yield	
	2012	2013	2012	2013
Stendes Dārta	6.01	7.23	12.31	7.91
32659	5.19	7.04	9.01	8.66
32986	5.99	8.03	11.19	11.17
32584	5.95	7.68	9.37	8.72
Kirovec	5.72	7.36	11.33	7.39
Stendes Līva	4.95	6.18	10.63	7.66
Arta	4.51	6.23	7.22	7.43
Corona	6.20	8.40	10.36	8.92
Pergamon	6.16	8.14	8.52	9.44
Laima	5.45	7.79	10.04	10.59
Vendela	5.21	7.85	10.45	10.88
33122	5.55	7.78	9.85	8.24
Duffy	5.69	8.38	12.12	8.52
Scorpion	6.81	8.36	15.27	9.62
Aveny	6.72	8.78	12.23	11.60
Māra	5.44	7.06	11.82	7.25
Kerstin	6.05	8.02	10.85	9.04
Freja	6.11	7.84	10.72	10.35
Rajtar	6.74	8.86	12.96	8.91

Although yield in 2013 was higher, some yield forming parameters were lower, like, number of plants, productive tillers, number of grains per panicle and size of the plant. Though grains were greater and heavier, as thousand kernel weight demonstrate (in 2012 – 36.98 g, but in 2013 – 39.91g) and also kernel size distribution (number of large grains (>2.5 mm) was raised by 4.49%). The small grain number was lower in 2013, because of number of unproductive tiller decreased. In the seasons when oat cultivars are producing many unproductive tillers, the lack of nutrients appears for grain growing and filing, that is the main reason for small grains appearing also mentioned by Zute et al. 2010.

Table 3. Correlative connections among several measured parameters (n=19; $r_{0.05}$=0.456) in 2012

Parameters	*PT*	*UT*	*PH*	*PL*	*PW*	*KW*	*NGP*	*R*
PT	1							
UT	0.472	1						
PH	-0.005	-0.094	1					
PL	-0.268	-0.387	**0.681**	1				
KW	-0.021	-0.495	-0.325	-0.269	0.377	1		
NGP	-0.484	-0.626	0.230	0.601	**0.601**	-0.094	1	
R	0.200	-0.446	**-0.473**	-0.075	0.267	0.626	0.154	1

Table 4. Correlative connections among several measured parameters (n=19; $r_{0.05}$=0.456) in 2013

Parameters	*PT*	*UT*	*PH*	*PL*	*PW*	*KW*	*NGP*	*R*
PT	1							
UT	-0.263	1						
PH	0.061	0.016	1					
PL	-0.423	0.330	**0.680**	1				
KW	-0.190	0.232	-0.292	-0.097	0.377	1		
NGP	-0.195	0.199	-0.203	0.118	**0.601**	-0.163	1	
R	0.150	-0.016	**-0.757**	-0.410	0.267	0.335	0.353	1

Correlation among measured parameters (performed in Table 3 and Table 4) showed significant negative correlation to yield and plant height in both years (r=-0.473 (2012); r=-757 (2013) > $r_{0.05}$=0.456), but there is no literature describing that smaller sized cultivars characterizes with higher yield.

Such result is achieved, because of the choice of cultivars. Berry et. al. 2004 has mentioned that breeding programs use dwarf forms of wheat to increase lodging resistance and preserve high yields, Strong positive significant correlation was between plant height and panicle length (r=-0.681 (2012); r=-680 (2013) > $r_{0.05}$=0.456). As well as between panicle weight and number of grains per panicle (r=-0.601 (2012); r=-601 (2013) > $r_{0.05}$=0.456).

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.

Conclusions

Based on two years of research, the following conclusions can be drawn: For all tested parameters there were observed significant (p<0.01) difference between years and tested cultivars. In the year 2013 the growing conditions for oat in early growing stages were good for tillering, because the number of unproductive tillers was four times lower comparing with 2012, when differences in meteorological conditions were really radical. With higher yield characterized the year 2013, although few yield forming parameters were lower, grains were greater and heavier, as thousand kernel weight showed (in 2012 – 36.98 g, but in 2013 – 39.91g) and also kernel size distribution (number of large grains (>2.5 mm) was raised by 4.49. Correlation analysis showed significant negative correlation between yield and plant height (r=-0.473 (2012); r=-757 (2013)).

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