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PRODUCTIVE FEATURES OF OAT VARIETIES GROWN IN ORGANIC PRODUCTION IN THE REGION OF STRUMICA

DRAGICA SPASOVA[1*]; BILJANA ATANASOVA[1]; DARINA VALCHEVA[2]; DUSAN SPASOV[1]; MITE ILIEVSKI[1]; ADRIJANA BUROVSKA[1]
[1]*University GoceDelcev – Stip, Faculty of Agriculture, 2400 Strumica, Macedonia*
[2]*Institute of Agriculture, BG-8400 Karnobat Republic of Bulgaria*

Abstract

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The research was conducted during 2015 and 2016 of 11 oats genotypes in conditions of organic production. Three of the genotypes are domestic (*Krivogastani, Trebenista and Kuceviste*), 3 genotypes are from Serbia (*Rajac, Slavuj and Lovken*) and five genotypes are from Croatia (*Kupa, Baranja, Eksplorer, Sampionka and Istra*).

The genotypes showed different average values almost for all analyzed yield components and according to the significance of the differences they are divided in groups. Of all the genotypes cultivated in the Strumica region, the highest total grain yield had varieties *Kupa* (3 850 kg/ha and 2 866 kg/ha) and *Istra* (3 600 kg/ha and 3 666 kg/ha).

The 11 varieties tested are divided into 3 clusters. The third cluster includes varieties *Kupa* and *Istra*, which are the most high-yielding compared with the rest of the group.

The analysis of variance showed that the genotype has the highest influence to the yield components: number of spikelet in the tassel, the length of the tassel, the plant height and the grain yield in the tassel.

There is a strong positive correlation between the grain yield per tassel and grain yield per 1ha (0.716).

From the distribution of the components of the yield and yield of the grain in the factorial plane, we obtained that the yield can be increased only by selecting tassels with a high grain yield.

Key words: oats; organic production; genotype; yield; yield components

Introduction

Oats (*Avena sativa* L.) is grown primarily for grain. Because of its biological value is used in the diet of humans and animals. Today, oats are among the many important crops in the human diet, with increased demand in modern gastronomy and food technology.

Plates under oats, on a worldwide scale, are in constant decline, compared to wheat and barley. The reasons for low oat productivity are the cultivation of poorly productive varieties and inadequate agrotechnology (Nikolić, 2002)

With improved oats varieties, three times more green fodder can be produced, which is 60 to 80 t / ha, and can be fed twice as many animals per unit area as opposed to traditional fodder crops (Haqqani et al., 2003).

Peeled oat grains are easily digestible, and in the diet of people enter through a number of industrial products: oat flour, dietary bread, oat snowflakes, meal, muesli, etc.

The increasing demand for human nutrition is a consequence of the high biological value and nutritional components that oats contain. According to Pržulj et al. (1998), oat contains soluble dietary fiber, mainly ß-glucans, whose content varies from 2.5-6.5%. The content of ß-glucans in

*Corresponding author: dragica.spasova@ugd.edu.mk

oat grain effect on lowering cholesterol levels, so that the modern diet food recommended dishes based on oat flakes, (Mlinar, 1996).

The global tendency for the production of healthy food has imposed the need, in the Republic of Macedonia, to carry out research in this direction, and to obtain appropriate knowledge about the reaction of the oat genotypes to the applied agro-technology.

Organic production in the Republic of Macedonia is defined by the Law on organic production, which is in accordance with the EU laws.

According to Lockeretz et al. (1981), oat is one of the most suitable cereals for organic production. It is in accordance with Galie et al. (2004), who found that oats are a very suitable cereal crop for organic production, examining varieties of oats in organic farming conditions, taking into account the high yields they received, ranging from 4 to 5 t/ha. Similar results were obtained by Konstantinos (2007), who cultivated new varieties of barley and oats in conditions of organic production, which showed great stability in yield, good productivity and resistance to disease.

Bearing in mind the foregoing, the purpose of our trials was to determine the differences of some of the elements that determine the oat production in organic production. The analyzes of the tested varieties and populations will determine which of them is most suitable for organic production, ie which variety or population will guarantee high quality.

Material and Methods

The tests were carried out in 2015 and 2016, in field and laboratory conditions. Field experiments were placed on the field of experiments at the Faculty of Agriculture at the Goce Delcev University – Stip in Strumica, and the laboratory analysis were carried out at the laboratories of the Faculty of Agriculture.

11 genotypes of oats have been analyzed, three of which are domestic populations: the population of *Krivogastani*, *Trebenista* and *Kuceviste*. The others are introduced varieties from Serbia and Croatia. From Serbia were analyzed 3 varieties: the variety *Slavuj*, *Rajac* and *Lovken*. The other five varieties are from Croatia: the variety *Kupa*, *Baranja*, *Eksplorer*, *Sampionka* and *Istra*.

The trials were set in three repetitions, distributed by the random block system method, with a dimension of the basic parcel of 5 m^2.

The distance between the variants was 0,50 m, and between repetitions 1 m. The distance between raw was 20 cm. It was used sowing seed rate of 550 grains of 1 m^2. The basic soil treatment was performed at a depth of 35cm. Prior to sowing, additional processing and fertilization with 30 t/ha biological fertilizers were carried out according to the regulations for organic production.

In full maturity, the height of a whole oats plant, to 10 plants from each parcel, or to 30 plants of each variant, was measured.

Before the harvest, material from plot of 1m^2 for laboratory analysis is taken. In the laboratory the number of spikelet in the tassel, the number of grains in the tassel, the number of grains in the spike, the yield of grain in the tassel and the total yield was measured.

For these analyzes 30 plants of each parcel were used, i.e. 120 plants of each variant.

The total yield is calculated on the basis of the mass of the grain from each parcel, reduced to the unit area.

The statistical analysis of the results was performed using the variance analysis method, Fit analysis, cluster analysis and Principal Component Analysis, with the JMP, SPSS and Statgraf utility programs.

Climate Conditions

In the period of two-year trials, the meteorological indicators for average monthly air temperatures in Celsius were monitored and monthly sums of precipitation in millimeters.

For the period of ten years, 2004/2014, the average annual temperature in Strumica valley (Table 1) amounts to 13,5°C, and an average fall of 663.9 mm precipitation (Table 2).

The schedule of precipitation (Table 2) by months and by seasons is quite unbalanced. The most robust mass, for a period of ten years, is the month of October with an average of

Table 1
Average monthly temperatures in Celsius

Year	Month												Ann. amount of temp.	Average ann. temp
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
2015	2.8	5.3	7.2	12.4	19.8	21.4	26.7	24.9	20.1	13.8	8.8	3	5052,2	13,8
2016	1.4	9.4	9.5	15.5	16.9	23.5	25.5	24.2	19.1	13.4	7.2	1,3	5073,5	13,9
2004/2014	2.4	4.1	8.8	13.5	18.2	22.4	25.1	24.9	19.4	12.6	7.8	3,4	4927,5	13,5

Table 2
Amount of monthly precipitation in mm

Year	Month												Ann. amount of precipitation in mm
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2015	50.4	81.4	83	16.6	16.1	40.1	6.6	65.6	95	102.9	54.4	0	612,1
2016	61.3	23.5	135.5	52.5	96.2	38.3	18.7	18.7	31.4	64.3	53.3	0	593,7
2004/2014	43.5	51.5	50.5	44	66.3	60.1	52	39.9	61	80.1	48.3	66,9	663,9

80.1 mm. The driest month, with the lowest average amount of precipitation, is August 39.9 mm.

The analysis of the temperatures in the study period 2015-2016 (Table 1) showed a high similarity with the average annual temperatures in the Strumica valley at the ten-year average. The mean annual temperature in 2015 is 0.3°C higher than the multiyear average, and in 2016 it is 0.4°C higher than the average.

Here it must be noted that the amount of precipitation and temperature smaller or larger than average amount is sufficiently reliable factor for the successful completion of the vegetation, ie good yield.

According to the data in Table 1, it can be concluded that the average monthly air temperatures during the spring oats (March – July) vegetation in the two years of testing are the lowest in the first month of the oat vegetation, ie in March (from 7.2 – 9.5°C), and the highest in July (25.5 – 26.7°C). These mid-month temperatures, which prevailed in the two years of testing, are considered to be good for growing oats.

Spring oatmeal is known as low temperature sensitive culture and should not be grown in areas where temperatures fall from -10 to -14°C, before forming a snow cover. But the degree of resistance depends to a large extent on the stage development, the stages of organogenesis, the sowing time, the species, the variety, the availability of soil with nutrients, the duration of the low temperatures, the humidity of the soil, etc.

For successful vegetation oats requires a lot of water and are therefore considered a cereal that has the greatest need of it.

According to Vasilevski (2004), critical water periods are the stages of the formation of generative organs (about 15 days before tasseling) and the time of intense growth (until the tasseling).

In Table 2, it can be noted that during the vegetation period of the oats, the precipitation scales are relatively good and correspond to the needs of the oats.

Oats have the greatest need for water in relation to other cereals, due to the large leaf mass that it forms during vegetation. The oats transpiration coefficient ranges from 400 to 570, but it largely depends on the variety, agrotechnical measures, the type of soil, relative humidity of the air, etc.

Results and Discussion

In Table 3, data about the yield and yield elements of oat varieties for the period 2015-2016, are presented. The results show that the highest average yields for the group were formed in 2016 – an average of 2553 kg/ha. In 2015, the most productive are the varieties *Kupa* and Istra, which yield an average of 3850 kg/ha and 3600 kg/ha. The *Istra* variety has the highest yield and in 2016 (3666 kg/ha). Low yields in 2015 had *Trebenishta* (1550 kg/ha), and in 2016 *Kucheviste* and *Baranja* with yields of 2066 kg/ha.

In 2015 (Table 3), tested oat varieties have formed lower stems, with plant height averaging 108.6 cm for the group. The highest stem had variety *Krivogashtani* variety – 116.7cm, and the lowest variety *Kupa* – 78.3cm, which falls into group **a,** based on established LSD values. That same year, the length of the tassel and the number of spikes in tassel has values lower than those in 2016. The greatest length of the tassel has variety *Lovken* – 28.2 cm, and the smallest is the tassel of variety *Kupa* (13.2 cm). Six of the tested varieties have formed a large number of spikes in the tassel and are in group **a**.

In 2016, 10 of the varieties have a height of over 100 cm, and the highest is the variety *Krivogashtani* – 143.3cm. Variety *Kupa,* again, is with the lowest stem. Variety *Krivogashtani* is with the longest tassel in 2016 and variety *Kupa* with the lowest tassel. In group **a**, by number of grains in the tassel is variety Rajac – 82.8. In 2015, the indicators number of grains in tassel and the number of grains in spikels, varieties has higher values compared with 2016. The weight of the grain in the tassel is lower in the first year, while in the second is larger. The results show that, on average for 2015, the grain is smaller than in 2016.

Figure 1 shows the yield dendrogram and the elements of productivity of oat varieties. The 11 varieties tested are divided into 3 clusters. The first cluster consists only of the *Krivogashtani* variety, which differs from the others in that it is high-pitched. The second cluster includes 8 varieties. In it, the most closely related are the varieties *Rajac* and *Slavuj*, which form a subgroup with the least distant units. The third cluster includes the varieties *Kupa* and *Istra*, which are with the highest yields in comparison with the rest of the group.

Table 3
Yields and elements of productivity of oat varieties by years

Varieties	Plant height (cm)	Tassel length (cm)	Number of spikelet in tassel	Number of grains in tassel	Number of grains in spike	Grain yield per tassel (g)	Grain yield per ha (kg)
				2015			
Krivogastani	116.7 f	20.8 ab	61.1 ab	120.3 bcd	1.9 ab	1.8 b	2750 b
Trebenista	88.1 bc	18.2 c-f	71.8 a	149.6 ab	2.0 ab	0.8 e	1550 e
Kuceviste	97.8 b-e	16.5 e-f	75.2 a	116.3 a-d	1.5 c	0.8 d-e	1600 de
Rajac	95.8 de	18.5 b-e	78.0 a	144.3 abc	1.7 abc	1.3 b-e	2150 b-e
Slavuj	94.6 e	19.3 a-d	73.3 a	142.6 abc	1.8 abc	1.4 bcd	2200 bcd
Lovken	88.1 bcd	28.2 a	75.8 a	141.1 abc	1.8 bc	1.5 bc	2250 bc
Kupa	78.3 a	13.2 g	45.4 c	89.0 d	2.0 ab	2.5 a	3850 a
Baranja	94.0 de	18.0 c-f	63.5 abc	138.3 abc	2.1 a	1.1 cde	1950 cde
Eksplorer	87.0 b	16.8 def	63.3 abc	131.2 abc	1.9 ab	1.3 cde	2050 cde
Sampionka	90.9 e	19.4 abc	80.7 a	164.9 a	1.9 ab	1.1 cde	1800 cde
Istra	87.4 cde	15.8 f-g	51.6 bc	107.5 cd	1.9 ab	2.7 a	3600 a
Average	108.6	18.06	67.60	130.8	1.92	1.56	2340.9
LSD	9.94	2.57	18.7	33.6	0.29	0.43	645.6
VC%	5.41	8.36	16.4	15.2	9.37	16.0	16.32
				2016			
Krivogastani	143.3 f	26.8 a	74.8 ab	117.3 ab	1.5 a	2.0 bc	2226 bc
Trebenista	101.3 e	18.3 e	78.3 ab	98.8 bc	1.1 cd	1.9 bc	2800 b
Kuceviste	103.1 de	18.8 de	74.6 ab	85.4 cd	1.0 d	1.6 c	2066 c
Rajac	107.8 b-e	20.1 cd	82.8 a	118.8 ab	1.3 b	2.3 b	2800 b
Slavuj	115.3 bc	22.2 b	77.7 ab	126.6 a	1.5 a	1.9 bc	2333 bc
Lovken	132.7 de	21.0 bc	79.6 ab	86.3 cd	1.0 d	1.9 bc	2533 bc
Kupa	83.4 a	16-6 f	64.1 b	71.0 d	0.9 d	1.6 c	2866 bc
Baranja	139.5 bcd	20.0 cde	68.0 ab	92.5 cd	1.3 bc	1.5 c	2066 c
Eksplorer	100.4 e	19.0de	72.4 ab	99.8 bc	1.2 bc	1.7 c	2533 bc
Sampionka	117.6 b	21.2 bc	74.0 ab	103.6 abc	1.3 b	1.9 bc	2200 bc
Istra	107.5 cde	19.2 de	71.4 ab	106.3 abc	1.3 ab	3.0 a	3666 a
Average	113.8	20.2	74.3	100.5	1.2	1.9	2553
LSD	9.91	1.71	16.80	24.42	0.12	0.53	718.26
VC%	5.40	5.02	13.36	14.36		16.32	16.46

Table 4 presents the results of the analysis of the variance and factor strength (η) genotype and year and the interaction genotype x year. In the investigated oats varieties, the genotype plays an important role in the formation of the yield, the number of spikelet in the tassel, the length of the tassel, the height of the plant and the grain yield per tassel. The year has a decisive role in the formation of the number of grains in the spike, hence the number of grains in the tassel.

Table 5 presents the results of established correlations between yield and productivity elements in the tested varieties of oats. High positive correlation well established (0.759) exists between plant height and length of the tassel. High positive correlation was found between the number of grains in the tassel and the number of grains in spike (0.652) and the length of the tassel and the number of spikes in tassel (0.549). Strong positive correlation exists between the weight of the grain in the tassel and the yield (0.716).

Proven average negative correlations are established between the plant height and the number of grains in spikes (-0345), between the number of spikes in the tassel and the number of grains in spikes (-0360), between the number of spikes in tassel and yield (-0.420) and the number of grains in the tassel and yield (-0381).

The relationship between the yield and productivity of the elements in the tested group of oats varieties are presented by means of principle component analysis through

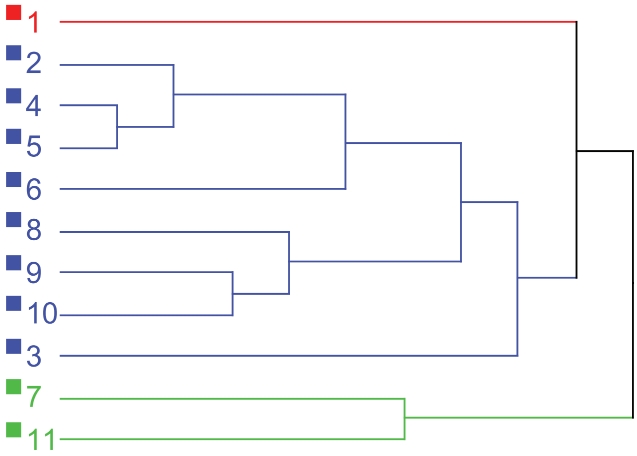

Fig. 1. The dendrogram of production and the elements of productivity of oats varieties for the period 2015-2016
*1, 2, 3, 4.....11 – the numbering corresponds to the sequence number of Table 3

the imaged pattern on the basis of values on major components. Figure 2 show that the yield vector forms an acute angle with the vector of the grain yield per tassel. This

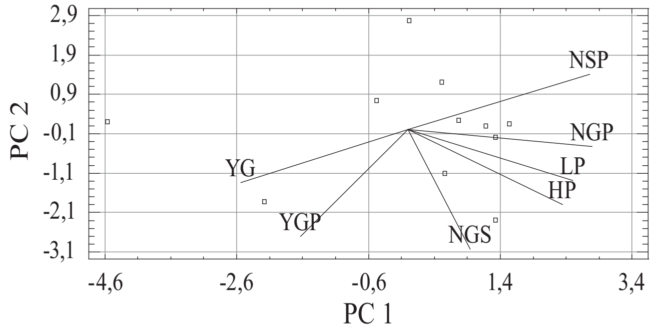

Fig. 2. Scatter-plot of genotypes according to the yield components and grain yield in a factorial space

means that the variation in yield for the tested varieties is determined by the grain yield per tassel. The location of the vectors of the other elements of productivity and the lack of correlation with the grain yield per ha and grain yield per tassel shows that it is difficult to improve the yield through them. Selection of high yield genotypes can only be based on the choice of varieties with high-yielded tassels.

Table 4
Analysis of the variance of grain yield and yield components in examined oat genotypes for the period 2015-2016

Yield components	The source of variation					
	Genotype		Year		Interaction genotype x year	
	MS	η	MS	η	MS	η
Plant height	845.808***	62.56	4253.170***	31.46	80.847***	5.98
Length of the tassel	30.981***	68.75	92.182***	20.46	4.861**	10.79
Number of spikelet in the tassel	371.056***	69.23	761.601***	14.21	88.798*	16.56
Number of grains in the tassel	1256.671***	36.81	15634.085***	45.79	593.944*	17.40
Number of grains in the spike	0.092***	11.ян	6.810***	81.34	0.640**	7.65
Grain yield per tassel	0.999***	57.04	3.274***	18.70	0.425***	24.26
Grain yield kg/ha	1849613.636***	75.68	945606.061***	3.87	499856.061***	20.45

MS – mean squares; η – effect of factor

Table 5
Correlation between yield components and grain yield in the investigated oat genotypes

Yield components	Plant height	Length of the tassel	Number of spikelet in the tassel	Number of grains in the tassel	Number of grains in the spike	Grain yield per tassel	Grain yield kg/ha
Plant height	1	0.759**	0.342**	-0.080	-0.345**	0.217	-0.015
Length of the tassel		1	0.549**	0.199	-0.285*	0.117	-0.184
Number of spikelet in the tassel			1	0.331**	-0.360**	-0.056	**-0.420****
Number of grains in the tassel				1	0.652**	-0.195	**-0.381****
Number of grains in the spike					1	-0.221	-0.059
Grain yield per tassel						1	**0.716****
Grain yield kg/ha							1

**. Correlation is significant at the 0.01 level
*. Correlation is significant at the 0.05 level

Conclusion

Based on the results of the survey, the following important conclusions can be drawn:

Genotypes showed different average values for almost all of the analyzed components of the yield and based on the significance of the differences in the average values are divided into groups. Of all the genotypes cultivated in the Strumica region, with the highest average grain yield for the two years, are the varieties *Kupa* (3 850 kg/ha and 2 866 kg/ha) and *Istra* (3 600 kg/ha and 3 666 kg/ha).

The 11 varieties tested are divided into 3 clusters. The third cluster includes varieties *Kupa* and *Istra*, which are the most high-yielding compared with the rest of the group.

Through the analysis of the variance, it was determined that the genotype has the greatest influence on the following yield components: the number of spikelet in the tassel, the length of the tassel, the height of the plant and the grain yield per tassel.

A strong positive correlation exists between the grain yield per tassel and the grain yield per 1 ha (0.716).

From the distribution of the yield components and the grain yield in the factorial plane, we obtained that the yield can only be increased by selecting high-yielded tassels.

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