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

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**Abstract**


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

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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 car-
ry out research in this direction, and to obtain appropriate
knowledge about the reaction of the oat genotypes to the ap-
plied agro-technology.

Organic production in the Republic of Macedonia is de-
fin ed by the Law on organic production, which is in accord-
dance with the EU laws.

According to Lockeretz et al. (1981), oat is one of the
most suitable cereals for organic production. It is in accord-
dance 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 deter-
mine 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 variet-
ies 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,
Ekzplorer, 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 m².

The distance between the variants was 0,50 m, and be-
 tween repetitions 1 m. The distance between raw was 20 cm.
It was used sowing seed rate of 550 grains of 1 m². 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 regu-
lations 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 1m² for labora-
tory analysis is taken. In the laboratory the number of spike-
let in the tassel, the number of grains in the tassel, the num-
ber 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 us-
ing the variance analysis method, Fit analysis, cluster analy-
sis and Principal Component Analysis, with the JMP, SPSS
and Statgraf utility programs.

**Climate Conditions**

In the period of two-year trials, the meteorological indi-
cators 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 pe-
riod of ten years, is the month of October with an average of

<table>
<thead>
<tr>
<th>Year</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
<th>XI</th>
<th>XII</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>2.8</td>
<td>5.3</td>
<td>7.2</td>
<td>12.4</td>
<td>19.8</td>
<td>21.4</td>
<td>26.7</td>
<td>24.9</td>
<td>20.1</td>
<td>13.8</td>
<td>8.8</td>
<td>3</td>
</tr>
<tr>
<td>2016</td>
<td>1.4</td>
<td>9.4</td>
<td>9.5</td>
<td>15.5</td>
<td>16.9</td>
<td>23.5</td>
<td>25.5</td>
<td>24.2</td>
<td>19.1</td>
<td>13.4</td>
<td>7.2</td>
<td>1.3</td>
</tr>
<tr>
<td>2004/2014</td>
<td>2.4</td>
<td>4.1</td>
<td>8.8</td>
<td>13.5</td>
<td>18.2</td>
<td>22.4</td>
<td>25.1</td>
<td>24.9</td>
<td>19.4</td>
<td>12.6</td>
<td>7.8</td>
<td>3.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ann. amount of temp.</th>
<th>Average ann. temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>5052,2</td>
<td>13,8</td>
</tr>
<tr>
<td>5073,5</td>
<td>13,9</td>
</tr>
<tr>
<td>4927,5</td>
<td>13,5</td>
</tr>
</tbody>
</table>
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 – 116.7 cm, and the lowest variety Kupa – 78.3 cm, 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 – 143.3 cm. 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.

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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 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 (-0.345), between the number of spikes in the tassel and the number of grains in spikes (-0.360), between the number of spikes in tassel and yield (-0.420) and the number of grains in the tassel and yield (-0.381).

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
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 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

<table>
<thead>
<tr>
<th>Yield components</th>
<th>Plant height</th>
<th>Length of the tassel</th>
<th>Number of spikelet in the tassel</th>
<th>Number of grains in the tassel</th>
<th>Grain yield per tassel</th>
<th>Grain yield kg/ha</th>
<th>Genotype</th>
<th>The source of variation</th>
<th>The source of variation</th>
<th>The source of variation</th>
<th>The source of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genotype</td>
<td>MS</td>
<td>η</td>
<td>MS</td>
<td>η</td>
<td>MS</td>
<td>η</td>
<td>MS</td>
<td>η</td>
<td>MS</td>
<td>η</td>
<td>MS</td>
</tr>
<tr>
<td>Genotype</td>
<td>845.808***</td>
<td>62.56</td>
<td>4253.170***</td>
<td>31.46</td>
<td>80.847***</td>
<td>5.98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genotype</td>
<td>30.981***</td>
<td>68.75</td>
<td>92.182***</td>
<td>20.46</td>
<td>4.861***</td>
<td>10.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genotype</td>
<td>371.056***</td>
<td>69.23</td>
<td>761.601***</td>
<td>14.21</td>
<td>88.798*</td>
<td>16.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genotype</td>
<td>1256.671***</td>
<td>36.81</td>
<td>15634.085***</td>
<td>45.79</td>
<td>593.944*</td>
<td>17.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genotype</td>
<td>0.999***</td>
<td>11.94</td>
<td>6.810***</td>
<td>81.34</td>
<td>0.640**</td>
<td>7.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genotype</td>
<td>0.999***</td>
<td>57.04</td>
<td>3.274***</td>
<td>18.70</td>
<td>0.425***</td>
<td>24.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genotype</td>
<td>1849613.636***</td>
<td>75.68</td>
<td>945606.061***</td>
<td>3.87</td>
<td>499856.061***</td>
<td>20.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MS – mean squares; η – effect of factor

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

<table>
<thead>
<tr>
<th>Yield components</th>
<th>Plant height</th>
<th>Length of the tassel</th>
<th>Number of spikelet in the tassel</th>
<th>Number of grains in the tassel</th>
<th>Number of grains in the spike</th>
<th>Grain yield per tassel</th>
<th>Grain yield kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genotype</td>
<td>1</td>
<td>0.759**</td>
<td>0.342**</td>
<td>-0.080</td>
<td>-0.345**</td>
<td>0.217</td>
<td>-0.015</td>
</tr>
<tr>
<td>Genotype</td>
<td>1</td>
<td>0.549**</td>
<td>0.199</td>
<td>-0.285*</td>
<td>-0.056</td>
<td>-0.420**</td>
<td>-0.381**</td>
</tr>
<tr>
<td>Genotype</td>
<td>1</td>
<td>0.331**</td>
<td>0.652**</td>
<td>-0.195</td>
<td>-0.059</td>
<td>0.716**</td>
<td>1</td>
</tr>
</tbody>
</table>

**. 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.

References


Georgieva, T., 1995. Survey of the core units of winter oat growing technology. Abstract of the dissertation for obtaining the scientific degree Candidate for agricultural sciences, Higher Agricultural Institute – Plovdiv, Department of Plant Production.


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