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# COMPARATIVE ANALYSIS OF OATS QUALITY GROWN IN CONDITIONS OF ORGANIC PRODUCTION

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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*), three 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 for almost all analyzed yield components and according to the significance of the differences they are divided into groups. From all genotypes grown in the region of Strumica, the highest average grain yield, in both years of production, had varieties *Istra* and *Kupa* (3633 kg/ha and 3358 kg/ha).

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

There is a strong positive correlation between the grain yield per panicle 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 panicles with a high grain yield.

**Key words:** oats, organic production, yield, yield components

**Introduction.** Oats (*Avena sativa* L.) is a culture that is mainly grown for the grain.

Apart from the grain, the vegetative green mass, pure or in admixture with other plants, is used for feeding cattle [1].

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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 [2].

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 [3].

Today oatmeal is one of the most important crops in human nutrition, with increased demand in modern culinary and food technology.

According to the content of the fat in the grain (4–7%), the oats give place only to the corn. Among the cereals, oats are the richest source of minerals: Ca (57 mg/100 g grains), P (520 mg/100 g grains), K (384 mg/100 g grains) and Fe. It also contains vitamins B1, B2, B6, K1, E [4].

The increasing demand for oats in human nutrition is a consequence of the high biological value and nutritional components that oats contain. It contains soluble dietary fiber mainly β-glucans whose content varies from 2.5-6.5% [5]. The content of β-glucans in the grains of the oats acts to lower cholesterol in the blood, so modern dietologist s recommend dishes based on oatmeal [6].

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 [7], which is in accordance with the EU laws.

Oatmeal is one of the most suitable cereals for organic production [8].

Conducted studies with certain oat species in organic production [9], showed that oats are very suitable for organic production, taking into account the high yields they received, ranging from 4 to 5 t/ha. Similar results were obtained from another author [10], 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.

The purpose of our investigations 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, i.e. 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 analyses were carried out at the laboratories of the Faculty of Agriculture.

Eleven genotypes of oats have been analyzed, three of which are domestic populations: the population of *Krivogastani*, *Trebenista* and *Kuceviste*. The others are varieties introduced from Serbia and Croatia. Three varieties from Serbia were analyzed: 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 replications, distributed by the random block system method, with a dimension of the basic plot of 5 $m^2$.

The distance between the variants was 0.5 m, and between replications 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 35 cm. 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 plot, or to 30 plants of each variant, was measured.

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

Thirty plants of each plot were used for these analyses , i.e. 120 plants of each variant.

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

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

To determine the lowest significant difference (LSD) between examined genotypes for the yield components and grain yield, the software JMP has been used. According to the lowest significant difference between the average values, the genotypes are divided into four groups named a, b, c, d.

**Results and discussion.** Table 1 gives data on the yield of grain and the components of the yield of oats varieties in the period 2015–2016.

The results give reason to believe that the varieties *Istra* and *Kupa* are the highest yielding, having formed an average of 3633 kg/ha and 3358 kg/ha, for the two years, respectively. Moreover, it can be observed that the differences between the genotypes grown under the same conditions are due to the variety specificity, which is in accordance with the results of other authors [11].

Since the height of the plants in oats is negatively correlated with resistance to lodging [4], then the tested varieties with acceptable terms of selection are varieties *Kupa*, *Eksplorer*, *Trebenista* and *Istra*, whose height is less than 100 cm. Average for the period, varieties *Krivogashtani* and *Lovken* are with the longest panicle, 23.8 cm and 24.6 cm, respectively. The highest number of spikes in the panicle, on average for two years has *Rajac* variety and the greatest number of grains in a panicle varieties *Slavuj* (134.6), *Sampionka* (134.2) and *Rajac* (131.5). According to surveys of Georgieva [12], the number of spikes in panicle varies

T a b l e 1

Average grain yield and yield components of the tested oats genotypes for the period 2015–2016

| Varieties | Plant height (cm) | Panicle length (cm) | Number of spikelets in panicle | Number of grains in panicle | Number of grains in spike | Grain yield per panicle (g) | Grain yield per ha (kg) |
|---|---|---|---|---|---|---|---|
| *Krivogastani* | 130.0a | 23.8ab | 68.0abc | 118.8a | 1.7a | 1.9ab | 2488bc |
| *Trebenista* | 94.7ab | 18.3cd | 75.1ab | 124.2a | 1.5a | 1.3b | 2175c |
| *Kuceviste* | 100.4ab | 17.7cd | 74.9ab | 100.8a | 1.2a | 1.2b | 1833c |
| *Rajac* | 101.8ab | 19.3a-d | 80.4a | 131.5a | 1.5a | 1.8ab | 2475bc |
| *Slavuj* | 105.0ab | 20.8abc | 75.5ab | 134.6a | 1.6a | 1.6b | 2267c |
| *Lovken* | 110.4ab | 24.6a | 77.7a | 113.7a | 1.4a | 1.7b | 2392c |
| *Kupa* | 80.8ab | 14.9d | 54.7c | 80.0a | 1.4a | 2.0ab | 3358ab |
| *Baranja* | 116.7ab | 19.0bcd | 65.7abc | 115.4a | 1.7a | 1.8b | 2008c |
| *Eksplorer* | 93.7ab | 17.9cd | 67.8abc | 115.5a | 1.5a | 1.5b | 2292c |
| *Sampionka* | 104.2ab | 20.3a-d | 77.3ab | 134.2a | 1.6a | 1.5b | 2000c |
| *Istra* | 97.4ab | 17.5c-d | 61.5bc | 106.9a | 1.6a | 2.8a | 3633a |
| Average | 103.2 | 19.5 | 70.8 | 116.0 | 1.5 | 1.7 | 2447.3 |
| LSD | 38.85 | 5.54 | 16.08 | 92.93 | 1.08 | 1.06 | 932.67 |
| VC% | 17.11 | 12.96 | 10.33 | 41.07 | 31.80 | 28.1 | 17.33 |

in a narrow range – 19.98 at the variant treated with combination $N_0$; 20.57 at combination $N_6$; 21.06 at $N_{12}$ and 22.25 at combination $N_{18}$.

The best indicator of fertility of oats varieties is the number of grains in panicle and and shorter stem [13].

Varieties *Krivogastani* and *Baranja* have the most grains in the spikes (1.7). According to the number of grains in the spikes, all examined varieties belong to the group **a** and based on the set LSD values.

The heaviest panicle, average for the period, has formed variety *Istra* (2.8 g). According to the grain yield per panicle the variety *Istra* belongs to the group **a** and based on the set LSD values.

Table 2 presents the results of the analysis of variance and factor strength ($\eta$) 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 spikelets in the panicle, the length of the panicle, the height of the plant and the grain yield per panicle. The year has a decisive role in the formation of the number of grains in the spike, and hence the number of grains in the panicle.

T a b l e 2

Analysis of 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 | $\eta$ | MS | $\eta$ | MS | $\eta$ |
| Plant height | 845.808$^{***}$ | 62.56 | 4253.170$^{***}$ | 31.46 | 80.847$^{***}$ | 5.98 |
| Length of the panicle | 30.981$^{***}$ | 68.75 | 92.182$^{***}$ | 20.46 | 4.861$^{**}$ | 10.79 |
| Number of spikelets in the panicle | 371.056$^{***}$ | 69.23 | 761.601$^{***}$ | 14.21 | 88.798$^{*}$ | 16.56 |
| Number of grains in the panicle | 1256.671$^{***}$ | 36.81 | 15634.085$^{***}$ | 45.79 | 593.944$^{*}$ | 17.40 |
| Number of grains in the spike | 0.092$^{***}$ | 11.01 | 6.810$^{***}$ | 81.34 | 0.640$^{**}$ | 7.65 |
| Grain yield per panicle | 0.999$^{***}$ | 57.04 | 3.274$^{***}$ | 18.70 | 0.425$^{***}$ | 24.26 |
| Grain yield | 1849613.636$^{***}$ | 75.68 | 945606.061$^{***}$ | 3.87 | 499856.061$^{***}$ | 20.45 |

MS – mean squares; $\eta$ – effect of factor (%)

$^{*}$significant at the 0.05 level; $^{**}$significant at the 0.01 level; $^{***}$significant at the 0.1 level

T a b l e 3

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

| Yield components | Plant height | Panicle length | Number of spikelets in panicle | Number of grains in panicle | Number of grains in spike | Grain yield per panicle | Grain yield kg/ha |
|---|---|---|---|---|---|---|---|
| Plant height | 1 | 0.759$^{**}$ | 0.342$^{**}$ | −0.080 | −0.345$^{**}$ | 0.217 | −0.015 |
| Panicle length | | 1 | 0.549$^{**}$ | 0.199 | −0.285$^{*}$ | 0.117 | −0.184 |
| Number of spikelet in panicle | | | 1 | 0.331$^{**}$ | −0.360$^{**}$ | −0.056 | −0.420$^{**}$ |
| Number of grains in panicle | | | | 1 | 0.652$^{**}$ | −0.195 | −0.381$^{**}$ |
| Number of grains in spike | | | | | 1 | −0.221 | −0.059 |
| Grain yield per panicle | | | | | | 1 | 0.716$^{**}$ |
| Grain yield kg/ha | | | | | | | 1 |

$^{*}$Correlation is significant at the 0.05 level

$^{**}$Correlation is significant at the 0.01 level

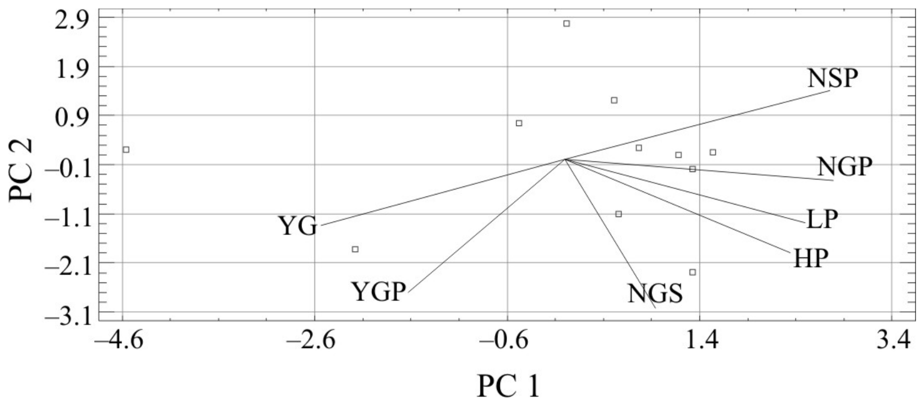


Fig. 1. Scatter-plot of genotypes according to the yield components and grain

The degree of connection of the components of yield and grain yield in tested oat genotypes is given in Table 3, made through correlation coefficients. The coefficient of correlation actually determines the direction and strength of the relationship between the yield components and the grain yield in the tested genotypes.

A high positive correlation well-proven (0.759) exists between the height of the plants and the length of the panicle. A high positive correlation is found between the number of grains in the panicle and the number of grains in the spike (0.652), as well as between the length of the panicle and the number of spikelets in the panicle (0.549). A strong positive correlation exists between the grain yield per panicle and the grain yield per ha (0.716).

Also, median negative correlations between the height of the plants and the number of grains in the spikes (−0.345), between the number of the spikes in the panicle and the number of grains in the spikelet (−0.360), between the number of the spikelets in the panicle and the grain yield per ha (−0.420) and number of grains in panicle and grain yield per panicle (−0.381), are established.

For better visualization of the investigated genotypes in terms of yield components and grain yield, a scatter plot in a factorial plane is made (Fig. 1).

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 1 shows that the yield vector forms an acute angle with the vector of the grain yield per panicle. This means that the variation in yield for the tested varieties is determined by the grain yield per panicle. 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 panicle 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 panicles.

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

1. 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* and *Istra* (3358 and 3633 kg/ha).

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

3. A strong positive correlation exists between the grain yield per panicle 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 panicles.

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