The effect of N fertilization and sowing density on the first-class grain contents in two-rowed spring barley

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Abstract
Grain sorting is the most important barley quality criterion. According to EBC regulations, barley is categorized by sorting into three classes, depending on grain thickness (I class: >2.5 mm, II class: from 2.2 to 2.5 mm and III class <2.2 mm). Good-quality malting barley should have 90% and more I-class grain. The objective of this study was to examine the first-class grain percentage in five spring barley cultivars grown at three different sowing densities (300, 400 and 500 germinating seeds m⁻²) and three nitrogen (N) fertilization rates (50, 80 and 110 kg N ha⁻¹) during three vegetation seasons (2003-2005). The highest first-class grain percentage was recorded with the 300 seeds m⁻² density. The increasing N rates induced reduction in the first-class grain percentage. A highly significant difference was recorded between the highest N rate in relation to control without topdressing (50 kg N ha⁻¹) and treatment with totally 80 kg N ha⁻¹.

Key words: cultivars, spring barley, N nutrition, sowing density, first-class grain percentage.

Introduction
The barley (Hordeum sativum Jessen) is among the most important field crops. As regards its world acreage, it ranks fourth, after wheat, rice and maize. In 2008, barley was cultivated on 92,469 ha in the Republic of Serbia. The two-row barley subspecies (Hordeum sativum Jessen ssp. distichum L.) serves as a basic raw material for malt and beer industries. Adequate technology of cultivar production should be applied in order to obtain good-quality raw material.

The use of nitrogen (N) is a serious issue in malting barley production. N is uptaken by barley plant until several days prior to moisture reduction in the kernel to 14%. There is a risk of stem elongation resulting from abundant N nutrition, which frequently leads to crop lodging. Lodging induces protein accumulation in the kernel, which is unsuitable for beer industry (Malesevic et al, 1992). Namely, apart from directly inducing an increase in the protein content of the kernel, N has a much higher indirect effect, by leading to increases in protein content through lodging. Therefore, an optimal N rate to be applied in barley nutrition should be defined (Veigh K. R., Rajkai, K, 2006, Paunovic et al, 2007).

Sowing density (number of germinating seeds m⁻²) affects not only yield but also yield quality. Increasing sowing density inevitably leads to an increasing spike number, as opposed to decreasing sowing density inducing tillering that is highly pronounced in barley. The increased stem and spike numbers are a burden to a single plant that might not be able to provide nutrition to all of its kernels. This is being reflected through a higher percentage of smaller kernels and uneven ripeness due to prolonged tillering. Small kernels have a low accumulation of starch and extract and higher protein content, which is not suitable for beer industry (Madic et al., 2006).
Material and methods

The experimental research was conducted over a three-year period (2003, 2004 and 2005) on five two-rowed spring barley cultivars (Kraguj, Dinarac, Dunavac, Jastrebac and Novosadski 294) at the trial field of the Small Grains Research Institute in Kragujevac (Sumadija region of Central Serbia). Three sowing densities (SD: 300, 400 and 500 germinating seeds m$^{-2}$) and three N fertilization rates (50, 80 and 110 kg N ha$^{-1}$) were applied in four replicates (the experimental plot = 5.0 m$^{2}$). Identical NPK fertilizer rates (kg ha$^{-1}$: 50 N + 50 P$_2$O$_5$ + 50 K$_2$O) were applied in the autumn/winter of the previous year. Spring barley was sown at optimal sowing dates. The remaining amount of N was distributed by topdressing (0, 30 and 60 kg N ha$^{-1}$) in April-May. Content first-class grain consolidate with Steincker electrical apparatus for kernel sort. The data were analysed by ANOVA, F test and LSD test use of standard computer program (Microsoft excel 5.0.).

Results and discussion

The highest and lowest average percentage of the first-class kernel in the first year of study was determined in cv. Kraguj (93.03 %) and cv. Jastrebac (89.33 %), respectively. The testing of the significance of differences in the cultivars examined showed that the first-class kernel percentage was highly significantly greater in cv. Kraguj than in cv. Jastrebac. The Novosadski 294 and Dunavac cultivars produced a considerably higher percentage of the first-class kernel as compared to cv. Jastrebac. Other differences were not statistically significant.

The analysis of the effect of sowing density on the first-class grain percentage in the first year of study suggested that the highest first-class grain percentage was obtained by the 300 seeds m$^{-2}$ density. There was a highly significantly greater percentage of larger grains at the 300 seeds m$^{-2}$ density as compared to the other sowing densities. The difference between the densities of 400 and 500 seeds m$^{-2}$ was not statistically justified. The increasing N rates induced a reduction in the first-class grain percentage. The differences in first-class grain percentage between the 60 (110) kg N ha$^{-1}$ rate and the control and 30 (80) kg N ha$^{-1}$ rates was highly significant, whereas the difference between the control and the 30 kg N ha$^{-1}$ rate was statistically significant.

In the second year of study, the highest and the lowest average percentages of the first-class grain were recorded in cv. Dunavac (90.1 %) and cv. Kraguj (87.9 %), respectively. The difference between the cvs. Dunavac and Kraguj was significant. Other differences in the first-class grain percentage between the cultivars studied were not statistically justified. The sowing density of 300 seeds m$^{-2}$ gave the highest first-class grain percentage on average, as opposed to the 500 seeds m$^{-2}$ density yielding the lowest percentage. The difference between the stated densities was highly significant. Other sowing densities did not exhibit any significant differences.

The effect of increasing N (topdressing) rates in the second year of study induced decreases in the first-class grain percentage. A highly significant difference was determined between the highest N rate and both the control and the 30(80) kg N ha$^{-1}$ rate. There were no significant differences between the control and the latter treatment.

In the third year of study, the highest first-class grain percentage on average was recorded with the cultivar Novosadski 294 (88.9 %), the lowest being determined with the cv. Jastrebac (80.6 %).

An analysis of variance of the average first-class grain percentage in the cultivars examined revealed highly significant differences. Testing of individual differences by Lsd test showed that cv. Novosadski 294 had a highly significantly greater percentage of the
first-class grain as compared to the cvs. Kraguj, Dunavac and Jastrebac. The difference between the cv. Novosadski 294 and cv. Dinarac was significant.

Table 1. The effects of cultivar (A), sowing density (B) and N fertilization (C) on the first-class grain percentage in spring barley over a 3-year period

| Cult. | SD | 2003 | 2004 | 2005 | Mean | 2003 | 2004 | 2005 | Mean | 2003 | 2004 | 2005 | Mean |
|-------|----|------|------|------|------|------|------|------|------|------|------|------|------|------|
|       |     | C (kg N ha\(^{-1}\)) | Mean | C (kg N ha\(^{-1}\)) | Mean | C (kg N ha\(^{-1}\)) | Mean |
| A1    | 50  | 94.3 | 93.2 | 91.7 | 93.0 | 88.9 | 88.6 | 86.1 | 87.9 | 87.3 | 83.8 | 80.3 | 83.8 |
| A2    | 80  | 92.5 | 90.8 | 88.8 | 90.7 | 91.4 | 90.7 | 85.6 | 89.2 | 90.5 | 88.1 | 81.4 | 86.7 |
| A3    | 110 | 94.7 | 92.8 | 88.4 | 92.0 | 92.3 | 90.7 | 87.3 | 90.1 | 85.5 | 86.7 | 83.0 | 85.1 |
| A4    | 50  | 92.5 | 89.6 | 85.9 | 89.3 | 92.8 | 92.0 | 80.3 | 88.4 | 82.6 | 80.6 | 78.6 | 80.6 |
| A5    | 80  | 94.8 | 93.1 | 90.3 | 92.7 | 92.6 | 90.1 | 86.0 | 89.5 | 90.7 | 88.8 | 87.1 | 88.9 |
| Mean  | 93.8| 91.9 | 90.0 | 91.6 | 90.4 | 85.0 | 87.3 | 85.6 | 82.1 |

Statistical analysis (Lsd)

<table>
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<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>AB</th>
<th>AC</th>
<th>BC</th>
<th>ABC</th>
</tr>
</thead>
<tbody>
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<td>LSD 5%</td>
<td>2.2</td>
<td>1.7</td>
<td>1.7</td>
<td>3.8</td>
<td>3.8</td>
<td>4.3</td>
</tr>
<tr>
<td>LSD 1%</td>
<td>2.9</td>
<td>2.2</td>
<td>2.2</td>
<td>5.0</td>
<td>5.0</td>
<td>5.7</td>
</tr>
</tbody>
</table>

*C (kg N ha\(^{-1}\)): 50 kg N ha\(^{-1}\) + 0/control variant/ = 50 kg N ha\(^{-1}\); 50 kg N ha\(^{-1}\) + 30kg N ha\(^{-1}\) = 80 kg N ha\(^{-1}\); 50 kg N ha\(^{-1}\) + 60 kg N ha\(^{-1}\) = 110 kg N ha\(^{-1}\)

A highly significant effect of sowing density on the first-class grain percentage was also registered in this year. The highest large grain percentage again was recorded at the lowest sowing density. This was used to determine the highly significant difference in the first-class grain percentage between the lowest and the highest densities, whereas the differences between the other densities were significant.

Topdressing of barley with different N rates induced highly significant differences between the highest N rate and the other ones, the difference between the 30 kg N ha\(^{-1}\) rate and the control being statistically significant (Madic et al., 2006, Paunovic et al., 2007).

Conclusions

The investigation suggested that the highest first-class grain percentage on average was determined in cv. Novosadski 294 (90.4 %), followed by cvs. Dunavac (89.1 %), Dinarac (88.8 %), Kraguj (88.2 %) and Jastrebac (86.1 %). Decreasing sowing densities in all three research years resulted in increasing first-class grain percentage. The highest percentage of large grains was determined at the lowest density of 300 grains m\(^{-2}\). Increased N rates in barley nutrition (50, 80 and 110 kg N ha\(^{-1}\)) induced the highest first-class grain percentage to be produced at the lowest N rate (50 kg N ha\(^{-1}\)) in the tested barley cultivars.
References


