

The Effect of Nitrogen Nutrition and Sowing Density on the Proportion of Class I Grains in Malting Barley

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Abstract: Grain classification is the most important barley quality criterion. According to EBC regulations, barley is classified into three classes, depending on grain thickness (Class I: >2.5 mm, Class II: from 2.2 to 2.5 mm and Class III <2.2 mm). High-quality malting barley should have at least 90 % of Class I grains. The objective of this study was to examine the proportion of Class I grains in five spring barley cultivars grown at three different sowing densities (300, 400 and 500 germinating seeds m⁻²) and three N fertilization rates (50, 80 and 100 kg N ha⁻¹) during three growing seasons. The highest proportion of Class I grains was obtained at a density of 300 seeds m⁻² in all years of study. Increasing N rates induced a reduction in the proportion of Class I grains. A highly significant difference was observed between the highest N rate and the control without topdressing (50 kg N ha⁻¹) and the treatment with 80 kg N ha⁻¹.

Key words: malting barley, nitrogen nutrition, sowing density, proportion of Class I grains

Introduction

Barley (*Hordeum sativum* Jessen) is among most important field crops. In terms of global 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 the malting and beer industry. Adequate technology of cultivar production should be applied in order to obtain high-quality raw material.

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

Sowing density (number of germinating seeds m^{-2}) affects not only yield but also yield quality. Increasing sowing density inevitably results in a higher spike number, as opposed to decreasing sowing density inducing tillering that is highly intensified 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 grains. This is being reflected through a higher proportion of smaller grains and uneven ripeness due to prolonged tillering. Small grains have a low accumulation of starch and extract and a higher protein content not suitable for beer industry (Madić *et al.* 2006).

Material and Methods

A research on five two-rowed spring barley cultivars (*Kraguj*, *Dinarac*, *Dunavac*, *Jastrebac* and *Novosadski 294*) was conducted at the experimental field of the Small Grains Research Institute in Kragujevac (Šumadija region of Central Serbia) over a three-year period (1996, 1997 and 1998). 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 basic plot = 5.0 m^{-2}). Identical NPK fertilizer rates (kg ha^{-1} : 50 N + 50 P_2O_5 + 50 K_2O) were applied in the autumn/winter of the previous year. 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.

Results and Discussion

The highest and lowest average proportions of Class I grains in the first year of study were determined in cv. Kraguj (93.0 %) and cv. Jastrebac (89.3 %), respectively.

The testing of the significance of differences in the cultivars showed that the proportion of Class I grains was highly significantly greater in cv. Kraguj than in cv. Jastrebac. The Novosadski 294 and Dunavac cultivars gave a considerably higher proportion of Class I grains as compared to cv. Jastrebac. Other differences were not statistically significant.

Tab. 1. The effects of cultivar (A), sowing density (B) and N fertilization (C) on the proportion of Class I grains in spring barley over a 3-year period

Proportion of Class I grains: effects of sowing density m ⁻² (SD), fertilization (N=kg N ha ⁻¹) and barley cultivar (Kraguj=A1, Dinarac=A2, Dunavac=A3, Jastrebac=A4 and NS-294=A5)														
Cult.	SD	1996			Mean	1997			Mean	1998			Mean	
		C (kg N ha ⁻¹)				C (kg N ha ⁻¹)				C (kg N ha ⁻¹)				
		50	80	110		50	80	110		50	80	110		
Two-row spring barley: proportion of Class I grains														
Interaction AC				A	Interaction AC				A	Interaction AC				A
A1		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		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		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		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		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 C		93.8	91.9	90.0		91.6	90.4	85.0		87.3	85.6	82.1		
Interaction BC				B	Interaction BC				B	Interaction BC				B
	300	95.9	95.2	91.4	94.2	93.0	92.5	87.6	91.0	90.2	87.6	83.4	87.1	
	400	93.3	91.3	87.4	90.7	91.4	90.4	87.0	89.6	86.1	85.6	83.2	85.0	
	500	92.1	89.3	85.5	88.9	89.9	88.9	85.9	88.2	86.2	83.1	79.6	83.0	
Statistical analysis (LSD)														
		A	B	C		AB	AC	BC		ABC				
	LSD 5%	2.2	1.7	1.7		3.8	3.8	4.3		6.5				
	LSD 1%	2.9	2.2	2.2		5.0	5.0	5.7		8.6				
*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														

The analysis of the effect of sowing density on the proportion of Class I grains in the first year of study suggested that the highest proportion was obtained under the 300 seeds m⁻² density applied. There was a highly significantly greater proportion of larger grains at a density of 300 seeds m⁻² as compared to the other sowing densities used. The difference between the densities of 400 and 500 seeds m⁻² was not statistically significant. The increasing nitrogen rates induced a reduction in the proportion of Class I grains. The difference in the proportion of Class I grains 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 (Knežević *et al.* 2007).

In the second year of study, the highest and the lowest average proportions of Class I grains were recorded in cv. Dunavac (90.1 %) and cv. Kraguj (87.9 %), respectively. The difference between cvs. Dunavac and Kraguj was significant. Other differences in the proportion of Class I grains between the cultivars studied were not statistically significant. The sowing density of 300

seeds m^{-2} gave the highest proportion of Class I grains on average, as opposed to the 500 seeds m^{-2} density yielding the lowest proportion. The difference between the stated densities was highly significant. Other sowing densities did not exhibit any significant differences (Paunović *et al.* 2006).

The effect of increasing nitrogen (topdressing) rates in the second year of study induced decreases in the proportion of Class I grains. A highly significant difference was determined between the highest nitrogen 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 average proportion of Class I grains was found in cv. Novosadski 294 (88.9 %), and the lowest in cv. Jastrebac (80.6 %) (Paunović *et al.* 2007).

An analysis of variance of the average proportion of Class I grains in the studied cultivars revealed highly significant differences. Testing of individual differences by Lsd test showed that cv. Novosadski 294 had a highly significantly greater proportion of Class I grains as compared to cvs. Kraguj, Dunavac and Jastrebac. The difference between cv. Novosadski 294 and cv. Dinarac was significant.

A highly significant effect of sowing density on the proportion of Class I grains was also reported in this year. The highest proportion of large grains was obtained at the lowest sowing density. This was used to determine the highly significant difference in the proportion of Class I grains between the lowest and the highest densities, whereas the differences between the other densities were significant.

Topdressing of barley with different nitrogen rates induced highly significant differences between the highest nitrogen rate and the other ones, the difference between the 30 kg N ha^{-1} rate and the control being statistically significant.

Conclusions

The investigation suggested that the highest average proportion of Class I grains was determined in cv. Novosadski 294 (90.4 %), followed by cvs. Dunavac (89.1 %), Dinarac (88.89 %), Kraguj (88.2 %) and Jastrebac (86.1 %). Decreasing sowing densities in all three years of observation resulted in an increasing proportion of Class I grains. The highest proportion of large grains was determined at the lowest density of 300 grains m^{-2} . As for the nitrogen rates applied in barley nutrition (50, 80 and 110 kg N ha^{-1}), the highest proportion of Class I grains was produced at the lowest nitrogen rate (50 kg N ha^{-1}) in all cultivars.

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UTICAJ MINERALNE ISHRANE AZOTOM I GUSTINE SETVE NA UDEO ZRNA PRVE KLASKE KOD PIVARSKOG JEČMA

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Rezime

Kvalitet zrna pivarskog ječma za proizvodnju slada definišu sledeći parametri: što veći procenat krupnih i ujednačenih zrna koja će ujednačeno klijati, visok procenat klijavosti i energije klijanja. Prema propisima EBC, sortiranjem se ječam deli na tri klase na osnovu debljine zrna, i to: I klasa ima debljinu preko 2,5 mm, II klasa od 2,2 do 2,5 mm i III klasa ispod 2,2 mm. Dobar pivarski ječam mora sadržati najmanje 90% zrna I klase. Za proizvodnju slada upotrebljava se samo ječam I i II klase. Cilj istraživanja predstavlja ispitivanje sadržaja zrna prve klase kod pet sorti jarog pivarskog ječma uzgajanih pri tri različite gustine setve (300, 400 i 500 zrna m⁻²) i tri doze đubrenja azotom (50, 80 i 110 kg N ha⁻¹) tokom tri godine. Analiza uticaja gustine setve na sadržaj zrna prve klase pokazala je visoko značajne razlike između gustine od 300 zrna m⁻² u odnosu na 400 i 500 zrna m⁻². Pri gustini od 300 zrna m⁻² utvrđen je najveći sadržaj zrna prve klase u svim godinama ispitivanja. Rastuće količine azota uticale su na smanjivanje udela zrna prve klase. Utvrđena je visoko značajna razlika između tretmana s najvišom dozom N u odnosu na kontrolnu varijantu bez prihrane (50 kg N ha⁻¹) i varijantu s ukupno 80 kg N ha⁻¹, dok je razlika između ove varijante i kontrole bila statistički značajna.