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Original scientific paper

PRODUCTION CHARACTERISTICS OF DIFFERENT MALTING BARLEY GENOTYPES IN INTENSIVE NITROGEN FERTILIZATION

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Malešević M., Đ. Glamočlija, N. Pržulj, V.Popović, S.Stanković, T. Živanović and A. Taparanova (2010): *Production characteristics of different malting barley genotypes in intensive nitrogen fertilization*.- Genetika, Vol 42, No. 2, 323 -330.
Two-year trials have been conducted in Technological Research Center in Zaječar. Research objects were six malting barley genotypes. The experimental crop was top dressed with the following amounts of nitrogen: 40, 60, 80 and 100 kg ha^{-1}. The control variant was not top dressed. The obtained results showed that the genotypes reacted significantly to the increased amounts of nitrogen by changing their production characteristics and seed quality. In addition, the genotypes demonstrated certain varietal

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differences. A new genotype, Premijum, was highest yielding and it had the lowest total proteins in the grain. The genotype NS-525 had the highest 1000-grain weight (46.8 g). The effect of nitrogen on the studied characteristics depended on N quantity applied. Increasing amounts of nitrogen decrease positive effects on spike length, number of grains per spike, 1000-grain weight and yield. However, the protein content in grain kept increasing to the highest nitrogen dose, which lowered the quality of malting barley. The highest yield was obtained by applying 80 and 100 kg ha^{-1} of nitrogen, depending on the year of study.

Key words: genotype, malting barley, nitrogen fertilization, morphological characteristic, yield, grain quality.

INTRODUCTION

Barley is a prospective small grain, especially from the standpoint of climate changes that have affected our planet, including the agricultural regions of Serbia. To be good raw material for beer industry, barley grains should be balanced uniform in size, with the absolute weight over 40 grams and with the total protein below 12%. For growers, grain yield per unit area is as important as grain quality. Barley yield can be increased by balanced nitrogen nutrition, but it can also significantly reduce seed quality due to increased protein content (GLAMOČLIJA *et al*., 1998). Quantitative characteristics of barley have been the topic of numerous studies (PRŽULJ *et al., 1998, 2002, 2005;* MOMČILOVIĆ, PRŽULJ*, 2005, 2008;* PAGOLA *et al., 2008;* NINKOV *et al., 2009*). According to previous studies, barley genotypes respond differently to increased nutrition (MAKSIMOVIĆ *et al*., 2000). Intensive nitrogen nutrition reduces grain quality and it causes other problems. The fact that mineral nutrition is an important factor in the total costs of barley production raises the question of cost-effective use of mineral fertilizers (BOOKER *et al.,* 2007). Another issue is excess nitrogen ions that plants do not use and which remain as a potential source of contamination of the entire ecosystem (SOARES and LEWIS, 1986).
The objectives of this study was to examine the productive characteristics of two newly created barley lines and compare their performance against those of the genotypes currently grown in the region of Timočka Krajina.

MATERIALS AND METHODS

The trials were carried out on the farm of Technological Research Center in Zaječar, under the agroecological conditions of the region of Timočka Krajina. The type of soil was the limeless smonitza soil which, according to agrochemical analyses, has a weak acid reaction (pH 5.80), is medium provided with phosphorous (P_2O_5 - 17.5%) and potassium (K_2O - 29.9%), poor with nitrogen (N_2O - 0.12%) rich in humus (3.08%), but deficient in calcium.

The research object were genotypes of winter malting barley *Kristal* (G_1), *Premijum* (G_2), *NS-519* (G_3), *NS-525* (G_4) and two lines, *ZA-82/1* (G_5) and *ZA-12/1* (G_6). The control variant (N_0) was not top dressed. The top dressing was performed in March, using ammonium nitrate, applying the following quantities of nitrogen: 40, 60, 80 and 100 kg ha^{-1} (variants N_1, N_2, N_3 and N_4). In the two years, the amounts of rainfall were 665 mm and 672 mm. These levels were higher by 9% and 15% than the long-term average (586 mm) (Fig. 1).

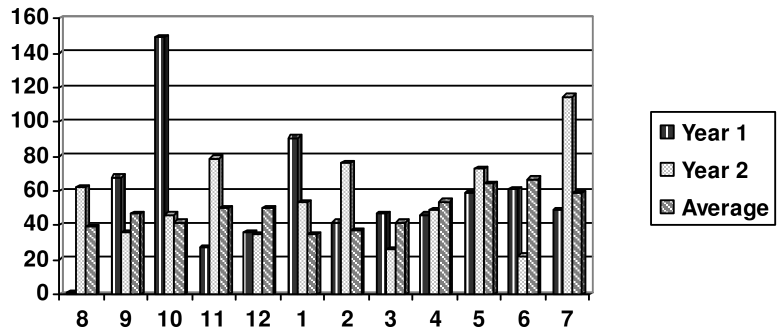

Fig. 1. Monthly rainfall, mm (Zaječar)

In the first year of study, the total rainfall and distribution per barley phenophases were more favorable than in the second year. Because of the heavy rainfall in October, barley sowing was performed at the end of the month, but the subsequent thermal regime favored the pre-winter development of plants. The low amounts of rainfall in April and May did not affect barley development, i.e., the genotypes showed satisfactory tolerance to drought. In the second year, the dry period that copincided with the highest barley requirement for water affected more the vegetative growth of plants than grain yield. In the first year, the monthly temperature distribution during barley growing season was within the limits of the long-term average for the region of Timočka Krajina. In second year, the temperature conditions were less favorable. In February, there occurred a period of low temperatures, with frosts below –18^{0}C. As the crops were under thick snow blanket, there was no excessive winterkill (Table 1).

Table 1. Mean monthly air temperatures, ^{0}C (Zaječar)

Month	10	11	12	1	2	3	4	5	6
2003/2004	9	7	1	-2	2	7	12	15	20
2004/2005	12	7	2	1	-3	4	11	17	17
1976-2006	10	5	1	-1	1	5	11	17	20

RESULTS

The average spike length in both years showed considerable dependence on the genotype and the amount of top dressed nitrogen (Table 2).

Table 2. Spike length, cm

Genotype	2003/4						2004/5						
	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	$\overline{X}$
G_1	8.7	9.6	10.5	10.6	10.7	10.0	7.7	8.5	8.6	9.1	9.5	8.7	9.6
G_2	8.7	9.8	10.6	10.9	10.9	10.2	7.4	8.4	9.0	9.4	9.4	8.8	9.0
G_3	8.7	10.2	10.8	11.4	11.2	10.5	7.8	9.2	9.8	10.2	10.5	9.5	10.0
G_4	8.3	9.8	10.5	10.9	10.9	10.1	7.7	8.6	9.2	9.4	9.4	8.9	9.5
G_5	8.5	10.0	10.6	10.8	10.7	10.1	7.9	8.6	9.2	9.4	9.4	8.9	9.5
G_6	9.3	10.2	11.3	11.7	11.9	10.9	8.0	9.2	10.0	10.4	10.3	9.6	10.3
Average	8.7	9.9	10.7	11.1	11.1	10.3	7.8	8.8	9.3	9.7	9.8	9.1	9.7

Characteristic	Test	2002/3			2002/3		
		Genotype	Nitrogen	A x B	Genotype	Nitrogen	A x B
	F test	*	**	NS	**	**	*
Spike	LSD 5%	0.4380	0.4121	1.0175	0.2330	0.1820	0.4695
length	1%	0.6229	0.5425	1.3709	0.3314	0.2395	0.6367

Table 3. Number of grains per spike

Genotype	2003/4						2004/5						
	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	$\overline{X}$
G_1	18.1	25.9	28.1	28.7	29.8	26.1	17.6	22.1	25.5	25.9	26.1	23.4	24.8
G_2	21.3	25.6	28.5	29.1	29.9	26.9	20.3	23.0	25.6	26.5	26.4	24.3	25.6
G_3	20.7	25.4	27.8	28.4	29.1	26.3	21.6	21.9	24.2	25.0	25.9	23.7	25.0
G_4	22.7	24.8	28.2	29.0	29.7	21.7	21.6	21.9	24.2	25.0	25.9	23.7	22.7
G_5	23.1	25.1	27.9	29.0	29.4	26.9	20.5	21.4	24.6	26.1	26.4	23.8	25.4
G_6	20.7	25.6	28.3	29.7	29.5	26.8	20.6	23.2	25.9	26.3	26.4	24.5	25.6
Average	21.1	25.4	28.1	29.0	29.6	26.6	20.4	22.3	25.0	25.8	26.2	23.9	25.3

Characteristic	Test	2002/3			2002/3		
		Genotype	Nitrogen	A x B	Genotype	Nitrogen	A x B
	F test	NS	**	NS	**	**	*
Number	LSD 5%	1.4599	0.7903	2.3102	0.5941	0.6278	1.5164
of grains	1%	2.0764	1.0403	3.1771	0.8451	0.8263	2.0358

On average, spike length varied from 9.0 cm (*Premijum*) to 10.3 cm (ZA-12 / 1). The nitrogen fertilizer increased the length of the spike by about 22%, while the favorable weather conditions in the first year increased the spike length by 13%.The number of grains per spike depended on the amount of nitrogen in both years, and the genotype affected this characteristic only in the second year (Table 3).The weight of 1000 grains, on the overall average, was over 45 g and it fully met the requirements of the beer industry (Table 4).

Table 4. 1000 grain weight, g

Genotype	2003/4						2004/5						
	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	$\overline{X}$
G_1	40.0	43.5	44.7	45.9	46.0	44.0	41.1	44.5	46.2	46.7	47.1	45.1	44.6
G_2	40.7	41.4	43.4	43.9	43.9	42.6	41.6	43.8	45.3	45.7	46.0	44.5	43.6
G_3	40.6	44.5	46.0	47.3	47.1	45.1	45.7	46.5	48.1	49.5	49.7	47.9	46.5
G_4	40.0	44.8	47.7	47.1	48.2	45.6	41.1	47.2	49.3	50.7	51.8	48.0	46.8
G_5	40.7	43.3	44.4	44.9	45.5	43.8	42.1	46.7	48.0	49.1	49.5	47.1	45.5
G_6	41.2	42.3	43.6	44.1	44.4	43.1	41.2	44.0	46.2	46.4	46.7	44.9	44.0
Average	40.5	43.3	45.0	45.6	45.9	44.0	42.1	45.5	47.2	48.0	48.5	46.3	45.1

Characteristic	Test	2002/3			2002/3		
		Genotype	Nitrogen	A x B	Genotype	Nitrogen	A x B
	F test	**	**	**	**	**	*
1000-grain	LSD 5%	0.4558	0.5602	1.3223	0.9658	0.8543	2.1376
weight	1%	0.6483	0.7374	1.7679	1.3737	1.1246	2.8861

Table 5. Grain yield, kg ha^{-1}

Genotype	2003/4						2004/5						
	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	$\overline{X}$
G1	2843	6740	6603	6957	7007	6030	2960	5997	5913	6747	6920	5707	5869
G2	2723	6860	6840	7026	6987	6087	2493	6033	6410	6593	6773	5661	5874
G3	2913	6580	6933	6690	7033	6030	2760	5853	6247	6747	6807	5683	5857
G4	3037	6480	6893	6763	6940	6023	2587	6027	6443	6657	6640	5671	5847
G5	3277	5970	6380	6753	6720	5820	3027	5753	6147	6267	6530	5545	5682
G6	2713	6160	6207	6467	6717	5653	2247	6003	6213	6503	6643	5522	5588
Average	2918	6465	6643	6776	6901	5941	2679	5944	6229	6586	6719	5632	5787

Characteristic	Test	2002/3			2002/3		
		Genotype	Nitrogen	A x B	Genotype	Nitrogen	A x B
	F test	**	**	**	NS	**	*
Grain	LSD 5%	187.9025	153.7270	391.8559	204.4150	171.2480	433.9645
yield	1%	267.2635	202.3549	530.5117	290.7501	225.4183	587.0250

Largest grains were found in the genotype *NS-525* (46.8 g), smallest in the genotype *Premijum* (43.6 g). Differences between individual treatments were highly significant.

Nitrogen fertilizers significantly affected seed size. However, the increases above 80 kg/ha^{-1} had no effect on the weight of 1000 grains.

Grain yield was significantly affected by nitrogen nutrition. On the overall average, the highest yield was achieved with 100 kg/ha^{-1} of nitrogen (Table 5).

In addition to nitrogen amount, grain yield was influenced by nitrogen form. According to PAGOLA *et al.* (2008), increased concentrations of nitrogen added to barley grown under controlled conditions positively affected the physiological processes in the leaf. SOARES and LEWIS (1986) concluded that a combination of nitrate and ammonium nitrogen brought a higher yield than the individual components of the nutrients. The genotypes showed significant yield variations only in the first year.

The content of total proteins in grain depended on genotype and nitrogen nutrition, the interaction of these two factors being significant only in the second year (Table 6).

Table 6. Protein content, %

Genotype	2003/2004						2004/5						
	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	N_0	N_1	N_2	N_3	N_4	$\overline{X}$	$\overline{X}$
G1	11.5	12.2	12.6	12.8	13.1	12.4	11.3	12.5	12.8	12.9	13.3	12.6	12.5
G2	11.1	11.3	11.6	12.1	12.5	11.7	10.7	11.7	12.2	12.4	12.9	12.0	11.9
G3	11.1	12.0	12.6	12.9	13.2	12.4	10.7	12.6	12.8	13.1	13.6	12.6	12.5
G4	12.3	12.5	12.6	12.7	13.3	12.7	12.0	12.7	12.9	13.2	13.5	12.9	12.8
G5	11.6	11.6	12.0	12.3	12.8	12.1	11.2	12.0	12.2	12.6	12.9	12.2	12.2
G6	11.7	12.4	12.6	12.9	13.3	12.6	12.0	12.6	12.9	13.2	13.5	12.8	12.7
Average	11.6	12.0	12.3	12.6	13.0	12.3	11.3	12.4	12.6	12.9	13.3	12.5	12.4

Characteristic	Test	2002/3			2002/3		
		Genotype	Nitrogen	A x B	Genotype	Nitrogen	A x B
	F test	**	**	NS	**	**	*
Protein	LSD 5%	02022	0.2403	0.5699	0.1871	0.1772	0.4368
content	1%	0.2876	0.3164	0.7626	0.2661	0.2332	0.5884

Nitrogen significantly affected the vegetative growth as well as the protein synthesis in barley grain. Increasing doses of nitrogen applied in laboratory conditions increased the amount of total proteins up to 30% (CORKE and ATSMON, 1988). Important role of nitrogen in protein synthesis in grain was reported by PECIO and BICHONSKi (2002) who concluded that 100 kg/ha^{-1} of nitrogen is optimal for malting barley. To obtain higher yields by increasing the amount of nitrogen, it is necessary to select genotypes that respond well to intensive plant nutrition. (PRŽULJ and MOMČILOVIĆ, 2002).

DISCUSSION

The results of this study showed that the genotypes responded differently to intensive nitrogen nutrition in the agroecological conditions of Timočka Krajina.

Important variations were registered in the main yield components as well as in grain quality, the grain being an essential raw material for beer industry. The new genotype *Premijum* was most productive and it had the lowest total proteins in grain. The genotype *NS-525* had the highest 1000-grain weight (46.8 g). The effect of nitrogen on the studied characteristics depended on N quantity applied. Increasing amounts of nitrogen decrease positive effects on spike length, number of grains per spike, 1000-grain weight and yield. However, the protein content in grain kept increasing to the highest nitrogen dose, which lowered the quality of malting barley. The highest yield was obtained by applying 80 and 100 kg ha^{-1} of nitrogen, depending on the year of study.

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PRODUKTIVNE OSOBINE RAZLIČITIH GENOTIPOVA PIVARSKOG JEČMA U USLOVIMA POJAČANE ISHRANE AZOTOM

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I z v o d

Dvogodišnja istraživanja izvedena su na poljima Centar za poljoprivredna i tehnološka istraživanja u Zaječaru. Predmet istraživanja bila su šest genotipova pivarskog ječma. Za prihranjivanje useva korišćene su sledeće količine azota 40, 60, 80 i 100 kg ha^{-1}. Kontrola je bila varijanta bez prihranjivanja. Dobijeni rezultati pokazali su da genotipovi značajno reaguju na povećane količine azota promenom proizvodnih osobina i kvaliteta semena. Pri tome su ispoljene određene sortne razlike. Novi genotip *Premijum* bio je najrodniji i sa najmanje ukupnih proteina u zrnu. Najveću masu 1000 zrna (46,8 g) imao je genotip *NS–525.* Efekti azota na ispitivane osobine zavise od upotrebljene količine. Sa rastućim količinama opada pozitivan efekat na dužinu klasa, broj zrna u klasu, masu 1000 zrna i prinos. Međutim sadržaj proteina u zrnu je rastao do najveće doze azota, čime se pogoršava kvalitet pivarskog ječma. U zavisnosti od godine ispitivanja, najveći prinos zrna dobijen je ishranom biljaka sa 80 odnosno 100 kg ha^{-1} azota.

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