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Full Length Research Paper

Effects of nitrogen fertilization on yield and grain quality in malting barley

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The aim of this study was to investigate the effect of different nitrogen rates on the yield and physicochemical properties of four malting barley genotypes (Kristal, Premijum, Novi Sad 519 and Novi Sad 525). Three-year trials (2008 to 2010) were carried out on the non-calcareous smonitza soil type. The following nitrogen rates were applied: 50, 70, 90 and 110 kg ha^{-1}. Obtained results show that nitrogen significantly increased the grain yield (2219 to 2987 kg ha^{-1}). Grain quality was decreased by increasing nitrogen rates (1.24 to 2.13%). Apart from nitrogen rates, the genotype also affected the yield. Premijum variety gave the highest grain yield and the lowest protein content. The optimal plant nutrition was achieved by applying 50 kg N ha^{-1}. By further increasing nitrogen amounts, the grain yield increased from 380 to 769 kg ha^{-1}, but the differences were not significant. Different nitrogen rates showed a significant effect on the absolute grain weight (3.00 to 5.76 g) and volume grain weight (2.22 to 5.28 kg hL^{-1}).

Key words: Malting barley, nitrogen, quality traits, yield.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is an important crop in the world mainly used for animal feed and malt. Due to the earliness of barley and its escape of the drought period in July (in Serbia), it can be cultivated in the areas where irrigation water is less available. Yields of malting barley were increased in the previous period, primarily due to the effect of plant breeding (Abeledo et al., 2003a; Pržulj and Momčilović, 2011). New winter barley genotypes have a high yield potential, nearly as the winter wheat. Agro-ecological conditions and production technology, primarily the natural soil fertility, the amount of applied nitrogen (Abeledo et al., 2003b), and primarily the carbon to nitrogen (C/N) ratio (Acuna et al., 2005), significantly affected the grain yield of malting barley. Leistrumaite (2005) emphasised that the grain yield and quality traits of spring barley varieties varies greatly due to growing conditions.

Regarding the barley quality, it was observed that high protein content decreases the extract yield, turbids the beer and slows down the start of germination, while a too low protein content results in a lower enzymatic activity and slow growth of yeast in brewery (Pettersson, 2007). Cereal breeders select barley for large grain, thin husk and low protein content to improve malt quality, and select barley for high protein content on account of animal feed (Pržulj et al., 2010). For production of the European type of beer, the optimal crude protein content (CP) is 10.07%, and the optimal dry matter (DM) content ranges from 9.5 to 11.5% (Palmer, 2000). Malting barley breeders all over the world are challenged by the difficulty in producing barley with appropriate CP level (Wang et al., 2001; McKenzie et al., 2005; Mengel et al., 2006). One reason for difficulties in establishing acceptable CP content of grain is that it depends on the nitrogen (N) supply from fertilizer and soil, as well on the carbon (C) supply from the atmosphere. This renders N and C dynamics in the soil/plant system sensitive to environ-

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mental conditions (Pettersson, 2007). New winter barley genotypes have a high yield potential, nearly as the winter wheat.

The aim of this study was to investigate the effect of different nitrogen rates on yield and grain quality; that is the physical and chemical properties of malting barley grain, in order to determine the most suitable system of nitrogen nutrition in production praxis in Serbian region of Timočka krajina (Zaječar).

MATERIALS AND METHODS

The study included four winter malting barley genotypes (G1 - Kristal, G2 - Premijum, G3 -NS 519, and G4 - NS 525). Cultivar Kristal was selected at the Centre for Agricultural and Technological Studies in Zaječar, while the other genotypes were selected at the Institute of Field and Vegetable Crops in Novi Sad.

The field experiment

Three-year micro trials were set up in a randomized block design with four replications (basic plot 16 m^2) on the non-calcareous vertisol in Timočka krajina region (Centre for Agricultural and Technological Research Zaječar: latitude 43°42' N and longitude 22°24' E). The study included four winter malting barley genotypes: Kristal (G_1), Premijum (G_2), Novi Sad 519 - NS 519 (G_3) and Novi Sad 525 - NS 525 (G_4). NPK mineral fertilizers were used for plant nutrition. During the basic tillage, the whole amounts of nitrogen (80 kg ha^{-1}) and potassium (60 kg ha^{-1}) were ploughed down. At the same time, nitrogen mineral fertilizers were applied, as follows: 20 (N_1), 40 (N_2), 60 (N_3) and 80 kg ha^{-1}(N_4). Also, 30 kg N ha^{-1} was applied in the tillering phase of all variants. The control variant (N_0) was the variant with no NPK mineral fertilizers applied.

Furthermore, standard agronomy practices for winter malting barley were applied. Sowing was carried out in the second half of September, using 160 kg ha^{-1} of seed. Necessary crop protection measures were performed. Harvesting was carried out manually. The threshers designed for the experiments were used.

Sampling, chemical and statistical analysis

The grain yield was measured for each basic plot, and the samples for analysing grain quality were taken from each variant. Four grain quality characteristics were determined: the test weight, the 1000 grain weight, protein content, and yield. The values of the test weight were measured with the Shopper hectolitre scale, while the values of the absolute weight were determined by measuring an average sample of the 1000 grains. The protein content was determined according to Kjeldahl by applying a semi-micro procedure, using"Tecator-Kjeltec System 1002" apparatus equipment (Kaluđerski and Filipović, 1998).

The statistical analysis of the obtained experimental results were first presented by the indicators of the descriptive statistics (mean and its standard error, the interval of variation, standard deviation and coefficient of variation), and then by the indicators of the analytical statistics, using statistical package STATISTICA 8 for Windows and SPSS Statistics 17.0. Considering the aim of the study, the equality of the variances was tested using the Levene′s test. In accordance with the obtained results, the statistical significance of testing the differences between average values of each parameter was performed using the analysis of variance (ANOVA) for two factors. The result of the Levene′s test for all of the tested grain characteristics indicates the fulfilment of the preconditions, both the variance of homogeneity of the selected samples, and performance of the parametric tests. Simple comparisons of the two means were carried out by the least significant difference test (LSD test) (Maletić, 2005) for the significance levels of 5 and 1%, and the specified number of degrees of freedom. The effect of each factor, as well as their interaction, was measured by the partial eta squared coefficient, which was then classified according to Cohen's criteria (Cohen, 1988).

Soil and weather characteristics

The trials were carried out on the non-calcareous vertisol. The soil was characterized by a slightly acid reaction (pH 5.8), medium phosphorus (P_2O_5, 17.5%) and potassium (K_2O, 29.95%) content; it was poor in nitrogen (N, 0.12%), and rich in humus (3.08%), but without $CaCO_3$. Total precipitation during October to June was the lowest in the first year (392 mm), 9 mm higher in the second year and 16 mm higher in the third year. These differences indicated that the water regime was consistent in the three-year period of the study. Temperature conditions were also consistent and in the range of the average (Table 1).

RESULTS AND DISCUSSION

The rate of N fertilizer addition is an influential agronomic variable affecting yield and quality of malting barley in this study. In all tested varieties, the lowest grain yield was in the control variant (N_0) (2790 kg ha^{-1}). This value was significantly lower ($p < 0.01$) compared to the variants with the added nitrogen. By increasing nitrogen (20, 40, 60 and 80 kg ha^{-1}), the grain yield of the malting barley (5009, 5389, 5680 and 5777 kg ha^{-1}) also increased. However, the differences between these grain yields were not statistically significant ($p > 0.05$) (Table 2).

McKenzie et al. (2004) pointed out in their results that the grain yield was significantly affected by nitrogen and the variety, and emphasized that nitrogen rate of 33 kg ha^{-1} was optimal for achieving the maximum yield. According to the results of this study, the optimal nutrition of plants was achieved by adding 50 kg ha^{-1}nitrogen (variant N_1). By increasing the total amount of nitrogen to 110 kg ha^{-1} (variant N_4), the grain yield also increased, but these differences were not significant. There was a difference in the yield between the varieties. NS-519 variety had the lowest average yield (4896 kg), while Premijum variety had the highest average yield (4991 kg). According to Momčilović and Pržulj (1999), NS-519 grain yield potential was significantly higher than the yield achieved during this study. An increase in yield of 1% is not statistically significant. The differences between grain yield in the different variants (N_1, N_2, N_3 and N_4) were also non-significant (LSD test). The variety × nitrogen rate interaction was not significant. Measured partial eta squared coefficients confirmed the results of the ANOVA test and indicate that increased nitrogen rates had a very strong effect on the yield (28%), while both tested varieties and the interaction of the factors had a very little effect on the yield (0.1 and 0.4%, respectively) (Table 2).

Table 1. Monthly precipitation and mean air temperatures for Zaječar.

Year/Month	2007/2008		2008/2009		2009/2010		Average 1967 to 2010	
	P	T	P	T	P	T	P	T
X	19	11	54	11	49	9	42	10
XI	24	7	31	7	27	7	50	5
XII	16	3	63	2	36	1	50	1
I	19	1	53	-1	51	-2	35	-1
II	29	4	19	-3	42	2	37	1
III	48	9	17	4	47	7	42	5
IV	79	11	89	10	46	12	54	11
V	68	17	61	19	29	15	65	17
VI	90	19	14	23	81	20	67	20
Sums	392	-	401	-	408	-	442	-
Average	-	12.1	-	10.8	-	11.1	-	10.7

P, Precipitation in mm; T, temperature in ℃

Table 2. Mean values and variability indicators of malting barley grain yield.

Variety	N rate	$\overline{x} \pm s_{\overline{x}}$	X max – X min	Standard deviation	Cv (%)	Total average
	N_0	2902 ± 136	3370 - 2450	331.929	11.44	
	N_1	5017 ± 685	6820 - 2280	2055.91	40.98	
Kristal	N_2	5117 ± 587	6740 - 2700	1761.65	34.43	4900[a]
	N_3	5677 ± 589	7140 - 3280	1769.1	31.16	
	N_4	5789 ± 597	7420 - 3320	1789.9	30.92	
	N_0	2608 ± 138	2980 - 2150	337.66	12.94	
Premijum	N_1	5153 ± 530	6920 - 2480	38.32	38.32	
	N_2	5574 ± 534	6940 - 3400	1589.58	28.52	4991[a]
	N_3	5751 ± 84	7100 - 3560	1602.9	27.87	
	N_4	5869 ± 511	7040 - 3680	1532.5	26.11	
	N_0	2837 ± 84	3150 - 2550	206.46	7.28	
NS - 519	N_1	4893 ± 672	6840 - 2200	2016.12	41.2	
	N_2	5358 ± 624	7060 - 3280	1873.08	34.96	4896[a]
	N_3	5617 ± 555	6960 - 2820	1663.84	29.62	
	N_4	5778 ± 574	7200 - 3380	1721.64	29.8	
	N_0	2812 ± 212	3370 - 2080	519.32	18.47	
NS - 525	N_1	4971 ± 648	6760 - 2240	1943.64	39.1	
	N_2	5508 ± 588	7140 - 3040	1763.64	32.02	4928[a]
	N_3	5678 ± 520	6990 - 3400	1559.12	27.46	
	N_4	5673 ± 561	7140 - 3340	1683	29.66	
	N_0	2790[b]				
	N_1	5009[a]				
Total average	N_2	5389[a]				
	N_3	5680[a]				
	N_4	5777[a]				
Test of homogeneity		**Test**	**Variety**	**N rate**		**Interaction**
Levene¢s	5.27	F - test	0.029[Ns]	14.57**		0.048[Ns]

Table 2. continues.

test p - level	0.053				
		LSD 0.05	684.7	765.5	1531
		0.01	901.3	1007.7	2015.4
Partial Eta Squared of value			0.001	0.283	0.004

[Ns]non significant; **significant at the level of 1%.
[a, b, c]Values without same letter in superscript are significantly different (p<0.05).

The samples from the variant N_0 had the lowest average absolute grain weight (39.85 g). In the variant N_1, when the side dressing was 20 kg ha^{-1}, the absolute grain weight was 42.85 g. With further increase of the nitrogen rate, the absolute grain weight increased as follows: 44.44 g (variant N_2), 45.11 g (variant N_3) and 45.61 g (variant N_4: the maximum amount of nitrogen). The F-test indicate that the differences in absolute grain weight between the studied nitrogen rates were highly significant ($p < 0.01$). The variants N_0 and N_1 had significantly lower absolute grain weight than the other three variants: $p < 0.01$. There was, however, no significant difference between the variants N_2, N_3 and N_4 ($p < 0.05$) (Table 3).

Futhermore, the analysis by genotype revealed that NS-525 variety had the largest grain (absolute weight of 45.04 g), which was consistent with the results of Momčilović et al. (2000). NS-519 variety had the second largest grain (44.72 g), followed by Kristal variety (42.53 g), while Premijum variety had the smallest grain (42.00 g). The analysis of variance showed that the differences between the absolute weights of the studied barley varieties were highly significant ($p < 0.01$). Statistically, a significantly smaller difference in absolute grain weight was determined between Kristal and Premium varieties compared to the one between NS-519 and NS-525 varieties. The absolute grain weight for top yielding varieties (Kristal and Premium) was not statistically different ($p < 0.05$), which was also true for the varieties with the highest absolute grain weight (NS-519 and NS-529). The absolute grain weight was characterized by low variability, which indicate that the empirical series contained homogeneous data (Cv<8%). Partial eta squared coefficient indicates that not only do the studied factors (variety and nitrogen rate) have a statistically significant effect, but they also have a very strong effect on the change in the absolute grain weight of barley. According to Cohen's criteria, a variety has an impact of 18.20% and a nitrogen rate of 35.50%. The interaction of factors (variety – nitrogen rate) did not show statistical significance ($p < 0.05$).

Different nitrogen rates showed a significant effect on the volume weight of grain. In the total average, the highest volume weight of grain was determined in the variant with the nitrogen rate of 110 kg ha^{-1} (N_4) (70.64 kg). When the total nitrogen rate was decreased to 90, 70 and 50 kg ha^{-1}, the volume weight of grain also decreased. The volume grain weight was 70.10 kg in the variant N_3, 69.49 kg in the variant N_2, and 67.58 kg in the variant N_1. The lowest volume grain weight was in the control variant (N_0) (65.36 kg). The differences in volume grain weight were statistically significant ($p < 0.01$) between the control and the variants with nitrogen, and for variant N_1 compared to the other variants with increased nitrogen rate (Table 4). Most authors who have dealt with this issue in different malting barley genotypes, confirmed similar results (Öztürk et al., 2007; Lalić et al., 2009; Kiliç et al., 2010).

In addition, the ANOVA test showed statistically significant differences between measured volume grain weight of the different varieties (F= 3.13*). The individual LSD test showed that Kristal variety had the lowest volume grain weight (67.39 kg). This difference was significantly lower ($p < 0.05$) compared to NS-519 (68.49 kg), Premijum (69.15 kg) and NS-525 varieties (69.50 kg). Volume grain weight has a greater homogeneity of the material compared to absolute weight. The maximum variability measured was 5.5%. The values of the partial eta squared coefficients indicate the significant effect of the variety and nitrogen rate on the studied quality traits of grain. Thus, the variety showed medium effect size of 5.5%, while the nitrogen rate had a very strong effect of 25% (according to Cohen's scale). The interaction of factors (nitrogen rate - variety) did not have a significant effect on the change of the volume grain weight ($p > 0.05$). Moreover, the overall effect presented by the partial eta squared coefficient was very low (1.9%), (Table 4).

Increased nitrogen rates significantly affected the total protein content in malting barley grain. With increase in the total nitrogen rate (50, 70, 90 and 110 kg ha^{-1}), the protein content also increased (12.57, 12.84, 12.88 and 13.46%), which was consistent with the results presented by Kiliç et al. (2010). In the control variant, malting barley grain had a significantly lower total protein content (11:33%) compared to the variants with the nitrogen fertilizer ($p < 0.01$). The individual LSD test showed that, with increase in the nitrogen rate, the total protein content of grain also significantly increased ($p < 0.01$). The highest total protein content of grain was found in the variant with 110 kg ha^{-1} of nitrogen (Table 5). The ANOVA test defined significant differences in total protein

Table 3. Average values and variability indicators of absolute grain weight of malting barley.

Variety	N rates	$\bar{x} \pm s_{\bar{x}}$	X max – X min	Standard deviation	Cv (%)	Total average
	N_0	39.18 ± 0.828	42.70 - 35.30	2.485	6.34	
Kristal	N_1	41.91 ± 1.066	44.80 - 37.40	3.197	7.63	
	N_2	43.29 ± 1.098	46.40 - 38.80	3.294	7.61	42.53^b
	N_3	43.96 ± 1.200	47.00 - 39.00	3.601	8.19	
	N_4	44.33 ± 1.119	47.40 - 39.80	3.357	7.57	
	N_0	39.73 ± 0.795	42.60 - 36.40	2.386	6.01	
Premijum	N_1	40.93 ± 0.916	44.00 - 37.40	2.75	6.72	
	N_2	42.62 ± 0.906	45.60 - 39.00	2.717	6.38	42.00^b
	N_3	43.18 ± 0.841	46.00 - 39.80	2.524	5.85	
	N_4	43.56 ± 0.761	46.20 - 40.40	2.284	5.24	
	N_0	41.31 ± 1.289	48.60 - 37.10	3.867	9.36	
NS - 519	N_1	43.81 ± 0.890	46.60 - 40.00	2.671	6.1	
	N_2	45.38 ± 0.912	48.40 - 41.60	2.738	6.03	44.72^a
	N_3	46.40 ± 1.074	50.20 - 42.00	3.222	6.94	
	N_4	46.68 ± 0.960	50.00 - 43.00	2.88	6.17	
	N_0	39.18 ± 0.828	42.70 - 35.30	2.485	6.34	
NS - 525	N_1	44.73 ± 0.724	47.40 - 42.00	2.172	4.86	
	N_2	46.49 ± 1.037	49.60 - 42.40	3.111	6.69	45.04^a
	N_3	46.91 ± 1.071	51.40 - 43.00	3.213	6.85	
	N_4	47.87 ± 1.243	54.00 - 43.40	3.728	7.79	
	N_0	39.85^b				
	N_1	42.85^b				
Total average	N_2	44.44^a				
	N_3	45.11^a				
	N_4	45.61^a				

Test of homogeneity		Test	Cultivar	N amount	Interaction
Levene¢s test p - level	0.837 0.66	F - test	11.86**	22.05**	0.76^{Ns}
		LSD 0.05	1.228	1.373	2.747
		0.01	1.617	1.808	3.616
Partial Eta Squared of value			0.182	0.355	0.054

[Ns]non significant ; ** significant at the level of 1%.
[a, b, c] Values without same letter in superscript are significantly different (p<0.05).

content between the studied varieties (p < 0.01). NS-525 variety had the highest total protein content (13.09%), followed by NS-519 (12.81%) and Kristal (11.65%) varieties, while Premijum had the lowest total protein content (11.07%). Statistically, significant differences were determined between NS-525 and NS-519 varieties (p < 0.05), while the difference between other varieties was highly significant (p < 0.01). However, there was no significant variation between Kristal and NS-519 varieties.

The coefficient of variation for all the variants (nitrogen, variety and interaction) was very small (Cv<8%), which indicated that the empirical series contained homogeneous data. The interaction of variety-nitrogen rate factors did not have a significant effect on the change in the total protein content of malting barley grain. The values of the partial eta squared coefficients indicated that both studied factors had a very strong effect on the change in the total protein content. Nitrogen rates

Table 4. Average values and indicators of volume grain weight variability of malting barley.

Variety	N rates	$\bar{x} \pm s_{\bar{x}}$	X max – X min	Standard deviation	Cv (%)	Total average
Kristal	N_0	65.18 ± 1.176	71.30 - 60.30	3.528	5.41	67.39[b]
	N_1	66.23 ± 1.087	70.20 - 62.20	3.263	4.93	
	N_2	67.92 ± 1.324	72.60 - 62.60	3.974	5.85	
	N_3	68.56 ± 1.354	72.80 - 63.40	4.064	5.93	
	N_4	69.08 ± 1.255	73.20 - 64.20	3.764	5.45	
Premijum	N_0	65.78 ± 1.080	71.20 - 61.40	3.241	4.93	69.15[a]
	N_1	67.83 ± 0.973	71.80 - 64.20	2.919	4.3	
	N_2	69.91 ± 1.223	74.60 - 65.60	3.668	5.25	
	N_3	70.81 ± 1.118	75.20 - 66.20	3.355	4.74	
	N_4	71.41 ± 1.092	75.60 - 67.40	3.277	4.59	
NS - 519	N_0	65.13 ± 0.879	68.30 - 61.20	2.636	4.05	68.49[a]
	N_1	68.29 ± 1.760	78.60 - 63.80	5.28	7.73	
	N_2	69.46 ± 1.232	75.80 - 65.00	3.694	5.32	
	N_3	69.59 ± 1.080	72.80 - 65.00	3.24	4.66	
	N_4	70.00 ± 1.128	74.60 - 65.40	3.383	4.83	
NS - 525	N_0	65.37 ± 0.943	68.80 - 61.10	2.829	4.33	69.50[a]
	N_1	67.98 ± 0.888	70.30 - 64.40	2.665	3.92	
	N_2	70.66 ± 1.212	73.90 - 65.40	3.6373.	5.15	
	N_3	71.46 ± 1.161	74.70 - 66.60	484	4.88	
	N_4	72.07 ± 1.174	75.50 - 67.10	3.521	4.88	
Total average	N_0	65.36[b]				
	N_1	67.58[b]				
	N_2	69.49[a]				
	N_3	70.10[a]				
	N_4	70.64[a]				
Test of homogeneity		**Test**	**Variety**	**N rate**		**Interaction**
Levene¢s test p - level	0.584 0.914	F - test	3.13*	13.61**		0.26[NS]
		LSD 0.05	1.453	1.625		3.249
		0.01	1.913	2.138		4.277
Partial Eta squared of value			0.055	0.254		0.019

[Ns]Non significant; * significant at level of 5%; **significant at level of 1%.
[a, b, c, d]Values without same letter in superscript are significantly different (p<0.05).

determined the change in the protein content up to 59.9%, and in the variety up to 32.3% (Table 5)

The rate of N fertilizer application is among the most critical decisions for malting barley production, due to its large impact on grain yield and quality (McKenzie et al. 2004). Most authors (Bole and Pittman, 1984; Baethgen et al., 1995; Pržulj et al., 2002; McKenzie et al., 2004), who have dealt with this issue in different cultural conditions, found that N rates above 100 kg N ha^{-1} could be used if available soil water was greater than 150 mm, but only 20 to 50 kg N ha^{-1} could be applied if available soil water was less than 100 mm due to excessive protein

Table 5. Average values and indicators of total protein content variability of malting barley.

Variety	N rate	$\bar{x} \pm s_{\bar{x}}$	X max - X min	Standard deviation	Cv (%)	Total average
Kristal	N_0	11.40 ± 0.229	12.30 - 10.70	0.562	4.93	12.65[b]
	N_1	12.60 ± 0.144	13.19 - 12.10	0.431	3.42	
	N_2	12.84 ± 0.080	13.15 - 12.50	0.239	1.86	
	N_3	13.01 ± 0.069	13.35 - 12.80	0.207	1.59	
	N_4	13.38 ± 0.122	13.89 - 13.00	0.367	2.74	
Premijum	N_0	10.87 ± 0.256	11.70 - 10.10	0.628	5.78	12.07[c]
	N_1	11.85 ± 0.186	12.58 - 11.20	0.558	4.7	
	N_2	12.17 ± 0.156	12.73 - 11.60	0.47	3.86	
	N_3	12.47 ± 0.124	12.97 - 12.00	0.371	2.98	
	N_4	12.97 ± 0.140	13.59 - 12.50	0.42	3.24	
NS - 519	N_0	10.90 ± 0.380	12.50 - 9.90	0.932	8.54	12.81[b]
	N_1	12.80 ± 0.275	13.89 - 11.80	0.826	6.45	
	N_2	13.14 ± 0.215	14.05 - 12.50	0.645	4.91	
	N_3	13.45 ± 0.228	14.39 - 12.90	0.684	5.09	
	N_4	13.77 ± 0.205	14.59 - 13.10	0.616	4.47	
NS - 525	N_0	12.15 ± 0.228	13.00 - 11.50	0.558	4.59	13.09[a]
	N_1	13.03 ± 0.234	14.02 - 12.30	0.703	5.39	
	N_2	13.19 ± 0.221	14.10 - 12.60	0.664	5.04	
	N_3	13.39 ± 0.218	14.27 - 12.70	0.655	4.89	
	N_4	13.70 ± 0.172	14.41 - 13.10	0.515	3.76	
Total average	N_0	11.33[d]				
	N_1	12.57[bc]				
	N_2	12.84[b]				
	N_3	12.08[b]				
	N_4	13.46[a]				

Test of homogeneity		Test	Variety	N rate	Interaction
Levene¢s test p - level	4.376 0.069	F - test	23.54**	55.17**	1.22[Ns]
		LSD 0.05	0.236	0.273	0.528
		0.01	0.31	0.347	0.694
Partial Eta Squared of the value			0.323	0.599	0.09

[NS]Non significant; **significant at level of 1%.
[a, b, c, d]Values without same letter in superscript are significantly different (p<0.05).

concentrations.

Conclusion

Nitrogen nutrition of plants significantly increased the grain yield in all varieties. The optimal nutrition of plants was obtained with 50 kg ha^{-1} N, 80 kg ha^{-1} P_2O_5 and 60 kg ha^{-1} K_2O. With a further increase in the nitrogen rate, yield also increased, but the differences were not significant compared to the variant N_1. The nitrogen rate significantly affected the absolute grain weight, while both absolute grain weight and 1000 - grain weight were affected by the variety. The increased nitrogen rates in plant nutrition significantly affected the total protein content in grain, with significant variation determined between the varieties. The analysis of the variety response to intensive nitrogen nutrition distinguished Premijum variety that had less than 13% of total protein content by using 110 kg ha^{-1} of nitrogen.

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