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PARAMETERS OF YIELD AND QUALITY OF SPRING MALTING BARLEY GRAIN

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Abstract

During a two-year period, two varieties of spring malting barley, Mile and Marko, were studied, which were created at the Institute of Field and Vegetable Crops in Novi Sad.Grain yield, weight of 1000 grains and hectoliter mass of grains were examined. The experiment was carried out in the vicinity of Kruševac according to the plan of a random block system in four repetitions, and the size of the base parcel was $5m^2$.The sowing standard was 400 germinable kernels/m^2. The experiment includes the fertilization factor with growing nitrogen doses N_0, N_{80}, N_{100}, N_{120}. At variants with a nitrogen dose, another 90 $kgha^{-1}$of P_2O_5 and K_2O were used. Sowing density and applied nitrogen doses are two extremely important factors in the production technology of spring malting barley. In the interaction with the genotype of the variety and different soil factors as well as climatic factors, it contributes decisively to obtaining high yields of good grain quality.The aim of this research is to examine the influence of increased nitrogen doses in mineral nutrition on fertility parameters and grain quality of spring malting barley. The achieved results of the study show that the use of nitrogen had a positive effect on fertility parameters and grain quality of spring malting barley in all varieties and at both varieties.Using a higher nitrogen dose, a somewhat larger mass of 1000 grains was found in the fertilization variant of 100 kg ha^{-1}N per average for the examined two-year period, while the hectolitre mass was somewhat higher in the case of the fertilizer variant of 80 kg ha^{-1}N in the Mile variety as well as the higher yield of grain in relation to the variety Marko.The different reaction of the tested varieties on the application of mineral fertilizers is the result of their varietal specificity.

Keywords:*mass of 1000 grains, spring barley, yield, variety*

Introduction

Barley is cultivated at around 49, 43 million hectares in the world, with an annual production of about 144, 49 million tons and an average yield of 2.9 t ha^{-1} (FAOSTAT 2015). Barley (*Hordeum vulgare* L.) is a very important cereal, which occupies the fourth place behind wheat, corn and rice by sown areas (Bengtsson, 1992; Langridge and Barr, 2003; Zečević*et al*., 2011; Awika, 2016).Barley is grown around the world and is used as an important component in the production of beer and malt; it is also an important and quality component in the nutrition of domestic animals, while it is partially used in human nutrition. In Serbia, for the last five years, about 50% of barley production has been used for animal feed production, and 50% in the brewing industry (Kandić, 2015).In comparison to the older varieties of barley that were in the production in the eighties, newer varieties are characterized by good technological quality, better resistance to lodging and disease, shorter stem and more efficient use of assimilatives (Bratković*et al*., 2014; Đekić*et al*., 2010;). The weight of 1000 grains in brewer barley ranges from 68 to 75 kg ha^{-1} (Paunović*et al*., 2006).

The yield and quality of the grain is greatly influenced by the balanced mineral nutrition, which is adapted to the natural fertility of the soil and the needs of the barley (Glamočlija*etal*., 1998). The influence of mineral nutrition on the characteristics of beer barley originates both from the quantity of individual nutrients and from their relationship, as well as from the way they are introduced into the soil and the time of their application(Stanković*et al.*, 2000).Unlike other stubble cereals, barley has higher demands on mineral nutrition, with a particular influence of nitrogen on the yield and quality of barley grains (Knežević, 2005). Nitrogen is the element that has the greatest influence on the vegetative development of the plant, its photosynthetic capacity and yield (Evans, 1983; Knežević, 2014). It is an integral part of many important cellular compounds, such as amino acids, proteins (enzymes and structural proteins), nucleic acids (DNA and RNA), adenosine triphosphate (ATP), chlorophyll and some phytohormones (auxin and cytokinin) (Santiago-Antonio *et al.*, 2014).Since barley plants adopt nitrogen almost to the very end of vegetation, its excessive concentration in soil can leads to great adoption by the plant, and consequently to an increase in protein content in grains (Paunović and Madić, 2011). The content of protein in barley grains is of the highest importance from the standpoint in the brewing industry, and their content should range from 8.5 to 12.5% (Gali and Brown, 2000). In spite of the direct influence of nitrogen on the increase in protein content in grains, its indirect influence is also importantconcerning thelodging of plants (Perić, 1982, 1986; Paunović, 2001). Therefore, it is very important to know the properties of the resistance of the variety to lodging.

Spring barley occupies much larger areas in most European countries than winter barley.

The production of beer barley with high yield of grain and appropriate quality is possible only by choosing a quality assortment with suitable growing conditions and appropriate production technology. In the two-year period at a field experiment in the village of Globoder near Kruševac, two Novi Sad varieties of spring barley were examined in order to determine the selection of the best varieties for the production conditions in Serbia.

Material and Methods

During a two-year period, two varieties of spring malting barley, Mile and Marko, were studied, which were created at the Institute of Field and Vegetable Crops in Novi Sad.Grain yield, 1000 grain weight and hectolitre grain weight of two varieties of spring malting barley were examined.An experiment was set in the vicinity of Kruševac in the region of the village of Globoder.The size of the base parcel was 5.0 m^2 in four repetitions per split-plot method with a random schedule of treatment. The sowing was carried out manually in rows with 400 germinable kernels/m^2.The experiment includes the fertilization factor with growing nitrogen doses N_0, N_{80}, N_{100}, N_{120}. At variants with a nitrogen dose, another 90 $kgha^{-1}$ of P_2O_5 and K_2O were used.The following properties were analyzed: grain yield, mass of 1000 grains and hectolitre mass. Standard production technology was used in the experiment.Barley harvest was done at a full maturity stage with grain yield measured and corrected to 14% moisture. From the qualitative characteristics of the grains, the hectolitre mass of the grain was made, measured on the hectolitre scale and the weight of 1000 grains.

The land on which the experiment was performed by type is alluvial (fluvisol). The subtype of leached fluvisol represents a somewhat older alluvial soil, in fact, transitional formation from carbonate fluvisol to a poorly developed meadow black soil.Although it does not contain $CaCO_3$ in the arable horizon, the derived fluvisol has fairly favorable chemical properties. The land is medially provided by humus (3.25%), pH in H_2O = 6.50 in KCl = 5.72, while the total nitrogen content is 0.23. The content of the easily accessible phosphorus was 17 mg of 100 g^{-1} soil, the content of easily accessible potassium was 20 mg of 100 g^{-1} of the soil.

The area of Kruševac is bounded by the coordinates of 43˚22'29 "and 43˚42'17" north latitude, and 21˚9 'and 21˚34'8 "of the eastern latitude. The climate is moderately continental.

Barley has relatively low heat requirements. The total temperature sum of 1750˚ C (Miržinski*et al.*, 1966) is required for the development of spring barley. The years in which the meteorological conditions were tested differed from the multiyear average characteristic for this area (Table 1).The average air temperature was higher by 1.3˚C in 2014 compared to the perennial average.The period February, March, April was marked by a much warmer time than the perennial annual average, and the thermal conditions for emergence in 2014 were favourable.The precipitation was in smaller quantities and the sprouting was uneven and inconsistent. The relatively favorable thermal regime of plants in May was accompanied by higher precipitation quantities.Elevated temperatures accelerated the vegetation cycle, which resulted in accelerated barley ripening and earlier harvesting. The average amount of precipitation during the vegetation period of spring barley (February - July) was 595.9 mm, while the perennial average was 320.5 mm.A critical period in terms of demand for water is also in the filling phase of the grain. Spring barley is the most sensitive to reducing soil moisture in the six-leaf phase.

In 2015, the average air temperature was higher by 0.8˚ C compared to the perennial average.The first three months of this year were marked by a warmer time compared to the perennial average. The precipitation was in sufficient quantities and the sprouting was even and uniform unlike in 2014.The relatively favorable heat regime in the remaining four months of the vegetation period in this year of testing was followed by a lower amount of precipitation compared to the same period in 2014, which did not interfere with further development of life processes in spring malting barley in further stages of development in the year of testing.The average amount of precipitation for the February-July vegetation period in this year was 379.0 mm compared to the perennial precipitation average of 320.5 mm, which is significantly less compared to the first year of testing.

Based on data on mean monthly air temperatures and precipitation amounts during the study, we conclude that the weather conditions varied by year, especially in terms of the amount and distribution of precipitation and that they were somewhat more unfavorable in 2014.

Table 1. Average monthly temperature and precipitation sum

year	Months						Average
	II	III	IV	V	VI	VII	
Mean monthly air temperatures (C^o)							
2014	6.6	9.4	11.9	15.9	19.7	21.7	14.2
2015	2.9	6.3	11.4	17.7	19.7	24.2	13.7
average	2.6	5.9	11.3	16.3	20.1	21.6	12.9
Precipitation amount (mm)							
2014	9.3	63.5	188.8	126.6	115.3	92.4	595.9
2015	50.9	105.8	55.2	62.6	101.7	2.8	379.0
average	33.2	41.7	54.4	61.0	66.4	63.8	320.5

Results and Discussion

Numerous experiments on the optimization of the application of the nitrogen fertilizers for achieving high yields in the world and in our country are quite contradictory. Thus, Ruza et al., (2011). in the pedologic and climatic conditions of Lithuania determines the optimum yield increase of 26.7% using 90 kg h^{-1} N; further increase in the application of N was not accompanied by an increase in yield. According to Medić et al. (2017) on acidic soils the yield of barley is significantly influenced by mineral nutrition applied in combination with calcification of soil or genetics, i. e. cultivated variety. These results and many other point to the complex interactions of climatic-pedological conditions, genetics, and applied mineral nitrogen in the production of barley.

In our tests the influence of 100 kg h^{-1} N during the two years in the investigated varieties proved to be optimal in the given soil-climatic conditions (Table 2). The influence of the

optimum application of N (120 kg h^{-1}) on the tested variety Marko in climatic conditions during 2014 influenced the increase in the yield for 2050 kg h^{-1} compared to the control(N_0 kg h^{-1}). The achieved yield increase was 105% compared to the control. During the same year (2014) and the same optimal treatment (120 kg h^{-1}) with the Mile variety, an increase of 1530 kg h^{-1} was achieved, which increased the yield by 66% compared to the control (N_0 kg h^{-1}).
In contrast, with Mile variety in the climatic conditions that were present in 2015 when the optimal application of N (120 kg h^{-1}) was realized, there was an increase in the yield of 1900 kg h^{-1} and with Marko variety 1590 kg h^{-1}, indicating all the complexity of the interaction of the variety x environment, or selection of a variety for certain climatic conditions.

Table 2. Yield (kg h^{-1}) by varieties, fertilization variants and years

variety	Year	Fertilization variants				
		0	80	100	120	Average
Mile	2014	2.657	3.677	4.210	3.900	3.611
	2015	2.100	3.420	4.000	3.768	3.322
	average	2.379	3.549	4.105	3.834	3.467
Marko	2014	1.950	3.512	4000	3.968	3.358
	2015	2.300	3.300	3.890	3.618	3.277
	average	2.125	3.406	3.945	3.793	3.317
average		2.252	3.478	4.025	3.814	3.392

Lsd	•	(B)	(AxB)	(C)	(AxC)	(BxC)	(AxBxC)
0,05	249,2	249,2	517,3	172,4	356,5	356,5	633,3
0,01	333,2	333,2	676,5	232,8	475,5	475,5	961,1

A-variety, B-fertilizer dose, C-the year of study

The influence of the variety, the dose of nitrogen application in the two years studied, influenced the absolute mass of 1000 grains by 4.96 g. (variety Marko, application of N 80 kg h^{-1}, 2015 36,07 g and maximum value of 41,03 g on the same variety without application of N during 2014). However, the impact of the individual influence of the variety, the application of mineral nitrogen and the year influenced little to the absolute weight of 1000 grains (Table 3).

Table 3. Absolute mass of 1000 grains (g) by varieties, fertilization variants and years

Variety	year	Fertilization variants				
		0	80	100	120	average
Mile	2014	39.05	39.00	38.02	38.09	38.54
	2015	39.25	39.22	41.06	39.04	39.64
	average	39.15	39.11	39.54	38.57	39.09
Marko	2014	41.03	38.00	38.40	40.05	39.37
	2015	37.15	36.07	38.90	38.16	37.57
	average	39.09	37.04	38.66	39.11	38.46
average		39.12	38.08	39.10	38.84	38.78

Lsd	(A)	(B)	(AxB)	(C)	(AxC)	(BxC)	(AxBxC)
0,05	1,04	1,04	2,08	0,73	1,47	1,47	2,94
0,01	1,38	1,38	2,76	0,97	1,95	1,95	3,90

A-variety, B-dose of fertilizer, C-the year of studyest

For all variants of the application of nitrogen fertilizer and the year Mile variety had a higher hectolitre mass by 0.82 kg hl^{-1}(Table 4). In general, thehectolitre mass by 0.82 kg hl^{-1} , depending on the variety, fertilization variants during the two years varied by 6.05 kg hl^{-1}

(variety Mile, application of N 100 kg h^{-1}, in 2015 68.83 kg $hl^{-1}$and the maximum value of 74.85 kg hl^{-1}on the same variety with the application of 80 kg h^{-1} of N during 2014).

Table 4. Hectolitre mass (kg hl^{-1}) by varieties, fertilization variants and years

Variety	year	Fertilization variants				
		0	80	100	120	average
Mile	2014	73,01	74,85	72,06	73,05	73,24
	2015	70,60	73,60	68,83	72,16	71,30
	Average	71,81	74,23	70,45	72,61	72,28
Marko	2014	71,25	73,35	70,13	72,34	71,77
	2015	68,14	73,05	73,22	70,18	71,15
	average	69,70	73,20	71,68	71,26	71,46
average		70,76	73,72	71,07	71,94	71,87

Lsd	(A)	(B)	(AxB)	(C)	(AxC)	(BxC)	(AxBxC)
0,05	0,99	0,99	1,99	0,70	1,41	1,41	2,82
0,01	1,32	1,32	2,64	0,93	1,87	1,87	3,74

A-variety, B-dose of fertilizer, C-the year of study

Using the simple correlation coefficients significant ($p \leq 0.05$) negative correlation between yield and absolute mass of 1000 grains (r=-0.662) was found as well as between the absolute mass of 1000 grains and the hectolitre mass in Mile variety. There was no significant ($p \geq 0.05$) interrelation between the traits found in Marko variety (Table 5).

Table 5. Correlation coefficients between tested properties (n=10)

	Variety					
	Mile			Marko		
property	I	II	III	I	II	III
yield (kg h^{-1}) I	-	-0.662*	0.077 NS	-	-0.102 NS	0.422 NS
Absolute mass of 1000 grains (g) II		-	-0.662*		-	0.170 NS
Hectolitre mass (kg hl^{-1}) III			-			-

Statistical significance levels: *$p \leq 0.05$, NS – not significant ($p \geq 0.05$).

Conclusions

The investigated varieties behaved differently according to the climatic conditions in which the yield was formed, as well as for the interdependence of grain yield and quality parameters: the absolute mass of 1000 grains and the hectolitre mass. On the basis of the coefficient of correlation, it was established that significant interdependence was not found in variety Marko, while in variety Mile significant ($p \leq 0.05$) negative interdependence was found between the yield and the absolute mass (r=-0.662) and between the absolute mass of 1000 grains and the hectolitre mass (r=-0.648).This points to all the complexity of choosing a variety to achieve maximum yields and grain quality.

In given pedological climatic conditions, the application of nitrogen of 100 kg h^{-1} clearly proved to be optimal for both tested varieties and during both years.

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