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THE INFLUENCE OF WEATHER CONDITIONS AND NITROGEN FERTILIZATION ON SOME CHARACTERISTICS OF WINTER BARLEY

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Abstract

This study examined the impact of weather conditions and increasing doses of nitrogen fertilization on the productivity (yield) and quality characteristics of two varieties of winter barley (Grand and Record). The two-year trial (2005-2007) was set in a randomized block system in four replications, which included control and three different doses of nitrogen fertilization (0, 80, 100 and 120 kg ha^{-1}). The soil on which the experiment was performed was of alluvium type and the size of the experimental plot was 10 m². The research has determined the optimum amount of nitrogen to achieve maximum yield and grain quality of winter barley genotypes which were studied. The tests have shown that the highest grain yield and quality of winter barley varieties was achieved with fertilization variant of 80 kg ha^{-1} and the lowest in the control variant. Winter barley variety Grand, in both tested years, had a significantly higher grain yield (4.48 t ha^{-1}) compared to the other studied variety Record (3.58 t ha^{-1}). Variety Grand also had higher values of a 1000 grain mass and hectoliter mass compared with variety Record.

Meteorological conditions, in two tested years, had a great influence on the yield and quality. The lack of rain and extreme heat in the second year caused the abrupt termination of grain filling stages which led to a decline in yield and grain quality. The results of these studies would be valuable in terms of its growing as forage crop as well as in terms of its breeding for grain quality and productivity.

Key words: *winter barley, nitrogen, weather conditions, a 1000 grain mass, hectoliter mass.*

Introduction

Barley (*Hordeum sativum* L.) represents one of 40 species of the grass family *Hordeum* (*fam. Poaceae*). It is one of the oldest cultivated plants, and it has been known as a plant species for 10 000 years. Its importance is reflected in the remarkable plasticity and the possibility of growing in different environmental conditions as well as in its versatile use. According to Djuric et al (2009), in recent years, the production of barley in Serbia is done on the surface of 70-80 000 ha, with an average yield of about 3 to 3.5 t ha^{-1}. In our country barley is mostly used for livestock feed and beer production, rather than for human consumption.

Unlike other small grains, winter barley has higher requirements of growing technology, particularly with respect to nitrogen nutrition of the plant. Barley plants have shallower root system compared with other small grains, so they adopt less soluble substances from the soil poorly. If we take into account the sensitivity of barley genotypes expressed in increased rates of nitrogen fertilizer, mineral nutrition of barley must be adapted to the requirements of individual species (Peric, 1982; Jelic et al., 2002).

The aim of the research was to determine the possibilities of cultivation of winter barley in agro-ecological conditions of Montenegro, as well as the optimum amount of nitrogen in addition to provide high yield and good grain quality.

Material and method of work

Two varieties of winter barley (Grand and Record), created in the Center for Small Grains in Kragujevac, and three variants of nitrogen fertilization (80,100 and 120 kg ha^{-1}) were used as the material for this research. The tests were conducted in the north of Montenegro during two growing seasons (2005-2007). The trial was set in a randomized block system in four replications. The trial was conducted on alluvial soil and the size of experimental plot was 10 m^2. The technology common in the production of winter barley was used during the research. After manually performed harvest, in the stage of full maturity, hectoliter mass was measured as well as a 1000 grain mass and grain yield adjusted to 14% moisture.

The obtained results are given in average values, processed by the analyses of variance, and the significance was tested by the LSD test.

Results and discussion

Before the beginning of this study, the samples of the soil, on which the trial was conducted, were taken and their analyses was carried out. Based on the results, it was found that the soil has slightly acid reaction with total carbonate content of 5.62 to 5.63%,it is humus rich 3.98-4.35% and poor in available phosphorus (5.68-8.71 mg/100g soil) and potassium (4.47-3.71 mg/100g soil).

Table 1. Middle monthly air temperature and precipitation amount

Year	Month										Average
	X	XI	XII	I	II	III	IV	V	VI	VII	
Middle monthly air temperature (°C)											
2005-06	9.7	3.3	1.2	-2.6	0.4	4.2	11.1	14.6	16.8	19.0	7.77
2006-07	11.4	2.6	0.3	1.8	4.8	7.0	11.5	16.0	19.8	21.9	9.71
Precipitation amount (mm)											
2005-06	85.2	116.1	182.5	36.6	87.7	180.8	58.4	78.6	119	52.9	890.7
2006-07	39.5	74.6	182.5	92.9	45.8	104.7	15.7	60.8	76.9	23.9	717.3

Meteorological conditions i.e. temperature and precipitation are the main non-genetic factors that determine the success of cultivation of winter barley and other small grains. In the growing season 2005/06 there were 997.8mm of rainfall which is 280.5mm more than in the second year of the research, while the average air temperature was lower by 1.9°C. also, in October and November 2005/06 there were 201.3mm of rainfall, which is 87.2mm more than in the same period of 2006/07, while the average air temperature was lower for 1°C. From the above it can be concluded that the conditions for germination, emergence and development of plants in the first year were more favourable. The rainfall in December was the same. Significantly less rainfall during February, March, April and May in 2007, with higher air temperatures, caused the shortening of the period of grain filling and accelerated ripening, which has resulted in significantly lower yield compared to 2006.

A 1000 grain mass and hectoliter mass are important indicators of technological value of seeds. Such features are very important because they directly affect the yield.

Absolute grain mass

A 1000 grain mass is an indicator of coarseness i.e. grain size and it represents the relationship between weight and number of grains.

Both varieties included in the trial, in the first year had a 1000 grain mass which was significantly much higher compared to the second year of study. High air temperatures and low humidity in June and July in 2007 caused the shortening of the grain filling period compared to 2006. A 1000 grain mass is affected by growing conditions to a large extent as Przulj et al (1997) indicated.

In both tested genotypes, a 1000 grain mass was highest in the variant fertilized with 80 kg ha^{-1} in both years. Further increase of nitrogen has led to a reduction of values of absolute mass. Variety Record had the highest absolute mass (45.1g) when fertilized with 80kg ha^{-1} of nitrogen, and the same variety had the lowest absolute mass (35.9g) when fertilized with 120 kg ha^{-1} of nitrogen. Our results are in agreement with the results of Przulj and Momcilovic (2002) where a dose of 80 kg ha^{-1} of nitrogen is referred to as optimal from the point of seed size.

Table 2. Absolute mass of grains of winter barley (g)

Year (C)	Cultivar (A)		(B) Fertilization (kg ha^{-1})				
			0	80	100	120	Average
2006	Grand		39	43	41.7	40.5	41.05
	Rekord		37.9	45.1	44.8	43	42.7
AVERAGE			38.45	44.05	43.25	41.75	41.9
2007	Grand		36	44	43	40	40.75
	Rekord		34.5	42	41	35.9	38.35
AVERAGE			35.25	43	42	37.95	39.55
Two-year average			36.85	43.5	42.6	39.85	40.7
LSD	A	B	AB	C	AC	BC	ABC
0.05	0.106	0.463	0.654	0.106	0.654	0.926	1.309
0.01	0.142	0.618	0.874	0.142	0.874	1.236	1.748

Hectoliter mass

Hectoliter mass is also an important indicator of the technological value of seed. The obtained results are in agreement with literature data, which point out that beside the variety and nutrition, meteorological conditions show significant influence on hectoliter mass. It can be seen from the table, that both varieties, in both years, had the highest value of hectoliter mass when fertilized with 80 kg ha^{-1} of nitrogen. Variety Grand had the highest hectoliter mass (63.4 kg) when fertilized with 80 kg ha^{-1} of nitrogen, while variety Record had the lowest hectoliter mass (60 kg) when fertilized with 120 kg ha^{-1} of nitrogen, that is in accordance with the results (Thompson and Woodward, 1994) which show that nitrogen in higher quantities can adversely affect the quality of the grain. The data in the table indicate the great dependence of hectoliter mass of meteorological conditions in the years of study, since both varieties had significantly higher values of the tested feature compared to the second year. Przulj et al., (1997) emphasized in their work the significant influence of the year on the hectoliter mass.

Table 3. Hectoliter mass of winter barley (kg)

Year (C)	Cultivar (A)		(B) Fertilization (kg ha^{-1})				
			0	80	100	120	Average
2006	Grand		60.1	63.4	62.4	60.8	61.7
	Rekord		61.2	63.3	62.2	60.6	61.9
AVERAGE			60.65	63.35	62.3	60.7	61.8
2007	Grand		59.3	62.5	62	60.2	61
	Rekord		60.2	62.3	62	60	61.1
AVERAGE			59.75	62.4	62	60.1	61.1
Two-year average			60.2	62.9	62.15	60.4	61.45
LSD	A	B	AB	C	AC	BC	ABC
0.05	0.476	0.673	0.673	0.476	0.673	0.952	1.346
0.01	0.635	0.898	0.898	0.635	0.898	1.271	1.797

Grain yield

Grain yield is a complex feature of polygenic mode of inheritance. It is the resultant of the interaction of the variety, the applied agro-techniques and growing conditions throughout the entire life cycle.

Table 4. Grain yield of winter barley (kg ha^{-1})

Year (C)	Cultivar (A)		(B) Fertilization (kg ha^{-1})				
			0	80	100	120	Average
2006	Grand		4475	4937.5	4840	4252.5	4626.25
	Rekord		3425	4060	3922.5	3275	3670.6
AVERAGE			3950	4498.75	4381.25	3763.75	4148.4
2007	Grand		4200	4640	4550	3982.5	4343.12
	Rekord		3180	3950	3880	2930	3485
AVERAGE			3690	4295	4215	3456.25	3914.1
Two-year average			3820	4396.9	4298.12	3610	4031.25
LSD	A	B	AB	C	AC	BC	ABC
0.05	172.98	244.64	345.977	172.979	244.643	345.977	489.285
0.01	231.04	326.69	462.009	231.040	326.690	462.009	653.379

The data in the table show that the application of nitrogen in the supplementary feeding of barley showed a significant increase in grain yield compared to the control. Both tested genotypes had the highest yield when the smallest amount of nitrogen (80 kg ha^{-1}) was used in the supplemental nutrition, while further increase in nitrogen led to a reduction in yield. Variety Grand, in both years, had very significantly higher yield (4484.7 kg ha^{-1})with all variants of fertilization compared to the other studied variety Record (3577.8 kg ha^{-1}). Variety Grand obtained the highest yield (4937.5 kg ha^{-1}) when using 80 kg ha^{-1} of nitrogen in the first year, while variety Record obtained the lowest yield (2930 kg ha^{-1}) at a dose of 120 kg ha^{-1} of nitrogen in the second year. Our results are in agreement with the results of Malesevic et al., (2010) which, according to their research, indicate that the highest yield was obtained when barley was fed with 80 kg ha^{-1} of nitrogen.

Conclusion

Using the results of this research of the effect of nitrogen and weather conditions on the yield and yield components of winter barley, the following conclusions can be drawn:

- Favourable climatic conditions in the first year have influenced all the tested features to have a significantly higher values compared to the second year of the research.
- Variety Grand, in both years, obtained higher values of hectoliter mass and grain yield in comparison with the other tested variety Record.
- Variety Record had the highest absolute mass (45.1g) when fertilized with 80 kg ha^{-1} of nitrogen, and the same variety had the lowest absolute mass (35.9g) when fertilized with 120 kg ha^{-1} of nitrogen.
- Variety Grand had the highest hectoliter mass (63.4 kg) when fertilized with 80 kg ha^{-1} of nitrogen, while variety Record had the lowest hectoliter mass (60 kg) when fertilized with 120 kg ha^{-1} of nitrogen.
- Variety Grand obtained the highest yield (4937.5 kg ha^{-1}) when using 80 kg ha^{-1} of nitrogen, in the first year, while variety Record obtained the lowest yield (2930 kg ha^{-1}) at a dose of 120 kg ha^{-1} in the second year of the research.
- Both varieties, in terms of yield, hectoliter mass and a 1000 grain mass, responded best at fertilizing dose of 80 kg ha^{-1} of nitrogen, while further increase of nitrogen led to a reduction in values of mentioned features.
- For the research area in the production of barley, we recommend the lowest applied dose of 80 kg ha^{-1} of nitrogen, and for the choice of variety, taking into account the level and quality of yield, we prefer variety Grand.

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