REACTION OF BARLEY VARIETIES TO NITROGEN-POTASSIUM FERTILIZATION

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Abstract: Reaction of barley varieties to nitrogen (0, 200, 400, 600 mg $N.kg^{-1}$ soil) and potassium (0, 200, 400 mg $K_2O.kg^{-1}$ soil) fertilization was studied on a background of 200 mg $P_2O_5.kg^{-1}$ soil under greenhouse conditions in a pot experiment. The highest grain yield and dry biomass in maturity was obtained at a moderate nitrogen and high potassium fertilization $N_{400}K_{400}$. High nitrogen-potassium supply $N_{600}K_{400}$ increased the grain protein concentration and protein yield. Genotypic response was established at moderate nitrogen fertilization combined with K_0-$_{400}$ where standard Obzor demonstrated the highest productivity, followed by Emon, and Krami.

Key words: barley, nitrogen, potassium, varieties

Introduction

The use of potassium fertilizers in Bulgaria was sharply decreased and the potassium balance from a positive (+90 kg.ha-^{1}) has become a negative (Gorbanov et al., 2000). Potassium nutrition of barley is influenced by levels of supplying of nitrogen, cultivation practices, crop species and environmental conditions (Dessougi et al., 2002; MacLead, 1999). The natural potassium reserves in Bulgarian soils are relatively high, but the need of potassium fertilization is increased under intensive nitrogen and phosphorus applications (Rachovski et al., 2010). Compared to N, the application of phosphorus and potassium has been neglected from many farmers and this has resulted in the continual depletion of soil P and K (Tomov et al., 2006). Inadequate potassium applications lead to imbalance in agricultural ecosystems and stagnation of yields will become more pronounced with time (Regmi et al,. 2002). Long term experiments have shown that high yields and good grain quality can be achieved from balanced NPK supply (Belay et al., 2011). A nitrogen-potassium interaction generally exists in agricultural ecosystems (Brar et al., 2009). The genotypic differences in the efficiency of absorption of potassium were established (Dessougi et al. 2002). Mechanisms which lead to higher efficiency of potassium absorption were mainly connected to the size of the root system and the ability of plants to increase the solubility of nitrogen in the rhizosphere (Steingrobe and Claassen 2000; Rengel and Damon 2008). The effect of potassium fertilization on the productivity and grain quality of barley grown on soils with different availability of potassium in Bulgaria was studied on a small scale. The objective of the present study was to establish the effect of increased levels of nitrogen and potassium on the yield and grain quality of barley plants under pot experiments.

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Material and methods

A pot experiment with increased nitrogen and potassium fertilization levels was conducted under greenhouse conditions with Bulgarian barley varieties Obzor, Emon and Krami. The effect of different levels of nitrogen and potassium fertilization was studied on the background of phosphorus fertilization 200 mg $P_2O_5.kg^{-1}$ soil. The investigated levels of nitrogen and potassium were 0, 200, 400 mg $N.kg^{-1}$ soil and 0, 200, 400 mg $K_2O.kg^{-1}$ soil, respectively. The plants were grown in plastic pots (5L volume). Each pot contained 5 kg Molic fluvy soil with $pH_{(H2O)}$ - 7.3, humus content 3.2%, Nmin - 29.8 mg $N.kg^{-1}$, available phosphorus (method of Egner - Riehm) - 109 mg $P_2O_5.kg^{-1}$, and available potassium (2 N HCL) - 330 mg $K_2O.kg^{-1}$. The levels of nitrogen, phosphorus and potassium in the soil were created by applying NH_4NO_3, $Ca(H_2PO_4)_2.H_2O$, and K_2SO_4 dissolved in water.

Thirty seeds were sown in each pot at the beginning of December. The barley plants were reduced to equal number in each pot (15) at the tillering stage. The analyses of plant vegetative mass and grain were done after wet combustion using concentrated H_2SO_4 and H_2O_2 as a catalyst by using common methods. The grain protein concentrations were calculated by multiplying total nitrogen concentrations of grain by factor 5.7 (% N total x 5.7). An overall analysis of variance (ANOVA) was performed to evaluate the effect of the experimental treatments on the referred variables, and Duncan's multiple range test (α = 0.95) was used in order to establish the difference among the means.

Results and discussion

The level of nitrogen supply was the main factor affecting barley productivity of grain and dry biomass in maturity (Table 1 and Table 2). The results showed no significant differences in grain yields and accumulated aboveground dry biomass in maturity among the studied varieties. The productivity of barley was increased in parallel with the increase of applied nitrogen up to level N_{400} and it was observed in all three levels of potassium in the soil. Barley varieties produced the highest average grain yield and dry biomass yield at a fertilization level $N_{400}K_{400}$.

Table 1. Grain yield of barley depends on fertilization and variety, g.pot^{-1}

Main Factors	K_0	K_{200}	K_{400}
Nitrogen			
N_0	4.1 d*	7.6 d	7.7 d
N_{200}	17.6 c	19.0 c	23.2 c
N_{400}	24.1 a	25.6 a	27.6 a
N_{600}	21.2 b	22.3 b	25.4 b
Variety			
Obzor	18.2 ns	19.9 ns	22.2 ns
Emon	16.2	18.2	21.2
Krami	15.8	17.8	19.5

*Values in each column followed by the same letters are not significantly different at $p<0.05$ according to Duncan's multiple range test.

Table 2. Dry biomass of barley in maturity depends on fertilization and variety, $g.pot^{-1}$

Main Factors	K_0	K_{200}	K_{400}
Nitrogen			
N_0	11.6 d*	20.8 d	22.1 c
N_{200}	48.2 c	52.0 c	65.0 b
N_{400}	73.8 a	73.6 a	79.2 a
N_{600}	63.9 b	59.4 b	74.1 a
Variety			
Obzor	52.6 ns	56.4 ns	62.6 ns
Emon	46.6	48.3	63.0
Krami	49.0	49.6	54.6

*Values in each column followed by the same letters are not significantly different at $p<0.05$ according to Duncan's multiple range test.

The high level of soil nitrogen resulted in decreased productivity of grain and dry biomass of barley and it was demonstrated in all studied levels of potassium fertilization K_0, K_{200} and K_{400}.

Table 3. Grain yield of barley varieties in interaction with fertilization factors and variety, $g.pot^{-1}$

Variants	K_0	K_{200}	K_{400}
N_0 x Obzor	4.4 g*	7.6 g	8.0 g
N_0 x Emon	3.9 g	7.5 g	7.7 g
N_0 x Krami	3.8 g	7.7 g	7.4 g
N_{200} x Obzor	19.0 e	19.7 e	24.1 de
N_{200} x Emon	16.8 f	18.6 f	23.6 ef
N_{200} x Krami	17.0 f	18.7 f	22.0 f
N_{400} x Obzor	26.4 a	28.4 a	29.8 a
N_{400} x Emon	23.6 b	24.8 b	27.8 b
N_{400} x Krami	22.2 c	23.6 c	25.2 de
N_{600} x Obzor	23.2 bc	24.0 c	27.0 bc
N_{600} x Emon	20.4 d	21.7 d	25.7 cd
N_{600} x Krami	20.1 de	21.2 d	23.6 ef
Average	16.7ns	18.6	21.0

*Values in each column followed by the same letters are not significantly different at $p<0.05$ according to Duncan's multiple range test.

A tendency showed that potassium fertilization positively affected grain yield (Table 3). Average grain yield of barley varieties grown at levels K_{200} and K_{400} increased by 11.4 % and 25.7 %, respectively, to obtained yield of plants with no potassium fertilization. The significant difference among varieties Obzor, Emon and Krami did not demonstrate when barley plants were grown without nitrogen fertilization, regardless of the level of potassium fertilization. It was established a genotypic response of varieties at nitrogen level N_{400} indicated that variety Obzor had the highest productivity at the three levels of soil potassium, followed by a variety Emon, and variety Kram with the proven low yield.

Table 4. Concentration of protein in barley depends on fertilization and variety, %

Main Factors	K_0	K_{200}	K_{400}
Nitrogen			
N_0	9.81 d*	9.33 d	8.49 c
N_{200}	10.94 c	11.77 c	13.52 b
N_{400}	12.64 b	13.37 b	13.81 b
N_{600}	13.74 a	14.61 a	15.18 a
Variety			
Obzor	11.06 ns	12.16 ns	12.68 ns
Emon	12.39	12.34	13.04
Krami	11.90	12.31	12.53

*Values in each column followed by the same letters are not significantly different at $p<0.05$ according to Duncan’s multiple range tests.

The nitrogen fertilization significantly increased concentration of protein of barley grain (Table 4). This was established in all three soil levels K_0, K_0 and K_0. The highest content of protein in the grain, 15.18%, was obtained with combined high nitrogen-potassium fertilization $N_{600}K_{400}$. The changes of potassium nutrient regime by fertilizing alone in a range K_0 - K_{400} on the background of N_0P_{200}, slightly changed the grain protein concentrations of studied barley varieties.

Table 5. Concentration of protein of barley in interaction with fertilization factors and variety, %

Variants	K_0	K_{200}	K_{400}
N_0 x Obzor	7.87 f*	8.84 f	8.03 g
N_0 x Emon	10.66 e	10.06 e	9.14 f
N_0 x Krami	10.90 e	9.11 f	8.28 g
N_{200} x Obzor	10.53 e	12.07 c	13.09 e
N_{200} x Emon	11.87 d	11.20 d	13.61 cde
N_{200} x Krami	10.43 e	12.03 c	13.87 cd
N_{400} x Obzor	12.29 cd	13.24 b	14.12 bc
N_{400} x Emon	13.00 bc	13.43 b	14.00 c
N_{400} x Krami	12.63 c	13.43 b	13.32 de
N_{600} x Obzor	13.56 ab	14.47 a	15.49 a
N_{600} x Emon	14.03 a	14.68 a	15.40 a
N_{600} x Krami	13.63 ab	14.68 a	14.65 b
Average	11.8ns	12.3	12.8

*Values in each column followed by the same letters are not significantly different at $p<0.05$ according to Duncan’s multiple range tests.

The similar average concentrations of grain protein of barley in a range 11.8 – 12.8 % were obtained under potassium fertilization 0, 200 and 400 mg $K_2O.kg^{-1}$ soil (Table 5). The lowest concentration of protein in the grain 7.87% was obtained in Obzor variety grown without nitrogen and potassium fertilization. The interaction between high nitrogen-potassium fertilization $N_{600}K_{400}$ and varieties Obzor and Emon resulted in the highest protein concentrations of grain 15.49% - 15.40 %.

The best results with regard to the grain protein yield were observed when a high potassium fertilization K_{400} was combined with higher nitrogen supply N_{400} and N_{600}

(Table 6). Similar to the results obtained for grain yield and biomass, varieties Obzor, Emon and Krami did not significantly differ in the grain protein yield, regardless of potassium fertilization ranging K_{0}-$_{400}$.

Table 6. Grain protein yield of barley depends on fertilization and variety, g.pot^{-1}

Main Factors	K_0	K_{200}	K_{400}
Nitrogen			
N_0	0.39 c*	0.71 c	0.65 c
N_{200}	1.92 b	2.24 b	3.14 b
N_{400}	3.04 a	3.42 a	3.82 a
N_{600}	2.91 a	3.26 a	3.87 a
Variety			
Obzor	2.18 ns	2.57 ns	3.05 ns
Emon	2.09	2.34	2.94
Krami	1.93	2.31	2.62

*Values in each column followed by the same letters are not significantly different at $p<0.05$ according to Duncan's multiple range test.

Conclusion

Bulgarian barley varieties Obzor, Emon and Krami produced the highest yields of grain and dry biomass at a moderate nitrogen and high potassium fertilization level $N_{400}K_{400}$. High nitrogen-potassium $N_{600}K_{400}$ supply of barley significantly increased the concentration of protein in the grain and grain protein yield. Barley varieties had a similar productivity and grain quality when they were grown without nitrogen fertilization and levels of potassium fertilization K_0, K_{200} and K_{400}. Genotypic response of barley was established at moderate nitrogen fertilization combined with K_{0}-$_{400}$. Obzor had the highest productivity, followed by Emon variety, and Krami with the proven low yield. The interaction of high nitrogen-potassium fertilization $N_{600}K_{400}$ and varieties Obzor and Emon resulted in the highest protein concentrations in grain 15.49 % - 15.40 %.

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