WHEAT MINERAL NUTRITION AND QUALITY

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ABSTRACT: The bread-making quality was investigated in seven Kg winter wheat cultivars KG-56, Toplica, Takovčanka, Studenica, Lazarica, KG-100 and Matica that were grown at Kragujevac at 16 variants of fertilization and control variant without fertilization. Investigation was performed at a long-term stationary field trial. Analysis of sedimentation value, gluten content and thousand-grain weight were carried out. Grain quality of wheat significantly increased under NPK application. Sedimentation value and gluten content increased under N application and depended on analyzed cultivars. The NP and NK application are influenced positively on grain quality. The highest values of sedimentation in average for all cultivars were found at N_2 (53 ml) and $N_2P_1K_1$ (52 ml) variants, and wet gluten content at N_2P_2 (44.32%) and N_2 (42.51%) variants. Enhancer cultivars Toplica and Kg-56 were shown the best quality of all. In all investigated cultivars the lowest values of quality parameters were found at N_1P_1 and N_1P_2 variants. Combination NP nutrients had the best positive effect on grain quality. The highest thousand-grain weight was obtained at N_2 (36.20 g) and P_2 (35.62 g) variants. In average for all variants Matica cultivar had the highest thousand-grain weight (36.55 g) of all.

Key words: wheat, mineral nutrition, sedimentation, gluten content, thousand grain weight

INTRODUCTION

The suitable nutrient application in wheat needs knowledge about influence special nutrient on grain yield and quality. Deficiency of one fertilizer caused badly effects of other fertilizers, especially in the case of bad soil supply of that nutrient (Kostić, 1986). The uptake and utilization of nitrogen depend on the provision of soil by other mineral elements, such as phosphorus in particular (Djokić and Stojanović, 1998). Nitrogen fertilization causes increasing of protein content and other parameters of grain quality. Wheat quality is a complex subject. It depends on the genetic potential of wheat cultivars and the growing conditions.

The aim of this work was to study the influence of individual and all combinations of nitrogen, phosphorus and potassium fertilizers on grain quality characteristics of wheat.

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MATERIALS AND METHODS

Seven Kg winter wheat cultivars (KG-56, Toplica, Takovčanka, Studenica, Lazarica, KG-100 and Matica) were grown at Center for Small Grains Kragujevac. Investigation was performed at a long-term stationary field experiment, established in 1970. The soil has been pretty good supplied in available potassium, deficient in mineral forms of nitrogen, and very deficient in available phosphorus. The experiment had 16 variants of fertilization and control variant without fertilization: N_1=80 and N_2=120 $kgha^{-1}N$ (KAN 27%), P_1=60 and P_2=100 $kgha^{-1}P$ (P_2O_5 18%) and K_1=80 and K_2=100 $kgha^{-1}K$ (KCL 60%), individual and its combinations ($N_1P_1K_1$, $N_1P_2K_1$, N_1P_2, N_1P_1, N_1K_1, $N_2P_1K_1$, $N_2P_2K_1$, N_2P_2, N_2P_1 and N_2K_1). The method of the experiment was described in previous paper by Jelić et al. (2003). This study was accomplished in a two years (2002-2003), and the results are presented as average. The sedimentation value was determined by *Zelen*-y method, and gluten content and thousand grains weight (TGW) by standard methods (Kaludjerski and Filipović, 1998).

RESULTS AND DISCUSSION

Sedimentation value. The bread-making quality can be determined by Zeleny method, because of high positive correlations between sedimentation and loaf volume. The sedimentation values are presented in Table 1. The NPK fertilization is influenced positively on sedimentation value. In the case of N application only, the sedimentation was significantly increased. The phosphorus and potassium effect on sedimentation were positive and high significant. Investigated cultivars were differed of sedimentation values in dependence of NPK doses. The enhancer cultivars Kg-56 (63 ml) and Toplica (66 ml), and bread cultivars Studenica (65 ml) and Kg-100 (50 ml) had the highest sedimentation values at $N_2P_1K_1$ variant. But bread cultivars Takovčanka (57 ml) and Matica (38 ml) had the highest sedimentation at N_2K_1 variant. In average for all variants Toplica (53 ml) and Kg-56 (50 ml) had the highest sedimentation values. In average for all cultivars the highest sedimentation values were found at N_2 (53 ml) and at $N_2P_1K_1$ (52 ml) variants. Phosphorus nutrition influenced positively on nitrogen assimilation as mean as P increased protein fraction of nitrogen, what conditioned increasing of sedimentation at N and P combinations (Kostić et al., 1990). In all investigation cultivars the lowest sedimentation values were found at N_1P_1 and N_1P_2 variants. Genetically high quality cultivars (enhancer) require less quantity of fertilizers than bread and basic cultivars to realize good quality (Djokić, 1986; Malešević et al., 1996; Djurić, 2003).

Gluten content. Obtained results of wet gluten content are presented in Table 2. Application of different fertilizers influenced significantly on increasing of gluten content at all investigation cultivars. With N application realized higher increasing of gluten content than with P and K application. Potassium had higher positive influence on gluten content than phosphorus, may be because of well supplied our soil with K. Potassium improved translocation of nitrogen which resulted mainly in higher contents of prolamin, glutelin and soluble amino acids in the grain (Koch and Mengel, 1977). The highest value of wet gluten content established with N_2P_2 application at Kg-56 (52.20%), Toplica (49.11%), Takovčanka (41.56%), Studenica (41.22%) and Matica (43.20%). But cultivars Lazarica (42.06%) and Kg-100 (44.56%) had the highest gluten content at $N_2P_2K_1$ variant. In average for all cultivars the highest wet gluten content established at N_2P_2

(44.32%) and at N_2 (42.51%) variants. The highest values of gluten content in average for all variants had enhancer cultivars Kg-56 (42.02%) and Toplica (41.83%).

Table 1. Sedimentation value in different fertilization of wheat (ml)

Variants	Cultivar							Ave-rage
	Kg-56	Toplica	Takovčanka	Studenica	Lazarica	Matica	Kg-100	
Control	29	26	23	26	21	19	23	24
N_1	51	56	44	50	48	30	47	47
P_1	55	56	39	46	43	29	31	43
K_1	57	59	45	58	47	34	41	49
$N_1P_1K_1$	38	35	29	29	29	28	45	33
$N_1P_2K_1$	38	38	27	28	30	23	34	31
N_1P_2	35	36	24	27	25	22	35	29
N_1P_1	38	31	27	28	21	26	25	28
N_1K_1	50	62	40	46	38	30	28	42
N_2	60	64	54	57	55	33	49	53
P_2	55	62	51	61	44	30	48	50
K_2	57	61	43	64	40	28	47	49
$N_2P_1K_1$	63	66	41	65	47	32	50	52
$N_2P_2K_1$	59	64	38	57	48	27	46	48
N_2P_2	59	63	57	40	55	35	47	51
N_2P_1	49	61	43	47	52	36	44	47
N_2K_1	56	61	57	61	40	38	44	51
Average	50	53	40	46	40	29	40	–

Legend: N_1=80 and N_2=120 $kgha^{-1}$N; P_1=60 and P_2=100 $kgha^{-1}$P; K_1=80 and K_2=100 $kgha^{-1}$K

Physical properties of wet gluten differed and depended on cultivar and nutrition. Toplica, Kg-56, Takovčanka and Studenica had gluten with excellent physical properties (elastic and pearl colored). At N_1P_2 and N_1P_1variants established a little adhesive, mild and non-elastic gluten, but at N_2P_2 and N_2P_1 established strength, elastic and swell gluten. Nitrogen fertilization increased gluten content in all cultivars and improved its baking properties. This effect was more pronounced in enhancer cultivars, and agree with previous studies (Darkanbayev and Zairov, 1970; Souza et al., 2004). The results point had significant influence of nitrogen application on sedimentation and gluten content. Effect of P and K on sedimentation and gluten content increases in combination of NPK fertilizers and had the highest influence in the variants $N_2P_1K_1$ and $N_2P_2K_1$.

Table 2. Wet gluten content in different fertilization of wheat (%)

Variants	Cultivar							Ave-rage
	Kg-56	Toplica	Takovčanka	Studenica	Lazarica	Matica	Kg-100	
Control	35.56	27.27	20.49	25.35	29.55	24.60	26.89	27.10
N_1	43.80	39.57	34.74	40.53	38.91	40.84	40.74	39.88
P_1	48.99	46.86	35.01	38.79	36.66	37.14	35.45	39.84
K_1	46.92	44.39	31.08	39.93	37.77	39.31	36.96	39.48
$N_1P_1K_1$	34.02	33.06	44.01	28.20	30.78	28.95	31.11	32.88
$N_1P_2K_1$	34.98	36.36	26.65	27.00	30.21	28.74	32.70	30.95
N_1P_2	31.86	36.03	20.49	27.75	26.67	28.50	29.20	28.64
N_1P_1	31.68	31.62	29.97	26.31	29.55	27.78	27.81	29.24
N_1K_1	39.66	44.31	35.85	37.98	40.14	35.70	32.65	38.04
N_2	48.42	48.15	35.91	41.19	40.41	42.18	41.34	42.51
P_2	39.12	47.10	38.55	39.96	41.88	41.04	41.19	41.26
K_2	42.63	43.74	39.93	38.37	37.56	37.50	38.85	39.80
$N_2P_1K_1$	43.29	47.79	39.93	39.72	40.23	43.17	41.82	42.28
$N_2P_2K_1$	46.74	41.79	35.67	34.92	42.06	40.60	44.56	40.90
N_2P_2	52.20	49.11	41.56	41.22	40.53	43.20	42.45	44.32
N_2P_1	47.70	47.91	37.05	33.15	41.43	38.94	35.85	40.29
N_2K_1	46.71	46.11	41.55	35.79	41.49	40.68	38.52	41.55
Average	42.02	41.83	34.61	35.07	36.81	36.40	36.36	-

Legend: N1=80 and N2=120 kgha-1N; P1=60 and P2=100 kgha-1P; K1=80 and K2=100 kgha-1K

Thousand-grain weight (TGW). Thousand-grain weight was controlled as an attribute of physical wheat quality, which indicated milling quality. It depends on the genetic potential of wheat cultivars and the growing conditions. In this investigation TGW differed and depended on kind of fertilizers and its combinations. It was the highest at N_2 and P_2 variants, and the lowest with only phosphorus and potassium application at P_1 and K_1 variants.

Nitrogen and phosphorus fertilization increased TGW, that increasing was more pronounced with higher N (120 kg ha^{-1}) and higher P (100 kg ha^{-1}) doses. In average for all cultivars the highest TGW was obtained at N_2 (36.20 g) and at P_2 (35.62 g) variants. The highest value of TGW in average for all variants had Matica cultivar (36.55 g). Obtained results agree with previous studies (Kostić et al., 1990; Jelić and Kostić, 1992).

Table 3. Thousand-grain weight in different fertilization of wheat (g)

Variants	Cultivar							Ave-rage
	Kg-56	Toplica	Takovčanka	Studenica	Lazarica	Matica	Kg-100	
Control	31.63	30.63	31.38	27.89	25.42	33.62	24.20	29.25
N_1	35.37	35.78	35.97	32.86	30.72	37.43	34.99	34.73
P_1	33.09	31.93	33.12	31.24	28.05	34.21	30.63	31.75
K_1	32.09	31.72	32.88	28.76	27.62	35.35	28.54	30.99
$N_1P_1K_1$	36.29	34.64	32.77	30.83	30.31	35.33	33.23	33.34
$N_1P_2K_1$	36.92	34.16	31.81	30.7	29.41	33.93	34.80	33.10
N_1P_2	36.08	34.57	33.87	31.54	30.86	36.44	34.42	34.00
N_1P_1	37.50	34.89	34.05	30.83	28.71	37.79	36.45	34.32
N_1K_1	35.79	36.19	34.87	33.2	28.27	37.34	28.21	33.41
N_2	37.79	36.19	36.70	35.48	31.31	38.14	37.79	36.20
P_2	37.17	36.54	38.36	34.87	30.08	39.12	33.59	35.62
K_2	35.46	34.92	35.42	33.18	29.19	38.77	36.74	34.86
$N_2P_1K_1$	35.49	31.86	34.73	32.75	30.44	37.88	35.85	34.14
$N_2P_2K_1$	34.99	33.78	34.94	30.51	27.66	35.78	34.23	33.13
N_2P_2	34.94	34.14	34.61	32.72	28.96	37.74	34.30	33.92
N_2P_1	33.77	36.19	33.61	30.97	28.11	35.50	34.48	33.23
N_2K_1	33.05	33.46	34.12	30.83	28.59	37.01	32.48	32.79
Average	35.14	34.21	34.31	31.72	29.04	36.55	33.23	-

Legend: N1=80 and N2=120 kgha-1N; P1=60 and P2=100 kgha-1P; K1=80 and K2=100 kgha-1K

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