EFFECT OF NITROGEN RATE ON GRAIN YIELD OF BREAD WHEAT GENOTYPES

Biljana GORJANOVIĆ [1*], Miroslav ZORIĆ [2], Marija KRALJEVIĆ-BALALIĆ[1]

[1]Faculty of agricultural, Novi Sad, Serbia
[2]Faculty of technology, Novi Sad, Serbia

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The improvement in grain yield is the main objective of bread wheat breeding programs. Numerous studies indicate that nitrogen is the key factor of yield and quality in the wheat. The goal of this paper is to investigate variability of grain yield, of twelve bread wheat genotypes, on three nitrogen level. ANOVA showed that this trait was mostly under influence of the genotype (36, 3%), year × genotype interaction (26, 3%), year of investigation (14, 1%), and in the smallest amount of the nitrogen rate (8, 8%). On all three nitrogen level, the highest grain yield was found in the variety Malyska. The lowest grain yield in control was found in the variety Nevesinjka, while in the N_{75} and N_{100} rates it was found in the variety Tamaro. The mean performance of individual cultivars, in nine

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Corresponding author: Gorjanović Biljana, Dušana Jerkovića 22, 22320 Inđija, 065 8432167, e-mail: lazzaric@ptt.rs

environments (three years × three nitrogen rates), was depicted using which-won-were view of SREG2 biplot. The nine environments fall into two sectors, which is an indication of a strong crossover GE interaction. Genotype Malyska was the winner (the highest yielding variety) in first sector containing seven environments, while genotypes Pertrana and Axis were the winners in second sector containing two environments.

Key words: grain yield, nitrogen, sites regression (SREG) model, wheat

INTRODUCTION

The constant increase of use of nitrogen fertilizers leads to numerous ecological and health problems. One of the ways to solve these problems is creating genotypes that will give the appropriate yield with limited application of mineral fertilizers, i.e. genotypes with increased nitrogen uptake and nitrogen use efficiency.

MOMČILOVIĆ et al. (1990) stated that differences among genotypes in terms of nitrogen concentration in plant tissue were not so pronounced, while KRALJEVIĆ-BALALIĆ et al. (1991), MAY et al. (1997), LE GOUIS et al. (2000) and KRALJEVIĆ-BALALIĆ (2001) found significant variation among genotypes in plant nitrogen concentration. Parameters such as nitrogen harvest index, nitrogen remobilization efficiency and straw nitrogen content could be used in the development of cultivars with desired nitrogen use efficiency (VAN SANFORD and MC KOWN, 1987; KRALJEVIĆ-BALALIĆ et al., 1995; BARBOTTIN et al., 2005; GORJANOVIĆ et al., 2010).

Nitrogen (N) is the key factor of yield and quality in the cereals. Numerous studies indicate that N fertilization can increase both wheat grain yield and grain protein content (FOWLER et al., 1990; EHDAIE and WAINES, 2001; SUBEDI et al., 2007; GORJANOVIĆ and KRALJEVIĆ-BALALIĆ, 2008). The goal of this paper is to investigate variability of grain yield, of twelve bread wheat genotypes, on three nitrogen level, in the three-year period.

MATERIALS AND METHODS

The 12 bread wheat cultivars were studied in the three-year (2004-05, 2005-06 and 2006-07 growing seasons) field trial with three nitrogen rates (0, 75, 100 kg/ha N). Five cultivars originated from Serbia (Evropa 90, Nevesinjka, Pobeda, Zlatka and Sonata), five from Slovakia (Ilona, Malyska, Vanda, Petrana and Axis), one from France (Renan) and one from Switzerland (Tamaro). The experiment was conducted at the experimental field of the Institute of Field and Vegetable Crops, Novi Sad. The sowing rate was 600 grains/m^2. Plot size was 5 m^2. In all three years 45 kg/ha of each N, P and K before plowing were applied. In spring three N levels were applied (0, 75, 100 kg/ha N). Standard agronomic practices were used to keep the plots free of diseases. The grain yield was determinate at maturity.

The mean performance of individual cultivars, in nine environments (three years × three nitrogen rates: E1N1, 2004/05-N_0; E1N2, 2004/05-N_{75}; E1N3, 2004/05-N_{100}; E2N1, 2005/06-N_0; E2N2, 2005/06-N_{75}; E2N3, 2005/06-N_{100}; E3N1, 2006/07-N_0; E3N2, 2006/07-N_{75}; E3N3, 2006/07-N_{100}), was depicted using which-

won-were view of sites regression-SREG2 biplot (Yan et al., 2000). The SREG model is: $y_{ij} - \mu - \beta_j = \lambda_1 \alpha_{i1} \gamma_{j1} + \lambda_2 \alpha_{i2} \gamma_{j2} + \varepsilon_{ij}$, where y_{ij} is the mean grain yield of ith genotype at j^{th} environment; μ is grand mean; β_j is the main effect of jth environment; λ_1 and λ_2 are the sngular values for the first and second bilinear terms (PC1 and PC2, respectively); α_{i1} and α_{i2} are eigenvectors of ith genotype for PC1 and PC2, respectively; γ_{j1} and γ_{j2} are eigenvectors of jth environment for PC1 and PC2, respectively; ε_{ij} is the residual of unexplained variation associated with i^{th} genotype at j^{th} environment. All statistical analyses were done using *R* software (R Development Core Team, 2009).

RESULTS AND DISCUSSION

ANOVA showed that grain yield was mostly under influence of the genotype (36, 3%), year × genotype interaction (26, 3%), year of investigation (14, 1%), and in the smallest amount of the nitrogen rate (8, 8%). These results are in contradiction with the results of RHARRABTI *et al.* (2001) and FARER *et al.* (2006) who found that grain yield was mostly under influence of environmental factors. Significant differences were found between N_0 and N_{75} rate, N_0 and N_{100} rate, while there were no significant differences between N_{75} and N_{100} rates (Table 1). MA ET AL. (2004) found that the general trend was that higher N applications produces higher yield, but in some environments, higher N rates produced lower yields, associated with increased incidence of Fusarium head blight and other foliar diseases.

Table 1. ANOVA for grain yield

Source of variation	DF	Mean squares	F	%
Year	2	13,38	18,49**	14,1
Genotype	11	6,26	8,66**	36,3
Nitrogen rate	2	8,34	11,53**	8,8
Replication	1	0,40	0,55	0,2
Year × Genotype	22	2,27	3,14**	26,3
Year × N rate	4	0,53	0,74	1,1
Genotype × N rate	22	1,14	1,58	13,2
Error	151	0,72		
Total	216			
Significance of differences between N rates				
N rate			Differences	
N_0	N_{75}		-0,442**	
	N_{100}		-0,669**	
N_{75}	N_0		0,442**	
	N_{100}		-0,227	

* p<0.05; ** p<0.01

On all three nitrogen levels the grain yield was highest in 2005/06 growing season (x =6,34 t/ha, x =6,92 t/ha, x =7,08 t/ha), and a smallest in 2006/07 growing season (x =5,50 t/ha, x =6,12 t/ha, x =6,16 t/ha) (Table 2).

On N_0 rate, the highest grain yield was found in the variety Malyska ($\bar{x}$ =7,13 t/ha), while the lowest grain yield in control was found in the variety Nevesinjka ($\bar{x}$ =5,08 t/ha). On N_{75} rate, the most yielding varieties were Malyska ($\bar{x}$ =7,71 t/ha) and Vanda ($\bar{x}$ =7,13 t/ha), while the lowest grain yield was found in the variety Tamaro ($\bar{x}$ =5,31 t/ha). On the highest N rate, the highest grain yield was found in the varieties Malyska ($\bar{x}$ =8,00 t/ha), Petrana ($\bar{x}$ =7,78 t/ha) and Vanda ($\bar{x}$ =7,17 t/ha), while the lowest grain yield was found in the variety Tamaro ($\bar{x}$ =5,19 t/ha), table 2.

Table 2. Grain yield on thre nitrogen level

Genotype	N_0			$\overline{X}$	N_{75}			$\overline{X}$	N_{100}			$\overline{X}$
	2005	2006	2007		2005	2006	2007		2005	2006	2007	
Evropa 90	6,52	7,20	6,89	6,87	6,82	5,91	5,50	6,08	6,24	7,12	5,74	6,37
Nevesinjka	5,79	5,84	3,61	5,08	6,67	7,00	4,68	6,12	7,95	7,11	5,67	6,91
Pobeda	7,10	6,20	5,61	6,30	7,15	7,10	5,51	6,59	7,53	6,96	5,56	6,68
Zlatka	5,45	5,46	5,57	5,49	5,58	6,63	7,58	6,60	5,82	5,84	5,85	5,84
Sonata	6,94	7,21	5,21	6,45	5,79	7,98	5,98	6,58	7,90	7,47	5,47	6,95
Renan	4,84	6,80	5,93	5,86	5,06	6,81	6,89	6,25	5,20	6,68	6,84	6,24
Tamaro	5,63	5,81	5,20	5,55	4,88	5,92	5,13	5,31	4,76	6,40	4,41	5,19
Ilona	4,76	6,04	4,65	5,15	5,07	6,71	5,90	5,89	6,19	6,75	5,53	6,16
Malyska	7,20	6,93	7,27	7,13	7,80	7,37	7,95	7,71	7,71	8,06	8,24	8,00
Vanda	5,88	6,14	5,55	5,86	6,35	7,82	7,23	7,13	7,55	7,54	6,43	7,17
Petrana	6,63	5,96	5,12	5,90	7,68	7,04	5,25	6,66	7,98	7,64	7,72	7,78
Axis	7,76	6,43	5,43	6,54	7,10	6,80	5,80	6,57	6,89	7,42	6,42	6,91
$\overline{X}$	6,21	6,34	5,50		6,33	6,92	6,12		6,81	7,08	6,16	

The mean performance of individual cultivars, in nine environments (three years × three nitrogen rates), was depicted using which-won-were view of SREG2 biplot (Figure 1). This type of biplot are effective tool for study of mega-environments, defined as groups of test locations that share the best cultivar(s) consistently across yeas (YAN *et al*., 2000; BALALIĆ *et al.,* 2008).

A polygon is first drawn on genotypes that are furthest from the origine so that all other genotypes are contained within the polygon. Then perpendicular lines to each side of the poligon are drawn, starting from the biplot origine. Genotypes located on the vertices of the polygon performed either the best or the poorest in one or the more environments (YAN *et al*., 2000).
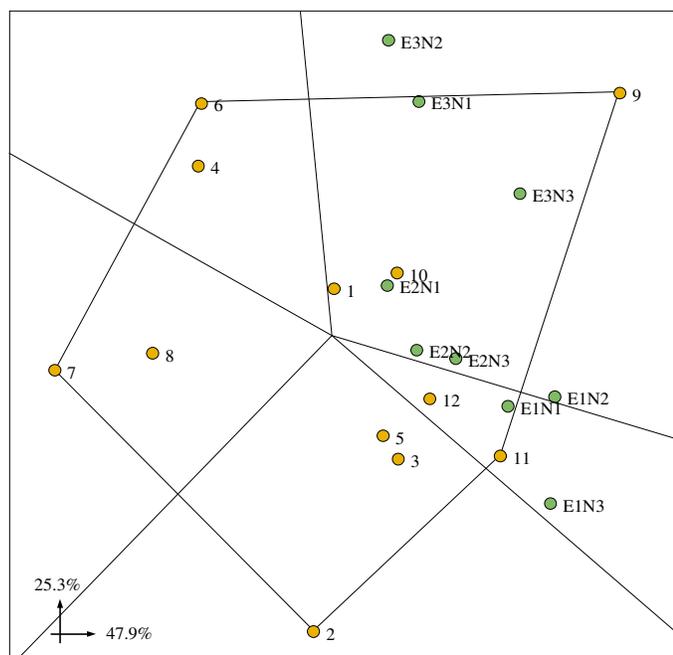
Figure 1. The "which-won-where" view of the SREG2 biplot for the genotype × environment two-way data, based on grain yield of 12 wheat genotypes. Abbreviations are: 1, Evropa 90; 2, Nevesinjka; 3, Pobeda; 4, Zlatka; 5, Sonata; 6, Renan; 7, Tamaro; 8, Ilona; 9, Malyska; 10, Vanda; 11, Petrana; 12, Axis; E1N1, 2004/05-N_0; E1N2, 2004/05-N_{75} ; E1N3, 2004/05-N_{100}; E2N1, 2005/06-N_0; E2N2, 2005/06-N_{75}; E2N3, 2005/06-N_{100}; E3N1, 2006/07-N_0; E3N2, 2006/07-N_{75}; E3N3, 2006/07-N_{100}.

      The distance between two genotypes approximates the Euclidean distance between them, which is the measure of overall dissimilarity between them. The dissimilarity can be due to difference in mean yield (G) and/or in interaction with the environments (GE) . Genotypes 5 (Sonata) and 3 (Pobeda), 6 (Renan) and 4 (Zlatka) and 7 (Tamaro) and 8 (Ilona) were quite similar (Figure 1).

      The length of the genotype vector, which is the distance between a genotype and a biplot origin, measures the difference of the genotype from the „average" genotype, i.e. its contribution to either G and GE or both. Therefore, genotype located near the biplot origine have little contribution to both G and GE and genotypes with longer vectors have large contributions to either G or GE or both. Therefore, genotypes with the longest vectors are either the best (Malyska) or the poorest (Tamaro).

The equality lines divide the biplot into sectors and the winning genotype for each sector is the one located on the respective vertex (YAN ET AL., 2000). The nine environments fall into two sectors, which is an indication of a strong crossover GE interaction. Genotype 9 (Malyska) was the winner (the highest yielding variety) in first sector containing seven environments (E3N2, E3N1, E3N3, E2N1, E2N2, E2N3, E1N2), while genotype 11 (Pertrana) and closely positioned genotype 12 (Axis) were the winners in second sector containing two environments (E1N1, E1N3) Figure 1.

Genotype Malyska performed best in E2 environments (2005/2006 growing season), which had the favourable weather conditions during the winter and vegetative growth, and E3 environments (2006/2007 growing season), which was caracterised by high temperatures in the winter and drought in the spring. Genotypes Petrana and Axis perfomed best in E1 environments (2004/2005 growing season) which was caracterised by water surplus at the beginning and at the end of the season, and low temperatures in the winter.

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UTICAJ DOZE AZOTA NA PRINOS GENOTIPOVA HLEBNE PŠENICE

Biljana GORJANOVIĆ[1], Miroslav ZORIĆ[2] i Marija KRALJEVIĆ-BALALIĆ[1]

[1]Poljoprivredni fakultet, Novi Sad
[2]Tehnološki fakultet, Novi Sad

I z v o d

Povećanje prinosa je glavni cilj u programima oplemenjivanja pšenice. Veliki broj autora navodi da je azot jedan od ključnih faktora u formiranju prinosa i kvaliteta kod pšenice. Cilj ovog rada je da se u trogodišnjem periodu ispita fenotipska varijabilnost prinosa dvanaest genotipova hlebne pšenice, na tri nivoa ishrane azotom. ANOVA je pokazala da je na ispoljavanje ovog svojstva najveći uticaj imao genotip (36,3%), zatim interakcija godina × genotip (26,3%) i godina (14,1%), a najmanji uticaj imala je doza azota (8,8%). Sorta Malyska je na sva tri nivoa ishrane imala najveći prinos. Najmanji prinos u kontroli je zabeležen kod sorte Nevesinjka, a na dozama N_{75} i N_{100} kod sorte Tamaro. Srednja vrednost genotipova, u devet sredina (kombinacija doza azota × godina), prikazana je pomoću „which-won-were" - SREG2 biplota. Devet sredina svrstano je u dva sektora, što je indikacija jake ukrštene (crossover) interakcije genotipa i spoljne sredine. Sorta Malyska je bila najprinosnija u prvom sektoru koji sadrži sedam sredina, dok su sorte Petrana i Axis bile najprinosnija u drugom sektoru koji sadrži dve sredine.