UDC 575:633.11
DOI: 10.2298/GENSR1102419G
Original scientific paper

PHENOTYPIC VARIABILITY OF BREAD WHEAT GENOTYPES FOR NITROGEN HARVEST INDEX

Biljana GORJANOVIĆ[1], Milka BRDAR-JOKANOVIĆ[2], and Marija KRALJEVIĆ-BALALIĆ[1]

[1]Faculty of Agriculture, Novi Sad, Serbia
[2]Institute for Vegetable Crops, Smederevska Palanka, Serbia

Gorjanović B., M. Brdar-Jokanović, and M. Kraljević-Balalić (2011): *Phenotypic variability of bread wheat genotypes for nitrogen harvest index*- Genetika, Vol 43, No.2, 419 -426.

Nitrogen harvest index (grain nitrogen content over total nitrogen content ratio) is a measure of the efficiency of nitrogen translocation from the vegetative portions of the plant to the grain. It can be recommended as a selection criterion for nitrogen use efficiency improvement. The aim of this study was to investigate nitrogen harvest index in twelve bread wheat genotypes at three nitrogen levels and to classify genotypes according to their phenotypic similarity for the examined trait. The results of factorial ANOVA showed that nitrogen harvest index was influenced mostly by the year × genotype interaction, year of investigation and genotype; and to the lowest extent by the applied nitrogen rate. Increasing nitrogen doses did

Corresponding author: Biljana Gorjanović, Dušana Jerkovića 22, 22320 Inđija, Serbia. Phone: +381 65 84 32 167, E-mail: lazzaric@ptt.rs

not lead to the increased nitrogen harvest index. The calculated nitrogen harvest index values were the highest for wheat growing season 2004/05, and the smallest for the season 2006/07. The highest nitrogen harvest indices were calculated for cultivars Pobeda at the N_0 rate and Zlatka at the N_{100} rate (0.93), and the lowest for cultivar Tamaro at the N_0 rate (0.63). Analyzing the constructed dendogram, cultivars Pobeda and Renan at all three levels of nitrogen supply can be singled out as the genotypes with the highest, and cultivar Tamaro as the variety with the lowest harvest index value. The results of this study may be used in developing new high-yielding bread wheat cultivars with improved nitrogen use efficiency. Growing such cultivars would provide the savings in mineral fertilizers and minimize their possible harmful effect on environment.

Key words: cluster analysis, nitrogen harvest index, wheat

INTRODUCTION

Improving yield, as the ultimate goal of each wheat breeding program, can be inter alia achieved through the research on traits and management practices responsible for tolerance to various abiotic (high temperature and drought, nutritional disorders) and biotic stresses, as well as through the research on adaptability and yield stability in particular environments. Besides on high and stable yields, much attention is focused on wheat quality parameters (BRDAR *et al.*, 2008, ANDERSON *et al.*, 2010, GORJANOVIĆ *et al.*, 2010, HRISTOV *et al.*, 2010). One of the possibilities for developing new high-yielding quality wheat cultivars is via improving nitrogen use efficiency (KRALJEVIĆ-BALALIĆ, 2001, HIREL *et al.*, 2007, GORJANOVIĆ *et al.*,2010, RAHIMIZADEH *et al.*,2010).

Nitrogen harvest index (the ratio of nitrogen content in grain and in the whole plant) is a measure of the efficiency of nitrogen translocation from vegetative organs to the grains. Nitrogen harvest index reflects the grain protein content and thus the grain nutrition quality (HIREL *et al.*, 2007). SLAFER *et al.* (1990) have studied the nitrogen harvest index in wheat genotypes and recorded a significant increase in the newer varieties. Nitrogen harvest index for wheat usually ranges from 0.70 to 0.80 (BRANCOURT-HUMMEL *et al.*, 2003, ANDERSSON, 2005).

The aim of this study was to investigate phenotypic variability of nitrogen harvest index in twelve bread wheat genotypes, grown at soil containing three nitrogen levels.

MATERIALS AND METHODS

Twelve bread wheat cultivars have been included in the three-year (2004/05, 2005/06 and 2006/07) complete randomized block designed field trial, with two replications. 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 trial was conducted at the experimental field Rimski Šančevi, Institute of Field and Vegetable Crops, Novi Sad. The main plot size was 5 m^2, with sowing rate of 600 grains/m^2. Before plowing, 45 kg/ha of each N, P and K were applied. The trial included control

(0); as well as two nitrogen treatments (75 and 100 kg/ha N), applied in the spring. Standard agronomic practices were used to keep the plots free from diseases. Grain yield was determined at maturity.

At maturity, ten plants per replication were cut at ground level. Samples were separated into vegetative (leaf + culm + chaff) and reproductive parts (grains). Each sample was weighed, oven-dried at 105ºC for 24 h and then weighed again. After drying, all samples were ground in a mill to generate 1-mm particles. The nitrogen content was determined by the standard Kjeldahl procedure. Nitrogen harvest index was calculated as the ratio of grain nitrogen content over total nitrogen content in above-ground parts at maturity.

The data was processed by factorial ANOVA. The cultivars were divided into groups according to degree of similarity for the examined trait, using hierarchical cluster analysis.

RESULTS AND DISCUSSION

The results of factorial ANOVA showed that nitrogen harvest index (NHI) was influenced mostly by the year × genotype interaction (52.70%), year of investigation (33.58%) and genotype (10.55%); and to the lowest extent by the applied nitrogen rate (1.56%), Table 1. In the study performed by BALDELLI *et al.* (1990), significant differences between years and no significant differences between genotypes in terms of NHI have been reported. On the other hand, BARRACLOUGH *et al.* (2010) noticed significant varietal differences concerning NHI.

Table 1. Factorial ANOVA for nitrogen harvest index in 12 wheat cultivars

Source of variation	DF	MS	F	%
Year	2	0.28	219.63**	33.58
Genotype	11	0.016	12.18**	10.55
Nitrogen rate	2	0.013	10.14**	1.56
Replication	1	0.0004	0.28	0.02
Year × Genotype	22	0.04	2.84**	52.70
Year × N rate	4	0.0008	0.66	0.19
Genotype × N rate	22	0.001	1.08	1.32
Error	151	0.001		
Total	216			

Significance of differences between N rates

N rate		Differences
$\mathbf{N_0}$	$\mathbf{N_{75}}$	0.019**
	$\mathbf{N_{100}}$	0.026**
$\mathbf{N_{75}}$	$\mathbf{N_0}$	-0.019**
	$\mathbf{N_{100}}$	0.006

* p<0.05; ** p<0.01

In our study, significant differences in NHI were found between control (N_0) and both N_{75} and N_{100} rates, while there was no significant difference between N_{75} and N_{100} rates (Table 1). Increasing doses of nitrogen did not lead to increased NHI; moreover, the majority of genotypes had the highest value on the control. This is in agreement with the results of LE GOUIS *et al.* (2000), RAHIMIZADEH *et al.* (2010) and BARRACLOUGH *et al.* (2010). ĐOKIĆ and LOMOVIĆ (1990) reported no significant change in NHI with increasing doses of nitrogen up to 120 kg N/ha, after which it began to decline. Similarly, CHEN *et al.* (2011) noted that high N application rates reduced the NHI.

The highest average NHI values have been calculated for 2004/05 (0.87, 0.84 and 0.84 for control (N_0) and N_{75} and N_{100} treatments, respectively), and the lowest for 2006/07 growing season (0.74, 0.73 and 0.72). Concerning genotypes, on control the highest average NHI had cultivars Pobeda (0.86) and Zlatka (0.85). As for N_{75} treatment, the highest NHI values have been calculated for Renan and Ilona (0.83 and 0.82, respectively), while cultivar Pobeda had the highest NHI on N_{100} treatment (0,84). The lowest NHI was noted for cultivar Tamaro (0.74, 0,74 and 0,75 on N_0, N_{75} and N_{100} rates, respectively), Table 2.

Table 2. Nitrogen harvest index at three nitrogen rates (N_0, N_{75}, N_{100}), in 12 wheat cultivars

Genotype	**N_0**				**N_{75}**				**N_{100}**			
	2005	**2006**	**2007**	$\bar{X}$	**2005**	**2006**	**2007**	$\bar{X}$	**2005**	**2006**	**2007**	$\bar{X}$
Evropa 90	0.89	0.83	0.73	**0.82**	0.89	0.80	0.69	**0.79**	0.85	0.83	0.76	**0.81**
Nevesinjka	0.90	0.83	0.68	**0.80**	0.85	0.78	0.76	**0.80**	0.86	0.77	0.71	**0.78**
Pobeda	0.93	0.86	0.78	**0.86**	0.84	0.84	0.76	**0.81**	0.91	0.86	0.76	**0.84**
Zlatka	0.92	0.85	0.77	**0.85**	0.91	0.76	0.76	**0.81**	0.93	0.76	0.77	**0.82**
Sonata	0.88	0.82	0.75	**0.82**	0.86	0.79	0.70	**0.78**	0.88	0.77	0.68	**0.78**
Renan	0.90	0.82	0.77	**0.83**	0.88	0.82	0.80	**0.83**	0.89	0.84	0.74	**0.82**
Tamaro	0.82	0.78	0.63	**0.74**	0.76	0.77	0.70	**0.74**	0.70	0.80	0.67	**0.72**
Ilona	0.86	0.83	0.74	**0.81**	0.86	0.82	0.78	**0.82**	0.79	0.85	0.80	**0.81**
Malyska	0.84	0.81	0.76	**0.80**	0.79	0.80	0.68	**0.76**	0.80	0.79	0.67	**0.75**
Vanda	0.81	0.81	0.76	**0.79**	0.82	0.80	0.68	**0.77**	0.79	0.81	0.66	**0.75**
Petrana	0.88	0.84	0.79	**0.84**	0.83	0.82	0.74	**0.80**	0.80	0.79	0.69	**0.76**
Axis	0.81	0.83	0.69	**0.78**	0.83	0.83	0.69	**0.78**	0.82	0.81	0.70	**0.78**
$\bar{X}$	**0.87**	**0.83**	**0.74**	**-**	**0.84**	**0.80**	**0.73**	-	**0.84**	**0.81**	**0.72**	-

Hierarchical cluster analysis has been employed in order to divide the analyzed wheat genotypes in groups, according to their phenotypic similarity in terms of NHI (Figure 1.). Dendograms depicting NHI at N_0 and N_{75} rates were almost identical. Two main clusters were formed, with the first one consisting of genotypes with the lowest NHI values (Tamaro, Malyska, Vanda and Axis). The second cluster can be divided into two sub clusters; the first one comprising genotypes characterized by average (Evropa, Sonata, Ilona and Nevesinjka at N_0; Evropa, Sonata and Zlatka at N_{75} rate) and the second one genotypes with the highest

NHI values (Pobeda, Zlatka, Petrana and Renan at N_0; Nevesinjka, Pobeda, Petrana, Renan and Ilona at N_{75}). As for N_{100} treatment, cultivars with the highest NHI values (Evropa, Pobeda, Renan and Zlatka) are singled out at the highest hierarchical level. At the second hierarchical level, the remaining cultivars with average NHI values (Nevesinjka, Sonata, Malyska, Petrana, Vanda and Axis) are clustered from the cultivars Tamaro (the lowest NHI) and Ilona (the highest NHI).

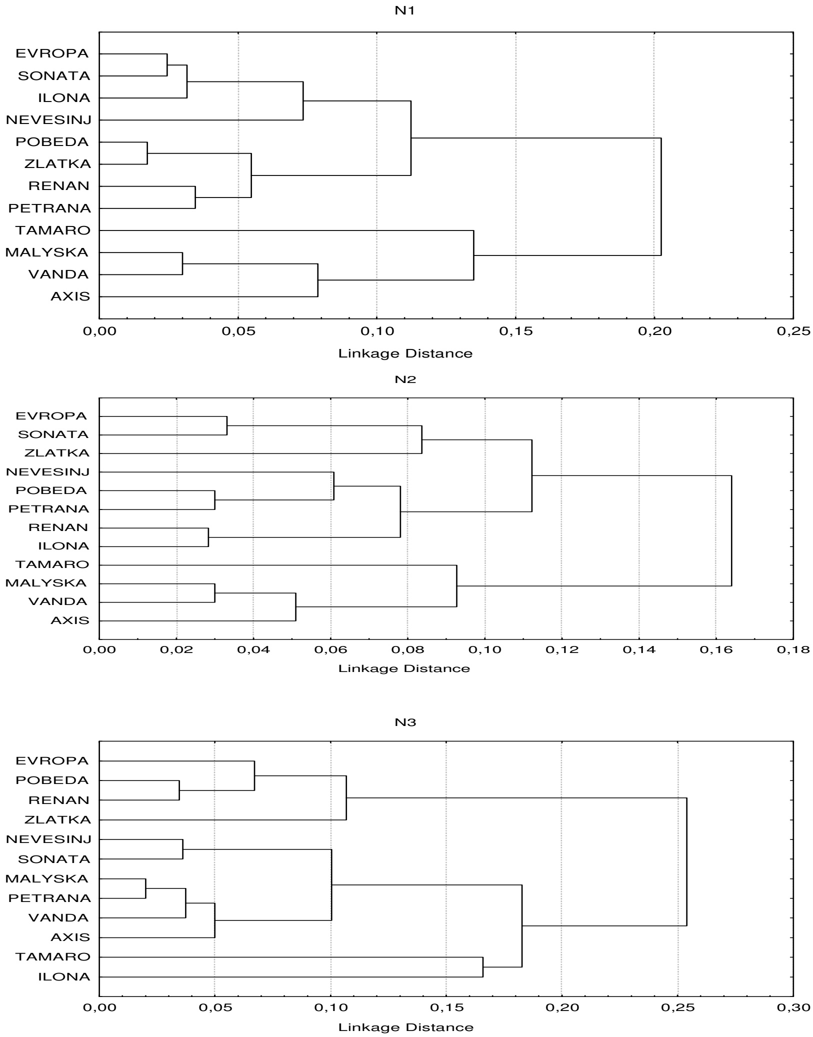

Figure 1: Hierarchical cluster analysis of 12 wheat cultivars with respect to nitrogen harvest index

Analyzing all three dendograms, it can be concluded that the cultivars included in the study clustered almost the same at control and N_{75} treatment. The exceptions were Zlatka and Ilona (replaced in two clusters); as well as Nevesinjka, the cultivar belonging to the group with average NHI values on control and to the group with the highest NHI values at N_{75} rate. Tamaro and Axis were the two cultivars positioned in groups with the lowest NHI values in all three dendograms, Pobeda and Renan in all cases belong to the group with the highest NHI values, while the cultivar Sonata fell in the average NHI group.

The results of this study may be used in developing new high-yielding bread wheat cultivars with improved nitrogen use efficiency. Growing such cultivars would provide the savings in mineral fertilizers and minimize their possible harmful effect on environment.

Received, March 20th2011
Accepted, July 05th 2011

REFERENCES

ANDERSSON, A. (2005): Nitrogen redistribution in spring wheat – Root contribution, spike translocation and protein quality. PhD thesis, Swedish University of Agricultural Sciences, Anlap.

ANDERSON, W.K. (2010): Closing the gap between actual and potential yield of rainfed wheat. The impacts of environment, management and cultivar. Field Crops Res., *116*:14-22.

BALDELLI, G., A. IANNUCCI, G. DE SANTIS, A. RASCIO, G. WITTMER (1990): Nitrogen accumulation model in traditional and recent durum wheat varietes and breeding for harvest index and protein content. Agr. Med., *120*:196-203.

BARRACLOUGH, P., J. HOWARTH, J. JONES, R. LOPEY-BELLIDO, S. PARMAR, C. SHEPHERD, M. HAWKESFORD (2010): Nitrogen efficiency of wheat: Genotypic and environmental variation and prospects for improvement. Eur. J. Agron., *33*:1-11.

BRANCOURT-HUMEL, M., G. DOUSSINAULT, C. LECOMTE, P. BERARD, B. LE BUANCE, M. TROTTET (2003): Genetic improvement of agronomic traits of winter wheat cultivars released in France from 1946-1992. Crop Sci., *43*: 37-45.

BRDAR, M.D., M.M. KRALJEVIĆ-BALALIĆ, B.Đ. KOBILJSKI (2008): The parameters of grain filling and yield components in common wheat (*Triticum aestivum* L.) and durum wheat (*Triticum turgidum* L. var. *durum*). Cent. Eur. J. Biol., *3*:75-82.

CHEN, C., G. HAN, H. HE, M. WESTCOTT (2011): Yield, protein, and remobilization of water soluble carbohydrate and nitrogen of three spring wheat cultivars as influenced by nitrogen input. Agron. J., *103*:786-795.

ĐOKIĆ, D. and S. LOMOVIĆ (1990): Uticaj različitih doza azota na akumulaciju i isorišćavanje suve materije i azota u nadzemnom delu biljke pšenice. Savremena poljoprivreda, *38*: 395-401. (in Serbian)

GORJANOVIĆ, B., M. KRALJEVIĆ-BALALIĆ, S. JANKOVIĆ (2010): Environmental effects on associations among nitrogen use efficiency traits in wheat. Cereal Res. Commun., *38*:146-153.

GORJANOVIĆ B., M. ZORIĆ, M. KRALJEVIĆ-BALALIĆ (2010): Effects of nitrogen rate on grain yield of bread wheat genotypes. Genetika, 42, *2*: 279-286.

HIREL, B., J. LE GOUIS, B. NEY, A. GALLAIS (2007): The challenge of improving nitrogen use efficiency in crop plants: toward a more central role of genetic variability and quantitative genetics within integrated approaches. J. Exp. Bot., *58*: 2369-2387.

HRISTOV, N., N. MLADENOV, V. DJURIC, A. KONDIC-SPIKA, A. MARJANOVIC-JEROMELA, D. SIMIC (2010): Genotype by environment interactions in wheat quality breeding programs in southeast Europe. Euphytica, *174*: 315-324.

KRALJEVIĆ-BALALIĆ M. (2001): Breeding nitrogen-efficient wheat genotypes. In: Plant Breeding Sustaining the Future. EUCARPIA Congress, Edinburgh, Scotland, 10-14. 09. 2001, Abstracts, 43.

LE GOUIS, J., D. BEGHIN, E. HEUMEZ, P. PLUCHARD (2000): Genetic differences for nitrogen uptake and nitrogen utilization efficiencies in winter wheat. Eur. J. Agron., *12*: 163-173.

RAHIMIZADEH, M., A. KASHANI, A. ZARE-FEIZABADI, A. KOOCHEKI, M. NASSIRI-MAHALLATI (2010): Nitrogen use efficiency of wheat as affected by preceding crop, application rate of nitrogen and crop residues. Aust. J. Crop Sci., *4*:363-368.

SLAFER, G.A., F.H. ANDRADE, S.E. FEINGOLD (1990): Genetic improvement of bread wheat (*Triticum aestivum* L.) in Argentina: relationship between nitrogen and dry matter. Euphytica, *50*: 63-71.

FENOTIPSKA VARIJABILNOST GENOTIPOVA HLEBNE PŠENICE ZA ŽETVENI INDEKS AZOTA

Biljana GORJANOVIĆ[1], Milka BRDAR-JOKANOVIĆ[2]
i Marija KRALJEVIĆ-BALALIĆ[1]

[1]Poljoprivredni fakultet, Novi Sad, Srbija
[2]Institut za povrtarstvo, Smederevska Palanka, Srbija

I z v o d

Žetveni indeks azota (odnos sadržaja azota u zrnu i u celoj biljci) predstavlja meru efikasnosti translokacije azota iz vegetativnih organa u zrno, i može se preporučiti kao selekcioni kriterijum u oplemenjivanju na povećanu efikasnost iskorišćavanja azota. Cilj ovog rada je da se ispita žetveni indeks azota kod dvanaest genotipova pšenice, na tri nivoa ishrane azotom, kao i da se genotipovi grupišu na osnovu sličnosti za ispitivano svojstvo. Rezultati faktorijalne ANOVA-e su pokazali da su na ispoljavanje ovog svojstva najveći uticaj imali interakcija godina x genotip, godina i genotip, a u najmanjoj meri doza azota. Povećanje doze azota kod većine genotipova nije dovelo do povećanja žetvenog indeksa azota. Najveće vrednosti za žetveni indeks azota su zabeležene u 2004/05, a najmanje u 2006/07. sezoni. Najveću vrednost za žetveni indeks azota su imale sorta Pobeda, kod kontrole, i sorta Zlatka na dozi N_{100} (0,93). Najniža vrednost zabeležena je kod sorte Tamaro, kod kontrole (0,63). Analizirajući dendogram može se zaključiti da su genotipovi Pobeda i Renan na sva tri nivoa ishrane izdvojeni od ostalih kao genotipovi sa najvišim vrednostima, dok je sorta Tamaro izdvojena kao sorta sa najnižim vrednostima azotnog žetvenog indeksa.

Primljeno 20.III. 2011.
Odobreno. 05.VII.2011.