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AMMI ANALYSIS OF NITROGEN HARVEST INDEX IN BREAD WHEAT

ABSTRACT: Nitrogen harvest index — NHI is a measure of efficiency of nitrogen translocation from vegetative organs to grain. The goal of this paper is to investigate variability and stability of nitrogen harvest index of twelve bread wheat genotypes, on three nitrogen levels. ANOVA showed that nitrogen harvest index was mostly under influence of the year x genotype interaction, year of investigation and genotype, and in the smallest amount of the nitrogen rate. Increasing doses of nitrogen did not lead to increased nitrogen harvest index. AMMI analysis showed that most genotypes differed in both the main effect and in GxE interaction. The highest stability i.e. the smallest interaction effect, was found in varieties Axis, Ilona, Sonata and Renan on N_0 rate, and in varieties Malyska, Petrana, Axis and Evropa 90 on N_{100} rate. Cultivar Pobeda with the high average values for nitrogen harvest index, also had small interaction effect, i.e. it proved to be a stable variety.

KEY WORDS: AMMI analysis, nitrogen harvest index, wheat

INTRODUCTION

Numerous studies indicate that nitrogen is the key factor of yield and quality in the wheat. Nitrogen harvest index (the ratio of nitrogen content in grain and whole plant) is a measure of efficiency of nitrogen translocation from vegetative organs to grain (Austin et al., 1977, McMullan et al., 1988; Sinclair, 1998). Nitrogen harvest index for wheat usually ranges from 0.70 to 0.80 (Calderini et al., 1995; Brancourt-Hummel, 2003, Andersson, 2005). Van Sanford and MacKown (1987) noted the extreme values of 0.51 to 0.91. Ortiz-Monasterio et al. (1997) have studied the nitrogen harvest index of genotypes recognized between 1950 and 1985 and recorded a significant increase in the newer varieties. Slafer et al. (1990) recorded similar results.

Löffler et al. (1985), Ortiz-Monasterio et al. (1997), and Anderson (2005) noted positive correlations between NHI and HI, as well as between NHI and grain yield (Löffler et al., 1985). McKendry et

al. (1995) and McMullan et al. (1988) did not find significant correlations between NHI and grain yield.

The goal of this paper is to investigate variability and stability of nitrogen harvest index of twelve bread wheat genotypes, on three nitrogen levels.

MATERIAL 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.

At maturity, ten plants were cut at ground level and they represented one sample/replication in the analysis. At maturity, samples were separated into vegetative (leaf + culm + chaff) and reproductive parts (grains). After drying, all samples were ground in a mill to generate 1-mm particles. The nitrogen concentration was determined by the standard Kjeldahl procedure. Nitrogen harvest index was calculated as the ratio of grain nitrogen content over total nitrogen content. AMMI (Additive main effects and multiplicative interaction) model was used to analyze the genotype x environment interaction (Zobel et al., 1988). The analysis was performed in GenStat 9 program (trial version).

RESULTS AND DISCUSSION

ANOVA showed that nitrogen harvest index was mostly under influence of the year x genotype interaction (52.70%), year of investigation (33.58%) and genotype (10.55%), and in the smallest amount of the nitrogen rate (1.56%) (Table 1) Baldelli et al. (1990) state that they have not recorded a significant difference between genotypes, but the difference between years was significant.

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). Increasing doses of nitrogen did not lead to increased nitrogen harvest index; moreover, the majority of genotypes had the highest value in the control, which is in agreement with the results of Le Gouis et al. (2000). Đokić and Lomović (1990) states that the nitrogen harvest index was not significantly changed with increasing doses of nitrogen up to 120 kg N/ha, after which it began to decline.

Tab. 1. — ANOVA for nitrogen harvest index

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**
N_0	**N_{75}**	0.019**
	N_{100}	0.026**
N_{75}	**N_0**	–0.019**
	N_{100}	0.006

* $p < 0.05$; ** $p < 0.01$

AMMI analysis was performed for all three nitrogen levels, but the principal component analysis for the N_{75} rate did not show any significant principal component, so in this paper it will be presented only AMMI analysis for N_0 and N_{100} levels of nutrition.

AMMI analysis of variance for N_0 rate showed that both additive sources of variation were highly significant, as well as the year x genotype interaction. Detailed separation of GE interaction variation revealed that explainable agronomic variation had been carried out by the first PC axis in the proportion of 74% of total GE interaction variance (table 2).

Tab. 2. — AMMI analysis of variance for nitrogen harvest index in wheat — N_0

Source of variation	SS	%	DF	MS	F
Treatments	0.319		36	0.0089	11.626**
Replications	0.0008		1	0.0008	1.049
Years	0.221		2	0.111	144.92**
Genotypes	0.063		11	0.0057	7.477**
GxE	0.035	100	22	0.0016	2.058*
PCA 1	0.026	73.96	12	0.0021	2.791**
Residual	0.009	26.04	10	0.0009	1.179
Error	0.027		35	0.0008	
Total	0.346		71		

* $p < 0.05$; ** $p < 0.01$

By analyzing the AMMI1 biplot, it was concluded that most genotypes differed in both the main effect and in interaction. The smallest GxE interaction effect was manifested in the variety Axis, which had a low average value for nitrogen harvest index, as well as in varieties Ilona, Sonata, and Re-

nan with values for the main effect higher than average. Cultivars Zlatko and Pobeda with the highest average values for nitrogen harvest index, also had small interaction effects, i.e. they proved to be stable varieties. The largest interaction effect was recorded in cultivars Nevesinjka and Vanda (Figure 1).

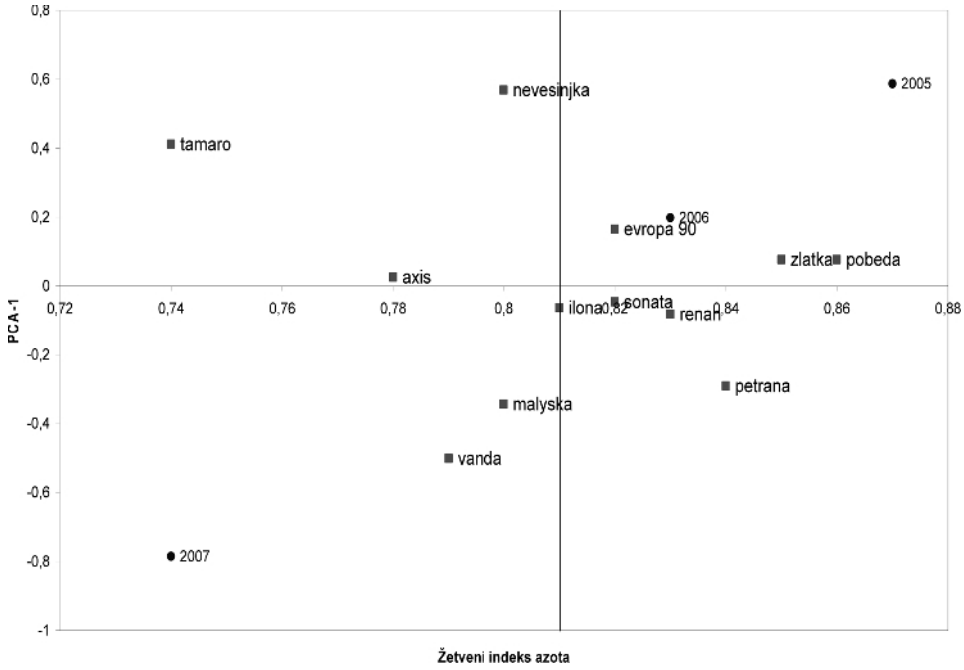

Fig. 1. — AMMI1 biplot for nitrogen harvest index in wheat — N_0

Smallest interaction effect was recorded in year 2006, which is characterized by average values for nitrogen harvest index. A large interaction effect was recorded in year 2005, in which the varieties had the highest mean values for nitrogen harvest index. The largest interaction effect was achieved in year 2007, which is characterized by the lowest values for the main effect, i.e. for nitrogen harvest index (Figure 1).

Cultivars Tamaro, Axis, Nevesinjka, Evropa 90, Zlatko, and Pobeda were in positive interaction with the years 2006 and 2005, while the cultivars Vanda, Malyska, Ilona, Sonata, Renan and Petrana were in positive interaction with the year 2007 (Figure 1).

AMMI analysis of variance for N_{100} rate showed that both additive sources of variation were highly significant, as well as the year x genotype interaction. Detailed separation of GE interaction variation revealed that explainable agronomic variation had been carried out by the first PC axis in the proportion of 80% of total GE interaction variance (Table 3).

Tab. 3. — AMMI analysis of variance for nitrogen harvest index in wheat — N_{100}

Source of variation	SS	%	DF	MS	F
Treatments	0.341		36	0.009	6.840**
Replications	0.0019		1	0.0019	1.374
Years	0.179		2	0.089	64.64**
Genotypes	0.085		11	0.0077	5.552**
GxE	0.075	100	22	0.0034	2.477**
PCA 1	0.060	79.66	12	0.0051	3.618**
Residual	0.015	20.34	10	0.0016	1.109
Error	0.048		35	0.0014	
Total	0.389		71		

* $p < 0.05$; ** $p < 0.01$

By analyzing the biplot, it was concluded that most genotypes differed in both the main effect and in interaction. The highest stability i.e. the smallest effect of the interaction, was found in varieties Malyska, Petrana, Axis and Evropa 90, whereby the first three varieties had a low average nitrogen harvest index, while Europe 90 had a nitrogen harvest index greater than the average. Varieties Renan, Pobeda and Vanda also showed the low interaction effect, with Pobeda and Renan had the highest average values for nitrogen harvest index. The largest interaction effect was achieved by cultivar Zlatko, which had a high average nitrogen harvest index, and cultivar Tamaro, which is the variety with the lowest average nitrogen harvest index (Figure 2).

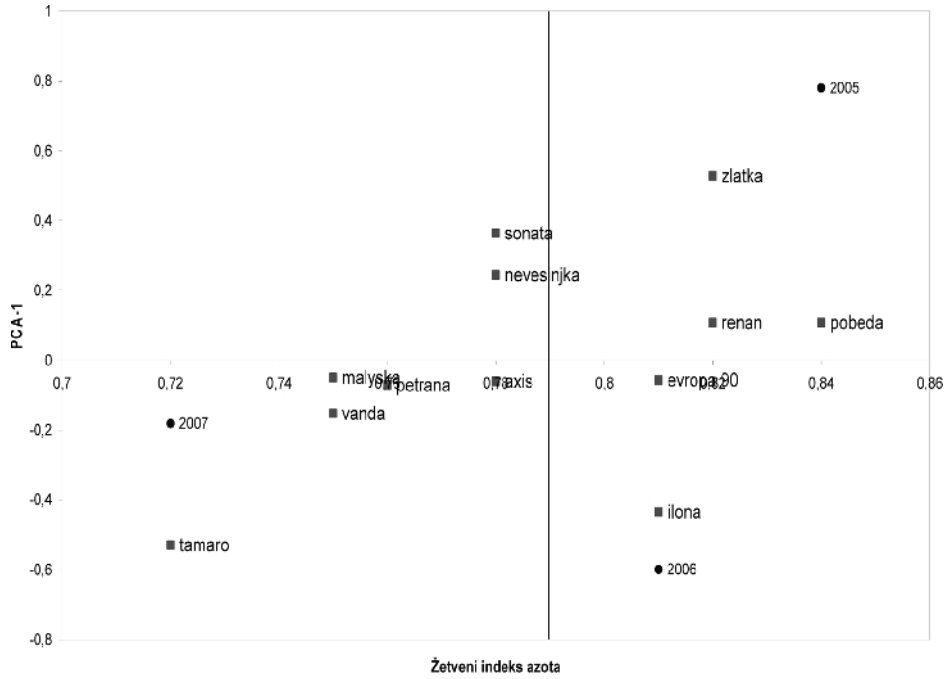

Fig. 2. — AMMI1 biplot for nitrogen harvest index in wheat — N_{100}

The year 2007, in which genotypes achieved the lowest nitrogen harvest index, is characterized by the lowest interaction effect. Year 2006 had high interaction effects, with average values for the main effect, while the year 2005 was characterized by the largest interaction effect and the highest values for nitrogen harvest index. Cultivars Sonata, Nevesinjka, Zlatko, Renan, and Pobeda were in positive interaction with the year 2005, while the varieties Tamaro, Vanda, Malyska, Petrana, Axis, Evropa 90 and Ilona were in positive interaction with the years 2006 and 2007 (Figure 2).

REFERENCES

Andersson, A. (2005): *Nitrogen redistribution in spring wheat — Root contribution, spike translocation and protein quality*. Doctoral thesis, Swedish University of Agricultural Sciences, Anlap.

Austin, R. B., Ford, M. A., Edrich, J. A., Blackwell, R. D. (1977): *The nitrogen economy of winter wheat*. J. Agric. Sci., 88:159—167.

Baldelli, G., Iannucci, A., De Santis, G., Rascio, A., Wittmer, G. (1990): *Nitrogen accumulation model in traditional and recent durum wheat varieties and breeding for harvest index and protein content.* Agr. Med., 120: 196—203.

Brancourt-Humel, M., Doussinault, G., Lecomte, C., Berard, P., Le Buance, B., Trottet, M. (2003): *Genetic improvement of agronomic traits of winter wheat cultivars released in France from 1946—1992*. Crop Sci., 43: 37—45.

Calderini, D. F., Tores-Leon, S., Slafer, G. A. (1995): *Consequences of wheat breeding on nitrogen and phosphorus yield, grain nitrogen and phosphorus concentration and associated traits*. Annals of Bot., 76: 315—322.

Đokić, D., Lomović, S. (1990): *Uticaj različitih doza azota na akumulaciju i iskorišćavanje suve materije i azota u nadzemnom delu biljke pšenice*. Savremena poljoprivreda, 38, 3—4: 395—401.

Le Gouis, J., Beghin, D., Heumez, E., Pluchard, P. (2000): *Genetic differences for nitrogen uptake and nitrogen utilization efficiencies in winter wheat*. European J. of Agron., 12: 163—173.

Löffler, C. M., Rauch, T. L., Busch, R. H. (1985): *Grain and plant protein relationship in hard red spring wheat*. Crop Sci., 25: 521—524.

McKendry, L. Anne, McVetty, P. B. E., Evans, L. E. (1995): *Selection criteria for combining high grain yield and high grain protein concentration in bread wheat*. Crop Sci., 35: 1597—1602.

McMullan, P. M., McVetty, P. B. E., Urquhart, A. A. (1988): *Dry matter and nitrogen accumulation and redistribution and their relationship to grain yield and grain protein in wheat*. Can. J. Sci., 68: 311—322.

Ortiz-Monasterio, R. J. I., Peña, R. J., Sayre, K. D., Rajaram, S., (1997): *CIMMYT's genetic progress in wheat grain quality under four nitrogen rates*. Crop Sci., 37, 3: 892—898.

Sinclair, T. R. (1998): *Historical changes in harvest index and crop nitrogen accumulation*. Crop Sci., 38: 638—643.

Slafer, G. A., Andrade, F. H., Feingold, S. E. (1990): *Genetic improvement of bread wheat (Triticum aestivum L.) in Argentina: relationship between nitrogen and dry matter*. Euphytica, 50: 63—71.
Van Stanford, D. A., Mac Kown, C. T. (1987): *Cultivar differences in nitrogen remobilization during grain fill in soft red winter wheat*. Crop Sci., 27: 295—300.
Zobel, R. W., Wright, M. J., Gauch, H. G. (1988): *Statistical analysis of yield trail*. Agron. J., 80: 388—393.

AMMI АНАЛИЗА ЖЕТВЕНОГ ИНДЕКСА АЗОТА КОД ХЛЕБНЕ ПШЕНИЦЕ

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Резиме

Жетвени индекс азота је мера ефикасности транслокације азота из вегетативних органа у зрно. Циљ овог рада је да се испитају варијабилност и стабилност жетвеног индекса азота дванаест генотипова хлебне пшенице, на три нивоа исхране азотом. Анализа варијансе је показала да је жетвени индекс азота у највећој мери био под утицајем интеракције године и генотипа, године испитивања и генотипа, а у најмањој мери примењене дозе азота. Повећање дозе азота није довело до повећања жетвеног индекса азота. AMMI анализа је показала да су се генотипови разликовали како у главном ефекту тако и у GxE интеракцији. Највећа стабилност је забележена код сорти Axis, Ilona, Sonata и Renan на N_0 дози, и код сорти Malyska, Petrana, Axis и Evropa 90 на N_{100} дози. Сорта Pobeda, са високим просечним вредностима за жетвени индекс азота, такође је имала мали ефекат интеракције, тј. показала се као стабилна сорта.