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SPIKE TRAITS VARIABILITY IN WHEAT GROWN ON SOLONETZ AND HUMOGLEY

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Abstract

The utilization of less productive soil could be one of the ways to enhance food production. That kind of soil under amelioration and suitable cultivar could give economically sound results. Wheat, being a durable cultivar could be used for agricultural production in less productive soil conditions. Moreover, single plant trait variability became increasingly important in abiotic stress conditions. A phenotypic variability for spike parameters was studied in trial established on two soil types – humogley and solonetz. Humogley exhibits less favorable water-physical properties, while solonetz represents sodium reach, alkaline soils with a subsurface clay horizon. Familiarization with wheat plant behavior in those agro-ecological conditions could be of help for special purposes wheat breeding or selection of suitable wheat varieties among existing genetic variability.
Key words: wheat, solonetz, humogley, spike traits

Introduction

Growing of bread wheat in order to provide food for about 70% of the world population, is one of the main tasks of intensive agricultural production. The fulfillment of this task is made difficult by global climate change, excessive use of chemical pesticides, inappropriate use of fertilizers and irrigation, leading to the degradation of arable land. The consequence is a phenomenon abiotic stress conditions affecting plants outdoor research and production. The study of bread wheat growing conditions in abiotic stresses that are less productive soils, contributes to the existing genetic variability selection of the genotypes suitable for growing in that conditions, increasing the usability of these soils, as well (Petrović *et al*., 2010).
About 81% is of the total area in Vojvodina belongs to agricultural land. The share of arable land is about 75% (Milić et al. 2011). Most of the arable land in Vojvodina are chernozem and humogley (about 80%), the rest are less productive soils. Solonetz belongs to halomorphic soil type that is characterized by unfavorable physical and chemical properties, high clay content in the B horizon, high content of sodium, and consequently alkaline reaction. Therefore, solonetz is commonly utilized as natural pasture non convenient to intensive farming. Somewhere in the neighborhood of 80,000 hectares in Vojvodina is classified as this type of soil, mostly in the Banat region (Belić et al., 2012). Soil salinity has negative effect on most crops, but its utilization is possible bythe appliement of ameliorative measures that could enhance the utility value of the land. Solonetz is subjected to chemical and physical meliorative measures. The chemical melioration measure frequently used is application of phosphogypsum. That way, calcium ions replace the harmful sodium ions that could be flushed by physical measure of soil drainage. Small grains including bread wheat are moderately tolerant to increased salt content in soil (Witcombe *et al*., 2008).
Hydromorphic black soil (humogley) is characterized by an occasional or permanent water saturation. Humogley generally have heavy mechanical composition and unfavorable water-air properties, but is not considered as a less productive soil, because of its chemical

properties that are favorable, the humus 3-6%, high adsorption capacity and high degree of saturation, mainly calcium ions. However, in areas under hydro-technical reclamation (flood prevention and lowering of groundwater level) is suitable for intensive agricultural production (Škorić, 1986).
The aim of this study is to investigate genetic variation for spike properties as important yield components in normal and abiotically stressfull experimental environments in order to select varieties of positive reaction to solonetz amelioration, within the existing genetic variability.

Materials and methods

The study included ten wheat cultivars (*Triticum aestivum ssp. vulgare, 2n=6x=42)* created in Institute of Field and Vegetable crops in Novi Sad: Renesansa, Mina, Sofija, Sara, Zlatka, Tiha, Anastasija, Pesma, Pobeda and Partizanka. The experiment was set in Pannonian Plain-Banat region, at the locality Kumane (45,54º N, 20,23º E, altitude 73 m) on two soil types: halomorphic soil (solonetz ameliorated by 25 t/ha phosphorgypsum) and hydromorphic black soil (humogley). In 2003/2004 the wheat cultivars were planted in a randomized complete block design in three replicates in 2m long rows, 20cm space between rows, 10cm space between plants in the row and 50kg NPK 15:15:15 fertilizer applied. A phenotypic variability for three spike parameters was analyzed: spike length (cm), grain number per spike and grain weight per spike (g). These traits were analyzed at full physiological maturity, and the base sample consisted of 10 plants per replication.
Variability of cultivars focusing on the genotype by environment interaction (G x E) was tested using AMMI (Additive Main Effects and Multiplicative Interaction) analysis by Zobel *et al.* (1988). Data processing was performed in GenStat 9th Edition (2006) VSN International Ltd (www. vsn-intl.com).

Results and discussion

Abiotically stressful environment brings individual plant properties into the foreground, diminishing intravarietal variation and enhancing genotype by environment interaction (Denčić *et al*., 2000, Dimitrijević *et al*. 2012). Consequently, three spike traits are discussed in this study. All three of them, spike length, grain number and grain weight per spike could be of the importance for grain yield formation in utilization of less productive soil. The trial has been established on halomorphic solonetz and humogley soil, parallel. The geographical distance of these two soil types was less than a mile, and the same agricultural practice was applied, so the main difference was expected to be due to soil type diversity. The amount of 25t ha^{-1} of phosphorgypsum has been applied as a measure for solonetz chemical amelioration, that gave a good effect on wheat grain yield components in previous investigations (Petrović *et al*., 2009). According to the results, ameliorated solonetz appeared to be of similar productive level as neighboring humogley. There were no significant differences in overall environmental means of spike length regarding soil type ($\overline{X}$=8.0cm, and $\overline{X}$=8.4cm, respectively). Some differences at a trend level were denoted comparing environmental means for grain number per spike, where amelirated solonetz part of the plot was slightly more fruitful ($\overline{X}$= 33 grains/spike on solonetz vs. $\overline{X}$= 29 grains/spike on humogley). Statistically significant difference was observed for the most sensitive mass trait – grain weight per spike. The spike yield was higher on ameliorated solonetz ($\overline{X}$=1.4g) than on humogley ($\overline{X}$=0.9g), tab. 1.
Table 1. Spike length (cm), grain number per spike and grain weight per spike (g) of 10 wheat cultivars grown in two environments- solonetz soil ameliorated by 25t ha^{-1} of

phosphorgypsum (S) and humogley (H). Mean values ($\bar{X}$), treatment variance (σ^2) and interaction PCA are given

Trait	Spike length [cm]				Grain number/spike				Grain weight/spike [g]			
Genotype	S	H	$\bar{X}$	$IPCA_G1$	S	H	$\bar{X}$	$IPCA_G1$	S	H	$\bar{X}$	$IPCA_G1$
Renesansa	8,1	8,1	8,1	-0,410	33	29	31	-0,017	1,3	1,0	1,2	0,199
Mina	7,4	7,9	7,7	0,011	31	24	27	-0,850	1,3	0,6	1,0	-0,273
Sofija	8,7	9,2	9,0	0,089	28	25	27	0,317	1,3	0,7	1,0	-0,172
Sara	7,6	7,9	7,7	-0,121	35	31	33	-0,100	1,4	1,0	1,2	0,030
Zlatka	6,9	8,0	7,5	0,509	29	33	31	1,901	1,3	1,2	1,3	0,367
Tiha	7,7	8,6	8,1	0,323	34	34	34	0,734	1,3	0,9	1,1	0,064
Anastasija	7,7	7,6	7,7	-0,383	37	27	32	-1,434	1,6	0,9	1,3	-0,306
Pesma	9,8	9,9	9,8	-0,252	36	29	32	-0,934	1,5	0,8	1,2	-0,205
Pobeda	8,0	8,7	8,4	0,194	33	30	31	0,150	1,4	1,0	1,2	0,030
Partizanka	8,0	8,5	8,3	0,037	31	28	29	0,233	1,2	1,0	1,1	0,266
$\bar{X}$	8,0	8,4	8,2	-	33	29	31	-	1,4	0,9	1,1	-
σ^2	0,75	0,74	-	-	19,4	23,6	-	-	0,07	0,07	-	-
$IPCA_E1$	-0,64	0,64	-	-	2,00	-2,00	-	-	-0,50	0,50	-	-
	$LSD_{0,05}$=4,947		$LSD_{0,01}$=6,619		$LSD_{0,05}$=4,947		$LSD_{0,01}$=6,619		$LSD_{0,05}$=0,291		$LSD_{0,01}$=0,389	

AMMI analysis of variance (ANOVA) identified and quantified the sources of phenotypic variation in trial (Zobel et al., 1988, Dimitrijević & Petrović, 2005). All three main sources of variation aggregated in treatments variation, appeared to be of significant mean square (tab. 2).

Table 2. AMMI ANOVA for the spike length (cm), grain number per spike and grain weight per spike (g) of 10 wheat cultivars grown in two environments- solonetz soil ameliorated by 25t/ha of phosphorgypsum

Trait		Spike length		Grain number/spike		Grain weight/spike		F-tab.	
Source of variation	df	MS	F-calc.	MS	F-calc.	MS	F-calc.	0,05	0,01
Trial	59	0,784	-	24,39	-	0,121	-	-	-
Treatments	19	1,718	**6,00	36,71	**2,45	0,234	**4,53	1,84	2,37
Genotypes	9	3,068	**10,71	34,60	*2,31	0,056	1,08	2,12	2,88
Environments	1	3,083	3,72	194,40	3,85	3,220	**15,58	4,08	7,31
Block	4	0,829	*2,90	50,53	*3,37	0,207	**4,00	2,61	3,83
G x E Interaction	9	0,216	0,76	21,29	1,42	0,080	1,55	2,12	2,88
IPCA 1	9	0,216	0,76	21,29	1,42	0,080	1,55	2,12	2,88
Trial Error	36	0,286	-	14,98	-	0,052	-	-	-

Closer analysis reveals that genotypes were significant cause of total variation for spike length and grain number per spike, but quite uniform, in a whole, spike yield. Since, two distinct environments were studied, a non-significant environmental component had been expected. However, the only significant mean square was calculated for the grain weight per spike. Mass parameters with its distinct quantitative nature are the most sensitive phenotypic markers. There was no significant cross over GE interaction, meaning that varieties reacted without rang changes, on average, over environments. The same goes for the one principal

axes that caught all the agronomically explainable. The existence of only one principal component axes in GE variance reveals that the predominant difference in trial was soil type and that wheat varieties based on the same ideotype reacted, on average, in a similar manner to environmental variation. The statistical data obtained using AMMI model ANOVA analysis, basically revealed that chemical amelioration by phosphogypsum combined by proper wheat variety selection out of existing and available gene pool could compensate, judging by yield components in study, unfavorable physico-chemical properties of solonetz soil. However, ANOVA trots out the variation calculated trough phenotypic average behavior of genotypes. Being, basically additive model ANOVA requires additional partition of multivariate GE variance by Principal Component Analysis. The lack of statistically significant and agronomically explainable variance on IPCA1 is just a consequence of similar average behavior of wheat varieties in study for examined spike properties on ameliorated solonetz and humoglay (tab. 2).

Additional insight of individual varietal behavior followed by AMMI model biplot reveals that some wheat varieties were better adapted to humoglay growth conditions, while the others performed better in the environment of ameliorated solonetz. Moreover, a part of the varieties exhibited more stable reaction in both environments, than the others.

The most stable reaction for the spike length was observed for varieties Mina and Partizanka, as well as, Sara and Sofija. On the contrary, varieties Zlatka, Renesansa, and Anastasija appeared to be least stable in given environmental conditions. The best overall performance for the trait showed variety Pesma, being moderately stable at the highest mean value of the spike length. Variety Zlatka was better adapted to humoglay experimental environment, while varieties Anastasija and Renesansa gave better general performance in the environment of ameliorated solonetz (fig. 1).

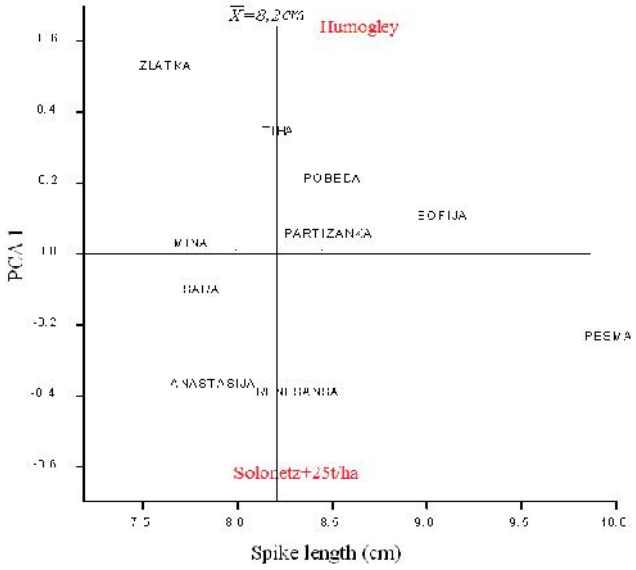

Figure 1. Spike length (cm) of 10 wheat cultivars in 2 environments grouping after mean and PCA1 values

Varieties Renesansa and Sara, followed by Pobeda, Partizanka and Sofija were of the most stable reaction over the environments, for the grain number per spike. Once more, variety Zlatka performed the best for the trait in humogley experimental surrounding, while variety Anastasia preferred ameliorated solonetz as a soil substrat (fig. 2).

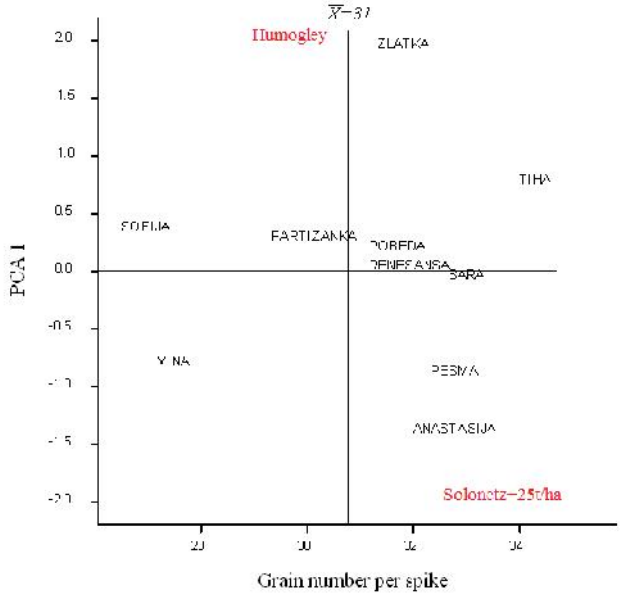

Figure 2. Grain number per spike of 10 wheat cultivars in 2 environments grouping after mean and PCA1 values

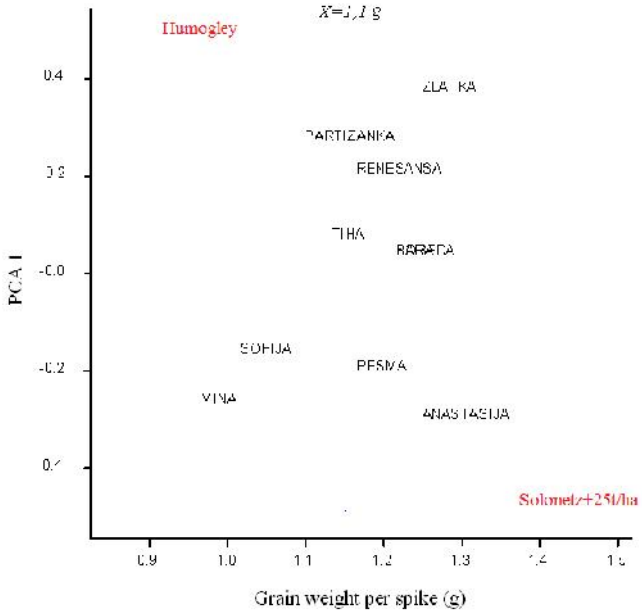

Figure 3. Grain weight per spike of 10 wheat cultivars in 2 environments grouping after mean and PCA1 values

A spike yield given through the grain weight per spike was of particular interest because it aggregates the performance of all plant traits. The most stable reaction for the trait was exhibited by varieties Sara, Pobeda, and Tiha, as well. Anastasija appeared to be of the best performance in ameliorated solonetz environmental conditions, while variety Zlatka, gave the best results among the studied group in humoglay experimental environment (fig. 3).

Conclusion

Results suggested that there is a possibility of the production performance improvement of wheat varieties grown in extremely abiotically stressful conditions of solonetz, to the level of normally productive humoglay, by chemical amelioration of solonetz and selection of wheat varieties within the existing genetic variability. In a trial that predominantly differed in soil type, it was possible to select genotype of desirable variation for the spike length, grain number and weight per spike. Variety Zlatka performed better in hunoglay experimental environment, while variety Anastasia preffered ameliorated solonetz conditions.

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