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AMMI ANALYZED GENOTYPE BY ENVIRONMENT INTERACTION IN BREAD WHEAT

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ABSTRACT

Dimitrijević M., Petrović S., Belić M., Vuković N. & Vukosavljev M. (2008): Ammi analyzed genotype by environment interaction in bread wheat. Proceedings of the III Congress of Ecologists of the Republic of Macedonia with International Participation, 06-09.10.2007, Struga. Special issues of Macedonian Ecological Society, Vol. 8, Skopje.

Additive and multivariate variation effects for stem height and weight, as well as, grain number and weight per spike of three wheat varieties in four vegetation seasons have been studied. The trial has been established on halomorphic soil in Banat, solonetz type, consisting of control as comparison standard, and two amelioration levels using phosphor gypsum. AMMI analysis revealed very complex nature of variation observed in trial, as well as, genotype by environment interaction.

Key words: wheat, yield components, GE interaction, AMMI, solonetz, amelioration

Introduction

Wheat (*Triticum sp.*) is commonly considered as strategically important crop. The grain of wheat is represents elementary source of nutrition for vast part of human population. Wheat is grown on more than 200 million hectares. Commonly, wheat is grown on productive soil suitable for the intensive agricultural production.

Being basically grass, durable and with thick veined root, wheat appeared to be more resistant to limiting factors in agricultural production than many other crops, and could be convenient for growing on less productive soils, serving to enhance its economical value and as biological ameliorative measure. This aspect of wheat utilization could be of interest, especially in flat Pannonian area. In Vojvodina province there is more than 80000ha of halomorphic soil, solonetz type, used predominantly as a pasture (Ministarstvo poljoprivrede,vodoprivrede i šumarstva,1997). With amelioration, this type of soil, could be used in more profitable way (Belić, 1999).

Studies of genetic variability, in this case, in wheat in variable agro-ecological conditions are an important part of developed breeding programs. Quantification and estimation of variability sources from these studies could be of significance for breeding for particular goals and growing areas (Dimitrijević i Petrović, 2005).

The aim of perennial trials that examine variability of wheat and in smaller extent other cereals on solonetz soil with and without usage of amelioration was to:

- follow genotype by environment interaction of yield and the yield components and
- compare the GE interaction behavior of several quantitative traits influencing the yield in two of the best performing wheat varieties on solonetz soil belonging to hexaploid wheat to variety of tetraploid (durum) wheat.

Material and Methods

The perennial trial is conducted following Random Block Design in three replications. Three varieties of wheat were in study. Two belonging to *Triticum aestivum* ssp. *vulgare* (2n=42 chromosomes), namely Pobeda (G1) and Renesansa (G3), and one variety of tetraploid wheat (*T. du-*

rum, 2n=28) named Durumko (G2). All three varieties are creation of the Institute of Field and Vegetable Crops in Novi Sad – Serbia. Stem height (cm), stem weight (g), grain weight per spike (g), and grain number per spike were analyzed in four vegetation periods: 2003/2004., 2004/2005., 2005/2006 and 2006/2007. The trial was conducted on solonetz soil without melioration (control) and with melioration of 25t/ha of phosphor gypsum, giving eight environments: E1 (2003/04 control), E2 (03/04 – 25 t·ha^{-1}), E3 (04/05 cont.), E4 (04/05 25 t·ha^{-1}), E5 (05/06 cont.), E6 (05/06 25 t·ha^{-1}), E7 (06/07 cont.), E8 (06/07 25 t·ha^{-1}). AMMI model was used to study GE interaction (Zobel et al**.** 1988).

Results and Discussion

Stem height. The greatest overall mean value for stem height (76.1 cm) was denoted for wheat variety Renesansa in a first year of study at the amelioration of 25 t·ha^{-1} phosphor gypsum applied. The very same variety exhibited the lowest mean value (43.2 cm) of stem height in a third year of trials at the control variant (no amelioration applied), Tab.1.

According to ANOVA all sources of total variations were statistically significant, except genotypes. Genotype by environment interaction was highly significant. The first IPCA carried out about 86% of the GE interaction sum of squares. That might be due to genetic background of stem height having major (*Rht*) and minor genes in joint action (Petrović et al. 2007), Tab. 2.

Screening genotypes behavior more detailed, lack of variation in main effect is obvious. That is understandable having in mind that hexaploid varieties (Pobeda, Renesansa), as well as, variety Durumko (tetraploid wheat) are selected to be semi-dwarf genotypes (60-80 cm of height). The significant variation has been denoted for multivariate sources of variation. Three genotypes differed in genotype by environment interaction. Variety Pobeda (G1) was the most stable over all environments, showing almost no cross interaction. On the contrary, the other two varieties exhibited remarkable GE interaction. Tetraploid variety Durumko responded quite good grown in less favorable environment of control variant, while variety Renesansa responded to amelioration giving more luxuriant vegetative part of the plant (Fig.1).

Stem weight. The variation of stem height influenced greatly stem weight variation. Though, mass parameters are commonly and predominantly under control of minor genes, in this case major *Rht*-genes exhibited effect on stem weight, as well. Consequently, the greatest average for stem weight was denoted for wheat varieties Pobeda and Renesansa (1.23 g and 1.19 g, respectively) in a first year of study at the amelioration of 25 t·ha^{-1} phosphor gypsum. Variety Renesansa showed the lowest average (0.37 g) of stem weight in a third year of trials at the control variant (no amelioration), Tab.3.

The ANOVA results are similar to those for stem height, showing most of the sources of variation highly significant, including GE interaction. The

Tab. 1. Stem height (cm) of three wheat varieties grown in eight environments, as well as, interaction PCA1 axes are given

Environments	Genotypes			Ex	PCA1e
	Pobeda	Durumko	Renesansa		
E1	64,1	56,4	69,8	63,4	1,78294
E2	73,6	62,4	76,1	70,7	1,91533
E3	65,7	61,6	63,4	63,6	0,10432
E4	63,2	59,1	66,2	62,8	0,84691
E5	45,0	53,3	31,3	43,2	-3,43556
E6	55,6	58,0	59,0	57,6	-0,13887
E7	44,7	57,8	49,8	50,8	-1,62002
E8	57,1	55,0	60,3	57,5	0,54495
Gx	58,6	58,0	59,5	58,7	
PCA1g	0,48878	-3,55807	3,06929		

Tab. 2. AMMI ANOVA for the stem height of three wheat varieties in eight environments

Source	df	SS	MS	F	F 0,05	F 0,01
Total	71	7724	108,8	*	*	
Treatments	23	6381	277,4	**13.72	1,93	2,55
Genotypes	2	28	13,9	0,69	3,32	5,39
Environments	7	4621	660,1	**15.18	2,34	3,3
Block	16	696	43,5	*2.15	1,93	2,55
Interactions	14	1732	123,7	**6.12	2,6	2,84
IPCA 1	8	1494	186,8	**9.24	2,27	3,17
Residuals	6	238	39,6	1,96	2,42	3,47
Error	32	647	20,2	*	*	

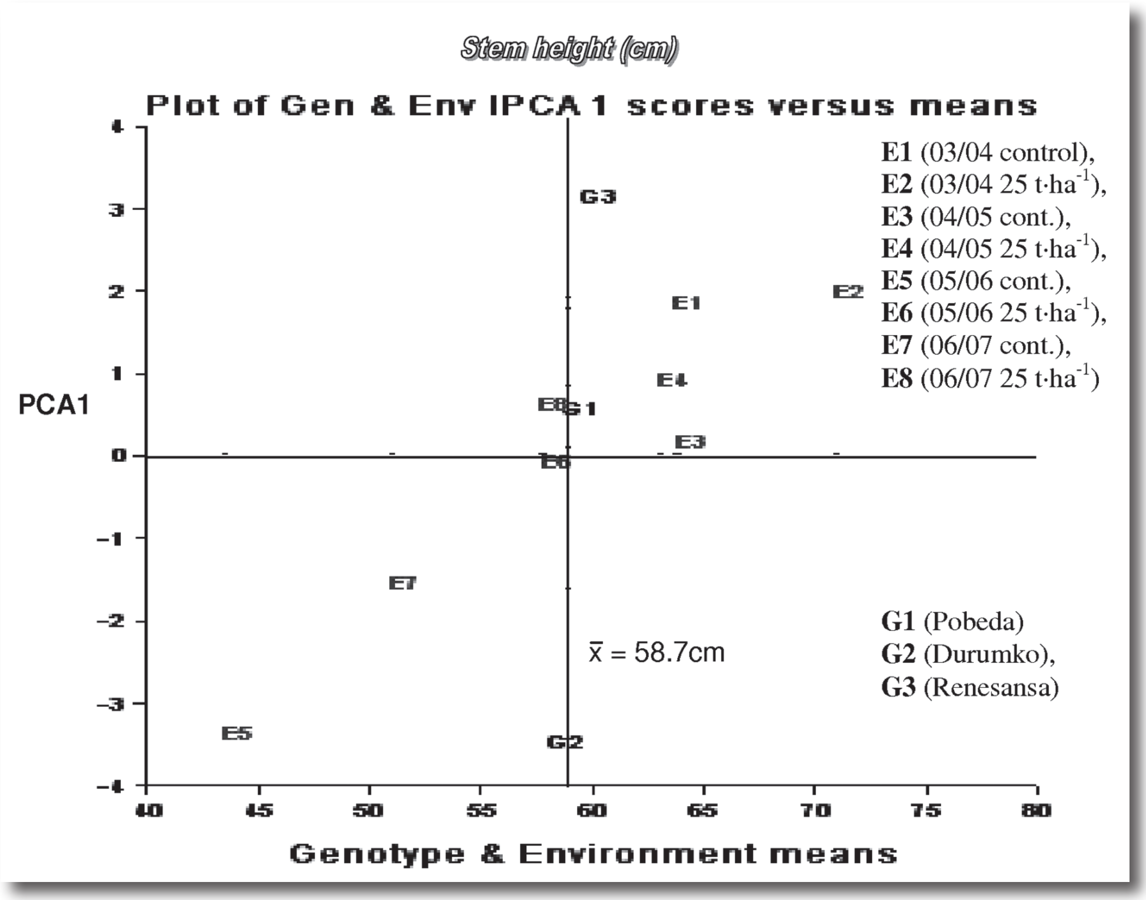

Fig. 1. Mean values of three wheat varieties grown in eight environments (4 years x 2 treatments), main and multivariate (genotype by environment interaction) effects

Tab. 3. Stem weight (g) of three wheat varieties grown in eight environments, as well as, interaction PCA1 axes are given

Environments	Genotypes			Ex	PCA1e
	Pobeda	Durumko	Renesansa		
E1	1,07	1,01	1,08	1,05	0,10247
E2	1,23	1,17	1,19	1,20	0,06478
E3	0,89	0,85	0,91	0,88	0,09466
E4	1,00	0,72	1,04	0,92	0,35176
E5	0,64	1,13	0,37	0,71	-0,66058
E6	0,98	0,92	0,89	0,93	0,033
E7	0,68	0,89	0,82	0,79	-0,06872
E8	1,01	0,93	0,96	0,97	0,08264
Gx	0,94	0,95	0,91	0,93	
PCAg	0,15808	-0,60768	0,4496		

Tab. 4. AMMI ANOVA for the stem weight of three wheat varieties in eight environments

Source	df	SS	MS	F	F	
					0,05	0,01
Total	71	3,982	0,05608	*		
Treatments	23	2,569	0,11169	** 4.12	1,93	2,55
Genotypes	2	0,027	0,01338	0,49	3,32	5,39
Environments	7	1,399	0,1998	**5.87	2,34	3,30
Block	16	0,544	0,03402	1,25	1,93	2,55
Interactions	14	1,144	0,08169	** 3.01	2,60	2,84
IPCA1	8	1,067	0,13339	**4.92	2,27	3,17
Residuals	6	0,077	0,01275	0,47	2,42	3,47
Error	32	0,868	0,02714	*		

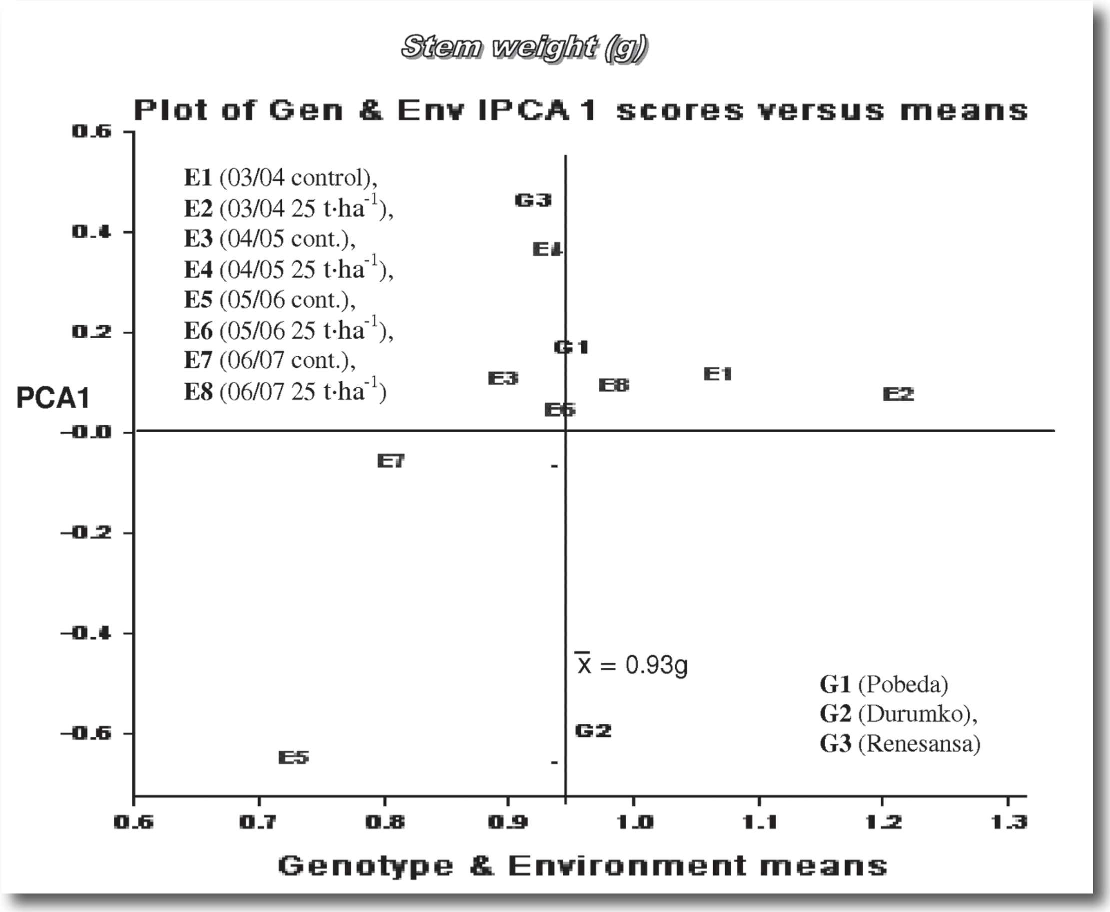

Fig. 2. Mean values for stem weight of three wheat varieties grown in eight environments (4 years x 2 treatments), main and multivariate (genotype by environment interaction) effects

Tab. 5. Grain number per spike of three wheat varieties grown in eight environments, as well as, interaction PCA1 axes are given

Environments	Genotypes			Ex	PCA1e
	Pobeda	Durumko	Renesansa		
E1	32.90	33.03	30.60	32.18	0.24327
E2	32.70	33.43	32.83	32.99	0.40992
E3	34.30	25.77	35.57	31.88	223.707
E4	34.17	26.27	34.20	31.54	198.079
E5	21.70	35.50	14.60	23.93	-280.708
E6	29.17	36.40	31.70	32.42	-0.50851
E7	8.27	20.93	11.07	13.42	-147.396
E8	21.73	26.53	24.10	24.12	-0.08149
Gx	26.87	29.73	26.83	27,81	
PCAg	135.515	-356.877	221.363		

first interaction PCA contributed with about 93% to total GE interaction sum of squares (Tab. 4).

The absence of main effect variation was observed. However, according to IPCA1 genotype array, significant GE interaction occurred. Variety Pobeda had the smallest interaction value, while variety Renesansa responded vigorously to amelioration (Fig.2).

Grain number per spike. Variety Durumko showed the greatest average for this trait (36.4) in environment 6 (amelioration variant). In a whole amelioration was the most effective in a first year of study (E2). Amelioration treatment had its positive effect in most of the examined years (Tab. 5).

According to ANOVA, the greatest contribution to GE interaction significant variation gave IPCA1 with participation of 92% in the interaction sum of squares (Tab. 6)

The variation in main effect was somewhat greater for grain number per spike than for two pre-

Tab. 6. AMMI ANOVA for the grain number per spike of three wheat varieties in eight environments

Source	df	SS	MS	F	F 0,05	F 0,01
Total	71	5346	75.3	*		
Treatments	23	4366	189.8	** 9.91	1,93	2,55
Genotypes	2	133	66.5	* 3.47	3,32	5,39
Environments	7	3000	428.5	**18.69	2,34	3,30
Block	16	367	22.9	1.20	1,93	2,55
Interactions	14	1234	88.1	**4.60	2,60	2,84
IPCA	8	1138	142.2	** 7.42	2,27	3,17
Residuals	6	96	16.0	0.84	2,42	3,47
Error	32	613	19.2	*		

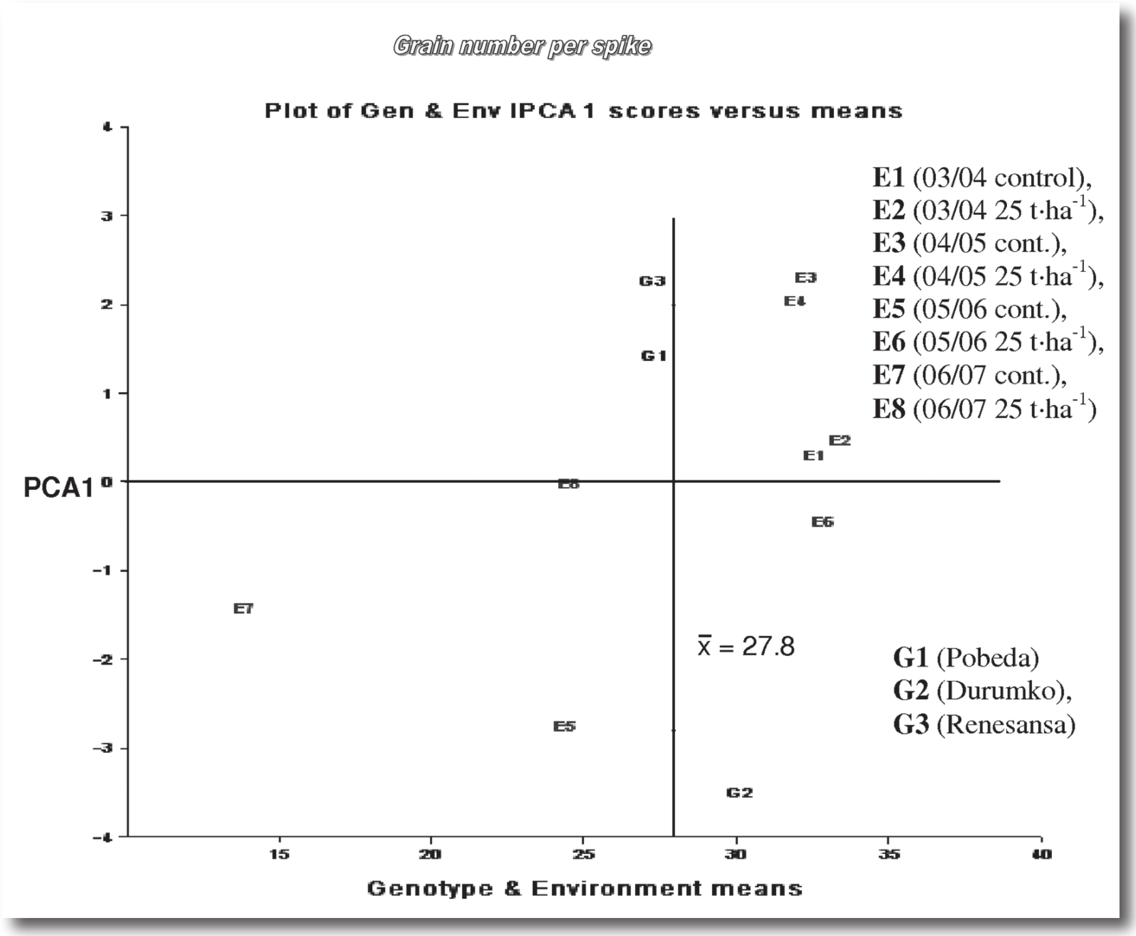

Fig. 3. Mean values for grain number per spike of three wheat varieties grown in eight environments (4 years x 2 treatments), main and multivariate (genotype by environment interaction) effects

viously reported traits. GE interaction was notable. Variety Renesansa responded well to amelioration,as well as, variety Pobeda in some extent. Variety Durumko responded durably to less favorable environments (Fig. 3).

Grain weight per spike. Variety Durumko expressed the highest mean value of 1.53 g in ameliorative conditions in a first year of study. In this year, overall effect of amelioration was the most significant (Tab. 7).

AMMI ANOVA carried out significant GE interaction, and highly significant IPCA1. The first interaction axes contributed about 82% to total interaction variation, picking up whole explainable and agronomical important variation (Tab.8).

Grain weight per spike. More complex variation, comparing to the first two examined traits, but similarity in pattern was observed. Notable GE interaction had its expression in G1, G2, and G2 array. Hexaploid wheat varieties responded better to amelioration, while tetraploid wheat variety Durumko persisted better in less favorable growing conditions (Fig.4).

Tab. 7. Grain weight per spike (g) of three wheat varieties grown in eight environments, as well as, interaction PCA1 axes are given

Environments	Genotypes			Ex	PCA1e
	Pobeda	Durumko	Renesansa		
E1	1,46	1,25	1,25	1,32	0,14591
E2	1,42	1,53	1,30	1,42	-0,117
E3	1,35	1,20	1,46	1,34	0,27756
E4	1,32	1,09	1,40	1,27	0,33855
E5	0,68	0,93	0,39	0,67	-0,34716
E6	1,22	1,05	1,37	1,21	0,31892
E7	0,32	0,96	0,47	0,58	-0,46704
E8	0,93	1,22	1,05	1,07	-0,14975
Gx	1,09	1,15	1,09	1,11	
PCAg	0,26429	-0,67281	0,40853		

Tab. 8. AMMI ANOVA for the grain weight per spike of three wheat varieties in eight environments

Source	df	SS	MS	F	F	
					0,05	0,01
Total	71	11,116	0,1566	*		
Treatments	23	8,098	0,3521	**7.76	1,93	2,55
Genotypes	2	0,075	0,0374	0,82	3,32	5,39
Environments	7	6,283	0,8976	**9.17	2,34	3,30
Block	16	1,566	0,0979	*2.16	1,93	2,55
Interactions	14	1,740	0,1243	*2.74	2,60	2,84
IPCA	8	1,426	0,1782	**3.93	2,27	3,17
Residuals	6	0,314	0,0523	1,15	2,42	3,47
Error	32	1,452	0,0454	*		

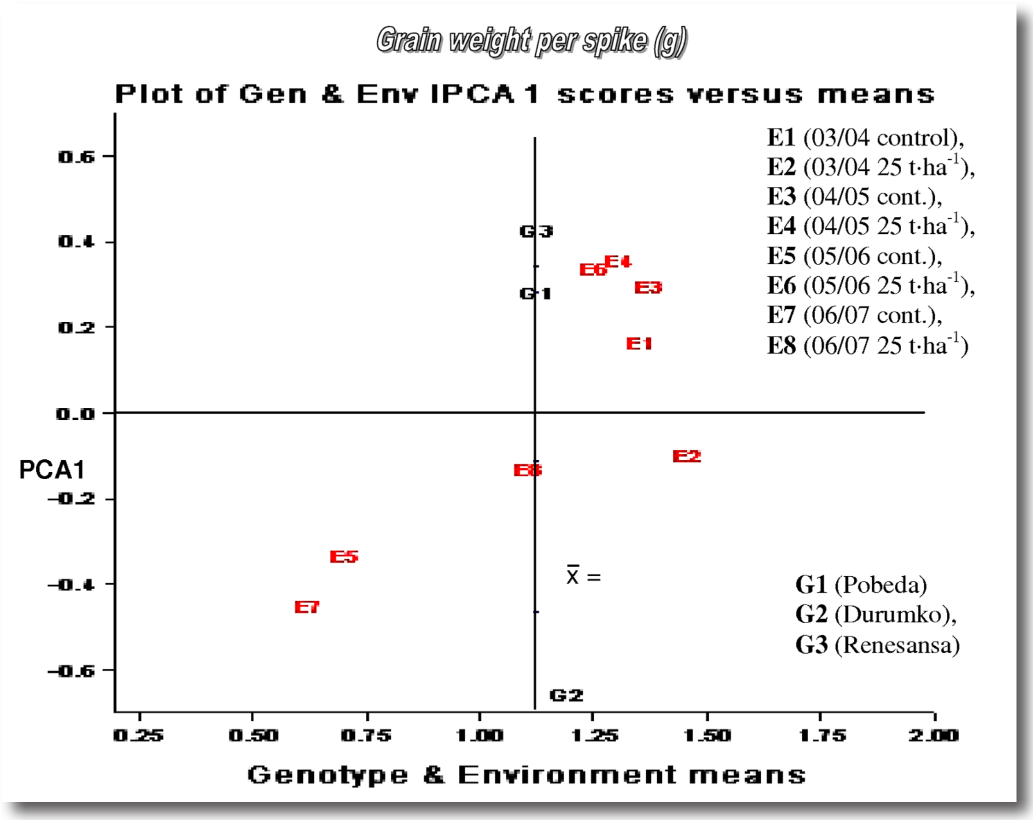

Fig. 4. Mean values for grain weight per spike of three wheat varieties grown in eight environments (4 years x 2 treatments), main and multivariate (genotype by environment interaction) effects

Conclusions

According to the results, a brief conclusion could be that:

- amelioration of 25t/ha phosphor gypsum had influenced the yield components studied in this trial. That was more expressed in mass traits and the number of grain per spike than in stem height, possibly due to gene systems (major + minor genes).
- the effect of melioration depended on year, as well as, on genotypes that reacted differently to amelioration.
- Variety Renesansa appeared to be less stable, showing enhanced GE interaction, that meant favorable response to amelioration. Variety Pobeda reacted to amelioration as well, having the smallest GE interaction exhibited in this trial.
- As expected, variety Durumko was best adapted unfavorable growing conditions, showing the smallest reaction to amelioration, but varying greatly due to vegetation periods. Consequently, GE interaction was quite expressed.

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Summary

The intensification that has taken place in agricultural production in a past four decades, partly led to agricultural soil degradation. In the other hand, there is still a lot of land unsuitable for intensive agricultural production that could be meliorated. Both of these environmental factors have a significant impact on plant behavior. There are several parametric and non-parametric models in plant stability/adaptability estimations. The aim of this investigations is to folow the impact of melioration of halomorphic soil on genotype by environment interaction in wheat using AMMI analysis.