2009

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UDC633.1:631
DOI: 10.2298/GENSR0902169D
Original scientific paper

PHENOTYPIC REACTION OF WHEAT GROWN ON DIFFERENT SOIL TYPES

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Dimitrijević M., S. Petrović, N. Mladenov, M. Belić, N. Hristov, B. Banjac and M.Vukosavljev (2009): *Phenotypic reaction of wheat grown on different soil type.* – Genetika, Vol. 41, No. 2, 169 -177.

Phenotypic variation of nine wheat varieties under different growing conditions was followed. Trials were conducted on solonetz, humoglay and black soil. The yield, as well as, the plant height, spike length and harvest index were studied. The effect of different environments on varietals phenotypic variability, with the emphasis on genotype by environment interaction, was analyzed using AMMI model.

Key word: AMMI, interaction, phenotype, soil, wheat

INTRODUCTION

There are 1.8 million hectars of agricultural land in Vojvodina. About one million hectars belong to chernozem soil, the rest are the less productive soil. Wheat is cultuvar that could bring less productive soil to more agriculturaly

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advanced use. Though, wheat requires well productive ground for the best performance, less productive soil under ameliorative measures could provide environment good enough to establish economically justified production. About 80000ha of solonetz soil, being mainly used as a grass land, could be enhanced to agricultural production using proper amelioration (BELIĆ, 1999). Humoglay, having less favorable water-physical properties could be ameliorated by water regulation, as well as organic and mineral fertilization.

Multienvironment wheat trials are necessery to define adaptation strategy in order to satisfy needs in breeding programs for getting new varieties in target selection for particular growing areas. The objective is to indicate and predict varietal behavior to perform the best in given agro-ecological conditions in a stable manner. Particularlly interesting areas for target breeding could be regions having soil of less productivity. Genotype ability to perform consistently, giving economic yield refers to economic yiled stability. That stability could be monitored by genotype/environment interaction quantification.

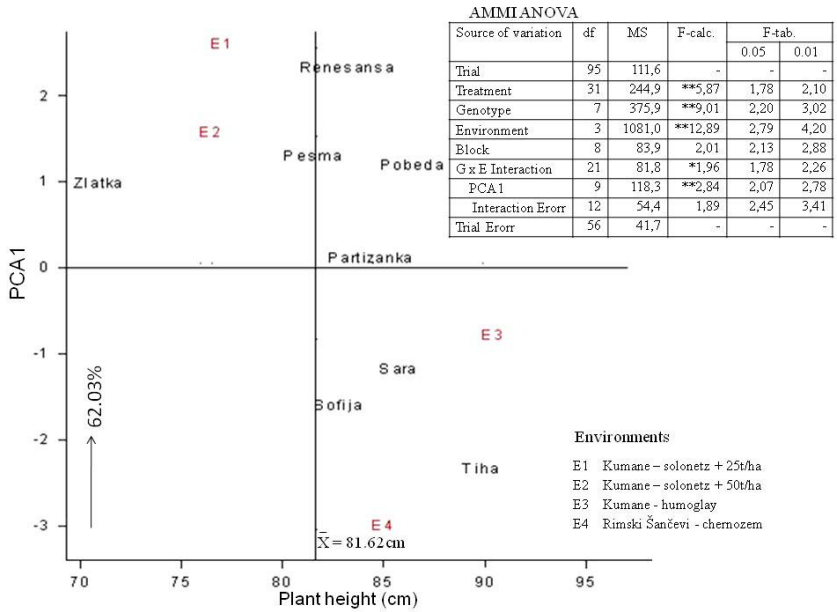
The aim of this study is to investigate genotype by environment interaction for plant heigth, spike lenght, harvest index, and grain yield of wheat varieties grown on different soil types.

MATERIALS AND METHODS

Nine wheat varieties (*Triticum aestivum ssp. vulgare*) created in Institute for Field and Vegetable Crops in Novi Sad: Renesansa, Mina, Sofija, Sara, Zlatka, Tiha, Pesma, Pobeda and Partizanka, were in study at localities of Kumane (Banat) on two soil types, solonetz ameliorated by 25t/ha and 50t/ha of phosphorgypsum (environments labeled E1 and E2, respectively), and humoglay (E3), as well as, Rimski Šančevi (Bačka) on chernozem soil (E4). In 2003/2004 the Randomize Block designed trial in three replications was established in 2m long rows, 20cm space between rows and 50kg NPK 15:15:15 fertilizer applied. Four traits were analyzed: plant height (cm), spike length (cm), harvest index (grain weight per plant/plant weight given in %) and grain yield (calculated from $5m^2$, in kg/ha). Variation in trial with the emphasis to genotype/environment interaction was analyzed using AMMI (Additive Main Effects and Multiplicative Interaction), ZOBEL *et al*. (1988). GenStat 8^{th} Edition, VSN International Ltd. (Trial) was utilized.

RESULTS AND DISCUSION

Plant height – Average values in trial differed from about 65cm for variety Zlatka on solonetz to about 99cm for variety Tiha grown on humoglay and chernozem. Varieties Zlatka and Tiha were the shortest (69.7cm) and the tallest (88.9cm), respectively, on average over all the environments. Generally, more productive environments of humoglay and chernozem donated about 10-15cm to plant height than less productive environments (solonetz with both meliorative treatments), fig.1.



AMMI ANOVA

Source of variation	df	MS	F-calc.	F-tab.	
				0.05	0.01
Trial	95	111,6	-	-	-
Treatment	31	244,9	**5,87	1,78	2,10
Genotype	7	375,9	**9,01	2,20	3,02
Environment	3	1081,0	**12,89	2,79	4,20
Block	8	83,9	2,01	2,13	2,88
G x E Interaction	21	81,8	*1,96	1,78	2,26
PCA1	9	118,3	**2,84	2,07	2,78
Interaction Erorr	12	54,4	1,89	2,45	3,41
Trial Erorr	56	41,7	-	-	-

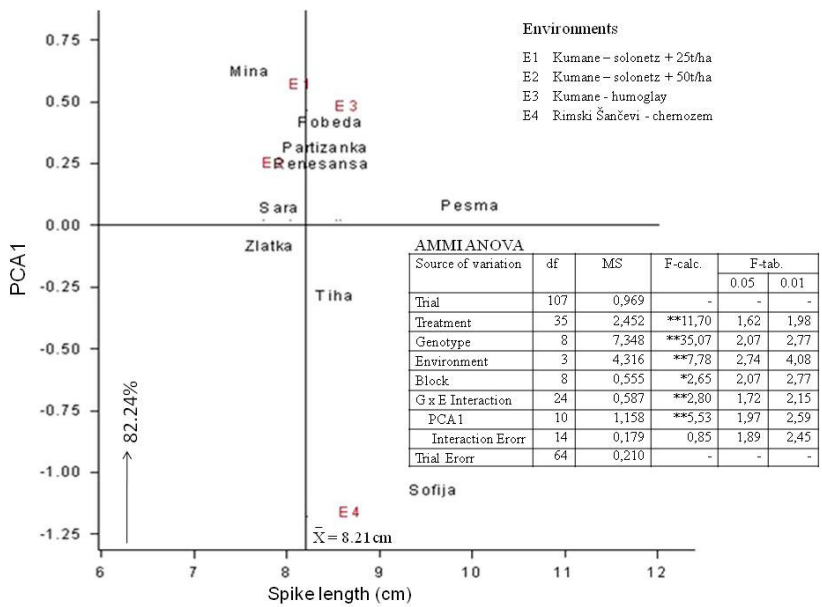
Figure 1. Plant height of 8 wheat cultivars in 4 environments grouping after mean and PCA1 values, and AMMI ANOVA

Analysis of variance showed statistically significant variation in all the main sources. GE interaction variation at significant level pointed out the presence of cross interaction in trial. Detailed separation of GE interaction variation revealed that explainable agronomic variation had been carried out by the first PC axis in proportion of 62% of total GE interaction variance (fig. 1). That is in accordance to previously reported results by DIMITRIJEVIĆ *et al*. (2005) and PETROVIĆ *et al*. (2008). The main variation source for the plant height appeared to be the soil type, according to environmental array. Genotipe differed both in additive and

multivariate variation. The smallest GE interaction had variety Partizanka holding its average height at the allover trial mean value. Varieties Pesma, Pobeda and Renesansa showed higher values of GE interaction better reacting to amelioration of solonetz soil. Variety Pobeda managed to develop plant height up to 80-83cm on solonetz in both treatments. Varieties Sara, Sofija, and particularly Tiha gave better performance on more productive ground (fig. 1). The results are in agreement to BRAUN *et al.* (1992) statement that the semi-dwarf wheat varieties apparence led to GE interaction enhancement.

Spike length – the trait varied from about 7cm (variety Zlatka on solonetz with 25t/ha phosphorgypsum of amelioration) to 11cm (variety Sofija on chernozem at Rimski Šančevi locality). Varieties Zlatka and Sofija offered the smallest (7.5cm) and the second highest (9.3cm), respectively, overall mean of spike length, as well. Environmental averages laid between 7.7cm (solonetz with 50t/ha phosphorgypsum of amelioration) to 8.6cm (chernozem soil), fig. 2.

AMMI analysis of variance showed all identified source of trial variation up as statistically significant. The presence of cross over variation was denoted by significant GE interaction variation. The vast variation (82%) was brought up on the first PCA (fig. 2).



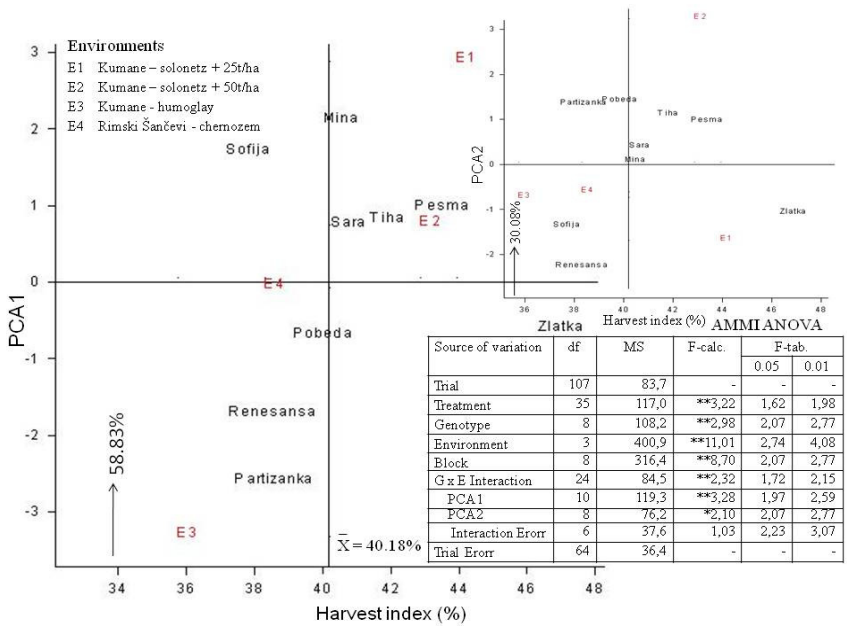
AMMI ANOVA

Source of variation	df	MS	F-calc.	F-tab.	
				0.05	0.01
Trial	107	0,969	-	-	-
Treatment	35	2,452	**11,70	1,62	1,98
Genotype	8	7,348	**35,07	2,07	2,77
Environment	3	4,316	**7,78	2,74	4,08
Block	8	0,555	*2,65	2,07	2,77
G x E Interaction	24	0,587	**2,80	1,72	2,15
PCA1	10	1,158	**5,53	1,97	2,59
Interaction Erorr	14	0,179	0,85	1,89	2,45
Trial Erorr	64	0,210	-	-	-

Figure 2. Biplot of spike lenght of 9 wheat cultivars in 4 environments grouping according to mean and PCA1 values, and AMMI ANOVA

Environmental scatteration leads to conclusion that the spike length strongly react to favorable growing conditions. The most stable genotypes were Zlatka, Sara with mean values close to trial average, and Pesma at the highest mean. Renesansa, Partizanak, Pobeda and Mina, in particular, expressed higher GE interaction and good reaction to amelioration on solonetz soil, as well as, good adaptation to less productive soil as a whole. Less stable variety Tiha and especially variety Sofija, demand ground of better quality for developing the trait in study (fig.2). Generally stated, despite smaller genetic divergence, non-additive effects of GE interaction appeared to be more expressive, that is in accordance to NOIROT *et al*. (1996).

Harvest index (HI) – the trait that express sink to source ratio affecting translocation from vegetative to generative parts of wheat plant was of the highest average for variety Zlatka (50%) on solonetz soil treated with 25t/ha of phosphorgypsum, and oppositely the lowest HI mean had variety Sofija (28%) on humoglay. Those two varieties held the border genotype mean values over all the environments from 37% (Sofija) to 46% (Zlatka). Environmental HI averages were in reverse order to plant height means, higher on less productive, and smaller on more productive soil (fig.3).



AMMI ANOVA

Source of variation	df	MS	F-calc.	F-tab. 0.05	F-tab. 0.01
Trial	107	83,7	-	-	-
Treatment	35	117,0	**3,22	1,62	1,98
Genotype	8	108,2	**2,98	2,07	2,77
Environment	3	400,9	**11,01	2,74	4,08
Block	8	316,4	**8,70	2,07	2,77
G x E Interaction	24	84,5	**2,32	1,72	2,15
PCA1	10	119,3	**3,28	1,97	2,59
PCA2	8	76,2	*2,10	2,07	2,77
Interaction Erorr	6	37,6	1,03	2,23	3,07
Trial Erorr	64	36,4	-	-	-

Figure 3. Biplot of harvest index of 9 wheat cultivars in 4 environments grouping according to mean and PCA1 values, as well as PCA2 (upper right corner), and AMMI ANOVA

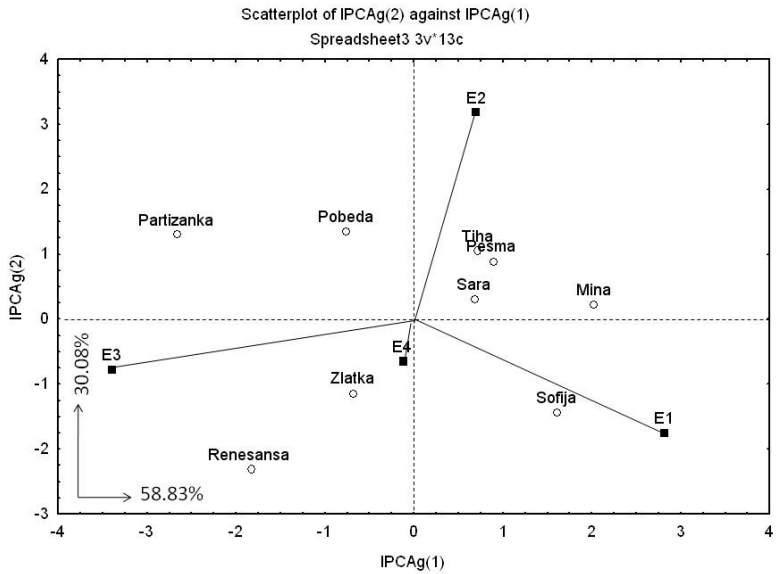


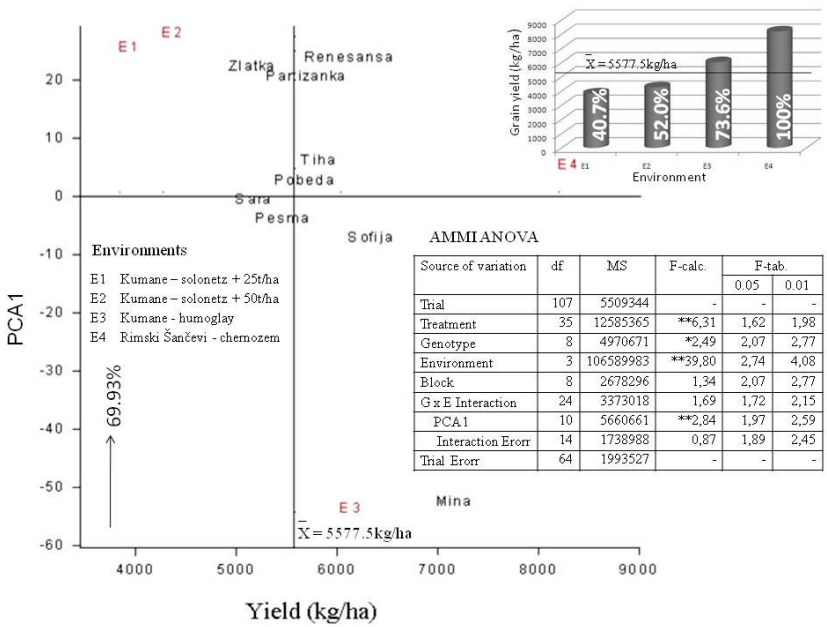
Figure 4. Biplot of the first and second PC axis for harvest index of nine wheat varieties in 4 environments

Variance analysis reveals somewhat more complex variation in GE interaction domain. Explainable GE variation was caused by two sources carried out by PCA1 (about 59%), and PCA2 (30%), fig. 3 and fig. 4. The similar pattern of HI variation was observed by PETROVIĆ *et al*. (1996).

Varieties under investigation differed more in non-additive than in additive effect under the influence of variation quantified by PCA1. GE variation brought up by PCA2 expressed both additive and multivariate effects. According to environmental array, the predominant source of GE variation was soil type. Wheat varieties on chernozem showed the smallest GE interaction. Multivariate component of GE variation was more present than additive, in respect to PCA1. Discussing the influence of the first variation source (PCA1), it could be denoted that variety Pobeda and Zlatka expressed the most stable reaction. However, variety Zlatka had the highest average value of HI over all environments. Varieties Sara, Tiha and Pesma with less expressed GE interaction, had good reaction to solonetz amelioration. Less stable varieties Sofija and Mina reacted well to lower level of amelioration on solonetz. Varieties Renesansa and Partizanka, with higher GE interaction, responded well on humoglay growth conditions (fig.3). Second source of GE interaction was more complex, because both additive and non-

additive GE variance components were notable. Varieties Sara and Mina had the smallest GE interaction in respect to second variation source brought on PCA2 (fig.3, upper right). Variety Sara, and locality Rimski Šančevi were the most stable considering both significant sources of GE variation. Smaller GE interaction at lower average was denoted on humoglay, while the less stable were varieties grown on solonetz soil (fig.4). The results go in favor that more stressed growth conditions enhance genotype by environment interaction .

Grain yield – Overall means goes in favour variety Mina that exhibited the highest grain yield value of about 7t/ha. Variety Zlatka held the last average spot keeping about 5t/ha of grain yield. In treatments the distance between minimum and maximum yield was even broader from 3t/ha for Sara on solonetz with the amelioration of 25t/ha of phosphor gypsum to 10t/ha for variety Tiha on chernozem soil. Average values at environments progressed linear, from 3.8t/ha at solonetz with the amelioration of 25t/ha to 8t/ha on chernozem.



Source of variation	df	MS	F-calc.	F-tab.	
				0.05	0.01
Trial	107	5509344	-	-	-
Treatment	35	12585365	**6,31	1,62	1,98
Genotype	8	4970671	*2,49	2,07	2,77
Environment	3	106589983	**39,80	2,74	4,08
Block	8	2678296	1,34	2,07	2,77
G x E Interaction	24	3373018	1,69	1,72	2,15
PCA1	10	5660661	**2,84	1,97	2,59
Interaction Erorr	14	1738988	0,87	1,89	2,45
Trial Erorr	64	1993527	-	-	-

Figure 5. Biplot of grain yield of 9 wheat cultivars in 4 environments grouping according to mean and PCA1 values, and AMMI ANOVA. The effect of environment to yield (upper right)

Analysis of variance showed non-significant GE interaction value. The weakness of additive model that is ANOVA was clearly shown. The significant sum of squares being burdened by 24 degrees of freedom, led to non significant

mean square. Further analysis of GE interaction revealed significant PCA1, carrying explainable variance. Similar was observed by a number of authors like Hristov (2004). Soil quality was predominant source of variation. Chernozem was the most stable environment. In GE variation non-additive effect had greater influence than additive. Varieties Tiha, Pobeda, Sara and Tiha had the smallest GE interaction at the trial level. Varieties Zlatka, Partizanka and Renesansa reacted well to amelioration with higher GE interaction, while variety Mina used the most of humoglay growth conditions (fig.5).

CONCLUSIONS

The multienvironment trial revealed the effects of different soil types to GE interaction. Diminished soil productivity enhances cross over interaction. Variety Sofija overall performance realized through yield was the steadiest. Mina used enhanced soil productivity well. Tiha responded to chernozem using its productivity to the best. Mina and Sofija had the best reaction to amelioration level enhancement on solonetz soil. Partizanka and Renesansa gave the best performance in more stressing environment of solonetz.

Received June 05th, 2009
Accepted August 18th, 2009

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FENOTIPSKA REAKCIJA PŠENICE NA RAZLIČITIM TIPOVIMA ZEMLJIŠTA

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I z v o d

Praćena je fenotipska reakcija devet sorti pšenice na uslove gajenja. Ogledi su postavljeni na zemljištu tipa solonjec, ritska crnica i černozem na lokalitetima Kumane i Rimski Šančevi. Ispitivan je prinos, kao i visina biljke, dužina klasa i žetveni indeks. AMMI modelom je analiziran uticaj različitih sredina na fenotipsku varijabilnost sorti, kao i interakcija genotipa i spoljne sredine.

Primljeno 05. VI.2009.
Odobreno 18. VIII. 2009.