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EFFECT OF GENOTYPE X ENVIRONMENT INTERACTION ON GRAIN YIELD OF WINTER WHEAT VARIETIES

R. PROTIC[1*], G. TODOROVIC[2], N. PROTIC[3], R. DJORDJEVIC[4], D. VICENTIJEVIC[5], D. DELIC[6], M. KOPANJA[5] and R. PRODANOVIC[5]

[1] *Institute for Science Application in Agriculture, Belgrade, Serbia*
[2] *Institute for Medicinal Plants Research „Dr Josif Pančić“, Belgrade, Serbia*
[3] *EKO-LAB, P. Skela, Belgrade, Serbia*
[4] *Institute of Vegetable Crops, Smederevska Palanka, Serbia*
[5] *University Business Academy, Novi Sad, Serbia*
[6] *Institute of Soil Science, Belgrade, Serbia*

Abstract

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In the period from 2002 to 2005, grain yield of fifteen wheat varieties grown in Serbia was studied in seven locations. At a triennial cross section, the proportion of genotypic variance was 51.56 %, and genotypic variance x environment 26.34 %. The genotype “cip“ had the highest grain yield in ZA, SO, SM, and CA environments, while the genotype “dra“ had the highest grain yield in PA and KI environments. Other corner genotypes, such as “zit“, “tek“, “viz“ and “min“ did not have high grain yields in any tested environment. The average grain yield distribution in the examined environments was as follows: SO>SM >CA >ZA >PA > KG > KI

Key words: wheat, variety, environment, grain yield

Introduction

The use of genotype main effect (G) plus genotype by environment (GE) interaction (G+GE) biplot analysis by plant breeders and other agricultural researchers has increased during the past year for analysing multi-environment trial (MET) data (Weikai et al., 2007).

Crop physiology and management studies often describe and quantify the changes plant breeders and geneticists have delivered in new germplasm but rarely address the specific changes needed to advance crop establishment, yield potential, or other agronomic goals (Snape, 2001). Extreme environmental conditions will always pose limitations for crop establishment, but continued progress in germplasm screening protocols and crop management research should lead to new varieties with a tailored set of agronomic practices for given environments and cultural practices (Amos, 2004).

Various institutions and companies carry out multi-environment trials worldwide. The goal is to determine top yielding variety for a certain location/region. The study of the certain regions is prerequisite for variety estimation and its recommendation to large production. Weikai and Hunt (1998); Braun et al. (1996), defines multi-environment as a space region, which is not necessary to be concentrated, and occurs in more than one country and it is often transcontinental, defined by similar biotic and abiotic conditions, and by growing system demands.

The goal of the paper is using the biplot method to show graphically the grain yields of different winter wheat varieties in different locations to examine the possibility of defining different regions for growing winter wheat in Serbia.

Material and Methods

As a material, winter wheat varieties were used, being of different genotypes according to the morpho-physiological traits, genetic potential for grain yield per area unit and quality made in the Institute for Field and Vegetable Crops in Novi Sad (Dragana – “dra”, Sofija – “sof”, Mina – “min”, Kantata – “kan”, Sonata – “son”, Vila – “vil”, Ljiljana – “ljilj”, Cipovka

**Corresponding author:* proticrade@yahoo.com

– "cip", and Pobeda – "pob"), Small Grains Research Centre in Kragujevac (Toplica – "top", Lazarica – "laz", Takovčanka – "tek" and Vizija - "viz") and Agricultural and Technological Research Centre in Zajecar (Marta – "mar" and Žitka – "zit") (Table 1). Trials were set up in the trial fields of the Agricultural Extension Service of Serbia (Pančevo – PA, Kikinda – KI, Sremska Mitrovica – SM, Sombor – SO, Zaječar – ZA, Čačak – CA, and Kragujevac - KG) (Table 2). Every year, ten to twenty-five winter wheat varieties, grown in that region along with newly registered or introduced varieties in the production, are grown in seven localities representing seven different breeding regions. Fifteen varieties being present in all localities in the productive from 2002/03 to 2004/05 are included in this work.

The experiment was conducted in a split-plot design with five replications. Preceding crop is sunflower in all localities with the usual agricultural practices for winter wheat in Serbia, with 120 kg/ha of nitrogen. Elementary plot size is 5 m^2. Planting was done in all locations in the mid-October. Mechanical sowing was done with seed density of 700 grains/m^2 and row spacing of 12.5 cm. The number of plants was determined in the spring, and the numbers of spikes per m^2 and crop health were determined at the beginning of summer. A combine did harvest in the full maturity stage, after which the grain yield was specified.

Results are shown as a three-year average for all properties and studied the instructions (Weikai and Hunt, 1998).

Results and Discussion

The biplot method is based on Principal Component Analysis, which has a spatial dimension and analyses the compo-

Table 1
Wheat genotype characteristics used in this study

No.	Genotypes	Maturity type	Resistance on			Weight 1000 grains, g	Test weight, kg	Protein content
			cryophylactic	lodging of stems	Puccinia and Erysiphe gram			
1	Toplica	Middle late	Excellent	Very good	Very good	44	82	13.5
2	KG-100	Middle late	Very good	Excellent	Good	42	80	13.0
3	ZA-75	Middle late	Very good	Very good	Very good	42	80	14.0
4	Takovčanka	Middle late	Very good	Very good	Very good	40	80	13.0
5	Sofija	Middle late	Excellent	Good	Good	42	85	15.0
6	Mina	Middle late	Excellent	Excellent	Very good	39	82	14.0
7	Kantata	Middle early	Very good	Very good	Very good	45	83	13.0
8	Anastasija	Middle early	Very good	Excellent	Good	42	81	12.0
9	Sonata	Middle late	Good	Good	Excellent	45	80	12.5
10	Vila	Middle late	Excellent	Very good	Very good	40	83	13.5
11	Ljiljana	Middle early	Good	Good	Good	40	86	15.0
12	Žitka	Late	Very good	Good	Excellent	48	75	16.0
13	Marta	Middle late	Good	Very good	Good	43	77	13.0
14	Pobeda	Middle late	Very good	Good	Good	43	85	15.0

Table 2
Locality characteristics where the genotypes are tested

No	Locality	Geographic coordinates		Altitude, m	Amount of rainfall during vegetation, mm/m^2
		North	East		
1	Pančevo (PA)	44053,	20066,	70	507
2	Kikinda (KI)	46031,	20030,	73	379
3	Sremska Mitrovica (SM)	44098,	19061,	82	546
4	Sombor (SO)	45078,	19012,	89	456
5	Zaječar (ZA)	43091,	22031,	137	568
6	Čačak (ČA)	43050,	20020,	204	511
7	Kragujevac (KG)	4401,	20055,	180	550

nents of variance using multidimensional axes. This analysis shows how much percentage of total variation accounts for genotype proportion, and how much for genotype x environment interaction.

At a triennial cross section, the proportion of genotypic variance was 51.56 %, and of genotypic variance x environment 26.34 % (Figure 1).

By analysing the components of variance for the size of wheat variety seed in different environments, Protić et al. (2010) determined that the proportion of environment variance was bigger than the proportions of genotypic variance and genotypic variance x environment interaction.

The biplot analysis is used to visually identify top yielding genotypes for each environment. Genotypes being far away from the beginning of biplot are connected with a straight line so that a polygon is formed with all other genotypes being found within the polygon. In this research, the genotypes placed in the corners, "zit", "tek", "viz", "cip", "dra" and "min", had the highest grain yield per area unit in their sector. These genotypes were the best or the worst ones in some or all environments. The formed polygon was divided into six sectors / quadrants; each one has its genotype placed in the corner. Corner genotypes for each sector / quadrant have the highest grain yield for the environments that belong to that sector / quadrant. Therefore, the genotype "cip" had the highest grain yield in ZA, SO, SM, and CA environments, while the genotype "dra" had the highest grain yield in PA and KI environments. Other corner genotypes, such as "zit", "tek", "viz"and "min"did not have high grain yields in any examined environment. They were the worst genotypes in some or all examined environments on average for the period from 2003 to 2005 (Figure 1).

According to the part of visual comparison of two varieties in different environments, the vertical line on the polygon side, which connects genotypes "cip" and "dra", makes easier the comparison of genotypes "cip" and "dra". The genotype "cip" had higher grain yields than the genotype "dra" in ZA, SO, SM, and CA environments, because these environments are on the side of the genotype "cip". In the same way, the genotype "dra" had the highest grain yields in PA and KI environments in the period from 2003 to 2005 (Figure 1).

The genotypes within the polygon had lower grain yields than the ones in the corners. According to visualisation of environment groups based on best genotypes, four groups distinguished from others. One group consisted of SM, CA, SO and ZA environments with the genotype "cip"that had the highest grain yield in those environments. Other group consisted of KI and PA environments with the genotype "dra" in the period from 2003 to 2005 (Figure 1).

The average grain yield distribution in the examined environments was as follows: SO>SM >CA >ZA >PA > KG > KI (Figure 2).

Plant breeders and genticists, as well as statisticians, have a long interest in research and integration of genotypes and environment for choosing superior genotypes (Barah et al.,

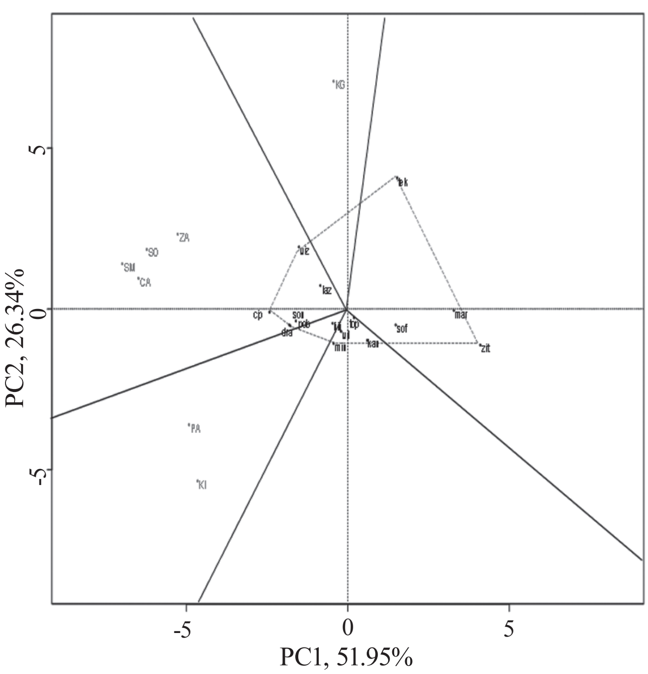

Fig. 1. The polygon view of the genotype + genotype by environment biplot for grain yield

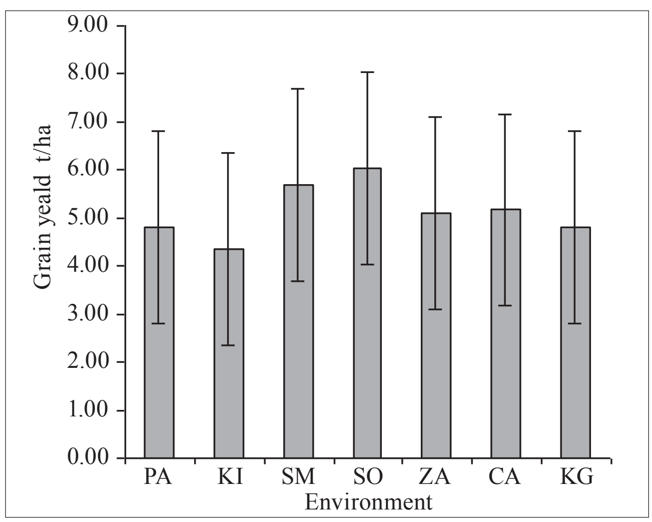

Fig. 2. Grain yield in t/ha of the winter wheat in different environments
(Average, 2003 – 2005)

1981; Kang, 1993; Eskridge, 1990; Huhn, 1996; Weikai et al., 2000). Many statistical methods are developed for GED analysis, Gauch (1992) and GGE biplot analysis Weikai and Kang (2003); Weikai and Tinker (2006).

According to Weikai et al. (2007), each variety has better yielding than the other one in localities with markers being on the side of the line which is vertical on the one between the markers and biplot centre and vice versa. The vertical line passing through the beginning of biplot on the line between the markers represents the locations where the varieties should have the same grain yield Weikai et al. (2007).

If the multi-environments are defined by different varieties prevailing there, the fact of more multi-environment existence is shown by Gauch and Zobel (1997). Protić et al. (2005) established highly significant difference in seed size between the years of testing, localities and genotypes, as well as highly significant difference between following interactions: year x locality, year x genotype, locality x genotype and year x locality x genotype.

Conclusion

Based upon the analysis of components of variance for examined wheat varieties in different locations, it was established that proportion of genotypic variance was bigger than genotype x location interaction variance. At a triennial cross section, the proportion of genotypic variance was 51.56 %, and genotypic variance x environment 26.34 %. The genotype "cip" had the highest grain yield in ZA, SO, SM, and CA environments, while the genotype "dra" had the highest grain yield in PA and KI environments. Other corner genotypes, such as "zit", "tek", "viz"and "min"did not have high grain yields in any tested environment. The average grain yield distribution in the examined environments was as follows: SO>SM >CA >ZA >PA > KG > KI.

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