

## Seed Size of Wheat Variety Grown in Multi-Environment

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### Abstract

Percent of four seed fractions (2.0 mm, 2.2 mm, 2.5 mm and 2.8 mm) was examined in six locations in the period from 2002 to 2005 for fourteen wheat varieties made in Serbia. Proportion of location variance was higher in the case of genotypic variance and genotype x location interaction variance. Location variance amounting 53.5 % was the lowest in the case of 2.0 mm-seed-size and the highest one amounting 73.5 % in the case of 2.8 mm-seed-size. Contrary to this, genetic variance and genotype x location interaction variance were higher in the cases of smaller seed fractions (2.0 and 2.2 mm) comparing to 2.5 and 2.8 mm-seed-sizes. Larger seed fractions of 2.5 and 2.8 mm-seed-sizes are the most significant in the seed production of wheat. Percent of 2.8 mm-seed-size in the examined locations was as follows: CA>SM>ZA>SO>PA>KI. "11" variety realized the highest seed content of 2.8 mm-seed-size in the ZA, PA, SM and CA environments. The highest proportion of 2.8 mm-seed-size fraction had "14" and "8" varieties in the SO and KI locations. Average percent of 2.5 mm-seed-size in the examined locations was as follows: KI>SO>ZA>CA>SM>PA. "13" variety had the highest percent of 2.5 mm-seed-size in ZA, SM, PA and CA locations, while "6" variety had the highest percent of 2.5 mm-seed-size in SO location and "11" variety in KI location. "13" variety had the highest percent of smaller 2.0 mm-seed-size in PA and ZA locations and 2.2 mm-seed-size in SO, ZA, SM and PA locations.

**Keywords:** environment, grown, seed size, variety, wheat.

### Introduction

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 [16]. Extreme environmental conditions will always pose limitations for crop establishment, but continued progress in germplasm screening protocols and crop management research should also lead to new varieties with a tailored set of agronomic practices for given environments and cultural practices AMOS [1]. Various institutions and companies carry out multi-environment trials worldwide. The goal is to determine top yielding variety for a certain region. Study of the certain regions is prerequisite for variety estimation and its recommendation to large production WEIKAI & HUNT [17]. BRAUN [2] 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. Growing of different wheat varieties in different regions is the need and result of existence of genotype-by-environment interaction. Environment is defined as the part of growing conditions of the region, which increases with the homogenous environment influencing that some genotype realizes the production level in the same way. The goal of this work was to raise a question of multi-

environment identification by using multi-environment (MET) data from Serbia and biplot techniques. Biplot methodology will graphically show the results of winter wheat genotypes and genotype-by-environment interaction. In addition, this methodology will help to determine which genotypes and where they are prevalent in Serbia, and then this would be used to examine the possibility of existence of different multi-environmental grouping Serbian winter wheat production region.

## 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 (Sofija – 5, Mina – 6, Kantata – 7, Anastasija – 8, Sonata – 9, Vila – 10, Ljiljana – 11, Pobeda – 14), Small Grains Research Centre in Kragujevac (Toplica – 1, KG 100 – 2 and Takovčanka – 4) and Agricultural and Technological Research Centre in Zajecar (ZA 75 – 3, Žitka – 12 and Marta – 13) (Table 2).

Trials were set up in the trial fields of the Agricultural Extension Service of Serbia (Čačak – ČA, Zajecar – ZA, Pančevo – PA, Sremska Mitrovica – SM, Kikinda – KI and Sombor – SO) (Table 1). 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 six localities representing six different breeding regions. Fourteen varieties being present in all localities in the productive from 2002/03 to 2004/05. year are included in this work. (?)

The experiment was conducted after the split-plot method in 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<sup>2</sup>. Planting was done in all locations in the mid-October. Mechanical sowing was done with seed density of 700 grains/ m<sup>2</sup> and row spacing of 12.5 cm. The number of plants was determined in the spring, and the number of spikes per m<sup>2</sup> and crop health were determined at the beginning of summer.

Harvest was done by a combine in the full maturity stage. Samples of each variety amounting 1000 g were taken, and grain size was determined in % using sieve of 2.8, 2.5, 2.2 and 2.0 mm.

Results are shown as a three-year average for all properties and studied the instructions WEIKAI & HUNT [19].

**Table 1.** Locality characteristics where the genotypes are tested

Locality	Geographic coordinates		Altitude	Amount of rainfall during vegetation in mm/m <sup>2</sup>
	North	East		
Čačak - ČA	43 <sup>0</sup> 50'	20 <sup>0</sup> 20'	204	511
Zajecar – ZA	43 <sup>0</sup> 91'	22 <sup>0</sup> 31'	137	568
Pančevo – PA	44 <sup>0</sup> 53'	20 <sup>0</sup> 66'	70	507
Sremska Mitrovica – SM	44 <sup>0</sup> 98'	19 <sup>0</sup> 61'	82	546
Kikinda – KI	46 <sup>0</sup> 31'	20 <sup>0</sup> 30'	73	379
Sombor - SO	45 <sup>0</sup> 78'	19 <sup>0</sup> 12'	89	456

**Table 2.** Wheat genotype characteristics used in this study

No	Genotype	Maturity type	Resistance on			Weight 1000 grains (g)	Test weight (kg)	Protein content
			Cryoph-ylactic	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	Katata	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

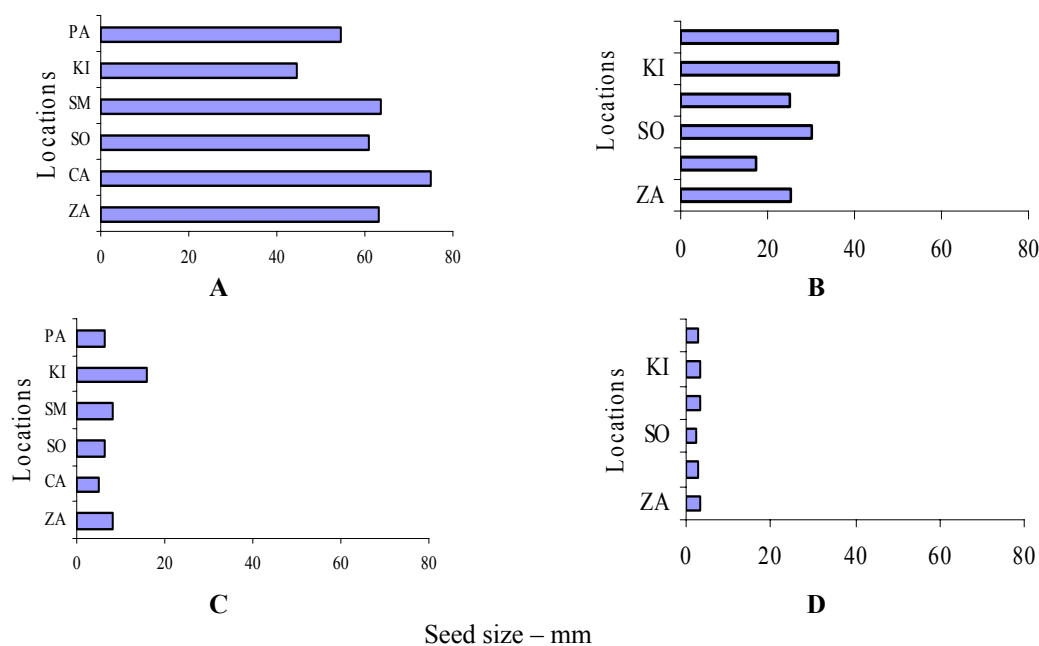
## Results and discussion

**Seed percent according to the size in the certain environment.** Projection of environment to the locations of average environment determines the average percent of 2.8 mm-seed size in the certain environment. The biggest 2.8 mm-seed size has different percents per locations in relation to the previous three seed sizes and it is as follows: ČA >SM >ZA >SO >PA >KI (Figure 1A).

Percent per locations in the case of 2.5 mm-seed size in relation to the previous seed sizes is changed and it ranged from 17.36 percents in ČA locality to 36.38 percents in KI locality (Figure 1B).

In the case of 2.2 mm-seed size, the locality ratio was the same as in the case of the previous size and it ranged from 4.83 percents in ČA locality to 15.86 percents in KI locality (Figure 1C).

In the case of 2.0 mm-seed size tested locations had this seed size among the mentioned data and they were as follows: KI >SO >PA >ZA >ČA >SM (Figure 1D).

**Figure 1.** Percent of presence according to the winter wheat seed size in different environments

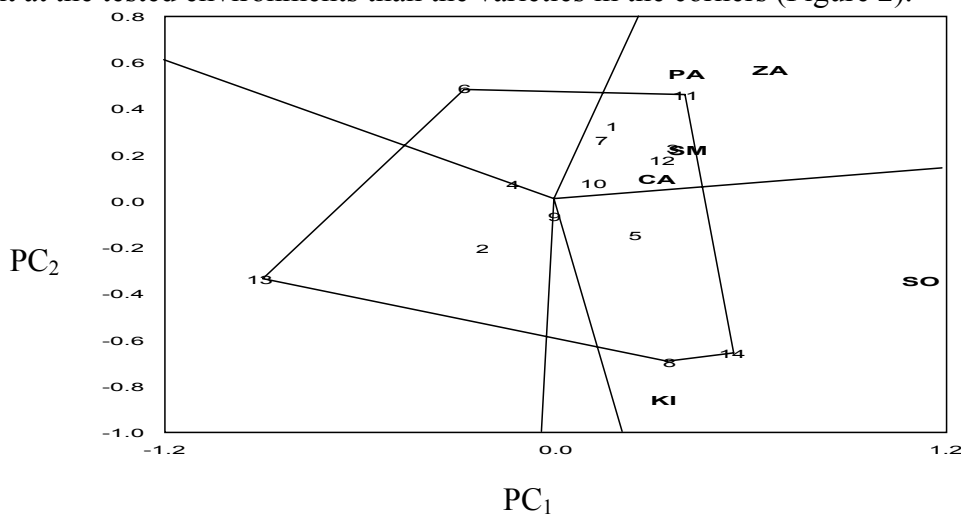
**Variance components.** The results of analysis of variance for the annual data give entire picture of relative variance terms G (genotype), L (locality) and GL (genotype x locality). Locality was always the most important source of variation of seed weight ranging from 53.5 % in the case of small size (2.0 mm) to 73.5 % in the case of large size (2.8 mm). Genotype-by-locality interaction was lower in the case of smaller sizes (2.0, 2.2 and 2.5 mm) than genotypic variance, except in the case of large size (2.8 mm) which was slightly higher. Genotypic variance was more evident in the case of small seeds than in the case of large seeds, and decreased with seed size increase. Localities had the opposite influence (Table 3).

**Table 3.** Variance components as a percentage of the total variance for various seed sizes

Source	The size of seeds (mm)			
	2,0	2,2	2,5	2,8
Cultivar	28,6	18,2	15,6	12,4
Environment	53,5	68,2	69,2	73,5
Interaction	17,9	13,6	15,2	14,1

**Seed size 2.8 mm.** Biplot methodology application is used to visually identify the genotypes with the biggest wheat seed size for each environment. Due to that reason, genotypes being far away from the beginning of biplot are connected by straight line so that the polygon is formed with all other genotypes being found within the polygon (Fig. 2). Varieties in the corner of this biplot are 14, 11, 6, 13 and 8, and they had the highest 2.8 mm-size seed content in their sector. These five varieties are the most reactive, they are the best or the worst ones in some or all environments. The lines from the beginning of biplot being vertical on the polygon sides divide it in five sectors and each one has its variety in the corner. Corner variety for each sector is the one having the highest 2.8 mm-size seed content within the environment (14, 11, 6, 13 and 8). Therefore, variety 14 had the highest 2.8 mm-size seed content in SO environment. Variety 11 produced the highest 2.8 mm-size seed content in ZA, PA, SM and CA environments, and variety 8 in KI environment (Figure 2).

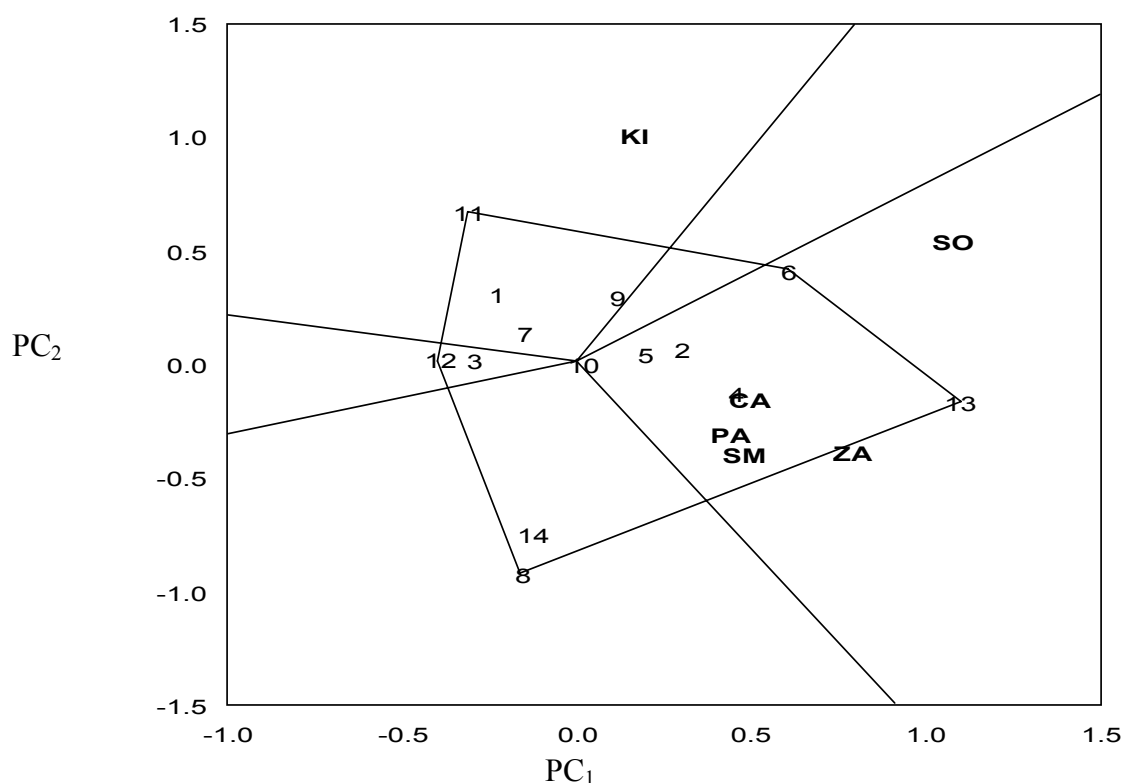
The other varieties, such as 13 and 6, did not have high 2.8 mm-size seed contents in any tested environment. They showed low 2.8 mm-size seed contents in some or all tested environments. Varieties within the polygon of this biplot (1, 7, 2, 5, 12, 4, 10 and 9) were less present at the tested environments than the varieties in the corners (Figure 2).



**Figure 2.** The polygon view of the genotype + genotype by environment biplot for 2.8 mm -size seed

**Seed size 2.5 mm.** Genotypes being present at the polygon corners are 13, 6, 11, 12 and 8 and they had the highest 2.5 mm-size seed content in their sector. The lines from the beginning of biplot being vertical on the polygon sides divide it in five sectors and each one has its variety in the corner. Corner variety for each sector is the one having the highest 2.5 mm-size seed content within the environment (13, 6, 11, 12 and 8). Therefore, variety 13 had the highest 2.5 mm-size seed content in ZA, SM, PA and ČA environments. Variety 6 had the highest 2.5 mm-size seed content in SO environment, and variety 11 in KI environment (Figure 3).

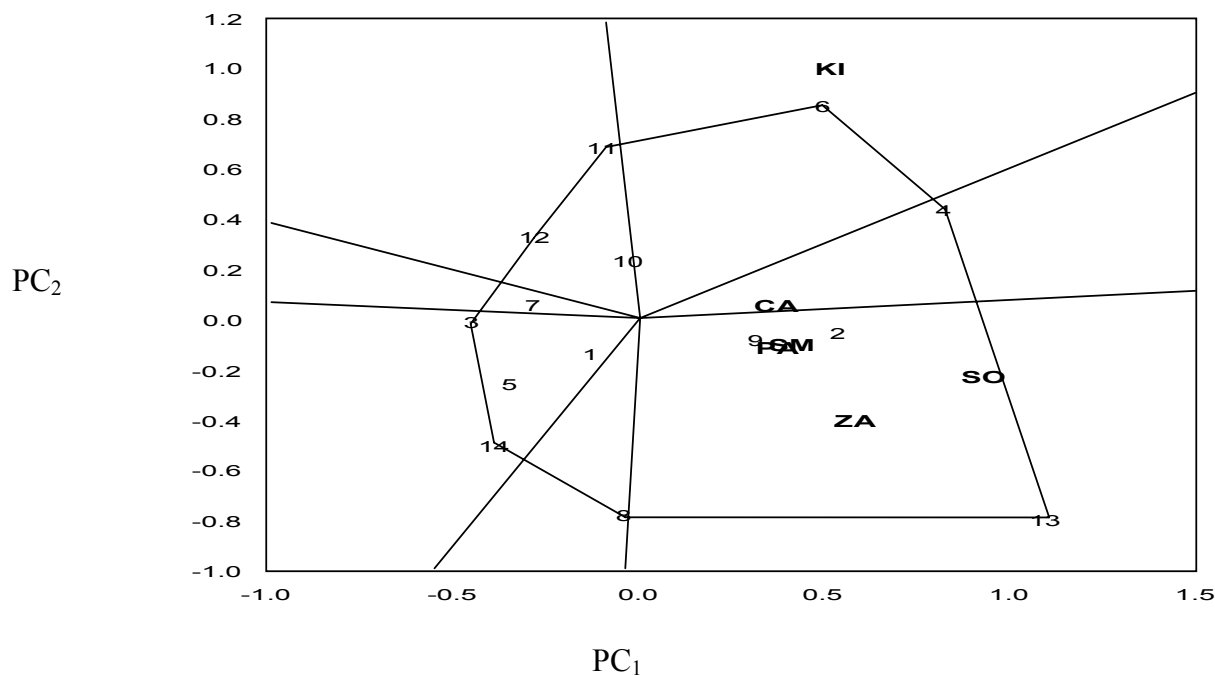
The other corner varieties, such as 12 and 14, did not have high 2.5 mm-size seed contents in any tested environment. They showed low 2.5 mm-size seed contents in some or all tested environments. Varieties within the polygon of this biplot (14, 1, 9, 3, 2, 7 and 5) were less present at the tested environments than the varieties in the corners (Figure 3).



**Figure 3.** The polygon view of the genotype + genotype by environment biplot for 2.5 mm- seed size

**Seed size 2.2 mm.** Genotypes being present at the polygon corners are 13, 4, 6, 11, 12, 3, 14 and 8 and they had the highest 2.2 mm-size seed content in their sector. The lines from the beginning of biplot being vertical on the polygon sides divide it in eight sectors, and each one has the variety in the corner. Therefore, variety 13 had the highest 2.2 mm-size seed content in SO, ZA, SM and PA environments. Variety 4 produced the highest 2.2 mm-size seed content in ČA environment, and variety 6 in KI environment (Figure 4).

The other corner varieties, such as 11, 12, 3, 14 and 8, did not have high 2.2 mm-size seed contents in any tested environment. In fact, they showed low seed content in some or all tested environments. The varieties within the polygon of this biplot (2, 9, 5, 1, 7 and 10) were less present at the tested environments than the varieties in the corners (Figure 4).



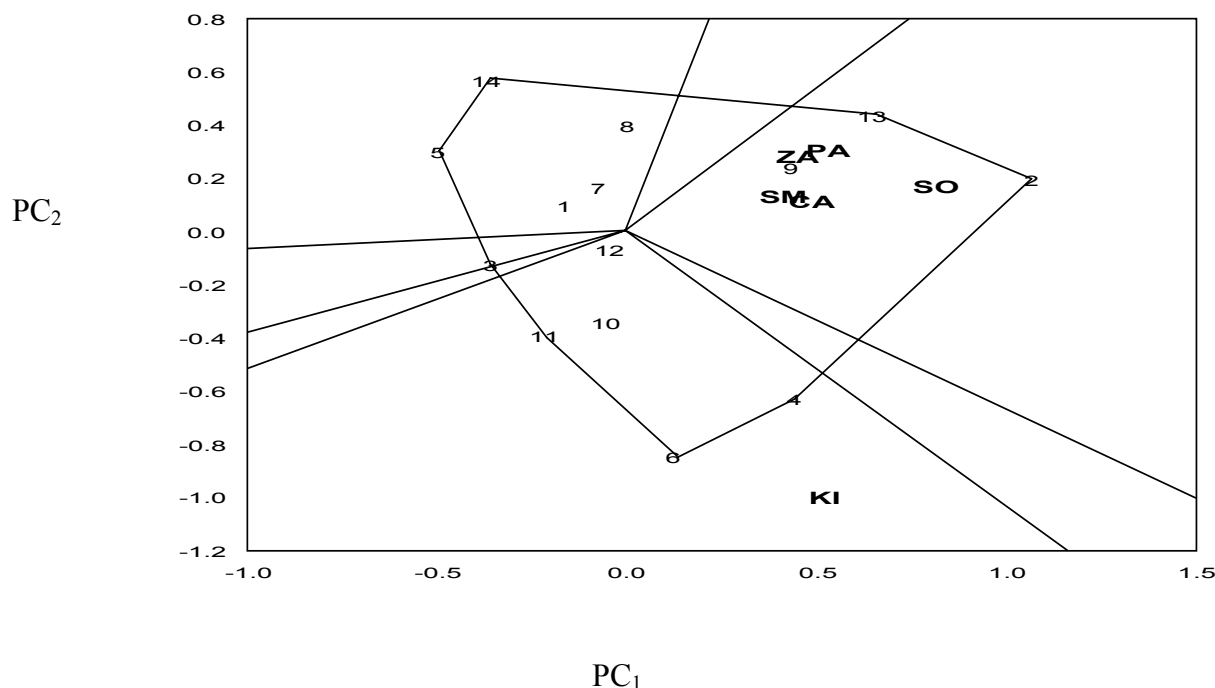
**Figure 4.** The polygon view of the genotype + genotype by environment biplot for 2.2 mm- size seed

**Seed size 2.0 mm.** Genotypes in the corners of the polygon are 6, 4, 2, 13, 14, 5, 3 and 11. These eight varieties are the most reactive, they are the best or the worst ones in some or all environments. Perpendicular to the polygon sides, starting from the beginning of biplot, divide the biplot in eight sectors, and each one has its variety in the corner. Corner variety for the sector is the one which has the highest percent of 2.0 mm-size seed for the environments within that sector. Therefore, variety 2 had the highest percent of 2.0mm-size seed in SO, ČA and SM environments, and variety 13 in PA and ZA environments. Variety 6 had the highest percent of 2.0 mm-size seed in KI environment. The other corner varieties, such as 4, 11, 3, 5 and 14, did not have the high percent of 2.0 mm-size seed in any tested environment. They had the lowest 2.0 mm-size seed content in some or all tested environments, which is very good characteristic of these varieties (Figure 5).

The explanation why the above mentioned results are valid. According to the part of visual comparison of two varieties in different environments, the vertical line on the polygon side, which connects varieties 6 and 11, makes easier the comparison of varieties 6 and 11. Variety 6 had higher 2.0 mm-size seed content than variety 11 in all tested environments because all environments are on the side of variety 6. In the same way, the line being vertical on the polygon side, which connects varieties 2 and 4, makes easier the comparison between varieties 2 and 4 because variety 2 had higher 2.0 mm-size seed content than variety 4 in five tested environments within variety 2 sector on its side. The tested KI environment is on the variety 4 side (Figure 5).

The line being vertical on the polygon side, which connects varieties 2 and 13, shows that variety 2 has higher 2.0 mm-size seed content than variety 13 in four tested environments (SO, ČA, SM i KI) belonging to its sector and they are on its side ( Figure 5).

The other varieties in the polygon corners, such as 13, 14, 5, 3 and 11, had the low 2.0 mm-size seed content. They were far away from the all locality markers reflecting the fact that they had low 2.0 mm-size seed content in all tested localities. The varieties within the polygon were less present at all tested localities than the varieties in the corners because they showed to have lower 2.0 mm-size seed content (Figure 5).



**Figure 5.** The polygon view of the genotype + genotype by environment biplot for the 2.0 mm-size seed

According to WEIKAI & al. [18], 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. Due to that, variety 2 had higher grain content of 2.0 mm diameter than variety 6 in SO, PA, ZA, ČA and SM localities, whereas variety 6 had higher content in KI locality. 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 & al. [18].

In wheat, seed size is positively correlated with seed vigour: larger seeds tend to produce more vigorous seedlings COOKSON & al. [5]. Similarly, KHAH & al. [9] found that low-vigour spring wheat seed produced lower yields only when it resulted in low plant populations or when planting was later than normal. However, MIAN & NAFZIGER [11] have found that seed size has little effect on emergence of soft red winter wheat.

Although many reports suggest that larger seeds produce seedlings with greater early growth and increased competitive ability against weeds and pests (CHASTAIN & al. [4]; DOUGLAS & al. [6]; MIAN & NAFZIGER [11]), the sheer range of examined in the literature is cause for careful interpretation of results on seed vigour. The relative performance of cultivars was similar for speed of emergence, haun stage and seedling shoot dry weight. Plants grown from small seeds emerged faster but accumulated less shoot dry weight than plants grown from large seeds. There was no cultivar by seed size interaction observed for speed of emergence and seedling shoot dry weight. Seed size, speed of emergence, and haun stage all contributed to differences between cultivars in seedling vigour. Seed size accounted for approximately 50% of the variation in seedling shoot dry weight. It was concluded that selecting for seedling vigour could be done by selecting for seed size, speed of emergence and/or rate of plant development LAFOND & BAKER [10].

The development of competitive cropping systems could minimize the negative effects of wild oat competition on cereal grain yield, and in the process, help augment herbicide use. A 3-yr field experiment was conducted at Kalispell, MT, to investigate the effects of spring wheat seed size and seeding rate on wheat spike production, biomass, and grain yield under a

range of wild oat densities. Wheat plant density, spikes, biomass, and yield all increased as seed size and seeding rates increased. Averaged across all other factors, the use of higher seeding rates and larger seed sizes improved yields by 12 and 18%, respectively. Accordingly, grain yield was more highly correlated with seed size than with seeding rate effects. However, the combined use of both tactics resulted in a more competitive cropping system, improving grain yields by 30%. Seeding rate effects were related to spike production, whereas seed size effects were related to biomass production. As such, plants derived from large seed appear to have greater vigor and are able to acquire a larger share of plant growth factors relative to plants derived from small seed ROBERT & STOUGARDA [15]. Averaged across all other factors, spring wheat plants derived from large seed reduced wild oat panicle numbers 15% and biomass and seed production 25% compared with small seed. Increasing spring wheat seeding rate from 175 to 280 plants m<sup>-2</sup> reduced the number of panicles 10% and wild oat biomass and seed production 20%. The combined effect of large seed plus increased seeding rate, reduced wild oat biomass and seed production by 45%. Results demonstrate that the use of large seed size and increased seeding rates can improve wheat competitiveness and provide an effective means to reduce wild oat biomass and seed production QINGWU & ROBERT [14].

Non-genetic variations in crop seed size affected the competitive dynamics between these species, where the major crop-weed interference mechanism involved wild oat seed weight FERNANDO & al. [7].

No effect of seed size on germination of wheat seeds, found MAIN & NAFZIGER [12]. Some of these discrepancies may be due to differences in environmental conditions including availability of soil moisture BRUCE & al. [3]. The interactive effects of seed size and seed placement on wheat yield and yield components are perhaps important to study in this regard. It was established a highly significant difference in seed sizes between years of researching, locality and genotypes, then highly significant interactions between year × locality, year × genotype, locality × genotype and year × locality × genotype PROTIC [13].

If the multi-environments are defined by different varieties prevailing there, the fact of more multi-environment existence is shown by GAUCH & ZOBEL [8]. These data represent the existence of more multi-environments for winter wheat in the Republic of Serbia.

## Conclusion

Based upon the analysis of components of variance for examined wheat varieties in different locations, it was established that proportion of location variance was higher than genotypic one and genotype x location interaction variance for the seed size trait. According to the seed size, location variance ranged from 53.5 % in the case of 2.0 mm-seed-size to 73.5 % in the case of 2.8 mm-seed-size. Proportion of genetic variance and genotype x location interaction variance was higher in the case of smaller seed fractions (2.0 and 2.2 mm) than in the case of 2.5 and 2.8 mm-seed-sizes.

Larger seed fractions are the most significant in the seed production of wheat. Percent of 2.8 mm-seed-size in the examined locations was as follows: CA >SM >ZA >SO >PA >KI. “11” variety realized the highest seed content of 2.8 mm-seed-size in the ZA, PA, SM and CA environments. The highest proportion of 2.8 mm-seed-size fraction had “14” and “8” varieties in the SO and KI locations.

Average percent of 2.5mm-seed-size in the examined locations was as follows: KI >SO >ZA >CA >SM >PA. “13” variety had the highest percent of 2.5 mm-seed-size in ZA, SM, PA and CA locations, while “6” variety had the highest percent of 2.5 mm-seed-size in SO location and “11” variety in KI location.

“13” variety had the highest percent of smaller 2.0 mm-seed-size in PA and ZA locations and 2.2 mm-seed-size in SO, ZA, SM and PA locations.



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