EVALUATION OF VARIABILITY FOR SOME COMPONENTS OF PLANT YIELD IN WINTER WHEAT

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Abstract. *Breeders are permanently looking for effective methods for developing cultivars with improved yield. For that goal, they should include different genotypes in many cross combination to obtain the recombination of desirable genes. The biological material was composed of 11 winter wheat varieties with different origin: Alex, Boema, Ciprian, Izvor, Glosa (Romania); Laurentio, Renan (France); Josef, Galio (Austria); Akteor, Exotic Germany). The wheat varieties were evaluated regarding the following traits: plant height; spike length; spikelet number/spike; spike weight; grain number/spike and grain weight/spike. This study evaluated the diversity of 11 winter wheat varieties with different origins for some plant yield traits, and the possibilities of using these varieties in breeding programs. Higher plant stature of Josef, Galio and Laurentio varieties was associated with the highest values of spike weight, number and weight of grains/spike, and values above the mean for spike length and spikelets number/spike, respectively. The results of this research show that some varieties achieved high values for different traits of plant yield. Therefore, these varieties are successively used for further breeding programs based on diallel-crossing methods, to develop new wheat varieties. For these varieties, the spike weight has the highest and significant contribution (64,83%) to the achievement of plant yield, followed by the plant height, which contributes with 10,26 % to the variability of this trait. The spike length and grain's number/spike had the lowest influence on plant yield. According to the high diversity between some varieties like the following Glosa-Akteor; Izvor-Josef; Izvor-Akteor; Josef-Exotic, these pairs are suitable for crossing to obtain hybrids with useful gene combinations for different yield components. Considering the highest variance for plant height and spike length, we appreciate that it is possible to identify valuable gene combinations for these traits in segregating generations.*

Keywords*: winter wheat, spike traits, phenotypic diversity*

INTRODUCTION

The yield capacity is a complex genetic trait, which is transmitted predominantly, recessively or intermediate depending on the variety, productivity elements and influencing factors (resistance to adverse action of external factor) (POTLOG *et al*.,1982).

Breeders are permanently looking for effective methods for developing cultivars with improved yield. For that goal, they should include different genotypes in many cross combination to obtain the recombination of desirable genes. The biological material was composed of 11 winter wheat varieties with different origin: Alex, Boema, Ciprian, Izvor, Glosa (Romania); Laurentio, Renan (Franța); Josef, Galio (Austria); Akteor, Exotic (Germania).

The variety-specific productivity elements are genetic traits used successfully in breeding programs. Actually yield is a result of value of yield components as well: plant height; spike length; spikelet number/spike; spike weight; grain number/spike and grain weight/spike (POTLOG *et al*.,1982; RACZ *et al.*.2014).

The characters as: plant stature, length of spike, the number of spikelets/spike are in positive correlation with grain yield (ZEČEVIĆ & KNEŽEVIĆ, 1998). Also positive correlation was established between spike length and number of fertile spikelets/ spike, the number of kernels spikes, grain mass spikes, and one thousand grain mass, and a negative correlation between length of spike and number of sterile spikelets (STOJANOVIĆ *et al*, 1998). Environmental conditions (precipitation, drought, temperature) have influence to efficiency of fertility, grain filling, capacity of assimilation acceptors and translocation of assimilates from the stalk and leaves to the grain (UŽIK & ŽOFAJOVÁ, 2006; KNEZEVIC *et al*., 2007 a).

Breeders are permanently looking for effective methods for developing cultivars with improved yield. For that goal, they should include different genotypes in many cross combination to obtain the recombination of desirable genes. For that reason for breeder is essential to estimate genotype/environmental interactions through phenotypic variability (UŽIK & ŽOFAJOVÁ, 2006; KNEZEVIC *et al*., 2007 a).

This study evaluated the diversity of 11 winter wheat varieties with different origins for some plant yield traits and the possibilities of using these varieties in breeding programs.

MATERIAL AND METHODS

The research was performed in Agricultural Research and Development Station Lovrin during 2019. The biological material was composed from 11 winter wheat varieties with different origin: Alex, Boema, Ciprian, Izvor, Glosa (Romania); Laurentio, Renan (France); Josef, Galio (Austria); Akteor, Exotic (Germany). The research was organized using a randomized block design with three replications, using plots of 10 m^2. From each plot 20 randomly selected plants were harvested and evaluated for the following traits: plant height (PH); spike length (SL); spikelet number/spike (SNS); spike weight (SW); grain number/spike (GNS) and grain weight/spike (GWS).

Data were analyzed using ANOVA method and the means of varieties for different traits were compared using Multiple Range Test according to CIULCA (2006a). The interrelations between different traits were evaluated using variance analysis for multiple regression and phenotypic correlations. The diversity between varieties was analyzed using JACCARD similarity coefficients, and principal components (CIULCA, 2006b). The distance matrix was used for cluster analysis based on the unweighted pair-group method with arithmetic averages (UPGMA), using the Neighbor program of the PHYLIP package, version 3.5c.

RESULTS AND DISCUSSIONS

Considering the values of the plant height (table 1) between the 11 varieties, an amplitude of variation of 20,21 cm is observed, between 98,75 cm in Galio and 78,54 cm in Glosa. About 74% of the varieties registered values higher than 90 cm. For this character, the statistically undifferentiated varieties Galio and Laurentio were particularly highlighted, which presented a plant stature significantly higher by 11,65-25,73% compared to the Boema, Izvor, Exotic and Glosa varieties. In the case of the Glosa variety, the height of the plants was significantly lower by more than 10% compared to the rest of the varieties, except for Exotic variety.

The length of the spike-presented values with the range of 8,11 cm to Izvor variety and 11,28 cm to Akteor variety, while the five varieties had values higher than 10 cm and four varieties values below 9 cm. As such, the spike length of the Akteor variety was significantly higher by 21,16-37,73% than other five varieties. In the case of Boema and Izvor varieties, values of this character were observed significantly lower by more than 17% compared to the most other, except the varieties: Exotic, Glosa and Alex .

Table 1

Mean values of plant height and different spike traits of wheat varieties studied at Lovrin in 2019

Variety	Plant height (cm)	Spike length (cm)	Spikelets number/spike	Spike weight (g)	Grains number/spike	Grains weight/spike (g)
Boema	87.29 bc	8.19 e	42.17 c	2.10 bc	33.51 bcd	1.32 cd
Laurentio	98.61 a	10.67 ab	53.87 b	2.60 ab	38.27 ab	1.42 c
Alex	90.12 ab	9.31 bcde	47.29 bc	2.17 bc	40.17 a	1.80 bc
Ciprian	90.87 ab	9.87 abcd	48.61 bc	2.30 abc	38.65 ab	1.85 bc
Glosa	78.54 d	8.43 de	47.95 bc	2.60 ab	35.24 abc	1.80 bc
Izvor	88.32 bc	8.11 e	42.53 c	2.14 bc	26.48 e	1.30 cd
Josef	94.08 ab	10.69 ab	54.17 ab	2.49 ab	40.39 a	2.45 a
Akteor	90.42 ab	11.28 a	60.81 a	1.25 d	33.17 bcd	0.90 d
Galio	98.75 a	10.37 abc	54.29 ab	2.80 a	30.54 cde	2.00 ab
Exotic	80.26 cd	8.92 cde	54.78 ab	1.81 cd	27.38 de	1.30 cd
Renan	90.49 ab	10.34 abc	54.16 ab	2.50 ab	36.18 ab	1.55 bc
Mean	89.80±1.92	9.65±0.34	50.97±1.73	2.25±0.13	34.54±1.46	1.61±0.13
LSD5%	*8.68*	*1.52*	*7.82*	*0.60*	*6.62*	*0.58*

*Different letters indicate significance at p <0.05.

The number of spikelets registered an amplitude of 18.64 against the background of a medium interpopulation variability. In the case of the six varieties values were observed over than 53 spikelet number/spike, while only two varieties had a number of 45 spikelet numbers/spike. For the Akteor variety values were significantly higher with 25,10- 44,20% compared to the six of the other varieties. The statistically

undifferentiated varieties Galio, Exotic, Renan, Josef and Laurentio achieved a significantly higher number of spikelets/spike by 26,66-29,90% compared to the Izvor and Boema varieties.

Regarding the values of the spike weight between the 11 varieties, there is an amplitude of variation of 1,55 grams between 2,80 grams for Galio and 1,25 grams for Akteor . Approximately 36 % of the varieties recorded values higher than 2,5 grams, while in only two varieties the grain mass of the spike was less than 2 grams. For this character they have in particular revealed Galio variety, which presented a spike weight significantly greater with 29,03 to 124 % compared to the Boema, Alex, Izvor, Akteor and Exotic varieties. In the case of the Akteor variety, value of this character was significantly lower by more than 40% compared to the rest of the varieties, except Exotic .

The number of grains/spike showed values with limits from 26,48 for the Izvor variety to 40,39 for the Josef variety, given that the two varieties had values higher than 40 and the other below 30. As such, the number of grains/spike from Alex and Josef varieties was significantly higher than 19,87 to 52,53 % than five of the other varieties. In the case of the Exotic and Izvor varieties , significantly lower values of this character were observed by more than 18 % compared to most of the other varieties, except Akteor, Galio and Boema variety.

The yield of the spike recorded an amplitude of 1,55 grams on the background of a high interpopulation variability. In the case of four varietieswere observed values of 1,5-2 grams, while only two varieties reached 2 grams. In the case of the Josef variety, the values of this character were significantly higher by more than 32,43% compared to the rest of the varieties barring Galio variety, which in turn showed significant increases of more than 41% compared to the other five varieties. The Akteor variety recorded a significantly lower yield/spike by more than 26% compared to the other one, except the Exotic variety.

Table 2

Correlation coefficient values between yield traits of wheat varieties studied at Lovrin in 2019

Traits	2	3	4	5	6
1. Plant height	0.678***	0.290	0.339	0.336	0.268
2. Spike length		0.851***	-0.028	0.428*	0.136
3. Spikelets/spike			-0.230	0.091	-0.066
4. Spike weight				0.306	0.712***
5. Grains number/spike					0.520**
6. Grains weight/spike					

$r_{5\%} = 0,349$; $r_{1\%} = 0,449$; $r_{0,1\%} = 0,554$

An analysis of the correlations (table 2) indicates the existence of a positive and statistically ensured between the yield of the spike and its weight, respectively the number of grains/spike. Thus, the orientation of the selection toward increasing the mass of the spike and the number of grains can also ensure an improvement yield of the spike. Also, there is a significant positive correlation between the size of the plant and the length of the spike and between the length of the spike and the number of spikelets or the number of grains in the spike. Thus, it is observed that in some varieties, the increase in plant size was associated with an increase in the length of the spike and its fertility, respectively, in the number of grains in the spike.

Table 3

Variance components of multiple regression between grains weight/spike and other yield traits in wheat varieties

Source of variability	SS	DF	MS	F
Regression	1.115 (87.95%)	5	0.223	7.30*
Plant height (x_1)	0.130 (10.26%)	1	0.130	4.34
Spike length (x_2)	0.007 (0.55%)	1	0.007	0.23
Spikelets/spike (x_3)	0.113 (8.88%)	1	0.113	3.75
Spike weight (x_4)	0.822 (64.83%)	1	0.822	27.39**
Grains number/spike (x_5)	0.043 (3.42%)	1	0.043	1.45
Residual	0.153 (12.05%)	5	0.031	
Total	1.268	10		

$y = -0.47 -0.008x_1 +0.027x_2 +0.002x_3 +0.647x_4 +0.028x_5$; $R^2 = 0.8795$; SDE=0.17 g; DW=1.99

Analysis of the variance of the multiple regression regarding the influence of the five characters on the spike yield of the wheat varieties attests the fact that 87,95 % of the mass grain/spike variability is due to the influence of those characters. Among them, it is noted that the weight of the spike has a significance different contribution of about 64,83 % to achieve yield spike, followed by plant height (10,26 %), while the length of the spike and number of grains/spike influenced in a small measure this character.

The regression model adopted for the analysis of the relationships between the yield spike and the other characters, presents a strong statistical assurance, evaluating the weight of the grains/spike with an error of $\pm$ 0,17,40 grams. Given that the Durbin-Watson index is higher than 1,4 it results that the possible errors that accompany the experimental results are not autocorrelated, and the order of the five variables in the regression equation does not influence the estimated weight.

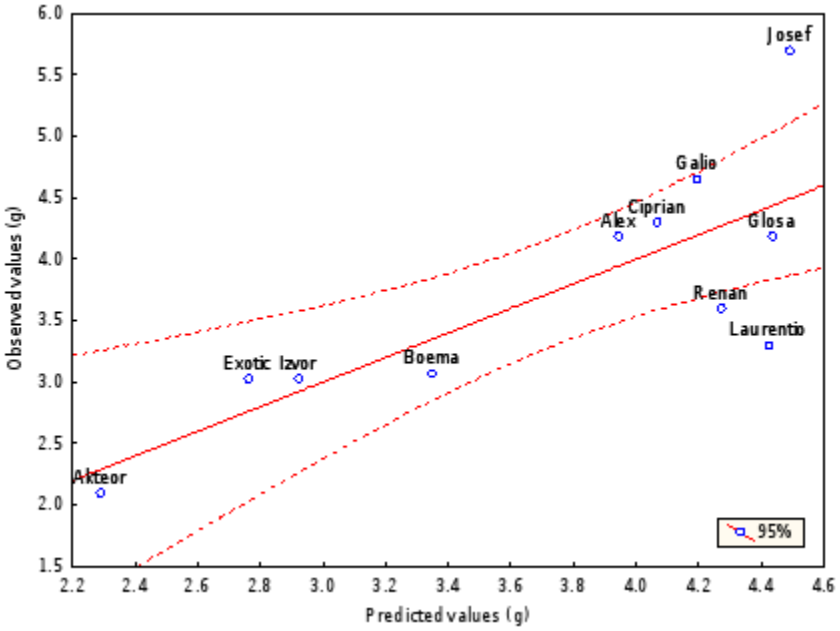


Figure 1. Observed and estimated values of grain weight/spike based on multiple regression model for wheat varieties

Considering the values of the weight grain/spike and the estimated ones (figure 1), it shows that only in the case of Josef variety (positive deviations) and Renan and Laurentio (negative deviations), there are significant variations compared to the regression model. Therefore, for the mentioned varieties, other indices are used to guide the selection and increase the productivity of the spike. The smallest differences between the observed values of the different characters and those estimated according to the multiple regression model were registered for the Exotic and Izvor varieties.

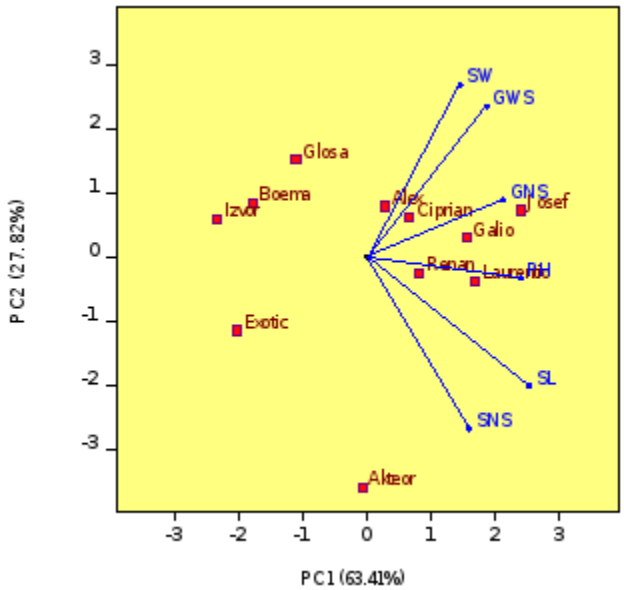


Figure 2. Biplot for wheat varieties and yield traits studied at Lovrin in 2019

The two-dimensional diagram based on the first two main components show that 91.23 % of the variability of the six characters included in the study. Depending on the projections of the varieties on the vectors of different characters, it is found that the high plant size in Josef, Gallio and Laurentio was associated with the highest values of spike weight, number and weight of grains/spike, respectively values above average to spike length and number of spikelets/spike. In the case of Alex and Ciprian varieties, values higher than the average is observed for the productivity elements of the spike, on the background of the average size of the plants and values lower than the average for the length of the spike and the number of spikelets. The small size of the plants in the Boema, Izvor and Exotic varieties is associated with lower levels of yield spike and its other components. It is found that Glosa variety has a yield/spike greater than the average based on the background of low values of plant size and spike length. In the case of the Akteor variety, high values of the spike length and number of spikelets were correlated with low levels of yield of the spike and its components.

Table 4

The similarity coefficients between wheat varieties based on yield traits

Varieties	2	3	4	5	6	7	8	9	10	11
1. Boema	0,7425	0,9088	0,8830	0,9159	0,9567	0,6685	0,6085	0,7235	0,8565	0,8293
2. Laurentio		0,8932	0,9325	0,7177	0,6510	0,9133	0,7758	0,9208	0,6650	0,9656
3. Alex			0,9904	0,8985	0,7851	0,9029	0,6908	0,8173	0,7637	0,9341
4. Ciprian				0,8869	0,7779	0,9397	0,7306	0,8795	0,7738	0,9672
5. Glosa					0,8471	0,7452	0,5421	0,7271	0,8586	0,8569
6. Izvor						0,5442	0,5666	0,7261	0,8824	0,7563
7. Josef							0,6494	0,8851	0,6003	0,9212
8. Akteor								0,6810	0,7863	0,8186
9. Galio									0,7149	0,9244
10. Exotic										0,8196
11. Renan										

In breeding programs, the use of phenotypic similarity can provide information on the prediction of hybrid combinations that show a high intensity of heterosis. According to the data presented in table 4, it is observed that from the perspective of the six characters, the greatest phenotypic similarity exists between the varieties: Alex-Ciprian (99,04%); Laurentio-Renan (96,56%); Ciprian-Renan (96,72%) and Boema-Izvor (95,67%).

As such, hybrids obtained by combining these varieties are unlikely to exhibit high levels of heterosis for the analyzed yield traits. A high degree of phenotypic differentiation was observed between the varieties : Glosa-Akteor (45,79%); Izvor-Josef (45,58%); Izvor-Akteor (43,34%); Josef-Exotic (3,97%). The crossing of these phenotypically differentiated varieties allows to obtain hybrids that possess combinations of useful genes for different component characters of yield.

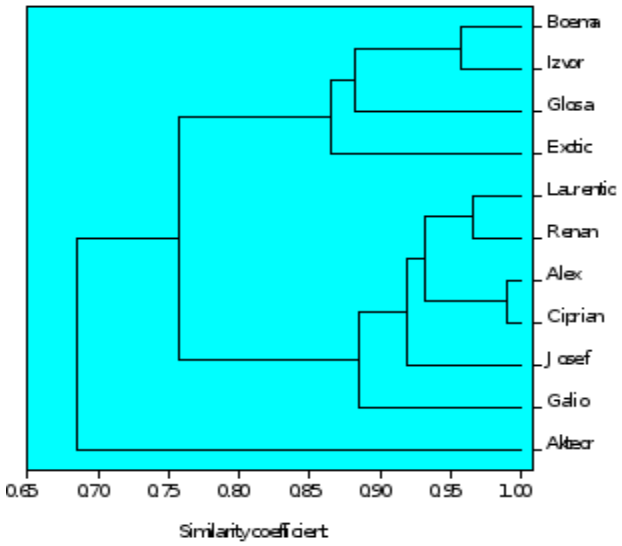


Figure 3. UPGMA clustering of wheat varieties based on yield traits

Given the phenotypic similarity between the 11 varieties, the dendrogram (figure 3) was performed by the method of the average of the clusters (groups), which have two main clusters . The first group, in which there is an average diversity of about 13% is made up of Boema and Izvor varieties, which show a reduced phenotypic differentiation of 4.33 % , along with Glosa and Exotic varieties. In the second cluster includes three subclusters, and between that there is a phenotypic similarity of 76 %. The local varieties, Alex and Ciprian have a phenotypic similarity of 99 % that makes up the first subcluster. The second subcluster consists of Renan and Laurentio varieties at which there is an average diversity about 6%, and the third subcluster includes Josef and Galio varieties at which there is a diversity about 8%-12% compared to the other varieties that make up the second subcluster. The Akteor variety is a distinct phenotype, given the average diversity about 32% compared to other varieties.

Table 5

Analysis of variance for yield traits analyzed in wheat varieties

Trait	Between groups		Within groups		F
	SS	DF	SS	DF	
Plant height	5.960	1	4.039	9	13.28**
Spike length	7.708	1	2.227	9	31.15**
Spikelets/spike	3.232	1	6.761	9	4.30
Spike weight	0.254	1	9.585	9	0.24
Grains number/spike	4.046	1	5.947	9	6.12*
Grains weight/spike	1.079	1	8.697	9	1.12

Regarding the analysis of variance (table 5) for the yield characters studied for wheat varieties , it is observed that high and significant values of variance were recorded in the case of spike length (34,60%) and plant height (26,75%), which have high contributions to the phenotypic diversity between clusters . The lowest diversity between varieties of the different groups was observed for the weight of the spike and the yield/spike.

Table 6

Analysis of variance for wheat varieties concerning the yield traits

Variety	Between groups		Within groups		F
	SS	DF	SS	DF	
Boema	31.031	1	34.615	4	3.59
Laurentio	50.059	1	34.926	4	5.73
Alex	29.637	1	32.628	4	3.63
Ciprian	33.064	1	28.532	4	4.64
Glosa	19.740	1	18.035	4	4.38
Izvor	38.524	1	31.889	4	4.83
Josef	33.164	1	23.364	4	5.68
Akteor	89.150	1	23.181	4	15.38**
Galio	47.876	1	27.201	4	7.04*
Exotic	50.238	1	14.663	4	13.71**
Renan	43.556	1	23.385	4	7.45*

On the basis of a hierarchical classification analysis of variance related to wheat varieties (table 6), it is noted that the variety Akteor generates the greatest differences between the yield characters studied, having a hight contribution (19,13%) in the total diversity. The smallest contributions to the general diversity were presented by the Romanian varieties Glosa (4,24%) and Alex (6,36%). Boema variety has the highest effect (34,89%) to the diversity in the first cluster, while the Exotic variety influence to diversity has a lesser extent (14,78%). In the case of the second cluster, Laurentio variety has a higher contribution (20,54%) , Josef variety has a lower contribution (13,74%) , and the other varieties have an intermediate effect on diversity from this cluster.

CONCLUSIONS

Higher plant stature of Josef, Galio and Laurentio varieties was associated with the highest values of spike weight, number and weight of grains/spike and values above the mean for spike length and spikelets number/spike, respectively.

The results of this study show that some varieties achieved high values for different traits of plant yield. Therefore, these varieties should be successively used for further breeding programs based on diallel-crossing methods, to develop new wheat varieties.

For these varieties, the spike weight has the highest and significant contribution (64,83%) to the achievement of plant yield, followed by the plant height, which contributes with 10.26% to the variability of this trait. The spike length and grain's number/spike had the lowest influence on plant yield.

According to the high diversity between some varieties like the following Glosa-Akteor; Izvor-Josef; Izvor-Akteor; Josef-Exotic, these pairs are suitable for crossing to obtain hybrids with useful genes combinations for different yield components.

Considering the highest variance for plant height and spike length, we appreciate that it is possible to identify valuable gene combinations for these traits in segregating generations.

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