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PRODUCTIVE CAPABILITIES OF PROMISING VARIETIES OF WHEAT (*Triticum aestivum* L.)

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ABSTRACT

The present research paper aims at comparing the similarity and remoteness of influence of the features of eight common wheat varieties and their grouping on the base of important structural indicators through the use of a mathematical approach and a cluster analysis; studying of a relationships between the examined indicators in order to make more objective evaluation using the possibilities of the factor analysis; reducing the number of correlating indicators into new factors. Two-year data were used, obtained from the examination of eight common wheat varieties. The subject of the present research were seven seven foreign varieties of wheat - Ingenio, Bologna, Dalara, Moyson, Falado, Gabrio, Pibrak, and the eighth variety - Factor - was a local Bulgarian selection. The introduction of common wheat varieties is related to the study of their productivity and ecological plasticity. For this purpose there were reported and analised yield structural elements: plant height, wheat-ear length, number of ears, number of grains per ear, weight of grains per ear, grain yield from hectare. The cluster analysis showed that the influence of wheat variety on the qualitative indicators led to their grouping into two new clusters. There was established a strong positive correlation between the number of grains per ear and the hectoliter mass (r = 0.811) as well as between the number of ears and the weight of grains per ear (r = 0.771). The correlation coefficient between the number and weight of grains - (r = 0.649). The factor analysis established the influence of three main factors influencing the group formation of wheat varieties. The first factor was related basically to plant height, ear length, number of grains per ear and hectoliter mass. The second component was basically related to the number of ears and weight of grains. The third factor was related to the mass of 1000 grains.

Keywords: wheat, correlation, cluster analysis, factor analysis.

INTRODUCTION

Climate changes in recent years have had unfavourable influence on crops of some cultures. The rise in temperature and shortage of precipitations are challenging for the ecological plasticity and for the wheat varieties as well. Despite the continuous improvements in technologies and culture varieties, wheather and climate are still the main uncontrollable factors influencing the agricultural production (Sirakov et al., 2016; Sirakov et al., 2017). Lobell and Field (2007) reported for a decrease of the average crop yield (wheat, rice, corn, barley, soybean and sorghum) with 0.6-8.9% at the rise in temperature with 1°C on a global scale. In many countries, the agricultural sector is subject to state support in order to overcome its dependence on natural and climatic conditions, the threat of the spread of diseases and pests on crops and others (Stoyanova, 2019).

For the period 1996-2007, Marijanović et al. (2010) established differences in wheat yield from 3.62 to 5.00 t/ha for the region of Croatia. Differences in productivity depend on a comlex relation between wheat yields and wheather (precipitation and average air temperatures).

According to Kheiri et al. (2017) rise in temperature is the main factor, which contributes to the increasing index of drought. For the period of 14 years they have analysed the influence of climatic factors temperature and precipitations.

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Wheat have always taken an important place in economics and people`s lives. For a long time it has been in the front burner for breeders and producers. Winter wheat breeding is directed to the obtainment of high and stable yields (Stoeva et al., 2009). Grain yield is a main criterion in the selection of different lines and varieties. According to Ivanova and Tsenov (2009) the meteorological conditions over the years have had the stongest influence on the average values of the examined indicators - plant height, number of productive ears, length of ear, number and weight of grains per ear, grain yield, hectoliter mass and mass of 1000 grains.

The right structure of the variety with relation to the corresponding agro-ecological conditions of the region can considerably increase the production yields and quality Ilieva (2011). Other researchers such as Gordana et al. (2014) and Döringa et al. (2015) have also evaluated the influence of environment through yield stability.

While until the beginning of the century almost 100% of wheat was a Bulgarian selection, in recent years there has been a tendency for the introduction of foreign vatieties (Bojnanská and Mocko, 2014; Chamurliyski et al., 2016).

Using a mathematical approach the present research aims at the following:

1) to compare with relation to similarity and remoteness of influence the variety features of eight common wheat varieties in order to be grouped on the base of important structural indicators through the use of a cluster analysis;

2) to examine the presence of a correlation dependence between the examined indicators in order to make a more objerctive evaluation;

3) to reduce their number using the possibilities of the factor analysis with uniting those that correlated between each other in new factors.

MATERIAL AND METHODS

Two-year data from examined wheat varieties were used for the purpose of the present research. The field experiment was conducted in three crop years (2017-2019). Eight common wheat varieties were examined. Seven of them were foreign - Ingenio, Bologna, Dalara, Moyson, Falado, Gabrio, Pibrak and another one (Factor) represent a Bulgarian selection. The experiment took place on the experimental field of the Faculty of Agronomy at the Trakia University, Bulgaria. The region has the planar nature of elevation height of 169 m, and geographic coordinates 42°41' N latitude and 23°19' E longitude GMT (GPS). The soil type in the experimental field is meadow-cinnamic soil. Characterized by powerful humus horizon that is highly expressed in the range of 0-50 cm. According to the humus content of the soil is an average stock (3.93%).

The experiment was set by the method of fractional parcels with size of the crop parcel - 10 m^2. The introduction of common wheat varieties is related to the study of the productivity and ecological plasticity of the examined wheat varieties. For this purpose there were reported and analysed the following yield structural elements: plant height, wheat-ear length, number of ears, number of grains per ear, weight of grains per ear and grain yield from a hectar. The level of the examined indicators was compared towards the average values for the whole group of varieties.

Grouping of the eighth examined varieties regarding the irrigational regime was performed through a hierarchical cluster analysis. The method of the intergroup connection was used (Ward, 1963; Dyuran and Odelly, 1977). The used measure for similarity was the Euclidean distance between two points:

$$D(x, y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

A dendrogram was built, which presented graphically the formed clusters. The dotted horizontal line of the dendrogram showed the rescale distance of the formed clusters. A correlation analysis was conducted aiming at establishing the presence of statistically significant correlations between the examined indicators. The study continued with the application of the factor analysis (Kline, 1994) aiming at reducing the number of the sixth initial indicators.

The factor analysis was conducted by the method of the main components (PCA). The number of the main components is determined by the number of their own meanings of the correlation matrix, which are bigger than 1 (Kaiser Criterion). The own meanings show the contribution of the own (private) factor at the explanation of the common dispersion in the variables.

Data processing was conducted with the statistical program SPSS.

RESULTS AND DISCUSSION

The analysis of the results shows that the Falado and Gabrio varieties are superior to the other varieties in terms of grain yield. The data indicate an excess of 44.7% in the Falado variety and 42.9% in the Gabrio variety (Figure 1). The results register the good adaptability and productivity under the specific climatic conditions. Ingenio is distinguished by 22.6% higher yields than the standard. For the Moison variety, the excess is 28.8%, and for the Dalara variety, it is 33.8%. In the case of the Pibrak variety, the excess of nearly 16.0% was recorded in two years. The variety is new and was registered only in 2018.

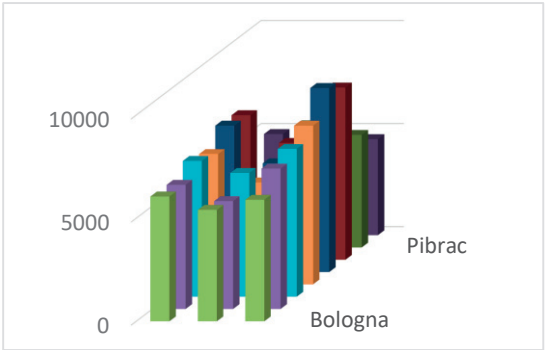

Figure 1. Productivity of common wheat varieties

The cluster analysis showed that the influence of the variety on wheat qualitative indicators was grouped into two main clusters. Results including the steps of cluster combination were presented graphically with a dendrogram (Figure 2).

The first cluster was more homogenious and included the varieties Bologna, Gabrio, Falado, which had similar indicators: length of wheat ear, number of grains per ear, weight of grains per ear, mass of 1000 grains, hectoliter mass and yield having the least Euclidean distance between them. The first sub-group included Bologna and Gabrio varieties possessing closer values of ear length, number of grains per ear, weight of grains per ear and hectoliter mass. Later they were joined by Bologna variety.

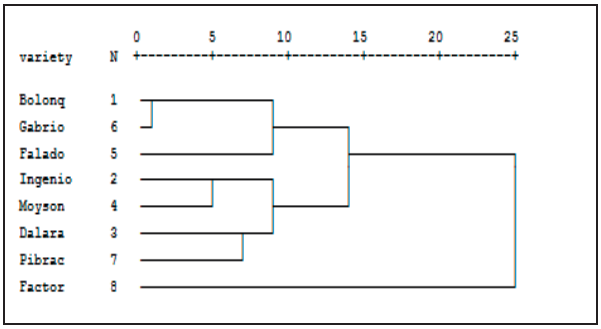

Figure 2. Dendrogram based on the average intergroup distances

The group was formed of varieties having high number of grains per ear (from 32.48 to 32.76). Taking into account the weight of grains per ear, it was reported a variation within narrow limits (from 1.40 to 1.45 g).

The second main cluster was bigger and included Ingenio and Moyson varieties. They had the biggest similarity in ear length, number of ears, number of grains per ear and yield. Later Dalara and Pibrac varieties were added to the cluster, which had identical indicators: number of ears, hectoliter mass and yield.

The most remote varieties were Bologna and Factor, which had different origin and genotype, and their intergroup distance was with a coefficient 27.127 presented on Table 1.

Table 1. Combining the clusters and the inregroup distances

Stage	Cluster combined		Coefficients
	Cluster 1	Cluster 2	
1	1	6	1.155
2	2	4	6.027
3	3	7	7.853
4	1	5	9.938
5	2	3	10.119
6	1	2	15.227
7	1	8	27.127

The correlation coefficients that express the interrelation between the examined wheat indicators (2018) are pointed out in the correlation matrix (Table 2).

It was established a strong positive correlation between the number of grains per ear and the hectoliter mass - r = 0.811; the number of ears and the weight of grains per ear - r = 0.771. The correlation coefficient between the number and weight of grains per ear was evaluated (r = 0.649). A similar approach has been used in the evaluation of wheat (Delibaltova et.al., 2014; Atanasov et al., 2020; Dunchev and Stoyanov, 2020).

A research conducted by Popova and Neykov (2013) pointed out that the correlation relation between the number and weight of grains in the main ear was higher (r = 0.86). The indicators: "number and weight of grains per ear" are directly related to yield. The analysis of the eighth wheat varieties reported the presence of a weak negative correlation between the number of grains per ear and the yield (r = -0.232) and it is a copied table, write it down an insignificant positive relation between the weight of grains per ear and the yield (r = 0.095). According to Zhang et al. (2012), the greater nuber of grains per ear not always leads to a higher yield.

The indicator "mass of 1000 grains" takes an important place in the formation of yield and the economic benefits of wheat. Taking into account the examined varieties, grain size was within a diapason from 34.8 to 43.68 g. Analyses sowed that the number of grains did not follow the mass of 1000 grains. A negative correlation was registered (r = -0.071), which was probably due to the greater number of set wheat-ears remained unfed.

The correlation between the plant height and the weight of grains per ear was negative (r = -0.754). All pointed correlation coefficients were statistically proven at a level of significance: α = 0.001.

Table 2. Correlation matrix

Indicators	Plant height	Wheat ear length	Number of ears	Number of grains per ear	Weight of grains per ear	Mass of 1000 grains	Hectoliter mass	Yield
Plant height	1	0.657	-0.364	0.196	-0.754*	-0.143	0.629	-0.376
Wheat ear length		1	0.127	0.555	-0.478	-0.001	0.598	-0.470
Number of ears			1	0.649	0.771*	-0.071	0.326	-0.258
Number of grains per ear				1	0.307	0.049	0.811*	-0.232
Weight of grains per ear					1	0.049	-0.063	0.095
Mass of 1000 grains						1	-0.293	-0.284
Hectoliter mass							1	-0.305
Yield								1

The conducted correlation analysis and the reported high and statistically proven values of r gave us ground to apply the methodology of the factor analysis.

In the course of the factor analysis and after the application of the method of the main components it was established that two of the factors had values of their own vectors greater than 1, which defined the selection of two main components (Figure 3).

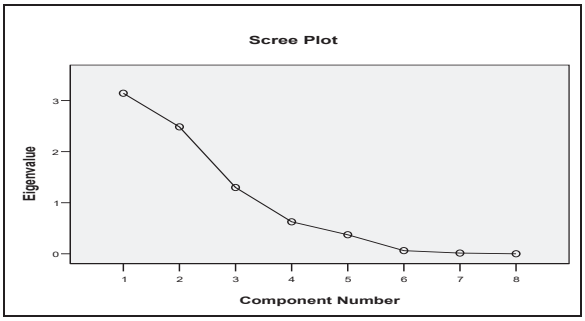

Figure 3. Values of the own vectors

Table 3 presents the factor weights and the way of variation between main components. The analysis shows the presence of three own values, which determined the selection of three main components.

Table 3. Factor matrix obtained by the method of main components

N	Indicators	Main components		
		1	2	3
1.	Plant height	0.783	-0.559	0.074
2.	Wheat ear length	0.880	-0.121	-0.114
3.	Number of ears	0.212	0.934	-0.004
4.	Number of grains per ear	0.705	0.614	0.042
5.	Weight of grains per ear	-0.347	0.922	0.007
6.	Mass of 1000 grains	-0.097	0.029	-0.904
7.	Hectoliter mass	0.878	0.225	0.304
8.	Yield	-0.560	-0.071	0.607
Percentage of the total variation, %		38.77	31.24	16.55
Cumulative percentage of the total variation, %		38.77	70.01	86.57

They explained 86.57% of the total dispersion of the sample. 38.77% of the dispersion was explained by the first main component (first factor), 70.01% - by the second one, and 86.57% - by the third one, correspondingly.

Variables 1, 2, 4 and 7 had high factor weights in the first component. It means that this factor must be related mainly with plant height, wheat-ear length, number of grains per ear and hectoliter mass. The research work of Bonchev (2020) pointed out that the highest influence of genotype was established for the indicators: plant height, ear length and number of grains per ear.

We could define this factor as a generalizing factor for these indicators, which have biggest relative weight for wheat group formation. The second component is mainly related to the number of ears and weight of grains. The third component is related to the mass of 1000 grains. The results received by the applied factor analysis were synchronized with the results of the cluster analysis at their formation into clusters according to their proximity based on the same indicators.

CONCLUSIONS

The cluster analysis showed that the influence of the variety on wheat qualitative indicators was grouped into two main clusters. The first cluster was more homogenious and included Bologna, Gabrio and Falado varieties similar in wheat ear length, number of grains per ears, weigth of grains per ears, mass of 1000 grains, hectoliter mass and yield, having the least Euclidean distance between each other. The second main cluster was bigger and included Ingenio and Moyson varieties being most similar in wheat ear ength, number of ears, number of grains per ear and yield.

A strong positive correlations was established between the number of grains per ear and the hectoliter mass and between the number of ears and the weight of grains per ear. The number and weight of grains per ears are also positive coorelated.

The factor analysis concluded the presence of three main factors influencing the grouping of wheat varieties. The first factor was mainly related to plant height, ear length, number of grains per ear and hectoliter mass. The second component was mainly related to number of ears and weight of grains. The third component was related to the mass of 1000 grains.

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