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AGROBIOLOGICAL EVALUATION OF GRAPEVINE VARIETIES FOR WHITE AND RED WINES

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Abstract

A comparative agrobiological evaluation of grapevine varieties for white and red wines from different ecological-geographic groups have been done through application of mathematical methods - analysis of variance, cluster and factor analysis using R language for statistical processing. It has been established that the varieties Fetească albă, Fetească regală, Pamid, Dimiat and Mavrud differ materially according to almost all examined characteristics. The analysed indicators in the structure of the yield in the case of the oriental varieties are summarized in five factors, in the case of those from the Black Sea – in four, which are enough to explain more than half of their total variability. The indicators from factor F3are with the biggest essential direct impact on the yield in the case of all varieties from the first group, and in the case of those from the second – F1. Other factors, which are not analysed, have also an impact on the formation of their yield.

Key words: *analysis of variance, cluster analysis, agrobiological indicators, wine grape varieties*

INTRODUCTION

The agrobiological characteristics of each vine variety contain extremely important indicators revealing its economic value. The most popular and most spread local varieties for white and red wines in Bulgaria are mainly from the Black Sea ecological-geographic group (convarietas pontica Negr.), Balkan subgroup (subconvarietas balcanica Negr.). There are rarely varieties from the Eastern ecological-geographic group (convarietas orientalis Negr.) (Bulgarian Ampelography, 1990; Roychev 2012). When grown on appropriate terrains and according to the corresponding technology, they can produce good and quality produce (Donchev 1990). The application of factor analysis in agrobiological studies of wine grape varieties allows economically most important indicators for the formation of their yield to be determined (Simeonov et al., 2015, Simeonov et al., 2016, Roychev 2017). Comparison of different agrobiological factors impact on the yield of grapes in the case of grapevine varieties from different ecological-geographic groups is of interest for ampelography and applied viticulture. The purpose of this study is to establish the possibilities for application of factor analysis in comparative agrobiological studies of wine grape varieties.

MATERIAL AND METHODS

Two varieties for white wines from the Eastern ecological-geographic group - Fetească albă and Fetească regală, two varieties for red wines - Mavrud and Pamid and one for white wines - Dimiat, which are grown in the ampelographic assortment of the Department of Viticulture - Agricultural University-Plovdiv are included in the study. The ampelographic indicators - shoot fertility coefficient (C), millerandage berries (%), average cluster weight (g), cluster length (cm), cluster width (cm), seeds in 100 berries (number), weight of seeds in 100 berries (g), grapevine yield (kg), average weight of 100 berries (g), berry length (mm), berry width (mm), sugars (%), acids (g/dm3) of 25 typical grapevines of each variety in the respective phenophases have been determined in the course of five consecutive years.

Experimental data processing has been performed with the functional programming language and environment for statistical data analysis R. The R open source principles allow access to software applications for solving specific statistical tasks. The presence of reliable variance between the varieties in the analysed indicators has been determined by single factor analysis of variance and evaluation of averages according to the Duncan's method. In the case of the Black Sea varieties the cluster analysis has been also applied. The inter-group connection method has been chosen as an agglomeration method for clustering, and a similarity measure is the quadratic Euclidean distance. The distance between two clusters A and B is defined as the average value of nA.nB of number of distances between nA points from A and nB points from B by the formula:

$$D(A,B) = \frac{1}{n_A n_B} \sum_{i=1}^{n_A} \sum_{j=1}^{n_B} d(x_i, x_j) \quad , (1)$$

where the sum changes in all xi and xj from A and B. With

$$d(x_i, x_j) = \sum_{m=1}^{p} (x_{im} - x_{jm})^2 \quad i, j = \overline{1,n} \quad , (2)$$

we denote the quadratic Euclidean distance between two vectors $x_i(x_{i1}, x_{i2}, ..., x_{ip})$ and

$x_j(x_{j1}, x_{j2}, ..., x_{jp})$

With the use of the R language statistical techniques a check for presence of the necessary conditions for application of a factor analysis has been done. A complex study of the factors (indicators) impact on the yield of grapes per grapevine has been carried out using R. The coefficients of the regression model are statistically significant at rates of statistical significance (Sig.) less than 0,05.

RESULTS AND DISCUSSION

Data from the multidimensional comparative analysis shows that the studied varieties from the Oriental ecological-geographic group differ materially in almost all biometric indicators, except for the percentage of millerandage berries, yield, berry size and acids (Tab. 1). Fetească albă differs with greater cluster length and seeds in 100 berries, and Fetească regală - with higher values of the indicators fertility coefficient, average cluster weight, cluster width, weight of seeds in 100 berries, sugars content. In the case of the varieties from the Black Sea group, the variances between the studied agrobiological indicators have not been proven only for weight of seeds in 100 berries. Statistical groups two and three are formed in the case of both varieties.

According to the dendrogram-clustering, the Pamid and Dimiat varieties form a cluster of the first level of similarity (Fig. 1). The relative distance between them is from 0,0 to 0,5. They are characterized by a high degree of closeness in the values of the studied indicators. Mavrud differs with a high degree of remoteness from the other two varieties in terms of the values of the studied indicators and is considered different from them. The relative distance between Mavrud and the rest of the varieties is in the range from 0,5 to 25,0.

The analysis of the factor distribution of the obtained agrobiological data shows that on the formation of the yield per grapevine in the case of the varieties Fetească albă and Fetească regală impact five summarizing factors (60,7% and 60,7%), as each of them covers more often two and rarely one indicator (Tab. 2). In F1 in the case of both varieties are included berry length and berry width with factor impact of 15,8% -15,8% and positive impact on the amount of grape yield. In F2 - in the case of the first variety (12,4%) are the average cluster weight and acids, and in the case of the second (15,2%) - cluster length and cluster width. The third factor - F3 covers the following indicators: fertility coefficient (with a negative value), millerandage berries (12,0%) and seeds in 100 berries, weight of seed in 100 berries (15,0%). In F4 the diversity of the studied indicators increases but their factor impact on the formation of the yield decreases - cluster

length, weight of seeds in 100 berries (with a negative value) (10,5%) and millerandage berries, sugars (10,1%). In the case of the first variety in F5 fall the indicators seeds in 100 berries (with a negative value) and sugars (10,0%), and in the case of the second - only average weight of 100 berries (9,9%). The formation of the yield in the case of the studied varieties from the Black Sea group is determined by four factors - Pamid (62,6%), five - Dimiat (61,8%) and seven - Mavrud (83,4%). The correlation coefficients for all the factors of Pamid have positive values, as for Dimiat there is one indicator with a negative value, and in the case of Mavrud - they are three. The agrobiological specificity between these varieties is demonstrated by the fact that the individual indicators fall into different factors. The fertility coefficient in the case of the first and the second varieties is in F4, and in the case of the third one in F6; millerandage berries - only in F6 of Mavrud; average cluster weight - F3 of Dimiat and F7 of Mavrud; cluster length and cluster width - F3 of Pamid and F2 - Dimiat and Mavrud; number and weight of seeds in 100 berries - F1 of Pamid, F5 - Dimiat and F3 - Mavrud; average weight of 100 berries - only in F5 of Mavrud; berry length and berry width - in the case of the three varieties sequentially in F2, F1 и F1; sugars - only in F4 of Mavrud and acids - F4 of Pamid, F3 - Dimiat and F4 - Mavrud.

The direct impact of the factors expressed by the standardized regression coefficient (Beta) shows that with the highest proven positive significance for the yield per grapevine in the case of Fetească albă is F5 (0,013), Fetească regală – F4 (0,173), Pamid - F4 (0,213), Dimiat – F2 (0,020), Mavrud –F7 (0,143) (Tab. 3). The coefficients of the regression model are statistically significant. The low coefficients of determination in the case of all varieties mean that the grape yield is not determined solely by the studied indicators in the summarizing factors.

The analysis of the main components in the varieties from the Oriental group shows that five of them are sufficient to explain 59,8% of the total variation of the studied indicators (Tab. 4). Their relative degree of variation correlates most strongly with the first major component. With berry length and berry width is explained 15,4% of the total variation. The second component explains 13,0% of the total variation, as with the highest correlation coefficients are the fertility coefficient and seeds in 100 berries, which is with a negative sign. The third major component explains 11,3% of the total variation, mostly with cluster length and weight of seed in 100 berries, as the second indicator has a negative impact on the total variation. The fourth component explains 10,1% of the total variation, as with the highest correlation coefficient are millerandage berries and sugars. With the highest correlation coefficients for the fifth major component is the cluster width, which explains 10,0% of the total variation. In the case of the varieties from the Black Sea group, four of the major components are sufficient to explain 63,8% of the total variation of the studied indicators. With average cluster weight, cluster length and cluster width is explained 21,0% of the total variation of the characteristics in the first basic component, in the second - with berry length and berry width (19,6%), in the third - number and weight of seeds in 100 berries (12,2%) and in the fourth - shoot fertility coefficient and millerandage grains (11,0%).

The coefficients of the regression model of variation of the studied indicators Beta show that a negative value and impact in the case of the oriental varieties is found only in F4 (-0,046) и F5 (-0,094) (Tab. 5). With the biggest direct impact on yield are the indicators of the summarized factor F3 (0,179). In the case of the varieties from the Black Sea group, there are no negative values for the summarized factors. Biggest direct impact has F1 – 0,323. The coefficients of the regression model in the case of both groups of varieties are statistically significant. The low values of the coefficient of determination - 4,9% and 15,9% show that on the formation of the grape yield in the case of the varieties from both of the groups impact have indicators other than the studied ones.

CONCLUDING REMARKS

1. The wine grape varieties Fetească albă, Fetească regală - Oriental ecological-geographic group and Pamid, Dimiat and Mavrud - Black Sea ecological-geographic group differ statistically proven according to almost all studied agrobiological indicators. The varieties Pamid and Dimiat form a cluster of first level of similarity, and Mavrud

is farthest from them.

2. Economically most important indicators having positive impact on the yield of grape in the case of the studied varieties are grouped in four to seven summarizing factors, as with the greatest proven positive significance are F2, F4, F5, and F7. The yield in the case of most of the varieties is mainly determined by the indicators cluster and berry length and cluster and berry width, followed by average cluster weight.
3. The importance of the studied indicators in the structure of the yield in the case of the oriental varieties is summarized in five factors, in the case of those from the Black Sea – in four, which are enough to explain more than half of their total variability. With the biggest proved direct impact on the yield in the case of all varieties from the first group are the indicators from the summarized factor F3, and from the second group – F1. Other factors which are not analysed have also an impact on the formation of their yield.

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Table 1. Multidirectional comparative analysis of fertility and yield indicators of the grapevine varieties studied

Group Variety	C	Millerandage berries (%)	Average cluster weight (g)	Cluster length (cm)	Cluster width (cm)	Seeds in 100 berries (number)	Weight of seeds in 100 berries (g)	Yield (kg)	Average weight of 100 berries (g)	Berry length (mm)	Berry width (mm)	Sugars (%)	Acids (g / dm^3)
Oriental ecologo-geographical group													
Fetească albă	1,28 ^{b}	1,41^a	124 ^{b}	23,18 ^{a}	8,58 ^{b}	178 ^{a}	6,33 ^{b}	6,28 ^{a}	157 ^{b}	13,80 ^{a}	14.39 ^{a}	18,75^b	6,69 ^{a}
Fetească regală	1,90 ^{a}	1,46^a	154 ^{a}	14,42 ^{b}	9,17 ^{a}	161 ^{b}	6,81 ^{a}	6,53 ^{a}	168 ^{a}	13,98 ^{a}	14,29 ^{a}	19,40^a	6,79 ^{a}
Black Sea ecologo-geographical group													
Pamid	1,36 ^{a}	1,76 ^{b}	179 ^{c}	12,80 ^{c}	8,37 ^{c}	181 ^{b}	6,81 ^{a}	5,36 ^{b}	214 ^{b}	13,83 ^{b}	12,81 ^{c}	20,76 ^{a}	6,06 ^{b}
Dimiat	1,47 ^{a}	4,10 ^{a}	200 ^{b}	14,11 ^{b}	10,14 ^{b}	211 ^{a}	6,70 ^{a}	7,76 ^{a}	297 ^{a}	16.56 ^{a}	15,49 ^{a}	18,63^b	6,04 ^{b}
Mavrud	1,08 ^{b}	2,24 ^{b}	357 ^{a}	17,86 ^{a}	12.83 ^{a}	216 ^{a}	6,69 ^{a}	7,78 ^{a}	181 ^{c}	14,35 ^{b}	14,33 ^{b}	19,05 ^{b}	6,78 ^{a}
a, b, c ..... a degree of proof according to the Duncan's method with error α = 0.05													

Table 2. Factor distribution of indicators having impact on the yield per grapevine in the case of the studied varieties

Variety Indicators	Fetească albă (60,7%)					Fetească regală (60,7%)					Pamid (62,6)				Dimiat (61,8)					Mavrud (83,4)						
	F_1	F_2	F_3	F_4	F_5	F_1	F_2	F_3	F_4	F_5	F_1	F_2	F_3	F_4	F_1	F_2	F_3	F_4	F_5	F_1	F_2	F_3	F_4	F_5	F_6	F_7
Shoot fertility coefficient			-0,734											0,712				0,743							-0,813	
Millerandage berries (%)			0,765						0,710																0,675	
Average cluster weight (g)		0,793															0,649									0,948
Cluster length (cm)				0,774			0,849						0,831			0,668					0,885					
Cluster width (cm)							0,866						0,824			0,830					0,934					
Seeds in 100 berries (number)					-0,731			0,899			0,919								0,708			0,871				
Weight of seeds in 100 berries (g)				-0,734				0,896			0,909								0,648			0,771				
Average weight of 100 berries (g)										0,818														-0,895		
Berry length (mm)	0,871					0,934						0,875			0,964					0,949						
Berry width (mm)	0,902					0,908						0,860			0,968					0,930						
Sugars (%)					0,748				0,770														-0,880			
Acids (g/dm^3)		0,639												0,619			-0,678						0,616			
Factor impact (%)	15,8	12,4	12,0	10,5	10,0	15,8	15,2	15,0	10,1	9,9	17,6	16,7	15,2	13,1	17,8	11,3	11,2	11,1	10,4	16,8	14,0	13,1	10,5	9,8	9,7	9,5

Table 3. Coefficients of the regression model of the variation of indicators having impact on the yield per grapevine in the case of the studied varieties

Variety	Factors	Regression coefficient (B)	Standardized regression coefficient (Beta)
Fetească albă	(Constant)	6,532	
	F_1	-0,072	-0,113
	F_2	-0,041	-0,064
	F_3	-0,011	-0,017
	F_4	-0,083	-0,130
	F_5	0,008	0,013
Coefficient of determination	R^2=3,4%		
Fetească regală	(Constant)	6,285	
	F_1	0,199	0,133
	F_2	-0,239	-0,160
	F_3	-0,018	-0,012
	F_4	0,258	0,173
	F_5	-0,066	-0,044
Coefficient of determination	R^2=7,5%		
Pamid	(Constant)	5,363	
	F_1	0,185	0,107
	F_2	-0,160	-0,092
	F_3	0,106	0,062
	F_4	0,375	0,213
Coefficient of determination	R^2=6,7%		
Dimiat	(Constant)	7,756	
	F_1	-0,046	-0,021
	F_2	0,044	0,020
	F_3	-0,136	-0,062
	F_4	-0,213	-0,096
	F_5	0,023	0,010
Coefficient of determination	R^2=1,4%		
Mavrud	(Constant)	7,776	
	F_1	0,172	0,086
	F_2	0,207	0,103
	F_3	0,246	0,122
	F_4	-0,398	-0,195
	F_5	-0,089	-0,045
	F_6	0,030	0,015
	F_7	0,290	0,143
Coefficient of determination	R^2=8,8%		

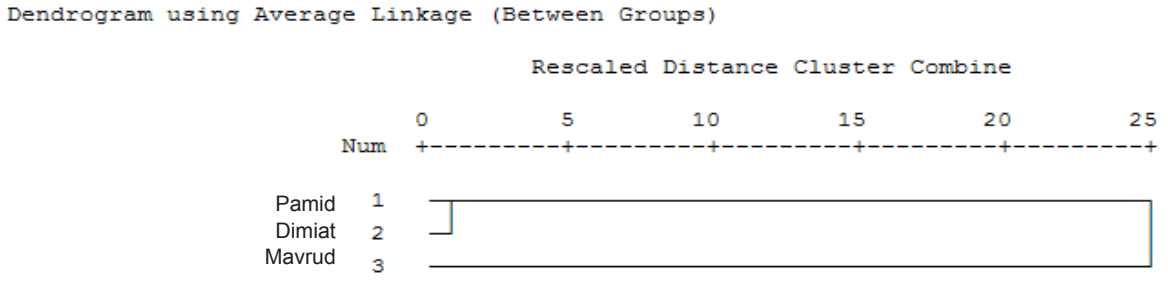
Table 4. General factor distribution of the indicators impact on the yield per grapevine in the case of all studied grapevine varieties

Varieties groups Indicators	Oriental varieties					Black Sea varieties			
	F_1	F_2	F_3	F_4	F_5	F_1	F_2	F_3	F_4
C Shoot fertility coefficient		0,703							0,690
Millerandage berries (%)				0,812					0,625
Average cluster weight (g)						0,713			
Cluster length (cm)			-0,643			0,838			
Cluster width (cm)					0,611	0,866			
Seeds in 100 berries (number)		-0,750						0,784	
Weight of seeds in 100 berries (g)			0,752					0,891	
Average weight of 100 berries (g)									
Berry length (mm)	0,899						0,902		
Berry width (mm)	0,907						0,916		
Sugars (%)				0,677					
Acids (g / dm^3)									
Factor impact (59,8%); (63,8%)	15,4	13,0	11,3	10,1	10,0	21,0	19,6	12,2	11,0

Table 5. Coefficients of the regression model of the variation of indicators having impact on the yield per grapevine in the case of all studied grapevine varieties

	Factors	Regression coefficient (B)	Direct impact of the factors (Beta)	Regression coefficient (B)	Direct impact of the factors (Beta)
		Oriental varieties		Black Sea varieties	
Varieties	(Constant)	6,411		6,965	
	F_1	0,086	0,075	0,729	0,323
	F_2	0,006	0,005	0,468	0,214
	F_3	0,207	0,179	0,245	0,114
	F_4	-0,053	-0,046	0,229	0,107
	F_5	-0,108	-0,094	6,965	
Coefficient of determination	R^2= 4,9%			R^2= 15,9%	

Figure 1. Dendrogram-clustering of the studied grapevine varieties from the Black Sea ecologo-geographical group



АГРОБИОЛОШКА ЕВАЛУАЦИЈА НА СОРТИ ГРОЗЈЕ ЗА ПРОИЗВОДСТВО НА БЕЛИ И ЦРВЕНИ ВИНА

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Резиме

Компаративна агробиолошка евалуација на сорти за производство на бели и црвени вина од различни еколошко-географски групи беше изработена со примена на математички методи и тоа: анализа на варијанса, кластер анализа и фактор анализа со користење на P јазик за статистичка обработка. Утврдено е дека сортите Fetească albă, Fetească regală, Pamid, Dimiat и Mavrud се разликуваат според речиси сите испитувани карактеристики. Анализираните индикатори во структурата на приносот во случај на ориенталните сорти се сумирани во пет фактори, оние од Црното Море - во четири, кои се доволни да објаснат повеќе од половина од нивната вкупна варијабилност. Со најголемото суштествено директно влијание врз приносот во случај на сите сорти од првата група се индикаторите од факторот F3, а во случај на оние од вториот - F1. Други фактори кои не се анализираат, исто така, имаат влијание врз формирањето на нивниот принос.

Клучни зборови: *анализа на варијанса, кластер анализа, агробиолошки показатели, вински сорти грозје*