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Grouping and evaluation of cornel-tree varieties according to some pomological indicators

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Abstract

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The subject of this study is the following genotypes of cornel-tree: Pancharevski cylindrical, Atkov, Kazanlashki pear-shaped, Vrachanski (Castel), Shandrian, Tsarigradski yellow, Yellow Hadzhiyski, Shumenski oblong and Yaltenski. They were grouped and assessed according to their genetic remoteness with respect to the pomological parameters: weight (g), length (mm) and width (mm) of the fruit as well as length of the stem (mm), weight (g), length (mm) and width (mm) of the stone. Hierarchical cluster analysis and factor analysis were applied for the processing of the experimental data. As a result of analyzes, the studied genotypes were found to be grouped into four clusters. The main indicators influencing the genotyping are: length of the fruit, length of the stem, weight and the length of the stone. The most distant genetically are Yaltenski and Shumenski oblong, on one side, and Pancharevski cylindrical and Atkov, on the other.

Keywords: biometric indicators; cluster analysis; cornel-tree

Introduction

Cornel-tree is a plant which is widely used in folk medicine (Dinda et al., 2016). The phytochemical examinations of various parts of the plant prove the contents of dozens of compounds, such as anthocyanins, flavonoids, vitamin C and others. Because of the antimicrobial, antidiabetic, anti-atherosclerotic, kidney protective and other properties, it is widely used in pharmacology. There are a number of studies related to its antioxidant properties (Ersoy et al., 2011; Celep et al., 2012; Popovic et al., 2012).

Zhivondov et al. (2007) found that in the three most common varieties of cornel-tree in Bulgaria, the average fruit weight ranges from 7.25 g for Pancharevski cylindrical variety to 9.00 g for Shumenski oblong variety. The average fruit weight of Kazanlashki pear-shaped is 8.03 g. The content of vitamin C in fresh fruits ranges from 70.18 mg in 100 g fresh fruits weight in Pancharevski cylindrical to 74.34 mg in 100 g fresh fruits weight in Shumenski oblong. It was also found that after four days of storage of fruit, the vitamin C content decreased by 5–7 mg in 100 g fresh fruits weight.

Tural & Koca (2008) studied varieties of cornel-tree that are widely spread in Turkey according to their physical, chemical and antioxidant properties. The weight of the stone is from 0.39 g to 1.03 g, the length of the fruit is between 14.24 mm and 22.20 mm and the width of the fruit is 9.59–13.21 mm.

Hamid et al. (2011) analyze cornel-tree varieties according to some chemical indicators. They prove that the total flavonoid has the greatest influence on the antioxidant properties of the plant. In Serbia, the province of Vojvodina, more than 200 genotypes of the cornel-tree are analyzed and a high degree of genetic instability in morphological and chemical indicators is established (Bijelić et al., 2011).

Gunduz et al. (2013) studied different cornel-tree genotypes according to some biometric (width, length and weight of the fruit) and chemical indicators. They found that the average values of the width, length and weight of the fruits were 17.4 mm, 23.5 mm and 4.9 g, respectively. The antioxidant activity is high and varies in the various stages of ripeness of the fruit. Significant instability is demonstrated in terms of color, photochemical properties, and some pomological features.

In the present work grouping of cornel-tree genotypes was performed according to the degree of similarity of the pomological indicators. There are differences between the analyzed varieties, on the basis of which the latter are classified in separate groups. Factor analysis is applied for the qualitative description of the clusters. It defines the indicators that influence the clustering of the cornel-tree varieties.

Materials and Methods

The subject of this study is the following nine varieties of cornel-tree, grown in Bulgaria: Pancharevski cylindrical, Atkov, Kazanlashki pear-shaped, Vrachanski (Castel), Shandrian, Tsarigradski yellow, Yellow Hadzhiyski, Shumenski oblong and Yaltenski. The indicators on the basis of which the study was carried out are: weight (g), length (mm) and width (mm) of the fruit, length of the stem (mm), weight (g), length (mm) and width (mm) of the stone. The data were obtained as a result of the experimental work carried out on the experimental field of the Fruit Growing Institute-Plovdiv.

A classical method for studying the genetic distances of varieties (hybrids) according to the degree of similarity in definite indicators is the cluster analysis. In the present work a hierarchical cluster analysis is applied. After clustering by various agglomeration methods, it was found that the best result for the grouping of the cornel-tree varieties was obtained by the intergroup binding method and a measure of similarity the quadratic Euclidean distance due to the maximum contingency coefficient. The calculation of the distances between the two clusters A and B is done by the formula:

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

where n_A and n_B are a number of points respectively from A and B.

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

is the square of the Euclidean distance between two vectors $x_i(x_{i1}, x_{i2},..., x_{ip})$ and $x_j(x_{j1}, x_{j2},..., x_{jp})$.

The data were previously standardized to avoid the impact of the different dimensions of the surveyed indicators. They were proved to have a distribution close to normal, which is a prerequisite for applying the relevant analyzes. As cluster analysis is performed without any tests for statistical significance, factor analysis is applied to the experimental data base. Through it the number of the surveyed indicators is reduced by combining the correlative ones in a common factor.

This method allows for a more detailed qualitative description of the resulting clusters, explaining the indicators with the greatest impact on the clustering. In the present work the main components method is applied for the factor extraction and Varimax– for the factor rotation method. An adequacy test of the applied approach was performed by a Kaiser-Meyer-Olkin test and a Bartlett's test of sphericity. Mathematical data processing was performed using the statistical programme product IBM Statistics SPSS 24 (Cronk, 2016; McCormick et al., 2017; Meyers et al., 2013).

Results and Discussion

From the results of the Livin homogeneity test, it follows that the experimental data have equal dispersions and the genotypes can be compared according to the corresponding indicators. On the other hand, the overall statistical assessment for each indicator has a significance level less than the error $\alpha = 0.05$, which is sufficient to consider that the studied varieties have statistical differences and that the common model is statistically significant.

The result of the cluster analysis of the cornel-tree lines is visualized by the dendrogram in Figure 1. It was found that Pancharevski cylindrical, Atkov and Kazanlashki pear-shaped varieties form the first cluster due to the proven similarity in the weight and size of the fruit as well as the width of the stone. The second cluster is self-contained - it includes the Vrachanski variety, which differs from the others in its broader fruit. The Shandrian, Tsarigradski yellow and Yellow Hadjiyski varieties form a third cluster because of the minimum weight and size of the fruit. The last cluster consists of the varieties Shumenski oblong and Yaltenski. These are the varieties with the longest berries, stems and stones.

The resulting differentiation of the cornel-tree genotypes in the cluster analysis is most likely due to their different geographical origins and the resulting peculiarities. This determines the differences in the phenotypic manifestations of separate pomological signs.

It has been proved that the conditions for applying factor analysis have been met: a positive value of the correlation matrix determinant, a KMO test (with value 0.695, greater than 0.5), and a Bartlett test (with a value of 0.000, less than 0.05). As a result, the number of surveyed indicators is

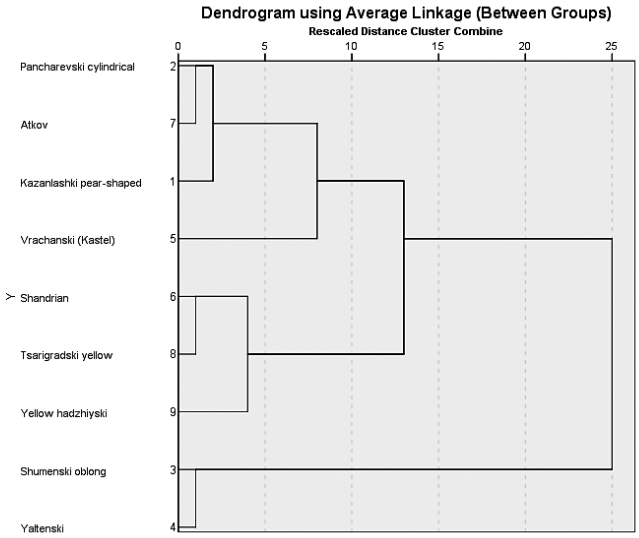

Fig. 1. Dendrogram presenting the result of the clustering procedure for cornel-tree varieties according to some biometric indicators

reduced to two factors, which combine the features of the included indicators.

They define the signs that influence the clustering of genotypes and explain the reasons for their genetic remoteness. As a result of the factor analysis, it has been proven that two factors have their own vectors with values greater than one, which determines the number of the main components. This fact is presented graphically in Figure 2.

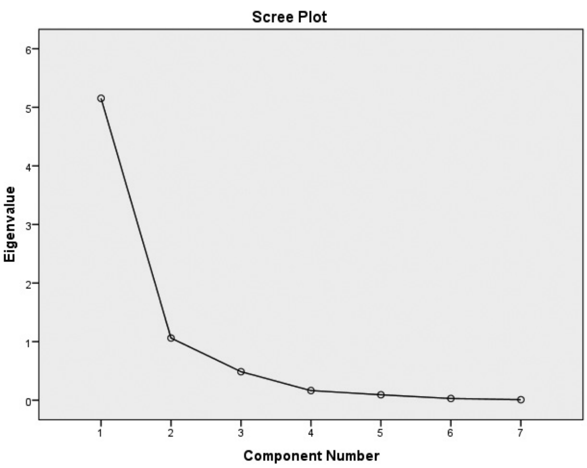

Fig. 2. Graphical presentation of the result of the factor analysis and the reduction of the number of indicators

The information in Table 1 shows that the indicators: length of the fruit, length of the stem, weight and length of the stone have high factor weights in the first factor. Therefore, it is related precisely to these features of cornel-tree.

Considering its high percentage of total variation (73.633%), we can summarize that these are the most influential indicators in the clustering of genotypes. These are the indicators influencing the genotypic differentiation of the studied varieties and forms. The second component includes: the weight and width of the fruit and the width of the stone and explains 15.165% of the total dispersion.

Table 1. Factor distribution of the pomological indicators in cornel-tree genotypes

Name of the indicator	Component	
	1	2
Weight of fruit		0.793
Length of fruit	0.686	
Width of fruit		0.983
Length of stem	0.970	
Weight of stone	0.872	
Length of stone	0.909	
Width of stone		0.573
Percent of the whole variation	73.633	15.165
Cumulative percent	73.633	88.798

Conclusions

As a result of the cluster analysis on biometric indicators, the studied cornel-tree genotypes are grouped into four clusters by degree of similarity. After applying factor analysis, the number of the studied signs is reduced to two factors explaining 88.798% of the total variability of the variables. The main indicators influencing the division of genotypes into clusters are: the length of the fruit, the length of the stem, the weight and the length of the stone. Genetically the most distant ones are Yaltenski and Shumenski oblong, on the one hand, and Pancharevski cylindrical and Atkov, on the other. The results of this study could be used in future selection practices. This will result in products with high economic value.

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