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STUDY OF THE PRODUCTION OF SOME STONE FRUITS IN THE COUNTRIES ON THE BALKAN PENINSULA THROUGH MATHEMATICAL APPROACHES

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Abstract

This is a study of the yields of stone fruits (apricots, cherries, peaches, nectarines and plums) on the territory of the Balkan countries for the period 2000-2016. A comparative assessment of the countries according to this indicator was made. Hierarchical cluster analysis and single factor analysis of variance were applied. For the period under study, the highest yield of apricots, cherries and plums is in Slovenia (157293.82 hg/ha, 313841.82 hg/ha and 1580446.53 hg/ha respectively). Greece (185991.47 hg/ha) and Italy (183474.12 hg/ha) have the highest yields of peaches and nectarines. The lowest yields of apricots are proven in Croatia (17966.59 hg/ha), followed by Bosnia and Herzegovina (21697.47 hg/ha). Bosnia and Herzegovina also has the lowest yields of cherries, peaches and nectarines (45717.29 hg/ha and 19491.18 hg/ha respectively). Slovenia has the highest proven instability of the yields of all crops. They are the most stable in Bosnia and Herzegovina.

Key words*: fruits, Balkan countries, cluster analysis*

INTRODUCTION

Fruit growing is a traditional subsector of plant growing not only in Bulgaria but also in many Balkan countries. In Bulgaria, the most favorable factors are the natural conditions, on the one hand, and the generations' traditions, on the other.

Fruits are known for their rich content of vitamins, minerals, fiber, folic acid, beta-carotene, etc. This makes them an important component of the everyday nutrition of every person who is striving for a healthy lifestyle.

There are many scientific developments in the field of fruit growing aimed at increasing crop yields (Trivedi, 2015: Ali et al., 2016; Bass et al., 2016; Dongnan Li et al., 2016; Sestraş et al., 2007).

Tanasescu and Paltineanu (2004) show the effects of various irrigation methods on the distribution of roots in the Golden Delicious apple cultivar grafted on MM 106 rootstock under the specific conditions of the hilly region of Pitesti - Maracineni, Southern Romania. The results obtained here showed that a higher influence was induced by the different irrigation treatments to the active tree root cross-sectional area (TRCSA) versus the total TRCSA. A direct, linear and distinctly significant correlation was found between the sum of the total TRCSA and the fruit yield on the one hand, and between the total TRCSA and the annual growth in tree trunk cross-sectional area on the other hand.

Radunic et al. (2015) evaluate the physical and chemical properties of eight pomegranate accessions (seven cultivars and one wild genotype) collected from the Mediterranean region of Croatia. Accessions showed high variability in fruit weight and size, calyx and peel properties, number of arils per fruit, total aril weight, and aril and juice yield. Variables that define sweet taste, such as low total acidity (TA; 0.37-0.59%), high total soluble solids content (TSS; 12.5-15.0%) and their ratio (TSS/TA) were evaluated, and results generally aligned with sweetness classifications of the fruit. Pomegranate fruit had high variability in total phenolic content (1985.6-2948.7 mg/L). HPLC-MALDI-TOF/MS analysis showed that accessions with dark red arils had the highest total anthocyanin content, with cyanidin 3-glucoside as the most abundant compound. Principal component analysis revealed great differences in fruit physical characteristics and

chemical composition among pomegranate accessions.

Pouyesh et al. (2017) studies the possibilities for hybridization of seven melon varieties, taking into account indicators such as yield, number of fruit from a plant, carotenoid and chlorophyll content. They found that combining the genotype Garmak × Rish-baba with other forms would result in plants with maximum yield and high concentration of chlorophyll. However, the authors recommend that parenting lines be improved before being used in future hybridizations.

Asmai Ozturk (2005) studies different types of apricots according to the stochastic, phenological parameters and yields. They prove that among these genotypes there are sensitive differences in the yield, total acidity, stone mass, etc. They find different correlations between the surveyed indicators, from which they conclude that the Levent variety is suitable for future selection research.

Diaa et al. (2016) evaluate varieties of watermelon according to the yields over a three-year period and the geographical location of their cultivation. They analyze the stability of yields and determine the correlations in the base of experimental data. They demonstrate the strong effect of genotype-environment interaction on watermelon production. The hybrid forms Big Crimson and Legacy stand out both with high yield and with considerable stability.

The present study aims to make a comparative assessment of the countries on the Balkan Peninsula according to the average yields of some stone fruit for the period 2000-2016. Based on proven differences in production quantities, the countries are grouped into clusters and the factors that influence the clustering are analyzed.

MATERIALS AND METHODS

The present work analyzes data connected with the average yields of the following stone fruit: apricots, cherries, peaches and nectarines and plums in the Balkan countries, namely: Bulgaria, Albania, Bosnia and Herzegovina, Serbia, Croatia, Greece, Romania, Turkey, Italy and Slovenia from 2000 to 2016. Montenegro is the only Balkan country that is not included in this study because of a lack of database for some of the indicators surveyed. The grouping of the countries from the Balkan Peninsula in clusters according to a similarity in the average yields of apricots, cherries, peaches and nectarines throughout the period was performed by hierarchical cluster analysis. Clustering has been done according to various agglomeration methods, but the intragroup binding method has a maximum contingency coefficient. This determined its application in the study. A measure of similarity is the square of the Euclidean distance. This method calculates all possible distances between all points of the two clusters A and B, i.e. the distances between all nA and nB points of the same cluster by the formula:

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

where the sum changes in all points x_i from A and x_j from B. Here

$$d(x_i,x_j)=\sum_{m=1}^{p}\left(x_{i_m}-x_{j_m}\right)^2$$

is the square of a Euclidean distance between two vectors.

The comparative assessment of the countries according to the average yields of the respective stone fruits was carried out using single-factor analysis of variance (ANOVA) and a Duncan test. The statistical data match Levene's test for equality of variances, which in turn means that the countries can be compared according to their respective indicators.

In order to study the trends in the production of each of the plants, graphs have been built that allow the countries to be compared according to the production quantities of each fruit.

The data in this publication are obtained from the FAOSTAT database. Their mathematical processing was performed using the statistical program product IBM Statistics SPSS 23 (Wendler and Grottrup, 2016).

RESULTS AND DISCUSSIONS

After a cluster analysis, it was found that the Balkan countries could be grouped into four clusters due to the similarity in the average

yields of apricots, cherries, peaches and nectarines and plums from 2000 to 2016. The dendrogram in Figure 1 presents the result of the clustering procedure. The first cluster includes the countries with the lowest yields of apricots, cherries and peaches and nectarines: Bulgaria, Serbia, Bosnia and Herzegovina and Croatia. The countries with the highest yields of peaches and nectarines are Greece and Italy, which form a second cluster. The third one includes Albania, Romania and Turkey, and the fourth cluster is single. It consists of Slovenia, the country with the highest yields of apricots, cherries and plums for the entire study period, significantly higher than those of the other European countries surveyed.

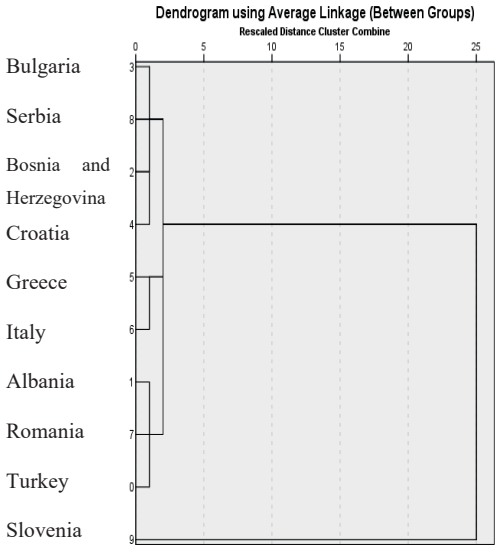

Figure 1. Dendogram showing the result of the clustering of the countries from the Balkan Peninsula according to the similarity in the average yields (hg/ha) of some stone fruit for the period 2000-2016

The comparative assessment of the countries according to the average yields of the respective stone fruit provides a more detailed qualitative description of the formed clusters (Table 1). After applying a single-factor analysis of variance and a Duncan test, it was found that for the period of study Slovenia (157293.82 hg/ha, 313841.82 hg/ha and 1580446.53 hg/ha respectively) has the highest yield of apricots, cherries and plums ha). Greece (185991,47 hg/ha) and Italy (183474.12 hg/ha) have the highest yields of peaches and nectarines. The lowest yields of apricots are proven in Croatia (17966.59 hg/ha), followed by Bosnia and Herzegovina (21697.47 hg/ha). Bosnia and Herzegovina has again minimum yields of cherries and peaches and nectarines (45717.29 hg/ha and 19491.18 hg/ha respectively). The standard deviation values in Table 1 give information on the degree of stability of the yields of each fruit for the country concerned. The most stable, albeit low, are the yields of all the studied crops in Bosnia and Herzegovina. The largest variation in the production of these crops is found in Slovenia.

Figures 2-5 show the trends in the change of the average yields of the studied fruits in each Balkan country.

There was an increase in apricot production in Albania in 2007, which remains until 2016 (Figure 2). For Slovenia, the whole period is full of peaks and falls in apricot production, which shows the yield instability throughout the period. For the other countries, there is comparative sustainability in the quantities of apricots produced. The whole period of the survey is characterized by the comparative stability of apricot yields in Bulgaria. No sharp fluctuations are detected, and the trend is towards increasing the production of this crop.

Figure 3 shows the change in cherry production. Slovenia still has the highest yields, but we can observe analogical fluctuations in the quantities over the years. However, it exceeds the yields in other countries several times. According to the Agro-Statistical Directory of the Republic of Slovenia, cherry yields in 2017 increased by 25% compared to the previous year and of apricots by 41%. This fact proves the wavy trend in the production of cherries in this country. In Bulgaria we have again stable yields for the whole period.

Analyzing the graph in Figure 4, peaches and nectarines can be said to be the crops with the highest degree of instability in the Balkans. There are periods of increase and decrease of their production in Greece, Albania, Italy, Slovenia, and they are overlapping over time. In 2001-2003 there were declines in Greece, Italy, Albania, Croatia and a rise in Romania and Slovenia. In Bulgaria, Serbia, Slovenia, Albania, there is a trend towards increasing the production of peaches and nectarines after 2012, which remains until the end of 2016.

As the quantity of plums produced in Slovenia exceeds the quantity in the rest of the Balkan countries, a further coordinate axis (at the right), which shows the yields in this country, is introduced on the graph in Figure 5. The left coordinate axis shows the production in the other countries. This allows for better visualization of the trends in the changes of the yields of the respective crop. It turns out that in most countries there are no sensitive peaks or drops in the production of plums. A significant increase occurred in 2009 in Albania, which continued until 2012, followed by a period of relative stability. The most unstable is the yield of plums in Slovenia, although this is the country with maximum quantities. The whole period is characterized by peaks and falls, and the smallest quantity for the seventeen years of research is produced in 2016. Low variations are observed for Bulgaria, wherein the period after 2014 there is a trend of increasing plum yields.

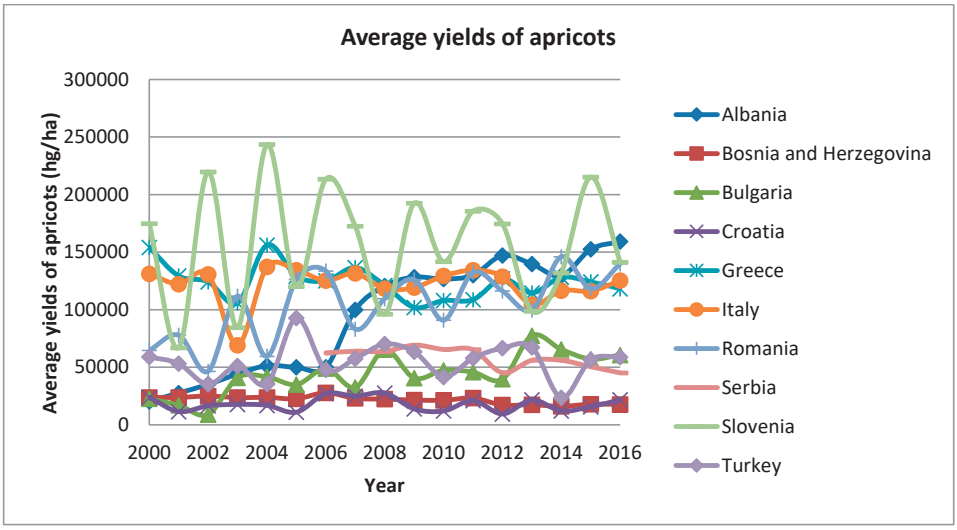

Figure 2. Changes the in average yields of apricots in the Balkan countries for the period 2000-2016

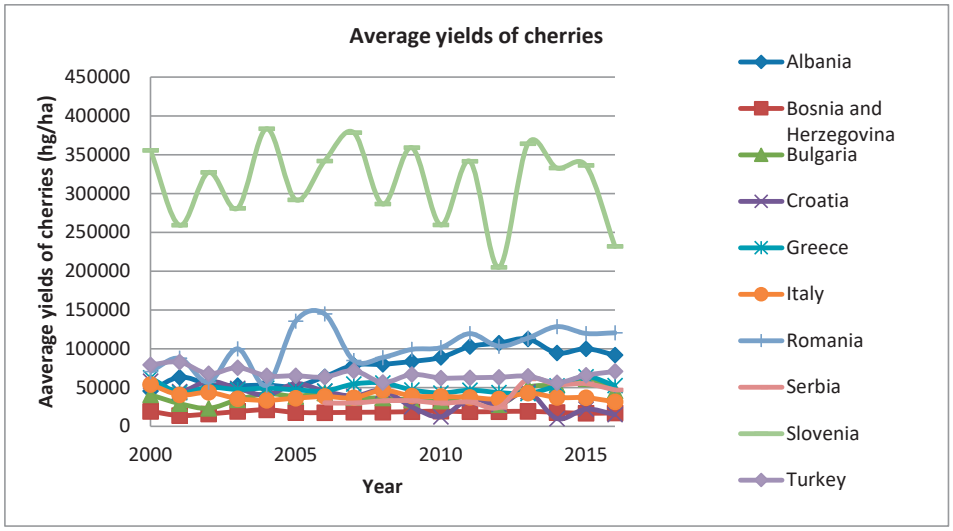

Figure 3. Changes in the average yields of cherries in the Balkan countries for the period 2000-2016

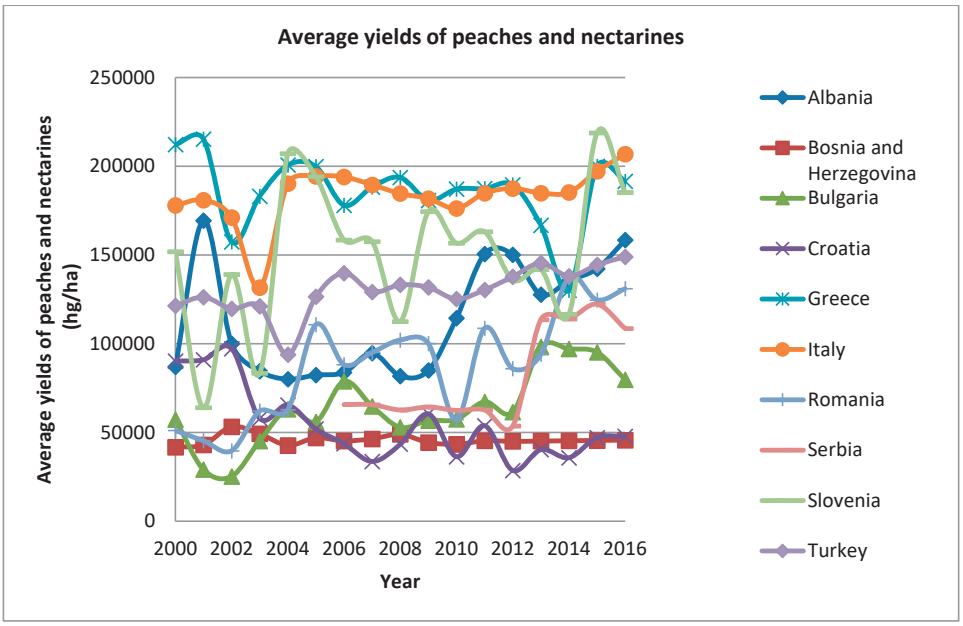

Figure 4. Changes in the average yields of peaches and nectarines in the Balkan countries for the period 2000-2016

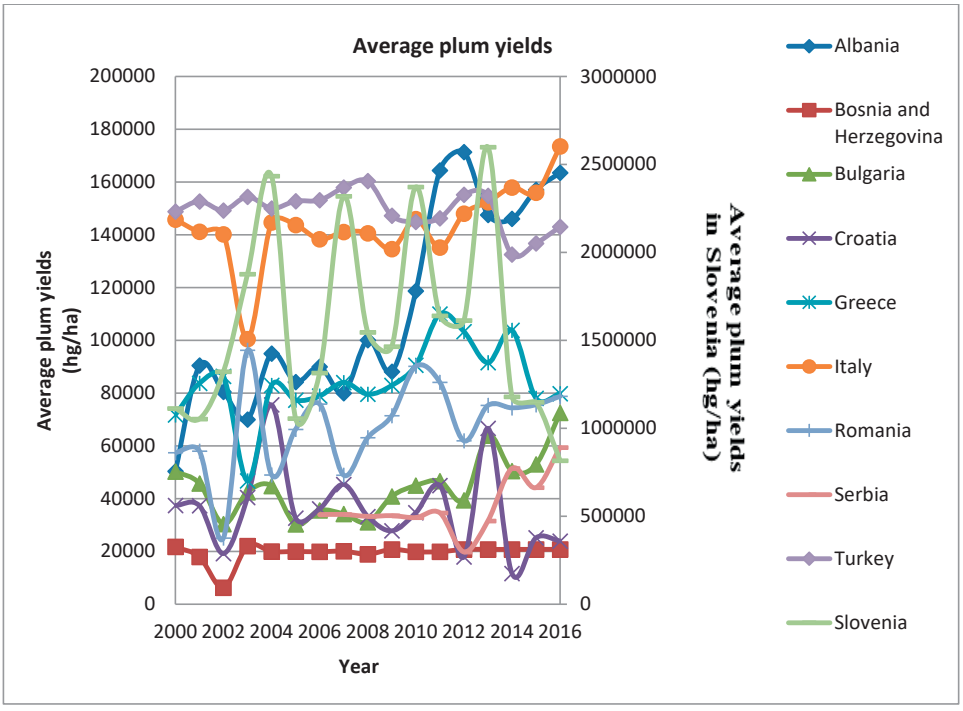

Figure 5. Change in the average plum yields in the Balkan countries for the period 2000-2016

Table 1. Comparative assessment of the countries on the Balkan Peninsula according to the average yield of some stone fruits for the period 2000-2016

Cluster №	Country	Apricots			Cherries		
		Duncan		Standard deviation	Duncan		Standard deviation
1	Bulgaria	43967.29	d	18015.14	39249.18	d	9571.19
	Serbia	58480.36	d	8444.62	39008.45	d	12682.46
	Bosnia and Herzegovina	21697.47	e	3288.28	18225.71	e	1659.25
	Croatia	17966.59	e	5911.72	37007.82	d	15612.35
2	Greece	124313.00	bc	15030.00	49824.35	d	6464.96
	Italy	122050.35	bc	15983.41	39089.00	d	5326.31
	Albania	94864.12	c	49732.97	77943.12	c	22022.70
3	Romania	104894.53	bc	29885.87	101616.71	b	26034.59
	Turkey	55226.29	d	15958.28	67075.35	c	7137.50
4	Slovenia	157293.82	a	52357.49	313841.82	a	52939.83

Cluster №	Country	Peaches and nectarines			Plums		
		Duncan		Standard deviation	Duncan		Standard deviation
1	Bulgaria	63858.94	ef	21099.00	44513.94	b	11508.25
	Serbia	81404.91	d	26699.74	37166.36	b	10747.56
	Bosnia and Herzegovina	45717.29	f	2752.03	19491.18	b	3545.91
	Croatia	54407.65	ef	20817.13	35908.53	b	16294.25
2	Greece	185991.47	a	20399.33	84216.71	b	14192.70
	Italy	183474.12	a	15810.75	143507.82	b	14646.78
	Albania	113389.29	c	31862.02	111618.82	b	38506.71
3	Romania	88026.65	d	30421.08	67760.88	b	17191.49
	Turkey	130188.06	c	12872.06	149422.00	b	7224.80
4	Slovenia	150628.47	b	40986.74	1580446.53	a	552359.92

a, b, ..., f - level of statistical significance at $\alpha = 0.05$

CONCLUSIONS

As a result of the analyses, it has been proven that in the Balkans Slovenia is the country with the highest but at the same time the most unstable yields of all stone fruit included in the survey. At the other pole are Bosnia and Herzegovina and Croatia. Bulgaria has a low yield of stone fruit and therefore occupies one of the last places based on this indicator. Considering that the yields of all crops in the respective countries are largely overlapping, the reasons for the low production could be sought in the geographic, soil and climatic characteristics of the individual Balkan countries.

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