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Morphological characteristics of greek strawberry tree (*arbutus andrachne* l.) genotypes

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Abstract: The morphological characteristics of fruits and leaves of ten Greek Strawberry tree (*Arbutus andrachne* L.) genotypes located on the middle course, from the left side of Konjska River, in South part of Republic of Macedonia are investigated. Among the investigated characteristics of Greek Strawberry tree genotypes it is noted a large level of polymorphism. The genotype 2 is characterized with twice as big fruit mass (1.87 g) as most of other investigated genotypes. The genotypes 2, 7 and 9 are included in the group with large fruits. According to CIELab color system the fruit skin of genotype 2 is characterized with unusually dark red coloration (L* 21.02; a* 18.8; b* 12.0), while the most attractive are the fruits from the genotype 9 (L* 23.9; a* 28.3; b* 17.4). The investigated genotypes show differences in the fruit anatomy, especially the genotype 7 which is characterized with significantly higher value for lobedness degree, pericarp area and pericarp thickness, percent of pulp and number of seeds in fruit. Large differences in the leaves dimension and form are also determined.

Key words: *Arbutus andrachne* L., genotype, fruit, leaf, polymorphism.

Introduction

Greek Strawberry tree (*Arbutus andrachne* L.) is a member of *Ericaceae* family and it is an evergreen, bushy shrub or a small tree up to 12 m, which grows along the Mediterranean coast spontaneously, separately or in association

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with the related species *Arbutus unedo* L. (Strawberry tree). It is an evergreen small tree, widely distributed from the East Mediterranean to Northern Black Sea area (Bertsouklis and Papafotiou, 2009). According to the phylogeographic investigations, during the Last glacial maximum (21.000 years ago) A. unedo was extinct from the East Mediterranean coast because the minimum monthly temperatures were bellow 4 ^{o}C limit for its survival, and after that again colonized from the North African glacial refugium (Santiso *et al.,* 2016). The *A. andrachne* seems that through Last glacial period was decimated but not extinct. Unlike the *A. unedo* which is now more prevalent, Greek Strawberry tree is present mostly along the coast of East Mediterranean, and as more tolerant to low winter temperatures, it penetrates trough river valley and gorges deeper into mainland. Exactly in that kind location this fruit species is founded, in purified composition through harsh winter weather conditions, with absence of related and tenderer *A. unedo* on the territory of Republic of Macedonia, or in river gorges of the two west tributaries of the river Vardar. One location is extent the lower course of Crna River, and the other is the middle course of Konjska River (Em *et al.,* 1974).

Otherwise, very related species to Greek Strawberry tree , Strawberry tree fruits have been occasionally used for consumption in the Iberian Peninsula and other Mediterranean regions (Molina *et al.,* 2011). Among the wild fruit species in Spain and Portugal, Strawberry tree fruits are very important and they are usually consumed in raw condition on the field and sometimes taken for home processing (Tardío *et al*., 2006). New studies suggest potential uses of Strawberry tree fruits in the food industry and raising commercial orchards for fruit production (Alarcão-E-Silva *et al*., 2001). *A. unedo* and *A. andrachne* fruits reach a satisfying flavor if consumed in overripe condition and have a wide range of antioxidants, such as vitamin C and E, niacin, carotenoids and polyphenolic compounds (Ruiz-Rodríguez *et al*., 2011). The antioxidant activity of Strawberry tree fruits was found to be one of the highest among 28 fruit kinds (García-Alonso *et al*., 2004). According to some authors (Celikel *et al*., 2008), both Srawberry and Greek Strawberry trees belong to the group of new, underutilized fruit tree species. But, Greek Strawberry tree owns one very important advantage. In late autumn Greek Strawberry tree has uniformly matured fruits which are ripen simultaneously, considering the short blooming period in spring. At the same time, in autumn, at the Strawberry tree can be found flowers, immature, underripe and ripe fruits, as a result of discontinuous blooming period in warmer subtropical conditions. The ripening of Greek Strawberry tree fruits lasts about 7 months, while at the Strawberry tree lasts about 12 months (Santiso *et al*., 2016). This type of phenology of the Greek Strawberry tree with a more prominent winter dormancy and short simultaneously ripening, represent its adaptation to the more severe climatic conditions of the East Mediterranean, which mean a genetic predisposition, and at the same time an opportunity to introduce this fruit species in commercial fruit production. The aim of this paper is to be done a first step to investigate possibility to start a positive selection of Greek Strawberry tree genotypes founded in Republic of Macedonia dendroflora and to choose those which will be most suitable for fruit orchard production.

Materials and Methods

During 2014 and 2015 is performed investigation of the morphological characteristics of ten Greek Strawberry tree (*Arbutus andrachne* L.) genotypes from locality Ampiratov Hill from the left side of Konjska River, municipality of Gevgelija, Republic of Macedonia, 75 km closest air line distance from the Aegean Sea, and 250 km from Adriatic Sea. The location is on 41^{o}10’07” N latitude, 22^{o}23’06” E longitude, altitude of about 350-400 meters on poor skeletal soil over gabbro or limestone, where dominate the special variant of submediterranean pseudomaquis (Carpinetum orientalis phillyretosum), exactly because the presence of Greek Strawberry tree in it (Em *et al*., 1974).

The fruits and leaves from Greek Strawberry tree are harvested at the end of November and kept at a temperature of 4 ^{o}C. Three repetitions by 100 randomly taken fruits and leaves from the tree crown are investigated. The parameters used in the analysis include fruit heigth (FH), fruit width (FW), mass of fruits (FM), leaf area (LA), leaf perimeter (LP), leaf length (LL), leaf width (LW), mass of leaf (LM) and mass of leaf petiole (Lpe).

The examination of the fruits and leaves characteristics (except their mass and number of seeds) is made using scanning device for obtaining high resolution images which are processed with the digital image processing method that performs precise analysis of the object dimensions (Markovski and Velkoska-Markovska 2015) trough computer softwares “ImageJ” (IJ) and “Tomato analyzer” (TA). It is used flatbed scanner device color calibration with X-rite ColorChecker card for measure internal (flesh) and external (skin) fruit color on the basis of CIELab color system. Under cross section anatomical characteristics, through longitudinal fruit section and latitudinal fruit section of the fruit is used TA software equations for some parameters, such as:

SH = S/H - Shoulder height (SH), the ratio of the average height (S) of the shoulder points above the proximal end point to Maximum Fruit Height (H),

PIA = K/S*10 - Proximal identation area (PIA), the ratio of the area of the proximal indentation (K) to the total area of the fruit (S), multiplied by 10.

DIA = Ki/S*10 - Distal indentation area (DIA), the ratio of the area of the distal indentation to the total area of the fruit, multiplied by 10.

LD = d*100 - Lobedness degree (LD), the standard deviation of distances (d) from the center of weight to the perimeter, multiplied by 100.

PA - Pericarp area (PA), the ratio of the area within the pericarp boundary to the area of the fruit.

PT = (h1 + h2, w1 + w2) / (H, W) Pericarp thickness, the ratio of the average length of pericarp along horizontal and vertical lines through the center of weight to the average of the Maximum Height and Maximum Width.

The data are statistically analyzed by ANOVA and Fisher's multiple comparisons testing at a level of 0.05. Clustering of the genotypes into similarity groups with the average linkage method, Pearson correlation matrix, Principal component analysis and ANOVA were performed using the Minitab and Xlstat softwares.

Results and Discussion

The mother plants, from which is collected the plant material, are in excellent condition, without any kind of important diseases and pests presence. The investigated trees are multi trunk with 3 to 5 meters high. The investigation trough computer vision techniques, which are applied, usually are used to recognize a fruit rely on four basic features which characterize the object: intensity, color, shape and texture (Arivazhagan *et al.,* 2010). The Greek Strawberry genotypes in our case are characterized mainly with spherical fruit form, or a little bit greater height, measured from the stem to calyx. The genotypes 4 and 7 are exception, and they have the greater width than height of the fruit (Table 1). According to the fruit dimensions, the genotypes 9 and 2 have statistically significant bigger fruits than the other genotypes. The mass and quality of the fruit depend mostly by the genotype and by climatic conditions of the region and fruit weight is most important selection criteria used in order to choose superior types of Strawberry tree (Sulusoglu *et al*., 2011). In our case the genotype 2 has statistically significant greater fruit mass than the other investigated genotypes. The seeds number per genotypes fruits is different. The fruits from genotype 7 have significantly greater number of seeds per fruit (17.9) (Table 1). Content of the fruit pulp obviously depend from the seeds number per fruit, or in our case the fruits from genotype 7 have greatest percent of pulp (54.1%).

Computer color measurements are based on the CIELab color system. The CIELab color space, which uses L*, a*, b*, describe the colors more receptive for the human visual perception, actually they are translated from the average RGB values for each pixel, taken by Color test module (Rodríguez *et al*., 2010). The investigations of the fruit external (skin) coloration using Tomato analyzer (TA) show great difference at Greek Strawberry tree genotypes. TA is rapidly becoming the standard for fruit morphological characterizations (Brewer *et al.,* 2006; Brewer *et al.,* 2007; Gonzalo and Van der Knaap, 2008). In the CIELab color space L*, a* and b* describe a three-dimensional space, where the values for +L* is lightness direction, values for –L* show darkness direction and consequently, +a* is red direction, -a* is green direction, +b* is yellow direction, -b is blue direction (Ornelas-Paz *et al.,* 2008). The Greek Strawberry fruits generally are characterized with orange to dark red skin color. In our case the genotype 5 is characterized with significantly greater light yellow color coverage (L* 31.7; b* 23.8) and with a reduced additive reddish color (a* 16.2) coverage of the fruit skin. The fruits from genotype 2 have darkest coloration (L* 21.0) with minimum yellow (b* 12.0) or red (a* 18.8) zones of the fruit skin. At the genotype 9 is noted significantly higher red coloration (a* 28.3) with average orange-yellow overflow (b* 17.4), so the fruits from this genotype are the most attractive. We have noted that high value for L* indeed are related to unripeness of the fruit (Mohd Hudzari *et al.,* 2012). Higher variation is recorded to the b* values (yellow additive coloration) (10.7-23.8), and smallest to L* values (21.0-31.7).

Table 1. Fruit characteristics of Greek Strawberry tree genotypes

	Fruit height mm	**Fruit width mm**	**Fruit mass g**	**Number of seeds in fruit**	**Pulp %**	**Average fruit skin color values**		
						L	**a**	**b**
Type 1	12.3[c]	11.8[d]	0.82[f]	12.6[b]	46.2[b]	23.4[cd]	20.8[c]	13.1[d]
Type 2	16.1[a]	15.7[a]	1.87[a]	11.2[bc]	49.0[b]	21.02[e]	18.8[c]	12.0[de]
Type 3	11.4[d]	11.4[d]	0.92[f]	9.3[bc]	38.3[cd]	23.3[cd]	20.5[c]	13.3[d]
Type 4	12.2[c]	13.3[c]	1.05[e]	11.4[bc]	44.8[bc]	27.1[b]	20.1[c]	17.4[b]
Type 5	11.4[d]	11.8[d]	0.64[h]	7.9[d]	35.8[d]	31.7[a]	16.2[d]	23.8[a]
Type 6	13.2[b]	13.4[c]	1.17[d]	10.2[c]	48.8[b]	21.8[de]	20.1[c]	10.7[e]
Type 7	13.3[b]	14.3[b]	1.31[c]	17.9[a]	54.1[a]	24.5[bc]	24.9[b]	15.9[bc]
Type 8	12.0[c]	11.6[d]	0.75[g]	7.9[d]	40.4[cd]	24.5[c]	24.9[b]	13.8[cd]
Type 9	16.2[a]	15.6[a]	1.74[b]	11.9[bc]	47.1[b]	23.9[cd]	28.3[a]	17.4[b]
Type 10	10.9[d]	10.5[d]	0.61[h]	12.4[b]	40.1[cd]	21.7[de]	19.3[c]	14.5[c]
Average	**12.9**	**12.9**	**1.09**	**11.3**	**44.5**	**24.3**	**21.4**	**15.2**

*The means followed by the same letter in each column are not significantly different at $P \leq 0.05$

Comparative analysis of fruit anatomical parameters could provide explanation of differences in investigation of different genotypes fruit anatomy (Rančić *et al.,* 2010). The investigation of the longitudinal fruit section analyzed with TA software not exposed statistically significant differences in relation to fruit shoulder high (SH) at the genotypes. With the larger SH is characterized the genotype 5. Furthermore, the statistically significant differences in relation to proximal indentation area (PIA) in the upper fruit part are not founded. The distal and proximal ends are used as a landmark points for every object through morphometrics function set of TA (Gonzalo *et al*., 2009). With the greatest value for PIA is characterized the genotype 4 (Table 2). The genotypes 9 and 7 have almost equal statistically significant value for distal indentation area, than the other genotypes. Latitudinal fruit section investigation show, that the genotype 7 has the most homogeneous fruits, according to the parameter Lobedness degree (LD). Significant difference in relation with this feature, exist between the genotype 7 and the genotypes 3, 6 and 9. The genotypes 9, 7, 4 and 8 stand out from the other genotypes by the pericarp area (PA). The genotype 7 is characterized with the highest pericarp thickness (PT), with highest number of seeds in fruit and highest pulp ratio per fruit (Table 1 and 2).

Table 2. Cross section characteristics of the fruit of genotypes

	Longitudinal fruit section			Latitudinal fruit section			Average mesocarp color values		
	Shoulder high	Indentation area		Lobedness degree	Pericarp				
		Proximal	Distal		Area	Thickness	L	a	b
Type 1	0.019^{a}	0.026^{a}	0.008^{b}	2.217^{ab}	0.556^{c}	0.246^{ab}	35.6^{d}	12.0^{a}	29.6^{d}
Type 2	0.009^{a}	0.024^{a}	0.011^{b}	1.806^{b}	0.556^{bc}	0.246^{ab}	49.9^{abc}	4.3^{c}	38.4^{ab}
Type 3	0.011^{a}	0.025^{a}	0.015^{ab}	1.735^{b}	0.556^{bc}	0.245^{ab}	47.5^{abc}	5.3^{bc}	40.1^{a}
Type 4	0.019^{a}	0.053^{a}	0.019^{ab}	2.695^{a}	0.558^{a}	0.243^{ab}	48.8^{abc}	4.4^{c}	35.1^{bc}
Type 5	0.023^{a}	0.047^{a}	0.012^{b}	2.863^{a}	0.556^{bc}	0.243^{ab}	50.4^{ab}	6.1^{bc}	37.5^{ab}
Type 6	0.016^{a}	0.040^{a}	0.018^{ab}	1.635^{b}	0.557^{ab}	0.245^{ab}	43.5^{c}	12.0^{a}	33.0^{cd}
Type 7	0.010^{a}	0.011^{a}	0.031^{a}	3.013^{a}	0.558^{a}	0.248^{a}	52.4^{a}	7.8^{abc}	40.2^{a}
Type 8	0.016^{a}	0.031^{a}	0.016^{ab}	2.611^{a}	0.558^{a}	0.243^{ab}	45.5^{abc}	10.4^{ab}	34.9^{bc}
Type 9	0.012^{a}	0.033^{a}	0.032^{a}	2.169^{ab}	0.558^{a}	0.242^{b}	44.5^{bc}	9.2^{abc}	34.8^{bc}
Type10	0.012^{a}	0.045^{a}	0.020^{ab}	2.153^{ab}	0.557^{ab}	0.243^{ab}	46.7^{abc}	11.2^{ab}	27.5^{d}
Average	**0.015**	**0.034**	**0.018**	**2.290**	**0.557**	**0.244**	**46.5**	**8.3**	**35.1**

*The means followed by the same letter in each column are not significantly different at $P \leq 0.05$

It is notable that at the investigated Greek Strawberry tree genotypes are not repeated the differences of the internal (mesocarp) coloration with the fruit skin coloration. Generally, the internal (flesh) color at the Greek Strawberry tree genotypes fruit is from pale yellow to bright orange. Carotenoids are the main pigments responsible for the yellow-orange color of fruit flesh at some fruit kinds (V´azquez-Caicedo *et al.,* 2005). The genotype 7 has statistically significant uniformly bright yellow (L* 52.4; b* 40.2) coloration of the mesocarp. With the lowest red pigmentation close to the epidermis layer is characterized the genotype 2 (a* 4.3). The highest values of that kind of red pigmentation are recorded to the fruits of genotypes 6 and 1 (a* 12.0). The variation in brightness (L* 35.6-52.4) of the flesh coloration is highest. High L* value coupled with high b* value, show that the flesh color of the genotypes is pale to bright yellow. The additional red pigmentation may become from the fruit overripeness (Table 2).

The larger differences are found in the leaf morphological characteristics among Greek Strawberry tree genotypes. Rapid phase of leaf growth and development (Phase II, late April to late May depending on species), followed by a final plateau (Phase III) were observed on *Arbutus andrachne* and *Arbutus unedo* trees (Kouki and Manetas, 2002). The leaves that we have investigated were collected at the middle of November. With statistically significant greatest leaf length is characterized the genotype 8. (Table 3). This may have been due to the bigger leaf thickness from thicker cuticle and longer palisade cells, and sometimes several layers of palisade cells of the leaves which affect over drastically the bigger mass (Villar *et al.,* 2013).

The genotype 7 has statistically significant the greatest leaf area (39.1 cm^2) compare with the most of the investigated genotypes, but because asymmetrical shape the genotype 8 has statistically significant the greatest leaf perimeter (25.98 cm). To minimize investment in support per leaf area in phenophase of rapidly growing in high, the trees produces large leaves (Reich *et al.,* 2004). With the most circular form of the leaves is characterized genotype 9 (0.71), while the most elongated are the leaves from the genotype 5. The genotype 9 has the highest petiole mass. Self-shading among larger leaves is avoided with longer and massive petioles and increased light interception capacity (Takenaka, 1994; King, 1998).

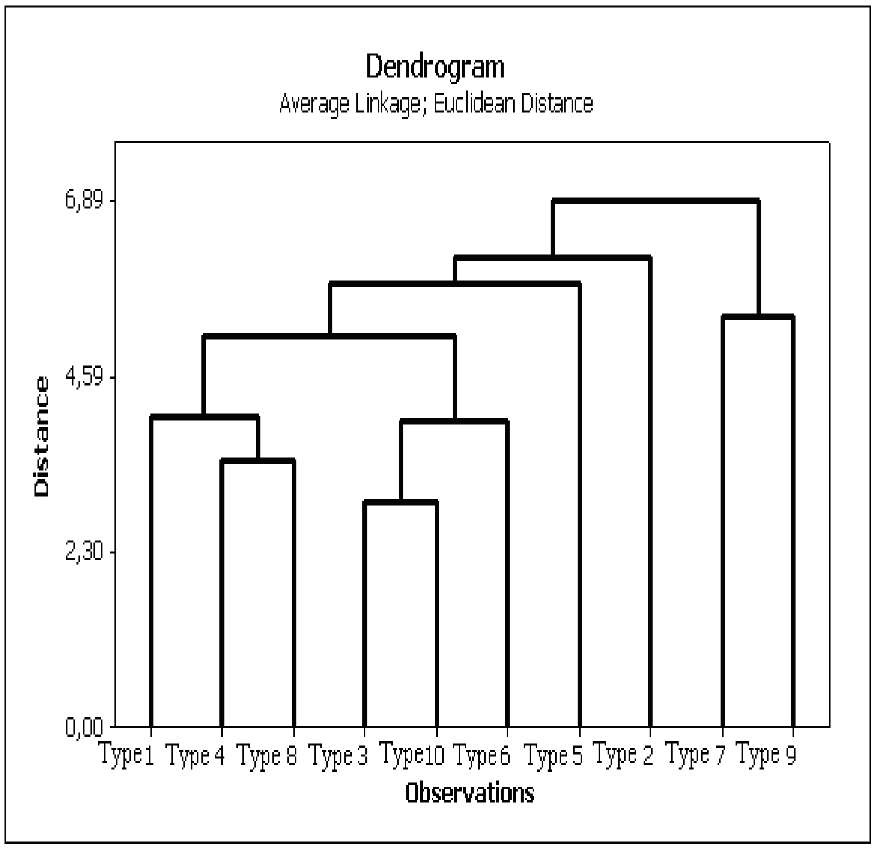
Table 3. Leaf characteristics of Greek Strawberry tree genotypes

	length mm	**width mm**	**mass g**	**Area cm^2**	**perimeter cm**	**circularity ratio**	**petiole mass g**
Type 1	8.34^{abc}	5.27^{bc}	1.21^{bc}	34.9^{ab}	25.02^{ab}	0.64^{bc}	0.098^{a}
Type 2	8.65^{ab}	5.11^{bcd}	1.26^{bc}	34.8^{abc}	23.70^{bcd}	0.59^{cd}	0.080^{b}
Type 3	7.63^{d}	4.99^{cd}	1.03^{cd}	31.2^{bcd}	22.52^{cd}	0.61^{bcd}	0.079^{b}
Type 4	8.13^{bc}	5.28^{bc}	1.27^{ab}	34.1^{bc}	24.18^{bc}	0.65^{b}	0.080^{b}
Type 5	7.98^{cd}	4.66^{d}	0.98^{d}	29.3^{d}	22.80^{cd}	0.58^{d}	0.075^{b}
Type 6	7.58^{d}	5.00^{cd}	1.05^{cd}	29.8^{cd}	22.01^{d}	0.66^{ab}	0.088^{ab}
Type 7	8.59^{ab}	5.79^{a}	1.28^{ab}	39.1^{a}	25.06^{ab}	0.68^{ab}	0.101^{a}
Type 8	8.71^{a}	5.62^{ab}	1.33^{ab}	38.7^{ab}	25.98^{a}	0.65^{b}	0.090^{ab}
Type 9	8.17^{bc}	5.80^{a}	1.49^{a}	37.6^{ab}	24.83^{ab}	0.71^{a}	0.105^{a}
Type 10	7.53^{d}	5.19^{bcd}	1.15^{bc}	32.5^{bc}	22.73^{cd}	0.59^{cd}	0.083^{b}
Average	**8.13**	**5.27**	**1.21**	**34.2**	**23.88**	**0.64**	**0.088**

*The means followed by the same letter in each column are not significantly different at $P \leq 0.05$

Investigation of the available variability present in the genetic material in the form of specific groups or classes, the divergence studies based on some desirable/suitable parameters is very essential and with high significance (Sharma *et al.,* 2013). Solution for different agricultural problems of various complexities through the use of cluster analysis in agriculture as effective techniques can be an intelligent way of using of data mining as a relatively new research field (Tiwari and Mishra, 2013). We have used the great number of measurements of fruits and leaves to make dendrogram generated from the average linkage cluster analysis and to classify 10 genotypes into 3 main groups (Figure 1). The First group includes the genotypes 3, 10 and 6, or 30% of genotypes from investigated population. It has smallest parameters for fruit and leaf dimensions. The second group includes also three genotypes 1, 4 and 8, or also 30 % from the total population. This group has average fruit size, above average big leaves and pronounced L* and b* coloration of the fruits. The third group contains 2 genotypes (genotype 7 and genotype 9).

Figure 1. Cluster analysis of ten Greek Strawberry tree genotypes



It is characterized by the greatest values for FH, SF, PR, LD, PA, highest values for a* coloration of the fruits, and for the leaf dimensions LW, LM, LA, LP, LC, Lpe. Outside of these three groups are the genotypes 2 and 5. Especially the genotype 2 is characterized by some very important characteristics such as above average big fruits, by which it is coming closer to the third defined group (genotype 7 and 9) (Figure 1).

Unlike the genotype 2, the genotype 5 is characterized by the smallest and also most intensive colored fruits, with lowest content of pulp, smallest and asymmetrical leaves among the other investigated Greek Strawberry tree genotypes, by which it come closer to the first group. The dissimilarity level from 3.20 to 6.89 alludes of the existence of some genetic distance among the investigated genotypes, which is unexpected, because the genotypes belong to one and the same geographically isolated population.

According to some authors (Rotaru *et al.,* 2012), the Principal component analysis method (PCA) is very useful in agriculture by downsizing the data, or with this method they are obtained reducing data to only two factors in which is concentrating over 80% of information derived from the 9 variables. The similarities and differences may highlight with using of PCA with identifying patterns and expressing the data in breading programs (Mratinić *et al.,* 2011). The PCA in our case show that more than 76 % of the variability observations is explained by the first 3 components, or F1 (44.98%), F2 (20.85%) and F3 (10.11%).

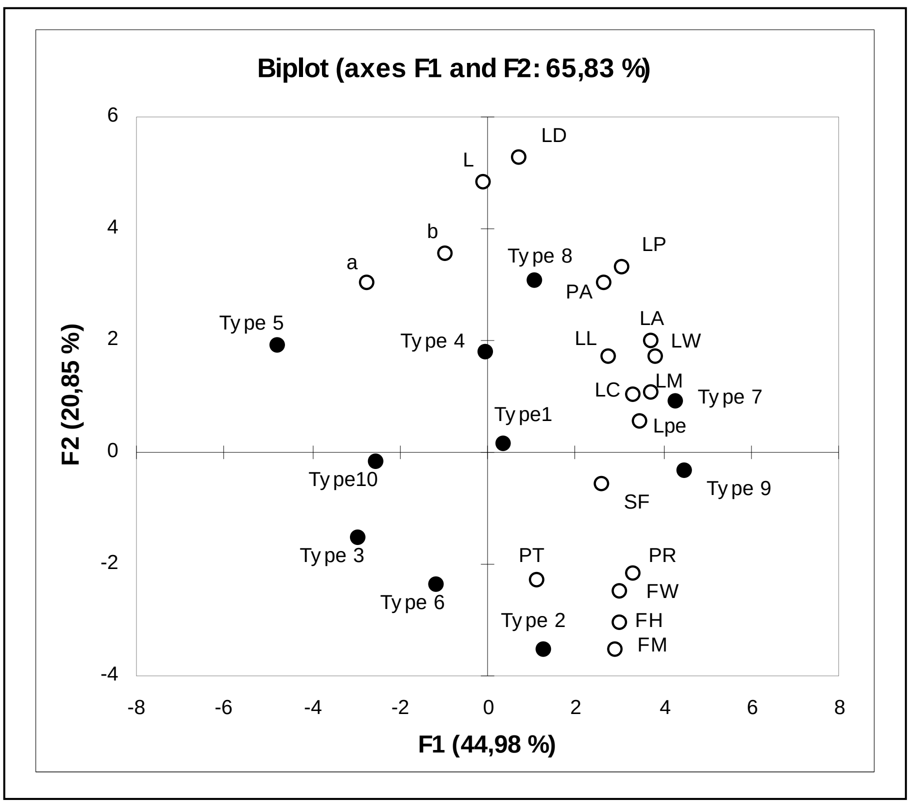
Table 4. Component loading for fruit and leaf characteristics of Greek Strawberry tree genotypes

Trait	**Component loading**			**Observation**	**Component scores**		
	F1	**F2**	**F3**		**F1**	**F2**	**F3**
Fruit height	0.7076	-0.4938	-0.2937	**Type 1**	0.3537	0.1525	1.6974
Fruit width	0.7158	-0.4036	-0.1677	**Type 2**	1.2597	-3.5108	0.1960
Fruit mass	0.6883	-0.5711	-0.2098	**Type 3**	-2.9481	-1.5264	-0.2088
Seeds in fr.	0.6186	-0.0905	0.5227	**Type 4**	-0.0411	1.7991	-0.3820
Pulp ratio	0.7860	-0.3465	0.3737	**Type 5**	-4.7835	1.9102	-0.2252
Lobedness	0.1729	0.8520	0.2453	**Type 6**	-1.1793	-2.3619	0.1528
Pericarp ar.	0.6271	0.4880	-0.2326	**Type 7**	4.2863	0.9222	2.4835
Pericarp th.	0.2639	-0.3708	0.8607	**Type 8**	1.0951	3.0691	-0.5343
Skin L*	-0.0240	0.7792	-0.2496	**Type 9**	4.4997	-0.3086	-2.9137
Skin a*	-0.6471	0.4899	0.0535	**Type 10**	-2.5425	-0.1454	-0.2656
Skin b*	-0.2288	0.5734	0.3531				
Leaf length	0.6531	0.2752	0.2426				
Leaf width	0.9082	0.2770	-0.0633				
Leaf mass	0.8863	0.1751	-0.3205				
Leaf area	0.8827	0.3234	0.0601				
Leaf perim.	0.7261	0.5386	0.0805				
Leaf circul.	0.7914	0.1664	-0.1599				
L. petiol. m.	0.8216	0.0932	0.0474				

With PCA it is founded high correlation between fruit dimension and leaf dimension characteristics. The high correlation between the fruits dimension characteristics (FH, FW, FM) and the pulp ratio (PR), but also, the low correlation with the seed number per fruit (SF) are determined at the genotypes. Also, we found very high correlation between the leaf dimensions (LW, LL, LM) and the fruit pericarp area (PA), between seeds number in fruit (SF) and pulp ratio (PR), between pericarp thickness (PT) and seeds number in fruit (SF) and pulp ratio (PR), also between lobedness degree of fruit (LD) and CIELab colors of the fruit skin just by that order (L*, a*, b*).

Positive values for F1 component includes the genotypes with high values for FH, FW, LW, LM, LA, such as the genotypes 9, 7, and 2 (Table 4, Figure 2). The lowest values for the same traits (FH, FW, LW, LM and LA) have the genotypes 5, 3 and 10. At the component F2 the genotypes 8, 5 and 4 have the highest values for L*, a*, b* coloration of the fruit skin, LD, LP and PA. The F2 component for the mentioned traits contains the genotypes 2, 6 and 3 which have the lowest values. The F3 component includes the traits with the highest values for PT, SF and PR which are characterized the genotypes 7 and 1 with. With the lowest values at the F3 component for these traits are characterized the genotypes 9 and 8 (Table 4, Figure 2).

Figure 2. Principal component analysis of Greek Strawberry tree genotypes



Conclusions

The existence of the Greek Strawberry tree in the temperate continental climate condition, far away from the sea shores, is phenomenon by itself, which indicate for the gradually adaptation of this tree species for spreading in uncommon condition for it. In other side, series of attributes which characterized the Greek Strawberry tree make this tree a pretender for new fruit kind for cultivation in commercial fruit orchards. From the investigation of relatively small part of isolated natural population in condition of South part of Republic of Macedonia, statistically significant differences in fruits and leaves characteristics of the genotypes are determined. Great differences in fruit anatomy between the genotypes are also noted. All of these parameters indicate for the presence of some polymorphism level in Greek Strawberry tree population in Republic of Macedonia from which with comprehensive selection process is intend to separate types with superior characteristics for cultivation in frame of new fruit culture.

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MORFOLOŠKE KARAKTERISTIKE GENOTIPOVA GRČKE MAGINJE (*Arbutus andrachne* L.)

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Rezime

Ispitivane su morfološke karakteristike plodova i listova deset genotipova Grčke Maginje (*Arbutus andrachne* L.) locirane dužinom srednjeg toka leve strane Konjske reke u južnom delu Republika Makedonije. Znatan stepen polimorfizma je zabeležen kod proučavanih karakteristika ispitivanih genotipova. Genotip 2 se karakteriše sa dvostruko većom masom plodova (1.87 g) u poređenju sa masom ploda većine ispitivanih genotipova. Tipovi 2, 7 i 9 se izdvajaju u grupu genotipova sa krupnijim plodovima. Prema CIELab sistemu boja, pokožica plodova kod genotipa 2 se odlikuje sa neubičajeno tamno crvenom obojenošću (L* 21.02; a* 18.8; b* 12.0), dok su najtraktvniji plodovi genotipa 9 (L* 23.9; a* 28.3; b* 17.4). Ispitivani genotipovi pokazuju razlike u anatomiji plodova, naročito genotip 7 koji se karakteriše sa značajnije većom vrednošću stepena lučnosti, površine i debljine perikarpa, procenta pulpe i broja semenki u plodu. Utvrđene su velike razlike u dimenzijama i formi listova kod različitih genotipova Grčke Maginje.

Kjučne reči: *Arbutus andrachne* L.; genotip, plod, list, polimorfizam.