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Morpho-physiological diversity in the collection of sour cherry (*Prunus cerasus*) cultivars of the Fruit Genebank in Naoussa, Greece using multivariate analysis

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ABSTRACT

The phenotypic characterization of sour cherry cultivars provides important information on their attributes, which is of paramount importance for their breeding and germplasm management. This study examined the Hellenic Sour Cherry Genebank, which consists of 27 sour cherry cultivars, located in the Institute of Pomology Fruit Genebank, Naoussa, Greece. The data analyzed in this study were obtained after a ten-year consecutive monitoring of 38 morpho-physiological descriptors of phenology, plant morphology, yield and fruit quality. For the statistical analysis were applied hierarchical cluster analysis and principal component analysis (PCA). According to the analysis, the descriptors demonstrated a high degree of variability, especially, yield, ratio of titratable acidity and soluble solids, number of flower buds, and pit weight. Moreover, the variables fruit equatorial diameter, fruit width, fruit weight, fruit size, fruit shape and lamella shape characters exhibited high discriminating power. Significant positive and negative correlations were detected as well among the studied quantitative traits. The highest significant positive correlation was found between the fruit equatorial diameter and the fruit width (0.974). Whereas, the highest significant negative correlation was found between the ratio of pit volume to fruit volume and the fruit weight (−0.737). An unsupervised hierarchical cluster analysis was performed using the Euclidean distance and the Ward's agglomeration method. The sour cherry cultivars were classified into three main clusters, suggesting that the characterized sour cherry collection has a high potential for specific breeding goals. We discuss the usefulness of the identified correlations among the traits, for potential breeding projects regarding fruit size and quality.

1. Introduction

Sour cherries are a highly important fruit crop with many health benefits, which contributed to the increase of their commercial importance, especially in the temperate zone (Toydemir et al., 2013). Moreover, sour cherry helped the development of new commercial cultivars of sweet cherry, used as rootstock imparting dwarf and resistant plants (Kappel et al., 2012). A large number of studies have been carried out in order to characterize Genebank collections of Cerasus germplasm and evaluate Cerasus germplasm from native populations (Hillig and Iezzoni, 1988; Khadivi-Khub et al., 2012; Krahl et al., 1991; Nazari et al., 2012; Perez et al., 2010; Rodrigues et al., 2008; Sánchez et al., 2008, among others).

The study of phenotypic traits is precise enough for the identification and analysis of the underlying genetic diversity between

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Table 1
Origin and the main fruit characteristics sour cherries cultivars analyzed.

Number (No)	Cultivar	Origin	Fruit shape	Skin colour	Fruit size
1	Vissino Episkopis	Greece	oblate	light red	very large
2	Kanaris	Greece	circular	light red	medium
3	Florinis	Greece	circular	light red	very small
4	Cacanski Rubin	Czech	circular	medium red	large
5	Cerise Belle Magnifique	France	circular	medium red	small
6	Cigahcica	Hungary	oblate	medium red	very large
7	Dwarf Meteor	U.S.A.	circular	light red	large
8	Dwarf Northstar	U.S.A.	oblate	light red	very small
9	Gelly	–	circular	light red	medium
10	Griotte De Provence	France	oblate	light red	medium
11	Keleriis	Denmark	oblate	light red	small
12	Heimann Rubin	Czech	oblate	light red	very large
13	Ilva	Romania	oblate	medium red	very large
14	Lotova	Russia	circular	blackish	very large
15	Marasca	Bulgary	oblate	light red	large
16	Marasca Moschata	Bulgary	circular	medium red	large
17	Meteor Korai	Hungary	oblate	light red	very large
18	Ministro Bodbieski	Russia	oblate	medium red	medium
19	Montmorency	France	oblate	light red	very large
20	Oblacinska	Serbia	reniform	medium red	very large
21	Pándy 48	Hungary	oblate	medium red	large
22	Randy Mecy	Hungary	circular	light red	very small
23	Rekseler	–	oblate	brown red	large
24	Rubin	Czech	circular	red	very small
25	Stark Montmorency	U.S.A.	elliptic	light red	very small
26	Suda Hardy	Germany	oblate	medium red	very large
27	N15	Greece	oblate	light red	small

the various sour cherry cultivars (IPGRI, 1985; UPOV, 1995), while the evaluation of morphological traits through phenotyping constitutes a quick method to both characterize the sour cherry germplasm and provide useful qualitative information for breeding.

Characterization of phenotypic diversity and structure is paramount in order to discover the phenotypic traits that contribute to the total diversity in a germplasm collection and discover the levels of variation among the cultivars (de Oliveira et al., 2012; Furones-Pérez and Fernández-López, 2009; Mehmood et al., 2014). A powerful statistical technique for analyzing genetic relations from morphological traits –a large data set consisting of many qualitative and quantitative traits- is multivariate data analysis (de Oliveira et al., 2012 Furones-Pérez and Fernández-López, 2009; Mehmood et al., 2014). PCA and cluster analysis are the most popular multivariate techniques for the morphological characterization of genotypes (Mohammadi and Prasanna, 2003; Peeters and Martinelli, 1989). The combination of PCA and cluster analysis could uncover important information concerning morphological traits that contribute to genetic diversity in plants (Khodadadi et al., 2011).

In many countries new breeding material of sour cherry cultivars and traditional local varieties are compared, in order to evaluate their performance in different climatic conditions (Grafe and Schuster, 2014; Schuster et al., 2009, 2014; Siddiq et al., 2011). In plant breeding programs, the attention has been focused on finding the appropriate parents for hybridizations. A large number of studies have been carried out towards the characterization of fruit traits involved in fruit quality. Recently, it has been discovered that some varieties of Hungarian sour cherries had functional properties that enhanced the health benefits of sour cherries (Papp et al., 2010; Veres et al., 2006). For the characterization and preservation of the genetic material of eight autochthonous sour cherry cultivars in Portugal, studies of commercially interesting morphological traits were also carried out; see Rodrigues et al. (2008). Rakonjac et al. (2010) studied the morphological traits of 41 accessions of the autochthonous and commercially important cultivar 'Oblačinska', and found that only two genotypes could be cultivated in Serbia. Moreover, the physicochemical composition and health potential of the cultivar 'Marasca' has been studied on a great scale (see Grafe and Schuster, 2014; Pedisić et al., 2007; Šarić et al., 2009).

The aims of this study were (i) to evaluate the phenotypic diversity in 27 international sour cherry cultivars preserved in a Greek GeneBank collection, (ii) to identify specific traits, and (iii) to detect relationships among the studied cultivars.

2. Materials and methods

2.1. Plant material

The 27 sour cherry cultivars studied originate from the Fruit Genebank of the Institute of Pomology, Naoussa, Greece (Table 1).

The Institute is located at 40°63′ N latitude, and 22°06′ E longitude, at an altitude of 115 m. The trees, propagated on Prunus avium rootstock, dated around 10–14 years old. Each cultivar was represented in the Gene Bank by three trees which were used to produce the data. Thirty-eight variables were selected as sour cherry descriptors and were included in the experimental collection for ten consecutive years (2000–2009). Different horticultural practices, including fertilizer application, spraying and irrigation, among others, were performed at regular intervals each year. At the beginning of the study, (2000), the trees were at fruit-bearing capacity (8 years old), healthy and in cropping condition.

2.2. Analysis of morpho-physiological traits

The 24 quantitative traits evaluated were yield [Yd], number of flower buds [NoFlBu], petiole length [PeLe], petiole width [PeWi], ratio petiole length/width [PeLe/PeWi], blade length [BlLe], blade width [BlWi], ratio blade length/petiole length [BlLe/BlWi], number of nectary glands [NoNeBu], number of flowers per spur [NoFlSp], fruit polar diameter [FrPoDi], fruit equatorial diameter [FrEqDi], fruit width [FrWi], fruit weight [FrWe], soluble solids [SoSo], titratable acidity [TiAc], ratio titratable acidity/soluble solids [TiAc/SoSo], pedicel length [PedLe], pit length [StLe], pit width [StWi], pit thickness [StTh], pit weight [StWe], ratio weight