RESEARCH ARTICLE

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Apricot fruit traits inheritance in offspring of the parental combination 'Modesto'x 'Harcot'

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ABSTRACT

It is known that apricot cultivation is sometimes risky so the cultivar list needs to be improved. Due to the high heterozygosity of the fruit species the breeding process is very difficult. Making a proper choice of donors of desirable traits would help the breeding process. Doing a suitable selection of donors is possible after examining the nature of inheritance of different traits.

In this study 114 apricot hybrids of the combination 'Modesto' x 'Harcot' together with the both parent cultivars were assessed. The hybrids were planted in 2011 at the Fruit Growing Institute in Plovdiv. In 2015 and 2016 the ripening period and fruit biometry, shape, color and suture were investigated. In 2015, the ripening period lasted 19 days, from mid of June until the first decade of July, and in 2016 it prolonged 17 days in June. The fruit weight variation coefficient in 2015 ranged from 1.82% to 30.68%. In 2016, the biggest was the group of hybrids with medium large fruits, and the variation coefficient was 4.46% to 33.34%. For the pomological characteristics of the fruits in both years, were observed almost identical tendencies of the inheritance of fruit shape, color and depth of suture. In both years of the study most of the hybrids had the same fruit shape as 'Harcot'. 'Modesto's fruit color and suture was inherited by a big group of the hybrids. A cluster classification of the biometry was performed.

Key words: *P. armeniaca*, breeding, fruit, characteristic

Introduction

Breeding of new fruit cultivars is a process that requires a lot of time and effort. Due to the high heterozygosity of the fruit species a lot of the traits are pollygenically inherited. Studying the ways of inheritance of the different traits in the progeny would result in a higher efficiency of the breeding process. It would help the choice of parental cultivars as donors of desirable characteristics. Apricots are in need of a genetic improvement with the aspects of adaptability to environmental factors, disease resistance and fruit quality. Apricots have low ecological plasticity and their cultivation in some regions is very difficult even when an intensive plant protection is applied (Bassi & Audergon, 2006). There are several dozen sponsored breeding programs and many breeders are interested in improving the adaptability of apricots to specific regions (Ledbetter, 2008). The new cultivars should be well adapted to the environmental conditions (Smykov, 1986). Environmental adaptability is not easy to be foreseen, for this reason the introduction of cultivars in new areas is often failed. To resolve this problem since 1992 in Italy was launched a national program for drawing up an annual list of 'Recommended Fruit Varieties' (Massai, 2010). Combining valuable pomological qualities, adaptability, resistance to biotic factors and sustainable yield is very challenging breeding task (Krška et al., 2006). More often fruit species show continuous variation in the phenotype of the progeny, which requires genetic analysis. Most of the traits in apricots are controlled polygenically i.e. their phenotype is determined by two or more polymer genes (Couranjou, 1995). The commercial value of apricots depends entirely on the quality of the fruit. Characteristic traits of fruit quality, such as size, flavour, taste, etc., can easily be improved by the breeding process because there is a great diversity of genetic resources for them (Krška et al., 2009). Trait inheritance is traced in many species of genus *Prunus*. The results of a study conducted by Ruiz (2012) et al. also showed the polygenic nature of the inheritance of most of the traits defining the fruit quality. Fruit size, flavour and the ripening period are quantitatively controlled traits (Sychov, 1996). Krška & Xiloyannis (2010) traced the transferring frequency of different traits of some apricot cultivars. The author reports that the cultivars 'Stark Early Orange' transferred to the progeny an early flowering attribute, 'Vestar' - resistance to cold, 'Veharda' - high yield and resistance to cold. 'Harcot' is used into many breeding programs as a donor of good fruit quality (Karayiannis, 2005). The quantitative nature of the inheritance and the high transferring ability of traits in the progeny indicate suitability

of the choice of parental component by their phenotype (Couranjou, 1995).

Materials and Methods

The study was conducted in 2015 and 2016 in a breeding orchard of the Fruit Growing Institute - Plovdiv. A hundred and fourteen apricot hybrids of the parental combination 'Modesto' x 'Harcot' were monitored. The hybrids were obtained by the method of classical fruit breeding and planted in 2011. To determine the fruit traits was taken an average sample of 25 fruits, from hybrids with lower number of fruits were taken the largest possible. To determine the descriptive characteristics of the fruits were used descriptors UPOV and IBPGR. The biometric data in average sample of fruits were measured with a digital calliper. All studied traits of the hybrids were compared with those of the parental cultivars – 'Modesto' and 'Harcot'. For statistical data processing were used descriptive analysis of frequencies and hierarchical cluster analyses using between-groups linkage method of the statistical software SPSS 13.0.

Results

In 2015, were observed 114 hybrids of the parental combination 'Modesto' x 'Harcot'. The ripening period lasted 19 days (from 16/06/2015 to 05/07/2015) (Figure 1).

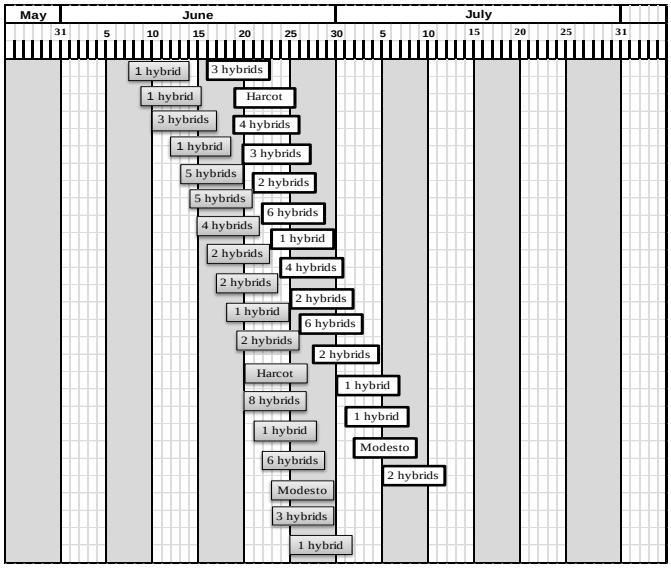

Figure 1. *Ripening calendar of the hybrid family - 2015 and 2016.*

Part of the observed hybrids died and so in 2016 were monitored 58. In this year the ripening period lasted 17 days (from 08.06.2016 to 25.06.2016). In 2016 most of the hybrids that had fruits in both years of the study ripened earlier than the previous year. According to Milošević et al (2010), the variation of the ripening period in the years is due to environmental factors, primarily the climate. Bassi & Negri (1991) assumed that the ripening period is inherited oligogenically. For one of our hybrids the date of fruit ripening in both years was not changed, for 2 other hybrids and 'Harcot' in 2016 the period of fruit ripening was shifted just one day. These data support an interesting assumption of Dirlewanger et al (2012), who detected quantitative trait locuses (QTL) for five progenies from three *Prunus* species. Several QTLs for maturity dates were highly stable, detected each year of evaluation, suggesting that they were not affected by climatic variations.

In 2015 both parental cultivars and 37 of the hybrids had fruits (Table 1).

Table 1. *Fruit categories according to the IBPGR descriptor.*

Fruit weight /g/	Categories according to the IBPGR descriptor	Number of hybrids in 2015	Number of hybrids in 2016
to 30	Very small	2	1
31 - 40	Small	12	5
41 - 45	Small/medium	8	9
46 - 55	Medium	Harcot + 8	15
56 - 60	Medium/large	Modesto +2	Modesto + 7
61 - 70	Large	4	Harcot +6
71 - 85	Very large	1	3
More than 85	Extremely large	0	0

Their average weight ranged from 25.05 g. to 78.04 g. In 2016, 46 of the hybrids and the cultivars 'Modesto' and 'Harcot' had fruits. The smallest measured average weight of the fruit was 27.81 g., and the largest - 83.02 g. Paunović (1987), Krška et al (2009), Bozhkova & Todorova (2012) consider the fruit weight as a variable trait. This completely corresponds with the data from our study (Figure 2).

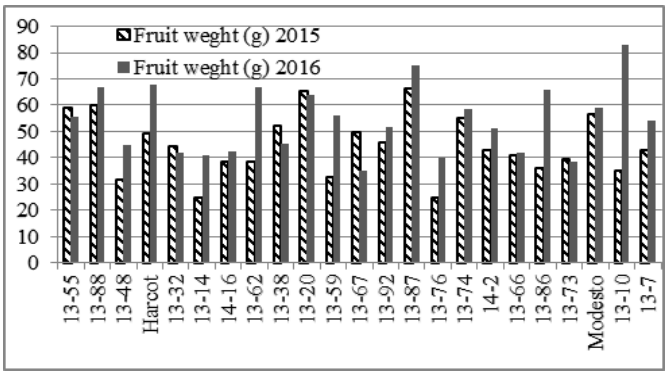

Figure 2. *Average fruit weight of the hybrid family for both 2015 and 2016.*

In IBPGR descriptor according to the average weight fruits are categorized in seven groups (Table 1). During the two years of the study a large number of hybrids were with small, or small to medium sized fruits. The fruit weight of

Table 2. *Coefficient of variance (CV) of the fruit weight for 2015 – 2016 (%).*

Descriptive statistics	Number of variants	Minimum	Maximum	Average	Std. Deviation
CV % 2015	33	1.81	30.67	15.26	6.16
CV % 2016	46	4.46	33.34	15.31	6.66

Table 3. *Fruit description.*

Observed traits				
Fruit shape in 2015	Ovate	Round		
	Harcot and 31 hybrids	Modesto and 6 hybrids		
Fruit shape in 2016	Harcot and 36 hybrids	Modesto and 10 hybrids		
Fruit ground color of skin in 2015	Yellow	Medium orange	Light orange	Dark orange
	3 hybrids	Modesto and 19 hybrids	6 hybrids	Harcot and 9 hybrids
Fruit ground color of skin in 2016	3 hybrids	Modesto and 26 hybrids	14 hybrids	Harcot and 3 hybrids
Depth of fruit suture in 2015	Moderately sunken	Deeply sunken	Slightly sunken	
	Modesto and 24 hybrids	Harcot and 1 hybrid	12 hybrids	
Depth of fruit suture in 2016	Modesto and 37 hybrids	Harcot and 3 hybrids	6 hybrids	

many of the well-known cultivars do not exceed 50 - 55 g, and according to this descriptor they also are classified as small or medium size (Bozhkova & Todorova; 2012). There is no significant difference between the calculated coefficients of variance for the fruit weight between both years. In 2015 the lowest coefficient was 1.82% and the highest – 30.68%. In 2016 fruit weight coefficient of variance was in the range of 4.46% to 33.34% (Table 2).

A coefficient of variance for 6 of the hybrids was not calculated because they had single fruit in 2015. Due to the same reason from the statistical data processing from 2016 are excluded 2 hybrids.

On Table 3 are shown traits that describe the fruits. In both years of the study were observed similar tendencies of the inheritance of fruit color, shape and suture. In 2015 and 2016 the largest group of hybrids inherited the shape of 'Harcot's' fruits. The orange color and the moderately sunken suture inherited from 'Modesto' were the most frequent traits in the progeny. According to Paunović (1987) the fruit shape is very stable trait that is inherited in the offspring. A hierarchical cluster analyses was carried out using between-groups linkage method. The dendogram (Figure 3), for the biometry data from 2015, shows that the hybrids are divided into five clusters.

The smallest distance of grouping is 1 and the largest is 25. In the first cluster are combined the mother cultivar 'Modesto' and two hybrids - MH13-55 and MH13-87, which by their biometric data are very much like it. The second cluster combines 5 hybrids (MH13-20 to MH14-6), which biometrics surpasses both parental cultivars. Cluster 3

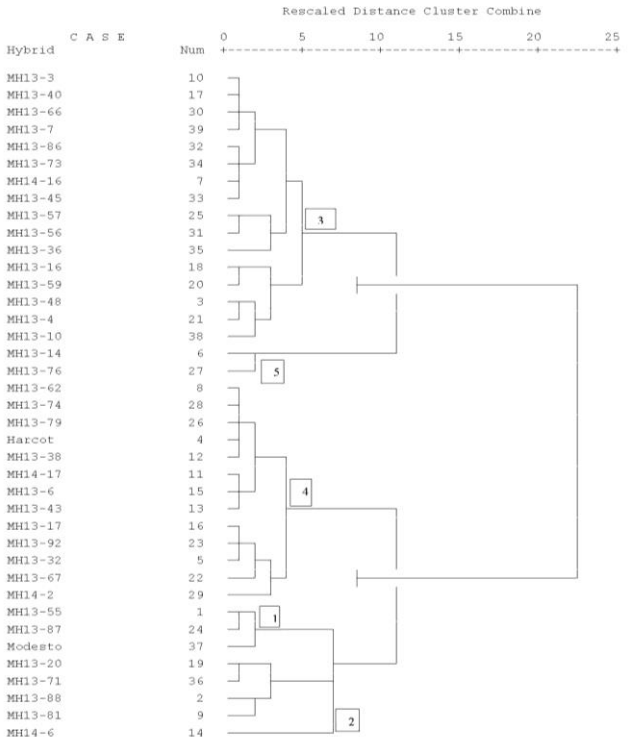

Figure 3. *Dendogram of hierarchical cluster analyses made for the biometry data from 2015, using average linkage (Between Groups).*

(MH13-3 to MH13-10) and 5 (MH13-14 and MH13-76) include respectively 16 and 2 number of hybrids. The data for their biometry show that they had smaller fruits. In the 4th cluster are the hybrids that had close to 'Harcot's' biometry

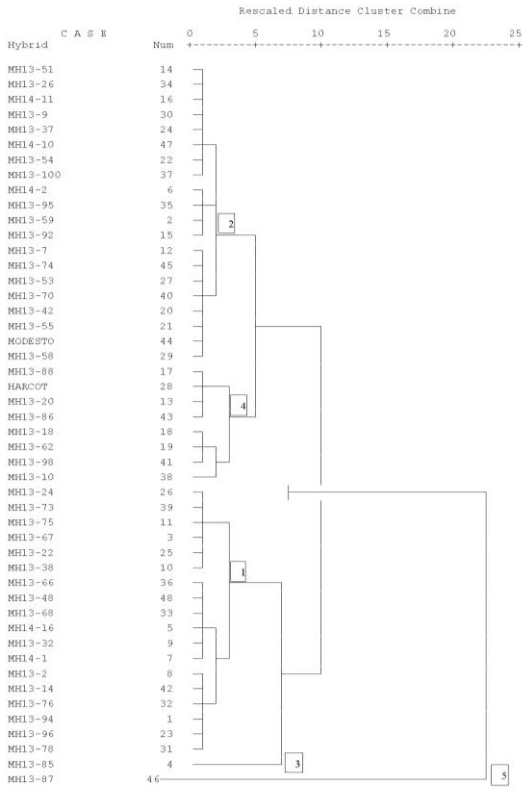

Figure 4. *Dendogram of hierarchical cluster analyses made for the biometry data from 2016, using average linkage (Between Groups).*

(MH13-62 to MH14-2). They are 12 in number. According to the hierarchical cluster analysis of the biometric data from 2016 (Figure 4), 19 hybrids have close to 'Modesto's' data (MH13-51 to MH13-58). Seven hybrids (MH13-88 to MH13-10) in 4th cluster are like 'Harcot'. In cluster 1 (MH13-24 to MH13-78) and 3 (MH13-85) are combined hybrids with smaller fruits. In cluster number 5 there is one hybrid that is quite different from the other hybrids and both parent cultivars.

Discussion

According to the data, the fruit ripening period of the investigated hybrids of crossbreed 'Modesto' x 'Harcot' was inherited intermediately. Fruit weight is a variable trait and the hybrids were grouped in 7 categories. Just 3 of the hybrids had very large fruits. This is much desired property of fruits for fresh consumption. For processing the best are medium sized fruits. The biggest number of the progenies belonged to the groups of small/medium and medium size. The fruit shape was preliminary closer to the father cultivar 'Harcot' while the fruit ground color was closer to the mother cultivar 'Modesto'.

The shape of the fruits is not so valuable trait while the orange and red color of the fruits is important both for traders and consumers. In conclusion it can be said that the crossbreed 'Modesto' x 'Harcot' is promising for breeding programs.

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