AGRICULTURAL ACADEMY
FRUIT GROWING INSTITUTE

„ Inheritance of traits determining biological and agricultural characteristics in three apricot hybrid families“

EXTENDED ABSRACT

Of PhD Thesis for awarding educational and scientific degree “Doctor”

Professional field 6.1 – Crop Science
Scientific specialty – 04.01.05 – Plant Breeding and Seed Production

PhD student: Marieta Kostadinova Nesheva

PhD Mentor: Prof. Valentina Bozhkova, PhD

Plovdiv, 2019

The research was conducted during the period 2015-2018 in a breeding orchard at the Fruit Growing Institute – Plovdiv, Bulgaria. The study is focused on 299 hybrids from three hybrid families - ‘Harlayne’ x ‘Harcot’ (153), ‘Modesto’ x ‘Harcot’ (114) and ‘Lito’ x ‘Silistrenska ranna’ (32).

The dissertation is written on 139 pages and contains 70 figures, 36 tables and 30 photographs. The cited literature includes 207 sources, of which 13 are in Cyrillic and 194 are in Latin.

The public defense of the dissertation will be held on 30.10.2019, at 10:00 o’clock in the conference hall in Fruit Growing Institute on a meeting of the Specialized Scientific Jury appointed by Order № РД-05-161/09.08.2019

1. INTRODUCTION

The interest in apricot in Bulgaria is high, as well as in most countries of the temperate and subtropical climate zones. It is caused by the fact that the fruits have excellent taste, specific aroma and high nutrition value, which ensures their unlimited market as fresh and processed fruits. The fruit breeding is a much slower process compared to the breeding of other plant species. That is why determining the goals and the proper genitors for achieving them are crucial. The breeding programs nowadays are built on genetic diversity created through planned crosses between carefully selected parents. A comprehensive study of hybrid populations makes it possible to determine the genetic potential of the different parental combinations. Part of the selected hybrids may be included in the next stage of the breeding process. Pyramiding of valuable genes is a long process, but only it can lead to new and better cultivars.

The Fruit Growing Institute has launched its apricot breeding program in 2008. A rich hybrid fund was created and afterwards selected using modern technologies (genetic markers) used in the fruit breeding. This allowed us through this dissertation to carry out a detailed hybridological analysis, to identify the ways of inheritance of some monitored traits, to evaluate the hybrid potential of the three parental combinations, and to select which hybrids to continue in the next stage of the breeding process.

2. OBJECTIVE AND TASKS OF THE RESEARCH

The main objective of the dissertation was to trace the inheritance of traits defining biological and agricultural qualities in apricot hybrids originating from three hybrid families - ‘Lito’ x ‘Silistrenska ranna’, ‘Modesto’ x ‘Harcot’, ‘Harlayne’ x ‘Harcot’. An aim of this study was also to determine the variation of all traits in the years and in the different hybrid populations, to determine the level of segregation of their phenotypic expression in the progeny. At the same time, it was intended to evaluate the hybrids and to select the ones combining most valuable traits for continuing in the next stage of the breeding process.

For achieving the objectives, the following tasks were formulated:

- ✓ To determine the flowering time and flower biology and to study the influence of some abiotic factors on “flowering” phenophase;
- ✓ To establish the ripening time and productivity of the hybrids;
- ✓ To determine the fruit quality of each hybrid;
- ✓ To study the growth characteristics of the trees and pomological leaf traits;
- ✓ To study the hybrids reaction to *Plum pox virus* and *Monilinia laxa*, by regular observations for symptoms.

3. MATERIALS AND METHODS

All researches were conducted in the period 2015-2018 in a breeding orchard at the Fruit Growing Institute in Plovdiv, Bulgaria. The study is focused on 299 hybrids from three hybrid families - ‘Harlayne’ x ‘Harcot’ (153), ‘Modesto’ x ‘Harcot’ (114) and ‘Lito’ x ‘Silistrenska ranna’ (32). The seedlings were planted in 2011 at between row spacing of 4 m and in-row

spacing of 1 m. All observed traits of the hybrids were compared with those of the parental cultivars ‘Harlayne’, ‘Harcot’, ‘Modesto’, ‘Lito’ and ‘Silistrenska ranna’, which were grown in a collection orchard of the institute.

Using standard methods and techniques the following characteristics were investigated:

1. Flowering – time and flowering abundance;
2. Flower morphology – petals shape and color;
3. Fruits – ripening time, biometrical analysis, shape, skin ground color, depth of suture, fruit flesh color. The listed traits were determined on an average sample of 25 fruits, randomized taken from each hybrid and parental cultivar. Total soluble solids content was measured. Sensory evaluation of the fruits of each hybrid and parental cultivar was done. The distribution of the basic number of fruits on different parts of the skeletal branch and the productivity of the hybrids were visually determined;
4. Stones – shape, surface and biometrical analysis of the stones from all fruits, and kernel taste;
5. Leaves – size, shape and leaf area – determined on an average sample of 15 leaves of each hybrid, taken from the middle part of the young shoots;
6. Growth habit characteristics – angle of growth of the skeletal branches and their secondary branches, internodes length were measured. The crown shape, young shoots position, length, thickness and coloration were visually determined;
7. Reaction of the hybrids to phytopathogenes – by regular observations were recorded the hybrids showing symptoms “blossom blight” and the specific *Plum pox virus* symptoms.

The obtained data from all observations and analysis were processed using the statistical software IBM SPSS Statistics 19 and Analysis ToolPak in MS Excel. One-way ANOVA was performed using Duncan's Multiple Range Test (MRT) and Cluster Analysis by Hierarchical Cluster Analysis; Average Linkage (Between Groups). For graphical illustration of the frequency distribution of hybrids traits were used histograms.

4. RESULTS AND DISCUSSION

FLOWER MORPHOLOGY

As a key component of the flowers, petals play an important role in attracting bees and ensuring successful pollination. In the observed hybrid population ‘Lito’ x ‘Silistrenska ranna’, both parental cultivars have light pink colored petals. In their progeny this trait segregates and hybrids with white petals were observed (Fig. 1). In the progeny of a cultivar with white-colored petals, such as ‘Modesto’, and dark-colored, such as ‘Harcot’, the hybrids with intermediate petals coloration were dominant - light pink colors (Fig. 2). The same trend was observed in the third hybrid family - ‘Harlayne’ x ‘Harcot’ (Fig. 3). This type of segregation is characteristic for incomplete dominance between the alleles. Concerning the shape in the three hybrid populations most hybrids had round petals, and the most rear was the broad elliptic shape. There is a slight variation in the ratio of the phenotypic expression both traits over the years, most likely due to environmental conditions.

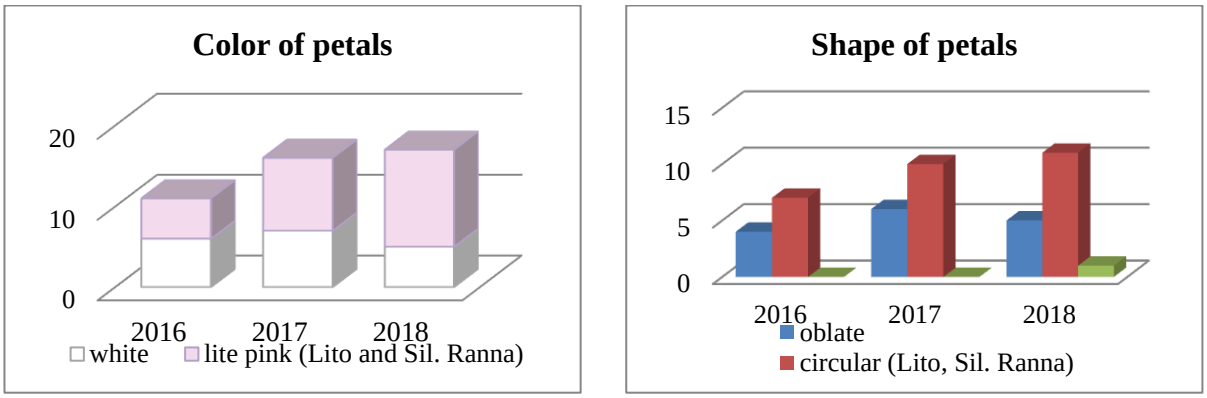


Figure 1. Color and shape of the petals of 'Lito' x 'Sil. ranna' hybrid family

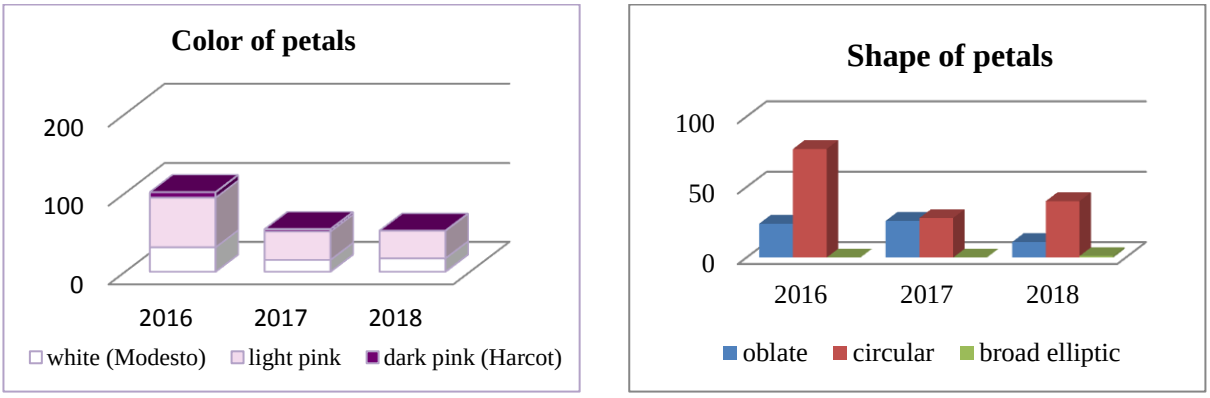


Figure 2. Color and shape of the petals of 'Modesto' x 'Harcot' hybrid family

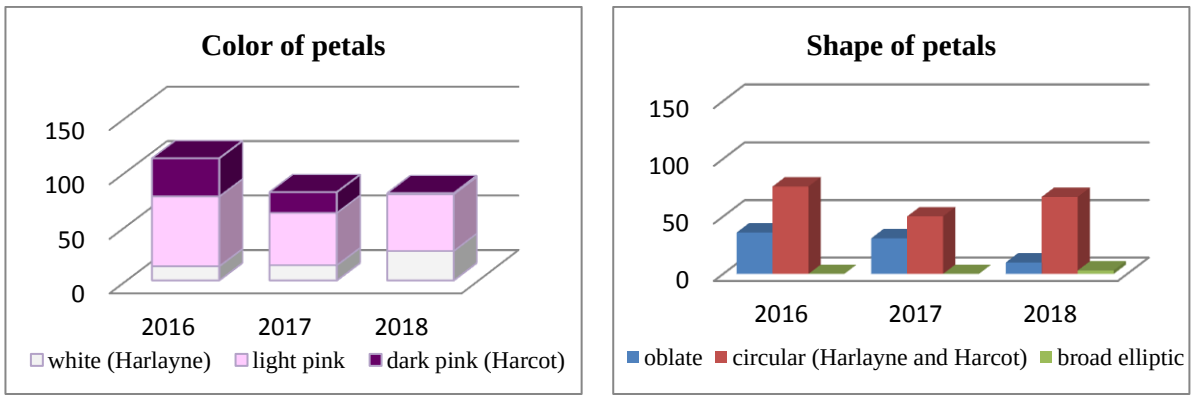


Figure 3. Color and shape of the petals of 'Harlayne' x 'Harcot' hybrid family

FLOWERING

Flowering time

The flowering time of the apricots is one of the most important agronomic features, as it determines the vulnerability to late frost damages. Because of the spring frosts danger, for our country, the late flowering cultivars are preferred by producers and breeders. The results of our study confirm the dominance of the later flowering period.

In 2016 the flowering phenophase, for all genotypes started earlier compared to the other two years. This was due to the sharp increase of the temperatures in February. In 2017 the coldest was January (-3,9 ^{o}C), and the warming up in February was smooth without atypically

high temperatures. In this year the flowering phenophase started on March 22nd. The temperatures during the flowering period were high and it ran "explosively". The duration of the "full flowering" phase was 5 days for ‘Lito’ x ‘Silistrenska ranna’ and ‘Modesto’ x ‘Harcot’ and 6 for ‘Harlayne’ x ‘Harcot’. January 2018 could be characterized with temperatures close to the norm. The increase of the temperatures in February was smooth and the flowering phenophase started on 15th of March. During the flowering period the agro climatic conditions were unfavorable – low temperatures and snow in the third decade of March. This was and the reason for the prolonged phenophase.

FRUITS

Ripening time

During the three years of the study, the fruits of the parental cultivar ‘Silistrenska ranna’ ripened in the first days of June. This is an extremely valuable quality because at that time ripen the fruits of only few cultivars (‘Ninfa’ and ‘Aurora’) and the demand for apricot fruits is high. The fruits of the other parental cultivar, ‘Lito’, were the last that ripened – in the last decade of July. All progenies had intermediate ripening time and mature in the days between both cultivars. In the other two hybrid families, in 2015 the generation was dominated by the intermediate manifestation of the trait, while in 2016 and 2017, with the increase in the number of hybrids that bare fruits, its strong segregation was observed. In the progeny were observed a large number earlier and later ripening hybrids compared to the parental cultivars. In these two hybrid families ‘Harcot’ ripenes earlier than the cultivars used as a mother plants - ‘Modesto’ and ‘Harlayne’. Both ripen at almost the same time in the tree years of observations, but in the two hybrid families a different level of segregation of this trait was observed. For ‘Modesto’ x ‘Harcot’ the greatest number of hybrids had earlier ripening period, while for ‘Harlayne’ x ‘Harcot’ the hybrids with later ripening period that both parental cultivars were the most. In both cases the greatest was the number of hybrids that ripen after ‘Harcot’. This shows us that the later ripening period of ‘Modesto’ and ‘Harlayne’ is dominant trait. For the ‘Harlayne’ x ‘Harcot’ parental combination the possibility for obtaining a late ripening genotype is higher.

Biometrical analysis

The size is one of the most important quality characteristic for fruits intended for fresh consumption. Its main indicator is the fruit weight. The IBPGR descriptor divides the apricot fruits into 9 categories according to their weight.

In the three different years of the study, the fruits of ‘Silistrenska ranna’ were very small to small. The fruits of the other parental cultivar ‘Lito’ were medium to large. The fruits obtained from this hybrid family were classified as very small and small to medium-sized (table 1). In the ‘Modesto’ x ‘Harcot’ and ‘Harlayne’ x ‘Harcot’ hybrid families, the small to medium-sized fruits, with an average weight from 30 to 55 g, predominate over the three years of the study (tables 2 and 3). The fruits of many well-known cultivars could also be classified as small or medium in size with an average weight of up to 50-55 g, and exactly this medium sized fruits with attractive appearance are the most preferred in the apricot breeding. In the hybrid families ‘Modesto’ x ‘Harcot’ and ‘Harlayne’ x ‘Harcot’ were observed and a

large number of hybrids which fruits were classified as medium-sized with an average weight from 46 to 55 g. There was no significant difference between the two hybrid populations in the percentage of fruits with attractive size. For the parental combination ‘Modesto’ x ‘Harcot’ there were more hybrids which outperform both parents with large and very large fruits.

Table 1. Classification of the fruits obtained from ‘Lito’ x ‘Silistrenska ranna’ hybrid family by their average weight

Fruit weight /g/	Fruit category according IBPGR descriptor	Number of hybrids in 2015	Number of hybrids in 2016	Number of hybrids in 2017
Up to 20 g	Extremely small	1	0	
20 - 30	Very small	‘Sil. ranna’ + 2.	0	5
31 - 40	Small	1	‘Sil. ranna’ + 4	‘Sil. ranna’ + 3
41 - 45	Small/Medium	0	1	2
46 - 55	Medium	‘Lito’	‘Lito’	‘Lito’ +1
56 - 60	Medium/Large	0	0	0
61 - 70	Large	0	0	0
71 - 85	Very large	0	0	0
More than 85 g	Extremely large	0	0	0

Table 2. Classification of the fruits obtained from ‘Modesto’ x ‘Harcot’ hybrid family by their average weight

Fruit weight /g/	Fruit category according IBPGR descriptor	Number of hybrids in 2015	Number of hybrids in 2016	Number of hybrids in 2017
Up to 20 g	Extremely small	0	0	2
20 - 30	Very small	2	1	6
31 - 40	Small	12	5	12 + ‘Modesto’
41 - 45	Small/Medium	7+’Harcot’	9	8
46 - 55	Medium	9	15	10
56 - 60	Medium/Large	2+’Modesto’	7+’Modesto’	6+’Harcot’
61 - 70	Large	4	6+’Harcot’	3
71 - 85	Very large	1	3	3
More than 85 g	Extremely large	0	0	0

Table 3. Classification of the fruits obtained from ‘Harlayne’ x ‘Harcot’ hybrid family by their average weight

Fruit weight /g/	Fruit category according IBPGR descriptor	Number of hybrids in 2015	Брой хибриди 2016 г	Брой хибриди 2017 г
Up to 20 g	Extremely small		0	2
20 - 30	Very small	1	0	13
31 - 40	Small	14+’Harlayne’	16	27
41 - 45	Small/Medium	11	10+’Harlayne’	13
46 - 55	Medium	15+’Harcot’	17	12+’Harlayne’
56 - 60	Medium/Large	2	4	5+’Harcot’
61 - 70	Large	0	3+’Harcot’	0
71 - 85	Very large	1 (HH12-42)	0	0
More than 85 g	Extremely large	0	0	0

Total soluble solids content

The total soluble solids content in the fruits obtained from all hybrid families varied over the three years of the experiment (Figure 4). The average total soluble solids content in the fruits of the hybrid progeny ‘Lito’ x ‘Silistrenska ranna’ in 2015 was 17,430, in 2016 - 17,770 and in 2017 - 15,520 Brix. The average for the ‘Modesto’ x ‘Harcot’ hybrid family was as it follows: 2015-17,930, 2016-18,10 and 2017-17,240. For ‘Harlayne’ x ‘Harcot’, the average total soluble solids content for the whole progeny in 2015 was 19,90, 2016 - 18,61 and in 2017 - 18,21. A large number of hybrids from the studied hybrid families outperform both parental cultivars by this indicator.

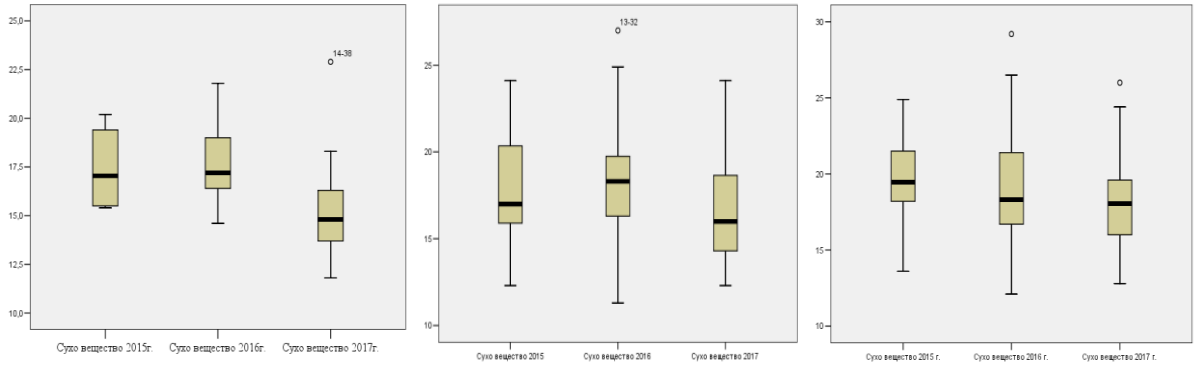


Figure 4. Total soluble solids content for the three hybrid families – left – ‘Lito’ x ‘Sil. ranna’, in the middle – ‘Modesto’ x ‘Harcot’, right – ‘Harlayne’ x ‘Harcot’

Using Duncan's multiple range test, the fruits obtained from the hybrids fruits were analyzed. In the three hybrid populations observed, the groups gradually overflow into each other and hybrids resembling the parental cultivars and genotypes having intermediate values of the traits were observed. According to the biometric data, a tendency that the fruit were smaller in the progeny was observed. However, some of the hybrids of ‘Modesto’ x ‘Harcot’ and ‘Harlayne’ x ‘Harcot’ outperform the parental cultivars by some biometric indicators, but in both crosses, their difference with ‘Harcot’ was not statistically proven. The results presented in Tables 7, 8 and 9 clearly show that the high total soluble solids content is inherited with a higher frequency, therefore, in the hybrid generations studied, almost all hybrids outperform one or both cultivars used as parents.

Table 7. Biometric data analysis of the fruits from ‘Lito’ x ‘Silistrenska ranna’ hybrid family

Hybrid №	Fruit height (mm)	Fruit width (mm)	Fruit thickness (mm)	Fruit average weight (g)	TSS (Brix ^{o})
LS 14-38	35,52 c	34,88 b	36,19 b	29,15 b	20,50 a
‘Sil. ranna’	37,59 bc	36,58 b	38,45 b	31,62 b	15,70 a
LS 14-18	38,68 b	37,23 b	38,93 b	31,79 b	17,93 a
‘Lito’	44,22 a	44,37 a	46,10 a	53,53 a	20,50 a

* Mean values followed by different letters in one column show a statistically proven difference ($p < 0.05$)

Table 8. Biometric data analysis of the fruits from ‘Modesto’ x ‘Harcot’ hybrid family

Hybrid №	Fruit height (mm)	Fruit width (mm)	Fruit thickness (mm)	Fruit average weight (g)	TSS (Brix ^{o})
MH13-76	38,98 g	36 c	38,03 d	31,04 f	17,93 bc
MH13-14	41,02 fg	36,31 c	38,53 d	33,22 ef	19 abc
MH13-73	42,40 efg	38,01 bc	40,87 bcd	40,01 cdef	19,93 abc
‘Modesto’	42,92 defg	41,34abc	44,59 abcd	48,90 abcdef	15,43 c
MH14-16	43,26 defg	36,56 c	41,03 bcd	37,31 def	15,4 c
MH13-38	43,46 defg	38,90 bc	41,49 bcd	44,15 abcdef	16,4 bc
MH13-32	44,08 cdefg	39,23 bc	43,29 abcd	44,30 abcdef	23,47a
MH13-10	45,31 bcdef	43,74 ab	46,50 abc	60,38 abc	19,23 abc
MH13-66	45,51 bcdef	37,92 bc	41,71 bcd	42,04 bcdef	21,03 ab
MH13-55	46,1 abcdef	44,87 ab	49,17 a	57,98 abcd	15,96 bc
MH13-74	46,79 abcde	41,68 abc	43,95 abcd	49,32 abcdef	19,57 abc
MH13-62	48,03 abcde	44,04 ab	47,22 abc	52,89 abcde	15,5 c
MH14-2	48,51 abcd	39,08 bc	42,09 abcd	45,32 abcdef	17,5 bc
MH13-7	49,47 abc	42,76 abc	46,86 abc	57 abcd	15,07 c
‘Harcot’	49,82 ab	44,12 ab	46,58 abc	58,44 abcd	17,37 bc
MH13-87	50,62 ab	47,32 a	48,22 ab	64,46 a	17,63 bc
MH13-88	51,48 a	45,03 ab	48,18 abc	61,69 ab	18,5 abc
MH13-20	51,68 a	42,45 abc	47,23 abc	56,86 abcd	18,2 bc

* Mean values followed by different letters in one column show a statistically proven difference ($p < 0.05$)

Table 9. Biometric data analysis of the fruits from ‘Harlayne’ x ‘Harcot’ hybrid family

Hybrid №	Fruit height (mm)	Fruit width (mm))	Fruit thickness (mm)	Fruit average weight (g)	TSS (Brix ^{o})
HH12-59	38,46f	38,40bcdef	39,60ef	37,30cd	18,67abcd
HH13-14	38,58f	37,39def	39,72ef	34,60cd	19,97abcd
HH12-60	38,80f	34,86f	39,49ef	30,22d	20,97abc
HH12-22	38,99ef	34,96ef	38,34f	32,73cd	21,9a
HH13-4	41,06def	34,54f	38,58ef	32,64cd	19,83abcd
HH13-43	41,13def	37,98cdef	39,51ef	35,53cd	18,6abcd
HH13-15	41,24def	38,44bcdef	40,88def	36,45cd	21abc
HH13-54	43,26cdef	37,93cdef	43,64abcdef	41,89bcd	21,47ab
HH12-41	43,45cdef	36,55def	40,31def	36,14cd	16,77abcd
‘Harlayne’	43,57cdef	39,72abcdef	43,30abcdef	43,29bcd	16,47bcd
HH12-62	44,56bcdef	38,77bcdef	42,50bcdef	42,12bcd	15,8cd
HH13-3	45,03bcdef	41,39abcdef	45,36abcde	48,43abc	20,07abcd
HH12-63	45,74bcde	40,97abcdef	45,34abcde	47,27abcd	18,8abcd
HH12-67	47,49abcd	39,60abcdef	45,36abcde	46,49abcd	19,83abcd
HH12-19	48,08abc	44,46ab	49,83a	59,02ab	20abcd
HH12-9	49,63abc	38,84bcdef	42,02cdef	44,40bcd	18,33abcd
‘Harcot’	49,83abc	44,12abc	46,58abcd	58,44ab	17,37abcd
HH12-42	50,65ab	45,74a	49,08ab	63,09a	15,5d
HH12-26	52,80a	41,63abcd	47,72abc	55,87ab	18,2abcd

* Mean values followed by different letters in one column show a statistically proven difference ($p < 0.05$

Pomological fruit characteristics

As the biometric data showed, after the visual determination of the fruit shapes of the 'Lito' x 'Silistrenska ranna' progeny, it could be said that all fruits in the hybrid family have very similar shapes (Table 10). In our case, both parental cultivars have round-shaped fruits, and this type in lateral view does not segregate in the progeny and is the only one observed. In ventral view, the fruits were oval or rounded, with the rounded shape being predominant again. In the visual determination of the ventral shape of the fruits, from the parental combinations of 'Modesto' x 'Harcot' and 'Harlayne' x 'Harcot', the ovate shape inherited from 'Harcot' (Table 11 and 12) is clearly dominant during the three years of the research. A large number of hybrids from this two hybrid populations had round shaped fruits in lateral view. The depth of fruit suture trait segregates in the progeny and a slight variation in the years was observed. Most likely, this trait is influenced by some abiotic factors, e.g. rainfall during the period of forming the young fruits. Due to the fact that the seedlings are still young trees it is not correct to define conclusions about their fruit bearing habit. Their first fruits were in the middle part of the crown, but in the third year of observations for part of the hybrids most of the fruits were in the periphery of the crown.

Table 10. Description of fruit shape and their distribution in the tree crown for 'Lito' x 'Silistrenska ranna' hybrid family

Trait	Year	Manifestation of the observed traits		
		ovate	*circular ('Lito' and 'Sil. ranna')*	
Fruit shape (lateral view)	2015	0 hybrids	4 hybrids	
	2016	0 hybrids	5 hybrids	
	2017	0 hybrids	11 hybrids	
		ovate	*circular ('Lito' and 'Sil. ranna')*	
Fruit shape (ventral view)	2015	2 hybrids	2 hybrids	
	2016	1 hybrids	4 hybrids	
	2017	3 hybrids	8 hybrids	
		Deeply sunken ('Lito')	*Moderately sunken ('Sil. ranna')*	*Slightly sunken*
Fruit suture	2015	0 hybrids	2 hybrids	2 hybrids
	2016	0 hybrids	4 hybrids	1 hybrids
	2017	1 hybrids	3 hybrids	7 hybrids
		In the periphery	*In the central part*	*Equally in all parts ('Lito' and 'Sil. ranna')*
Distribution of the fruits in the tree crown	2015	0 hybrids	4 hybrids	0 hybrids
	2016	0 hybrids	5 hybrids	0 hybrids
	2017	6 hybrids	5 hybrids	0 hybrids

Table 11. Description of fruit shape and their distribution in the tree crown for ‘Modesto’ x ‘Harcot’ hybrid family

Trait	Year	Manifestation of the observed traits		
		ovate (‘Harcot’)	*circular (‘Modesto’)*	
Fruit shape (lateral view)	2015 2016 2017	13 hybrids 17 hybrids 28 hybrids	24 hybrids 29 hybrids 22 hybrids	
		ovate (‘Harcot’)	*circular (‘Modesto’)*	
Fruit shape (ventral view)	2015 2016 2017	31 hybrids 36 hybrids 45 hybrids	6 hybrids 10 hybrids 5 hybrids	
		Deeply sunken	*Moderately sunken (‘Harcot’ and ‘Modesto’)*	*Slightly sunken*
Fruit suture	2015 2016 2017	1 hybrid 3 hybrids 4 hybrids	24 hybrids 37 hybrids 29 hybrids	12 бр. hybrids 6 бр. hybrids 17 бр. hybrids
		In the periphery (‘Modesto’)	*In the central part*	*Equally in all parts (‘Harcot’)*
Distribution of the fruits in the tree crown	2015 2016 2017	4 hybrids 6 hybrids 32 hybrids	33 hybrids 39 hybrids 2 hybrids	0 hybrids 1 hybrid 16 hybrids

Table 12. Description of fruit shape and their distribution in the tree crown for ‘Harlayne’ x ‘Harcot’ hybrid family

Trait	Year	Manifestation of the observed traits		
		ovate (‘Harcot’)	*circular (‘Harlayne’)*	*oblique rhombic*
Fruit shape (lateral view)	2015 2016 2017	9 hybrids 25 hybrids 39 hybrids	32 hybrids 24 hybrids 32 hybrids	3 hybrids 1 hybrid 1 hybrid
		ovate (‘Harlayne’ and ‘Harcot’)	*circular*	*elliptic*
Fruit shape (ventral view)	2015 2016 2017	29 hybrids 45 hybrids 67 hybrids	9 hybrids 5 hybrids 5 hybrids	6 hybrids 0 hybrids 0 hybrids
		Moderately sunken (‘Harcot’)	*Deeply sunken (‘Harlayne’)*	*Slightly sunken*
Fruit suture	2015 2016 2017	33 hybrids 41 hybrids 51 hybrids	9 hybrids 7 hybrids 17 hybrids	2 hybrids 2 hybrids 4 hybrids
		In the periphery	*In the central part*	*Equally in all parts (‘Harlayne’ and ‘Harcot’)*
Distribution of the fruits in the tree crown	2015	6 hybrids	36 hybrids	2 hybrids
	2016	2 hybrids	48 hybrids	0 hybrids
	2017	27 hybrids	2 hybrids	43 hybrids

The fruit color trait segregates in all three hybrid families, and the light skin ground color is inherited with a higher frequency in their progeny (Fig. 5). A very slight segregation in the inheritance of the fruit over color was observed and there were hybrids with pink and orange shades of it (Fig. 6). The intensive red blush is preferred by breeders and consumers and in the studied hybrids it was inherited with a higher frequency. For ‘Modesto’ x ‘Harcot’ and ‘Harlayne’ x ‘Harcot’ hybrid populations, the number of hybrids with intensive red over color covering up to 75% of the fruit surface was satisfactory (Fig. 7). Valuable for the breeding program were also the hybrids with over color covering 50% of the fruit surface. The solid flush over color is more attractive and it is inherited with the highest frequency in the progeny of ‘Harlayne’ and ‘Harcot’. In all hybrid populations over the three consecutive years, a difference in the intensity of red coloration was observed (Fig. 8). This is most likely due to the strong dependence of this trait on the environmental factors. The over color is determined by the anthocyanin content of the fruit, and it strongly depends on the intensity of sunlight and the temperature amplitudes.

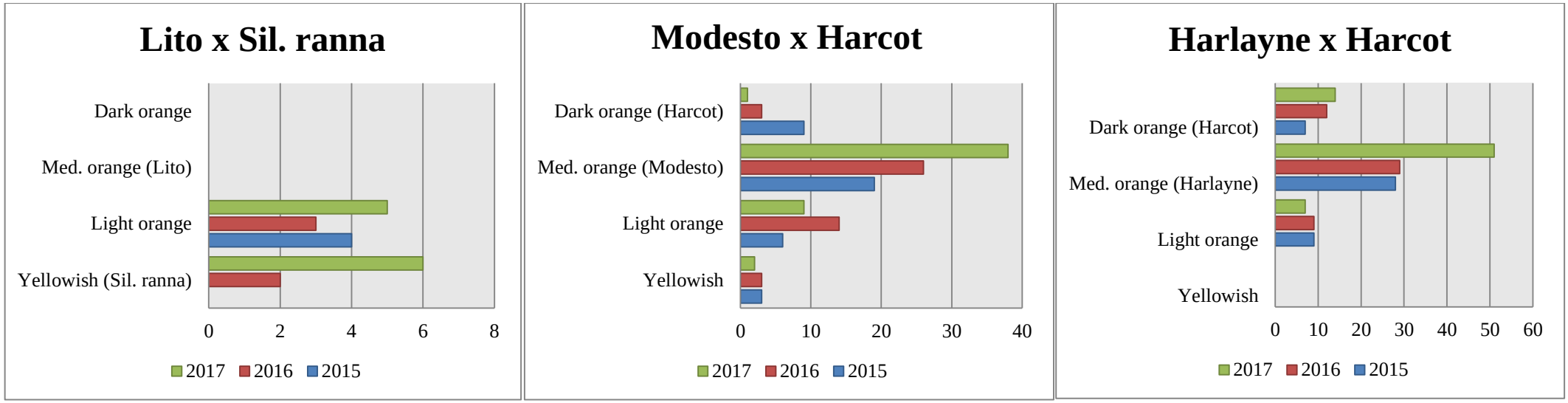


Figure 5. Fruit skin ground clor

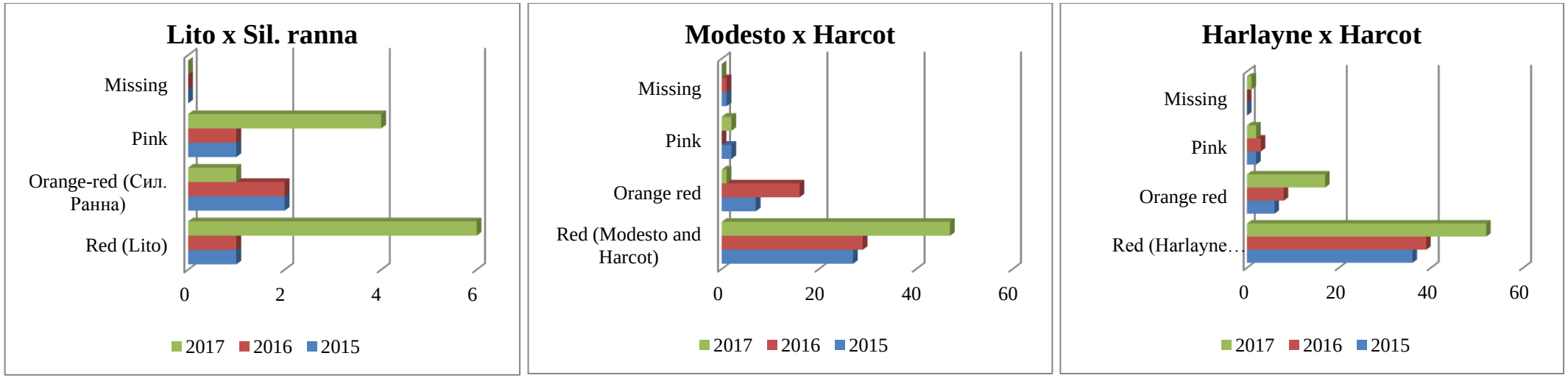


Figure 6. Hue of fruit over color

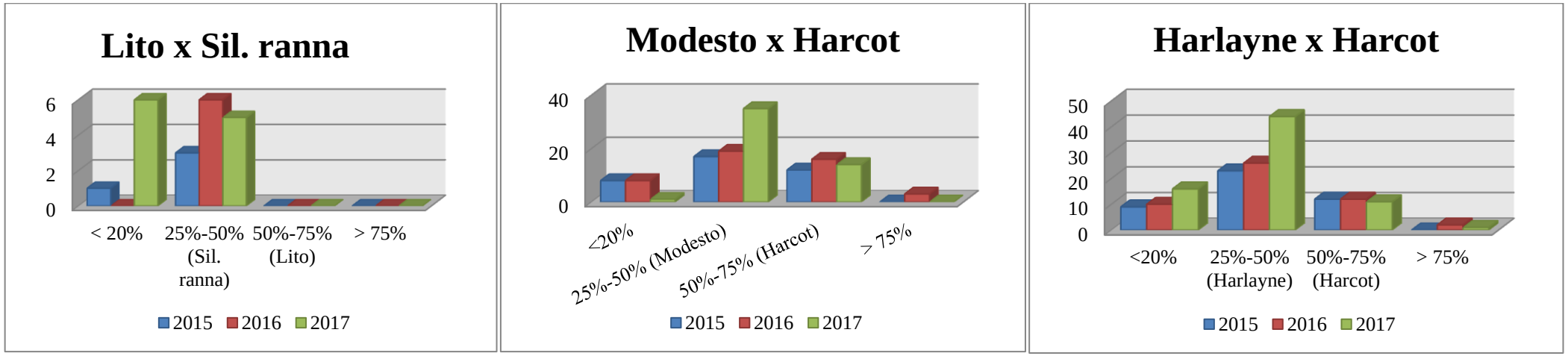


Figure 7. Relative area of the fruit over color

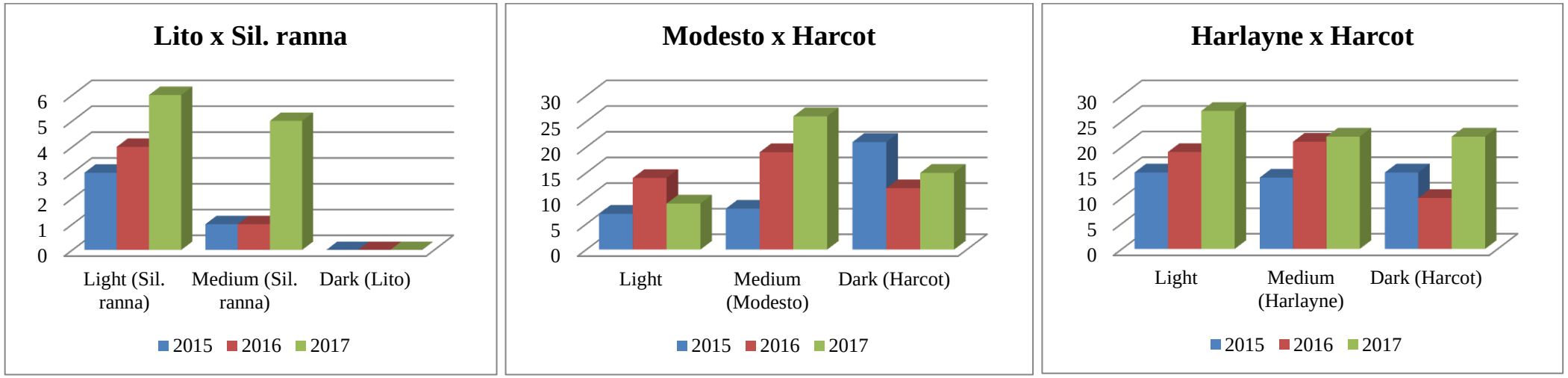


Figure 8. Intensity of fruit over color

Sensory evaluation

Good fruit taste is a goal in any breeding program. In 2016 and 2017, a total number of 33 degustations were held. The fruits obtained from the hybrids and the parental cultivars were evaluated by a group of trained consumers (Table 13). As a result of this study we can conclude that the good taste of the fruit dominates in the three studied hybrid families. In the progeny of 'Modesto' x 'Harcot' and 'Harlayne' x 'Harcot', although single, there were hybrids that outperform the parents with very good and excellent taste.

Table 13. Results from the sensory evaluation of the fruits

Total score		***'Lito' x 'Sil. ranna'***		***'Modesto' x 'Harcot'***		***'Harlayne' x 'Harcot'***	
		Number of hybrids 2016	**Number of hybrids 2017**	**Number of hybrids 2016**	**Number of hybrids 2017**	**Number of hybrids 2016**	**Number of hybrids 2017**
< 3	***Bad***	0	0	0	0	0	0
3-5	***Moderate***	0	3 hybrids	3 hybrids	6 hybrods	5 hybrids	8 hybrids
5-7	***Good***	'Lito', 'Sil. ranna' and 4 hybrids	'Sil. ranna' and 7 hybrids	'Harcot' and 39 hybrids	'Modesto', 'Harcot' and 37 hybrids	'Harlayne', 'Harcot' and 39 hybrids	'Harlayne', 'Harcot' and 56 hybrids
7-8	***Very good***	0	'Lito' and 1 hybrid	'Modesto' and 4 hybrids	5 hybrids	6 hybrids	4 hybrids
> 8	***Excellent***	0	0	0	1 hybrid (MH 13-2)	0	1 hybrid (HH 12-26)

STONES

Biometrical analysis

The stone size is strongly dependable on the fruit size. From the variation analysis of the biometric data on the stones obtained from the fruits of the three hybrid families, it could be said that the sizes of the stones are slightly variable in different years (Tables 14, 15 and 16). Relatively constant were the stone weight and the stone relative share. The very low variability of the stone characteristics makes them pomological valuable and that is why they are used for cultivars identification. The hybrid family 'Lito' x 'Silistrenska ranna' had the smallest stones with the smallest dimensional sizes and weight. As with the fruits, after the biometrical analysis of the stones, the groups gradually flow into each other. Single hybrids are similar to the one or the other parental cultivar according to different indicators.

Table 14. Biometric data analysis of the stones obtained from ‘Lito’ x ‘Silistrenska ranna’ hybrid family

Hybrid №	Stone height (mm)	Stone width (mm)	Stone thickness (mm)	Stone average weight (g)	Stone relative share (%)
LS 14-38	21,30 b*	10,75 c	17,06 b	1,98 b	6,83 a
‘Sil. ranna’	21,34 b	11,53 bc	18,11 b	1,80 b	5,63 a
LS 14-18	21,53 b	12,29 ab	18,77 ab	2,08 b	6,53 a
‘Lito’	25,80 a	12,81 a	20,67 a	2,94 a	5,51 a

* Mean values followed by different letters in one column show a statistically proven difference ($p < 0.05$)

Table 15. Biometric data analysis of the stones obtained from ‘Modesto’ x ‘Harcot’ hybrid family

Hybrid №	Stone height (mm)	Stone width (mm)	Stone thickness (mm)	Stone average weight (g)	Stone relative share (%)
MH 13-38	23,95 f	11,80 bcde	18,11 cdef	2,20 d	5,02 b
MH 13-76	23,99 f	12,71 abc	17,02 f	2,22 d	7,41 a
‘Modesto’	25,06 ef	12,17 abcd	20,05 abcde	2,83 bcd	5,95 ab
MH 13-55	25,22 def	12,70 abc	21,13 a	3,19 abc	5,48 ab
MH 13-32	25,26 def	11,82 bcde	20,44 abc	2,65 bcd	5,96 ab
MH 14-16	25,44 def	11,52 cde	19,85 abcde	2,46 bcd	6,69 ab
MH 13-10	25,51 cdef	12,78 abc	18,93 abcdef	3,08 abcd	5,40 ab
MH 13-73	26,00 cdef	10,46 e	17,77 def	2,26 cd	5,65 ab
MH 13-62	26,79 bcdef	12,57 abc	20,07 abcde	3,11 abcd	6,22 ab
MH 13-66	26,81bcdef	11,78 bcde	17,65 ef	2,37 cd	5,64 ab
MH 13-14	26,93 bcde	11,66 cde	18,40 bcdef	2,54 bcd	7,47 a
‘Harcot’	27,33 abcde	12,69 abc	20,14 abcde	3,04 abcd	5,19 b
MH 13-7	27,52 abcde	11,76 bcde	20,89 ab	3,02 abcd	5,45 ab
MH 13-88	27,63 abcde	13,34 a	20,46 abc	3,12 abcd	5,05 b
MH 13-74	28,13 abcd	11,88 abcde	18,45 bcdef	2,76 bcd	5,84 ab
MH 13-20	28,44 abc	12,88 abc	20,34 abcd	3,30 ab	5,94 ab
MH 14-2	29,52 ab	10,89 de	18,13 cdef	2,74 bcd	6,13 ab
MH 13-87	30,18 a	13,25 ab	21,38 a	3,82 a	6,08 ab

* Mean values followed by different letters in one column show a statistically proven difference ($p < 0.05$)

Table 16. Biometric data analysis of the stones obtained from ‘Harlayne’ x ‘Harcot’ hybrid family

Hybrid №	Stone height (mm)	Stone width (mm)	Stone thickness (mm)	Stone average weight (g)	Stone relative share (%)
HH 13-14	22,70 h	10,91 e	17,56 f	2,07 e	6,04 bcd
HH 13-43	22,86 gh	11,16 de	18,48 def	2,27 de	6,37 abcd
HH 12-59	23,51 gh	12,42 bcd	17,95 ef	2,49 cde	7,14 abcd
HH 12-60	23,89 fgh	12,29 bcde	19,36 bcdef	2,63 cde	8,82 a
HH 12-22	23,90 fgh	12,16 cde	17,90 ef	2,53 cde	8,56 ab
HH 13-15	24,30 efgh	12,15 cde	18,16 ef	2,28 de	6,42 abcd
HH 13-3	24,64 defgh	12,54 abcd	20,96 abc	3,06 abcd	6,32 abcd
‘Harlayne’	25,45 cdefg	11,71 cde	19,20 cdef	2,67 cde	6,23 abcd
HH 13-54	26,24 bcdef	12,69 abc	21,21 abc	3,27 abc	8,10 abc
HH 12-62	26,66 abcde	12,34 bcd	19,26 bcdef	2,77 bcde	6,85 abcd
HH 12-63	26,76 abcde	12,25 cde	20,69 abcd	3,07 abcd	6,51 abcd
HH 12-67	26,78 abcde	11,50 cde	19,35 bcdef	2,80 bcde	6,04 bcd
HH 12-41	27,05 abcd	11,50 cde	19,28 bcdef	2,46 cde	7,30 abcd
HH 13-4	27,21 abcd	11,31 cde	19,32 bcdef	2,77 bcde	8,58 ab
‘Harcot’	27,33 abcd	12,70 abc	20,14 abcde	3,04 abcd	5,19 d
HH 12-19	27,45 abc	13,64 ab	22,14 a	3,87 a	6,55 abcd
HH 12-26	27,95 abc	11,22 de	19,94 abcde	2,90 bcde	5,23 d
HH 12-42	28,43 ab	13,77 a	21,53 ab	3,57 ab	5,59 cd
HH 12-9	29,09 a	11,53 cde	18,53 def	2,63 cde	6,04 bcd

* Mean values followed by different letters in one column show a statistically proven difference ($p < 0.05$)

Pomology characteristic

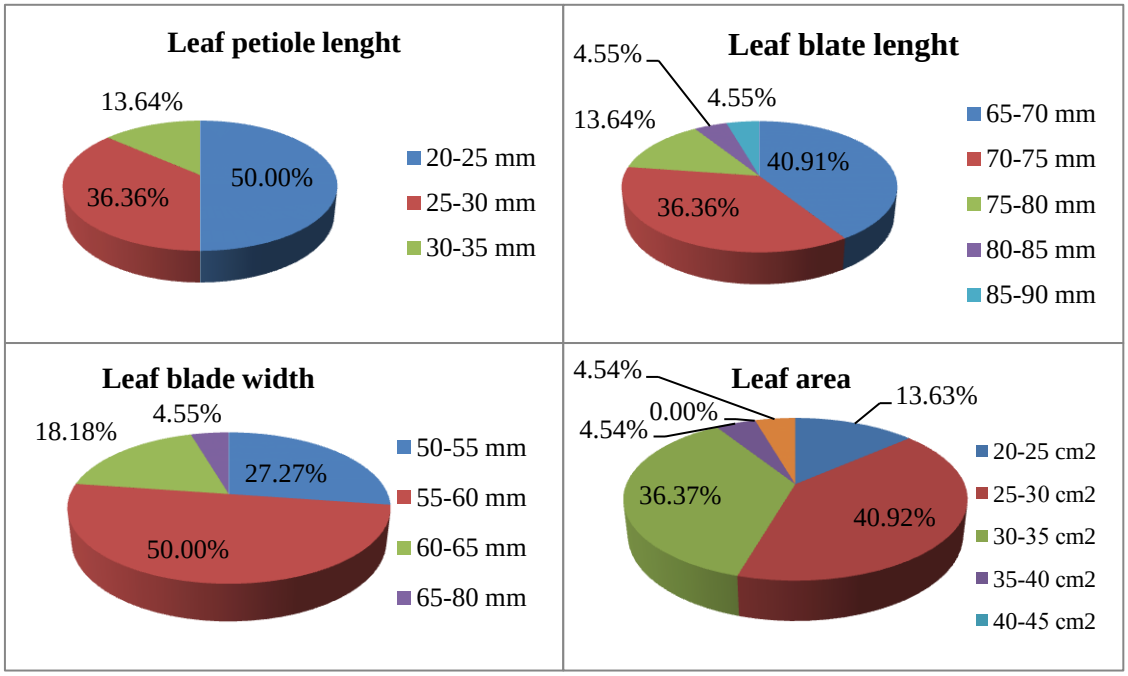
Stone shape is related to the fruit shape. In the ‘Lito’ x ‘Silistrenska ranna’ hybrid family most hybrids had circular fruit and stone shape. According to their shape the stones of the hybrids are entirely similar to Sillistrenska ranna. In ‘Modesto’ x ‘Harcot’ and ‘Harlayne’ x ‘Harcot’ hybrid families most hybrids had ovate stone shape. In the three hybrid populations most hybrids had furrowed stone surface. Only 2 hybrids from ‘Lito’ x ‘Silistrenska ranna’ and 1 from ‘Modesto’ x ‘Harcot’ hybrid families had medium adherence of stone to fruit flesh. This is an extremely undesirable trait in the apricot breeding. In 2017 for two of the studied hybrid families (‘Lito’ x ‘Silistrenska ranna’ and ‘Harlayne’ x ‘Harcot’) most frequent in the progeny was the bitter kernel taste. This was not in accordance with the statement that the sweet kernel taste is inherited monogenic and it is the dominating trait. Most likely, the kernel taste is determined by several genes and is not inherited monogenically.

LEAVES

Biometrical analysis

Leaf is an important plant organ associated with photosynthesis and transpiration. From the three hybrid families with the largest leaves in all parameters and in the three years was the progeny obtained from the cross of 'Harlayne' x 'Harcot'. The low values of standard deviation indicate poor segregation of the linear dimensions and leaf area of the leaves. In the three hybrid families variations in leaf size were observed in the hybrids and parental cultivars between the different years. This is probably due to the mixed influence of the factors of the environment and the age of the trees, so it is very difficult to see a trend and to draw conclusions about the ways of inheritance of the leaf sizes and area. After calculating the average data for the leaf size, the trends outlined in the data for the individual consecutive years were confirmed (Figs. 9, 10, 11). In the three hybrid families the leaf traits segregate and with a higher frequency in the progeny were the leaves with smaller sizes and area than the parental cultivars.

Figure 9. Percentage of the hybrids in the different intervals according to the mean values of their linear measurements and leaf area 2015-2017 for the hybrid family 'Lito' x 'Silistrenska ranna'



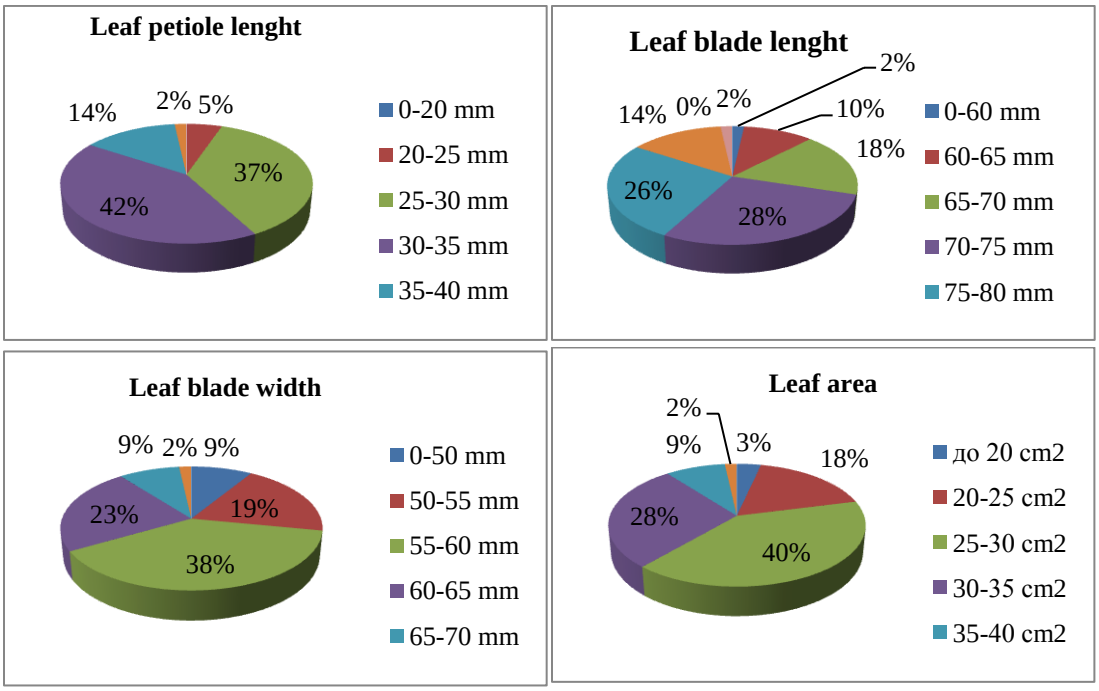


Figure 10. Percentage of the hybrids in the different intervals according to the mean values of their linear measurements and leaf area 2015-2017 for the hybrid family ‘Modesto’ x ‘Harcot’

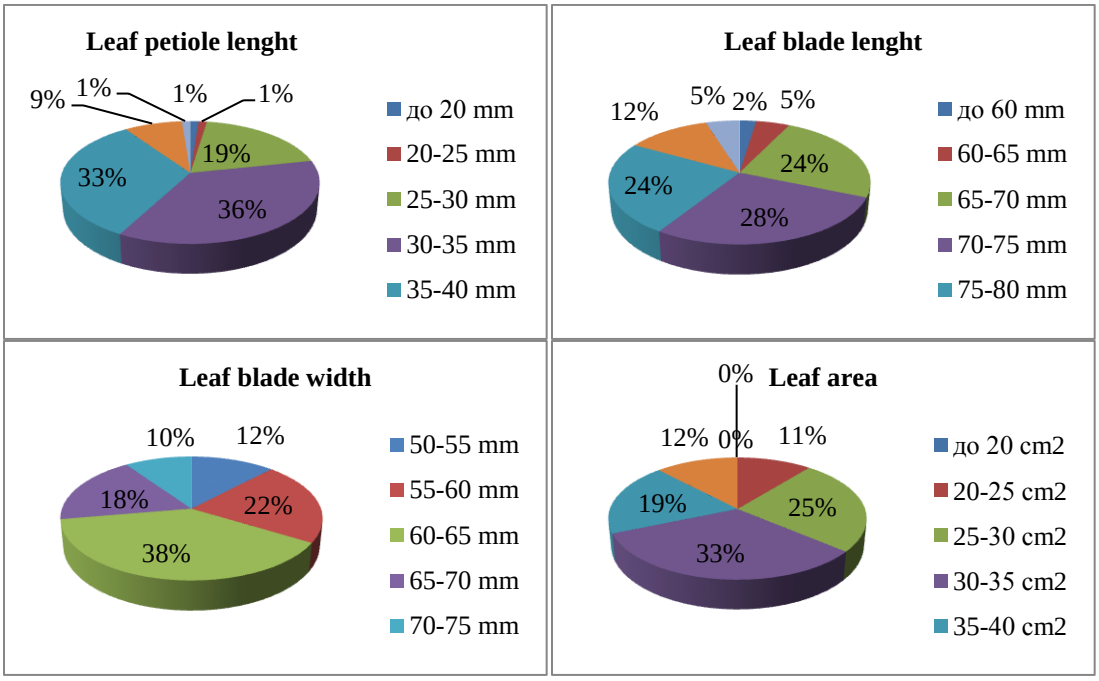


Figure 11. Percentage of the hybrids in the different intervals according to the mean values of their linear measurements and leaf area 2015-2017 for the hybrid family ‘Harlayne’ x ‘Harcot’

Leaf shape

The leaf shape is segregating in the three hybrid populations and genotypes with different leaf shapes, compared to the parental cultivars were observed. Leaf blade incisions of margins was two types – bicrenate and bisserate (picture 1), and the ratio between them in 'Lito' x 'Silistrenska ranna' and 'Harlayne' x 'Harcot' hybrid families was approximately 1:1. In 'Modesto' x 'Harcot' progeny the bisserate type of incisions of margins was dominating. With a higher frequency in the studied progeny was the moderately obtuse angle of apex. In 'Lito' x 'Silistrenska ranna' and 'Modesto' x 'Harcot' the largest number of hybrids had truncate leaf blade base and in 'Harlayne' x 'Harcot' the cordate shape of leaf base was dominating. In younger trees, the number of hybrids with pubescent leaves was greater (Picture 2). As the age of the hybrids increases the leaves got bigger, they get glabrous and the number of hybrids with pubescent leaves decreases in the next years. This is most likely a characteristic of the juvenile stage of the seedlings.

Picture 1. Leaf blade incisions of margins – left – bisserate and right– bicrenate

Picture 2. Leaf blade surface **-** left – pubescent; right – glabrous

TREE CHARACTERISTICS

Tree habit

Tree architecture is controlled by training systems that require a lot of effort and labor-intensive pruning operations. The reduced tree habit and small canopy make all agro-technical procedures easier and are objectives in the breeding programs of all fruit species. The hybrids in all three studied populations had vigorous growth which is typical for young trees. Most of the seedlings in 'Lito' x 'Silistrenska ranna' hybrid family had spreading tree habit (figure 12). The ratio between trees with upright to spreading and spreading habit in 'Modesto' x 'Harcot' and 'Harlayne' x 'Harcot' was approximately 1:1 (figure 13 and 14).

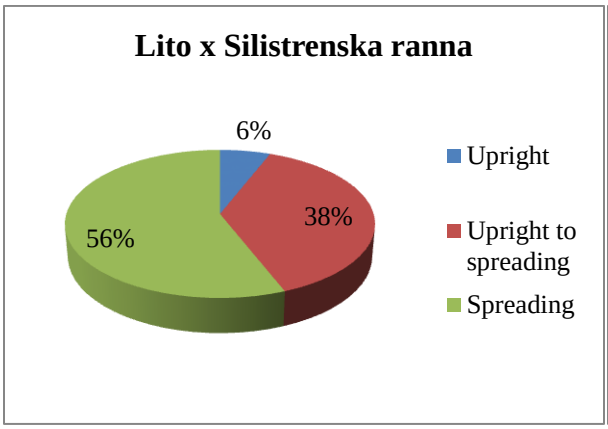


Figure 12. Distribution of the hybrids from 'Lito' x 'Silistrenska ranna' according the tree habit

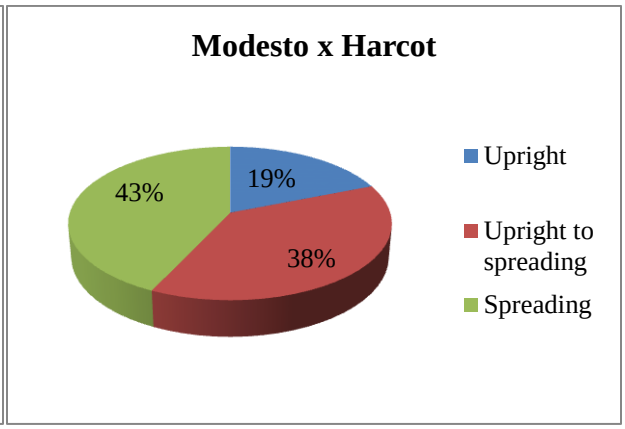


Figure 13. Distribution of the hybrids from 'Modesto' x 'Harcot' according the tree habit

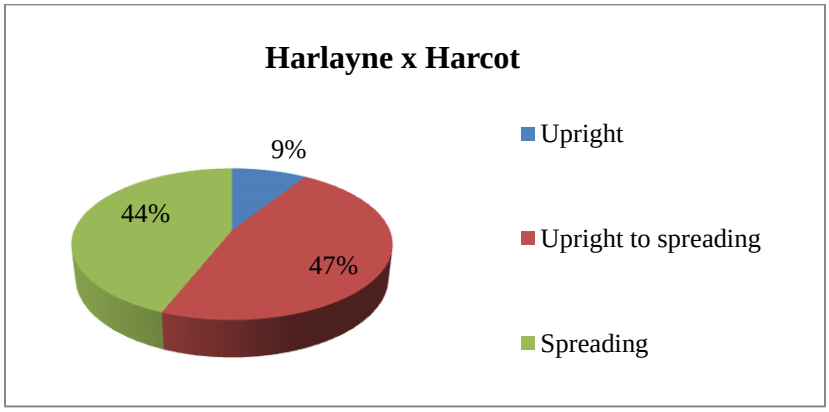


Figure 14. Distribution of the hybrids from 'Harlayne' x 'Harcot' according the tree habit

Angle of branching

The habit of trees depends on the angle of branching. The angle of branching of skeletal branches is segregating in the progeny of 'Lito' x 'Silistrenska ranna' in favor of the wider angle. The wide and spreading tree habit is the trait inherited with higher frequency. It shows that with this parental combination, the possibility of obtaining a genotype with the most desired angle of branching (45°) is relatively low. In the hybrid population of 'Modesto' and 'Harcot' the number of hybrids at which the skeletal branches and branches grow at a wider angle is greatest. In the third hybrid family prevalent was the smaller growth angle of the skeletal branches than that of the parental cultivars. After averaging the 2015-2017 data, we prove once again that, in terms of tree habit and angle of branching, the most promising is the 'Harlayne' x 'Harcot' parental combination.

Internode lenght

The reduced tree size makes all agro-technical operations and fruit harvesting much easier. In recent decades, genetic control of tree size has been an important goal in the fruit breeding programs. For breeding genotypes with naturally shorter internodes are extremely valuable in some fruit species, e.g. apples are widespread. In *P. armeniaca*, such forms are extremely rare.

Over the three consecutive years, the parental cultivar ‘Silistrenska ranna’ had longer internodes. In the progeny, single hybrids had similar internode length (table. 16). In the period of the study the number of hybrids with internodes shorter than ‘Lito’ was the highest. In the ‘Modesto’ x ‘Harcot’ hybrid family, the largest was the group of hybrids that resemble ‘Modesto’ with internode lengths between 1.5 and 1.75 cm. Also a large number of hybrids in this progeny had internodes with length between 1.75 and 2.25 cm. In this hybrid family the number of hybrids with shorter internodes than those of the parents was low (table 17). This was not the same with the third hybrid family. The largest was the group of hybrids resembling ‘Harcot’ with internodes of 1.75 to 2 cm in length, but the number of hybrids with shorter internodes (less than 1.75 cm) was also high (table 18).

Table 16. Distribution of the hybrids from ‘Lito’ x ‘Silistrenska ranna’ in different intervals according their internode length

Internode length (cm)	Number of hybrids in 2015	Number of hybrids in 2016	Number of hybrids in 2017
0-1	0	0	0
1-1,25	2	0	0
1,25-1,5	2	0	0
1,5-1,75	9	1	5
1,75-2	8	6	5
2-2,25	‘Lito’ and 5	‘Lito’ and 9	‘Lito’ and 7
2,25-2,5	‘Sil. ranna’ and 1	3	‘Sil. ranna’ and 5
2,5-2,75	0	‘Sil. ranna’ and 1	0
2,75-3	3	1	0
3-3,25	0	2	0

Table 17. Distribution of the hybrids from ‘Modesto’ x ‘Harcot’ in different intervals according their internode length

Internode length (cm)	Number of hybrids in 2015	Number of hybrids in 2016	Number of hybrids in 2017
0-1	0	0	0
1-1,25	4	1	0
1,25-1,5	19	4	8
1,5-1,75	30	‘Modesto’ and 20	‘Modesto’ and 25
1,75-2	‘Modesto’, ‘Harcot’ and 32	‘Harcot’ and 18	‘Harcot’ and 11
2-2,25	20	10	10
2,25-2,5	8	4	3
2,5-2,75	1	1	1
2,75-3	0	0	0
3-3,25	0	0	0

Table 18. Distribution of the hybrids from ‘Harlayne’ x ‘Harcot’ in different intervals according their internode length

Internode length (cm)	Number of hybrids in 2015	Number of hybrids in 2016	Number of hybrids in 2017
0-1	0	0	0
1-1,25	3	0	1
1,25-1,5	11	6	11
1,5-1,75	37	20	26
1,75-2	‘Harcot’ and 52	‘Harcot’ and 31	‘Harlayne’, ‘Harcot’ and 29
2-2,25	‘Harlayne’ and 33	‘Harlayne’ and 19	15
2,25-2,5	11	9	2
2,5-2,75	5	1	1
2,75-3	0	0	0
3-3,25	0	0	0

One-year-old shoots description

In the first two years of the study, the growth of the hybrids was more intense and the one-year-old shoots in the three families was long or medium-long. Next year, with the increased fruit production, the growth of the trees slowed down and in 2017 the largest was the group of hybrids with medium or short one-year-old shoots. There was not recorded a significant variation in the thickness of the shoots - in the three years more hybrids had medium thickness of their one-year-old shoots. Strong variation was observed in the coloration of the shoots. In 2017, when no large temperature amplitudes were observed during the winter months, 64% of the hybrids from the ‘Lito’ x ‘Silistrenska ranna’ hybrid family were with red brown coloration of the shoots and no purple brown was observed in any of the hybrids. The same trend was observed in the other two hybrid populations - the hybrids with purple brown colored shoots were decreasing in number when no large temperature amplitudes were observed. This indicates that this trait is highly variable under the influence of environmental conditions and especially temperature.

REACTION OF THE HYBRIDS TO SOME PHYTOPATHOGENS

Monilina spp.* and *Plum Pox Virus

Together with the other observations, in the period of this study, the hybrids showing symptoms of some of the most important phytopathogens for apricot were recorded. In the spring of 2015, a large number of hybrids showed blossom blight symptom, which is most likely caused by fungal phythopatogens from *Monilinia spp*. Figure 15 indicates that in the two years of observations in the hybrid family ‘Lito’ x ‘Silistrenska ranna’ was recorded the lowest number of hybrids showing blossom blight symptoms. In the Apricot Research Station in Silistra region the cultivar ‘Silistrenska ranna’ shows up as low susceptible to *Monilinia spp*., and the same was observed during this study in the region of Plovdiv. The most severely affected was the ‘Modesto’ x ‘Harcot’ hybrid population - with the highest number of hybrids showing blossom

blight symptoms. In 2017, due to unfavorable for this phytopathogen climatic conditions, only two of the hybrids showed symptoms in single branches (picture 3).

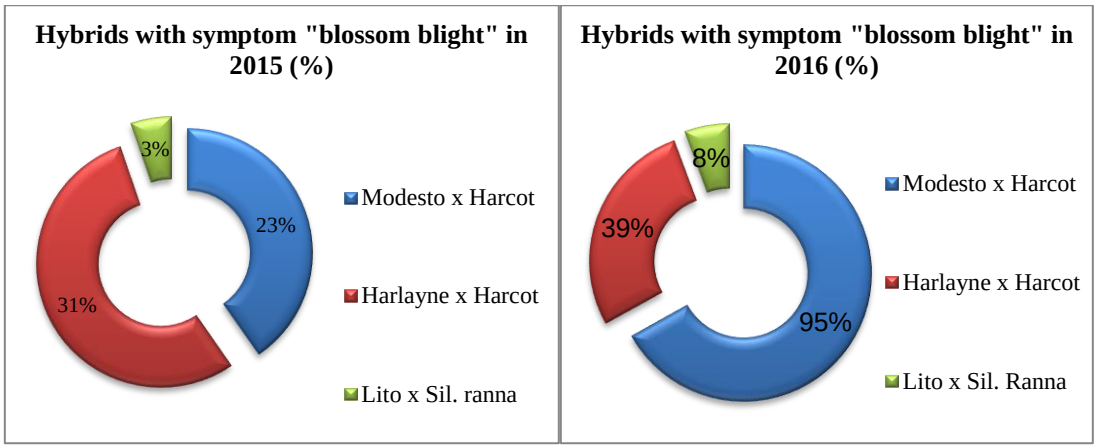


Figure 15. Relative share of the hybrids showing symptom "blossom blight" in 2015 and 2016

Picture 3. Single branch with symptoms (HH 13-56)

In the frame of the work on project MARS (7 WP- Project № 613654) the hybrids were genotyped using two sets of molecular markers located in a locus linked to *Plum Pox Virus* resistance. In the scientific literature and after genotyping the parental cultivars ‘Lito’ and ‘Harlayne’ were classified as resistant. In ‘Silistrenska ranna’ and ‘Harcot’ were identified alleles that determine their partial resistance to PPV. ‘Modesto’ is a cultivar susceptible to Sharka. The higher percentage of hybrids with PPV resistance alleles were obtained with the cross ‘Harlayne’ x ‘Harcot’ (figure 18). More than half of this hybrid progeny (67%) was genotyped as resistant or partially resistant. The hybrids genotyped as partially resistant were the biggest group (38%) in the ‘Lito’ x ‘Silistrenska ranna’ hybrid family (Figure 16). In the ‘Modesto’ x ‘Harcot’ cross were not identified hybrids with resistance alleles (figure 17). For breeding purposes it is advisable to use cultivars such as ‘Harlayne’ and ‘Lito’ because their PPV resistance is inherited in the progeny with higher frequency. In this respect, the most promising is the parental combination ‘Harlayne’ x ‘Harcot’.

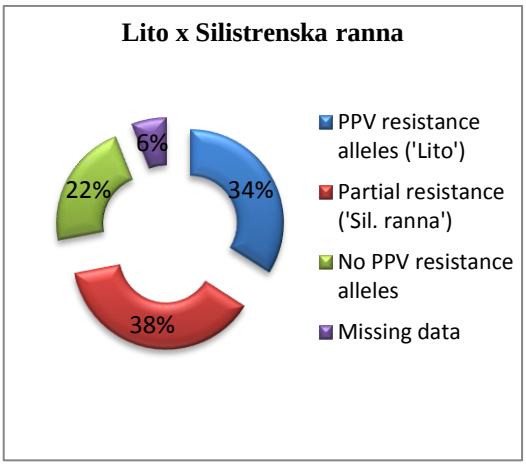


Figure 16. Results from MAS screening of 'Lito' x 'Silistrenska ranna' hybrid family

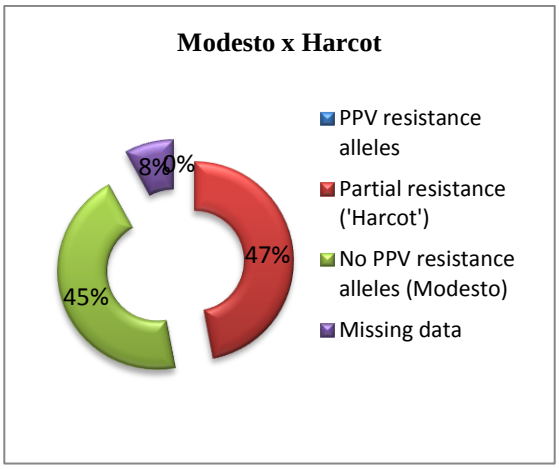


Figure 17. Results from MAS screening of 'Modesto' x 'Harcot' hybrid family

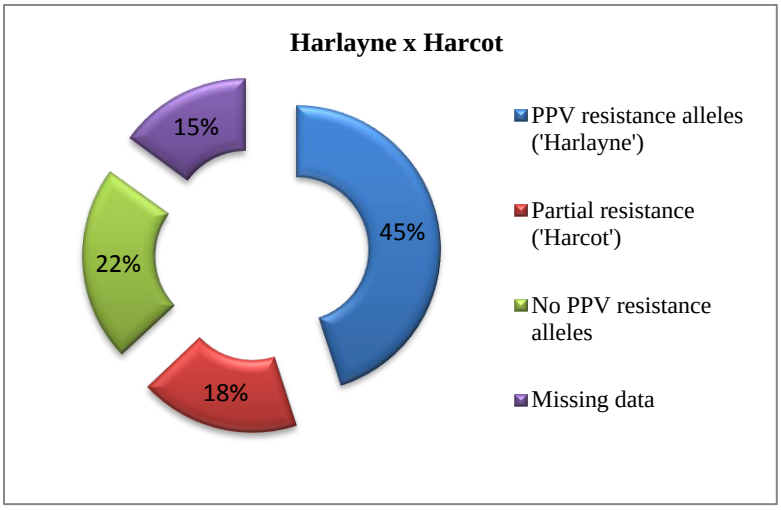


Figure 18. Results from MAS screening of 'Harlayne' x 'Harcot' hybrid family

As a result of the MARS project, from the 'Lito' x 'Silistrenska ranna' hybrid family were selected 11 hybrids with PPV resistance alleles. The number of selected hybrids from the 'Harlayne' x 'Harcot' parental combination was 63. As a result of this dissertation, 9 of the hybrids from 'Lito' x 'Silistrenska ranna' hybrid family and 63 of the 'Harlayne' x 'Harcot' hybrid family were propagated on a *Prunus cerasifera* Ehr rootstock and continue to the next stage of the breeding process. From the 'Modesto' x 'Harcot' hybrid family, 11 hybrids were selected and propagated, on the basis of their very good fruit quality.

4. POMOLOGICAL DESCRIPTION OF SOME OF THE SELECTED HYBRIDS

HH 12-19 (‘Harlayne’ x ‘Harcot’)

This hybrid ripens in the third decade of June – 26/06. The fruits are medium large to large with and average weight of 59 g. Their skin ground color is medium orange. Up to 70% of the fruit surface is covered with solid flush of over color with pink to red hue. The TSS content is 20 ^{o}Brix. Stone relative share is 6,56% from the total fruit weight. The tree has upright to spreading habit. The hybrid HH 12-19 was genotyped as resistant to *Plum Pox Virus.*

HH 12-42 (‘Harlayne’ x ‘Harcot’)

This hybrid ripens around 29/06. The fruits are large with an average weight of 63 g. Their skin ground color is medium orange and up to 60% of the fruit is covered with solid orange-red to red blush. In ventral view the fruits are ovate, in lateral view - circular. Their TSS content is 15,5 ^{o}Brix. The tree has spreading habit. This hybrid was also genotyped as resistant to *Plum Pox Virus.*

MH 13-32 (‘Modesto’ x ‘Harcot’)

The fruits ripen around 17-18/06 and are small or small to medium size with an avarage weight of 44 g. The fruit shape in lateral view is circular and in ventral – ovate. The skin ground color is dark orange. The extremely attractive red over color, covering up to 80% of the fruit surface makes a strong impression. The fruits of this hybrid also have very good taste qualities with intence aroma. The hybrid had very good productivity in 2016 when occurred spring frost that have compromised the harvests across the country. MH 13-32 was not genotyped as resistant to sharka but till now it hasen’t showed symptoms.

In addition to the above mentioned hybrids, which possess a complex of qualities and have the potential to be registered as new cultivars, hybrids having valuable traits but are in need of improvement of others were also selected. The work with them continues in the breeding program and some of them have been used as parental forms for obtaining an F2 generation.

HH 12-26 (‘Harlayne’ x ‘Harcot’)

The average ripening date of this hybrid is 26/06. Its fruits are medium large with 56 g weight and TSS content of 18,2 ^{o}Brix. The stone relative share is 5,23% of the fruit weight. The tree has upright growing habit. After MAS screening PPV resistance alleles were not identified for this hybrid and symptoms of the disease were observed. The three has low productivity. Strong impression makes the result of the sensitive analyses – the hybrid had the highest score for its taste qualities.

MH 13-55 (‘Modesto’ x ‘Harcot’)

The fruits ripen in the beginning of the second half of June - 17/06. MH 13-55 has medium large to large fruits (58 g.), with circular lateral and ovate ventral shape. Total soluble solids content in the fruits is 15,96 ^{o}Brix. In 2015 and 2016 the hybrid had low productivity. The fruits are very attractive - the skin ground color is orange, covered with attractive red blush, covering up to 70% of the surface.

MH 13-62 (‘Modesto’ x ‘Harcot’)

Hybrid which fruits have an attractive appearance and ripen in the second half of June - 18/06. Their average weight is about 57 g. The fruits are ovate in shape with orange color. The red over color is intensive and covers up to 70% of the fruit surface. Total soluble solids content is 15,5 ^{o}Brix. The fruits are evenly located in the tree's crown. The productivity in 2015 and 2016 is low.

5. CONCLUSIONS

1. Most of the hybrids in the three studied hybrid families have later flowering period than the parental cultivars used in the cross.
2. The late ripening period is inherited incompletely dominant and because of its polygenic nature strongly segregates in the progeny. This trait was strongly variable under the influence of environmental factors.
3. The largest fruits were obtained from the parental combination ‘Modesto’ x ‘Harcot’, and the smallest from ‘Lito’ x ‘Silistrenska ranna’.
4. The high total soluble solids content is predominantly inherited and most of the hybrids in the three studied populations outperform the parental cultivars.
5. The ovate fruit shape is dominantly inherited and the depth of fruit suture varies under the influence of climatic factors, and especially of rainfall.
6. The fruit skin ground color is segregating in the three hybrid populations, and as prevalent was the light coloration. In ‘Modesto’ x ‘Harcot’ and ‘Harlayne’ x ‘Harcot’ hybrid families, the possibility for obtaining a genotype with over color covering a larger area of the fruit surface is higher.
7. The linear dimensions of stones do not vary in a large extend in all three years of the study. The weight and the relative share of the fruit stones were also relatively constant. Smaller fruits have smaller stones.
8. The stone shape varies only between the different genotypes and is closely related to the fruit shape.
9. Kernel taste is polygenically determined.
10. In the three hybrid families a variation of the leaf size between the years was observed. Leaf linear dimensions determine their leaf area and in the hybrid populations prevalent were the smaller values of these traits.
11. The leaf shape is genetically determined. Pubescent leaf blade surface is characteristic of the young seedlings in their juvenile period.
12. When using ‘Harlayne’ and ‘Harcot’ cultivars as parents, the possibility of obtaining a hybrid genotype with a more upright tree habit is higher.
13. In the ‘Harlayne’ x ‘Harcot’ hybrid family, the highest number of hybrids had the most wanted in the breeding program angle of branching - between 40° and 50°.
14. The ‘Harlayne’ x ‘Harcot’ parental combination produced the highest number of hybrids with shorter internodes.
15. Observations related to the symptom blossom blight indicate that the development of the phytopathogens and the damages that they are causing are strongly dependent on the environmental conditions.
16. The cultivars ‘Lito’ and ‘Harlayne’ could successfully be used as donors of Plum Pox Virus resistance alleles in future breeding programs.

6. CONTRIBUTIONS

6.1 Original contributions

- For the first time in Bulgaria, the breeding value of three apricot parental combinations has been studied on a large number of biological and agronomical traits.

- The ways and frequency of inheritance of flowering period, total soluble solids content, fruit size, shape and color, kernel taste and leaf size in the three studied parental combinations have been determined.

- It has been determined which of the parental cultivars used transmit with a high frequency of inheritance the desired traits related to the breeding goals of apricot.

- A large number of elites with good fruit quality, compact tree habit and genetic factors determining *Plum Pox Virus* resistance were selected for the next stage of the breeding process.

6.2 Scientific and applicable contributions

As a result of the conducted in three years study 299 hybrids were evaluated. For the next stage of the breeding process, as elites, were selected 77 of them. They combine valuable biological traits, as well as good fruit quality and continue into the next stage of the breeding process by being propagated and grafted onto *Prunus cerasifera* Ehrh rootstock.

6.3 Confirmatory contributions

- It is confirmed that the late flowering period is dominantly inherited trait.
- It is confirmed that the frost damages are highly dependent on the phenophase of the tree's development.
- It is confirmed that the inheritance of the late ripening of the fruits is prevalent.
- It is confirmed that the high total soluble solids content is dominant trait.
- It is confirmed that the light skin and flesh color of the fruits are dominantly inherited.

Publications connected with the dissertation:

1. Nesheva, M and V. Bozhkova, 2017. Apricot fruit traits inheritance in offspring of the parental combination ‘Modesto’ x ‘Harcot’. Journal of Bioscience and Biotechnology. Special edition/online. pp. 39-42.
2. Nesheva M. and V. Bozhkova, 2018. Inheritance of some apricot fruit attractiveness characteristics. Journal of Mountain Agriculture on the Balkans, vol. 21(2). pp. 182-193.
3. Nesheva M., V. Bozhkova, S. Milusheva, 2018. ‘Harlayne’ x ‘Harcot’ – perspective crossbreed for combining good fruit quality and resistance to Plum pox virus, Scientific Papers. Series B. Horticulture, Vol. LXII. pp. 71-76.

SUMMARY

The aim of this study was to trace the inheritance of traits determining the biological and agricultural characteristics of the population of tree apricot hybrid families. It was determined the variation of all traits in the years to establish the level of segregation of their phenotypic expression. At the same time, it was intended to evaluate the hybrids and to determine which ones to continue in the next stage of the breeding process – as elites or as parental breeding material for obtaining F_2 generation.

All researches were conducted in an apricot breeding orchard at the Fruit Growing Institute – Plovdiv, during the period 2015-2018. Objects of this study were 299 hybrids obtained from the crosses ‘Lito’ x ‘Silistreska ranna’, ‘Modesto’ x ‘Harcot’ and ‘Harlayne’ x ‘Harcot’ and all five parental cultivars.

As a result, the ways and frequency of inheritance of the flowering period, total soluble solids content, size, shape and color of the fruits, kernel taste, leaf sizes and canopy shape of the three studied parental combinations were established. It was confirmed that the late flowering period, late maturity period, high total soluble solids content, light skin and fruit flesh color are dominant traits. It was established which of the used parental cultivars transmit with a high frequency of inheritance the desirable traits associated with the apricot breeding purposes. A selection of elites with excellent fruit quality and *Plum Pox Virus* resistance alleles was done. A great number of hybrids were selected as donors of valuable traits for future breeding schemes.