Scientific Papers. Series B, Horticulture. Vol. LXIV, No. 1, 2020
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

BEHAVIOUR OF SOME NEW APPLE SCAB RESISTANT CULTIVARS CULTIVATED IN BUCHAREST AREA

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Abstract

The aim of this study is to present the behaviour of new apple scab resistant varieties cultivated in Bucharest area. Apple scab (Venturia inaequalis) is an important and dangerous pathogen, specific treatment being required and, in many cases, the products exceed the new pesticides limits. Every year, new resistant varieties are released by breeders and before their spread into commercial orchards, they need to be tested in specific growing conditions. In the Didactic Experimental Orchard of the Faculty of Horticulture within USAMV of Bucharest more than 25 apple cultivars are planted and monitored. Most of the trees are grafted of M9 rootstock, planted at 3.5 x 1.0 m and led as Vertical Axe. The soil is maintained covered with a mixture of perennial grasses on the interrow and clean with herbicide on the row. Drip irrigation is applied. The paper presents the comparative results focused on the biometrical data like: average tree height, type, number and average length of fruiting shoots, trunk cross sectional area. For each variety fruit yield was calculated. Basic fruits analyses at the harvest moment are presented.

Key words: *canopy, fruit morphological parameters, Malus domestica, rootstock, Vertical Axe.*

INTRODUCTION

Apple is one of the ancient fruit that human mankind continuously appreciated and cultivated for its special nutraceutical properties (Mihăescu, 1977; Hoza, 2000; Tănăsescu, 2005; Chira, 2005; Grădinariu, 2002; Grădinariu and Istrate, 2003; Ghena et al., 2004). It can be found all over the world, in 2018 being reported 86,142,197 tons from which 643,856 tons in Romania (the second fruit crop after plums) (Faostat, 2020; INSSE, 2020).

In time, apple cumulated more pest and diseases, some of them very difficult to manage (Bowen et al., 2011). Apple scab (*Venturia inaequalis*) is an important and dangerous pathogen, specific treatment being required and, in many cases, the products exceed the new pesticides limits (Eppo Global Database, 2020).

Originally from Europe, it was first reported by Fries in 1819 in Sweden; in the USA appeared in 1834, in England in 1945 and in Austria in 1862.

In Romania it is spread in all the apple orchards and in the years with spring and rainy summers, the losses can reach 30-98%. Some of the traditional cultivars presented resistance (Ionescu et al., 2019). The fungicides have proved to be quite inefficient requiring a large number of unwanted sprays, both from the consumer's point of view and from the costs involved, due to the necessity of a very good synchronization of the fungicides application with the plant growth stages and also to the difficulty of its eradication.

The best way to control it seems to depend on the development of scab resistant cultivars (Stănică and Branişte, 2011; Petre and Petre, 2014; Chira et al., 2015; Dudu et al., 2015; Petre et al., 2015; Petre el al., 2019). Every year, new resistant varieties are released by breeders and before their spread into commercial orchards, they need to be tested in specific growing conditions.

The paper presents the comparative results for more than 25 apple scab resistant cultivars focused on the biometrical data like: average tree height, type, number and average length of fruiting shoots, trunk cross sectional area. For each cultivar, fruit production was calculated. Basic fruits analyses at the harvest moment are presented. The aim of this study is to present the behaviour of new apple scab resistant varieties cultivated in Bucharest area.

MATERIALS AND METHODS

In the Didactic Experimental Orchard of the Faculty of Horticulture within USAMV of Bucharest more than 25 apple varieties are cultivated and monitored. Most of the trees are grafted of M9 rootstock, planted in 2009, at 3.5 x 1.0 m and led as Vertical Axe. The soil is maintained covered with a mixture of perennial grasses on the inter-row and clean with herbicide on the row. Drip irrigation is applied. Apples were harvested in August 28th. Biometric and basic biochemical analyzes were made at the harvest time. Biological material consisted in more scab resistant cultivars: Ariwa, Aura, Bistrițean, Ciprian, Dalinbel, Dalinette, Dalinred, Evereste, Florina, Iris, Jonaprim, Luna, Mars, Mela, Opal, Orion, Pionier, Rajka, Real, Rebra, Red Devil, Red Topaz, Remar, Romus 3, Rosana, Sirius, Starkprim, Svatava (Figure 1).

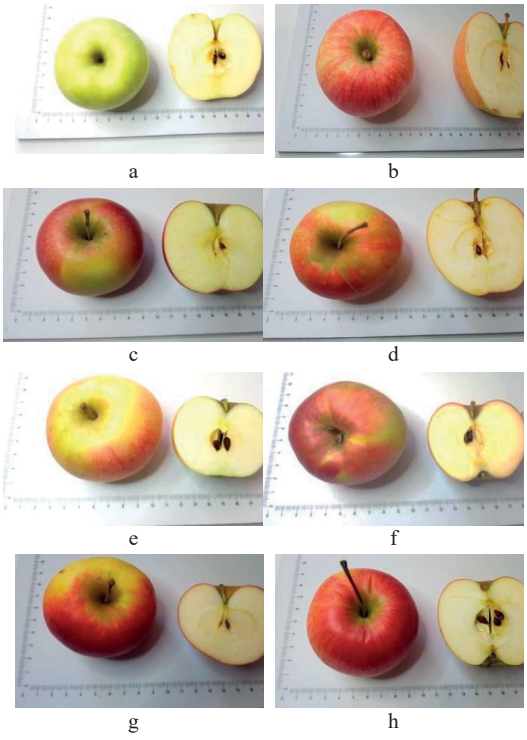

Figure 1. Apple scab resistant cultivars: Aura (a), Bistrițean (b), Dalinette (c), Iris (d), Rebra (e), Jonaprim (f), Remar (g), Starkprim (h)

Tree vigour, blooming period and rate, yield and fertility were analyzed to all above cultivars. Fruiting branches characteristics were determined at Orion, Luna, Red Topaz, Opal, Stark prim, Dalinbel, Jonaprim, Florina, Aura, Remar, Evereste and Real cultivars.

Physical and biochemical parameters were determined for several cultivars comparing with sensitive apple scab cultivars. The results were analyzed comparing with the cultivars descriptions and other researches (Asănică and Hoza, 2013; Petre et al., 2014; Ștefan et al., 2018; Cimpoieș, 2018).

The physio-chemical analyses were performed in the Researcher Centre for Study of Food Quality and Agricultural Products, USAMV Bucharest.

RESULTS AND DISCUSSIONS

Tree vigour

Tree height

Although all the trees on which measurements were made have M9 rootstocks, significant differences could be observed on their height. The highest tree cultivar was Florina, with an average height of 4.25 m in 2017 and 4.30 m in 2018, while at the opposite was the cultivar Iris, with the average height of 2.62 m in 2017 and 2.65 m in 2018 (Figure 2). Red Devil and Romus 3 registered the highest increasing rate of height, followed by Rosana, Dalinbel, Mars, Jonaprim, Red Topaz and Ariwa.

Trunk height

At the Svatava cultivar, the highest values were recorded on the trunk height, with 90 cm height in both years of monitoring. The shortest trunk variety had Evereste with 50.60 cm in 2017 and 51.60 cm in 2018, followed by Rebra and Bistrițean with 54.50 cm in 2017, respectively 56.00 cm and 55.50 cm in 2018. Although, the applied technology determined the initial trunk height, the evolution of this parameter was important for the cultivar description.

Trunk cross section area (TCSA)

The cultivar with the highest TCSA was Dalinbel, measuring 81.24 cm² in 2017 and 85.41 cm² in 2018, while Iris cultivar had the lowest values with 11.83 cm² in 2017 and 12.26 cm² in 2018 (Figure 3). Florina registered the highest TCSA increasing rate in the analyzed period, with 38.29%, highlighting the cultivar feature, followed by Mars cultivar with 5.75% and Dalinbel cultivar with 5.14%.

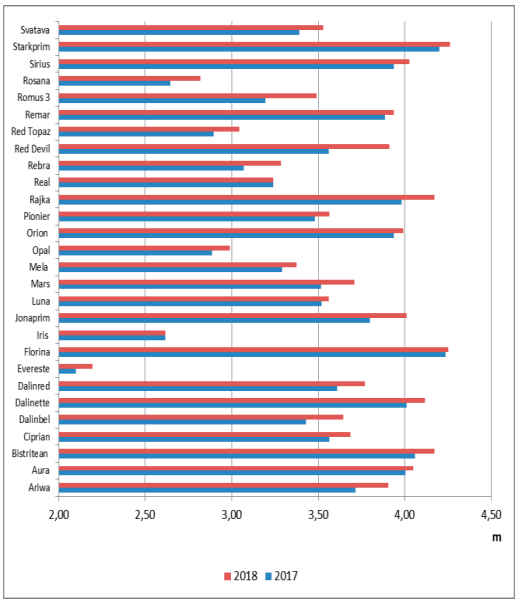

Figure 2. Tree height between 2017-2018 period

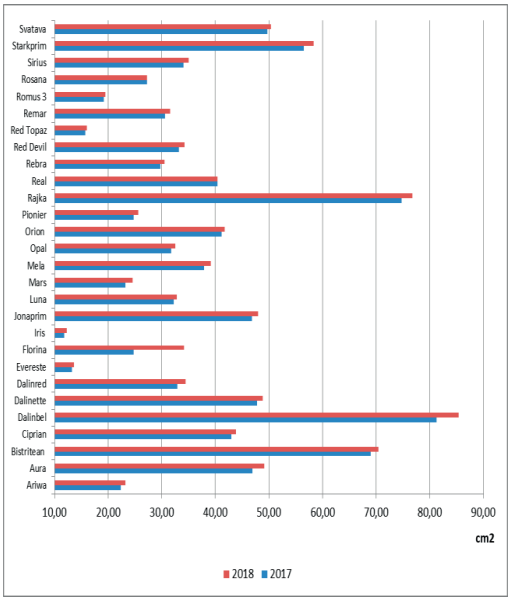

Figure 3. Trunk cross section area between 2017-2018 period

Evolution of the number and length of the fruiting branches

For fruiting branches analyses, for some of the cultivars considered in the study, spurs, water shoots, dards, brindles and offshoots were counted and measured. A detailed analyze with the evolution of their number, average length, rate of each type of fruiting branch and total vegetative growth per tree was presented. The applied agro-technics and the type of fruiting for each apple cultivar determined the obtained results.

The number of fruit branches significantly differed between cultivars. The number of spurs increased in 2018 compared to 2017 for all the analyzed cultivars. In 2017, Luna cultivar presented the lowest number of spurs (12.8) and Jonaprim cultivar (25.3) the highest number. In 2018, the Opal (18.0) and Dalinbel (25.4) were at the extreme.

The number of water shoots evolved during the two years of study different according to cultivars, in some cases increasing (Orion, Luna, Red Topaz, Dalinbel, Florina and Remar) and in others decreasing (Opal, Starkprim, Evereste and Real). At Jonaprim and Aura remained constant. Dards number increased for all cultivars in 2018 compared to 2017 with the exception of the Jonaprim cultivar.

The smallest number had the Orion cultivar (9.5 in 2017 and 12.5 in 2018) and the highest number of dards was presented by the Evereste cultivar. The smallest number of brindles was found at the Opal cultivar (3.5 in 2017 and 7.0 in 2018) and the largest number at Dalinbel cultivar (17.2 in 2017 respectively 15.6 in 2018). The smallest number of offshoots had the Starkprim cultivar (6.2 in 2017 and 9.6 in 2018) and the highest number was found at the Evereste cultivar (18.0 in 2017) and respectively Florina cultivar (18.6 in 2018) (Table 1).

The average length of the fruit branches were on average constant during the two years at spurs (2.1 cm) in the studied cultivars. The average length of the water shoots ranged from 49.9 cm in 2017 to 47.7 cm in 2018. The average length varied for dards from an average of 2.9 cm in 2017 to 2.7 cm in 2018, for brindles from an average of 23.9 cm in 2017 to 25.8 cm in 2018 and for the offshoots varied from an average of 33.4 cm in 2017 to 34.3 cm in 2018 (Table 2).

The total growth of the fruit branches varied between 2017 and 2018, several cultivars having an increasing evolution and others decreasing, influenced by the climatic factors and the applied culture technology. Thus, in 2017 the smallest growth was observed in the

Evereste cultivar with an average of 198 cm and the highest in the Jonaprim cultivar with an average of 2,791 cm. In 2018, the smallest growth was in the Opal cultivar with 991 cm and the highest in the Florina cultivar with 2,066 cm (Table 3 and Figure 4).

Table 1. Evolution of fruiting branches number between 2017-2018 period

Cultivar	Fruiting branches number									
	Spurs		Water shoots		Dards		Brindles		Offshoots	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Orion	14.5	22.3	14.0	15.5	9.5	12.5	5.5	7.3	7.0	11.3
Luna	12.8	23.6	4.6	13.4	14.6	18.0	5.2	7.0	9.8	12.8
Red Topaz	19.4	24.8	14.6	22.6	12.4	16.8	9.0	10.8	13.8	16.2
Opal	15.5	18.0	13.0	7.0	13.5	17.0	3.5	7.0	8.5	11.5
Stark prim	23.0	25.0	24.4	21.6	17.6	19.4	11.6	10.2	6.2	9.6
Dalinbel	23.4	25.4	16.2	17.2	22.4	23.6	17.2	15.6	16.4	12.8
Jonaprim	25.3	24.0	13.3	13.3	23.0	22.3	16.7	11.0	14.7	16.3
Florina	15.8	19.6	12.0	22.8	18.2	22.8	8.6	9.8	11.8	18.6
Aura	16.8	23.8	18.8	18.6	18.0	22.4	5.8	9.6	15.2	12.6
Remar	20.2	22.8	12.3	17.0	19.5	22.8	9.3	9.7	13.7	11.7
Evereste	20.0	22.0	21.0	19.0	24.0	25.0	17.0	13.0	18.0	13.0
Real	22.0	22.4	20.2	16.0	11.2	19.2	6.8	11.0	13.8	13.2
Average	19.1	22.8	15.4	17.0	17.0	20.2	9.7	10.2	12.4	13.3

Table 2. Evolution of fruiting branches length between 2017-2018 period

Cultivar	Average length of fruiting branches (cm)									
	Spurs		Water shoots		Dards		Brindles		Offshoots	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Orion	2.4	2.5	32.5	33.6	3.3	3.1	13.4	18.9	37.2	30.0
Luna	2.2	2.1	38.1	38.3	3.0	2.9	18.0	24.3	19.7	26.2
Red Topaz	2.1	2.1	42.2	45.4	3.0	2.4	20.0	25.0	35.8	36.9
Opal	1.8	2.2	54.3	55.6	2.8	2.6	19.0	25.1	25.2	29.3
Stark prim	1.8	1.9	60.6	64.0	2.6	2.3	29.0	27.3	33.9	32.5
Dalinbel	1.9	2.1	61.4	57.4	2.9	2.6	24.6	23.8	34.9	33.0
Jonaprim	1.8	1.9	67.2	50.4	2.6	2.6	27.3	24.8	37.6	34.8
Florina	2.1	2.1	56.5	45.3	3.1	3.0	29.7	28.4	40.4	36.2
Aura	2.1	2.0	50.2	47.5	2.9	3.1	25.4	31.8	39.9	40.6
Remar	2.1	2.1	54.5	55.9	2.9	3.0	29.0	25.9	26.2	34.4
Evereste	2.0	2.1	39.0	37.6	2.7	2.7	25.4	26.2	28.4	36.4
Real	2.2	2.4	42.1	41.7	2.9	2.8	25.7	28.0	41.7	41.3
Average	2.1	2.1	49.9	47.7	2.9	2.7	23.9	25.8	33.4	34.3

Table 3. Evolution of total vegetative growth between 2017-2018 period

Cultivar	Total vegetative growth (cm)											
	Spurs		Water shoots		Dards		Brindles		Offshoots		Total	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Orion	36	54	911	519	28	39	83	181	471	342	1,529	1,135
Luna	29	49	220	497	44	52	160	203	365	405	818	1,206
Red Topaz	42	52	1,019	1,018	42	40	236	264	849	602	2,188	1,976
Opal	29	39	1,413	390	76	46	133	182	429	335	2,080	992
Stark prim	41	49	1,471	1,354	45	45	452	291	359	314	2,368	2,053
Dalinbel	44	53	1,225	1,007	64	62	425	367	570	530	2,328	2,019
Jonaprim	46	45	1,371	681	60	57	467	275	848	572	2,792	1,630
Florina	32	40	1,081	1,008	55	67	251	271	603	680	2,022	2,066
Aura	37	48	898	1,126	51	68	247	308	767	497	2,000	2,047
Remar	43	48	768	922	58	68	319	303	454	397	1,642	1,738
Evereste	22	47	60	714	27	67	42	340	46	473	197	1,641
Real	49	53	860	830	53	53	266	299	955	543	2,183	1,778
Average	37.5	48.1	941.4	838.8	50.3	55.3	256.8	273.7	559.7	474.2	1845.6	1690.1

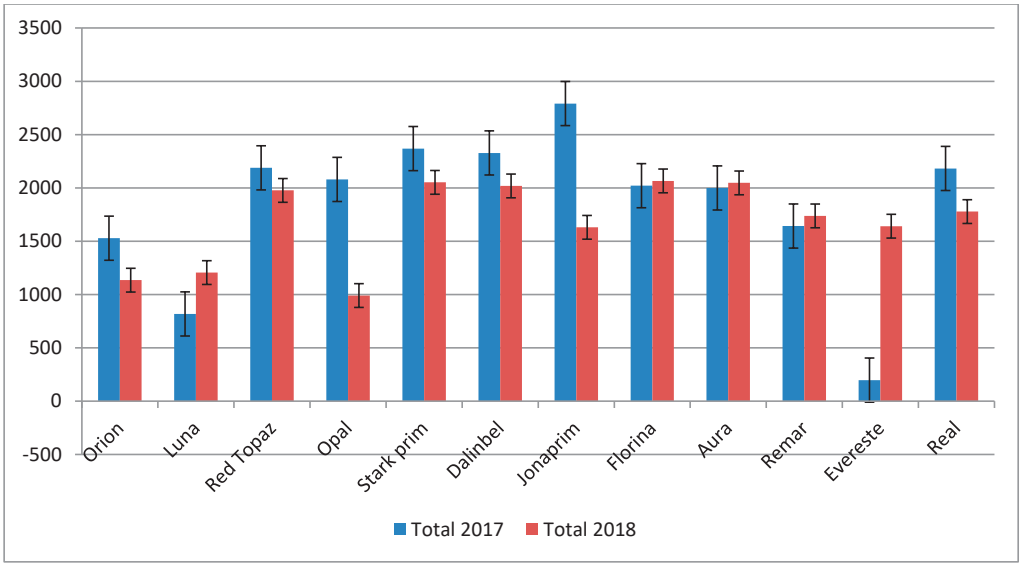

Figure 4. Evolution of total vegetative growth per tree between 2018 - 2019

The rate of the types of fruit branches was different in the analyzed cultivars. If the rate of the spurs and dards was relatively close, the rate of the water shoots in total was maximum in the cultivars Orion (60% in 2017), Opal (68% in 2017), Starkprim (62% in 2017) decreasing in 2018 (maximum 66% in Starkprim cultivar). The rate of the brindles ranged from 5% in Orion to 21% in Evereste in 2017 and between 13% in Red Topaz and 21% in Evereste in 2018. The rate of the offshoots varied between 15% in Starkprim and 39% in Red Topaz in 2017 and between 15% at Starkprim and 35% at Jonaprim in 2018 (Table 4).

Table 4. Fruiting type for each studied cultivar (2018-2019)

Cultivar	Fruiting branches percentage (%)									
	Spurs		Water shoots		Dards		Brindles		Offshoots	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Orion	2	5	60	46	2	3	5	16	31	30
Luna	4	4	27	41	5	4	20	17	44	34
Red Topaz	2	3	46	52	2	2	11	13	39	30
Opal	1	4	68	39	4	5	6	18	21	34
Stark prim	2	3	62	66	2	2	19	14	15	15
Dalinbel	2	3	53	50	3	3	18	18	24	26
Jonaprim	2	3	49	42	2	3	17	17	30	35
Florina	2	2	53	49	3	3	12	13	30	33
Aura	2	2	45	55	3	4	12	15	38	24
Remar	3	3	47	53	4	4	19	17	27	23
Evereste	11	3	30	44	14	4	21	21	24	28
Real	2	3	40	47	2	3	12	17	44	30
Average	2.92	3.17	48.33	48.67	3.83	3.33	14.33	16.33	30.58	28.50

Tree phenologic study

In order to study the specificity of phenology on the studied cultivars, the date of flowering and the percentage of average flowering/tree in the two years taken into the study were considered (Figure 5). The flowering started in April, in 2017 between April 16th-21th and in 2018 between April 11th and 14th. The flowering rate ranged from 5 (Florina, Opal, Pionier and Rajka) to 90 (Luna, Rebra, Red Topaz and Sirius) in 2017 and between 30 (Pioneer and Rosana) and 88 (Evereste) respectively 80 (Moon, Red Devil and Red Topaz) in 2018 (Figure 6).

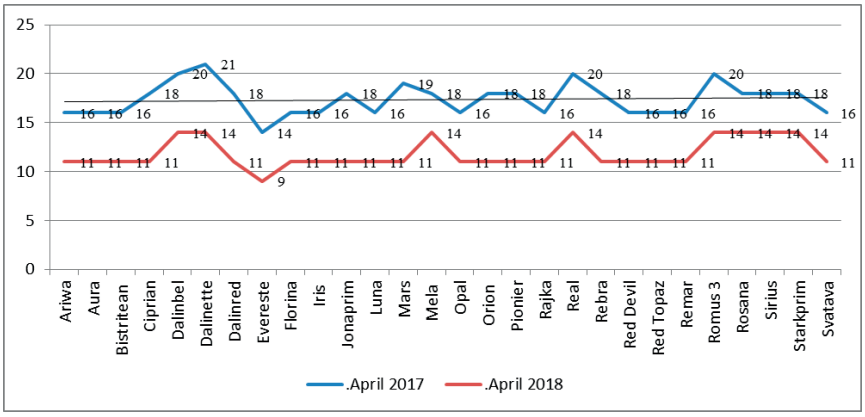

Figure 5. Blooming period of the apple cultivars

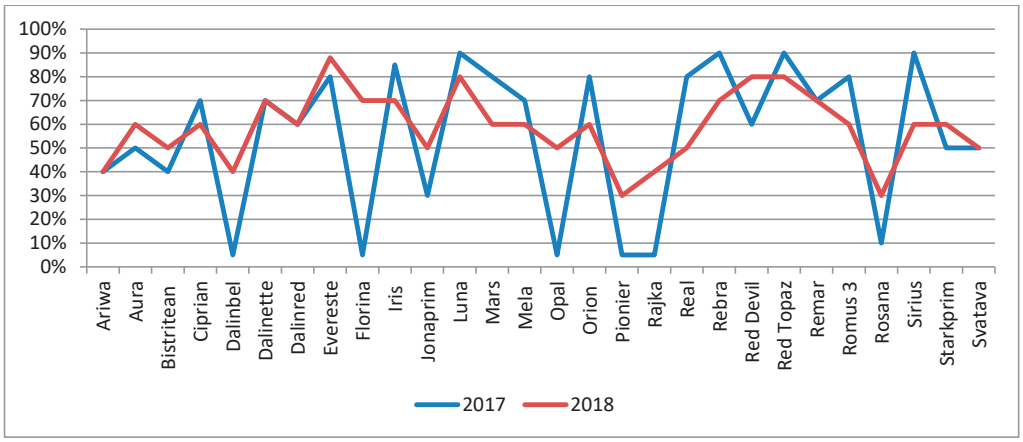

Figure 6. Blooming rate between 2018-2019 period

Tree productivity

One of the most productive cultivars was Mars, with a production of 120.5 fruits/ tree in 2018, followed closely by the Romus 3 cultivar, with a production of 109.5 fruits/ tree. At the opposite were the cultivars: Opal, with a production of 3.5 fruits/tree, and Rosana, with a production of 6 fruits/ tree (Figure 7). The analyzed cultivars presented lower yield values than the cultivars potential in 2018 year. Fertility index (kg/cm^2 TCSA) for several cultivars was presented in Figure 8.

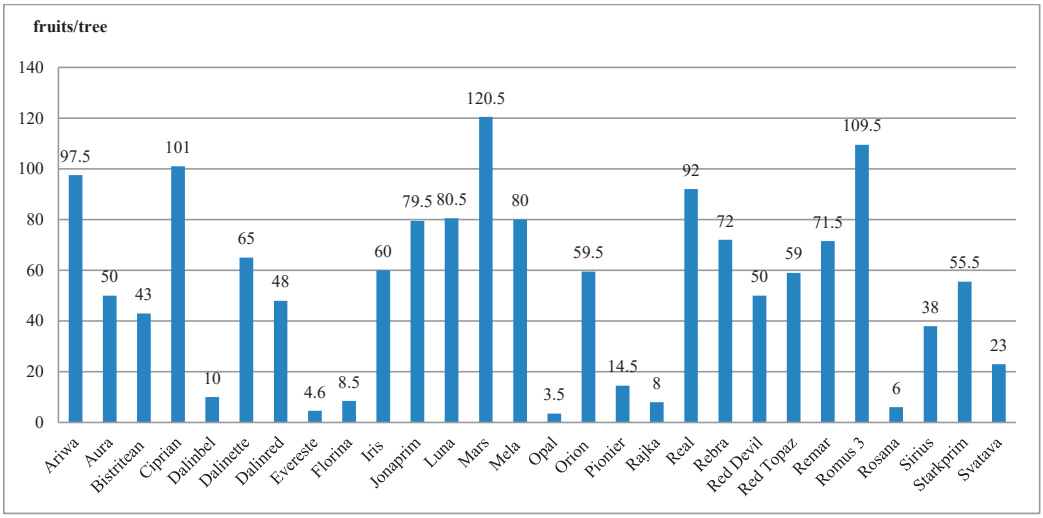

Figure 7. Fruit production registered in 2018

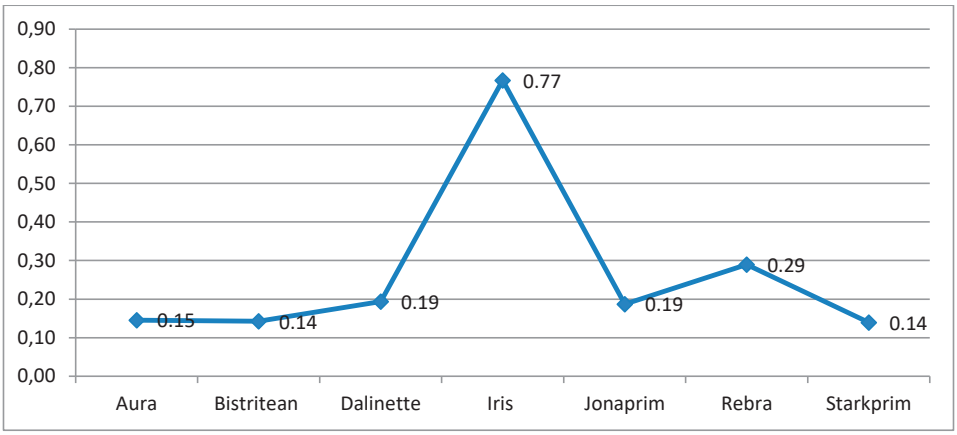

Figure 8. Fertility index in 2018 for several analyzed apple cultivars

Fruits physical and biochemical characteristics at the harvest moment

The cultivar with the highest weight/fruit was Bistrițean, registering an average weight of 233.4 g/fruit, significant higher than standard (Asănică and Hoza, 2013).

Iris with an average weight of 156.8 g/fruit was similar with the cultivar characteristics (150 g/fruit).

Aura with 143 g/fruit, Jonaprim with 112.8 g/fruit, Redix with 104 g/fruit and Starkprim with 146.6 g/fruit presented lower values than the cultivars potential (Asănică and Hoza, 2013) (Figure 9).

The fruits with the largest diameter belong to the Bistrițean cultivar (8.88 cm) and the smallest to the Rene cultivar (6.98 cm) (Figure 10).

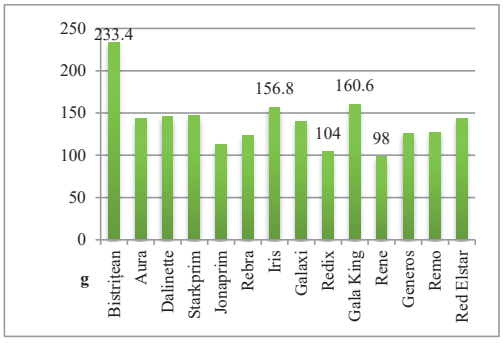

Figura 9. Average weight/fruits (2018)

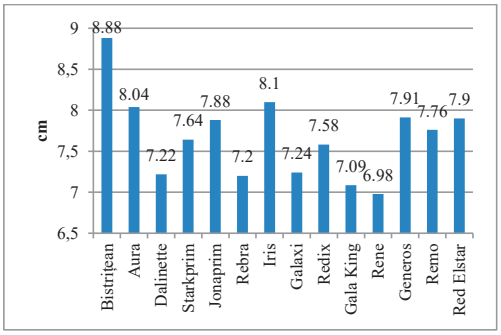

Figure 10. Average fruit diameter (2018)

Firmness, at the harvest moment, ranged between 4.57 kg/cm^2 (Starkprim), 4.88 kg/cm^2 (Red Elstar) to 7.89 kg/cm^2 (Dalinette). Soluble dry matter varied between 9.73 Brix (Bistrițean) to 13.51 Brix (Jonaprim) (Figures 11 and 12).

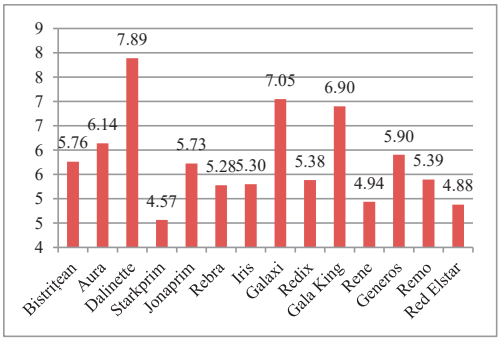

Figure 11. Flesh firmness depending on cultivars at the harvest moment (2018)

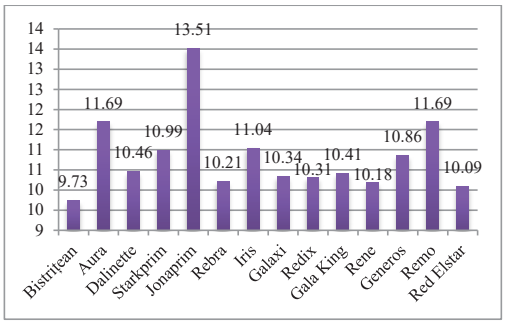

Figure 12. Soluble dry matter depending on cultivars at the harvest moment (2018)

CONCLUSIONS

This research presented several important characteristics of more than 25 apple scab resistant cultivars cultivated in Bucharest area. The applied agro-technics and cultivars specificity were highlighted through tree vigour (total height, trunk height, total cross section area), blooming characteristics, production and fertility index for several cultivars for 2017-2018 period.

Flowering rate was specific to cultivars and especially to climatic factors, blooming period being in April 16th-21th (2017) respectively 11th -14th (2018).

Apple scab resistant cultivars presented valuable characteristics and most of them can be spread in production in Romanian orchards.

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