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RESEARCH REGARDING THE INFLUENCE OF ROOTSTOCK ON THE PRODUCTION AND FRUIT QUALITY FOR THE PINOVA APPLE VARIETY

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Abstract

The research was carried out in the period 2016-2018, in an experimental plantation established in 2015, with the Pinova variety in several graft combinations, directly on the B9, M9, MM 106 and Pi 80 rootstocks, and with B9 as intermediary on the A2 and MM106 rootstocks. The soil was maintained worked along the row for most variants, for 2 variants with grafting intermediary the soil was kept grassed, and for other 2 variants the intermediary was buried at planting. The rootstock influenced fruit production and fruit quality differently. The highest average production in the first years of fructification, of over 26 t/ha, were obtained for the rootstocks B9, M9 and combinations with intermediary of B9/MM106. The largest fruit were obtained from trees grafted with intermediary on A2 and worked soil, over 169 g and about 78 mm in diameter. A higher amount of soluble dry matter was recorded for the fruit obtained from grafted trees from variants V2, V5 and V8, while higher carbohydrate content was recorded for the variants V2, V8 and V1. The best firmness had the fruit of the V8 variant, while higher content in anthocyanins had the fruit of the V8 and V7 variants.

Key words: *grafting, quality, production.*

INTRODUCTION

Apple culture is one of the most important cultures globally, while in Romania it occupies the first place. Fruits are capitalized as fresh or processed under different forms: jam, marmalade, compote, juice, dehydrated etc. Fruit quality depends on several factors, such as: age of the trees, rootstock used, using grafting intermediaries, intensity of pruning, management of soil (Zho et al., 1983; Lord et al., 1985; Dudu et al., 2015; Asanica et al., 2013; D` Abrosca et al., 2017; Iordănescu et al., 2018). Due to a relatively high consumption of workforce with pruning and harvesting, attempts are made regarding the reduction of the size of the trees and the increase of number of trees per unit of area (Hrutko, 2013). The intensification implies the existence of small rootstocks on one side, but also ensuring a good anchoring in the soil of the root system on the other hand. The small rootstocks frequently used in the modern fruit growing (M9, M27, B9) have a superficial rooting and require a support system the increases the production costs, but also imply a very careful irrigation and fertilization in order to ensure the water and nutrition necessary for the trees (Zhou et al., 2016). Using a grafting intermediary implies increasing the time needed to obtain trees by one year, and for this attempts are made to find solutions for producing trees in two years (Baciu et al., 2008). The grafting combinations used until now did not result in a tree close to the ideal tree, which is why research is still conducted to simplify the culture technology and to decrease the costs, but with maintaining a high fructification potential and a good commercial quality of the fruit. In order to ensure a better anchoring of the trees and to benefit from the soil resources, but in the same time to maintain the trees small, several grafting combinations have been tested, with low vigor intermediary on vigorous rootstocks (Bărăscu et al., 2017). It was observed that the intermediary used for grafting positively influences fruit quality (Vercammen et al., 2007; Zho et al., 1983; Samad et al., 1999), productivity (Rufato et al., 2006; Samad et al., 1999; Filho et al., 2019), increases the ramification capacity for young trees (Bărăscu et al., 2017), decreases tree vigor expressed through height and diameter of the trunk (Tojuko et al., 2007; Di Vaio et al., 2009; Oliviera et al., 2019; Karlidag et al., 2014), but also tree precocity (Webster et al., 1995). Research conducted by Samad, McNeil and Khan using as intermediary the M9 rootstock showed a reduction of tree size by 20% while the production increased by 30% (Samad et al., 1999). The length of the used intermediary influences the vigor, the elements being inversely proportionally correlated. A longer intermediary determined a better ramification capacity and a good precocity (Karlidag et al., 2014).

MATERIALS AND METHODS

The experiment was conducted during 2016-2018, within the Vâlcea plant nursery, situated in the northern part of the Vâlcea County, in the Mihăiești locality. The soil was typical preluvosoil, with medium texture and weakly alkaline reaction on the surface and weakly acid in the root growth area. The supply with mineral elements was medium. The plantation was established in 2015, with the Pinova variety, grafted into many combinations as it follows:

V1 - Pinova/B9/A2, grassed soil
V2 - Pinova/B9/A2, worked soil
V3 - Pinova /B9/A2 intermediary buried, grassed soil
V4 - Pinova/B9/MM106, grassed soil
V5 - Pinova/B9/MM106, worked soil
V6 - Pinova/B9/MM106 intermediary buried, worked soil
V7 - Pinova/B9
V8 - Pinova/M9
V9 - Pinova/MM106
V10 - Pinova /Pi 80

The technology applied in the orchard was specific for an intensive apple plantation, while the soil was maintained grassed for the majority of the variants, as shown in the experimental scheme. During fruit harvesting, the production per tree was recorded, the production per unit of area was calculated and measurements were made regarding fruit quality. For analysis purposes, 10 fruit from each part of the crown were harvested, while the physical-chemical measurements were made based on average samples resulted from these fruits.

Physical-chemical analysis

Determinations regarding fruit quality were made at the Research Center for Studies of Food Quality and Agricultural Products - University of Agronomic Sciences and Veterinary Medicine of Bucharest, and consisted of physical analysis: average weight, caliber and firmness, and also biochemical analysis: soluble dry matter, titrable acidity, carbohydrates and anthocyanins.

Average fruit weight was measured using the balance with two decimals, WTB 2000.

Fruit caliber was determined using the caliper, two readings being made for each fruit on two different directions.

The ***dry matter and water content*** of the samples were determined by oven drying for 24 hours at 105ºC using a UN110 Memmert oven, method used also by Delian (2011), Mureşan (2014), Ticha (2015). To determine the fruit firmness an electronic penetrometer TR was used, and the results were expressed in kg/cm^2 (Chen, 2015).

Carbohydrates were determined from apple juice (Mureşan, 2014; Oltenacu, 2015), with refractive device Kruss DR301-95 (% Brix).

Titratable acidity calculation was done using the formula: $\frac{F \times C \times a \times b \times 100}{b \times c}$, where F is the factor NaOH solution 0.1 N (1,002), C = coefficient of correction for citric acid (0.0064), a = quantity of 0.1 N NaOH titrated, b = volume of the extraction solution, c = mass of the sample. For titration with 0.1 N NaOH the automatic titrator TitroLine easy was used. The results were expressed in g citric acid/100 g.

Total anthocyanins content was measured with spectrophotometric absorbance at wavelength λ = 540 nm (Bărăscu et al., 2016), after an adapted method. The extracts were filtered under vacuum and completed up to 50 ml volume. The results were calculated using the formula: Total anthocyanins = DO_{540} x F, where DO_{540} is absorbance at wavelength λ = 540 nm and factor F = 11.16. The total anthocyanins content was expressed in mg/100 g in fresh weight. The interpretation of the results was made through variant analysis.

RESULTS AND DISCUSSIONS

The production capacity of the Pinova variety was very good, starting with the second year in the orchard the trees fructified and the average production for the first 3 years was over 9 kg/tree, with a maximum value of 12.7 kg/tree for the variant V5 (Table 1).

Using the MM106 rootstock with M9 intermediary led to very good results for the variants with normal tree planting (V4 and V5), with the partial burring of the intermediary slightly decreased the production (V6).

The heaviest fruit weight was obtained when using the vigorous A2 rootstock with B9 as intermediary, the fruit having values over 180 g. A positive influence over fruit size was also recorded for the MM 106 rootstock, with or without intermediary, the values being over 170 g, compared to the fruit obtained for the M9 grafting combinations, where fruit weight was under 140 g.

The fruit caliber was correlated with the average weight, the correlation coefficient being r^2 = 0.68 (Figure 1).

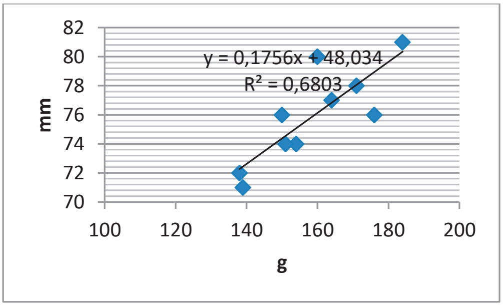

Figure 1. Correlation between the average weight and the diameter of the fruit

Table 1. The production capacity for the Pinova variety grafted on different rootstocks

Variant	Production (kg/tree)		Production (t/ha)		Average weight (g)		Caliber (mm)	
	Media	± St. Dev.	Media	± St. Dev.	Media	± St. Dev.	Media	± St. Dev.
1	9.0	0.24	20.0^{000}	2.15	150.62***	13.57	76.25***	4.10
2	9.5	0.51	21.1^{000}	3.16	138.34 N	25.26	72.50 N	4.65
3	11.6	0.23	25.7^{000}	4.25	184.49***	16.74	81.00***	3.35
4	12.3	0.72	27.3***	4.29	176.50***	22.66	75.84***	5.80
5	12.7	0.15	28.2***	3.78	160.71***	37.77	80.50***	6.95
6	11.9	0.16	26.4 N	3.87	154.68***	24.38	74.34**	4.45
7	12.0	0.11	26.6 N	2.98	164.14***	17.22	76.67***	5.32
8	11.9	0.14	26.4 C	3.64	139.14 C	10.44	71.15 C	4.75
9	10.0	0.09	22.2 ^{000}	2.24	171.58***	30.95	78.00***	6.20
10	11.3	0.12	25.1000	3.12	151.47***	9.91	74.00**	4.60
DL 5%			0.26		2.02		1.82	
DL 1%			0.37		2.91		2.61	
DL 0.1%			0.55		4.28		3.84	

The water content of the fruit was slightly influenced by the grafting combination, the values obtained being between 79.04 and 83.4%.

A higher value was obtained for V4, the variant with large fruit, which showed that growth was determined through a better fruit hydration (Table 2).

The total dry matter depended on the water content, the correlation between the two parameters being a negative one, with a coefficient value of r^2 = - 0.49 (Figure 2).

The fruit mineral content, expressed through the ash content, did not have a strong correlation with the dry matter, the coefficient being 0.47.

Fruit firmness was influenced by the grafting combination, the firmest fruit were obtained from the trees grafted on the M9 rootstock, the value measured being 9.24 kgf/cm^2, while the lowest recorded value for the trees grafted on MM106 with B9 intermediary, of 7.22 kgf/cm^2.

Titrable acidity was slightly influenced by the grafting combination, a higher value being recorded for the fruit obtained from trees grafted on MM 106 with intermediary M9, while the lowest value was recorded for the fruit obtained from trees grafted on A2 with intermediary B9 (Table 3).

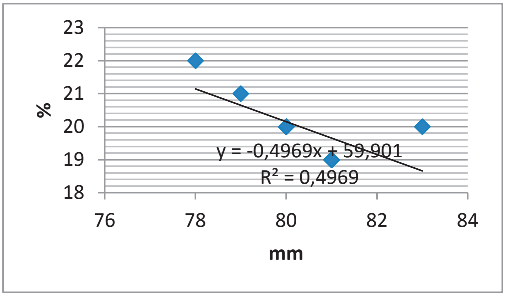

Figure 2. Correlation between total dry matter content and fruit diameter

The carbohydrates content had similar values amongst the variants, the deviation being under 1.5%.

The content in anthocyanins was heavily influenced by the rootstock or the grafting combination. Thus, the highest content was recorded for the fruit obtained from the trees grafted on B9, 2.16 mg/100 g, followed by the rootstock Pi 80, with a content of 1.72 mg/100 g. A good accumulation of anthocyanins was also determined by the rootstock MM 111, especially the variants V4 and V5 with over 1.48 mg/100 g, compared to only 0.98 mg/100 g for the fruit obtained from the trees grafted on the rootstock M9, the rootstock most used in super intensive plantations.

Table 2. Influence of the grafting combination on some physical indicators of the fruit

Variant	Water content (%)	Total dry matter (%)	Ash content (%)		Fruit firmness (kgf/cm^2)	
			Media	± St. Dev.	Media	± St. Dev.
1	80.22	19.78	0.26	0.01	7.98^{000}	0.52
2	78.25	21.75	0.44	0.02	8.2^{000}	0.56
3	81.40	18.60	0.28	0.01	7.47^{000}	0.78
4	83.48	16.52	0.20	0.01	7.22^{000}	0.58
5	79.04	20.96	0.24	0.02	7.86^{000}	0.43
6	81.33	18.67	0.28	0.01	8.13^{000}	0.82
7	80.34	19.66	0.27	0.01	8.03^{000}	1.1
8	79.53	20.47	0.21	0.01	9.24 C	0.67
9	80.69	19.31	0.37	0.02	7.93^{000}	0.75
10	80.14	19.86	0.38	0.02	7.99^{000}	0.69

DL5%=0.18 kgf/cm^2, DL 1%=0.26 kgf/cm^2, DL 0.1%=0.39 kgf/cm^2

Table 3. Influence of the grafting combination on some biochemical indicators of the fruit

Variant	Titrable acidity (g malic acid/100 g m.v.)		Carbohydrates (Brix %)		Anthocyanins (mg/100 g)	
	Media	**± St. Dev.**	**Media**	**± St. Dev.**	**Media**	**± St. Dev.**
1	0.32	0.0019	13.17	0.995	1.14	0.092
2	0.44	0.0019	13.02	1.052	1.04	0.018
3	0.43	0.0038	13.44	1.270	1.00	0.077
4	0.45	0.0009	13.52	0.815	1.58	0.005
5	0.50	0.0009	14.35	0.992	1.48	0.091
6	0.45	0.0009	13.17	0.863	1.17	0.078
7	0.41	0.0009	13.50	0.863	2.16	0.037
8	0.43	0.0009	14.34	1.441	0.98	0.209
9	0.48	0.0009	13.83	1.015	1.35	0.024
10	0.39	0.0009	13.22	1.220	1.72	0.076

CONCLUSIONS

The present study confirms the statements from the specialty literature regarding the possibility to improve fruit quality by using grafting intermediary. Using the rootstock B9 in combination the with vigorous rootstocks A2 and MM 111 led to an increase in fruit size, a slightly increased content in soluble dry matter, a better firmness and fruit coloring compared to the rootstock M9.

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