Scientific Papers. Series B, Horticulture. Vol. LXII, 2018
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

EFFECTS OF GRAFTING COMBINATIONS ON THE FRUIT QUALITY FOR THE PINOVA APPLE TREE

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Abstract

The quality of apple fruits is influenced by variety and within each variety by the rootstock and by the culture technology applied. The research presented in this paper highlighted the influence of the rootstock on the fruit quality. The experiment was conducted during 2016-2017 in the Vâlcea plant nursery, in Romania, as a comparative study for the 'Pinova' variety with several rootstocks (M9, B9, M20, Pi80, M106), including variants with grafting interstems (B9/A2, B9/M111). The size of the fruit was larger for the trees grafted on the rootstock B9 with the interstem M111, while the firmness was positively influenced by the rootstocks M9 and B9/A2. The content of soluble dry substance was favourably influenced by the rootstocks M20, B9 and Pi 80, while the titratable acidity had higher values for the fruits produced by the trees grafted on M106 and M9/M111. The total anthocyanins content was higher for the fruits obtained from the trees grafted on the rootstock B9 with the interstems M111 and A2.

Key words: *fruit weight, interstem, rootstock, soil management.*

INTRODUCTION

The apple tree is one of the most important fruit-growing specie cultivated in Romania due to its economic value and significant production. Fresh apples are highly appreciated for consumption throughout the whole year due to their healthy effects on the human body but can also be industrially processed in order to obtain various products based on pulp or juice.

The quality of fruits depends on a number of factors from which the following can be mentioned: the variety, the culture technology, the age of the trees, the pruning used (different training system) (Lord et al., 1985; Dudu et al., 2015; D' Abrosca et al., 2017).

Apple growers are constantly focused on making the apple production intensive with the aim of reducing the height of trees and the manual labour costs.

Making the production intensive is possible by grafting trees on dwarf rootstocks, particularly M9, but those trees need a supporting system.

Also, dwarf rootstocks are more sensitive to draught in comparison to standard rootstocks (Zhou et al., 2016).

In order to renounce the supporting systems and to ensure a better soil stability of trees, standard rootstocks and interstocks are used in order to decrease the vigour (Webster, 1995). The interstock influences the quality of fruits and the colour grade (Vercammen et al., 2007) and induces precocity (early fruiting) (Webster et al., 1995).

The length of the interstock influences the fruit production.

The one with a higher length leads to a higher productivity value and balances growth with fructification (Di Vaio, 2009).

The research conducted by Samad et al., (1999) with various dwarf rootstocks used did not highlight any significant differences of fruit weight in correlation with the rootstocks used.

In order to observe the way in which quality and quantity of fruits are influenced by the rootstocks and interstocks used a study was conducted using 13 grafting combinations at 'Pinova', a scab resistant apple variety, dwarf and semi-dwarf rootstocks and grafting interstocks to reduce the vigour.

MATERIALS AND METHODS

The research was conducted in the Valcea area during 2016-2017, in a 'Pinova' apple orchard established in 2015 with the planting distance of 3.6 m x 1.25 m and a number of 2222 trees/ha.

In order to highlight the influence of the grafting interstock, two lengths were used: 30 and 40 m respectively.

The soil was maintained either worked or grassy. Researchers used 13 grafting combinations, simple or with interstock, and for each combination they chose 9 trees divided in 3 repetitions.

The following experimental variants resulted:

V1 – Pinova/M106 – control;
V2 – Pinova/M9;
V3 – Pinova/M20;
V4 – Pinova/Pi 80;
V5 – Pinova/B9;
V6 – Pinova/B9/MM111, interstock 30 cm, worked soil;
V7 – Pinova/B9/MM111, interstock 30 cm, grassy soil;
V8 – Pinova/B9/MM111, interstock 30 cm, buried;
V9 – Pinova/B9/MM111, interstock 40 cm, worked soil;
V10 – Pinova/B9/A2, interstock 30 cm, grassy soil;
V11 – Pinova/B9/A2, interstock 30 cm, worked soil;
V12 – Pinova/B9/A2, interstock 40 cm, grassy soil;
V13 - Pinova/B9/A2 interstock 40 cm, buried, grassy soil.

For combinations with interstock the influence of deep planting was tested, the interstock being planted as well.

The maintenance technology applied in the orchard was the standard one used at high-density apple culture.

At harvest, the data registered regarded the production per tree and per hectare and average samples of 15 fruits were collected from each grafting combination on which physical and chemical determinations were carried out.

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

Soluble solids were determined from blueberry juice (Saei, 2011; Oltenacu, 2015), with the refractive device Kruss DR301-95 (% Brix).

The titratable acidity was determined by titration with 0.1N NaOH to pH 8.1 (Saei, 2011). For titration with 0.1 N NaOH the automatic titrator TitroLine easy was used. The results were expressed in g citric acid/100g of fresh weight.

Total anthocyanins content was measured with spectrophotometrically at wavelength $\lambda = 540$ 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 the absorbance and factor F = 11.16. The total anthocyanins content was expressed in mg/100 g of fresh weight.

All determinations described above were performed with Specord 210 Plus spectrophotometer. The preliminary data registered were statistically interpreted using the method of variant analysis for probability of 5%, 1% and 0.1 %.

RESULTS AND DISCUSSIONS

The average production of fruits per tree for the first 2 years of fructification (2nd and 3rd year of life) was moderate but different for the experimental variants (Table 1).

Approximately half of the variants had a relatively equal productivity.

A lower production was registered at the grafting combinations M20, MM111+B9 interstock with the length of 30 cm, buried and A2+B9 interstock of 40 cm.

The best production for ‘Pinova’ resulted from the combination MM111+B9 interstock of 30 cm and worked soil. Statistically, the highest production was registered at variants V6 and V7, very significant in comparison to the average one.

On the other hand, the lowest was at variants V3, V10 and V11, significantly negative.

Table 1. Fruit production and average fruit weight at the ‘Pinova’ apple variety

Variant	Production		Average fruit weight	
	kg/tree	t/ha	g	Std
V1	10.0^{oo}	22.22	161.47***	8.22
V2	11.9 *	26.44	137.41^{000}	7.24
V3	8.5^{ooo}	18.88	156.32***	6.53
V4	11.3 N	25.11	128.56^{000}	9.20
V5	12.0 **	26.66	151.62***	7.13
V6	12.7 ***	28.22	104.41^{000}	8.37
V7	12.3 ***	27.33	161.47***	6.57
V8	11.9 *	26.44	138.26^{000}	4.36
V9	12.1 **	26.88	194.52***	8.62
V10	9.0^{ooo}	19.99	141.91^{000}	5.34
V11	9.5^{ooo}	21.11	114.57^{000}	4.87
V12	11.2 N	24.88	157.70***	6.58
V13	11.6 N	25.77	169.04***	4.69
Average- control	11.16	24.61	147.48	4.21
LSD 5%	0.66		0.81	
LSD 1%	0.90		1.10	
LSD 0.1%	1.21		1.47	

* - significant values for the 5% probability; ** - significant values for the 1% probability; *** - significant values for the 0.1% probability.

Average fruit weight was influenced dramatically by the variants used. Thus, the biggest fruits were obtained at V9, over 194 g/ fruit, followed by V13 with 169 g /fruit and variants V1 and V7 with over 161 g/fruit. The smallest fruits were obtained at V6 with only 104 g/fruit and V11 with roughly 114g/fruit. It is worth mentioning that the first two variants with big fruits were the ones with grafting interstock on standard rootstocks. Statistically, the variants were divided in 2 groups: one under average, significantly distinctive and the other above the average, significantly positive.

The fruit diameter influenced fruit weight, even though the variation limit was small (Table 2). The correlation index between the average weight and fruit diameter was of r = -0.4881 (Figure 1). The grafting combination also influenced the fruit firmness. The strongest fruits were obtained by V2 with 10.24 kg/cm^2 followed by V11 with 9.14 kg/cm^2. Lower values were noted at V3 and V7 with 7.29 kg/cm^2 and 7.33 kg/cm^2, respectively. All other variants had intermediate values (Table 2). Statistically, values over 8.60 kg/cm^2 were significantly positive and the ones under 7.92 kg/cm^2 were significantly negative.

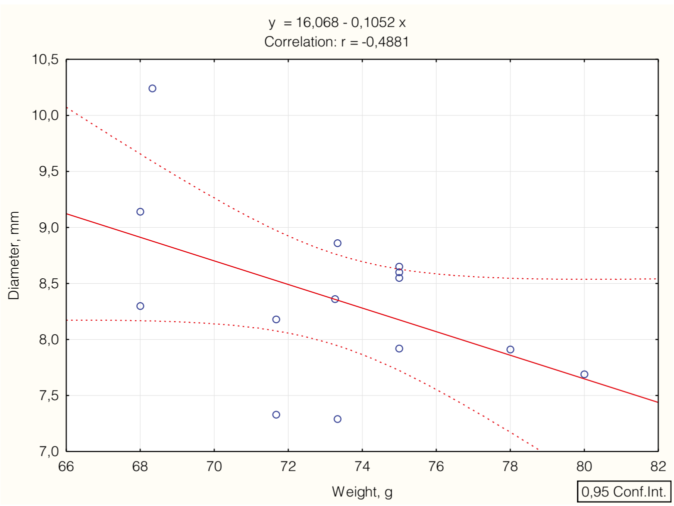

Figure 1. Correlation between fruit weight and fruit diameter

Table 2. Diameter and firmness of fruits at the 'Pinova' apple variety grafted on various rootstocks

Variant	Fruit diameter		Firmness	
	mm	Std	kg/cm^{-2}	Std
V1	75.00**	7.07	7.92^{ooo}	0.49
V2	68.33^{ooo}	5.77	10.24***	1.39
V3	73.33 N	2.89	7.29^{ooo}	0.39
V4	68.00^{ooo}	3.54	8.30 N	0.66
V5	73.33 N	5.77	8.86***	0.86
V6	75.00**	0.58	8.65***	0.44
V7	71.67 N	5.77	7.33^{ooo}	0.31
V8	71.67 N	2.89	8.18 ^{o}	1.10
V9	80.00***	0.58	7.69^{ooo}	0.43
V10	75.00**	5.00	8.60**	0.71
V11	68.00^{ooo}	3.54	9.14***	0.75
V12	75.00**	5.00	8.55**	0.75
V13	78.00 N	3.54	7.91^{ooo}	1.07
Average	73.26	4.00	8.36	0.72
LSD 5%	1.40	-	0.14	-
LSD 1%	1.90	-	0.19	-
LSD 0.1%	2.55	-	0.25	-

* - significant values for the 5% probability; ** - significant values for the 1% probability; *** - significant values for the 0.1% probability.

The water and the total dry substance content were less affected as opposed to the physical parameters of fruits (Table 3). The lowest content of water was observed at V11 of roughly 78.25%, and the highest at fruits from V13, of 81.40%. The content of total dry substance was complementary to the one of water. Statistically at V6, V9 and V11 the difference was significantly positive in comparison to the average and at V7, V8, V12 and V13 the difference was significantly negative in contrast to the average one. Glucides formulated in °Brix accumulated more at fruits from V3, reaching the maximum value (19 °Brix) and it was noted statistically as very significant. Lower values were obtained at V7 and V8, under 15.5 °Brix. The content of ash was between 0.21% at V2 and 0.44% at V11 without a visible correlation with the total dry substance and the content of glucides.

Table 3. Some biochemical parameters of fruits from the 'Pinova' variety grafted on various rootstocks

Variant	Water %	Total dry substance %	Glucides (°Brix)	Ash %
V1	80.69	19.31 N	16.6 N	0.37
V2	79.53	20.47**	17.27 N	0.21
V3	80.08	19.92 N	19***	0.27
V4	80.14	19.86 N	17.4 N	0.38
V5	80.34	19.66 N	15.8 ^{o}	0.27
V6	79.04	20.96***	16.82 N	0.24
V7	83.48	16.52^{ooo}	14.07 ^{ooo}	0.20
V8	81.33	18.67^{ooo}	15.52^{oo}	0.28
V9	78.91	21.09***	17.46 N	0.31
V10	80.21	19.79 N	16.65 N	0.26
V11	78.25	21.75***	17.5 N	0.44
V12	81.27	18.73^{ooo}	15.63 ^{o}	0.25
V13	81.40	18.60^{ooo}	15.47 N	0.28
Average- Control	80.36	19.64	16.55	0.29
LSD 5%		0.46	0.81	
LSD 1%		0.62	1.10	
LSD 0.1%		0.84	1.47	

* - significant values for the 5% probability; ** - significant values for the 1% probability; ***- significant values for the 0.1% probability.

Table 4. Titratable acidity and antocyanin content at fruits from the ‘Pinova’ variety grafted on various rootstocks

Variant	Titratable acidity		Anthocyanin	
	g/100 g f.w.	Std	mg/100g f.w.	Std
V1	0.379	0.001	0.763	0.037
V2	0.330	0.005	0.143	0.063
V3	0.296	0.016	0.706	0.052
V4	0.318	0.004	0.576	0.070
V5	0.348	0.012	0.773	0.060
V6	0.307	0.016	0.537	0.020
V7	0.186	0.001	0.848	0.034
V8	0.298	0.003	1.151	0.033
V9	0.369	0.004	0.603	0.870
V10	0.362	0.006	0.478	0.051
V11	0.342	0.002	0.591	0.057
V12	0.346	0.007	1.064	0.013
V13	0.270	0.005	0.673	0.085
Average - Control	0.319	0.006	0.685	0.111

Fruit acidity oscillated from simple to double, being weaker at V7, with roughly 0,186 g/ 100 g f.w. and maximum at V1, with 0.379 g/100 g f.w. All other variants registered intermediate values (Table 4). The highest quantity of anthocyanins was registered at fruits from V8 and V12 with over 1060 mg/100 g f.w and the smallest values were at fruits from V2 with only 0.143 mg/100 g f.w.

CONCLUSIONS

The present study proved how the grafting combinations influenced the size and quality of fruits of the ‘Pinova’ variety.

Generally, fruits of better quality were obtained at combinations were a grafting interstock was used. Interestingly, the most used rootstock, the M9, yielded well and produced firm fruits with a high content of dry substance but they were small, weakly coloured and with few minerals.

Good colours were obtained at V8 and V12 and a high content of dry substance, over 21%, was registered at V9 and V11.

The worked soil determined a better growth of fruits but it did not register other correlations for the other indicators observed. The grassy soil assured a better colouration.

The interstock of 30 cm induced a slight growth of the fruit size and a satisfactory accumulation of soluble dry substance in comparison to the interstock of 40 cm.

Deep planting of trees, including of the interstock actuated a slight growth of fruit size, a good firmness and a better colouration.

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