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THE GRAFTING BEHAVIOR OF 'ANDREEA' PLUM CULTIVAR GRAFTED ON GENERATIVE ROOTSTOCK WITH INTERMEDIARY

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Abstract

The behaviour of 'Andreea' plum variety was studied, on different rootstocks and with different grafting variants. As rootstock, selections of Prunus cerassifera and armeniaca vulgaris were used. And the graft variants were with the intermediary (Rival) and without the intermediary, by different grafting methods (improved copulation and budding chip). The diameter was analyzed at the grafting point, 5 cm above and below the grafting point, graft height, length and number of shoots. The results show that regardless of the rootstock used, the intermediary influences the growth force in a negative way.

Key words**:** *grafting, rootstock, intermediary.*

INTRODUCTION

Grafting is a common practice for fruit tree propagation. The rootstocks used for a specific culture are close relatives of the culture or wild selections (especially within the genera), but grafting between different species has also been observed (Warschefsky et al., 2016). The use of rootstocks that control the vigour is a method used to promote precociousness, reduce vigour and increase productivity (Webster, 2004). Also, grafting with intermediary is used to induce tolerance to cold, resistance to disease and vigour reducing (Rogers and Beakbane, 1957). The rootstock selection is a powerful tool for sustainable intensification of fruit production, as while graft can be used to induce fruit properties, adaptation to water deficit and high salinity, tolerance to alkaline soils and susceptibility to agents can be influenced by rootstock choice. (Jensen et al., 2012; Marguerit et al., 2012; Tamura, 2012). Necas and Krska (2013) evaluated the propagation potential and efficacy of fruit tree rootstocks using different phytohormone concentrations.

Koepke and Dhingra (2013) stated that rootstock controls many aspects of graft growth and physiology, including quality production and attributes, as well as biotic and abiotic stress tolerance, and the study of somatic genetic interactions between rootstock and graft is an area that can bring vast improvements in the next decade in today's agricultural environment, where sustainable production practices are needed, the rootstock offering a non-transgenic approach to respond quickly to the changing environment and to expand agricultural production of annual and perennial crops, where grafting is possible to responds to the needs of global food, fiber and fuel.

The plum cultivar 'Andreea' was obtained at SCDP Vâlcea, Romania, in 2000. The tree has medium vigour, with semi-erect bearing resistant to moniliosis and red spots of leaves, tolerant to Plum pox. The middle blossoming timing, partially self-fertilizing, requiring pollinators: Stanley, Anna Spath. The fruits are ripening at the end of August, showing a staggering ripening.

As generative rootstocks for grafting the 'Andreea' plum cultivar, the cherry plum (*Prunus cerasifera*) and the apricot tree (*Armeniaca vulgaris*) were used, and the Rival vegetative rootstock was used as an intermediary.

Specific to culture technology, the use of grafted material brings many advantages (Ercisli et al., 2006). Studies conducted on the influence of intermediary on growth parameters of grafted trees, have shown that the intermediary, depending on its length, has a greater or lesser impact on precocity and vigour, noting that the length of intermediary caused the reduction of trees vigour and fruit

production (DI VAIO et al., 2009). Moreover, it seems that the diameter and the number of wood vessels are the main characteristics of rootstock that influence the vigour of grafted trees, the absolute values of measured parameters being higher in the grafted trees with intermediary (Tombesi et al., 2010).
Hernández et al. (2010) analyzed the influence of rootstocks on flowering, cross-section area of trunk, yield and quality parameters of *Prunus armeniaca* L. fruits, grown in a Mediterranean agro-climatic environment, in an experimental orchard in the southeast Spain, also showed that the rootstock had no significant influence on the number of flowers, but induced a higher weight of fruits, the fruit weight being positively correlated with pulp production and negatively with the TCSA.
Also, the precocity and colour of fruits was influenced by rootstocks. Zhilong (2016) analyzed the effects of rootstocks on the increase of absorption, accumulation and use of nutrients, as well as the mechanism involved.
The aim of this study was to reduce the vigour of grafted variety for setting up superintensive plantations; for inducing the fruit-setting precocity and quantitative and qualitative improvement of fruits.

MATERIALS AND METHODS

The experiment regarding the studied material was established at the Didactic Station, Banu Mărăcine of the University of Craiova, located in the southern extremity of Getic Plateau between the coordinates 44º19'' north latitude and 23º48'' east longitude, at a distance of 6 km from the town of Craiova.
The grafting was performed at the table, both of the intermediary on the two rootstocks by the improved copulation method, and of cultivar on the intermediary using the chip budding method. The rootstock seedlings were harvested in autumn after the fall of leaves from the seedling and stratified nursery, and before grafting it was put to pre-forcing. Scions were harvested in autumn and kept in the refrigerator at 4°C. Both methods of grafting, both of the intermediary on the two rootstocks (cherry plum and apricot tree) in improved copulation and of the cultivar on the intermediary in chip budding, were performed in the first ten days of March. The grafting of intermediary on rootstocks and grafting of cultivar on the intermediary were carried out at the same time. The length of the intermediary was 20 cm. The same rootstocks and cultivars were used as control but without the Rival intermediary. The experiment is of a bifactorial type, located in a linear way.
Maintenance operations were carried out at regular intervals, such as removal of shoots started from rootstocks, irrigation, fertilization, phytosanitary treatments. At the end of vegetation period, the following observations and determinations were made: diameter (mm) at grafting point, diameter (mm) 5 cm above grafting point, diameter (mm) at 5 cm below grafting point, graft height. For determination of diameter, the electronic caliper with an accuracy of 0.01 mm was used. The determinations were made for both intermediate and non-intermediate variants. The data obtained were processed using the statistical analysis program (Stat Point Technologies, Warrenton, VA, USA).

RESULTS AND DISCUSSIONS

Rootstock improves the vigour of plants, extends the vegetation period (Lee et al., 2010), productivity and fruit quality (Huang et al., 2011; Rouphael et al., 2010; Tsaballa et al., 2013), extends the quality of fruits after harvest. (Zhao et al., 2011), increases tolerance to low and high temperatures (López-Marín et al., 2013; Li et al., 2016), reduces stress caused by salinity and heavy metals (Santa-Cruz et al., 2002; Estañ et al., 2005; Albacete et al., 2009; Schwarz et al., 2010; Huang et al., 2013a; Wahb-Allah, 2014; Penella et al., 2015, 2016), increases resistance to floods (Bhatt et al., 2015), improves efficiency of water usage (Cantero-Navarro et al., 2016), manages resistance to soil pathogens (Arwiyanto et al., 2015), manages nematode resistance (Lee et al. ., 2010), gets the weed control (Dor et al., 2010; Louws et al lab., 2010) and produces new plant species (Fuentes et al., 2014).
The grafting with intermediary was carried out in order to reduce the vigour of graft in order to intensify the plum crops, the earliness of the fruit-setting, to increase the productivity and quality of fruits. The obtained results regarding

Table 1. Characteristics of studied material

Variants	Descriptive Statistics	Diameter (mm)			Graft height
		At grafting point	At 5 cm above grafting point	At 5 cm below grafting point	
Andreea – Cherry plum	Average ± SE	18.25 ± 0.48	10.73 ± 0.43	11.98±0.46	113.79 ± 3.54
	Standard Deviation	1.79	1.62	1.75	13.26
	Minim/ Maxim	14.11/20.63	6.65/12.91	8.99/16.31	95/148
	Variation coeff. (CV %)	9.80	15.09	14.60	11.65
Andreea – Rival - Cherry plum	Average ± SE	12.62 ± 0.69	7.86 ± 0.35	9.58 ± 0.23	69.06 ± 3.64
	Standard Deviation	2.77	1.41	0.94	14.58
	Minim/Maxim	9.35/19.09	5.29/10.49	7.48/10.83	50/99
	Variation coeff.	21.94	17.96	9.82	21.11
Andreea – Apricot	Average ± SE	21.22 ± 0.51	12.12 ± 0.38	12.62 ± 0.32	130.03 ± 5.96
	Standard Deviation	2.79	2.11	1.80	32.65
	Minim/Maxim	13.33/26.34	6.21/16.53	9.17/16.61	84/211
	Variation coeff.	13.15	17.42	14.27	25.11
Andreea – Rival - Apricot	Average ± SE	13.57 ± 0.54	8.72 ± 0.25	10.21 ± 0.20	84.43 ±3.05
	Standard Deviation	2.16	1.22	0.96	14.65
	Minim/Maxim	10.47/18.13	6.17/11.03	8.76/12.30	60/117
	Variation coeff.	15.92	13.99	9.40	17.35

the characteristics of the studied material are presented in Table 1.

The average values regarding the height of the studied material show significant differences in the four variants studied, namely in the variants grafted with intermediary, the average height of graft was 69.06 cm in Andreea-Rival-cherry plum variant and 84.43 cm in Andreea- Rival-apricot, compared to the variants grafted without intermediary, namely: Andreea-cherry plum where the average height was 113.79 cm, and for the Andreea-apricot variant the average height was 130.03 cm.

Variation range regarding the height of graft had values between 50 cm and 99 cm for Andreea-Rival-plum cherry variant, 60 cm and 117 cm in Andreea-Rival-apricot variant and in variants without intermediary the limits were between 95 cm and 148 cm in Andreea-plum cherry and 84 cm and 211 cm in Andreea-apricot.

With regard to graft growth, major differences were observed in grafted variants without intermediary compared to the grafted variants with intermediary, highlighting the role of the intermediary in grafting. The coefficient of variation regarding the height of graft had the following values 21.11% in Andreea-Rival-plum cherry variant, respectively 17.35% in Andreea-Rival-apricot variant, and in the non-intermediate variants the values were 11.65% in Andreea-plum cherry and 25.11% in Andreea-apricot. The largest length of shoots growth was recorded in Andreea-apricot variant (211 cm).

The vigour of fruit trees and the vegetative growth is generally given by the size of trunk diameter. The determinations made on the values of diameter at the grafting point revealed that the variants grafted with intermediary had lower values, 12.62 mm in Andreea-Rival-plum cherry variant, respectively, 13.57 mm in Andrea-Rival-apricot variant, compared to the grafted variants without intermediary, which had values of 18.25 mm in Andreea-plum cherry variant and of 21.22 mm in Andreea-apricot variant.

Regarding the material studied, the limits were significant regarding the diameter at the grafting point being between 9.35 / 19.09 mm in Andreea-Rival-cherry plum variant and 10.47/18.13 mm in Andreea-Rival-apricot variant, and in variants without intermediary the limits were between 14.11/20.63 mm in Andreea-cherry plum and 13.33/26.34 mm in Andreea-apricot. The values of variation

coefficient on this feature were between 21.94% in Andreea-Rival-cherry plum variant and 15.92% in Andreea-Rival-apricot variant, and for non-intermediary variants they were 9.80% in Andreea-cherry plum and 13.15% in Andreea-apricot. The values of variation coefficient indicate a specific average variability for diameter at grafting point. The diameter at 5 cm above the grafting point for the variants grafted with intermediary had the average value between 7.86 mm in Andreea-Rival-cherry plum respectively 8.72 mm in Andreea-Rival-apricot and in grafted variants without intermediate the average value was 10.73 mm in Andreea-cherry plum and 12.12 mm in Andreea-apricot. Variation range for variants grafted with intermediate had values between 5.29/10.49 mm (Andreea-Rival-cherry plum) and 6.17/11.03 mm (Andreea-Rival-cherry plum), and for variants without intermediary they were 6.65/12.91 mm (Andreea-plum cherry) and 6.21/16.53 mm in Andreea-apricot. Variation coefficient had the following values, 17.96% (Andreea-Rival-cherry plum), respectively, 13.99% (Andreea-Rival-apricot) and 15.09% in Andreea-cherry plum, respectively, 17.42% in Andreea-apricot.

The average values of diameter at 5 cm below grafting point in the 2 variants grafted with intermediary were 9.58 mm (Andreea-Rival-cherry plum), respectively, 10.21 mm (Andreea-Rival-apricot), and for grafted variants without intermediate were in Andreea-cherry plum variant of 11.98 mm, respectively, 12.62 mm Andreea/apricot. Variation coefficient had values of 9.82% (Andreea-Rival-cherry plum), and 9.40% (Andreea-Rival-apricot), and in variants without intermediary the values of variation coefficient were 14.60% in Andreea-cherry plum, and 14.27% in Andreea-apricot. The values of variation coefficient for this characteristic show an average variability, indicating a good uniformity within the studied variants.

Di Vaio et al. (2009) showed that in apple tree the intermediate determined a vegetative growth of less than 50-80% compared to control plants, an increase of fruit production and the average weight of fruits and the increase of length of the intermediate caused the reduction of growth vigour of plants and the reduction of fruit production, the length of 10 cm of the intermediary being the one that gave the best results.

Many other scientific studies confirm the intermediary's effectiveness in controlling the vigour of trees and, in some cases, in inducing early fruiting and increased productive efficiency and fruit quality (Vercammen et al., 2007; Samad et al., 1999; Webster, 1995).

It is recommended to choose the intermediary based on agronomic factors, such as distance from the graft point and the length of intermediary (Beakbane and Rogers, 1956; Rufato et al., 2001).

Other experiments have shown that the decrease of growth induced by the intermediary depends on its vigour (Lockard and Lasheen, 1971), the rootstock and the cultivar used (Tukey, 1943; Carlson, 1965).

In order to verify criteria between the characteristics of material studied, the correlation coefficient between: diameter at grafting point and the height of graft, the diameter at 5 cm above grafting point and the height of graft, the diameter at 5 cm below grafting point and the height of graft, was determined, the correlation between the three diameters and the number of shoots, the correlation between the three diameters (at the grafting point, 5 cm above and 5 cm below the grafting point) and the total length of shoots (Table 2).

From the data obtained it is found that there are positive correlations between the three diameters, at the grafting point, 5 cm above and 5 cm below the grafting point and the graft growth in all the analyzed variants, the highest values being in Andreea-apricot ($r = 0.76$), and Andreea-Rival-apricot ($r = 0.75$), between the three diameters and the total length of shoots, in Andreea-apricot ($r = 0.70$), at Andreea-Rival-apricot ($r = 0.81$).

Table 2. Correlation coefficient of characteristics in studies material*

Characteristics/ Variants	H				No. of shoots				Total length of shoots			
	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4
DP	0.54	0.59	0.54	0.56	-0.10	0.23	-0.06	0.39	-0.28	0.50	0.06	0.59
DDP	0.52	0.76	0.64	0,75	0.38	0.23	0.12	0.57	0.23	0.56	0.27	0.81
DSP	0.17	0.57	0.34	0.40	0.38	0.49	0.08	0.44	0.57	0.70	0.39	0.61
No of shots/total length of shoots	V1				V2				V3			V4
	0.91				0.77				0.77			0.76

*DP: Diameter at grafting point; DDP: Diameter at 5 cm above grafting point; DSP: Diameter at 5 cm below grafting point; V1: Andreea-cherry plum; V2: Andreea-apricot; V3: Andreea-Rival-cherry plum; V4: Andreea -Rival-apricot.

Significant correlations were also calculated between the number of shoots and the total length of shoots, for all four variants analyzed ($r = 0.91$; $r = 0.77$; $r = 0.76$). The rootstock has a higher vigour to increase the graft compared to the rootstock on both graft variants (with and without intermediary).

The role of the intermediary used in the grafting process is to ensure the compatibility between graft and rootstock; to reduce the growth vigour of grafted cultivar; induces the precociousness of fruit-setting; ensures adaptability to environmental conditions of grafted cultivar it influences the increase of productivity and fruit size.

CONCLUSIONS

Resulting from the study, it was noted that grafting with an intermediary has a key influence on reducing the growth vigour in order to intensify the plum crops.

Apricot graft has imprinted a higher growth vigour of the graft compared to the cherry plum rootstock in both grafting variants (with and without intermediary).

The largest growth length of anticipated shoots was recorded in Andreea-apricot variant.

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