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Study of the Root System of some Clonal Apple Rootstocks in Coastal Lowland Conditions

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Abstract

Several clonal apple rootstock (M9, Pajam 1, Pajam 2, Supporter Pi-80, MM106. MM111 and M26) were planted in Lushnja area, west of Albania in order to study their suitability under specific soil and climate conditions of this region. The transplanting distanceswere 1.5 x 0.9 mm and each rootstock was represented by 10 plants. The analyses of root system was conducted by two different methods; the profile method with trenches and coring method. Based on their respective diameter, the roots were classified into three groups:<2mm, 2-4 mm, and > 4 mm. Based on the results of this study we conclude that the trench profiling and core drilling methods gave similar results regarding root system distribution. Under this specific environment conditions, Pajam 2, Pajam 1, Supporter and M9 demonstrated a more harmonious in depth and side distribution of the root system.Based on the number of shoots produced from each plant and their average diameter, Pajam2, Pajam 1 and Supporter seems to be the most convenient apple rootstokc for the conditions of Lushnja region.

Keywords: root system; clonal rootstock; trench profile method; core drilling method; symbiosis.

1. Introduction

Apples are among the most consumed fruits. The demand for this product is evergrowing, both nationally and internationally. This has led to radical changes that have resulted in the transition from traditional production systems (long distance planting) to intensive production systems; utilizing narrow distances and small crowns.Dwarfing rootstocks have been the key to the dramatic changes in tree size, spacing and early production. [27].

The construction of intensive orchards is seen as a necessity, not only for an early entry into production and for obtaining quality products, but also as an opportunity for an easier management of the canopy, with as the minimum costs. This leads to greater profitability of orchards [14;19;22].

Clonal rootstocks control the size of the tree and are more important from an economic point of view, as they allow to increase the density of the orchard, giving higher yields / ha. as well as superior quality fruit [18].The superficial root system, which generally characterizes clonal rootstocks, can explore a limited amount of the soil layer and this has been used in orchards to control growth power in orchards. [32].

Grafted plants represent a symbiotic relationship between two individuals who are able to modify many of the vegetative and

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productive characteristics as a result of the interaction between them (rootstock / graft). Regarding the rootstock, the most fundamental and important factor is the root system, which conditions the well-being of the entire vegetative and productive activity of the tree. Its adaptation as closely as possible to certain environmental conditions increases the efficiency and gives positive impacts on all of the vital activity of the tree [3;4;5;10;18;19;21;22;23;27].

After a long experience, almost 50 years, it has been concluded that the combinations of the two elements joined in grafting must be fully adapted with the soil and climatic conditions, the type of orchard and its biological and physiological characteristics[8;10;13;24;30;31;].

The level of environmental adaptability depends on the root-architecture, the anatomical and morphological characteristics of the roots (diameter and level of suberization), and the metabolic level (absorption and hydraulic conductance)[7;16;17;26;29].).

The density and length of the root system of the substratum varies by species and in different environments [9].

However, the root system of high density orchardshas still many unknowns. More studies and the harmonization of the study's results would increase the efficiency of the orchard, which is in turn directly related to the efficiency of the root system (absorption of water and minerals) [4;7;9].

In this context, choosing the most compatible cultivar and roostock with a specific environment remains the main purpose for an orchard. However, most of the research, for apparent reasons, are concentrated on the impact of rootstocks on the vegetative growth, decrease of crown volume, orchard productivity and quality[3;10;11;18;19;20;21;22;23;27].

Our study had the aim of exploring the allocation of root biomass and root architecture of several rootstocks in the conditions of the coastal area of Albania, which is a new area for the cultivation of apples.

2. Material and Methods

The study included rootstocks M9, Pajam 1, Pajam 2, Supporter Pi-80, MM106, MM111 and M26.

The seven aforementioned rootstocks were planted in the Lushnja area to conduct comparative studies on their behavior in the ecological conditions of our country. The study mainly focused on the root system architecture of each substrate in the coastal plain conditions (Lushnje).

The study is carried out in Dushk (Lushnja) (40 ° 58'33 "N, 19 ° 40'16" E) which belongs to the coastal area of Albania, with a warm Mediterranean climate and dry summers, for a total of 5245 h of average temperatures above 10 ° C.

The transplanting distances were 1.5 x 0.9m and each rootstock is represented by 10 mother plants.

The soil of the experimental site is classified silty-clay. Sand, silt and clay composition at the upper soil layer (0-30 cm) were respectively 11.07%, 46.58% and 42.35%, and at the second (30-60 cm) layer, were respectively 4.62%, 30.35% and 65.03% (***(Laboratori i UBT)***.

To study the root system we used:

A-the trench profile method, which was developed back in 1892 and was used by many authors until the end of the 1960s. Although it is a laborious and destructive method, it provides good results in cartography (mapping) of the root system[1;6].

The opened trench was1m deep in the transverse direction of the row.The distance of the trench's opening from the mother plant was 15 cm, while with a width of 70 cm on one side and 30 cm on the other.(fig.1)The mother plants were 4 years old.

For the purpose of counting and mapping the apple root we used a metallic screen with 8×10 cm quadrats, which has allowed us to calculate the distribution of roots in different categories

depending on their depth and width. Roots were grouped into three categories; roots with a diameter of <2 mm (or fine absorbing roots), roots with a diameter of 2-4 mm (or intermediate roots), and roots with a diameter >4 mm (thick roots)[12;25].

B- In addition to the trench profilemethod, the carrotage method (Sequential Core Method) was also used[28].which consisted in taking samples from a depth of up to 80 cm from a soil cylinder with a diameter of 7 cm, equivalent to 3077 cm3 of soil. For each substrate, three samples were taken at a distance of 15 cm; 45cm and 75 cm from the mother plant. The samples were then washed with running water and the roots were separated from the soil using a 1.5x1.5mm or 2.25mm2 strainer. The roots have been further divided according to the above categories. The fresh roots were weighed in the laboratory and further dried at 70 degrees for 6 days.

Data were analysed using the ANOVA test, followed then by the Tukey-Kramer test at 95%.

3. Results and Discussion

a- Total number of roots

The data obtained for the total number of roots shows that Pajam 2 rootstock is ranked first with 247 roots, followed by M26, Pajam 1, M9 and Supporter: 132, 111, 101roots respectively) (tab.). Pajam 1 and Pajam 2 are clones of M9 with more potent vegetative indicators, while M26 and Supporter are hybrids with participation of M9. All these rootstocks are recommended for intensive orchards and more fertile soils. M26 is not compatible with heavy (clayey) soils. The above data are consistent with those found by other authors[2;30;32].

b- Structure of the roots. In the structure of the root system, not only the total number of roots is important, but also their nature.In apples, the roots with a diameter of 2-4 mm, which are located at the beginning of the secondary structure, also perform absorption functions in a moderate amount.

Roots thinner than 2mm account for the majority of the total number of roots and range from 75% (P1) to 98% (M26). They are the most effective roots in absorbing water and nutrients.(Tab.1).

Roots of category > 4mm have indisputable advantages for Pajam 2, Pajam 1 and Supporter rootstocks

Table 1. Root category data obtained through the trench profile method

Rootstock	Total root	Root diameter						Depth							
		< 2 mm		2-4 mm		>4 mm		0-20 cm		21-40 cm		41-60 cm		61-80 cm	
Pajam 1	112	84	[C]	19	[A]	9	[A]	29	[A]	38	[A]	39	[A]	6	[A]
Pajam 2	247	222	[A]	14	[B]	11	[A]	49	[A]	87	[B]	80	[B]	31	[B]
S.4Pi80	89	72	[D]	9	[C]	8	[AB]	30	[A]	32	[B]	18	[B]	9	[BC]
M9	101	91	[C]	10	[C]	0	[D]	25	[A]	42	[B]	32	[BC]	2	[CD]
MM106	99	89	[C]	5	[D]	5	[BC]	57	[B]	29	[B]	13	[BCD]	0	[D]
M26	132	130	[B]	1	[E]	1	[D]	60	[B]	34	[B]	37	[CD]	1	[D]
MM111	88	82	[C]	4	[D]	2	[CD]	61	[B]	17	[B]	9	[D]	1	[D]

Different letters show statistical differences. Comparisons for all pairs using Tukey-Kramer HSD; α *-0,05*

c- Distribution of roots in depth and width

The data obtained through the trench profile method show that the Pajam 2, Pajam1 and

Supporter rootstocks occupy the largest volumes of soil reaching a depth of up to 80 cm.

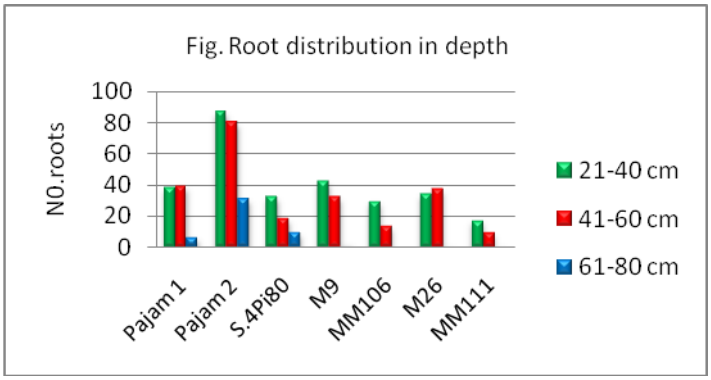


Figure 1.

However, we underline that for all rootstocks the depth 40-60 cm is the most utilized, except MM111 which does not exceed 40 cm in depth.(Tab.1, Fig.1)

Even when consideringthe width distribution, the Pajam 2, Pajam 1 Supporter rootstocks followed by the M9 remain in the upper positions. The rootstocks MM106, M26 and MM111 have a more limited distribution (Fig.2) This is apparently influenced by the nature of the soil, as it is known that these rootstocks are classified as more suitable for ventilated and dry soils. In the conditions of the area where the study was conducted, the soil is of the mud-clay type, which does not satisfy these rootstocks. The Pajam and Suporter subsoils are more likely to overcome the stressful conditions caused by this soil texture.

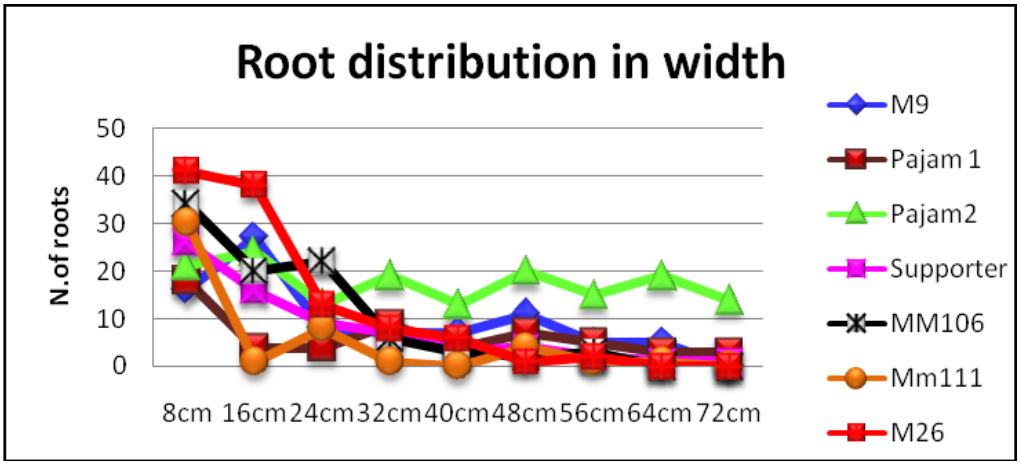


Figure 2. Spatial distribution of the root system

d- Mapping of the root system for the studied rootstocks.

The data obtained through the trench profile method and their placement in a planimetry (map) clearly presents the distribution of the root system by category,

in the different soil layers. Roots with diameter <2 mm, 2-4 mm and> 4 mm are marked respectively with a circle, X and square.(Fig.3).

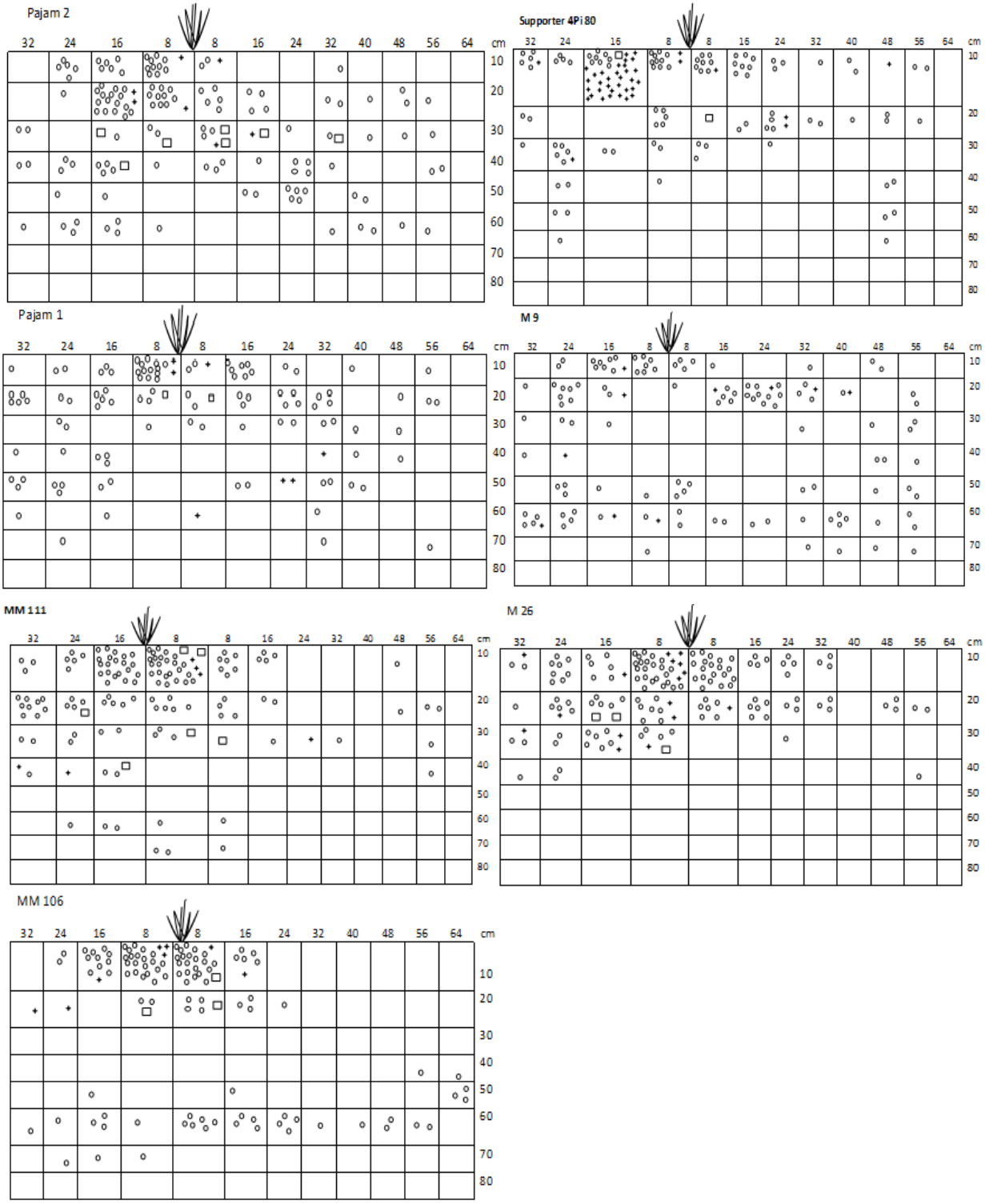


Figure 3. Spatial distribution of the radicl apparatus for the study rootstocks

The planimetric map representation shows that samples such as Pajam 2, Pajam 1 and M9 shows a more harmonious distribution in the soil profile. Pajam 2 contains abigger number

of skeletal roots. Supporter concentrates the roots close to the surface together with M26, while MM106 and MM111 concentrate the roots more around the plant stump.

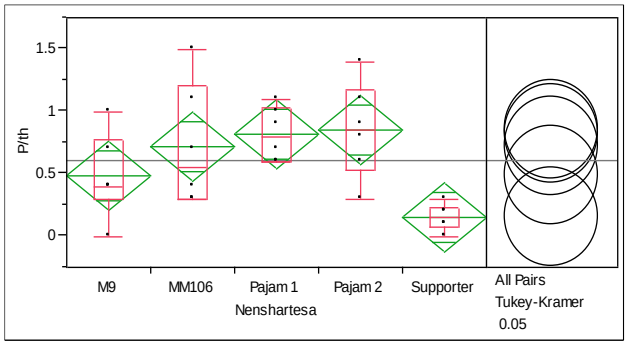
The core drilling method

Figure 4. Aspects of sampling

The results obtained with this method show that the Pajam 2 and Pajam 1 rootstocks reach the highest values of root weight for the same volume of soil. They also have an almost equal distribution in the space that occupies the entire volume of analyzed soil. The most uniform distribution is found in the Supporter rootstock, while for the M9 it was noticed that when moving away from the stump axis there is a reduction of the roots, which becomes even more pronounced in MM106.

The highest values were found for the Pajam 2 and Pajam 1 rootstocks. These rootstocks create more root biomass, as is also demonstrated by the trench profile method. With both methods, similar data are obtained, giving a senseabout the nature of the distribution of the root system under the conditions of our study.

Oneway Analysis of dry weight/By rootstocks



Level			Mean
Pajam 2	A		0.85000000
Pajam 1	A		0.81666667
MM106	A	B	0.71666667
M9	A	B	0.48333333
Supporter		B	0.15000000

Figure 5. Variability by dry weight of the root

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Root system and vegetative growth

Various authors [3;7;15;26].state that there is a dependence relationship between root growth, photosynthetic activity and vegetative growth of the plant.Rootstock stumps are always new as they provide the necessary rootstocks each year.This phenomenon is fully consistent with the nature of seedling production.

Number of shoots per stump and their diameter

The data reported in the table 2, show that the rootstocks Pajam 2, Supporter and Pajam 1 give a greater number of shoots and larger diameters. These are the two most important indicators for the production of quality plant in vivo, at the same time it testifies to the greater efficiency of the root system of these rootstocks in the ecological conditions of Lushnja where the study was conducted.

Table 2. Vegetation indicators

Rootstocks	No.of shoots		Height (cm)		Ø mm	
Pajam 1	32.00	[AB]	65.00	[B]	9.80	[BC]
Pajam 2	42.00	[A]	108.80	[A]	14.60	[A]
M9	20.00	[CD]	66.70	[B]	8.60	[BC]
Sup. 4Pi80	32.00	[AB]	73.80	[B]	11.00	[AB]
MM106	26.00	[BC]	59.50	[B]	7.00	[C]
M26	13.00	[D]	60.60	[B]	7.40	[BC]
MM111	16.00	[CD]	70.00	[B]	7.20	[C]

Different letters show statistical differences. Comparisons for all pairs using Tukey-Kramer HSD; α *-0,05*

4. Conclusions

Based on the data obtained and reviewed above, we conclude:

- The trench profile method and the core drilling methods gave similar results for the root distribution of the studied rootstocks.
- The rootstocks Pajam 2, Pajam 1, Supporter and M9 have a more uniform spatial distribution of the root system in the ecological conditions of Lushnja
- The most efficient root systems for these conditionsarethose of Pajam2, Pajam 1 and Supporter rootstocks.

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