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THE GROWTH AND FLOWERING OF THE SELECTED CULTIVARS OF ORNAMENTAL APPLE TREES DEPENDING ON ROOTSTOCKS USED

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ABSTRACT. In the carried out experiment the growth and flowering of selected cultivars of ornamental apple trees grafted on three vegetative rootstocks: M9, M26, MM106 were estimated. The rootstocks used significantly differentiated results for the following characteristics of ornamental apple trees: the sum of long-shoots length, the number of flowers and roots and the thickness of trunk. They did not affect the length of main shoot and the number of dwarf-shoots.

Key words: ornamental apple trees, cultivars, rootstocks, growth, flowering

Introduction

In recent years the increase of interest in ornamental trees caused that many plants of decorative value have been rediscovered. The trend towards planting only conifers has diminished and a return to deciduous plants, especially those, which are characterised by changing decorative traits, has been observed. Among such species there is an ornamental apple tree. In Poland, ornamental apple trees can be bought almost in each nursery, where at least a few cultivars are offered. Potential individual customers want a tree to be adjusted with its power of growth to the size of their garden. In the case of landscape firms, trees should have an adequately big size. Nurserymen use for ornamental apple trees different rootstocks. However, there is a lack of available studies on the usefulness of those rootstocks in ornamental apple trees' nursery production.

The experiment aimed at investigating the usefulness of three vegetative rootstocks of different power of growth in production of six cultivars of ornamental apple trees grown in a nursery. The results obtained were to answer the question, which of the rootstocks should be used for the production of a given cultivar of an ornamental apple tree.

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Material and methods

The experiment was carried out in the years 2003-2004, using a random block design with four replicates. There were 5 ornamental apple trees of the following cultivars: 'Hilieri', 'Hyslop Crab', 'Lemoinei', 'Makowiecki', 'Red Tip', 'Royalty' in each replicate. The cultivars were grafted in winter on three rootstocks: M9, M26 and MM106 and planted in a nursery in spring. Flowering of the cultivars based on the number of flowers was assessed in the second year of their growth. Flowers were counted in the second decade of May. The impact of the rootstocks used on the growth of ornamental apple trees was characterised by the following traits: the length of main shoot (measured from the place of grafting to the tip of the highest shoot in cm), the sum of the length of long-shoots (cm) and the number of dwarf-shoots. The measurements of the diameter of rootstock (under the place of grafting in mm) and the diameter of scion (above the place of grafting in mm) were taken. On digging of trees, the quality of rootstock root system was estimated. The measurements and observations were performed in the last decade of October on completion of plant growth. The statistical analysis of the data obtained was carried out using a two-factorial analysis of variance (cultivar, rootstock), followed by Duncan's test at the probability level $\alpha = 0.05$.

Results

The rootstocks used did not affect the length of main shoot of ornamental apple trees. However, the cultivars grafted significantly differentiated the results of the parameter of growth. Cultivars: 'Red Tip' and 'Royalty' had the shortest main shoot. The longest main shoot was characteristic of the cultivar 'Lemoinei', whose result did not differ, however, from the one for cultivars: 'Hilieri' and 'Hyslop Crab' (Table 1).

The sum of long-shoots length of ornamental apple trees differed depending on the rootstock and the cultivar. A significantly greater value of the parameter was obtained for trees on M26 rootstock. Data for the two other rootstocks did not differ. The sum of long-shoots length for the cultivars 'Hilieri' and 'Lemoinei' was markedly greater than that for the remaining cultivars considered in the experiment (Table 2).

The rootstocks and cultivars used in the experiment did not differentiate significantly the number of dwarf-shoots of ornamental apple trees (Table 3).

Ornamental apple trees on the rootstock M9 had significantly more flowers than on the two remaining rootstocks. The highest number of flowers was observed for the trees of 'Hilieri' cultivar, whose value did not differ significantly from the one for 'Makowiecki' cultivar. The trees of 'Lemoinei' cultivar did not flower (Table 4).

The diameter of a rootstock depended on its power of growth. The smallest thickness was achieved by M9 rootstock and significantly the largest one – by M26 rootstock. The value of the parameter for MM106 rootstock was intermediate, significantly different from the two remaining ones. Ornamental apple cultivars grown on rootstocks did not differentiate significantly the results of thickness of a rootstock trunk (Table 5).

Table 1

The length of main shoot of cultivars of ornamental apple trees depending on rootstocks (cm)
Długość pędu głównego drzewek odmian jabłoni ozdobnych w zależności od podkładki (cm)

Cultivar Odmiana	Rootstock Podkładka			Mean value for a cultivar Średnia dla odmiany
	M9	M26	MM106	
Hilieri	132.7 efg*	123.3 defg	138.3 fg	131.4 bc
Hyslop Crab	126.0 efg	129.3 efg	127.3 efg	127.6 bc
Lemoinei	137.7 fg	163.3 g	124.0 defg	141.7 c
Makowiecki	102.0 bcdef	114.7 cdef	112.0 cdef	109.6 b
Red Tip	47.7 a	89.7 abcde	79.0 abc	72.1 a
Royalty	80.0 abc	81.0 abcd	68.7 ab	76.6 a
Mean value for a rootstock Średnia dla podkładki	104.3 a	116.9 a	108.2 a	

*Means followed by the same letters are not significantly different at the level of α = 0.05.
*Średnie oznaczone tymi samymi liczbami nie różnią się między sobą istotnie na poziomie istotności α = 0,05.

Table 2

The sum of long-shoots length of cultivars of ornamental apple trees depending on rootstocks (cm)
Suma długości długopędów drzewek odmian jabłoni ozdobnych w zależności od podkładki (cm)

Cultivar Odmiana	Rootstock Podkładka			Mean value for a cultivar Średnia dla odmiany
	M9	M26	MM106	
Hilieri	93.3 abc*	270.5 e	81.7 abc	148.5 b
Hyslop Crab	48.3 ab	108.3 abcd	106.2 abcd	87.6 a
Lemoinei	165.3 cd	207.5 de	103.0 abcd	158.6 b
Makowiecki	41.3 ab	72.2 abc	82.5 abc	65.3 a
Red Tip	0.0 a	82.5 abc	129.8 bcd	70.8 a
Royalty	32.7 ab	51.7 ab	57.0 abc	47.1 a
Mean value for a rootstock Średnia dla podkładki	63.5 a	132.1 b	93.4 a	

*Means followed by the same letters are not significantly different at the level of α = 0.05.
*Średnie oznaczone tymi samymi liczbami nie różnią się między sobą istotnie na poziomie istotności α = 0,05.

Table 3
The number of dwarf-shoots of cultivars of ornamental apple trees depending on rootstocks
Liczba krótkopędów drzewek odmian ozdobnych jabłoni w zależności od podkładki

Cultivar Odmiana	Rootstock Podkładka			Mean value for a cultivar Średnia dla odmiany
	M9	M26	MM106	
Hilieri	4.3 a*	4.0 a	3.7 a	4.0 a
Hyslop Crab	3.3 a	3.7 a	2.7 a	3.2 a
Lemoinei	1.7 a	2.7 a	1.0 a	1.8 a
Makowiecki	1.7 a	2.0 a	2.3 a	2.0 a
Red Tip	4.7 a	4.0 a	1.3 a	3.3 a
Royalty	1.7 a	2.3 a	3.3 a	2.4 a
Mean value for a rootstock Średnia dla podkładki	2.9 a	3.1 a	2.4 a	

*Means followed by the same letters are not significantly different at the level of α = 0.05.
*Średnie oznaczone tymi samymi liczbami nie różnią się między sobą istotnie na poziomie istotności α = 0,05.

Table 4
The number of flowers on trees of ornamental apple cultivars depending on rootstocks
Liczba kwiatów na drzewkach odmian ozdobnych jabłoni w zależności od podkładki

Cultivar Odmiana	Rootstock Podkładka			Mean value for a cultivar Średnia dla odmiany
	M9	M26	MM106	
Hilieri	118.7 b*	23.3 a	0.0 a	47.3 c
Hyslop Crab	38.0 a	2.7 a	0.0 a	13.6 ab
Lemoinei	0.0 a	0.0 a	0.0 a	0.0 a
Makowiecki	36.0 a	28.3 a	22.0 a	28.8 bc
Red Tip	30.7 a	2.0 a	1.7 a	11.4 ab
Royalty	24.3 a	1.3 a	0.0 a	8.6 ab
Mean value for a rootstock Średnia dla podkładki	41.3 b	9.6 a	3.9 a	

*Means followed by the same letters are not significantly different at the level of α = 0.05.
*Średnie oznaczone tymi samymi liczbami nie różnią się między sobą istotnie na poziomie istotności α = 0,05.

Table 5

The thickness of a rootstock trunk depending on an ornamental apple cultivar (cm)
Grubość pnia podkładki w zależności od odmiany jabłoni ozdobnej (cm)

Cultivar Odmiana	Rootstock Podkładka			Mean value for a cultivar Średnia dla odmiany
	M9	M26	MM106	
Hilieri	1.6 bcde*	1.8 cdefg	1.6 bcde	1.7 ab
Hyslop Crab	1.3 ab	1.9 efg	1.9 defg	1.7 ab
Lemoinei	1.8 cdef	2.1 g	1.6 adcd	1.8 b
Makowiecki	1.6 bcde	1.8 cdefg	2.0 fg	1.8 b
Red Tip	1.2 a	1.8 cdefg	1.7 cdef	1.6 ab
Royalty	1.5 abc	1.8 cdefg	1.6 bcde	1.6 ab
Mean value for a rootstock Średnia dla podkładki	1.5 a	1.9 c	1.7 b	

*Means followed by the same letters are not significantly different at the level of α = 0.05.
*Średnie oznaczone tymi samymi liczbami nie różnią się między sobą istotnie na poziomie istotności α = 0,05.

Table 6

The thickness of a tree trunk of ornamental apple cultivars depending on rootstocks (cm)
Grubość pnia drzew odmian jabłoni ozdobnych w zależności od podkładki (cm)

Cultivar Odmiana	Rootstock Podkładka			Mean value for a cultivar Średnia dla odmiany
	M9	M26	MM106	
Hilieri	1.5 efg*	1.6 fgh	1.5 efg	1.5 c
Hyslop Crab	1.2 abc	1.5 defg	1.4 bcdef	1.3 ab
Lemoinei	1.4 bcdef	1.7 gh	1.2 adcd	1.4 bc
Makowiecki	1.4 cdef	1.6 efgh	1.8 h	1.6 c
Red Tip	1.1 a	1.4 cdef	1.4 abcdef	1.3 ab
Royalty	1.1 ab	1.3 abcde	1.3 abcde	1.2 a
Mean value for a rootstock Średnia dla podkładki	1.3 a	1.5 b	1.4 b	

*Means followed by the same letters are not significantly different at the level of α = 0.05.
*Średnie oznaczone tymi samymi liczbami nie różnią się między sobą istotnie na poziomie istotności α = 0,05.

The diameter of ornamental apple trees' trunk depended on the rootstock and the cultivar used. Greater diameters were obtained on M26, MM106 rootstocks and significantly smaller on M9 rootstock. Among cultivars the largest thickness of trunk was noted for 'Hilieri' and 'Makowiecki'. The smallest thickness was accomplished by 'Royalty' cultivar, whose value did not differ significantly from the one of 'Red Tip' and 'Hyslop Crab' (Table 6).

The rootstocks used affected the number of roots of ornamental apple trees. A lower number of roots was observed for apple trees on M9 rootstock and a higher one on the two remaining rootstocks: M26 and MM106. In the case of grafted cultivars, a smaller influence on the number of roots exerted: 'Hilieri', 'Hyslop Crab', 'Makowiecki', 'Red Tip' and 'Royalty' and a greater one – the cultivar 'Lemoinei' (Table 7).

Table 7

The number of roots of rootstocks depending on a grafted ornamental apple cultivar
Liczba korzeni podkładki w zależności od zaszczepionej odmiany ozdobnej jabłoni

Cultivar Odmiana	Rootstock Podkładka			Mean value for a cultivar Średnia dla odmiany
	M9	M26	MM106	
Hilieri	10.7 a*	15.3 abcd	12.3 abc	12.8 a
Hyslop Crab	9.3 a	16.7 abcd	17.0 abcd	14.3 a
Lemoinei	20.3 bcd	20.7 cd	21.0 d	20.7 b
Makowiecki	12.3 abc	15.3 abcd	15.7 abcd	14.4 a
Red Tip	12.3 abc	17.7 abcd	17.0 abcd	15.7 a
Royalty	10.3 a	15.7 abcd	12.0 ab	12.7 a
Mean value for a rootstock Średnia dla podkładki	12.6 a	16.9 b	15.8 b	

*Means followed by the same letters are not significantly different at the level of $\alpha = 0.05$.

*Średnie oznaczone tymi samymi liczbami nie różnią się między sobą istotnie na poziomie istotności $\alpha = 0,05$.

Discussion

Because of the lack of available publications on the growth of ornamental apple trees grafted on vegetative rootstocks all comparisons, concerning the impact of the rootstock on a cultivar and vice versa, are made in relation to orchard apple trees budded on M9, M26 and M106 rootstocks.

The impact of a rootstock on the power of growth of trees is best visible in the assessment of the sum of long-shoots length. From the experiment considered it follows that the rootstock M9 reduced most of all the growth of ornamental apple trees. MM106 rootstock was characterised by an intermediate power of growth between M9 and M26,

on which the sum of long-shoots length was the highest one. Similar results were obtained by **Ostrowska** and **Chełpiński** (2000), who observed the weakest long-shoots growth of a few apple cultivars on M9 rootstock, largest on M26 and intermediate, similar to the dwarf rootstock M9, on MM106 rootstock. Also **Gudarowska** (1998) and **Skrzyński** and **Poniedziałek** (1998) confirm the relationship. The authors mentioned stated that the rootstock M26 caused stronger growth of long-shoots as compared to MM106 rootstock.

To confirm the strength of growth of ornamental apple trees on the rootstocks investigated, the length of main shoot of trees was also measured. The results obtained confirm that the stronger the growth of side-shoots the longer the main shoot, however, the length of the main shoot was not so differentiated by a rootstock. One could state that the power of growth of apple trees depends on a rootstock and is directed mainly on the growth of side-shoots and to a smaller extent on the height of a tree, which is of great importance for the nursery production.

For some researchers the diameter of trunk is an important indication of to what extent a rootstock stimulates the growth of trees. In the case of M9 rootstock the smallest values were obtained, which is in accordance with the character of growth of the rootstock as a weak growing one. This observation confirmed **Ugolik** et **al.** (1996), who noted the smallest diameter of trunk of 'Elstar' apple cultivar on M9 rootstock measured in the year of planting of trees in an orchard. However, on M26 and MM106 rootstocks they obtained trees diameters significantly greater. Similar results were also obtained by **Ostrowska** and **Chełpiński** (2000).

Evaluating the power of growth of a cultivar itself one can state that the cultivars 'Hilieri' and 'Lemoinei' grow most strongly and the cultivar 'Royalty' grows most weakly. The cultivar 'Royalty' showed a weak growth on all rootstocks considered. That is why it should be grafted on strongly growing rootstocks like A2, in contrary to the cultivars 'Hilieri' and 'Lemoinei', which should be grafted on dwarf rootstocks of M9 type. It should be stated that the power of growth of ornamental apple trees is differentiated and the fact should be taken into consideration while selecting adequate rootstocks.

From the results obtained it cannot be unambiguously concluded that the rootstock affects the number of dwarf-shoots. Ornamental apple trees on different rootstocks achieved similar values of the parameter. Among cultivars 'Hilieri' deserves a special attention because, in spite of the strongest growth, it formed most dwarf-shoots.

It is commonly known that dwarf rootstocks accelerate beginning of flowering and fruiting of trees. In the case of ornamental apple trees, rootstocks significantly affected flowering of trees. All apple cultivars on M9 rootstock had the greatest number of flowers, except for 'Lemoinei' cultivar, which did not flower on any of the rootstocks in the experiment considered. MM106 rootstock stimulated flowering of ornamental apple trees most weakly. Trees of four cultivars on this rootstock did not flower. The rootstock is the least useful one because flowering of trees grafted on it is very weak, which is very important for the sale of nursery material in order to enable the customer to see the decorative value of a cultivar. From the experiment carried out by **Ostrowska** et **al.** (1996) it can be concluded that 'Jonagold' cultivar on M9 rootstock, in the second year after planting in an orchard, flowered richly (on average 5 flowers on a tree), and on M26 rootstock flowering was not noted. However, **Gudarowska** (1998) obtained

slightly different results. In the second year after planting of trees in an orchard the trees of 'Elstar' cultivar on M9 and M26 rootstocks were characterised by a similar number of flowers on a tree. Comparing the effect of a rootstock on flowering of cultivated apple trees and ornamental apple trees one can state that the initiation of flowering of ornamental apple trees is more closely related to the character of growth of a rootstock.

The impact of a rootstock was visible also in the case of number of roots. A positive relationship between the growth of a root system and the size of the upper part was observed in the experiment conducted. Trees of different cultivars did not differ significantly in the number of roots except for the 'Lemoinei' cultivar. The cultivar 'Lemoinei' had a greater number of roots because its upper part was growing most strongly.

Conclusions

1. The growth of ornamental apple trees differed depending on the power of growth of a rootstock and cultivar used. Apple trees' cultivars on M9 grew most weakly and the ones on M26 rootstock – most strongly.

2. The best flowering of ornamental apple trees was achieved on M9 rootstock and the worst on MM106.

3. Strongly growing ornamental apple trees' cultivars: 'Hilieri' and 'Lemoinei' for small gardens should be produced on M9 dwarf rootstock and weakly growing: 'Red Tip', 'Royalty' on M26 and MM106 rootstocks.

4. The cultivars investigated, for landscape purposes, can be produced on all the rootstocks considered, depending on the provided area of cultivation.

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WZROST I KWITNIENIE WYBRANYCH ODMIAN OZDOBNYCH JABŁONI W ZALEŻNOŚCI OD ZASTOSOWANEJ PODKŁADKI

S t r e s z c z e n i e

W przeprowadzonym doświadczeniu dokonano oceny wzrostu i kwitnienia wybranych odmian ozdobnych jabłoni zaszczepionych na trzech podkładkach wegetatywnych: M9, M26, MM106. Zastosowane podkładki zróżnicowały istotnie wyniki następujących cech drzewek: sumy długości długopędów, liczby kwiatów i korzeni oraz grubości pnia. Najsilniej rosły drzewka na podkładce M26, najsłabiej na M9. Najlepsze kwitnienie drzew odnotowano na podkładce M9, najgorsze na MM106. Podkładki nie wpłynęły istotnie na długość pędu głównego i liczbę krótkopędów drzewek odmian ozdobnych jabłoni.