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Growth and fruiting of apple trees of cultivar Rubin on six dwarf rootstocks (preliminary results)

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ABSTRACT

In the years 2002-2004 the effect of dwarf rootstocks M.9, P.16, P.61, M.27, PB.4 and BW on the growth and early stage of yielding of 'Rubin' apple trees was investigated. All the rootstocks were compared with M.9, which was used as a model. After preliminary investigations on the basis of the trunk cross-section area the rootstocks can be arranged in the following order of their growth vigour: BW (103%), M.9 (100%), PB.4 (97%), P.61 (94%), P.16 (92%), and M.27 (59%). In the first two years of fruit bearing trees on the M.9 rootstock gave the highest yield, these on PB.4, P.61 BW and P.16 a slightly lower one, while the lowest yield was obtained from trees on M.27. The highest productivity characterized trees on M.9 and the lowest those on M.27.

INTRODUCTION

In the last decades rootstocks brought about a revolution in fruit growing, completely changing the shape and methods of cultivation of apple orchards. These changes gradually appear also in the plantations of other species. The use of dwarf rootstock solved the issues connected with the too strong growth of trees, too late cropping and low yields from a surface area. The interest in breeding and use of new rootstocks constantly increases. The most popular and commonly used apple rootstock is M.9. It unites well with most cultivars, the trees grafted on it begin the stage of fruit bearing very early and the obtained apples are of very good quality. It should be used as a model in comparing the growth and yield of different rootstocks. The results of some investigations show that among the rootstocks of similar vigour, MAC 9 (MARK) and B.9 only were more productive than M.9 EMLA (Autio 2001). With respect to productivity some rootstocks characterized by a less vigorous growth can compete with M.9. In comparison with M.9 a greater productivity of P.16 was found in experiments conducted by Gruca (2001), Hirst (2001), Wrona and Sadowski (1999), Quamme et al. (1999), Sadowski et al. (1999). As Mika and Krawiec (1999), Sosna (1999), Szczygiel et al. (1999), Szwczuk and Gudarowska (1999), Wrona and Sadowski (1999), Skrzynski and Poniedziałek (1999), and Kviklys et al. (1999) showed, P.22 characterized by a less vigorous growth was another rootstock of higher productivity in comparison with M.9. In some investigations the rootstock P.59 was also found more productive than M.9 (Kruczynska et al. 1999). However, in an experiment conducted by Jakubowski (1999) all the new dwarf rootstocks produced in Poland (P.61, P.66, P.62 and P.67) were found more productive in comparison with M.9.

Super-dwarf rootstocks unfavourably affect the size of fruit. This most frequently occurs in the case of trees on P.22 (Szczygiel et al. 1999, Skrzynski 2002). The investigated cultivar ‘Rubin’ is highly valued on account of very good quality of apples; unfortunately its cultivation is fairly difficult. The trees grow too strongly, their flower bud setting is untypical and the fruit bearing period begins late (Kruczynska 2002).

The aim of the investigation was to determine the effect of selected rootstocks whose expected growth was less vigorous in comparison with M.9, on the growth and yields of ‘Rubin’ trees.

MATERIAL AND METHODS

The experiment was established in the Experimental Station of Garlica Murowana in autumn 2001. The trees were planted in a randomized block design in four

replications of five trees in each. The planted materials were one-year-old high-grade budded trees. After planting trees were trained in a spindle form. The soil between rows was grassed down. In the tree rows soil was kept free of weeds by using glifosate herbicides (Roundup). Every year the trees were fertilized with nitrogen at a dose of 40 kg ha^{-1}. From spring 2002 the tree trunk diameter was measured every year at a height of 30 cm above the soil, the result being calculated per trunk cross-section area (TCSA). In the first two years of the experiment all the one-year-old long shoots were measured, while in the following years only 10 selected long shoots were taken from each plot, the mean shoot length being calculated on this basis. In autumn 2004 the height and width of the crowns were measured and the crown volume was calculated. When the trees began the fruit bearing period, i.e. in 2003, the total yield, average weight of fruits and their colour were recorded and the productivity index was calculated (the total yield from the years divided by the TCSA in 2004 [kg cm^{-2}]).

Fruit quality was determined on the basis of the mean weight of an apple [g]; the degree of fruit coloration in a scale from 1 to 5 (where 1 denotes the coloration of the fruit peel up to 20%; 2 – 40-60%; 4 – 60-80%; 5 – above 80%) and the flesh firmness at harvest time [kG cm^{-2}]. The firmness of flesh was measured on 10 apples from each treatment on the side of the basic colour and on that of the flush. Since no significant difference was assessed between the opposite sides of the apple, means from two measurements on each apple were taken into consideration. The results are given in kilograms; the acidity and extract content were also determined at harvest time. The pH of juice taken from fruit was measured using potentiometric method according to PN-90/A-75101/07. The extract content was determined using Abbe's refractometer at 22^{o}C in juice squeezed from the homogenate of apple previously sampled for flesh firmness measurements. The results are given in percentages. Acidity was measured in the homogenate; the solution was adjusted to pH 8.1 with 0.1 n NaOH, this value being accepted as the neutrality level. The results are given in percentage values calculated into malic acid.

The following rootstocks were compared: M.9 (as the model rootstock); P.16; P.61; M.27; PB.4 and BW. The investigated rootstocks are in common use; the BW rootstock was selected by a Polish nurseryman Poplonikowski from the cross of B.9×James Grieve.

The results were analysed by using the variance method. Differences between the means were verified by using the Duncan test with the coefficient $\alpha = 0.05$.

RESULTS AND DISCUSSION

The preliminary results presented above relate to the growth and yields of trees evaluated during three years after planting. At the time of planting the cross-section area of trunks varied. The trees on the rootstock PB.4 had the thickest trunk and these on M.27 the thinnest; on the remaining rootstocks intermediate trunks were found (Table 1). In 2002 increases in the investigated cross-section area significantly differed. They were smaller on P.16 compared with M.9, but similar to those on M.27 and PB.4. In the case of the remaining rootstocks increases did not differ from the control. The M.9 rootstock was in the group of the most intensively growing trees. In the following year no differences were found in the increases in trunk cross-section area of trees growing on different rootstocks. In autumn 2003 no variation in the cross-section area was noted in the investigated treatments, showing that the growth of trees on different rootstocks was less and less varied probably owing to the drought observed in 2003. In 2004 the comparison of p.p.p.p increases shows the poorest growth on rootstock M.27. The effect of the remaining rootstocks on increases in the trunk cross-section area was similar. On this basis in 2004 the investigated rootstocks can be arranged in the following order: BW (103%), M.9 (100%), PB.4 (97%), P.61 (94%), P.16 (92%), M.27 (59%). However, the measurement of leading shoots (one-year old axis growth, means from the years 2002–2004) permits selecting M.9 as the rootstock of the most vigorous growth and M.27 as that of the poorest. The measurement of the crown volume shows the weakest growth of trees on M.27 and the strongest one on BW and M.9.

Table 1. Effect of rootstocks on the growth of 'Rubin' apple trees

Treatments	Total length of annual shoot growth leader per tree [cm]		Mean length of shoots [cm]	Mean volume of tree canopy [m^3]	Trunk cross-section area \per tree [cm^2]	
	2002	2003	2002-2004 mean	2004	2001	2004
1. M9	86.8 bcd*	185.5 d	27.2 c	0.54 bc	1.28 abc	5.38 b
2. P16	65.8 ab	138. bc	21.9 ab	0.38 abc	1.49 bc	4.96 b
3. P61	108.7 d	126.5 b	22.0 ab	0.37 ab	1.35 abc	5.05 b
4. M27	56.0 a	74.9 a	17.9 a	0.21 a	1.19 a	3.17 a
5. PB4	85.1 bc	140.6 bc	23.4 b	1.39 abc	1.52 c	5.23 b
6. BW	96.4 cd	170.7 cd	24.1 b	0.60 c	1.52 ab	5.55 b

* Values marked with the same letters in columns do not differ at the significance level of P = 0.05

The rootstocks had no effect on the intensity of blooming and percentages of fruit setting in the years 2003–2004 (Table 2). The effect of rootstocks on fruit setting is difficult to explain. Maybe the differences were modified by weather conditions and different sensitivity of rootstocks to drought. The first fruits were harvested in 2003. In 2003 the highest yield was recorded on PB.4 and P.61, however it did not differ from the control. The lowest yields were found on M.27 and intermediate yields on the remaining rootstocks. In 2004 the greatest number of fruits was collected on M.9, on the remaining rootstocks the yields were lower and did not differ from each other. An analysis of two-year yields of 'Rubin' apples shows that the highest crop, almost twice that on the remaining rootstocks, was obtained from trees on the M.9 rootstock, which is confirmed by other studies (Hirst 2001). The lowest yield was found on M.27 and PB.4.

Table 2. Effect of rootstocks on the cropping of 'Rubin' apple trees

Treatments	Flowering abundance scale [0-5]	% of flowers that set-fruit	Cumulative yield [kg per tree]			Efficiency index [kg cm^{-2}]
	2004	2003-2004 mean	2003	2004	2003+2004	2004
1. M9	4.5 a*	5.4 a	0.32 ab	2.23 b	2.55 c	0.47 c
2. P16	3.9 a	3.7 a	0.24 ab	0.94 a	1.18 b	0.24 b
3. P61	4.3 a	4.0 a	0.40 b	0.91 a	1.31 b	0.25 b
4. M27	3.6 a	4.9 a	0.13 a	0.47 a	0.60 a	0.16 a
5. PB4	4.2 a	4.4 a	0.41 b	0.44 a	0.85 ab	0.26 b
6. BW	3.9 a	3.9 a	0.30 ab	1.01 a	1.31 b	0.25 b

* Values marked with the same letters in columns do not differ at the significance level of P = 0.05

The productivity index (kg cm^{-2}) shows the most positive properties of trees growing on the rootstock M.9, and the worst on M.27. Intermediate values of this coefficient were found on the remaining rootstocks. The results reported by Jakubowski (1999), which showed the higher productivity of the rootstock P.61 compared with M.9, were not confirmed. Neither the higher productivity of the rootstock P.16 in comparison with the control reported in numerous works could have been confirmed (Autio, 2001). The rootstock M.27 is known for its low productivity and small fruits. This last tendency could have been also observed in the present experiment, since the smallest fruit yield was obtained from trees on this rootstock. In general all super-dwarf rootstocks with the exception of BW showed a tendency to fruit diminishing. 'Rubin' apples were very well coloured on all the rootstocks, especially in 2004, no differences being observed between them.

The results of fruit flesh measurements carried out in 2003 suggested that the hardest fruit were borne on the rootstock P.16 in contrast with P.61 and M.27 (Table 3). In the following year no differences were found between the rootstocks. In 2003 and 2004 the mean content of extract was not differentiated. However the pH value of juice differed as depending on the rootstocks. The lowest pH was found in fruit from the rootstocks M.27 and BW and the highest in that from P.61. The percent content of organic acids calculated per malic acid was varied, reaching the highest value in fruit from trees grown on M.9 and the lowest on BW.

Table 3. Quality of 'Rubin' apples depending on the rootstocks, mean of 2003-2004

Treatments	Mean fruit weight [g]	Fruit color [scale 1-5]**	Fruit firmness [kG cm^{-2}]	Soluble solids [%]	pH	Acidy of fruit [%]
1. M9	230 c*	4.2 a	7.2 a	14.1 a	3.32 ab	0.77 b
2. P16	201 b	3.8 a	7.4 a	14.1 a	3.32 ab	0.75 ab
3. P61	201 b	4.1 a	7.2 a	14.3 a	3.36 b	0.74 ab
4. M27	162 a	3.9 a	7.2 a	14.1 a	3.31 a	0.73 ab
5. PB4	198 b	4.1 a	7.3 a	14.0 a	3.32 ab	0.71 ab
6. BW	225 bc	4.1 a	7.4 a	14.2 a	3.31 a	0.70 a

* Values marked with the same letters in columns do not differ at the significance level of P = 0.05
** see Material and Methods

CONCLUSIONS

1. In the first two years the cultivar Rubin gave the highest yield on the rootstock M.9.
2. The M.9 rootstock was characterized by the highest productivity.
3. With the exception of BW the investigated rootstocks suppressed the growth of 'Rubin' apple trees in comparison with M.9.

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WSTĘPNE WYNIKI WZROSTU I OWOCOWANIA JABŁONI ODMIANY 'RUBIN' NA SZEŚCIU PODKŁADKACH KARŁOWYCH

Streszczenie: W latach 2002-2004 prowadzono badania nad wpływem podkładek karłowych M.9, P.16, P61, M.27, PB.4 i BW na wzrost i początkowy okres owocowania drzew odmiany Rubin. Podkładka M.9 była wzorcową, do której porównywano pozostałe podkładki. Podkładka M.9 jest obecnie najczęściej stosowaną z grupy podkładek karłowych. Niektórzy sadownicy uważają ją za zbyt silnie rosnącą zwłaszcza dla niektórych odmian o silnym wzroście. Celem badań było poszukiwanie podkładki słabiej rosnącej od M.9 i bardziej od niej produktywnej. Po wstępnych badaniach na podstawie wielkości pola przekroju poprzecznego pnia można uszeregować podkładki w następującej kolejności pod względem siły wzrostu drzew: BW (103%), M.9 (100%), PB.4 (97%), P61 (94%), P.16 (92%), M.27 (59 %). W pierwszych dwóch latach owocowania najwyższe plony jabłek zebrano z drzew rosnących na podkładce M.9, nieco niższe z podkładki PB.4, P.61, BW, P.16, a znacznie niższe z M.27, co przekładało się również na produktywność drzew, gdzie najwyższą odnotowano u drzew na podkładce M.9, a najniższą na M.27.

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