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Effect of rootstocks and double trunk on growth and fruiting of 'Rubin' apple trees

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ABSTRACT

'Rubin' apple trees grafted on M.9, P22, and P59 rootstocks were planted in spring 2000. In June 2000 the trees on M.9 and P59 rootstocks were grafted again with 10 cm scion of P22 rootstock. Moreover each year on the same grafted trees a 1 cm wide ring of bark was taken from the main trunk. On the basis of trunk cross section area growth of studied rootstocks can be ranged as following: M.9 (100%), P22 (99%), P59 (83%). A tendency was found to decrease the growth of the trees and better fruiting on rootstock M.9, and also better colour on double grafted trees. There was no difference in flowering and fruiting on trees growing on rootstocks M.9, P59 and P22. Fruits from trees grown on rootstock P22 had higher firmness and higher concentration Ca and P comparing to M.9.

INTRODUCTION

Dwarfing rootstocks are effective in reducing tree growth, ensuring early fruiting and reducing training effort. Use of dwarfing interstocks is still taken into consideration even in case of trees grafted on dwarf rootstocks. In experiments carried out by Wertheim et al. (1995) on apple trees with interstocks, six cultivars produced average cumulative yield similar to or significantly higher than knipboom trees. Bootsma (1995) found the highest yields of 'Elstar' and 'Jonagold' apples grafted on M.9 rootstock with Zoete Aagt interstock. Good results were also obtained with 'Summerred' interstock for 'Jonagold' and 'Elstar' (Bal 1996). The dwarf rootstock is necessary for cultivars characterized by strong growth, as for example 'Rubin'. Among fruit growers prevails the opinion that dwarf rootstock M.9 is too strong for this cultivar. 'Rubin' cultivar bears very valuable apples that can compete with fruits of many others cultivars, e.g., 'Elstar'. It is an early-winter cultivar; its fruits, ripening in November, can be stored until March in a cold store and even up to June in a CA store. The apples tolerate transporting well. The cultivar is easily adapted to Polish climatic conditions. Drobny (1988) gave a detailed description of this cultivar, classifying it as an early-winter one.

In the investigation conducted by Mika and Krawiec (1999) 'Rubin' apple trees on P22 rootstock showed a similar bearing efficiency as 'Elstar', though their productivity was poorer with trees spaced at 3.5 × 1.0 m.

Lithuanian studies showed that the growth of 'Rubin' trees on M.26 rootstock was as vigorous as of the cultivar 'Elstar' (Uselis 2001). 'Rubin' manifested a stronger frost hardiness than 'Elstar' or 'Rubinette', a slight frost damage being only observed in its case. The blooming was medium-early, the yield equally poor as in the cultivars 'Elstar', 'Alva', and 'Štaris'. In the Czech studies the cultivar 'Rubin' on M.9 rootstock also gave poor yields particularly in cooler regions (Blažek and Hlušicková 2003).

The objective of the study was to test the growth and bearing of 'Rubin' trees on the promising Polish rootstocks P22 and P59 in comparison with the standard M.9 rootstock. The effect of double-trunk (interstock bridge grafting) method was also investigated.

MATERIAL AND METHODS

In spring 2000 one-year old trees of the cultivar 'Rubin' were planted on brown soil originated from loess spaced at 4 m × 1.2 m. In June 2000 the trees growing on M.9 and P59 rootstocks were grafted with the 10 cm scions of P22 rootstock ("double-trunk"). These scions were taken from one year long shoot and were cut longitudinally in two halves. Only one half of scions was grafted in the middle of

the trunk. Grafted scions should stick tight to the cambium of tree trunks. Moreover, each year a ring of bark 1 cm in width was removed from the circumference of the trunk opposite to the place of half-scions grafting with the aim of blocking the flow of assimilates and bioregulators to the roots.

The following treatments were investigated:

– Trees on rootstocks P22
– Trees on rootstocks M.9
– Trees on rootstocks M.9 with double trunk of P22
– Trees on rootstocks P59
– Trees on rootstocks P59 with double trunk of P22.

Each treatment had 5 replication with 2 trees on single plot. Soil was clean cultivated by herbicides along tree row and alleyways were grassed down after tree planting. Mineral fertilization was applied according to recommendation for commercial orchards. Trees were trained to spindle system.

Every year tree trunk circumference at the altitude of 30 cm was measured e.g. 10 cm below the lower place of double-trunk grafting. The similar measurement was made 10 cm above the higher place of grafting. The length of branch leaders, and the height and width of tree canopies were measured. When the trees came into the blooming and bearing period, the percentage fruit setting was calculated, yield, mean mass of fruit, and the colour. Colour was determined in the scale 1-5 (1 – 20%, 2 – 40%, 3 – 60%, 4 – 80%, 5 – 100% surface covered with blush). Firmness, extract, acidity and pH of juice, and mineral elements in leaves were also determined. The productivity coefficient was calculated by dividing of cumulative yield in the years 2002 – 2003 by the cross-section area of the trunk in the last year of the experiment. The results were subjected to analysis of variance. The means were separated by the Duncan range test at $p = 0.05$.

RESULTS

In 2002 an increase in the trunk cross-section area above the grafting point was smaller on P59 than on M.9 rootstock but the difference between P22 and M.9 was not significant (Table 1). No influence of the double trunk was observed on the trunk cross section area below grafting. In the following year the P59 rootstock with double trunk reduced increase in trunk cross-section area in comparison with rootstocks P22 and M.9, irrespective the double trunk treatment. In 2004 differences, in the cross-section area above and below grafting were significant only between trees on P59 with double-trunk and trees on P22 and M.9. The volume of tree canopy in the last year of experiment showed no differences between treatments (Table 2). Mean length of shoots increased on the ‘Rubin’ trees grown on M.9 rootstock under the influence of double trunk.

Table 1. Trunk cross-section area of ‘Rubin” apple trees depending on rootstocks and double-trunk

Treatments	Trunk cross-section area [cm^2]		Increase in trunk cross-section area [cm^2]						Trunk cross-section area [cm^2]	
	2001		2002		2003		2004		2004	
	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below
	double-trunk grafting				double-trunk grafting				double-trunk grafting	
Control rootstock P22	2.6 a*	2.6 a	2.9 bc	2.9 a	4.2 a	4.2 b	4.4 b	4.4 a	14.1 b	14.1 b
Control rootstock M.9	2.6 a	2.6 a	4.0 c	4.0 a	4.1 a	4.1 b	4.2 b	4.2 a	14.9 b	14.9 b
M.9 double trunk and ringing	3.5 b	3.6 b	3.2 bc	3.6 a	2.7 a	4.1 b	4.1 a	1.8 a	13.5 ab	13.1 ab
Control rootstock P59	2.6 a	2.6 a	2.4 ab	2.4 a	3.6 a	3.6 b	3.7 ab	3.7 a	12.3 ab	12.3 ab
P59 double-trunk and ringing	3.3 b	3.1 ab	1.4 a	2.4 a	2.0 a	2.3 a	4.0 a	1.7 a	10.7 a	9.5 a

*Values designated with the same letters within columns do not significantly differ at 5% error.

Table 2. Effect of rootstocks and double-trunk treatment on growth of 'Rubin' apple trees

Treatments	Mean length of limb leader [cm]				Canopy volume per tree [m^3]
	2002	2003	2004	Mean 2002 – 2004	2004
Control rootstock P22	29 bc*	34 b	29 a	31 bc	2.3 a
Control rootstock M.9	17 a	34 bc	27 a	26 a	1.9 a
M.9 double trunk and ringing	33 c	38 c	28 a	33 c	2.2 a
Control rootstock P59	26 b	30 a	29 a	28 ab	1.9 a
P59 double-trunk and ringing	26 b	29 a	24 a	26 a	1.9 a

*Note: see Table 1

The fruit setting was not different (Table 3). The fruiting began in the second year after the planting of trees. In the next year the yield of about 3 kg per tree was obtained. Only in 2003 was a tendency to higher fruiting observed in trees with double trunk. The efficiency index was also not significant. The mean mass of fruit and extract of fruits were unchanged. The colour of fruits was improved on trees grown on M.9 in the treatment of double trunk. The fruit firmness was higher on P22 than on M.9 (Table 4). The double trunk increased the acid content and increased pH of fruit growing on M.9 rootstock only (Table 5). Concentration of mineral elements in leaves was different on investigated rootstock (Table 6). Concentration of P was the lowest on M.9 rootstock, and K was the lowest on P59. Concentration of Ca was the highest on P22. Double trunk on rootstock M.9 increased concentration of K in leaves, but on rootstock P59 lowered N and increased Mg.

Table 3. Effect of rootstocks and double-trunk on fruiting of 'Rubin' apple trees

Treatments	Percent of fruit set	Yield [kg per tree]			Cumulative yield [kg per tree]	Efficiency index [$kg\ cm^{-2}$]
	Mean 2003 – 2004	2002	2003	2004	2002 + 2004	2004
Control rootstock P22	6.8 a*	0.12 a	2.5 ab	11.9 a	14.5 a	1.03 a
Control rootstock M.9	5.6 a	0.22 a	2.3 a	8.1 a	10.6 a	0.71 a
M.9 double-trunk and ringing	4.5 a	0.13 a	3.0 ab	12.1 a	15.2 a	1.16 a
Control rootstock P59	5.8 a	0.11 a	2.9 ab	10.2 a	13.2 a	1.08 a
P59 double-trunk and ringing	6.2 a	0.30 a	4.0 b	8.1 a	12.4 a	1.30 a

*Note: see Table 1

Table 4. Effect of rootstocks and double-trunk on quality of 'Rubin' apple trees fruits.

Treatments	Mean mass of fruit [g]	Fruit colouing [skale 0-5]	Firmness after harvest [kG]		
	Mean 2002 – 2003	Mean 2003 – 2004	2003	2004	Mean 2003 – 2004
Control rootstock P22	192 a	4.6 ab	8.1 a*	6.7 ab	7.4 b
Control rootstock M.9	198 a	4.4 a	7.7 a	6.4 a	7.1 a
M.9 double-trunk and ringing	200 a	4.7 b	8.2 a	6.4 a	7.3 ab
Control rootstock P59	202 a	4.6 ab	7.8 a	6.7 ab	7.3 ab
P59 double-trunk and ringing	184 a	4.7 b	7.8 a	6.9 b	7.3 ab

*Note: see Table 1

Table 5. Effect of rootstocks and double-trunk on quality of 'Rubin' apple trees

Treatments	Soluble solids [%]			pH of juice after harvest			Apple acid [g 100 g^{-1}]		
	2003	2004	Mean 2003 – 2004	2003	2004	Mean 2003 – 2004	2003	2004	Mean 2003 – 2004
Control rootstock P22	13.8 a	13.8 a	13.8 a	3.3 a	3.3 a	3.3 a	0.65 b	0.72 a	0.68 a
Control rootstock M.9	13.8 a	13.3 a	13.5 a	3.4 b	3.2 a	3.3 a	0.63 ab	0.66 a	0.64 a
M.9 double-trunk and ringing	15.2 a	13.3 a	14.6 a	3.4 b	3.4 b	3.4 b	0.78 c	0.70 a	0.74 b
Control rootstock P59	13.8 a	13.3 a	13.5 a	3.3 a	3.3 ab	3.3 a	0.58 ab	0.68 a	0.63 a
P59 double-trunk and ringing	13.8 a	13.4 a	13.6 a	3.3 a	3.3 ab	3.3 a	0.55 a	0.69 a	0.62 a

*Note: see Table 1

Table 6. Content of mineral constituents (N, P, K, Ca, Mg) in leaves of 'Rubin' depending on the rootstock and double-trunk (mean of year 2002 – 2004)

Treatments	N	P	K	Ca	Mg
Control rootstock P22	2.5 bc	0.20 b	1.5 ab	0.25 b	1.1 b
Control rootstock M.9	2.6 c	0.17 a	1.6 b	0.20 a	1.0 b
M.9 double-trunk and ringing	2.4 a	0.18 ab	1.9 c	0.19 a	0.8 a
Control rootstock P59	2.6 c	0.20 b	1.4 a	0.19 a	1.1 b
P59 double-trunk and ringing	2.4 a	0.18 ab	1.4 a	0.20 a	1.3 c

*Note: see Table 1

DISCUSSION

It seems that the transportation of hormone and assimilates in the tree trunk plays a key role in the dwarfing effect and can affect such an important processes as growth, bud formation, fruit-set and fruiting.

The advantages of the double-trunk method are: (1) grafting can be done not only in nursery but also in the orchard, (2) girdling does not completely stop the transport only limits it, so is less dangerous for the tree.

The method of double trunk (the interstock bridge grafting) gave good results with strongly growing rootstocks. With the use of this method Samad et al. (1999) obtained the yield of apples increased by 35% and Jiang Shou Fu et al. (2000) by about 45%. In the present study an increase in yields was 43% on M.9.

In an earlier research a significant 44% yield increase was recorded (Poniedziałek et al. 2001).

CONCLUSIONS

1. On the basis of trunk cross-section area the studied rootstocks can be ranged as following: M.9 (100%), P22 (99%), P59 (83%).
2. A tendency was found to decrease growth of trees and to better fruiting on rootstock M.9, and better colour of fruits in the treatment of double trunk.
3. 'Rubin' trees showed similar flowering and fruiting on rootstocks M.9, P59 and P22.
4. Fruits from trees grown on rootstock P22 had higher firmness and higher concentration Ca and P, as compared to M.9 rootstock.

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WPŁYW PODKŁADEK I PODWÓJNEGO PNIA NA WZROST I PLONOWANIE DRZEW ODMIANY RUBIN

Streszczenie: Drzewa jabłoni odmiany Rubin rosnące na podkładkach M.9, P22 i P59 posadzono wiosną 2000 roku. W czerwcu 2000 roku wszczepiono w pnie drzew połówkowe odcinki pędów 10 cm długości z podkładki P22. Ponadto każdego roku na tych drzewach wycinano na wysokości wszczepienia pędu z P22 obrączkę kory szer. 1 cm z pozostałej części obwodu pnia. Porównując siłę wzrostu odmiany Rubin na badanych podkładkach i posługując się wskaźnikiem pola przekroju poprzecznego pnia można je uszeregować w następującej kolejności: M.9 (100%), P22 (99%), P59 (83%). W kombinacjach z podwójnym pniem zaobserwowano tendencję do osłabiania siły wzrostu drzew, lepszego plonowania i lepszego wybarwienia tylko u drzew na podkładce M.9. Kwitnienie i plonowanie na badanych podkładkach było podobne. Owoce z drzew rosnących na P22 oznaczały się wyższą jędrnością i większą zawartością Ca i P w porównaniu z owocami z drzew rosnących na podkładce M.9.

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