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Performance of Two Apple Cultivars Grafted on 10 New Polish-bred Rootstocks During 6-year-experiment

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Abstract

Growth and fruiting of 'Gloster' and 'Melrouge' apple trees grafted on 10 Polish-bred rootstocks (P series) were studied during a 6-year-experiment (1991-1996). The most vigorous were trees on semi-dwarfing rootstocks P 1, P 14 and on M.26. The trees of both cultivars on P 16 and P 59 dwarfing rootstocks were similar in size and smaller than those grafted on standard M 9. Size of the trees on P 22 was between those on P 59 and M.9.

Trees of both cultivar on dwarfing rootstocks started to bear fruit in the second year and semi-dwarfing trees (on M.26, P 1, P 14 and P 60) started fruiting in the third year after planting. A cumulative yield over 6 years was the highest for trees of both cultivars on P 14. Of the dwarf trees, the highest cumulative yield was from those on P 2 and M.9. Yield efficiency, expressed as a yield per square cm of TCA, was the highest for both cultivars on P 16, P 2, P 22 and P 59 rootstocks and for 'Melrouge' also for the trees on P 14. Of the tested semi-dwarfing rootstocks the most valuable are P 14 and P 60. In the dwarfing group trees on P 2, P 16 and P 59 performed well. Pomological value of P 16 rootstock is similar to M.9 and it should be planted in a milder climate. Also promising is the very dwarfing rootstock P 59 but it requires future studies on winter hardiness.

Introduction

Modern apple orchards are planted almost exclusively with dwarf and semi-dwarf trees (1, 2, 5, 11, 12). However, despite wide selection of apple rootstocks available for tree production, there still is a lack of dwarfing rootstocks promoting early bearing and well adapted to Polish soil and climatic conditions (3, 4, 7).

Especially an important factor taken into account during evaluation of a new rootstock is their potential to promote early bearing (1, 6, 8, 12). The aim of the work presented was to evaluate 8 Polish-bred apple rootstocks, with special attention paid to promotion of early bearing in late-bearing cultivars.

Materials and Methods

One-year-old apple trees cvs 'Gloster' and 'Melrouge'[1] grafted on 10 dwarfing and semi-dwarfing rootstocks (Table 1)

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[1]Red sport of Melrose cv.

Table 1. Tree losses (number of tree lost of 12 planted) during 6 years of experiment (1991-1996)

Rootstocks	Cultivars	
	Gloster	Melrouge
M.26*	2	0
P 1	0	1
P 14	0	0
P 60	0	0
M.9*	1	1
P 2	1	4
P16	1	4
P 22	3	0
P 59	2	0
B.9	0	0

*Standard rootstocks.

were planted in the autumn 1990 in the Experimental Station of the Research Institute of Pomology and Floriculture in Nowa Wieś near Grójec (central Poland). The experimental orchard was located in the plain landscape on grey-brown pseudopodsolic soil overlaying boulder clay. The trees were grafted from 6 to 8 cm above the soil surface. The experiment was set up in a randomized complete block design with 4 replicates of 3 trees per plot. There were two sub blocks consisted of semi-dwarf trees (spaced at 4.0 x 2.5 m and dwarf ones (spaced at 4.0 x 2.0 m)). All trees had supports from the first year. Each cultivar was planted in 4 neighboring rows.

The trees were trained as free-standing central leader with a short trunk. During first four years after planting the pruning was oriented on forming a tree canopy with main limbs branching from the central leader at wide angles. After the fifth year regulatory pruning was applied. The soil was clean-cultivated during first three years. In the summer of the third year grass was sown in the alleyways and in the tree rows herbicide strips were maintained.

Trees were fertilized with 110 kg N, 70 kg P_2O_5 and 120 kg K_2O per hectare during first four years after planting. Since the 5th year fertilization was increased to 200 kg N, 80 kg P_2O_5 and 200 kg K_2O. During first 4 years the fertilizer was applied directly under each tree and later on it was broadcasted over the whole orchard surface. Protection against pests and diseases was applied according to a standard plant protection program.

During the course of experiment general tree health and performance was observed. Trunk circumferences and fruit yield were recorded each year. In 1994 and 1996, when the total yield was high, the fruits were graded into three sizes: with diameter >7.0cm, 5.5-7.0 cm and <5.5 cm. Percentage of fruits with more than 50% skin surface covered with a blush was also recorded. The results were analyzed by analysis of variance and the means were separated according to Duncan's multiple range test at 5% confidence level.

Results

Tree health. No trees were lost due to frost damages during 6 years (1991-1996) of the experiment. A few of tree losses were caused by mechanical damages (tree lodging) and rodents. The highest number of trees lost were among those grafted on P 2 and P16 rootstocks (Table 1). 'Melrouge' trees grafted on P 2 and P 16 rootstocks were heavily infected with apple canker (*Nectria galligena*). Three trees of Gloster cv. grafted on P 22 were lost due to broken skeleton roots, causing lodging.

Tree size. During the 6 years experiment, the most vigorous were trees of both cultivars on P 1, M.26 and P 14 rootstocks (Tables 2 and 3). 'Gloster' and 'Melrouge' trees grafted on P 60 were significantly smaller than those grafted on M.26 rootstock. Trees of both cultivars on P 14 were similar in size to those grafted on M.26. The trees of both cultivars on P 16 and P 59 were similar in size and the smallest of all the trees in the experiment. Size of trees on P 22 was between those on P 59 and M.9 and did not differ significantly from those grafted on M.9. Size of trees on P 2 and P 60 was between those grafted on M.9 and M.26.

Fruiting. Trees of both cultivars grafted on dwarfing rootstocks M.9, P 2, P 16, P 22, P 59 and B.9 started to bear fruit in the second year from planting (Tables 2 and 3). The only exception were 'Mel-

Table 2. Trunk cross-section area, yield and yield efficiency of 'Gloster' trees grafted on various rootstocks

Rootstock	TCA in 1996 (cm^2)	Yield** (kg.tree)					Yield efficiency (kg/cm^2 TCA)
		1992	1993	1994	1996	Σ1992-1996	
M.26*	45.1 c	0.0	2.8	15.6	50.0	68.4 de	1.71 ab
P 1	44.7 c	0.0	1.4	19.4	42.7	63.5 cd	1.54 a
P 14	46.4 c	0.0	2.8	16.4	66.3	85.4 g	1.87 abc
P 60	34.8 b	0.0	4.4	30.9	42.0	77.2 f	2.32 bcd
M.9*	31.4 b	0.2	5.4	15.0	29.2	49.8 b	1.72 ab
P 2	32.1 b	0.2	7.5	21.1	51.7	80.5 fg	2.67 de
P 16	17.0 a	0.2	3.9	13.6	32.0	49.8 b	3.27 e
P 22	29.0 b	0.2	5.3	20.8	42.4	68.6 de	2.44 cd
P 59	16.9 a	0.1	9.0	16.8	11.3	35.4 a	2.13 abcd
B.9	28.3 b	0.3	5.4	8.1	39.3	53.0 b	1.99 abcd

Averages with the same letters do not differ significantly at p = 5% (Duncan's test).
*-standard rootstocks.
**-in 1995 trees didn't crop, all flowers were killed by frost.

rouge' trees grafted on B 9, which started fruiting in the third year. All the trees grafted on semi-dwarfing rootstocks (M.26, P 1, P 14 and P 60) started fruiting in the third year after planting. However, the yield from semi-dwarf trees in that year (from 0.3 to 4.4 kg per tree) was lower than from dwarf ones (from 2.2 to 9.0 kg per tree). The highest yield in the third year after planting was produced by trees of both cultivars grafted on P 59 rootstock. In the next years of experiment fruit yield was proportional to tree size. A cumulative yield during 6 years was the highest for trees of both cultivars grafted on P 14. Of the dwarf trees, the highest cumulative yield was from those grafted on P 2 and M.9 and the lowest from trees grafted on P 59. The highest cumulative yield of 'Melrouge' was from trees on P 2. The cumulative yield of 'Melrouge' from trees on P 16, P 22 and B.9 similar to those on M.9.

Yield efficiency, expressed as a yield per square centimeter of trunk cross-sec-

Table 3. Trunk cross-section area, yield and yield efficiency of 'Melrouge' trees grafted on various rootstocks.

Rootstock	TCA in 1996 (cm^2)	Yield** (kg.tree)					Yield efficiency (kg/cm^2 TCA)
		1992	1993	1994	1996	Σ1992-1996	
M.26 *	38.5 g	0.0	1.9	19.9	26.6	48.4 g	1.32 ab
P 1	46.3 h	0.0	0.3	13.2	27.1	40.7 def	0.93 a
P 14	33.2 fg	0.1	0.9	20.9	43.8	65.6 i	2.02 def
P 60	30.6 ef	0.0	0.8	17.3	21.2	39.2 cdef	1.43 abc
M.9*	22.6 bcd	0.1	2.2	12.8	25.5	39.9 cdef	2.02 def
P 2	29.5 def	0.1	3.7	13.2	37.8	54.7 h	2.09 def
P 16	17.0 ab	0.1	4.8	12.3	21.0	38.2 cde	2.55 f
P 22	18.1 abc	0.2	4.4	11.3	19.8	35.7 bcd	1.98 cd
P 59	14.2 a	0.1	6.0	8.1	14.3	28.4 a	2.46 ef
B.9	25.2 cd e	0.0	2.2	13.3	19.8	35.2 bc	1.52 bcd

Averages with the same letters do not differ significantly at p = 5% (Duncan's test).
*-standard rootstocks.
**-in 1995 trees didn't crop, all flowers were killed by frost.

Table 4. Fruit size and coloring of two apple cultivars grown on various rootstocks in 1996

Rootstock	Gloster		Melrouge	
	Fruits with diameter > 7.0 cm	Fruits with blush on > 50% of skin surface	Fruits with diameter > 7.0	Fruits with blush on > 50% of skin surface
M.26*	52	92	100	15
P 1	38	100	85	100
P 14	47	100	44	100
P 60	62	100	100	100
M.9 *	43	100	100	100
P 2	75	100	100	100
P 16	47	100	91	100
P 22	81	100	79	100
P 59	21	100	35	100
B.9	46	100	63	100

*- standard rootstocks

tion area (TCA) was the highest for both cultivars grafted on P 16, P 2, P 22 and P 59 rootstocks and for 'Melrouge' also on P 14 (Tables 2 and 3). High yield efficiency has also 'Gloster' on P 60 and 'Melrouge' on M.9. Lower yield efficiency was observed on trees of both cultivars grafted on P 1, which however did not differ significantly from yield efficiency of trees grafted on M.26 rootstock.

Fruits size was measured in two years. In 1994 nearly all fruits of two cultivars had a diameter larger than 7 cm. In 1996, the highest percentage of 'Gloster' fruits with a diameter larger than 7 cm was harvested from trees grafted on P 2 and P 22 rootstocks and of 'Melrouge' fruits from trees grafted on M.26, P 60 M.9, P 2 and P 16 rootstocks. Rootstocks had little affect on fruit coloring. The only rootstock which affected coloring was M.26, which decreased slightly percentage of 'Gloster' and severely percentage of 'Melrouge' fruits with a blush over more than 50% of a fruit surface (Table 4).

Discussion

Dwarfing effect of the rootstocks tested was similar to that observed in earlier experiments (2, 3, 4, 8). The relation between sizes of trees grafted on P 59 and P 60 rootstocks in our experiment was also similar to that observed by Zagaja et al. (13), though in that experiment the trees were planted on fertile, brown soil in Albigowa and their absolute size was bigger than in the present work.

The vigor of trees of both cultivars grafted on P 14, which was similar to the vigor of trees grafted on standard M.26 rootstock deserves special attention. This confirms our earlier results (2) on McIntosh and Cortland cvs. Vigor of both cultivars grafted on P 60 was intermediate between that of trees grafted on M.26 and M.9. The more vigorous growth of trees grafted on P 60 suggests that this rootstock may be a valuable one for intensive orchards planted on light soils, not suitable for trees grafted on M.9. Trees on P 2 grew similarly. However, vigor of a tree grafted on P 2 depends largely on soil fertility—on fertile soils trees on P 2 grow much more vigorously (2). The lowest was vigor of trees P 16 and P 59 rootstocks—these were frequently even smaller than those grafted on P 22. The vigor of trees on P 16 confirms results of Ligonniere (6) and van Oosten (9).

All the rootstocks tested in this experiment improved fruit yield. An especially a high yield efficiency index was obtained for 'Gloster' cv. grafted on P 16, P 2, P 22 and P 60 and for 'Melrouge' cv. grafted on P 16, P 59, P 2, P 14 and M.9 rootstocks. High productivity of trees of both cultivars

grafted on P 16 was observed previously in experiments of Ligonniere (6) and Wertheim (12).

An especially high yield efficiency was obtained on P 59 rootstock. This proves its high value, especially for 'Melrouge' cv., which starts bearing very late, usually in the fifth year after planting (10). Also very productive were trees grafted on P 2, confirming the results of (2, 4). However, a drawback of this rootstock is weak development of the root system in the orchard and low rooting efficiency in the stoolbeds.

The precocity of both cultivars also deserves attention—both bearing fruit in the second year after planting.

Conclusions

1. Of the tested semi-dwarfing rootstocks the most valuable are P 14 and P 60. The advantages of P 14 rootstock are growth vigor comparable with M.26 and very high productivity with better than M.26 rooting ability in the stoolbeds. The advantages of P 60 are: small size of tree canopy, high productivity and lower soil requirements than M.9. Very easy its rooting in stoolbeds.
2. The following rootstocks also performed well: P 2, P 16 and P 59. However, suitability of P 2 rootstock is significantly decreased by its low rooting potential. Pomological value of P 16 rootstock is similar to M.9. However, its winter hardiness is low and it should be used in orchards planted in milder climates. The advantages of P 59 rootstock are: very small tree size, very precocious, high productivity and easy propagation in the stoolbed. In the future this rootstock may replace P 22.

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Apple Pollenizer Potency

In two consecutive years fruit set and yield were higher when 'Topred' was adjacent to 'Golden Delicious' compared to 'Jonathan'. 'Jonathan' and 'Topred' share allele S9 and a comparison of seedlings it was found with 'Jonathan' only S7 the unshared allele took part in fertilization. Whereas both alleles of 'Golden Delicious' (S2, S3) participated at equal rates. From Goldway et al. 1999. J. HortSci Biotech 74(3):381-385.