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SUITABILITY OF SOME SEMIDWARF AND DWARF ROOTSTOCKS TO THREE APPLE CULITIVARS IN THE SUB-CARPATHIAN REGION

ABSTRACT. An experiment was carried out over 8 seasons (1994-2001) on a medium heavy loam, using maiden unfeathered apple trees of three cultivars: 'Jonica' – on 5 rootstocks, and 'Ligol' and 'Fiesta' – on 4 rootstocks. In all cultivars tree growth was the weakest on P 22 and the strongest on M.26. Tree vigour of 'Jonica' on P 60 was slightly weaker than on M.9 and P 2, on which it was similar for all the cultivars tested. Yield per tree was always the smallest on P 22 and the highest on M.26. However, the crop efficiency index was the highest for trees on P 22 in cvs. 'Jonica' and 'Ligol', but equal to that of 'Fiesta' on M.9. The lowest index was found for trees on M.26. Fruit colouring and size of the three cultivars was similar on all the tested rootstocks.

Key words: apple, rootstocks, cultivars, sub-Carpathian region

INTRODUCTION. One of the most efficient ways of achieving early apple cropping is to plant dwarf trees (Czynczyk, 1998; Mika, 1996).

Such trees can be obtained by using dwarfing rootstocks for their production. There is, however, no universal rootstock for all apple cultivars (Tukey, 1994) nor for all soil conditions.

In Western Europe, with its mild climate, M.9 is the most commonly used apple rootstock for commercial orchards (Webster, 1984; Wertheim, 1985; van Oosten, 1986). However, trees on M.9 are not well adapted to Polish conditions (Czynczyk, 1997). Their root system may be damaged by low temperature, especially during winters without snow cover. The most commonly used apple rootstock in Poland is M.26. Trees on this rootstock are more frost resistant, but they grow too vigorously, especially in deep fertile soils. This is generally the case in the sub-Carpathian region of Poland. Therefore, selection of a proper rootstock for a given cultivar to suit the local conditions is justified.

The aim of the present study was to evaluate the suitability of several rootstocks of different dwarfing potential, among them three of Polish origin (P 2, P 60 and P 22) considered as frost resistant (Czynczyk and Zagaja, 1984; Zagaja et al., 1988), for apple cultivars ‘Jonica’, ‘Ligol’ and ‘Fiesta’, recently introduced in the sub-Carpathian region; thus providing the ground for the recommendation to practice and for the elaboration of the most suitable spacing.

MATERIALS AND METHODS. The experiment was established on a slight south-easterly slope with medium heavy loam, after removing a 20-year-old sour cherry orchard. Trees of the cultivars ‘Ligol’ and ‘Fiesta’ on four rootstocks (M.26, P 2, M.9 and P 22), and of ‘Jonica’ on five rootstocks (additionally on P 60), were produced in the nursery of the Experimental Station at Brzezna (sub-Carpathian region). They were one-year-old unfeathered maidens, budded at a height of 10 cm. In the spring of 1994, trees were planted at 3.5 m spacing between rows, with different spacing along the rows (1.7 m for M.26 and P 60; 1.5 m for M.9 and P 2; 1.3 m for P 22). There were 7-8 trees per plot, repeated three times for each treatment. Trees were trained to form a spindle. The soil was maintained in a standard

way – herbicides applied along the rows and mown sward maintained in alleyways.

Trunk thickness at a height of 30 cm and crop quantity and quality were recorded each year for 4 medial trees of each plot. Size, weight and colouration were estimated for all fruits until the fifth year after planting and later on 100 fruits randomly selected from the same 4 trees.

The occurrence of diseases on wood and bark of the trunk and in the area of budding was checked at the end of the experiment. Also, instances of frost injury to flower buds were recorded in the spring of 2002.

The results were evaluated statistically using an analysis of variance, and Student`s t - test was used to compare the differences of means. The weight, size and colouration of fruits were expressed for two cropping periods (1996-1997 and 1998-2001) by weighted means.

RESULTS. No damage by winter frost occurred during the experiment. There were, however, some spring frost injuries to flower buds in 2001 (2.3-12%), but they were not specifically rootstock related.

There were some infections with pome fruit canker (*Nectria galligena*). Only one tree of cv. ‘Ligol’ on P 22 (4.2%) and one of ‘Jonica’ (4.8%) on each of the rootstocks P 22, P 60 and M.26 were found infected. However, more infections occurred on ‘Fiesta’ trees (20.8% on M.9, 16.6% on M.26, 8.3% on P 2 and only 4.2% on P 22).

Tree vigour indicated that there was a significant interaction between the rootstocks and the cultivars (Tab. 1). All trees on M.26 had a larger final trunk cross-sectional area (TCSA) than those on other rootstocks, while in trees on P 22 TCSA was the smallest. This characteristic was visually correlated with the tree canopy volume. However, each cultivar responded differently to the dwarfing ability of the tested rootstocks. In ‘Jonica’, the TCSA of trees on P 22 was only about 41% of this parameter for trees on M.9 after 4 seasons and about 30% after 8 seasons. For other cultivars the relevant data were:

'Ligol' – about 64.5 and 47.0%, and 'Fiesta' – about 71.0 and 63.0%, respectively. Rootstock P 60, used only for 'Jonica', influenced the growth of trees to the same degree as M.9 during four years after planting, but at the end of the experiment the trees on P 60 were smaller by about 24%. Those on P 2 had a similar TCSA as trees of 'Jonica' and 'Fiesta' cvs. on M.9 but in 'Ligol' they were significantly smaller after four years of growing.

Cropping started in the third year after planting. After the first two years of cropping the lowest yield was provided by cv. 'Jonica' on P 22, and the highest on P 60, while for the other three rootstocks it was similar (Tab. 1). For cvs. 'Ligol' and 'Fiesta' the yield was also the lowest on P 22, while it did not vary between P 2, M.9 and M.26. These proportions changed later, but the total yield per tree for all three cultivars on P 22 was even more distinctly reduced. On other rootstocks it did not significantly vary between the cultivars, although some slight differences occurred.

The crop efficiency index, expressed as total yield in kg per cm^2 of TCSA, was the highest for 'Jonica' on P 22 in both examined periods (Tab. 1). This parameter did not vary among the other rootstocks in the first period, but in the second it was distinctly higher for M.9 and P 60, as compared to P 2 and M.26. Cultivar 'Ligol' showed a similar crop efficiency index for all rootstocks in the first two years of yielding, but at the end of experiment its highest value was found for trees on P 22 and the lowest for those on M.26. For M.9 and P 2 the results obtained were very close to each other. In cv. 'Fiesta' the crop efficiency index varied according to the rootstock in both examined periods and finally it was similar for trees on M.9 and P 22, distinctly prevailing over the values obtained for P 2 and M.26.

The size of fruit (Tab. 2) did not significantly vary among the rootstocks in any of the cultivars in 1996-1997, but in 1998-2001 fruits of cvs. 'Jonica' and 'Ligol' on P 22 were smaller. Neither fruit colouration significantly differed among the rootstocks in any of the cultivars, although there was some positive tendency in favour of cv. 'Jonica' on P 22 and a slight determination of fruit colouring in 'Ligol' on M.26.

T a b l e 1 . Growth and cropping of three apple cultivars grafted on semidwarf and dwarf rootstocks

Cultivar	Root-stock	Spacing in rows [m]	Fruit yield [kg tree^{-1}]			Trunk cross-sectional area [cm^{2}]		Crop efficiency index [kg cm^{-2}]	
			1996-1997	1998-2001	1996-2001	1997	2001	1997	2001
‘Jonica’	P 22	1.3	7.2 a*	19.8 a	27.1 a	3.5 a	11.3 a	2.12 b	2.41 d
	M.9	1.5	10.4 b	65.4 b	75.8 b	8.0 b	37.6 bc	1.3 a	2.02 bc
	P 2	1.5	10.8 b	57.8 b	68.5 b	7.4 b	39.0 bc	1.47 a	1.76 ab
	P 60	1.7	12.9 c	47.2 b	60.1 b	8.4 b	28.5 b	1.55 a	2.11 c
	M.26	1.7	11.1 bc	58.5 b	69.6 b	7.8 b	44.3 c	1.45 a	1.59 a
‘Fiesta’	P22	1.3	9.4 a	25.8 a	35.2 a	3.9 a	13.3 a	2.38 c	2.68 b
	M.9	1.5	11.3 b	41.4 b	52.7 b	5.5 b	21.2 b	2.09 bc	2.48 b
	P2	1.5	10.9 ab	34.5 ab	45.4 ab	6.1 be	26.3 b	1.78 ab	1.74 a
	M.26	1.7	11.6 b	44.9 b	56.5 b	7.2 e	34.4 c	1.62 a	1.66 a
‘Ligol’	P 22	1.3	12.3 a	42.5 a	54.9 a	14.7 a	14.2 a	0.84 a	3.87 c
	M.9	1.5	18.1 b	59.8 ab	77.9 b	22.8 c	30.2 b	0.80 a	2.59 b
	P 2	1.5	17.1 b	56.4 ab	73.5 ab	18.2 ab	30.7 b	0.96 a	2.39 ab
	M.26	1.7	19.2 b	67.4 b	86.6 b	20.6 be	44.8 c	0.93 a	3 a

* Means followed by the same letter do not differ significantly at P = 0.05 according to Duncan’s multiple range t – test.Significance of differences for each variety is presented separately

Table 2. Fruit quality characteristics of three apple cultivars grafted on semidwarf and dwarf rootstocks

Cultivar	Rootstock	Mean fruit weight [g]		% of fruits with diameter >70 mm**		% of fruits with coloured surface >50%	
		1996-1997	1998-2001	1996-1997	1998-2001	1996-1997	1998-2001
'Jonica'	P 22	185 a*	170 a	97.1 a	91.0 a	100.0 a	79.8 a
	M.9	212.8 b	228.6 c	99.7 a	99.2 b	100.0 a	58.6 a
	P 2	204 ab	217 bc	98.8 a	98.2 b	99.4 a	59.9 a
	P 60	190 ab	184 ab	98.4 a	96.2 b	100.0 a	77.2 a
	M.26	204 ab	212 bc	99.8 a	96.5 b	99.8 a	63.8 a
'Fiesta'	P 22	154 a	142 a	89.2 a	64.3 a	98.1 a	77.2 a
	M.9	157 a	142 a	91.8 a	62.5 a	99.1 a	75.8 a
	P 2	156 a	149 a	88.7 a	72.9 a	98.6 a	71.5 a
	M.26	160 a	149 a	89.2 a	73.1 a	98.6 a	68.0 a
'Ligol'	P 22	245 a	230 a	95.4 a	65.7 a	98.6 a	60.9 a
	M.9	260 a	247 ab	95.5 a	83.5 b	99.2 a	59.6 a
	P 2	260 a	255 ab	96.9 a	83.7 b	100.0 a	65.3 a
	M.26	264 a	271 b	95.8 a	90.2 b	99.6 a	46.9 a

* Explanations - see Table 1

** Fruit diameter of 'Ligol' > 80 mm

Quality characteristics of fruits (weight, diameter, colouration) in weighted means

DISCUSSION. Results of the experiment confirmed a distinctly greater dwarfing effect of P 22 rootstock on apple trees in comparison with M.9. Such an effect was even higher as that reported before (Bielicki et al., 1999; Szczygieł et al., 1999ab). Similar outcome was also noted for cv. 'Šampion' by Kurlus and Ugolik (1999) and for 'Jonagored' by Jadczuk and Wlosek-Stangret (1999). In the first case, it was a weakly growing cultivar while in the second the budding was rather excessive for P 22 rootstock (Szczygieł, 2000). Nevertheless, in the present experiment the varying dwarfing effect of P 22 (from 29% in 'Fiesta' to 61% in 'Jonica') suggests that apple cultivars differently respond to this rootstock.

P 60 (used only for cv. 'Jonica') had a similar dwarfing effect to that of M.9 during the first four years after planting, but later on trees on the first rootstock were smaller. This is in agreement with observations by other authors (Jadczuk and Wlosek-Stangret, 1999), but differs from the previous general opinion regarding P 60 as more vigorous than M.9 and even P 2 (Bielicki et al., 1999). Since the latter rootstocks were grown on rather light sandy soils and P 60 showed a considerable dwarfing effect on a deep and fertile loam, differences in tree vigour could be related to soil conditions. Cultivar appears to be another factor determining tree vigour. On light soil a dwarfing effect of P 60 was more pronounced for cv. 'Cortland' than for 'Gloster' and 'Lobo' (Czynczyk et al., 1999). Also, in the previous experiment (Szczygieł et al., 1999a) established on soil similar to that in the present trial, the growth of 'Elstar' on this rootstock was comparable to that on M.26. Dwarfing effect can also be influenced by the planting depth and budding height, but this was not subject of references cited here.

In the present experiment, trees on P 2 showed a vigour similar to those on M.9 for all three cultivars. This is in agreement with the results of previous studies conducted at the same location (Szczygieł et al., 1999ab), where the growth of 'Gloster' and 'Elstar' trees on P 2 was only slightly stronger than on M.9. Some increase in 'Idared' vigour (by about 11% as compared to M.9 T337) was also caused by P 2 in Hungary (Hrotko and Mózer, 1999).

Cropping in the present experiment was correlated with tree vigour. However, a relatively low fruit yield from trees on P 22 was unexpected since in previous trials at the same location it was much higher in comparison with other rootstocks (Szczygieł et al., 1999ab). A low cropping was mainly due to a very weak tree vigour on that rootstock. This suggests that P 22 should not be recommended for low vigour cultivars grown on light or replanted soils. Instead, P 2 seems to be a suitable rootstock for cultivars of the 'Jonagold' group, especially on poor or replanted soils. It can also be recommended for 'Ligol', but not for 'Fiesta' because of its low crop efficiency index.

CONCLUSIONS

1. Dwarfing effect of P 22 rootstock can be much stronger than that of M.9. Therefore, P 22 seems to be unsuitable for light or replanted soils and for low vigour cultivars.
2. Dwarfing effect of P 2 in the sub-Carpathian region appears to be similar to that of M.9. Therefore, P 2 can be recommended for some cultivars, especially those of the 'Jonagold' group, for which it seems to be especially suitable on replanted soils.
3. Growth intensity and crop efficiency of some apple cultivars (including those of the 'Jonagold' group) may be acceptable on P 60 in certain soil conditions. This rootstock showed a considerable dwarfing effect on deep fertile soils.

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