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Early performance of 'Auksis' apple trees on dwarfing rootstocks in the Baltic region

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Abstract. 'Auksis' apple trees on P22, P59, P61, P62, P66, P67, PB-4, Pure 1, B.9, B.396, M.9 and M.26 rootstocks were planted in Estonia, Latvia and Lithuania in 2005. After five growing season, the strongest growth and the highest yield were recorded in Lithuania. The growth rate of trees on B.396, B.9, P62, P67, P66 and Pure 1 was similar to those of trees M.9. The rootstocks P22, P59 and PB-4 appeared to be more dwarfing than M.9. The highest cumulative yield of 'Auksis' was obtained from trees grafted on M.9, M.26, P62 and P67. The least productive were trees on PB-4 rootstock at all the places. Effects of rootstock on fruit weight were modest. Rootstock and location interaction was recorded for P61 in growth vigour control, and P22 and Pure 1 in cumulative yield.

Key words: *Malus domestica* Borkh., dwarfing rootstocks, growth, yield

INTRODUCTION

The Baltic region is situated in a cold climate zone, –20°C occurs almost every winter. Some winters can be very cold. The winter cold and spring frost damage is more hazardous in continental part of the Baltic countries (minimum –43°C). In recent years, however, significant warming of the climate has been observed in the Baltic Sea area. The length of the frost-free season has increased and an increasing length of the growing season in the Baltic Sea basin has been observed during the last century (HELCOM, 2007). The absence of severe winters has encouraged fruit growers of the Baltic region to use vegetatively propagated apple rootstocks. In the last decade, M.26 was widely used apple rootstock in new orchards of the Baltic region. Unfortunately, the roots of M.26 are susceptible to low temperatures (Quamme & Brownlee, 1997). In Russia, Poland, Belorussia, Latvia, Sweden, Finland and Estonia, apple rootstock breeders have paid special attention to winter hardiness of the rootstock (Potapov, 1999; Tahvonen et al., 2000; Univer, 2000; Lepsis, 2004; Szynczyk & Jakubowski, 2007). Based on the earlier rootstock tests, it can be concluded that rootstocks bred in Poland are with moderate growth vigour and induce early bearing and high production (Bite, 1999; Kviklys, 2002).

Rootstock influence on tree performance depends on many factors: soil, climate, moisture, orchard management etc. For this reason series of multi-site rootstock trials were established around the world (Autio et al., 2007; Robinson et al., 2004). There were observed that the vigour and tree productivity induced by rootstocks depend on local climatic and soil conditions in the earlier Baltic fruit rootstock studies program (Haak, 2006; Kviklys et al., 2006).

The objective of the trial was to evaluate new dwarfing rootstocks effect on tree vigour, yield and fruit quality in different geographical locations and environmental conditions.

MATERIALS AND METHODS

In spring of 2005, a trial of dwarf apple rootstocks was planted in Babtai, Lithuanian Institute of Horticulture (LT), Pure Horticultural Research Station (LV) and Polli Horticultural Research Centre of the Estonian University of Life Sciences (EST). The geographical locations are following: Babtai in Lithuania 55˚06' N, 23˚48' E, Pure in Latvia 57˚02' N, 22˚52' E, and Polli in Estonia 58˚07' N, 25˚33' E.

Apple cultivars were chosen and experimental design was compiled under the initiative of D. Kviklys. Twelve rootstocks coming from different breeding programmes were compared. They included the Polish rootstocks P22, P59, P61, P62, P66 and P67, the Belorussian PB-4, the Latvian Pure 1, the Russian B.9 and B.396, as well as the standards M.9 and M.26. One-year-old trees of Lithuanian apple cultivar 'Auksis' were spaced 4 × 1.5 m (1666 trees ha^{-1}). The test material was produced in Lithuania. The trees were cut to 90 cm height and later spindle-trained. In 2005, all trees were deblossomed. The trial consisted of four replications with 3 trees on each. Replications were randomized.

The following measurements were taken: trunk diameter 30 cm above the soil surface (mm), tree height (m), canopy spread (m), yield (kg $tree^{-1}$) and fruit weight (g), as well as top shoot length (cm).

The results were elaborated statistically by the analyses of variance using Duncan's multiple range tests.

RESULTS AND DISCUSSION

The trunk diameter and tree height of the young apple trees of 'Auksis' grown on different rootstock differed to a great extent and was affected by climatic and soil conditions of the growing place. The trees in Lithuania had the largest tree height and trunk diameter after 5 years in orchard. The tree height of rootstocks PB-4 and P59 was smaller in all the experimental places, whereas M.26 produced the highest trees (Table 1). In Estonia and Latvia the trees on P22, P61 and P66 were small, as well.

The increase of trunk diameter describes the most objectively the rootstock effect on tree growth. In 2009, the trunk diameter of 'Auksis' apple trees was larger in Lithuania (28–59 mm) and smaller in Latvia (36–42 mm) and Estonia (22–41 mm) (Table 2). The trunk diameter of the trees on PB-4 and P59 were smallest in Lithuania, on PB-4, P22 and P59 in Latvia and on P61, P59, PB-4 and P22 in Estonia. For rootstock P61 contradictory results were obtained. In Latvia its trunk diameter was the

largest and in Estonia the smallest. According to Bielecki et al. (2007) and Jadczuk et al. (2007), P61 can be classified as very dwarfing rootstocks. The rootstocks M.26, M.9 and P62 were the largest in Lithuania, M.26 and P61 in Latvia and M.26 and B.9 in Estonia.

Table 1. Tree height of 'Auksis' apple trees on various rootstocks in 2009.

Rootstock	Tree height (m)		
	LT	LV*	EST
M.9	3.51 de**	2.01 b	1.91 b
M.26	3.77 e	2.57 c	2.44 c
P22	2.62 b	1.74 ab	1.71 a
P59	2.01 a	1.67 a	1.78 a
PB-4	2.10 a	1.66 a	1.57 a
P61	2.55 b	1.80 ab	1.71 a
P62	2.99 c	1.88 ab	1.98 b
P66	2.94 c	1.87 ab	1.84 a
P67	3.36 d	2.05 b	2.05 b
Pure 1	2.43 b	1.74 ab	2.07 b
B.396	3.10 cd	2.05 b	2.19 b
B.9	2.90 c	2.04 b	2.15 b

* data of 2008; ** Means followed by the same letter do not differ significantly at $P \leq 0.05$; Duncan's multiple range tests

Table 2. Trunk diameter of 'Auksis' apple trees on various rootstocks in 2005 and 2009.

Rootstock	Trunk diameter (mm) in 2005			Trunk diameter (mm) in 2009		
	LT	LV	EST	LT	LV	EST
M.9	16.5 d*	16.0 e	16.9 de	51.8 f	40.2 de	34.5 de
M.26	16.2 d	14.7 cde	15.5 cd	59.0 g	42.1 ef	41.2 f
P22	14.5 c	12.9 ab	14.1 b	41.0 cd	29.2 ab	26.2 b
P59	12.7 a	12.8 ab	12.5 a	28.5 a	31.9 b	23.7 ab
PB-4	13.0 ab	12.2 a	13.8 ab	29.8 a	26.0 a	24.7 ab
P61	13.7 b	12.7 ab	12.8 a	34.3 b	41.7 ef	22.0 a
P62	15.7 d	14.3 abcd	14.1 b	51.3 f	36.6 cd	35.5 d
P66	14.7 c	14.2 abcd	14.4 b	43.0 d	36.6 cd	30.7 c
P67	15.7 d	14.6 bcd	14.1 b	46.8 e	39.8 de	34.0 d
Pure 1	13.7 b	13.6 abcd	14.0 b	38.5 c	37.8 d	31.7 cd
B.396	16.5 d	15.5 de	14.9 bc	47.0 e	39.0 de	36.7 e
B.9	14.7 c	15.4 de	17.2 e	41.5 d	34.0 bc	40.0 f

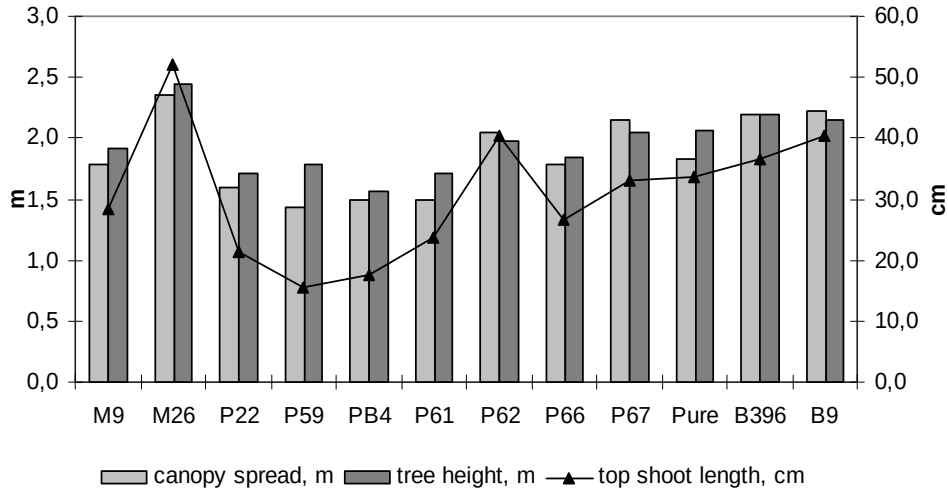
* Means followed by the same letter do not differ significantly at $P \leq 0.05$; Duncan's multiple range tests

The top shoot length characterizes the conditions of growing season and rootstock cultivar combination reaction to them. The shoots of the trees were longer on rootstocks M.26, B.9, B.396 and P62, if compared to trees on M.9 (Fig. 1). The canopy spread was affected by rootstock as well. It was smaller on trees with smaller trunk diameter. The rootstocks PB-4, P59 and P61 decreased shoot growth of the trees. The coefficients of correlation (r) between tree height and canopy spread was strong (r = 0.91 ± 0.05). All the tested rootstocks according to growth vigour control could be

grouped into several size categories. The vigour of the rootstocks B.396, B.9, P62, P67, P66 and Pure 1 was similar to M.9. The rootstocks P22, P59, PB-4 seemed to be weaker than M.9.

The greatest cumulative yield per tree (2006–2009) was obtained in Lithuania, and the lowest one in Latvia (Table 3). In 2007, severe spring frosts damaged flowers and decreased yielding potential of apple trees in Latvia. The trees on rootstocks M.9, M.26, P62 and P67 yielded the most in Lithuania and in addition to these B.396 and B.9 performed well in Estonia. The smallest trees tended to have the lowest yield per tree. Therefore, trees growing on the rootstocks PB-4 showed the lowest cumulative yield in all the locations. On the other hand, the smallest trees usually had the highest efficiency expressed as a ratio of yield per tree to the trunk cross-sectional area (kg cm^{-2}), what is declared in many trials (Kviklys, 2006; Bielicki et al., 2007).

The effects of rootstock on fruit weight were modest (Table 3). In Lithuania M.9, M.26, P62, P66 and P67 resulted in the highest average fruit weight. The rootstock M.26 resulted in the largest fruits weight, whereas Pure 1 resulted in the smallest fruits weight in Estonia.



$LSD_{0.05}$ = for canopy spread 0.2; $LSD_{0.05}$ = for tree height 0.3; $LSD_{0.05}$ = for top shoot length 8.6

Figure 1. Rootstock effect on canopy spread (m), tree height (m) and top shoot length (cm) of 'Auksis' apple trees at the Polli Horticultural Research Centre in 2009.

Table 3. Rootstock effect on cumulative yield and fruit weight of 'Auksis' apple trees in 2006–2009.

Rootstock	Cumulative yield (kg tree^{-1})			Average fruit weight (g)	
	LT	LV	EST	LT	EST
M.9	28.1 e*	3.2 ab	15.0 c	171 d	133 abc
M.26	24.7 d	3.0 ab	14.2 c	162 cd	136 c
P22	17.9 c	3.7 ab	9.5 b	150 abc	132 abc
P59	9.0 a	3.9 ab	9.6 b	150 abc	128 abc
PB-4	8.3 a	2.9 a	7.0 a	140 a	126 ab
P61	13.3 b	3.3 ab	7.0 a	159 bc	133 abc
P62	24.2 d	5.0 b	15.4 c	175 d	130 abc
P66	19.3 c	4.2 ab	10.4 b	161 bcd	125 ab
P67	23.7 d	3.4 ab	17.7 d	166 cd	128 ab
Pure 1	17.7 c	3.1 ab	11.0 b	146 ab	123 a
B.396	20.0 c	2.7 a	14.6 c	146 ab	124 ab
B.9	17.2 c	4.6 ab	15.7 c	145 ab	127 abc

*Means followed by the same letter do not differ significantly at $P \leq 0.05$; Duncan's multiple range tests

CONCLUSIONS

The results presented here must be labelled as preliminary ones, since they are based only on the first five growing seasons, but they give an early look at some of the newest and potentially useful dwarfing apple rootstocks for the Baltic region.

1. The rootstocks B.396, B.9, P62, P67, P66 and Pure 1 can be classified as dwarfing, having similar growth vigour to M.9
2. The rootstocks P22, P59 and PB-4 appeared to be more dwarfing than M.9
3. The trees on the rootstocks M.9, M.26, P62 and P67 gave the highest cumulative yield and the least productive ones were the trees on the PB-4 rootstock.
4. Rootstock and location interaction was recorded for P61 in growth vigour control, and P22 and Pure 1 in cumulative yield.

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