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Assessment of apple cultivars for organic fruit cultivation

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Abstract. In 2005–2008 apple tree cultivars and selections were tested at the Lithuanian Institute of Horticulture in an organic apple tree orchard. Apple trees on rootstock B.396 were spaced at distances of 4 x 2 m; the orchard floor was a cultivated soil. The bioinsecticide Bioshower against aphids was applied once a year, fungicides were not used. Apple trees of cultivars. 'Pilot' and 'Pinova' were significantly affected by apple scab (*Venturia inaequalis* Cke. Wint), and 'Lodel' – by apple powdery mildew (*Podosphaera leucotricha* (Ellis et Everh.) Salm).

Apple trees of the cultivar. 'Aldas' and selection 18501 were the most vigorous. In 2007–2008 the greatest average yield was from the cultivars 'Florina', 'Rosana', selections 20,490 and 22,1709.1–14.7 t ha^{-1}. These same cultivars and selections were the most yield efficient. The greatest average fruit weight was from cultivar. 'Witos' (272 g), the smallest from the cultivars 'Pilot', 'Pinova', 'Goldrush' and 'Lodel' (111–137 g). The highest taste score was from 'Goldstar', 'Rubinola', 'Topaz', 'Rajka' and 'Lodel' apples.

Key words: apple scab, yield, fruit weight, taste

INTRODUCTION

Technological progress in agriculture and related branches of industry has resulted in an increase in agricultural production. Highlydeveloped countries produce more food than they consume themselves. People concerned about their health have begun to seek more healthy products. This has promoted farmers to supply consumers with organically grown products. The organic movement covers all branches of agriculture.

The organic fruit industry in Europe still has a relatively low market share of 1–5% of the total market (Weibel et al., 2007) and cannot satisfy consumer demand. Less availability of fertilizers and means for pest and disease control are the most limiting factors for an increase in organic fruit cultivation. Apple scab (*Venturia inaequalis* Cke. Wint) is the most harmful disease in Lithuania. The best means to avoid this problem is to grow scab-tolerant or resistant apple cultivars. As a result of breeding programs different scab resistant cultivars are now available (Fideghelli, 2002; Janick, 2002; Blažek, 2004; Blažek & Křelinová; 2006). Modern cultivars differ from older ones in better apple quality parameters (Godec, 2004).

Scab-resistant apple cultivars 'Štaris', 'Aldas', 'Rudenis' and 'Skaistis' were bred at the Lithuanian Institute of Horticulture (Gelvonauskienė et al., 2008). The Lithuanian market still lacks long-stored apples. To date only 'Florina' and 'Lodel'

apples from Lithuanian organic orchards are suitable for longer storage. New promising scab resistant cultivars are always awaited by fruit growers.

The objective of the research – to select apple cultivars suitable for organic fruit growing.

MATERIALS AND METHODS

A field trial was carried out at the Lithuanian Institute of Horticulture in 2005–2008. One-year-old nursery trees of tested apple cultivars and selections were planted in the orchard in the spring. Rootstock used was B.396, planting scheme – 4 x 2 m. The experiment was designed in four random blocks; each experimental plot consisted of four trees. The orchard floor was cultivated soil. Bioinsecticide Bioshower against aphids was applied once a year, fungicides were not used.

Fourteen cultivars and three selections genetically resistant or with low susceptibility to apple scab were tested: 'Goldstar', 'Rajka', 'Rosana', 'Rubinola', 'Topaz' (bred in Czech Republic); 'Enterprise', 'Goldrush', 'Freedom' (bred in USA); 'Pinova' and 'Pilot' (bred in Germany); 'Witos' and 'Lodel' (bred in Poland); French cultivar 'Florina'; Lithuanian cultivar 'Aldas' and selections 18501, 20490, 22170.

Tree trunk cross section area (cm^2), yield (t ha^{-1}), yield efficiency (kg cm^{-2} of TCSA), mean fruit weight (g), fruit taste (score), leaf blotch (*Phyllosticta spp.*), apple scab (*Venturia inaequalis* Cke. Wint), powdery mildew (*Podosphaera leucotricha* (Ellis et Everh.) Salm) incidence (%) on leaves were evaluated.

Trunk cross section area was calculated according to trunk diameter measurements 25 cm above the graft join in autumn 2007 and 2008. Marketable yield was recorded for the whole experimental plot consisting of four trees and recalculated to yield per hectare. Yield efficiency was calculated as an average of yield efficiencies of two years (2007 and 2008). It is expressed as a fruit weight ratio with trunk cross-section area (TCSA). Mean fruit weight was determined on a representative sample of 50 apples per plot. Sensory taste analysis was assessed at the end of December by a panel of eight trained assessors (scores from 1, the lowest, to 5, the highest). Disease incidence was calculated in the second decade of July using the formula: $P = n/N \cdot 100$. (P – disease incidence, %; n – number of attacked leaves; N – total number of investigated leaves).

Experimental data were subjected to analysis of variance. For mean separation LSD or Duncan's test at $P = 0.05$ was used. Data were analysed by the 'ANOVA' statistical program.

RESULTS AND DISCUSSION

Apple trees of 'Aldas' and 'Pilot' cultivars were the most sensitive to leaf blotch: disease incidence was 42 % and 36 %, respectively (Table 1). The least number of leaf blotch affected leaves (10 % and less) was of 'Florina', 'Rosana', 'Rajka', 'Enterprise' cultivars and selection 20490.

Table 1. Disease incidence on apple leaves in organic orchard. Babtai, 2007–2008.

Cultivar, selection	Leaf blotch incidence, %	Scab incidence, %	Powdery mildew, %
Aldas	42.0 e*	0 a	0 a
Enterprise	8.5 ab	0 a	0 a
Florina	3.0 a	0 a	0 a
Freedom	29.0 de	0 a	0 a
Goldrush	21.5 c	0 a	0 a
Goldstar	23.0 cd	0 a	0 a
Lodel	17.5 c	0 a	22.6 b
Pilot	36.0 e	39.0 b	0 a
Pinova	19.5 c	54.5 c	0 a
Rajka	7.0 ab	0 a	0 a
Rosana	6.0 ab	0 a	0 a
Rubinola	16.0 bc	0 a	0 a
Topaz	14.0 bc	0 a	0 a
Witos	18.5 c	0 a	0 a
18501	11.0 b	0 a	0 a
20490	10.0 ab	0 a	0 a
22170	23.5 cd	0 a	0 a

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

The leaves of 'Pilot' and 'Pinova' were significantly damaged by apple scab – 39–54.5 %, whereas the fruits were only slightly affected. The rest of the cultivars and selections were not scab damaged. 'Lodel', distinguished for high susceptibility to powdery mildew: disease incidence, reached 22.6 %. Other cultivars and selections showed low susceptibility to this disease and were not affected during the years of investigation. Some of the cultivars tested in our experiment were susceptible to powdery mildew if climate conditions favoured disease development (Blažek, 2004; Blažek & Křelinová. 2006; Bryk & Broniarek-Niemiec, 2008; Czynczyk et al., 2008).

After four years of growth in the orchard the apple trees of selection 18501 and the 'Aldas' cultivar were the most vigorous. Their trunk cross section area was respectively 25.5 and 25.2 cm^2 (Table 2). Vigorous trees are more demanding of pruning and training. These operations significantly increase orchard management expenses. Selection 20490, 'Florina', 'Rajka', 'Rubinola' and 'Witos' cultivars distinguished themselves by moderate growth vigour. Apple trees of the 'Goldrush', 'Goldstar', 'Enterprise', 'Lodel', 'Rosana', 'Pinova', 'Freedom', 'Pilot', 'Topaz' cultivars and selection 22170 grew slightly. Their trunk cross section area reached 10.2–13.5 cm^2.

The apple trees of 'Florina' and selection 20490 produced the highest mean yields – respectively 14.7 and 11.7 t ha^{-1}. 'Rosana' and selection 22170 were slightly less productive – 9.1–9.6 t ha^{-1}. The yields of 'Pilot', Rajka', 'Rubinola', 'Enterprise', 'Pinova' and 'Goldstar' were the least productive – 4.1–4.9 t ha^{-1}. Our results were obtained in a young orchard and cropping tendencies may differ in future. Some cultivars increased yield rapidly, others achieved full bearing later (Blažek & Křelinová, 2006). In the opinion of Szklarz (2004; 2006), 'Florina' is a very good yielding cultivar.

Table 2. Apple tree growth, yield and fruit quality. Babtai, 2005–2008.

Cultivar, selection	TCSA, cm^2	Mean yield 2007–2008, t ha^{-1}	Mean yield efficiency, kg cm^{-2} of TCSA	Mean fruit weight, g	Taste score, (1–5 scale)
Aldas	25.2	6.5	0.21	193	4.2 ab*
Enterprise	11.1	4.4	0.33	181	4.3 b
Florina	17.9	14.7	0.79	158	4.3 b
Freedom	11.7	7.5	0.53	196	4.2 ab
Goldrush	10.2	7.6	0.61	127	4.0 a
Goldstar	10.2	4.9	0.45	171	4.5 bc
Lodel	11.4	6.2	0.52	137	4.4 bc
Pilot	12.1	4.1	0.30	111	4.1a
Pinova	11.5	4.7	0.31	126	4.2 ab
Rajka	15.2	4.2	0.29	170	4.4 bc
Rosana	11.4	9.1	0.71	185	4.3 b
Rubinola	15.5	4.2	0.23	179	4.6 c
Topaz	13.5	5.9	0.39	157	4.5 bc
Witos	15.0	5.3	0.28	272	4.3 b
18501	25.5	5.7	0.19	161	-
20490	14.5	11.7	0.76	169	4.2 ab
22170	12.7	9.6	0.70	193	4.1 a
LSD_{05}	4.02	3.85	0.200	34.4	-

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

An experiment in Poland showed that 'Pinova' and 'Topaz', grown on the plot with a limited spraying programme, had the greatest summarized yield, whereas 'Goldstar' and 'Rubinola' – has the least (Czynczyk et al., 2008). Cultivar productivity depends not only on genetic characteristics but also on agricultural treatments and the specificity of the site.

The yield efficiency indicator shows a tree's tendency to bearing. Yield efficient cultivars produce more fruits per unit of tree vegetative mass. 'Goldrush', 'Rosana', 'Florina' cultivars and selections 20490, 22170 were the most yield-efficient in our experiment. The index value reached 0.61–0.79 kg cm^{-2} of TCSA. The least yield efficient were apple trees of selection 18501, cultivars 'Aldas', 'Rubinola', Witos', 'Rajka', 'Pilot', 'Pinova', 'Enterprise' and 'Topaz' (index value – 0.19–0.39 kg cm^{-2} of TCSA). In the experiment of Blažek and Křelinová (2006) yield efficiency of 'Topaz' cultivar was one of the highest. In Poland 'Pinova' showed a high cropping efficiency index in the plots with no spraying programme, whereas in the plots with a limited spraying programme 'Topaz' was also yield efficient (Czynczyk et al., 2008). Yield efficiency, as the yield, may vary depending on tree age and other factors.

'Witos' had the largest fruits in our evaluation with a mean fruit weight equal to 272 g. Apples of the most cropping cultivar 'Florina' and selection 20490 reached weights respectively of 158 and 161 g. Fruits of 'Pilot', 'Pinova', 'Goldrush' and 'Lodel' were the smallest – 111–137 g.

'Rubinola' apples were rated with the highest taste score – 4.6. Good taste was achieved by 'Goldstar', 'Topaz', 'Rajka' and 'Lodel' apples. The lowest taste score

was given for ‘Pilot’, ‘Goldrush’ and selection 22170 – 4.0–4.1. It was still difficult to grow scab resistant cultivars on a commercial scale because of poor fruit quality. Fruit quality of new disease resistant cultivars can be at least equal to that of currently popular commercial cultivars (Godec, 2004).

Tentative data of apple storage properties in cool storage at a temperature between1-2°C indicate selections to store as well as autumn or early winter cultivars (data not presented). The longest storage period is expected for ‘Lodel’, ‘Rubinola’, ‘Enterprise’, ‘Topaz’, ‘Pinova’, ‘Pilot’, ‘Goldstar’ and ‘Goldrush’ apples. Long-stored scab resistant apples are the most desired by fruit growers in Lithuania.

CONCLUSIONS

Tested cultivars and selections, except ‘Pilot’ and ‘Pinova’, were resistant to the main apple disease – apple scab. ‘Lodel’ was distinguished for susceptibility to powdery mildew, ‘Aldas’ and ‘Pilot’ – to leaf blotch.

Apple trees of selection 20490 and ‘Florina’ produced the highest mean yields – 11.7–14.7 t ha^{-1}, ‘Rosana’ and selection 22170 were slightly less productive – 9.1–9.6 t ha^{-1}. ‘Goldrush’, ‘Rosana’, ‘Florina’ cultivars and selections 20490, 22170 were the most yield efficient. The best fruit taste was from ‘Goldstar’, ‘Rubinola’, ‘Topaz’, ‘Rajka’ and ‘Lodel’ apples.

From the complex range of indices the best cultivars at a young age are ‘Rosana’ and ‘Florina’. In anticipation of higher yields in older orchard the promising cultivars are ‘Rubinola’, ‘Topaz’, ‘Goldstar’ and ‘Rajka’.

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