

Evaluation of agronomical characters and resistance to fungal diseases of apple cultivars

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In 2004–2009 at the Lithuanian Institute of Horticulture blooming period and abundance, trunk cross sectional area, yield, productivity, resistance to scab (*Venturia inaequalis*) and apple blotch (*Phyllosticta mali*) were studied in 7 apple (*Malus × domestica* Borkh.) cultivars. Trees were grafted on rootstock B.118 with spacing 4 × 2.5 m.

‘Auksis’ and ‘Connell Red’ were the best ones among the tested cultivars. The following apple cultivars were distinguished for particular characteristics: ‘Kim’ – earliest blooming, ‘Winterbanana’ – latest blooming, ‘Connell Red’ – blooming abundance, ‘Connell Red’ – weakest growth, ‘Auksis’ and ‘Connell Red’ – yield in young orchard, ‘Auksis’ and ‘Birgit Bonnier’ – resistance to scab, ‘Auksis’ and ‘Connell Red’ – resistance to apple blotch.

Key words: apple, cultivars, growth, phenology, *Phyllosticta mali*, productivity, *Venturia inaequalis*, yield.

Introduction. Superior fruit qualities, high productivity, resistance to diseases and pests, winter hardiness, storability and marketability are the crucial requirements to new apple cultivars (Kellerhals et al., 1999; Kellerhals et al., 2003; Sansavini et al., 2005; Rutkowski et al., 2005). Apple scab (*Venturia inaequalis*) is one of the most important diseases in fruit orchards in Lithuania (Raudonis, Valiūškaitė, 2003). High quality scab resistant cultivars have been developed over the last 50 years. Scab resistance determined by the gene V_r , derived from *Malus floribunda* 821, has been considered durable for a long time (Kellerhals et al., 1999). However, before the appearance of races of scab virulent to V_r (Parisi et al., 1993) it was obvious that breeding for scab resistance should include alternative sources of resistances. On the other hand, cultivars with durable resistance to other diseases – apple blotch (*Phyllosticta mali*), powdery mildew (*Podosphaera leucotricha*) and fire blight (*Erwinia amylovora*) – are important for ecological and economical considerations. Resistance to biotic and adaptation to abiotic factors of newly introduced apple cultivars and promising hybrids is being studied at the Lithuanian Institute of Horticulture (Sasnauskas et al., 2006; Gelvonauskienė et al., 2007; Sasnauskas et al., 2007; Sasnauskas et al., 2009).

Objective of the work was to study some agronomical characters and resistance to fungal disease of the introduced apple cultivars.

Object, methods and conditions. Trial years and place. The trial of 7 apple cultivars was planted at the Lithuanian Institute of Horticulture in the spring of 2004. Trees were grafted on B.118 rootstock. Evaluation and characterization of the cultivars was performed in 2006–2009.

Meteorological conditions. The late spring frost at the beginning of bloom injured blossoms in 2007. At this time the minimal air temperature above the ground dropped from -3 °C to -2.5 °C, what injured fruit settings. Such conditions negatively affected yield parameters. In 2006 during flowering and after it weather was cold, but were no frosts and such condition didn't affect yield.

Plant material. The following introduced apple cultivars were compared with the standard cv. 'Auksis' (Lithuania): 'Bavendorf' (Germany), 'Birgit Bonnier' (Sweden), 'Connell Red' (USA), 'Kim' (USA), 'Nyckelby' (Sweden) and 'Winterbanana' (USA).

Experimental design. The trees were planted at the distance of 4 × 2.5 m. The trial was established in five replications. Each plot contained 1 fruit-tree. They were formed as spindle. Growing, fertilizing, pest, disease and weed control, soil cultivation, pruning, shaping and care of apple cultivars were maintained as recommended for commercial orchards (Intensyvios obelų ir kriaušių auginimo technologijos, 2005).

Observations and statistical analysis. In the trial the following characters of apple cultivars was established: blooming periods, days; blooming abundance, scores (1-no blooming detected on trees, 9-bloomed more than 90 % of flowers); apple tree trunk cross-section area, cm²; yield, t ha⁻¹; productivity, kg/cm², resistance to scab (*Venturia inaequalis*) and apple blotch (*Phyllosticta mali*), scores (1-no disease symptoms detected on leaves, 9-injured more than 75 % of leaf area). All data were subjected to analysis of variance. The significance of differences between the cultivars was estimated at 0.05 levels (Fisher's Protected LSD and Duncan's Multiple Range Test) (Tarakanovas, Raudonius, 2003).

Results. Blooming period. Apple trees started blooming in their third year in the orchard. All the blooming stages (beginning of blooming, beginning of full blooming, end of full blooming and end of blooming) began earliest in 'Kim', while the latest blooming was observed in 'Winterbanana' trees (Table 1). According to investigation data, blooming period continued 10–12 days.

Table 1. Dates of blooming periods of apple cultivars
1 lentelė. Obelų veislių žydėjimo tarpsniai

Babtai, 2006–2008

Cultivars Veislės	Beginning of blooming (month, day) Žydėjimo pradžia, mėn., diena	Beginning of full blooming (month, day) Masinio žydėjimo pradžia, mėn., diena	End of full bloo- ming (month, day) Masinio žydėjimo pabaiga, mėn., diena	End of blooming (month, day) Žydėjimo pabaiga, mėn., diena
1	2	3	4	5
'Auksis'	05-12 ab*	05-16 ab	05-20 ab	05-22 a
'Bavendorf'	05-16 bcd	05- 20 bcd	05-23 bcd	05-26 bc
'Birgit Bonnier'	05-16 bcd	05-20 bcd	05-22 bcd	05-25 abc

Table 1 continued
1 lentelės tęsinys

1	2	3	4	5
‘Connell Red’	05-17 cd	05-19 bcd	05-24 bcd	05-27 bc
‘Kim’	05-10 a	05-15 a	05-18 a	05-21 a
‘Nyckelby’	05-18 cd	05-22 cd	05-26 d	05-28 bc
‘Winterbanana’	05-18 d	05-23 d	05-25 cd	05-29 c
Mean	05-16	05-19	05-22	05-25
Veislių vidurkis				

* Duncan’s multiple range t-test / Duomenys apskaičiuoti pagal Dunkano kriterijų Means followed by the same letter are not significantly different at P = 0.05

* Tarp vidurkių, pažymėtų tomis pačiomis raidėmis, nėra esminių skirtumų, kai P = 0,05

Blooming abundance. In the third year of growth apple trees ‘Connell Red’ (5.5 scores) bloomed most abundantly, while cvs. ‘Kim’ (1.1 scores) and ‘Aukšis’ (1.3 scores) bloomed little (Table 2). In the fourth year of growth apple trees bloomed little (3.3 scores). During the evaluation period spring frosts in this year at the beginning of bloom injured blossoms. In the fifth year of growth apple trees bloomed better (4.5 scores). Apple trees ‘Connell Red’ (6 scores) and ‘Nyckelby’ (5.3 scores) bloomed most abundantly. On the other hand, cv. ‘Bavendorf’ (2.3 scores) bloomed little.

Table 2. Blooming abundance of apple cultivars
2 lentelė. Obelių žydėjimo gausumas

Babtai, 2006–2008

Cultivars Veislės	Blooming abundance (scores) Obelių žydėjimo gausumas, balais		
	2006	2007	2008
‘Aukšis’	1.3 a*	4 bcd	4.6 ab
‘Bavendorf’	1.5 ab	2 a	2.3 a
‘Birgit Bonnier’	2.5 ab	3 ab	3.6 ab
‘Connell Red’	5.5 d	6 d	6 c
‘Kim’	1.1 a	3 ab	5 bc
‘Nyckelby’	2.5 ab	2 a	5.3 bc
‘Winterbanana’	3.5 bcd	5.6 cd	4 ab
Mean	2.5	3.3	4.5
Veislių vidurkis			

* Duncan’s multiple range t-test / Means followed by the same letter are not significantly different at P = 0.05

* Duomenys apskaičiuoti pagal Dunkano kriterijų / Tarp vidurkių, pažymėtų tomis pačiomis raidėmis, nėra esminių skirtumų, kai P = 0,05

Tree growth. In the fifth year of growth apple trees of the investigated cultivars showed that the trees of ‘Birgit Bonnier’ (36.7 cm²) and ‘Kim’ (36.5 cm²) grew significantly stronger, while ‘Connell Red’ (23.5 cm²) – weaker, compared with the other tested apple cultivars (Fig. 1).

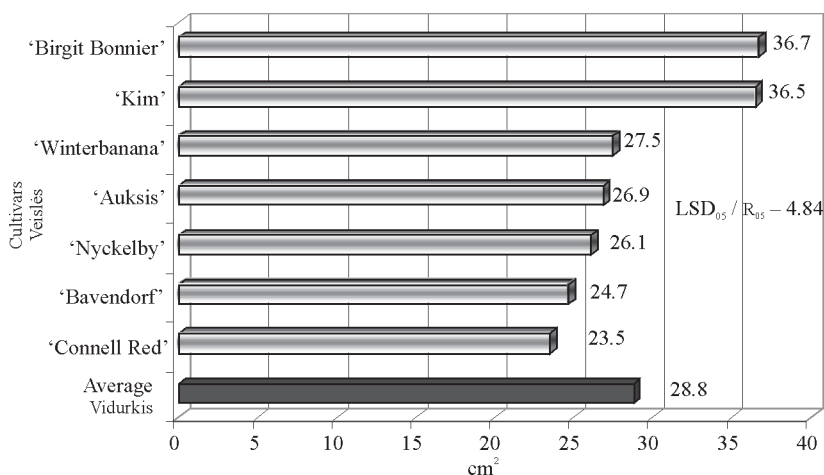


Fig. 1. Trunk cross sectional area (cm²)
1 pav. Obelių veislių kamieno skerspjūvio plotas, cm²
 Babtai, 2008

Yield and productivity. The yield per year is cumulatively presented in Fig. 2. These data show that the highest cumulative yield per hectare is from 'Auksis' (23.7 t ha⁻¹). 'Connell Red' (21.8 t ha⁻¹) gives almost the same yield. The next in yield capacity were cvs. 'Bavendorf' (18 t ha⁻¹) and 'Nyckelby' (15.1 t ha⁻¹). 'Kim' (6.1 t ha⁻¹), 'Birgit Bonnier' (8.9 t ha⁻¹) and 'Winterbanana' (13.3 t ha⁻¹) had the lowest yield.

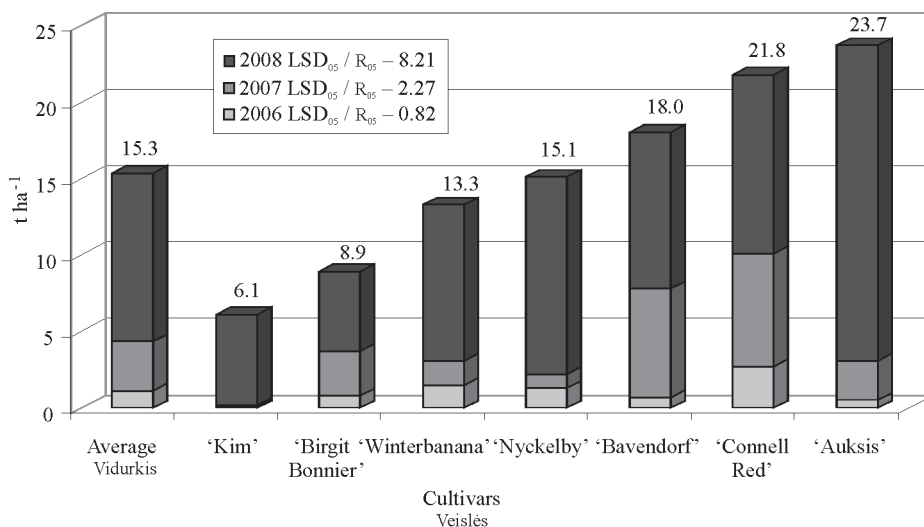


Fig. 2. Cumulative yield of apple cultivars (t ha⁻¹)
2 pav. Obelių veislių suminis derlius, t ha⁻¹
 Babtai, 2006–2008

The average of productivity of the investigated apple cultivars was 0.40 kg/cm² (Fig. 3). The highest productivity was assessed for cultivar ‘Auksis’ (0.77 kg/cm²). The significantly lowest productivity showed ‘Birgit Bonnier’ (0.14 kg/cm²) and ‘Kim’ (0.16 kg/cm²). Productivity of cultivars ‘Bavendorf’ (0.42 kg/cm²) ‘Winterbanana’ (0.42 kg/cm²) and ‘Nyckelby’ (0.50 kg/cm²) was close to the average and significantly differed from cultivars discussed before.

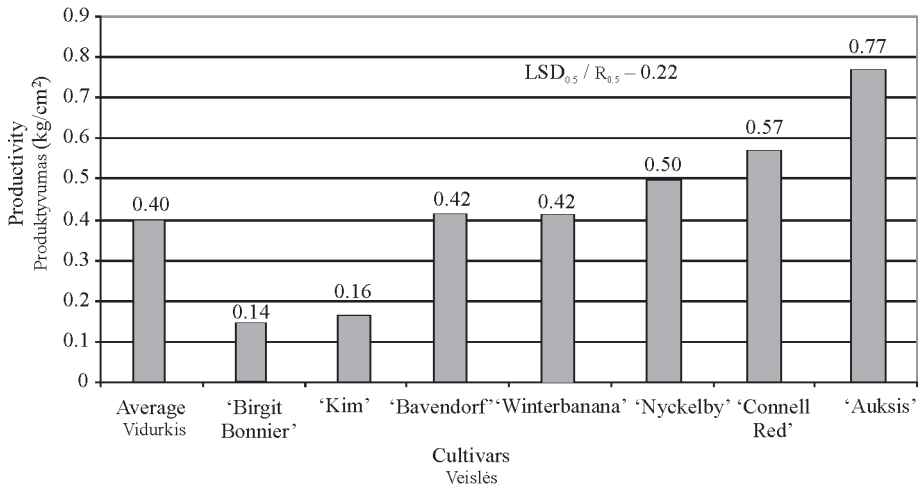


Fig. 3. Productivity of apple cultivars (kg/cm²)
3 pav. Obelų veislių produktyvumas, kg/cm²
 Babtai, 2008

Disease resistance. Tested apple genotypes demonstrated different field resistance to apple scab. In the fourth year in orchard, cvs. ‘Bavendorf’ (2.6 scores) and ‘Nyckelby’ (2.9 scores) were the most susceptible on leaves (Table 3). In the fifth year in orchard, ‘Kim’ (2 scores) was the most susceptible to this disease. In the sixth year in orchard, all cultivars displayed higher apple scab symptoms on leaves. More resistant to this disease on leaves was cvs. ‘Auksis’, ‘Birgit Bonnier’ and ‘Kim’ (2 scores), while ‘Nyckelby’ (5 scores) was the most susceptible to apple scab.

All cultivars displayed apple blotch symptoms on leaves in 2007 (Table 3). Cv. ‘Auksis’ (1.1 scores) showed high resistance. Cv. ‘Bavendorf’ (2.6 scores) was the most susceptible. In the fifth and sixth year in orchard, cvs. ‘Auksis’ and ‘Connell Red’ (1 score) were free from apple blotch symptoms on leaves. On the other hand, cv. ‘Kim’ and ‘Birgit Bonnier’ were the most susceptible to this disease.

Table 3. Scab and apple blotch injury on apple-tree (scores)
3 lentelė. Obelių pažeidimas rauplėmis ir filostiktoze, balais

Babtai, 2007–2009

Cultivars Veislės	Scab Rauplės			Vidurkis Average	Apple blotch Filostiktozė			Vidurkis Average
	2007	2008	2009		2007	2008	2009	
‘Auksis’	1.7	1.6	2.0	1.7	1.1	1.0	1.0	1.03
‘Bavendorf’	2.6	1.5	3.0	2.37	2.6	1.0	2.3	1.97
‘Birgit Bonnier’	1.3	1.9	2.0	1.73	2	1.5	2.0	1.87
‘Connell Red’	1.8	1.8	3.2	2.27	1.8	1.0	1.0	1.27
‘Kim’	1.8	2.0	2.0	1.93	1.6	1.5	2.6	1.9
‘Nyckelby’	2.9	1.6	5.0	3.17	1.5	1.0	2.0	1.5
‘Winterbanana’	1.4	1.8	2.2	1.80	1.8	1.7	1.8	1.77
Average Veislių vidurkis	1.92	1.74	2.78	2.15	1.77	1.24	1.82	1.61
LSD ₀₅ / R ₀₅	0.49	0.26	1.10	0.51	0.38	0.13	0.51	0.36

Discussion. One of the requirements for successful pollination is that the pollinator must flower at the same time as the cultivar to be pollinated (Grauslund, 1996). For this purpose cultivars were divided into groups of similar blooming time. The early blooming apple cultivars suffer a great risk of being damaged by the late spring frost (Kiprijanovski et al., 2009). Results of investigation show that ‘Kim’ is characterized with the earliest start of blooming, while ‘Winterbanana’ start blooming much later.

During three years of full blooming apple trees of cv. ‘Connell Red’ bloomed most abundantly. Less intensive bloom was characterized for other apple cultivars. Apple trees of cv. ‘Bavendorf’ bloomed worst.

Trunk cross sectional area (TCSA) is an integral indicator of the development of the complete above ground part of the fruit-tree (Ristevski, 1986). The data of investigation showed that cvs. ‘Birgit Bonnier’ and ‘Kim’ had the largest TCSA at the end of the fifth year, whereas the ‘Connell Red’ type had the smallest.

Highly significant yield differences were found among the trees of the tested apple cultivars. The highest yield and productivity showed trees of ‘Auksis’ and ‘Connell Red’. As reported earlier (Uselis et al., 2007; Sasnauskas et al., 2008), cvs. ‘Auksis’ and ‘Connell Red’ were the most productive. The lowest yield and productivity was observed for ‘Kim’ and ‘Birgit Bonnier’.

Resistance breeding in apple is aimed at the development of cultivars durably resistant to biotic and abiotic stresses. Resistant cultivars are suited for sustainable and ecological production methods due to less application of pesticides needed for healthy growth. Tolerance to abiotic stresses can promote a better adaptation to the environment and climatic changes (Peil, 2009). Our investigation data demonstrated that ‘Auksis’ and ‘Birgit Bonnier’ were resistant to scab, ‘Auksis’ and ‘Connell Red’ – resistant to apple blotch.

Conclusions. 1. ‘Auksis’ and ‘Connell Red’ were the best ones among the tested cultivars.

2. The following apple cultivars were distinguished for particular characteristics: ‘Kim’ – earliest blooming, ‘Winterbanana’ – latest blooming, ‘Connell Red’ – blooming abundance, ‘Connell Red’ – weakest growth, ‘Auksis’ and ‘Connell Red’ – yield in young orchard, ‘Auksis’ and ‘Birgit Bonnier’ – resistance to scab, ‘Auksis’ and ‘Connell Red’ – resistance to apple blotch.

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Obelių veislių agronominių požymių ir atsparumo grybinėms ligoms tyrimas

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Santrauka

2004–2009 m. Lietuvos sodininkystės ir daržininkystės institute tirta septynių introdukuotų obelių (*Malus × domestica* Borkh.) veislių žydėjimo tarpsniai, žydėjimo gausumas, vaismedžių augumas, derlius, produktyvumas, atsparumas rauplėms (*Venturia inaequalis*) ir filostiktozei (*Phyllosticta mali*). Dvimečiai obelių sodinukai su B.118 poskiepiu pasodinti 2004 m. pavasarį. Sodinimo schema – 4 × 2,5 m, po vieną vaismedį laukelyje penkiais pakartojimais.

Pagal tirtų požymių visumą, vaismedžiai ‘Aukšis’ ir ‘Connell Red’ įvertinti geriausiai. Tirtais požymiais išsiskyrė šios obelių veislės: ‘Kim’ – ankstyvu žydėjimu, ‘Winterbanana’ – vėlyvu žydėjimu, ‘Connell Red’ – žydėjimo gausumu, ‘Connell Red’ – silpniausiu augumu, ‘Aukšis’ ir ‘Connell Red’ – derliumi jauname sode, ‘Aukšis’ ir ‘Birgit Bonnier’ – atsparumu rauplėms, ‘Aukšis’ ir ‘Connell Red’ – atsparumu filostoktozei.

Reikšminiai žodžiai: augumas, derlius, fenologija, obelys, *Phyllosticta mali*, produktyvumas, veislės, *Venturia inaequalis*.