

PRODUCTIVITY AND FRUIT QUALITY OF SCAB RESISTANT APPLE CULTIVARS AND HYBRIDS

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A B S T R A C T

From 1997 to 2004, six new apple hybrids and three standard cultivars grafted on M26 rootstock were evaluated at the Lithuanian Institute of Horticulture. Data recorded included frost damage, blossoming time, harvest time, storability, chlorophyll content, carotenoids content, fruit quality parameters, and biochemical composition. Of the new varieties, 'Skaistis' and 'Rudenis' had the best overall results. The following apple genotypes were selected for breeding of certain characteristics: blossoming time: 'Skaistis', 18429 and 18501; flower resistance to frost: 'Prima' and 18437; winter hardiness: 18422; leaf chlorophyll content: 'Staris' and 18437; yield: 'Rudenis', 18429 and 'Skaistis'; storability: 'Tellissaare', 'Staris' and 'Skaistis'; fruit weight: 'Skaistis' and 18501; fruit quality: 18429, 18437, 'Rudenis' and 'Skaistis'; biochemical composition: 'Tellissaare' and 18422.

Key words: apple, productivity, quality of fruits, cultivars, hybrids

INTRODUCTION

New apple cultivars should have the following traits: excellent fruit quality, reliably high yield, excellent taste, storability, marketability and disease resistance, especially to apple scab (*Venturia inaequalis*), powdery mildew (*Podosphaera leucotricha*) and fire blight (*Erwinia amylovora*) (Fischer, 2000; Blazek, 2001; Kelderer and Lardschneider, 2004; Kemp et al., 2004; Werth, 2004).

The apple breeding program has been in existence at the Lithuanian Institute of Horticulture since 1952. Several commercially grown cultivars

have been released, including 'Auksis', 'Noris', 'Staris' and 'Aldas'. The most successful of these is 'Auksis', which has become the most important cultivar in Lithuania. The primary goals of our breeding work have been fruit quality, yield and resistance to apple scab. Scab resistant cultivars allow growers to save on disease control costs, decrease environmental contamination associated with fungicide use, and meet consumer demands for apples with lower amounts of pesticide residue (Kühn and Thybo, 2001). There is currently widespread resistance to using scab resistant cultivars in organic apple production, even though they have great ecological and economic advantages. Apple growers undermine their credibility by planting trendy scab susceptible cultivars (Weibel and Leder, 2003).

The objective of this study was to evaluate yield and fruit quality in new scab resistant apple cultivars and hybrids.

MATERIAL AND METHODS

From 1997 to 2004, six new apple hybrids and three standard cultivars were evaluated at the Lithuanian Institute of Horticulture.

Temperature is the most important factor determining yield in apples, especially minimal winter and spring temperatures. Late spring frosts in 1999, 2000 and 2004 did a lot of damage to the developing blossoms. At these times, the minimal air temperature above the ground dropped to -5°C in the orchard.

The following scab resistance hybrids were evaluated: 'Skaistis' (18307), 'Rudenis' (18451), 18422, 18429, 18437 and 18501 (Katja x Prima). All were developed at the Lithuanian Institute of Horticulture. They were compared to the standard cultivars 'Tellissaare', 'Prima' and 'Staris'.

In the spring of 1997, trees were planted 4 x 2.5 m in twelve replicates of one tree each. Trees were trained as spindles. All trees were maintained in accordance with standard procedures recommended for commercial orchards.

Trees and fruits were evaluated in accordance with UPOV Test Guidelines (2005). Carotenoids and chlorophylls were recorded in mg/m^2 . Appearance, taste and quality were evaluated on a scale from 1 to 9.

Data were elaborated by analysis of variance, followed by Fisher's protected LSD and Duncan's multiple-range t-test at $P=0.05$.

RESULTS

Blossoming of apple trees

Apple trees of most varieties started blossoming in their second year in orchard. Blossoming was earliest in 'Tellissaare' and 'Rudenis' (May 5), and latest in 'Staris' (May 9). Full blossoming began earliest in 'Rudenis' (May 8), and latest in Hybrid 18429 (May 17). Full blossoming ended earliest in 'Tellissaare' and Hybrid 18437 (May 16), and latest in Hybrid 18429, Hybrid 18501 and 'Skaistis' (May 19).

Blossoming and cold injury on shoots

During the evaluation period, severe spring frosts occurred in three years: 1999, 2000 and 2004. In 1999, blossoms on most varieties were moderately damaged, with damage scores between 2.2 and 3.2. In 2000, the damage was very severe, with damage scores between 7.0 and 7.6. In 2004, damage was again moderate, with an average damage score of 3.9.

The varieties with the highest level of resistance to flower damage by frost were 'Prima' and Hybrid 18437.

In 2003-2004, slight frost damage was observed on shoots of 'Prima', with a damage score of 2.0.

In 2004-2005 annual shoots of some varieties were slightly damaged, for example 'Prima' had a damage score of 1.9, and Hybrid 18429 had a damage score of 1.8. Shoots of Hybrid 18422 were not damaged.

Chlorophyll

Leaf chlorophyll levels were highest during intense fruit growth in all of the varieties evaluated. Leaf chlorophyll levels were highest in 'Staris' and Hybrid 18437, and lowest in 'Tellissaare' and Hybrid 18501 (Fig. 1).

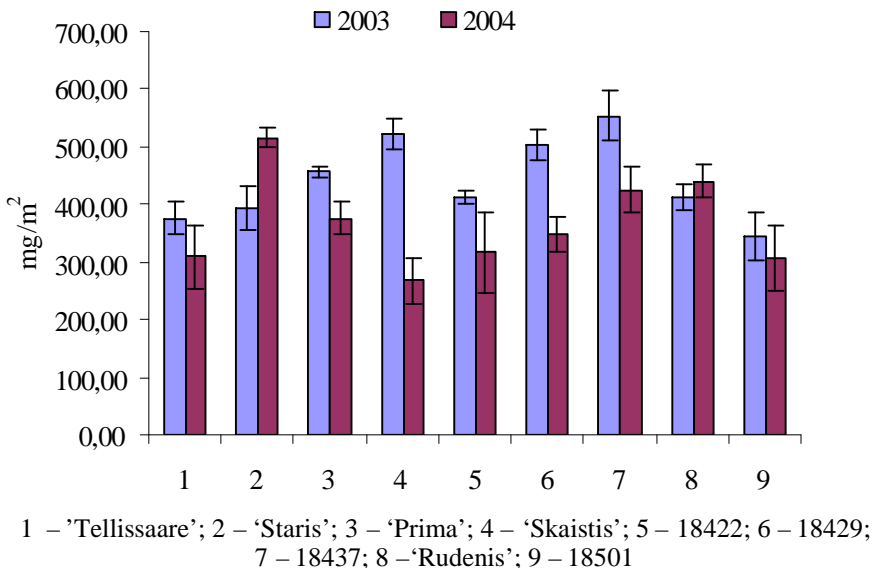
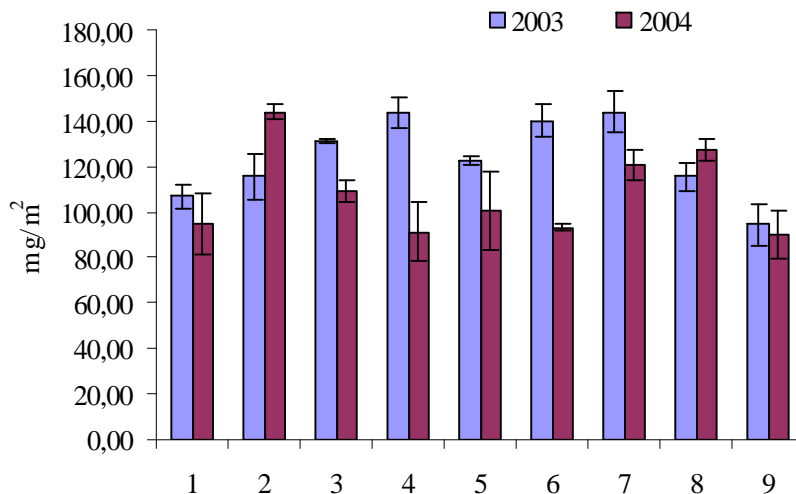


Figure 1. Total amount of chlorophylls [mg/m^2] in apple leaves

Carotenoids

Carotenoids take active part in photosynthesis. The level of carotenoids changes during the vegetative growth and in response to stress. The level of carotenoids was highest in ‘Staris’ and Hybrid 18437, and lowest in ‘Tellissaare’ and Hybrid 18501 (Fig. 2).



1 – ‘Tellissaare’; 2 – ‘Staris’; 3 – ‘Prima’; 4 – ‘Skaistis’; 5 – 18422; 6 – 18429; 7 – 18437; 8 – ‘Rudenis’; 9 – 18501

Figure 2. The amount of carotenoids [mg/m^2] in apple leaves

Yield

In the third year in the orchard, yield was highest in ‘Tellissaare’ (4.8 t/ha), while ‘Prima’ and Hybrid 18501 did not bear fruit at all (Fig. 3).

In the fourth year, yield were low in all varieties because of the severe spring frost damage (0.4 to 1.5 t/ha).

In the fifth and seventh years, yields were higher.

In the sixth year, yields were highest in ‘Rudenis’ (115.3 t/ha), Hybrid 18429 (99.6 t/ha) and ‘Skaistis’ (87.5 t/ha), and lowest in Hybrid 18422 (48.8 t/ha), ‘Staris’ (46 t/ha), and Hybrid 18501 (34.4 t/ha).

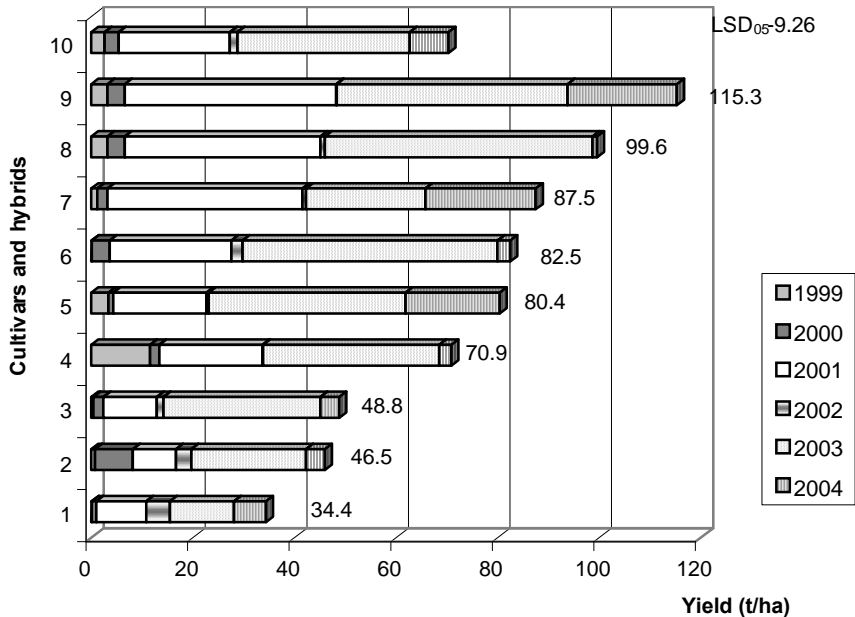


Figure 3. Yield of apple cultivars and hybrids in t/ha 1 – 18501; 2 – ‘Staris’; 3 – 18422; 4 – Tellissaare; 5 – 18437; 6 – ‘Prima’; 7 – ‘Skaistis’; 8 – 18429; 9 – ‘Rudenis’; 10 – Average of cultivars and hybrids

Storage life

Harvest was earliest in ‘Rudenis’, Hybrids 18437 and Hybrid 18501 (September 5), and latest in ‘Tellissaare’ (September 25) (Tab. 1).

Storability in cold storage varied from variety to variety. Storability was best in ‘Tellissaare’ (April 10), ‘Staris’ (March 1) and ‘Skaistis’ (February 10), and shortest in Hybrid 18451 (November 7), Hybrid 18501 (November 7), and Prima (November 5).

Table 1. Harvest date, storage life and quality parameters of apple cultivars and hybrids, 1999-2004

Cultivars and hybrids	Harvest date, [month, day]	End of storage [month, day]	Fruit weight [g]	Appearance, scores	Taste, scores	Quality evaluation, scores
Tellissaare	09.25 e *	04.10 d	95.0 a	7.4 bc	7.0 b	7.1 b
Staris	09.14 bc	03.01 cd	121.0 b-d	7.2 a	5.9 b	7.0 b
Prima	09.20 c-e	11.05 a	120.0 b-d	7.3 ab	7.0 b	7.1 b
Skaistis	09.18 bc	02.10 b-d	128.0 d	7.6 de	7.4 de	7.5 cd
Rudenis	09.04 a	11.07 a	123.3 b-d	7.6 de	7.3 c	7.5 cd
18422	09.12 b	01.03 ab	122.0 b-d	7.2 a	5.7 a	5.8 a
18429	09.14 bc	01.15 ab	95.7 ab	7.5 c-e	7.6 a	7.6 d
18437	09.05 a	12.08 a	125.3 cd	7.7 e	7.3 c	7.5 cd
18501	09.05 a	11.07 a	125.7 cd	7.3 ab	7.0 b	7.1 b

*Means followed by the same letter do not differ significantly at P=0.05 according to Duncan’s t-test

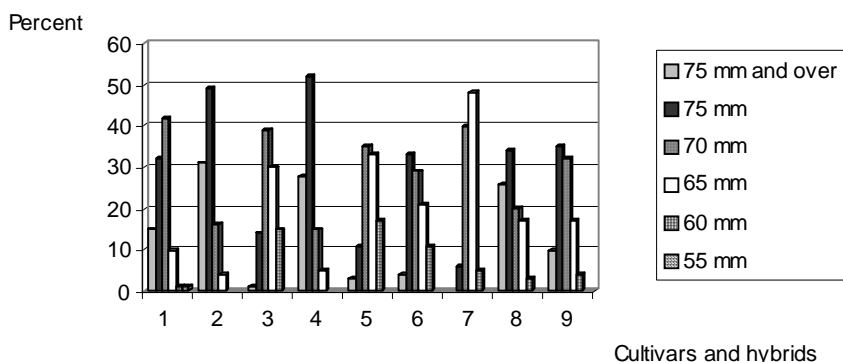
Quality parameters

Fruit appearance was good (7.0 to 7.5) or extremely good (> 7.5) in all varieties. Fruit appearance was best in Hybrid 18437 (7.7), ‘Skaistis’ (7.6) and ‘Rudenis’ (7.6) (Tab. 1).

Taste was extremely good in Hybrid 18429 (7.6) and ‘Skaistis’ (7.4), moderately good in ‘Staris’ (5.9) and Hybrid 18422 (5.7), and good in all the other varieties.

Organoleptic quality, which is a general estimate of both appearance and taste, was very good in Hybrid 18429 (7.6), Hybrid 18437 (7.5), ‘Rudenis’ (7.5) and ‘Skaistis’ (7.5), and good in all the other varieties except Hybrid 18422 (5.8).

Fruit size was large in all varieties (120-128 g), except in ‘Tellissaare’ and Hybrid 18429, which had average sized fruits. The proportion of fruits over 70 mm in diameter was highest in ‘Skaistis’ and ‘Staris’ (28 to 31%). The proportion of fruits of the smallest size class was highest in Hybrid 18422 and Hybrid 18501 produced the highest amount of smallest fruits (Fig. 4).



1 – ‘Tellissaare’; 2 – ‘Staris’; 3 – ‘Prima’; 4 – ‘Skaistis’; 5 – ‘Rudenis’; 6 – 18422; 7 – 18429; 8 – 18437; 9 – 18501

Figure 4. Classification of apple cultivars and hybrids according to fruit diameter [%] (Babtaï, 2002-2004)

Chemical composition

Soluble solids content was highest in ‘Tellissaare’ (13.6%), and lowest in Hybrid 18437 (10.8%) (Tab. 2). Titratable acidity ranged from 0.31 to 0.72%. Dry matter content in apples ranged from 12.1% in Hybrid 18437 to 15.2% in ‘Tellissaare’. Skin firmness was highest in ‘Tellissaare’ and ‘Staris’. Flesh firmness was highest in ‘Tellissaare’ and Hybrid 18422.

Table 2. Chemical and physical characteristics of apple cultivars and hybrids, 2003-2004

Cultivars and hybrids	Soluble solids [%]	Titrateable acidity [%]	Dry matter [%]	Firmness of skin [kg/cm ²]	Firmness of flesh [kg/cm ²]
'Tellissaare'	13.6 h *	0.52 d	15.2 h	38.1 i	6.0 d
'Staris'	11.6 b	0.31 a	13.2 b	33.2 h	4.1 a
'Prima'	12.1 c	0.43 b	13.6 d	28.3 g	5.1 g
'Skaistis'	12.3 d	0.53 d	13.3 c	23.8 b	5.3 b
'Rudenis'	11.6 b	0.60 g	13.5 b	24.6 c	4.5 e
18422	13.4 g	0.48 c	14.6 g	24.8 d	6.0 d
18429	13.1 f	0.72 h	13.8 e	26.2 e	4.6 f
18437	10.8 a	0.58 f	12.1 a	22.3 a	5.3 b
18501	12.9 e	0.57 e	14.3 f	26.4 f	5.4 h

*Means followed by the same letter do not differ significantly at P = 0.05 according to Duncan's t-test

DISCUSSION

Blossoming time depends on several factors, including spring weather, exposure, soil, moisture and rootstock. The differences in blossoming time from year to year were caused by weather differences, particularly differences in temperature. Weather differences also affected pollination. Late blossoming is a desirable trait because it minimizes damage by late spring frosts (Blazek, 2001). The earliest blossoming varieties were 'Tellissaare' and 'Rudenis', and the latest blossoming varieties were Hybrids 18429, Hybrid 18501 and 'Skaistis'. In 'Staris', blossoming was more intense in our study than in a previous study, in which blossoming was weaker, even in the fourth year in the orchard (Rašinskienė and Žika, 1997).

Both chlorophylls and carotenoids were highest in 'Staris' and Hybrid 18437. Our data show that different genotypes might have different strategies for productivity.

Eight-year cumulative yield was highest in 'Rudenis', 'Skaistis' and Hybrid 18429, and lowest in 'Staris', Hybrid 18422 and Hybrid 18501. 'Staris' on M26 rootstock was late cropping and low yielding in the maiden age (Rašinskienė and Žika, 1997).

Storability is the most important criterion when selecting cultivars for a commercial orchard. Storability was best in 'Tellissaare', 'Staris' and 'Skaistis'.

Fruit quality parameters reflect desirable sensory properties such as color, size, shape, flavour, firmness, juiciness and texture. Fruit quality in apples is difficult to measure because of its subjective nature (Blazek and Hlusickova, 2003). Consumer preferences for apples are generally based on the interaction between texture and taste. All fruit quality parameters depended on the variety

and varied from year to year. Organoleptic evaluation gave the best overall results for Hybrid 18429, Hybrid 18437, 'Rudenis' and 'Skaistis' in terms of appearance and taste. The best results for chemical composition were recorded in 'Tellissaare' and Hybrid 18422.

Based on these results, two of the new scab resistant apple cultivars can be recommended for cultivation in Lithuania: 'Skaistis' and 'Rudenis'.

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PLENNOŚĆ I JAKOŚĆ OWOCÓW JABŁONI ODMIAN I HYBRYD PARCHOODPORNÝCH

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STRESZCZENIE

W latach 1997-2004 w Litewskim Instytucie Ogrodnictwa badano 6 nowych hybryd i 3 standardowe odmiany jabłoni zaszczerpione na podkładce M.26. Oceniano uszkodzenia mrozowe, termin kwitnienia, termin zbioru, trwałość przechowalniczą, zawartość chlorofilu, zawartość karotenoidów, parametry jakości owoców i skład biochemiczny owoców.

Nowe odmiany 'Skaistis' i 'Rudenis' uzyskały najwyższe oceny pod względem wszystkich ocenianych cech. Do dalszej hodowli wybrano następujące genotypy jabłoni ze względu na ich ustalone cechy: czas kwitnienia – 'Skaistis', 18429 i 18501; odporność kwiatów na mróz – 'Prima' i 18437; zimoodporność – 18422; wyższą zawartość barwników fotosyntetycznych w liściach – 'Staris' i 18437; plenność – 'Rudenis', 18429 i 'Skaistis'; trwałość przechowalniczą – 'Tellissaare', 'Staris' i 'Skaistis'; masę owoców – 'Skaistis' i 18501; jakość owoców – 18429, 18437, 'Rudenis' i 'Skaistis', najlepszy skład biochemiczny – 'Tellissaare' i 18422.

Słowa kluczowe: jabłoni, plenność, jakość owoców, odmiany, hybrydy