

EVALUATION OF SCAB RESISTANT APPLE CULTIVARS IN SWEDEN

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A B S T R A C T

Two trials of scab resistant apple cultivars were conducted in Sweden. The first trial was carried out from 1997 to 2003 with eight scab resistant cultivars from the Czech Republic. The cultivar with the highest five-year cumulative yield was 'Bio Golden' (55 kg), followed by 'Topaz' (51 kg) 'UEB 2074/1' (44 kg), 'UEB 2345/1' (39 kg), 'Vanda' (38 kg), 'Rubinola' (37 kg), 'UEB 2257/4' (36 kg) and 'Rajka' (35 kg). The second trial was carried out from 1998 to 2003 with thirteen cultivars from different countries with the Swedish cultivar 'Amorosa' as a control. The cultivar with the highest four-year cumulative yield was 'Vanda' (43 kg), followed by 'Scarlet O'Hara' (35 kg), 'Dayton' (21 kg), 'Co-op 24' (17 kg), 'Remo' (17 kg), 'BM 41497' (16 kg), 'William's Pride' (15 kg), 'Redfree' (14 kg), 'Reglindis' (13 kg), 'Co-op 12' (12 kg), 'Katinka' (11 kg), 'Amorosa' (10 kg) and 'BM 51596' (1 kg). The cultivars with best storability were 'Co-op 26', 'Rajka', 'Reglindis', 'Rubinola', 'Scarlet O'Hara', and 'Topaz'. The two most promising cultivars for organic growing in Sweden are 'Rubinola' and 'Scarlet O'Hara'.

Key words: *Malus*, *Venturia inaequalis*, organic production, fruit quality

INTRODUCTION

Consumers are becoming increasingly concerned about the use of pesticides and fungicides in food production (Burr et al., 1996). Organic fruit production allows growers to produce apples with minimum contamination of the environment with fertilizers and other chemicals. The availability of

disease and pest resistant cultivars is essential for successful organic fruit production (Janse, 1993; Kellerhals et al., 1997).

The major disease of apples is apple scab, which is caused by the fungus *Venturia inaequalis* (Biggs, 1990; Chevalier and Laurens, 1999). This study describes two trials with scab resistant cultivars. The aim of this study was to evaluate scab resistant apple cultivars from several different countries in terms of yield, fruit size, fruit quality, and resistance to pests and diseases.

MATERIAL AND METHODS

Two trials of scab resistant apple cultivars were carried out at SLU/Kivik in the province of Skåne in southern Sweden.

The first trial was carried out from 1997 to 2003 with eight scab resistant cultivars from the Czech Republic. In the spring of 1997, the trees were planted in a randomized block design with five blocks of one tree of each cultivar. The cultivars evaluated were: 'Bio Golden', 'Rajka', 'Rubinola', 'Topaz', 'Vanda', 'UEB 2345/1', 'UEB 2257/4' and 'UEB 2074/1'. 'Vanda' and 'Bio Golden' were grafted on MM 106 rootstock, and the other six cultivars were grafted on M 9 rootstock.

The second trial was carried out from 1998 to 2003 with thirteen cultivars from several different countries. In the spring of 1998, the trees were planted in a randomized block design of three blocks of one tree of each cultivar. The cultivars evaluated were: 'Katinka' from Norway; 'Vanda' from the Czech Republic; 'Remo' and 'Reglindis' from Germany; 'Dayton', 'Redfree', 'Scarlet O'Hara', 'William's Pride', 'Co-op 12', 'Co-op 24' and 'Co-op 26' from the United States; and 'BM 41497' and 'BM 51596' from the breeding program at Balsgård in Sweden. The Swedish cultivar 'Amorosa' was used as a control. 'Reglindis', 'Co-op 24' and 'Co-op 26' were grafted on MM 111 rootstock, and the other ten cultivars were grafted on M 26 rootstock. The control, 'Amorosa', was grafted on MM 106 rootstock.

No pesticides, herbicides or fungicides were used. Weeding was performed with a rotary cultivator, and by hand close to the trunks. Drip irrigation was used during periods of drought.

The optimum harvest time was defined as the date on which the Streif index was 0.25. The Streif index is calculated as the firmness divided by the soluble solids content multiplied by the starch index. Firmness was measured on opposite sides of each fruit with a penetrometer (Effigi, probe diameter 11.1 mm). Soluble solids content was measured with a refractometer (Atago, Japan). Starch index was measured by slicing the apple in half at the equator and dipping it in an iodine solution. The degree of staining was graded on

a scale from 1 to 9, where 1 equals maximum staining, and 9 equals no staining.

After picking, the apples were weighed, counted and assessed for damage caused by insects, other animals, fungi, and other causes. The chief out again pests were noctuid, tortricid and geometrid moths, the codling moth, the apple fruit moth, the apple sawfly, the red apple aphid (*Dysaphis plantaginea*), and the foxglove aphid (*Dysaphis anthrisci*). Other animal pests included birds, earwigs and snails. Fungal diseases included scab, brown rot (*Monilia*) and anthracnose. Other causes of damage included fruit deformity, mechanical damage, russetting, small fruit (less than 60 mm in diameter), cracking, frost, hail and watercore. In the first trial, the apples were harvested from 1998 to 2003, and were assessed for damage from 1998 to 2003. In the second trial, the apples were harvested from 1999 to 2003, and assessed for damage from 2000 to 2003.

A sample of apples was stored at 2-3°C and 90% RH for two months. Ten fruits from each block were assessed for firmness, soluble solids content, and decay both before and after storage.

The Kolmogorov-Smirnov test showed that the data for yield and damage were not normally distributed. Non-parametric statistics were therefore used for further analysis.

The Mann-Whitney U-test was used to compare yields among cultivars in the first trial.

Data for fruit quality and storability were elaborated by analysis of variance, followed by Duncan's multiple-range t-test at $P = 0.05$.

Statistical calculations were performed using the SPSS 10 Data Analysis Package (Norusis, 1990) and MS Excel (Microsoft Inc., USA).

RESULTS

In the first trial, one tree each of 'Vanda' and 'UEB 2345/1' died during the course of the trial. The results for these cultivars are therefore based on four trees instead of five.

In the second trial, one tree each of 'Amorosa', 'BM 51596', 'Dayton', 'Reglindis' and 'Vanda' died during the course of the trial. The results for these cultivars are therefore based on two trees instead of three. Two trees of 'Scarlet O'Hara' died during the course of the trial. The results for this cultivar are therefore based on one tree instead of three. Results for yield were not analyzed for the second trial because so many trees had died. The dead trees were replaced in 2000, and the results for fruit quality and storability were analyzed.

Results for the first trial are presented in Table 1 and Figure 1, and results for the second trial are presented in Table 2 and Figure 2.

Table 1. Quality and storability of cultivars in the first trial (1998-2002)

Cultivar	At harvest		After storage		
	firmness [Kg/cm ²]	SSC [%]	firmness [Kg/cm ²]	SSC [%]	decay [%]
Bio Golden	6.4	13.0	5.2	11.7	3.3
Rajka	5.4	13.5	4.3	13.1	2.9
Rubinola	6.2	13.8	5.1	13.1	2.8
Topaz	6.7	13.8	4.9	12.6	2.9
UEB 2345/1	7.3	13.8	5.8	14.0	7.4
UEB 2257/4	6.7	15.0	5.5	13.4	4.8
UEB 2074/1	5.8	13.5	4.0	12.0	3.2
Vanda	4.8	13.0	4.1	12.0	6.1
LSD _{0.05}	1.6	1.6	1.0	1.2	2.5

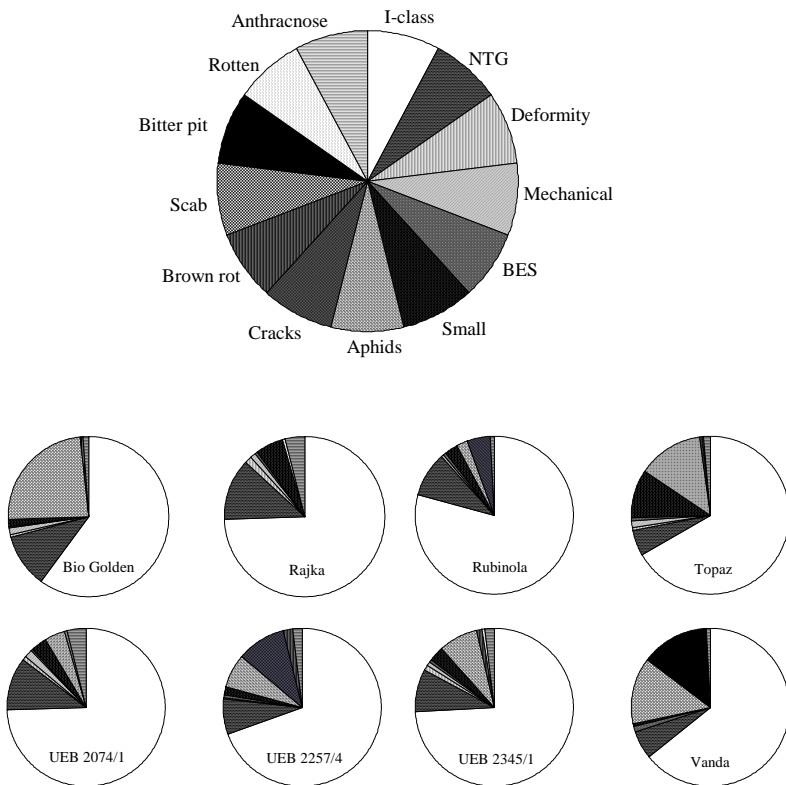


Figure 1. Apple cultivars from the first trial categorized as Class I, NTG (noctuids, tortricids and geometrids), deformed, mechanical damage, BES (birds, earwigs and snails), too small, aphids, cracks, brown rot, scab, bitter pit, decayed and anthracnose based on mean percentage from 1998 to 2003

Table 2. Quality and storability of cultivars in the second trial (2000-2002)

Cultivar	At harvest		After storage		
	firmness [Kg/cm ²]	SSC [%]	firmness [Kg/cm ²]	SSC [%]	decay [%]
Amorosa	6.8	12.3	5.1	11.9	15.0
Katinka	5.7	11.7	4.1	10.4	8.8
Dayton	7.2	11.4	4.9	11.7	7.9
Vanda	6.8	12.7	3.8	12.2	3.3
Remo	7.2	13.6	4.5	10.6	4.6
Reglindis	10.5	11.6	5.4	11.7	2.1
Co-op 12	5.3	12.5	3.6	10.5	24.2
Redfree	6.8	13.1	5.3	10.6	5.8
William's Pride	6.5	12.9	5.2	10.7	11.3
Co-op 24	9.7	11.7	6.6	11.1	3.3
Scarlet O'Hara	9.9	11.9	6.8	12.1	1.7
Co-op 26	9.0	12.6	5.7	12.2	3.3
BM 41497	6.3	13.5	4.0	11.4	35.0
BM 51596	10.0	15.2	6.9	15.2	7.5
LSD _{0.05}	1.8	1.3	1.2	1.5	9.7

In the first trial, the cultivar with the highest five-year cumulative yield was 'Bio Golden' (55 kg), followed by 'Topaz' (51 kg) 'UEB 2074/1' (44 kg), 'UEB 2345/1' (39 kg), 'Vanda' (38 kg), 'Rubinola' (37 kg), 'UEB 2257/4' (36 kg) and 'Rajka' (35 kg). The cultivar with the largest fruits was 'UEB 2345/1' (152 g), and the cultivar with the smallest fruits was 'Topaz' (99 g). The cultivars with the highest proportion of fruits less than 60 mm in diameter were 'Topaz' (10%) and 'Rajka' (5%). The cultivar with the highest five-year proportion of Class I fruits was 'Rubinola' (82%), followed by 'UEB 2074/1' (76%), 'Rajka' (74%), 'UEB 2345/1' (72%), 'UEB 2257/4' (70%), 'Vanda' (69%), 'Topaz' (68%) and 'Bio Golden' (65%).

In the second trial, the cultivar with the highest four-year cumulative yield was 'Vanda', (43 kg) followed by 'Scarlet O'Hara' (35 kg), 'Dayton' (21 kg), 'Co-op 24' (17 kg), 'Remo' (17 kg), 'BM 41497' (16 kg), 'William's Pride' (15 kg), 'Redfree' (14 kg), 'Reglindis' (13 kg), 'Co-op 12' (12 kg), 'Katinka' (11 kg), 'Amorosa' (10 kg) and 'BM 51596' (1 kg). 'Vanda' is the only cultivar included in both trials. 'Vanda' had a higher cumulative yield per tree (43 kg) during the four years of the second trial than during the five years of the first trial (38 kg). 'Scarlet O'Hara' was the only other cultivar with a high cumulative yield (35 kg). The other cultivars were significantly less productive.

In the second trial, the cultivar with the largest fruits was 'Dayton' (159 g), and the cultivar with the smallest fruits was 'Reglindis' (86 g). The cultivar with the highest proportion of fruits less than 60 mm in diameter was 'Reglindis' (22%), followed by 'Katinka' (21%), 'William's Pride' (14%), 'Redfree' (13%), 'Co-op 24' (7%), 'Amorosa' (6%), 'Co-op 26' (6%) and 'Co-op 12' (5%). The only cultivars with no fruits less than 60 mm in diameter were 'BM 51596' and 'Scarlet O'Hara'.

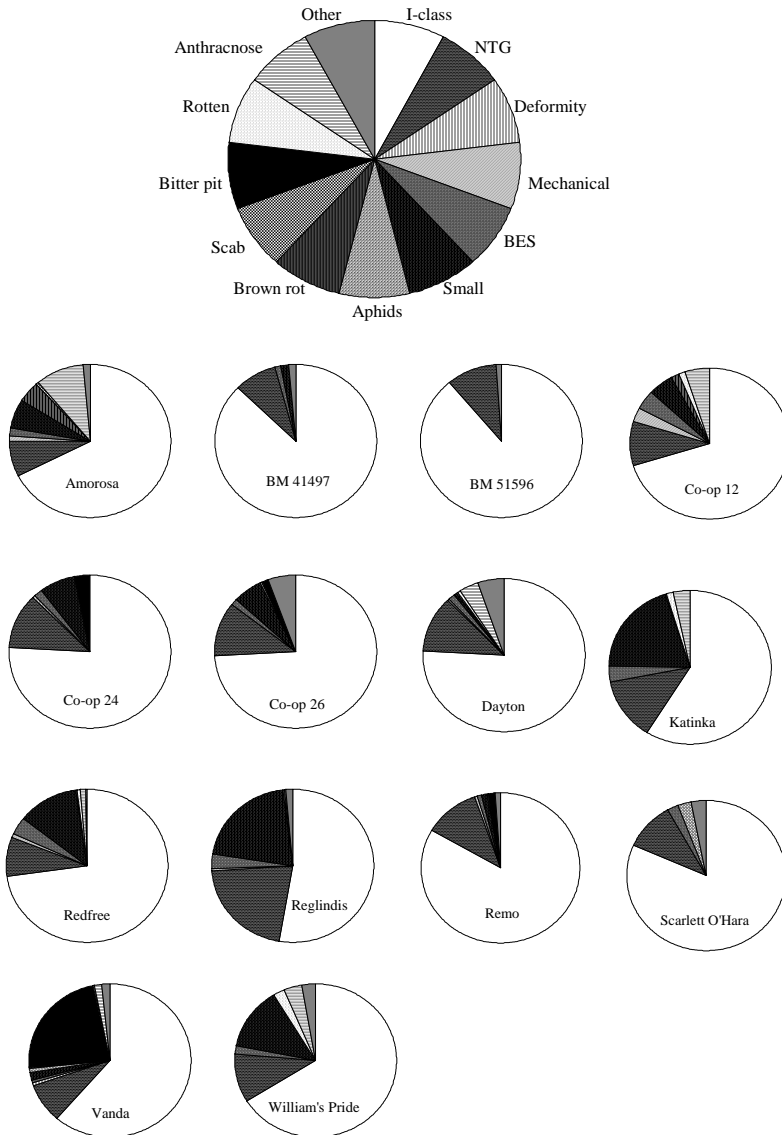


Figure 2. Apple cultivars from the second trial categorized as Class I, NTG (noctuids, tortricids and geometrids), deformed, mechanical damage, BES (birds, earwigs and snails), too small, aphids, brown rot, scab, bitter pit, decayed, anthracnose and other damage based on mean percentage from 2000 to 2003

In the second trial, the cultivar with the highest four-year proportion of Class I fruits was 'BM 51596' (89%), followed by 'BM 41497' (85%), 'Remo' (84%), 'Scarlet O'Hara' (83%), 'Co-op 24' (78%), 'Dayton' (76%), 'Redfree' (76%), 'Co-op 26' (74%), 'Co-op 12' (73%), 'William's Pride' (68%), 'Amorosa' (67%), 'Vanda' (64%), 'Katinka' (61%) and 'Reglindis' (56%)

In the first trial, noctuid, tortricid and geometrid moths caused a total mean damage of 9% for all cultivars and all years. The cultivar with the most damage caused by noctuid, tortricid and geometrid moths was 'Rajka' (12%), and the cultivar with the least damage was 'Vanda' (5%). The red apple aphid and the foxglove aphid caused a combined total mean damage of 9%. The cultivar with the most damage caused by aphids was 'Bio Golden' (26%), followed by 'Topaz' (13%), 'Vanda' (12%), 'UEB 2345/1' (8%), 'UEB 2257/4' (7%), 'UEB 2074/1' (4%) and 'Rubinola' (2%). The only cultivar not damaged by aphids was 'Rajka'. The cultivar with the most damage caused by cracking was 'UEB 2257/4' (10%). The cultivar with the highest incidence of bitter pit was 'Vanda' (12%).

In the second trial, noctuid, tortricid and geometrid moths caused a total mean damage of 11% for all cultivars and all years. The cultivar with the most damage caused by noctuid, tortricid and geometrid moths was 'Reglindis' (22%), and the cultivar with the least damage was 'Amorosa' (7%). The only cultivar with more than 1% damage caused by aphids was 'Scarlet O'Hara' (3%). The cultivars with most damage caused by anthracnose were 'Amorosa' (10%) and 'BM 51596' (5%). The cultivar with the highest incidence of bitter pit was 'Vanda' (24%).

In the first trial, the cultivar with the firmest fruits at harvest was 'UEB 2345/1' (7.3 kg/cm²), followed by 'Topaz' (6.7 kg/cm²) and 'UEB 2257/4' (6.7 kg/cm²). 'Rajka' and 'Vanda' were softer and lost 20% of their firmness during storage. There was no significant difference in soluble solids content among the cultivars. The cultivars with the highest proportion of decayed fruits after storage were 'UEB 2345/1' (7%) and 'Vanda' (6%). The cultivars with the best storability (firmness \geq 6 kg/cm², soluble solids content > 12%, low proportion of decayed fruits) were 'Rubinola', 'Rajka' and 'Topaz'.

In the second trial, the cultivar with the firmest fruits at harvest was 'Reglindis' (10.5 kg/cm²), followed by 'BM 51596' (10.0 kg/cm²), 'Scarlet O'Hara' (9.9 kg/cm²), 'Co-op 24' (9.7 kg/cm²) and 'Co-op 26' (9.0 kg/cm²). Of these cultivars, 'Reglindis' lost the most firmness during storage. There was no significant difference in soluble solids content among the cultivars, except for 'BM 51596', which had a significantly higher soluble solids content both before and after storage. 'Remo', 'Redfree', 'William's Pride', 'BM 41497' and 'Co-op 12' lost some of their soluble solids content during storage and were less sweet than at harvest. The cultivars with the highest proportion of decayed fruits after storage were 'BM 41497' (35%) and 'Co-op

12' (24%). The cultivars with the best storability were 'Co-op 26', 'Reglindis' and 'Scarlet O'Hara'.

DISCUSSION

No pesticides or fungicides were used in our trials. In all likelihood, the cultivars evaluated would produce more Class I apples in an orchard where organic methods are used to control pests and diseases. For example, *Bacillus thuringiensis* could be used to control noctuid, tortricid and geometrid moths, and pyrethrum and fatty acids could be used to control aphids. It is more difficult to do anything about small fruits, low yields, and bitter pit.

In the first trial, the most productive cultivars were 'Bio Golden', 'Topaz' and 'UEB 2074/1'. In the second trial, the most productive cultivars were 'Vanda' and 'Scarlet O'Hara'.

Even though 'Rajka' had the lowest yield in the first trial, it is recommended for organic fruit production in Sweden because it is not damaged by aphids and is considered healthy, attractive, tasty and easy to grow (Juhlin, 2004).

'Amorosa' is a very productive, relatively healthy cultivar, and is also recommended for organic fruit production in Sweden (Juhlin, 2004). Surprisingly, 'Amorosa' had the second lowest yield in the second trial and would definitely not be recommended for organic fruit production on the basis of this trial. Yields were quite low for many other cultivars in this trial, which suggests that yields in this trial are not entirely representative.

The choice of rootstock has a considerable effect on productivity, and should be taken into account when comparing yields among cultivars. The most dwarfing rootstock in these trials was M 9, followed by M 26, MM 106 and finally MM 111 (Westwood, 1993). 'Vanda' had a higher yield when grafted on M 26 in the second trial, than when grafted on MM 106 in the first trial. Trees grafted on the less vigorous M 26 rootstock start producing earlier than trees grafted on MM 106 rootstock. 'Co-op 24', 'Co-op 26' and 'Reglindis' were grafted on the most vigorous rootstock, MM 111, and would probably have had higher yields in the first years of the study if they had been grafted on the less vigorous M 26 rootstock. Carrying out trials of especially promising cultivars on several different rootstocks would give a better picture of their potential productivity.

'Katinka', 'Redfree', 'Reglindis', 'Topaz' and 'William's Pride' all had a high proportion of fruits less than 60 mm in diameter. None of these cultivars can therefore be recommended for organic fruit production in Sweden.

'Topaz' is the most widely grown scab-resistant cultivar in Europe (Sansavini, 2004). Unfortunately, it ripens late and can be grown only in warm, protected areas in southern Sweden (Jensen, 2001). This is probably

the reason why it had such a high proportion of fruits less than 60 mm in diameter.

'Vanda' had problems with bitter pit, and therefore cannot be recommended for organic fruit production in Sweden.

'UEB 2257/4' had problems with cracking, and also cannot be recommended.

It is important to have some cultivars that can be stored to prolong the season. The cultivars with best storability were 'Co-op 24', 'Co-op 26', 'Rajka', 'Rubinola', 'Scarlet O'Hara', 'Topaz' and 'UEB 2047/1'.

'Rubinola' had lower than average yields, but the highest proportion of Class I fruits in the first trial. In a consumer evaluation of twelve apple cultivars in Sweden, 'Rubinola' had the highest scores for taste and overall appeal (Jönsson, in press). Therefore, 'Rubinola' can be recommended for organic fruit production in Sweden.

'Scarlet O'Hara' had above average yields, but was the cultivar most susceptible to damage by noctuid, tortricid and geometrid moths. However, these pests can be controlled with *Bacillus thuringiensis*. 'Scarlet O'Hara' is a late ripening cultivar that keeps well in storage, and is a promising cultivar for organic fruit production in Sweden.

'Bio Golden' and 'UEB 2074/1' may be suitable for organic fruit production, though further study is needed, including a consumer acceptability evaluation.

'BM 41497', 'BM 51596', 'Co-op 12', 'Co-op 24', 'Co-op 26', 'Dayton' and 'Remo' also require further study before they can be recommended. Although they were more productive than the control, 'Amorosa', they have not shown any other outstanding qualities.

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OCENA SADOWNICZA ODMIAN JABŁONI ODPORNYCH NA PARCHA W SZWECJI

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S T R E S Z C Z E N I E

Odmiany jabłoni odporne na parcha badano w dwóch doświadczeniach. W pierwszym, założonym w 1997 roku, oceniano 8 odmian wyhodowanych w Czechach. Najwyższe sumaryczne plony za lata 1998-2003 zebrano z drzew odmiany 'BioGolden' (55 kg), następnie odmiany 'Topaz' (51 kg) i w dalszej kolejności 'UEB 2074/1' (44 kg), 'UEB 2345/1' (39 kg), 'Vanda' (38 kg), 'Rubinola' (37 kg), 'UEB 2257/4' (36 kg) i 'Rajka' (35 kg). Drugie doświadczenie z 13 odmianami z różnych krajów i odmianą szwedzką 'Amorosa', jako odmianą kontrolną, założono wiosną 1998 roku. Drzewa odmiany 'Vanda' miały najwyższe plony sumaryczne za lata 1999-2003, średnio 43 kg owoców z drzewa, w dalszej kolejności wysokie plony zebrano z drzew odmiany 'Scarlet O'Hara' (35 kg), 'Dayton' (21 kg), 'Co-op 24' (17 kg), 'Remo' (17 kg), 'BM 41497' (16 kg), 'William's Pride' (15 kg), 'Redfree' (14 kg), 'Reglindis' (13 kg), 'Co-op 12' (12 kg), 'Katinka' (11 kg), 'Amorosa' (10 kg) i 'BM 51596' (1 kg). Odmianami, które charakteryzowały się najlepszą zdolnością przechowalniczą były 'Co-op 26', 'Rajka', 'Reglindis', 'Rubinola', 'Scarlet O'Hara' i 'Topaz'. Najbardziej obiecującymi odmianami do organicznej produkcji owoców w warunkach Szwecji okazały się 'Rubinola' i 'Scarlet O'Hara'.

Słowa kluczowe: *Malus*, *Venturia inaequalis*, produkcja organiczna, jakość owoców