Rate of scab infection and quality parameters of apple fruit in organic and integrated production systems

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Gonda I.[1], Holb I. J.[2] and Bitskey K.[1]

[1]*Debrecen University, Centre of Agricultural Sciences, Faculty of Agronomy, Dept. of Horticulture, H-4015 Debrecen, Böszörményi út 138., Hungary*

[2]*Debreceni University, Centre of Agricultural Sciences, Faculty of Agronomy, Dept. of Plant Protection, H-4015 Debrecen, Böszörményi út 138., Hungary*

Key words: apple scab, dry matter, sugar content, total acids, vitamin-C, Thiault-quality index, specific weight, flesh firmness, integrated production, organic apple production

Abbreviations: cv. = cultivar, qi = quality index

Summary: In this study, the rate of scab infection and quality parameters (content of vitamin-C, dry matter, sugar, total acids, specific weight, quality index and flesh firmness) of some apple cultivars are given, moreover, the relation between those characters was examined in two environmental systems (organic and integrated) in a rainy season. In the organic fruit production, scab infection of leaves was significantly higher than in the integrated system, in case of the same cultivars, which means that the rate of decrease in leaf area was heavier in the organic production. Cultivars did not differ statistically in parameters of inner content when the integrated system was compared to the organic one. Results did not show statistical difference between loss of leaf area caused by apple scab and the parameters of inner content, which is attributed to the regeneration of leaf area due to favourable weather conditions. Data on apple scab and inner content of the fruit justify essentially the environmental systems of apple production.

Introduction

Values of the apple fruit (size, colour, and freshness) are determined by the inner content. Phenomena coded genetically and circumstances of production are affecting the properties appearing in the phenotype. Main conditions of production are the ecological circumstances and the elements of technology. Those factors are influencing the physiological balance of trees, the harmony between leaf area and fruit load. One fraction of the organic matters produced is stored in the woody parts of the trees while others are built into the fruit. The amount of the organic matter assimilated depends on the size of the leaf area and its health. Besides several factors, apple scab disease is one of the important factors which may decrease the active leaf area of some susceptible cultivars at a high rate especially in a rainy season.

One of the most important diseases of apple, both phytopathologically and economically, is the apple scab (*Venturia inaequalis* (Cke.) Winter). Most of plant protection costs in apple production are due to treatments against apple scab. It is well known that this disease damages leaf and fruit. The contaminated tissue dies and assimilation of the foliage decreases. The decrease of leaf area and consequently decrease of photosynthesis and assimilates may reach a high rate in susceptible cultivars and in plantations which were not protected sufficiently *(Spotts & Ferree,* 1979). Fruit losses caused by apple scab are important let alone quality.

Increasing interest of consumers to the *organic* products has an increasing impact on the growers also, who show higher affinity to *organic* production. However, some parts of environmentally friendly technologies as phytotechnical operations or plant sanitation means a huge challenge; thus excellent results are promised by resistant cultivars and phytotechnical operations combined with special sanitation techniques recommended in those systems *(Gonda,* 1993).

In several cases costs are higher, and economical aspects cannot be neglected *(Ellis et al.* 1998). Priority of 'bioproducts' however, is proven by examinations to the pesticide residues in fruits compared to traditional production. *Soltész* (1998) presents class intervals to parameters of inner content in apple (C-vitamin, dry matter, sugar, acid content). Parameters of inner content are examined by several researchers *(Ruger,* 1984; *Keipert et al.* 1990), but significant differences cannot be shown between products of traditional and *ecological* production. Data are not published yet concerning the decrease of leaf area caused by apple scab and parameters of inner content of fruits.

The aim of the study was to determine scab infection on leaf of some apple cultivars and parameters of the fruit (content of C-vitamin, dry matter, sugar, total acids, moreover, specific weight, quality index, and flesh firmness). The relationship between those characters in two environmental systems (*integrated* and *organic*) was examined in a rainy season.

Material and methods

Orchard site

Data assessments were done in the apple cultivar collection in the Debrecen-Pallag experimental fruit plantation of Debrecen University, Department of Horticulture. The plantation was planted in 1997, on M26 rootstock, at a spacing of 4x1.5m. Seven trees per cultivar was one plot. Experimental design was a block system, with 5 replicates. The orchard has been treated from the beginning according to two different production and plant protection systems. On one half of the area the *integrated* methods on the other the *organic* methods were applied. Eleven cultivars (three old cvs: *Húsvéti rozmaring, Batul, Téli banán*; three resistant cvs: *Renora, FAW 7262, Liberty*; five current cvs: *Red Elstar, Idared, Gala Must, Jonagold* and *Jonica*) were selected for the examination of disease incidence of apple scab and the characters of fruits.

Apple scab assessment

Disease assessments were made on leaves and fruits at 17–19 August 1999. Ten (2x5) trees per cultivar were observed in both environmental systems. Three hundred (6x50) leaves per tree and eighty (2x40) fruits per cultivar were chosen from the middle part of each tree observed. The proportion of diseased leaves and fruits (disease incidence, I) was calculated separately as the number of diseased leaves or fruits divided by the total number of leaves and fruits. After this, cultivars were classified into 4 disease incidence groups: (4) heavily infected, (3) medium, (2) weekly, and (1) not infected.

Examinations of fruit characters

Fruits were harvested according to the technological maturity of the respective cultivar. Fruit characters (parameters of vitamin C, dry matter, sugar, acids, specific weight, quality index and flesh firmness) were measured in samples taken from the stored fruits (1–1 kg of fruit per plant protection system) in the middle of November 1999.

Statistical analysis

Data analysis and connected examination was done with "Excel 7.0" and "Statistix 2.0" programs.

Results

Apple scab incidence

Weather conditions during vegetation period provided continuous disease infections. From March 1999 till the end of the assessments, Mills infection periods were heavy 15 times, moderate 5 times and light 4 times. Leaf infection of the examined cultivars showed a wide range in the *organic* and *integrated* production system of the orchard. *(Table 1).* Selected resistant cultivars did not show any symptom. Leaves of most current cultivars had a high range of infection level in the *organic* part of the plantation. Cultivars *Red Elstar* and *Idared* were exceptions with medium values. Infection rate of old cultivars showed considerable differences only in the *organic* part of the plantation. Leaf infection rate of old cultivars was up to middle value. The same cultivars had higher infection rate in the *integrated* part as in the *organic* part, but infection rates of those cultivars were statistically lower. Fruit infection in the integrated part was minimal. On the fruit of resistant cultivars only traces, on old cultivars 5% in average and on the current cultivars 15% of fruits showed symptoms of infection as observed in the *organic* part. Classification of cultivars was differentiated to the *integrated* and *organic* part, separately *(Table 1.).* In the *integrated* part cvs *Jonica* and *Jonagold* were heavily (4), cvs *Idared, Gala Must* and *Húsvéti rozmaring* medium (3), cvs *Téli banán* and *Red Elstar* weak (2), cvs *Renora, FAW 7262, Liberty* and *Batul* had no infections. In the *organic* part, cvs *Gala Must, Jonica* and *Jonagold* were heavily (4), cvs *Red Elstar, Idared, Batul, Téli banán* and *Húsvéti rozmaring* medium (3), and cvs *Renora, FAW 7262* and *Liberty* were not susceptible to infections.

Inner contents

Dry matter content. Values of dry matter of apples in the *organic* part were higher or almost the same as fruits from the *integrated* part *(Figure 1).* Fruits of higher dry matter content contain relatively less water, and are more compact. Fruits having those properties are stored better. Values of resistant cultivars (*Liberty, FAW 7262* and *Renora*) were more different in the two technologies. Cultivars *Jonica* and *Gala Must* were more different among the current cultivars.

Sugar. Sugar content has similar tendency to dry matter values *(Figure 2).* Relative sugar content values of "*bio fruits*" are higher or slightly lower (*Húsvéti rozmaring* and

Table 1 Disease incidence classes and leaf disease incidence of apple scab in some apple cultivars grown according to two environmental production systems

	Disease incidence classes	Disease incidence (%)
Old cultivars		
Húsvéti rozmaring (int)	3	10,8
(org)	3	35
Batul (int)	1	0
(org)	3	38,8
Téli banán (int)	2	5,6
(org)	3	49,2
Resistant cultivars		
Renora (int)	1	0
(org)	1	0
Faw-7262 (int)	1	0
(org)	1	0
Liberty (int)	1	0
(org)	1	0
Current cultivars		
Red Elstar (int)	2	6,4
(org)	3	40,8
Idared (int)	3	6,4
(org)	3	36
Gala Must (int)	3	6,8
(org)	4	48
Jonagold (int)	4	14,8
(org)	4	74
Jonica (int)	4	18
(org)	4	78,8

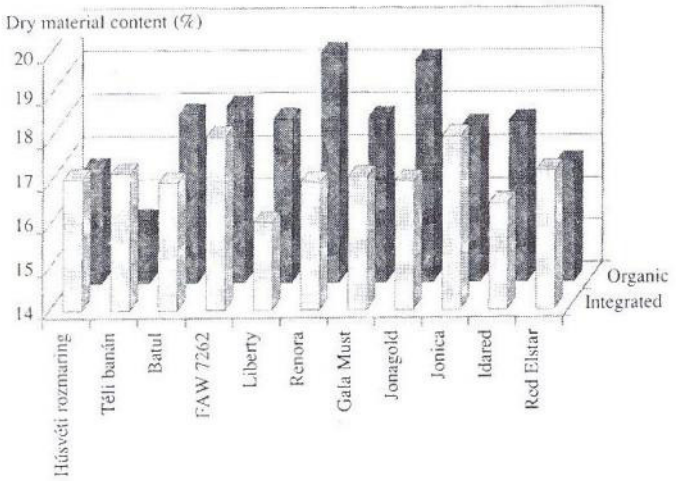

Figure 1 Dry matter content of fruit of some apple cultivars at harvest in integrated and organic production systems (Debrecen–Pallag, 1999)

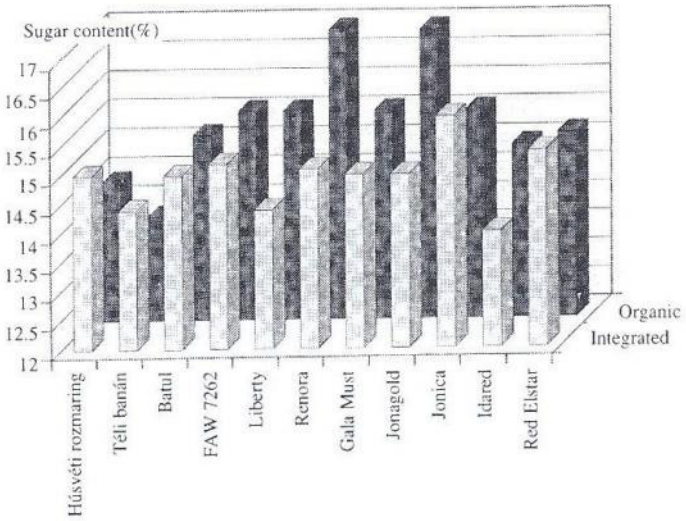

Figure 2 Sugar content of fruit of some apple cultivars at harvest in integrated and organic production systems (Debrecen–Pallag, 1999)

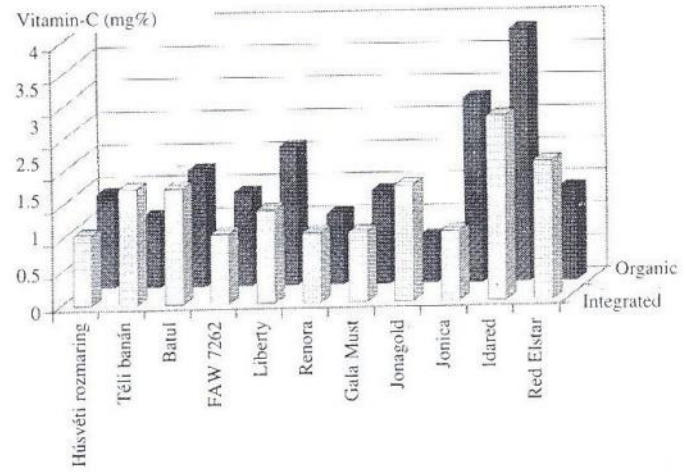

Figure 3 Vitamin-C content of fruit of some apple cultivars in integrated and organic production systems (Debrecen–Pallag, 1999)

Téli banán) compared to fruits from the *integrated* part. Data of resistant cultivars were more different depending on the technologies. Values are near the higher border of the range indicated in literature (10–14%) or higher than that. Sugar content over 13% is considered to be high. Values of all the cultivars examined were higher than that.

Vitamin-C. Values of vitamin-C content are within the range published by the literature *(Figure 3).* In eight cultivars vitamin-C content was higher in the *"bio fruits"*. Vitamin-C content of cv. *Liberty, Jonica,* and *Idared* was extremely high.

Total acids. Eight cultivars of *bio fruits* had higher acid content than the *integrated* fruits. In case of 3 cultivars the values were lower, but this difference is not significant. Higher acid content provides freshness to the apple, and it is less subject to decay during storage. The fruit keeps a good texture for longer time.

Thiault-quality index. A complex record number of inner content is, this internationally accepted index which is calculated by the sugar content and acid content multiplied by 10. This index is the only one, which concludes to the consumption quality of fruits from objective data *(Figure 5).* High QI value means relatively high acid content. According to the literature values above 160 are favourable. All of the cultivars examined by us had a higher value or was within the given range (140–170). Fruits from the *bio* part had definitely higher QI values than *integrated* fruits.

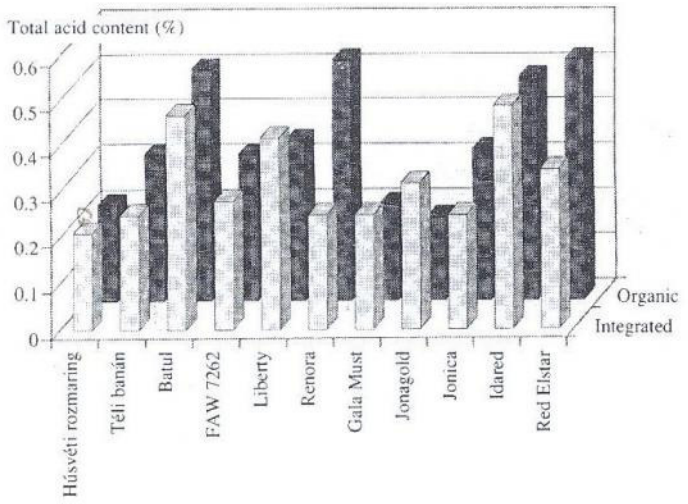

Figure 4 Total acid content of fruit of some apple cultivars in integrated and organic fruit production systems (Debrecen–Pallag, 1999)

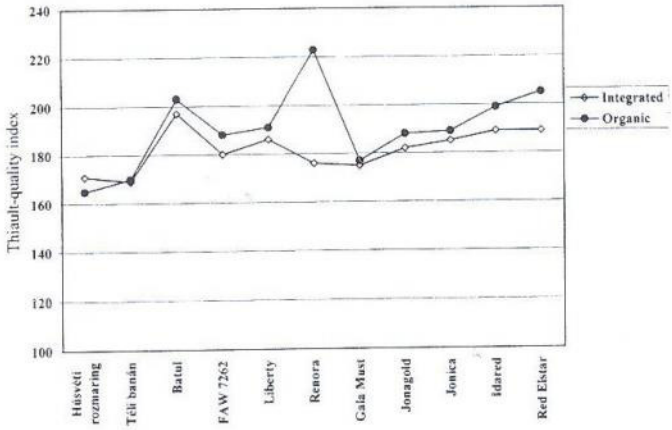

Figure 5 Thiault-quality index of fruit of some apple cultivars in integrated and organic fruit production systems (Debrecen–Pallag, 1999)

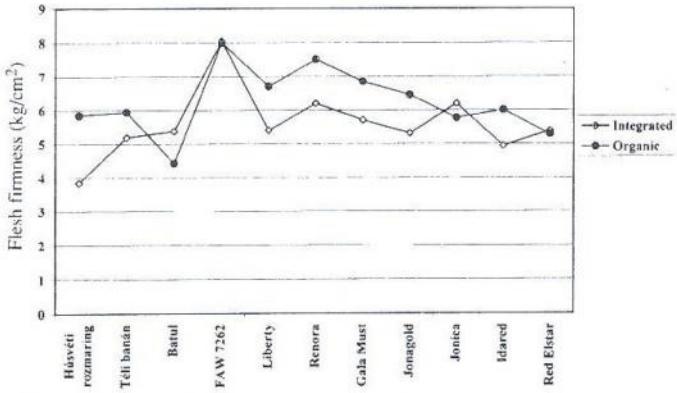

Figure 6 Flesh firmness of fruit of some apple cultivars in integrated and organic fruit production systems (Debrecen–Pallag, 1999)

Specific weight. During storage both the weight and volume of fruits decreased-according to decay and water loss, and it is related to the fact that they had lower water content by relatively higher dry material content *(Table 2)*. It means that the less water loss, and the higher acid content are responsible for the slower decays. Substances remain better till the end of storage, so they have probably better storage properties.

Flesh firmness. In March, the time of storing out the *bio fruits*, they remained more firm or the values were less low than that of the *integrated fruits (Figure 6)*. Quality requirement for apple firmness is at least 5 kg/cm^2 so we can conclude that both of the environmental systems produced quality fruits to the end of storage. Firmness of resistant cvs were extremely high compared to the other cvs.

As a summary, it can be stated that inner content values of the examined cvs were within the optimal values given by *Soltész* (1998). In the *integrated* part the cvs did not show significant differences to the *organic* part, in the connection of decrease in leaf area by apple scab and inner content of the fruit significant differences could not be shown in the year of the examination.

Table 2 Specific weight of some apple cultivars at the end of storage in the percentage of specific weight before the storage

	Integrated (%)	Organic (%)
Old cultivars		
Húsvéti rozmaring	102.2	100.6
Batul	99.6	100.6
Téli banán	100.1	100.6
Resistant cultivars		
Renora	100.8	100.4
Faw-7262	100.8	100.0
Liberty	104.6	101.0
Red Elstar	99.8	99.0
Idared	101.6	100.2
Gala Must	103.2	101.6
Jonagold	101.4	101.3
Jonica	101.2	101.1

Conclusion

Scab infection classes justified the statements of the literature *(Holb,* 2000). Results of fruit parameters are in agreement with the statements of *Ruger* (1984) and *Keipert* et al. (1990), who did not find any significant difference between fruit quality parameters when compared the traditional production to *ecological* production. Although we did not find any significant correlation between the reduction of leaf area caused by apple scab and fruit content parameters, but it does not mean that there is no connection between the two factors. Our results can be interpreted in several ways. Although rainy weather enhanced scab development, it also enhanced continuous nutrient flow enhanced photosynthetical activity of healthy leaf parts and development of new leaves. Consequently, the trees could compensate the damage of scab. All of these, however, can exhaust the resources of the tree, and after several years, condition of the trees and parameters of the fruit will

decrease as well. Probably the harmful effect accumulated by several years will lead to the decrease in number, size and content of the fruits. In order to clear that precisely, further assessments and examinations are needed, by evaluating other technological elements such as the influence of nutrition and water management.

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