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Evaluation of crop yield and fruit quality in organic apple production

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Summary: In this study, crop yield and fruit quality parameters (soluble solid concentration, sugar, total acid, and vitamin C content) of 15 apple cultivars including old, resistant and currently grown cultivars. The highest fruit yield among all 15 cultivars was obtained on cv. Jonagold with 15.5 kg/tree, while the lowest yield was measured on the resistant cultivar Reanda with 8.1 kg/tree. There were no significant differences among the cultivars in fruit diameter ranging from 70 mm in the case of cv. Húsvéti rozmaring to 82 mm for cv. Mutsu. Values of soluble solids concentration of the cultivars varied between 15.5% for cv. Téli Banán and 19.2% for cv. Renora. Sugar content values showed a similar tendency to soluble solids content. The highest and lowest total sugar content was observed on cvs. Jonagold and Renora and cv. Retina with 17% and 12.4%, respectively. Total acid content values ranged between 0.18% and 0.53% for cvs. Jonagold and Remo, respectively. Values of vitamin C content for the 15 apple cultivars varied between 2 mg% and 4 mg% for cv. Retina and cv. Mutsu, respectively.

Key words: yield, fruit diameter, soluble solid concentration, sugar content, total acid, vitamin C, organic apple, resistant apple cultivar

Introduction

Sustainable and environmentally-benign production including organic apple production is a major principle of today's fruit growing sector (*Gonda*, 1993, 2000). In organic production, only organic manures can be applied, while in the integrated production artificial fertilizers can also be used, with respect to environmental and health protection limitations (*Soltész & Szabó*, 1997). In the pest management used in organic orchards, copper- and sulphur-based and natural products can be applied, while in the integrated systems, the use of numerous synthetic, environmentally-friendly products is permitted (*Soltész & Szabó*, 1997; *Holb & Heijne*, 2001).

Increasing interest of consumers toward organic fruits has an increasing impact on the growers also, who show higher affinity to organic apple production. However, some parts of organic production technology, such as nutrient supply, phytotechnical operations and plant protection, are a great challenge to most growers (*Gonda*, 1993, 2000). Especially plant protection can be a difficult task to be solved in organic apple production (*Holb*, 2000). In several cases, costs of organic apple production are higher compared to integrated or conventional production, and therefore, economic aspects of organic production cannot be neglected (*Ellis* et al. 1998). However, priority is given to 'organic fruits' as harmful pesticide residues of fruits are less compared with traditional apple production. *Soltész* (1998) and *Gonda* et al (2000) presented class intervals of inner content parameters of some apple cultivars (vitamin C, soluble solid content, sugar, and acid content). Inner content parameters of fruits in organic vs. integrated or conventional apple production were investigated by some researchers. *Ruger* (1984) and *Keipert* et al. (1990) showed no significant differences of inner content of fruit between conventional and organic apple production. *Gonda* et al. (2000) were not able to prove higher vitamin C, soluble solid content, sugar, and acid content of organic apple fruits compared to integrated ones. Detailed study on crop yield and fruit quality parameters has not been conducted in organic apple production on a large number of apple cultivars.

The aim of the present study was to determine crop yield and fruit quality parameters (soluble solid concentration, sugar, total acid, and vitamin C content) of 15 apple cultivars including old, resistant and currently grown cultivars.

Materials and methods

Orchard site

Data assessments were made in an apple cultivar collection at Debrecen-Pallag, Debrecen University, Department of Horticulture and Plant Biotechnology. The orchard was planted in 1997, on M26 rootstock, with a spacing of 4 x 1.5m. In one plot, there were 7 trees per cultivar. Plots were arranged in a randomized block system, in 3 replicates in the orchard. The orchard was treated since the plantation year according to the Hungarian Organic Guidelines (Anon, 1997). Orchard soil type was brown forest

soil. Orchard was not irrigated. Nutrient supply was maintained with synthetic fertilizers in the integrated orchard part. Stable manure, 30 t ha^{-1} was applied to the soil in 2001 and 2003 in the orchard. The orchard consisted of 39 apple cultivars. Fifteen cultivars (six resistant ones: cv. Retina, cv. Rewena, cv. Remo, cv. Reanda, cv. Renora, and cv. Liberty; six currently grown ones: cv. Gala Must, cv. Jonagold, cv. Jonica, cv. Idared, cv. Red Elstar, and cv. Mutsu; and three old ones: cv. Húsvéti rozmaring, cv. Téli banán, and cv. Batul) were selected for evaluating crop yield and four fruit quality parameters of harvested fruits.

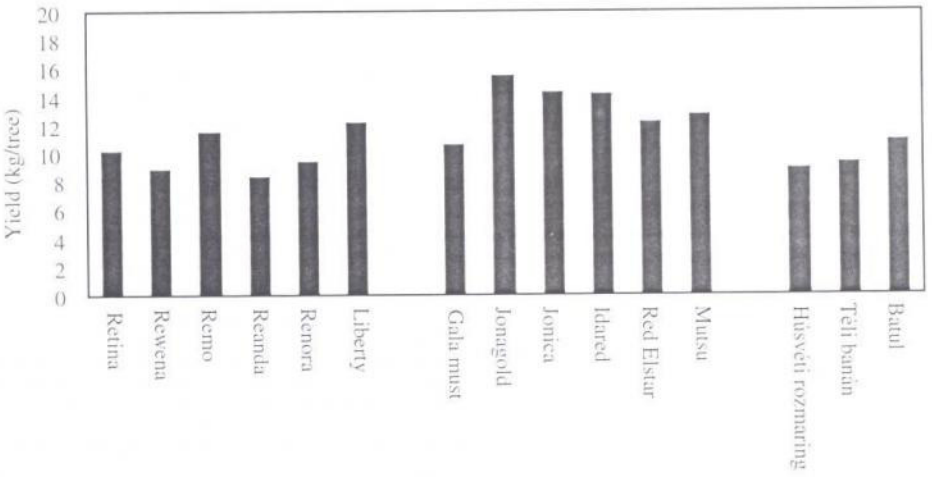

Figure 1 Mean yield (kg/tree) of 15 selected apple cultivars in an organic apple orchard (Debrecen-Pallag, Hungary, 2001, 2002 and 2004).

Yield

Fruits of each cultivar were harvested at the technological maturity phase in 2001, 2002 and 2004. The largest fruit diameter of each cultivar was measured with a vernier caliper then total weight of fruits per tree was measured with a commercial scale. Both measures (fruit diameter and weight) were averaged to get mean fruit diameter and yield values per tree for each cultivar.

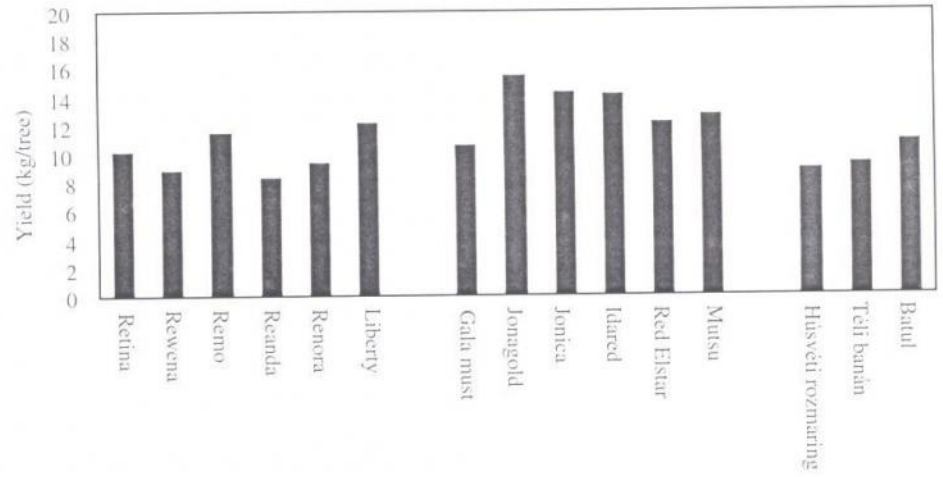

Figure 2 Mean fruit diameter (mm) of 15 selected apple cultivars in an organic apple orchard (Debrecen-Pallag, Hungary, 2001, 2002 and 2004).

Fruit quality parameters

After measuring fruit diameter and weight, 5 fruits from 4 trees of each cultivar were randomly selected for fruit quality measures. Fruit samples were used to measure soluble solids concentration, total sugar, total acidic and vitamin C content for each cultivar. Soluble solids concentration was determined on a freshly squeezed juice sample from each fruit using a refractometer calibrated prior to use with a 10% (weight:volume) sucrose solution. Total sugar, total acidic and vitamin C contents were determined by standard Hungarian Fruit Quality Evaluation Methods.

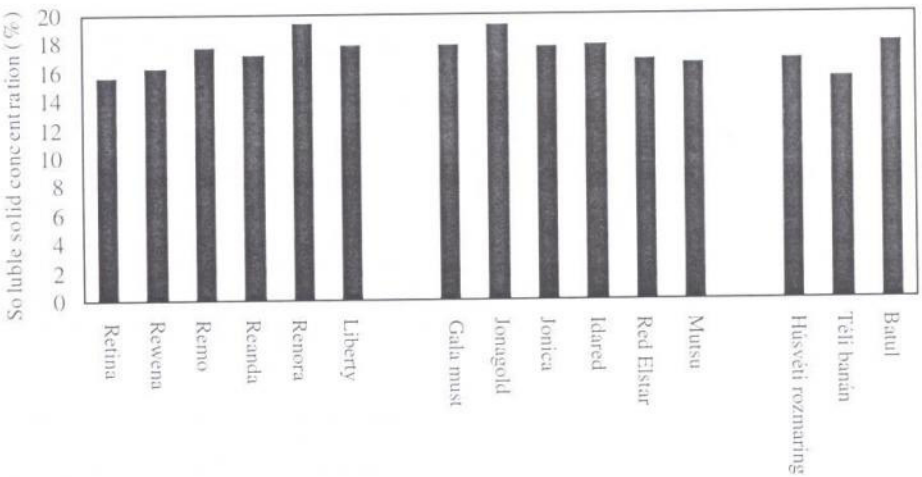

Figure 3 Mean soluble solids concentration (%) of 15 selected apple cultivars in an organic apple orchard (Debrecen-Pallag, Hungary, 2003).

Statistical analysis

Analyses of variance were used to separate means of fruit yield and fruit

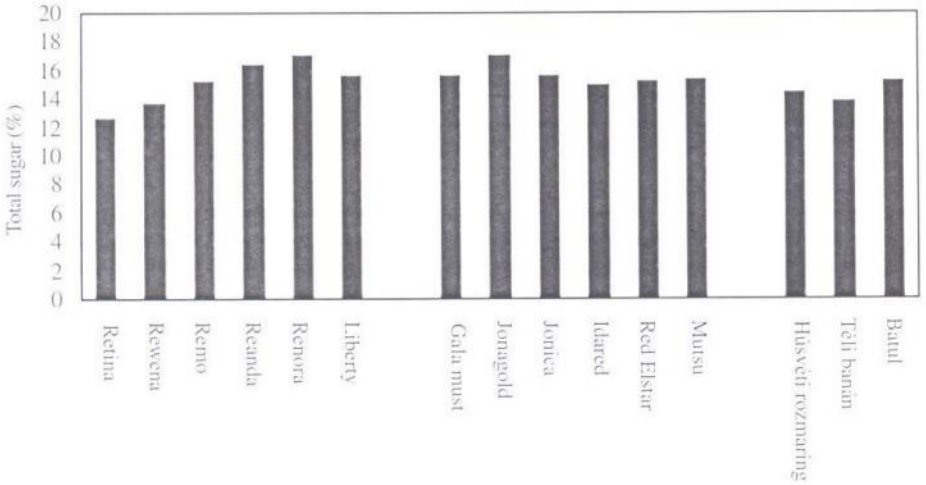

Figure 4 Mean total sugar content (%) of 15 selected apple cultivars in an organic apple orchard (Debrecen-Pallag, Hungary, 2001, 2002, 2004).

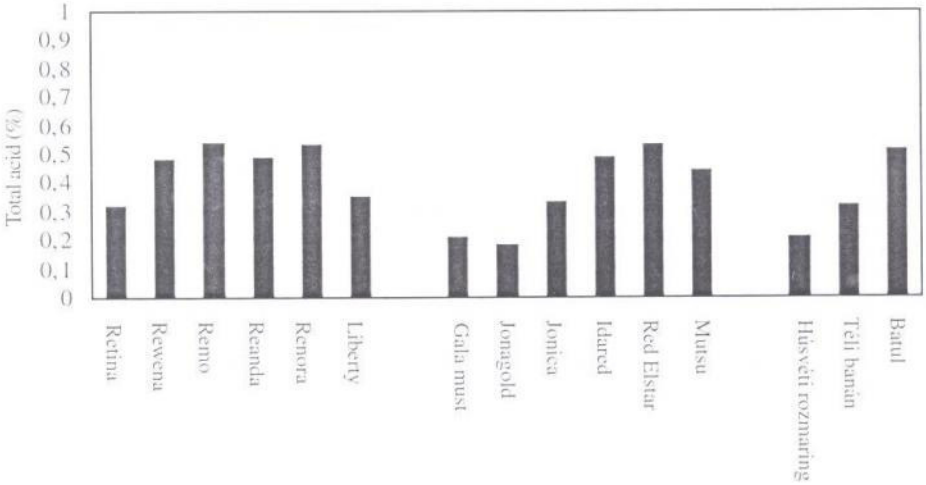

Figure 5 Mean total acid content (%) of 15 selected apple cultivars in an organic apple orchard (Debrecen-Pallag, Hungary, 2001, 2002 and 2004).

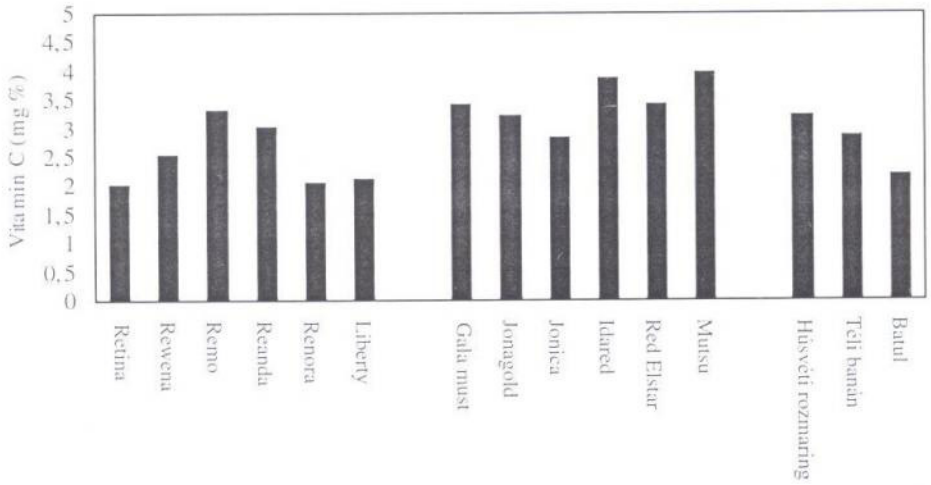

Figure 6 Mean vitamin C content (mg%) on 15 selected apple cultivars in an organic apple orchard (Debrecen-Pallag, Hungary, 2001, 2002 and 2004).

quality parameters for the cultivars. Significant differences were determined at $P = 0.05$.

Results and discussion

Yield and fruit diameter

In the average of three years, the highest fruit yield among all 15 cultivars was obtained on cv. Jonagold with 15.5 kg/tree, while the lowest yield was measured on the resistant cultivar Reanda with 8.1 kg/tree *(Figure 1)*. The highest yield among the resistant and old cultivars was measured on cv. Liberty and cv. Batul with 12 kg/tree and 10.8 kg/tree, respectively. Cvs. Húsvéti rozmaring and Gala Must gave the lowest yields among the old and currently grown cultivars with 10.5 kg/tree and 9 kg/tree, respectively.

There were no significant differences among the cultivars in fruit diameter ranging from 70 mm in the case of cv. Húsvéti rozmaring to 82 mm for cv. Mutsu *(Figure 2)*.

Fruit quality parameters

Soluble solids concentration

Values of soluble solids concentration of the cultivars varied between 15.5% for cv. Téli Banán and 19.2% for cv. Renora *(Figure 3)*. Among the currently grown cultivars cv. Jonagold and cv. Mutsu had the highest (19%) and lowest (16.3%) soluble solids content, respectively. The lowest soluble solids contents were measured on cv. Retina and cv. Téli Banán among the resistant and old cultivars, respectively. Fruits with higher soluble solids concentration contain relatively less water, and these are more compact. Fruits having such properties can be stored better.

Total sugar content

Sugar content values showed a similar tendency to soluble solids content *(Figure 4)*. The highest and lowest total sugar content was

observed on cvs. Jonagold and Renora and cv. Retina with 17% and 12.4%, respectively. Among the old cultivars, the highest and lowest sugar contents were obtained for cvs. Batul and Téli Banán, respectively. The lowest sugar content among the currently grown cultivars was measured in cv. Idared, its total sugar content was similar to that of cv. Batul, which had the highest sugar content among the old cultivars.

Total acid content

Total acid content values ranged between 0.18% and 0.53% for cvs. Jonagold and Remo, respectively *(Figure 5)*. The highest values were similar for all three groups of the cultivars. Among the currently grown and old cultivars, the highest values were obtained for cv. Red Elstar (0.52%) and cv. Batul (0.51%) respectively. Apple fruits with higher acid content maintain their freshness and good texture for a longer time and decay more slowly during storage.

Vitamin C content

Values of vitamin C content for the 15 apple cultivars varied between 2 mg% and 4 mg% for cv. Retina and cv. Mutsu, respectively *(Figure 6)*. The largest vitamin C content among the resistant and the old cultivars was detected in cvs. Remo and Húsvéti rozmaring, respectively. The lowest vitamin C contents were measured in cv. Jonica (2.8 mg%) among the currently grown cultivars and cv. Batul (2.2 mg%) among the old cultivars.

As a summary, it can be stated that inner content values of the examined cultivars were within the optimal values given by *Soltész* (1998). Similarly to a previous study of *Gonda* et al. (2000) higher vitamin C, soluble solid content, sugar, and acid content of organic apple fruits were found compared with fruits from integrated orchards.

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