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Effect of cultivars and different growing technologies on strawberry yield and fruit quality

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Abstract. The interest in organic farming and organically produced products is increasing every year in Estonia. In 2003 the trial with four widely grown strawberry cultivars: 'Polka', 'Bounty', 'Korona' and 'Senga Sengana' in two variants, the organic and the conventional, was established at the Polli Horticultural Research Centre. The objective of this study was to assess the strawberry cultivars in organic and conventional growing with regard to their yield and berry quality. No significant differences in commercial and defective yield per plant between two growing variants were observed in 2004, but the commercial yields were significantly higher in the conventional variant in 2005 and 2006. It was noted that organically grown strawberries had a higher content of soluble solids, but a lower content of ascorbic acid comparing with conventionally grown strawberries. Due to its good productivity and high content of soluble solids and ascorbic acid, 'Bounty' was the most profitable cultivar in this study, and appeared highly suitable for organic cultivation.

Key words: *Fragaria x ananassa* Duch., conventional, organic, yield, berry quality

INTRODUCTION

Strawberries are appreciated for their biochemical content, unique, highly desirable taste and flavour. It is one of the most popular summer fruits in European and Scandinavian countries. An increasing number of consumers demand agricultural products grown without the use of synthetic pesticides. Organic production excludes the use of synthetic fertilizers and pesticides, and requires soil building and biological pest control. Organic foods are generally considered healthier than conventionally grown products (Järvan & Edesi, 2009).

In some European countries organic strawberry production has reached a level of 4–6% (Steffek et al., 2004). In 2008, cultivation of organic strawberry covered 29 ha in Estonia, which is 4.5% of the total strawberry growing area (648 ha). One of the reasons for the low percentage is that the options to control pests and weeds are limited and expensive.

High yield of good quality berry production depends on adequate mineral nutrition, weather terms and cultivars (Kikas & Libek, 2005). Cultivar choice is of the most important single factors for organic strawberry production as choosing the wrong cultivar inevitably leads to problems (Berglund, 2007). Strawberries are a good source of ascorbic acid, which is very important nutrient, being essential, e.g. for the synthesis

of collagen. Ascorbic acid is also a natural antioxidant used in foodstuff formulations in order to prevent browning, discolouring and to enhance shelf life (Castro et al., 2004).

The objective of this study was to investigate strawberry cultivars in organic and conventional growing with regard to their yield and berry quality.

MATERIALS AND METHODS

The trial was carried out at the Polli Horticultural Research Centre in the southern part of Estonia during 2004–2006. The planting was established in spring 2003 with four cultivars, two variants and three replicates. Planting distance was 1.2 m between the rows and 35 cm between the plants in the row. Each plot contained 70 strawberry plants of which three representative plants were selected. The strawberry cultivars 'Polka' and 'Korona' (Netherlands), 'Bounty' (Canada), 'Senga Sengana' (Germany) were used in the trial. The choice of cultivars was based on previous results from conventional trials. The soil type in the trial area was a sandy loam, containing 1.7% of humus. The preceding crop was cereal (rye and barley). No irrigation system was used in the trial area. The following trial variants were used:

- Organic. The experimental plot was fertilized with 80 t ha^{-1} of farmyard manure before planting. Every year the plants were sprayed with 0.2% NeemAzal + 1.5% Allgrow solution before the flowering. The next year after flowering, the predatory mite (Tripex), at a rate of 50-piece m^2 was applied. After harvesting the natural fertilizer Algomin (1–7–15) at a rate of 4 kg 100 m^2 was applied annually.
- Conventional. Potassium chloride at rate of 500 kg ha^{-1} and super-phosphate at rate of 1200 kg ha^{-1} were used before planting. Mineral fertilizer (Cropcare 6–14–23) at rate of 250 kg ha^{-1} and 1.0% calcium-nitrate solution at rate of 400 l ha^{-1} before the flowering, and Cropcare (3–11–20) at rate of 250 kg ha^{-1} in every autumn were applied. Before flowering plants were sprayed with Flint Multi WG (1.3 kg ha^{-1}) or Teldor 500 SC (1.5 kg ha^{-1}) and after the harvesting with Topas 100 EC (0.4 l ha^{-1}) to control diseases. To control pests, before flowering the plants were sprayed with Fastac 50 EC and after the harvesting with Envidor 240 SC water solution both at rate of 0.4 l ha^{-1}.

In the both variants the soil between the rows was kept clean mechanically. All runners were removed leaving the original plants as separate plants.

The commercial and defective (small, damaged by pests, birds and diseases) yield from 70 plants was harvested from each of the variants, three times a week. Average yield of commercial and defective fruits per plant was calculated. Analysis of ascorbic acid and total soluble solids was carried out in the biochemical laboratory of the Polli Horticultural Research Centre. The ascorbic acid content was determined by using the modified Tillman's method, where ascorbic acid was titrated with 2.6 dichloroindophenol in acid environment. Total soluble solids expressed as ^{0}Brix were measured with the refractometer. The data were analyzed statistically using two-factor analysis of variance (ANOVA), at significance level $P < 0.05$.

RESULTS AND DISCUSSION

In our trial the first cropping year was 2004. From Table 1 is visible that in organic cultivation the marketable yield per plant was in average 376 g while in conventional cultivation it was similar, in average 377 g. Accordingly, no significant differences between the two variants was observed in 2004. In both treatments the cultivar 'Polka' had the highest yield. The defective yield per plant of cultivar 'Korona' was significantly smaller in both treatments in comparison with the control cultivar 'Polka'. In 2005, the marketable yield was significantly higher in conventional cultivation, but defective yield was significantly smaller in organic. Again, among the cultivars, the highest yield (513 g per plant) was obtained from 'Polka'. In 2006, strawberry yield was greatly influenced by the climatic factors. The period from January 18 till January 23 was very cold, with the lowest air temperature –27°C. This caused significant crop losses. In addition, the summer was very dry: from May to August the sum of precipitation was only 119 mm. Average marketable yield per plant was only 180 g in organic and 212 g in conventional variant. In this year the highest yield (318 g per plant) was produced by the cultivar 'Bounty'. It was noted also that the yields diminished in successive harvest. By Berglund (2007), no more than two years of harvesting in organic production is recommended.

The average berry weight varied from 11 to 13 g, being the largest in 'Korona' (Table 1). No significant differences in fruit weight were found between the growing technologies.

Table 2 shows the average contents of ascorbic acid and soluble solids in fruits of strawberry in 2004–2006. Among the cultivars, significantly higher ascorbic acid content as an average over all the years in both treatments was found in 'Bounty'.

This is in agreement with the results obtained by Haffner et al. (1998). Content of ascorbic acid in cultivars 'Bounty' and 'Senga Sengana' was considerably but not significantly higher in 2006 than it was in 2005 and 2004. There were no significant differences between the ascorbic acid contents of the two variants. This result is in accordance with the other investigation (Cayuela, et al., 1997).

As an average of three years the soluble solids content was significantly higher in organically grown strawberries (Table 2). The highest average content of soluble solids was found in 'Bounty', being comparable with data from Kallio & Hakala (2000), and the lowest in 'Senga Sengana'. The soluble solids contents in most cultivars were consistently higher in 2006 compared to 2005 and 2004.

Table 1. Average commercial yield and berry weight of strawberry cultivars in organic and conventional cultivation.

Cultivation/ Cultivar	Marketable yield per plant, g			Defective yield per plant, g			Berry weight, g
	2004	2005	2006	2004	2005	2006	2004–2006
Organic							
Polka	583g*	437c	273e	121d	77d	24a	12a
Bounty	416d	353b	136b	73c	22a	25a	11a
Korona	252b	313a	101a	50b	35b	32ab	13a
Senga Sengana	252b	360b	210d	121d	39b	52cd	11a
Conventional							
Polka	463f	587f	215d	121d	78d	54d	11a
Bounty	383c	484d	318f	74c	33b	35abc	12a
Korona	224a	524e	143b	36a	82d	63d	12a
Senga Sengana	437e	510de	171c	143e	60c	50bc	11a
$LSD_{0.05}$	8.5	27.4	13.0	12.7	12.5	18.5	3.5
Polka	523d	513b	244d	121c	78d	55b	12a
Bounty	400c	419a	227c	74b	27a	30a	12a
Korona	238a	418a	122a	43a	59c	47b	12a
Senga Sengana	344b	435a	190b	132d	49b	51b	11a
$LSD_{0.05}$ of cultivar	6.0	19.4	9.2	9.0	8.9	13.1	2.4
Organic	376a	366a	180a	91a	43a	41a	12a
Conventional	377a	527b	212b	93a	63b	50a	12a
$LSD_{0.05}$of cultivation	4.3	13.7	6.5	6.3	6.3	9.3	1.7

*means followed by the same letter in the same column are not significantly different (LSD test, $P > 0.05$)

Table 2. Average content of ascorbic acid and soluble solids in strawberry cultivars in organic and conventional cultivation.

Treatment	Cultivar	Ascorbic acid, m%			Soluble solids, %		
		2004	2005	2006	2004	2005	2006
Average of cultivar	Polka	45a	34c	44b	8.2a	12.2b	13.1c
	Bounty	56c	44d	69d	8.9d	13.1c	13.3c
	Korona	47b	33b	42a	8.5c	10.8a	12.4b
	Senga Sengana	44a	24a	56c	8.4b	10.9a	10.3a
$LSD_{0.05}$		1.2	0.6	0.7	0.1	0.2	0.2
Average of cultivation	Organic	47a	33a	53b	8.4a	12.3b	12.7b
	Conventional	50b	35b	52a	8.6b	11.2a	11.8a
$LSD_{0.05}$		0.8	0.4	0.5	0.1	0.1	0.1

*means followed by the same letter in the same column are not significantly different (LSD test, $P > 0.05$).

CONCLUSIONS

In our trial the most productive cultivars were 'Polka' and 'Bounty', which gave the highest average yields per plant. No significant differences in commercial and defective yield per plant between the growing variants were observed in 2004, but the commercial yields were significantly higher in the conventional variant in 2005 and 2006. No significant differences in fruit weight and the ascorbic acid content were found between the growing variants. In both variants the significantly higher average ascorbic acid content was found in 'Bounty'. The soluble solids content was significantly higher in organically grown strawberries. The highest average content of soluble solids was found in 'Bounty'.

The current study indicated that strawberry is a suitable and perspective crop for organic cultivation.

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REFERENCES

Berglund, R. 2007. Organic production of strawberry. Doctoral diss. Dept. of Horticulture. SLU. *Acta Universitatis Agriculturae Sueciae*. 2007, p. 30.

Castro, I., Teixeira, J.A., Salengke, S., Sastry, S.K. & Vicente, A.A. 2004. Ohmic heating of strawberry products electrical conductivity measurements and ascorbic acid degradation kinetics. *Innov. Food Sci. Emerg. Tech*. **5**, 27–36.

Cayuela, J.A., Vidueira, J.M., Albi, M.A. & Gutierrez, F. 1997. Influence of the ecological cultivation of strawberries (*Fragaria x ananassa* Cv. Chandler) on the quality of the fruit and on their capacity for conservation. *Journal of Agriculture and Food Chemistry*, **45**, 1736–1740.

Haffner, K., Vestrheim, S., Jeksrud, W.K. & Tengesdal, G. 1998. 1-ascorbic acid and other quality criteria in frozen and dehydrated strawberries *Fragaria x ananassa* Duch. *Nahrung*, **4** (1), 32–35.

Järvan, M & Edesi, L. 2009. The effect of cultivation methods on the yield and biological quality of potato. *Agronomy Research* **7** (Special Issue 1), 289–299.

Kallio, H., Hakala, M., Pelkkikangas, A.-M., & Lapveteläinen, A. 2000. Sugars and acids of strawberry varieties. *Journal of Agricultural and Food Chemistry*, **212**, 81–85.

Kikas, A. & Libek, A. 2005. Influence of Temperature Sums on Growth and Fruit mass and Yield of Strawberry. *Europ. J. Hort. Sci*.**70** (2), 85–88.

Steffek, R., Bylemans, D., Nikolova, G., Carlen, C., Faby, R., Daugaard, H., Tirado, L., Pommier, J.J., Tuovinen, T., Nyerges, K., Manici, L., MacNaeidhe, F., Trandem, N., Wander, J., Evenhuis, B., Labanowska, B., Bielenin, A., Svensson, B., Fitzgerald, J. & Blümel, S. 2004. Status of sustainable strawberry production within Europe. In: Simpson, D.H. (eds.). *Acta Horticulturae* **649** *Euro Berry Symposium – Cost 836 Final workshop*. Ancona, Italy, pp. 247–250.