

## **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<sup>-1</sup> 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 (Triplex), at a rate of 50-piece m<sup>2</sup> was applied. After harvesting the natural fertilizer Algomin (1–7–15) at a rate of 4 kg 100 m<sup>2</sup> was applied annually.
- Conventional. Potassium chloride at rate of 500 kg ha<sup>-1</sup> and super-phosphate at rate of 1200 kg ha<sup>-1</sup> were used before planting. Mineral fertilizer (Cropcare 6–14–23) at rate of 250 kg ha<sup>-1</sup> and 1.0% calcium-nitrate solution at rate of 400 l ha<sup>-1</sup> before the flowering, and Cropcare (3–11–20) at rate of 250 kg ha<sup>-1</sup> in every autumn were applied. Before flowering plants were sprayed with Flint Multi WG (1.3 kg ha<sup>-1</sup>) or Teldor 500 SC (1.5 kg ha<sup>-1</sup>) and after the harvesting with Topas 100 EC (0.4 l ha<sup>-1</sup>) to control diseases. To control pests, before flowering the plants were sprayed with Fastac 50 EC and after the harvesting with Envirdor 240 SC water solution both at rate of 0.4 l ha<sup>-1</sup>.

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 °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  $-27^{\circ}\text{C}$ . 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/<br>Cultivar           | Marketable yield<br>per plant, g |       |      | Defective yield<br>per plant, g |      |       | Berry<br>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 <sub>0.05</sub>                | 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 <sub>0.05</sub> 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 <sub>0.05</sub> 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 <sub>0.05</sub>    |               | 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 <sub>0.05</sub>    |               | 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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