The yield of tomato cultivars grown in organic and conventional system

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Abstract

Three tomato varieties were grown in the greenhouse during 2008-2010, using two growing systems: organic and conventional. Production substrate consisted of 30% soil, 50% manure and 20% peat and a small part of the marble. Planting (2.64 plants/m²) was done on April 18 and harvest lasted from June to beginning of September. Organic system obtained optimal production level but with higher costs of cultivation compared with the conventional one. At the same time, organic tomatoes achieved a better price, guaranteed placement, so that the entire production is placed at 1.8 € per kg. The best results were obtained by variety Elpida F₁ in organic production with an average yield of 89.87 t/ha.

Key words: Lycopersicon esculentum Mill., variety, production system, yield

Introduction

Organic agriculture is developing rapidly, and statistical informations are now available from 154 countries of the world. According to the Research Institute of Organic Agriculture (FiBL), and the International Federation of Organic Agriculture Movements (IFOAM), 35 million hectares of agricultural land was under organic management (both certified and in conversion) in 2008. In Switzerland for instance, organic vegetables account for 10% of all vegetables sold. In U.S., organic fruit and vegetables account for 37% of all organic food sales (retail value). The largest producer is Italy (121,000 hectares). Key challenges for organic horticultural crops, especially for fresh consumption, tend to be insect pest and disease management, weed control in vegetables, and resource efficiency (Wiler, 2010).

Organic agriculture in Greece has its roots in the ecological movement at the beginning of the 1980s. The first organic farmers were mostly amateurs who experimented with different organic cultivation methods. Commercial organic agriculture started in 1982 with the demand for organic currants (sultanas) from a Dutch firm. Individual farmers converted their farms in the following years, supervised by foreign certification and inspection bodies. In 1999, both the share of organically utilised area as well as the number of organic farmers reached 0.6% of the overall country. EU-Regulation 2092/91 brought a major change. Many farmers officially converted their farms to organic agriculture. A second expansion took place after the introduction of hectare subsidies in 1996 with the adoption of the EU-Regulation 2078/92. In Greece, there is now 3.8% of total arable land under organic production or 317,824 ha with about 24,057 registered manufacturers.

According to the FAO, tomato is the second most widely cultivated vegetable in the world after potato, with worldwide annual production of nearly 1.25 x 10⁸ tons of fresh tomato from 4.6 x 10⁶ ha. China, the USA and Turkey are the leading producers (FAO, 2006). This study is focused on tomatoes because the fresh tomato consumption per capita (8.1 kg in 2000) and tomato products consumption per capita (31.1 kg in 2000) in the United States is very high, second only to the potato (Lucier et al., 2000). Tomatoes are important not only because of the large amount consumed, but also because of their high health and nutritional contributions to humans. A survey conducted by the University of California at Davis ranked tomatoes as the single most important fruit or vegetable of western diets in terms of overall source of vitamins and...
minerals. Most important, tomato consumption has been shown to reduce the risks of cardiovascular disease and certain types of cancer, such as cancers of prostate, lung, and stomach (Canene-Adams et al., 2005). The benefits of tomatoes and tomato products have been attributed mostly to the significant amount of lycopene contained, which constitutes 80 to 90% of the total carotenoid content present in tomatoes and tomato products. Tomatoes provide an important and significant source of vitamin C (19 mg/100 g of fresh weight), lycopene (3.0 mg/100 g of fresh weight), and flavonoids (USDA, 2006). Greece is at the 15th place in the world and at the 3rd place in Europe with a total annual tomato production of 1,338,600 MT. Tomato is very important crop in the total Greek export and it is located on the fourth place, just behind the olive, cotton and grapes (FAOSTAT, estimated, 2008). Organic tomatoes production in its simplest form means going back to the production methods that farmers used before the advent of synthetic chemicals. This production method avoids or largely reduces the use of synthetic chemical inputs, such as fertilizers and pesticides, and aims to minimize negative effects on the environment and maintains the biological diversity of the soil (Mäder et al., 2002).

In this study, the effect of conventional and organic production systems on yield, physicochemical properties of three greenhouse tomato cultivars was determined. The tomatoes were cultivated in certified organic fields and in a conventional field in Sapes (Rodopi region, North-East Greece).

Material and methods

Three tomato varieties (Robin-F1, Amati-F1, and Elpida-F1) were grown in the greenhouse (plastic tunnel 3.5 m high, covered by termolux 180 μm) during 2008-2010 located in the Sapes, Nort-Eastern Greece, using organic and conventional growing system. Substrate for the production consisted of 30% soil, 50% manure and 20% peat and a small part of the marble.

Tomato seeds were sown on first decade of February in seed trays containing a peat and perlite mixture. At the third true leaf stage, the seedlings were transplanted to the soil with plant density 2.64 plant/m². Soil solarization against the nematodes was applied before transplanting. It was an early-medium production. Planting was done on April 18 and harvest period lasted from mid-June to late August. Production systems were differ about the fertilizer used (organic: goat manure; conventional: mineral fertilizer NPK 12-12-17, Nitrophos blue special+2MgO+8S+Trace elements - amount of 400 kg/ha), the number of phytosanitary treatments (larger in organic system), and the pesticide types applied (preventive in the organic system and preventive or healing with variable period of effectiveness in the conventional one). All plants were irrigated using drip irrigation. As the plants grew, all lateral shoots were manually removed and poles were used to support single stem plants. Plants were topped after sixth truss. Bumblebees were used for pollination during the organic tomato production in the greenhouse.

Yield

Yield was evaluated through the fruits harvesting from eight central rows in the plots, with 10 pits harvested per variety. Fruits were classified as unmarketable or marketable, whether the fruits defects were presented or not.

Statistical analyses

All statistical analyses were performed using SAS procedure (SAS Institute, Cary, NC) for analyses of variance. Means were compared by Tukey's multiple range test.

Results and discussion

Effective greenhouse production means dealing with environmental conditions. Location properties relate to components such as: climate (irradiation, temperature, the length of the day, water balance, etc.), edaphic (structure, chemical and biological soil properties, water and air content at different water tensions), and management (cultivation measures) factors.

Greenhouse vegetable production offers advantages compared to production at the open field with regard to quality assurance principally, because the plants are not exposed directly to the rapid changes of climate conditions. An important role for this purpose is also the cultivar selection by using tomato hybrid varieties.
The yield of tomato cultivars grown in organic and conventional system

with a high yield potential and a good fruit quality. Combinations of manure, peat and small part of the marble were used for fertilization in organic production, and mineral fertilization was included in conventional production as the control. Organic fertilization results in improved yield and fruit quality compared to conventional fertilization. In addition, organic fertilization should be supported in order to facilitate reuse and disposal of organic wastes and to maintain and/or increase soil fertility.

There was significant difference in the fruits number per plant between cultivars in production system tested. The number of fruits per plant (from 13.9 to 20.7) in organic system was significantly higher than in conventional (between 10.3 and 14.9).

![Figure 1 Average fruit number per plant in different tomato cultivation systems](image1)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Production System</th>
<th>Average number of fruits/ plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robin</td>
<td>Org</td>
<td>a</td>
</tr>
<tr>
<td>Amati</td>
<td>Con</td>
<td>a</td>
</tr>
<tr>
<td>Elpida</td>
<td></td>
<td>a</td>
</tr>
</tbody>
</table>

![Figure 2 Average fruit mass (g) in different different tomato cultivation systems](image2)

There were no significant differences between production systems in varieties 'Robin' and 'Amati' (figure 1) while 'Elpida' produced significantly more fruits per plant as compared to the other cultivars in conventional system. 'Elpida' is a prolific cultivar as a whole, and produced significantly more per plant under organic conditions too. However, this comparison is between production systems.

Average fruit mass depends of cultivars and production system. Overall, fruit mass was higher in all cultivars in conventional production. The fruit weight ranged from 166.9 to 179.3g (Robin F₁ in conventional production). There were no significant differences in the fruit weight between individual cultivars and production systems (figure 2). Thicker pericarp tissue and high skin wax in 'Elpida' fruit could serve as a good water reservoir and would most probably contribute to fruit firmness (data not shown).

There are many aspects to be considered when analyzing differences in production between the organic and conventional production system. The overall purpose of comparing organic and conventional production system was to determine whether yield or fruit quality would be compromised by converting from a conventional to an organic production system. Significant plant diseases or pest was not determined during the entire course of organic-biological tomato production. Duration of organic-biological production from planting till harvest was shorter than in the conventional production.

![Table 1 Yield of three tomato cultivars in organic and conventional production system](table1)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Production System</th>
<th>Robin F₁</th>
<th>Amati F₁</th>
<th>Elpida F₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>70.61</td>
<td>51.35</td>
<td>79.96</td>
<td>62.77</td>
</tr>
<tr>
<td>2009</td>
<td>75.82</td>
<td>55.0</td>
<td>64.56</td>
<td>59.4</td>
</tr>
<tr>
<td>2010</td>
<td>31.21</td>
<td>31.12</td>
<td>51.18</td>
<td>34.4</td>
</tr>
<tr>
<td>Average</td>
<td>59.21</td>
<td>45.82</td>
<td>65.23</td>
<td>52.19</td>
</tr>
</tbody>
</table>

Average commercial production of the three cultivar tested in organic system (71.4 t/ha) was significantly higher than average of the three cultivars in conventional system (54.95 t/ha). The best result was achieved by variety Elpida F₁ in organic production with an average yield of 89.87 t/ha (table 1). Differences in the yield between production years were evidence. In the third year of the study total yield was the lowest. We surmise that these differences resulted from climatic conditions because the temperature in early summer
was approximately 2 °C lower compared to the first and second year. It is generally supposed that lower temperature may result in lower intake of organic fertilizers. Organic fertilization resulted in improved yield and fruit quality compared to conventional fertilization (Polat et al. 2010). Martinia et al. (2004) reported that there was no difference in tomato (Lycopersicon esculentum Mill.) growth or yield between an established organic system and the comparable conventional system. When production system data were combined, marketable yield was not affected by cultivar. When averaged across cultivars, organic yield was only about 63% of the conventional one. Stoleru et al. (2007) showed that fertilizing with mature manure resulted with increased tomato yield from 59.1 t/ha (when ‘Arletta’ was fertilized with 30 t/ha) to 65.4 t/ha (when ‘Belle’ was fertilized with 40 t/ha). The differences between regions were associated with soil type and climate and, demonstrated the need for more studies to be carried out under different conditions (Polat et al. 2010).

Conclusions

High tunnels are a valuable tool for organic farmers, improving crop yields and quality while reducing many disease and pest problems relative to the open field. Further studies will help to determine cultivation system and selection of varieties in tomato production in high tunnels.

Organic system let to obtained optimal production level but with higher costs of cultivation (certification procedures, manual weeding, higher cost per unit of fertilizer, phytosanitary treatments applied etc.) compared with conventional farming. At the same time, organic tomatoes achieved a better price and guaranteed placement, so that the entire production is placed at 1.8 euro per kg. The agricultural production system and cultivation practices are critical factors in determining yield and food nutritional quality.

Three tomato hybrid varieties were cultivated in conventional and organic production in the greenhouse to evaluate the yield and fruit quality. Maximum yields were obtained ‘Elpida’ cultivar in organic production.

References


