Yield and quality of fruits of strawberry cultivars in an organic production system

Produtividade e qualidade de frutos de cultivares de morangueiro em sistema de produção orgânico

Yield and quality of fruits of strawberry cultivars in an organic production system: competition of cultivars; fragaria x ananassa; ratio; soluble solids.

Abstract

Most works on strawberry refer to conventional production systems and in traditional regions, so there is little scientific knowledge for its cultivation in other conditions, such as in the organic production of northwestern RS, Brazil. The objective of this work was to evaluate the productive aspects and physicochemical characteristics of strawberry cultivars grown in an organic production system in the northwest of RS. The experiment was carried out at the Cerro Largo Campus of the Federal University of the Southern Frontier between June 2013 and January 2014. The experimental design was a randomized block design with six blocks composed of three experimental units. Each unit consisted of 20 plants arranged in four interspersed lines, with plants spaced 0.30 m apart. Three strawberry cultivars were compared: Albion, Aromas and San Andreas. Yield variables were determined by mass, number, volume of pseudofruits and production percentage of non-marketable pseudofruits. Quality was determined from soluble solids content (SS), titratable acidity (TA), SS/TA ratio and pH. The cultivars Aromas and Albion were the most adapted to the organic production system under the conditions determined in this work.

Additional keywords: competition of cultivars; fragaria x ananassa; ratio; soluble solids.

Resumo

Grande parte dos trabalhos realizados com o morangueiro se referem a sistemas de produção convencionais e em regiões tradicionais, de modo que há pouco acúmulo científico para seu cultivo em outras condições, como na produção orgânica do noroeste do RS. Objetivou-se com este trabalho avaliar aspectos produtivos e as características físico-químicas de cultivares de morangueiro conduzidos em sistema orgânico de produção no noroeste do RS. O experimento foi realizado no Campus Cerro Largo da Universidade Federal da Fronteira Sul entre os meses de junho de 2013 a janeiro de 2014. O delineamento experimental utilizado foi de blocos ao acaso, com seis blocos compostos por três unidades experimentais cada uma. Cada unidade foi constituída por 20 plantas dispostas em quatro linhas intercaladas, com plantas distanciadas entre si em 0,30 m. Foram comparadas três cultivares de morangueiro: Albion, Aromas e San Andreas. As variáveis produtivas foram determinadas pela produção em massa, número, volume de pseudofrutos e porcentagem da produção de pseudofrutos não comercializáveis. A qualidade foi determinada a partir do teor de sólidos solúveis (SS), acidez titulável (AT), relação SS/AT e pH. As cultivares Aromas e Albion mostraram-se as mais adaptadas ao sistema de produção orgânico nas condições determinadas neste trabalho.

Palavras-chave adicionais: Competição de cultivares; fragaria x ananassa; ratio; sólidos solúveis.

Introduction

The cultivation of strawberry (Fragaria x ananassa) in Rio Grande do Sul is carried out mainly by family farmers that are concentrated in three specific regions of the state: Vale do Cai, Serra Gaúcha and Pelotas region (Camargo et al., 2010; Specht & Blume, 2011), characterized by tropical climate and high altitude (Conti et al., 2002). With this, much of the research focused on this crop is directed to the context
of these productive centers, that is, to specific edaphoclimatic conditions. The production of strawberries, in general, has great social and economic importance, allowing increased income to farmers and acting as an important tool for economic emancipation. Moreover, the crop is favored by the possibility of an increase in the added value, since the use of certificates, such as the organic, for example, tends to value the product (Henz, 2010). For Calvete et al. (2008), the crop has been highlighted in recent years and, together with the small fruit group, attracts a range of consumers who, among other characteristics, appreciate the nutraceutical value of the strawberry. In addition, the acceptance in the consumer market is also attributed to the taste and the various possible forms of processing (Fachinello et al., 2011).

Although the strawberry production chain has been increasing since the last decade, it is necessary to make some considerations on the management of the crop, especially regarding the control of pests, diseases and weeds. In conventional crops, the strawberry receives an abusive load of chemical inputs (Castro et al., 2003; Martins et al., 2011), however, the consumer is increasingly demanding and concerned with the purchase of healthier foods (Schuch et al., 2010). Given the situation, the search for healthier and with an altitude of 210 m. The soil of the site was classified as Red Latosol, according to the Brazilian Soil Classification System (SiBCS), and the climate is Cfa, according to Köppen classification. To correct soil fertility and acidity, laboratorial analysis was performed, according to Table 1, from which the fertilizer and limestone requirements were calculated. The soil was incorporated with 90 t ha\(^{-1}\) solid bovine manure and 1.96 t ha\(^{-1}\) shell limestone, the latter according to the SMP index. These applications were carried out two months in advance in relation to the transplant of the seedlings. Furthermore, after planting, the biofertilizer Supermagro (4%) was applied weekly, according to Mangnabosco (2010). The experiment was carried out on June 27, 2013, at an experimental area of the Federal University of the Southern Frontier, Cerro Largo Campus - RS, at approximately 28° 08’ S latitude, 54° 44’ W longitude and with an altitude of 210 m. The soil of the site was classified as Red Latosol, according to the Brazilian Soil Classification System (SiBCS), and the climate is Cfa, according to Köppen classification. To correct soil fertility and acidity, laboratorial analysis was performed, according to Table 1, from which the fertilizer and limestone requirements were calculated. The soil was incorporated with 90 t ha\(^{-1}\) solid bovine manure and 1.96 t ha\(^{-1}\) shell limestone, the latter according to the SMP index. These applications were carried out two months in advance in relation to the transplant of the seedlings. Furthermore, after planting, the biofertilizer Supermagro (4%) was applied weekly, according to Mangnabosco (2010).

### Material and methods

<table>
<thead>
<tr>
<th>pH(H(_2)O)</th>
<th>Al(^{3+})</th>
<th>Ca(^{2+})</th>
<th>Mg(^{2+})</th>
<th>H(^+)Al(^{3+})</th>
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<tr>
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<table>
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<tr>
<th>Al saturation</th>
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<th>Clay</th>
<th>CEC</th>
<th>CEC pH7</th>
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<tr>
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<table>
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<th>Zh</th>
<th>Cu</th>
<th>S</th>
<th>B</th>
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<td>3</td>
<td>200</td>
<td>48.01</td>
<td>14.6</td>
<td>84</td>
<td>0.1</td>
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</tbody>
</table>

O.M. – Organic matter; CEC – Cation exchange capacity

Beds covered with low tunnels were used, arranged in the east-west direction, with dimensions of 1 m x 12 m and equipped with a drip irrigation system, with two drip tapes in each bed. For soil cover, a black polyethylene cover was used. The management adopted during the growing cycle consisted in the
removal of diseased leaves together with applications of Bordeaux mixture (1%), neem oil (Azadirachta indica) (1%) and Curamor (product based on Bordeaux mixture plus vegetable extracts) (3%), when risk situations were observed.

The experimental design was a randomized block design with six blocks, each block being composed of three experimental units. Each unit consisted of 20 plants arranged in four interspersed lines, with plants spaced 0.30 m apart. Three neutral photoperiod strawberry cultivars were tested: Albion, Aromas and San Andreas. The seedlings were provided by EMBRAPA Temperate Climate.

The yield characteristics evaluated were pseudofruit production, number of pseudofruits, volume of pseudofruits and production percentage of non-marketable pseudofruits, being considered as non-marketable those whose mass was less than six grams (6 g) or with damage caused by insects or diseases, as performed by Schuch & Barros (2010). These characteristics were evaluated monthly throughout the growing cycle and in the general accumulated production.

All yield variables were determined immediately after each harvest, which began on August 30, 2013 and ended on January 7, 2014. The mass of pseudofruits was determined with the aid of an analytical balance. The volume of pseudofruits was determined using a container graduated in milliliters, filled with water. Through knowledge of the volume of liquid displaced by the fruits when fully immersed, the volume of these fruits was observed, in cm³.

Throughout the production cycle, samples of pseudofruits were collected from each treatment of the six blocks, totaling 18 samples of 70 g each, which were stored in an ultra-freezer at -180 °C until the end of the experiment, when physicochemical analyses were carried out. Soluble solids content (SS), titratable acidity (TA), SS/TA ratio and pH were evaluated. All evaluations were performed on the pseudofruits.

The determination of soluble solids content was performed using a digital benchtop refractometer (Instrutherm RTD-95), with temperature corrected at 20 °C. The pure juice of the pseudofruits was put on the prism of the equipment and the reading expressed in °Brix. Titratable acidity was determined by titrating 10 mL of juice and 100 mL of distilled water until the pH was 8.1 using 0.1 N NaOH solution, with the result being expressed by the percentage of citric acid. For pH, the reading was performed with a digital benchtop pH meter (MS TECNOPOM mPA-210). These variables (SS, TA and pH) were determined as proposed by the Association of Official Analytical Chemists (1997).

The data variance normality obtained for each variable was verified and later submitted to analysis of variance through the statistical software ASSISTAT (Silva & Azevedo, 2002). The significant variables by F test (p ≤ 0.05) had their means compared by Tukey test at 5% error probability. A quadratic transformation was applied to the data referring to the count of pseudofruits.

**Results and discussion**

For yield of marketable pseudofruits (Figure 1) and number of pseudofruits per plant (Figure 2), there was no significant difference between cultivars for the first harvest, which occurred in August. In the second harvest, in September, the cultivars Albion and Aromas obtained the highest yield values, differing statistically from the cultivar San Andreas (Figure 1). The same occurred for the number of pseudofruits, where the two cultivars (Albion and Aromas) produced a greater number of fruits.

*Means followed by the same letter do not differ by Tukey test at 5%.

**Figure 1** - Monthly and total values of pseudofruits productivity.
In the third harvest, in October, Albion had the highest production (Figure 1) and number (Figure 2) of pseudofruits, when compared to the others. In the fourth harvest, corresponding to the month of November, the cultivar Aromas obtained higher yield, differing from the cultivar Albion, but being statistically equivalent to the cultivar San Andreas. Regarding the number of pseudofruits, the cultivar Aromas stood out over the other cultivars (Figure 2). For the harvests carried out in December and January, there was no statistical difference for both yield and number of pseudofruits per plant among the cultivars.

For the total mass yield produced by the plant, the cultivars Aromas and Albion, respectively, had the best performances, not differing from each other and being superior to the cultivar San Andreas. In an experiment carried out in Pelotas, RS, under a conventional production system, Carvalho et al. (2013) found that the cultivar Albion presented higher yield in relation to the other cultivars, Aromas and San Andreas, unlike what was found in this work. Such difference may indicate differentiated adaptation of the cultivars for both systems and crop regions.

For the total number of pseudofruits accumulated per plant, the cultivar Aromas was statistically superior to the others. Analyzing the accumulated data of mass and number of pseudofruits, it is noted that although the cultivars Aromas and Albion differ statistically in relation to the number of pseudofruits per plant, both cultivars are statistically matched in relation to the total fruit mass yield. It was thus observed that the pseudofruits produced by the cultivar Albion tend to be larger in mass, when compared to the cultivar Aromas.

Martins (2010), conducting an experiment in Pelotas, RS, in an organic production system, also verified that Aromas was the cultivar with the highest number of fruits produced, standing out over the other cultivars and differing statistically from four of the six tested in the experiment. In the same study, the cultivar Albion did not differ statistically from the cultivars with less pseudofruits produced.

In the first harvest, the volume of the pseudofruits did not differ among the cultivars tested (Figure 3). In the second harvest, the cultivar Albion presented pseudofruits with the highest volumes, differing statistically from the cultivar Aromas, but not from the cultivar San Andreas. The cultivars Albion and San Andreas obtained the highest fruit volumes for the third evaluation, not differing statistically from each other, but differing from the cultivar Aromas. The cultivar San Andreas produced the largest pseudofruits in the fourth harvest. For the last two harvests (December and January), there was no statistical difference between cultivars (Figure 3).

In the aggregate data analysis, there is a general tendency among the three cultivars to decrease the volume of pseudofruits as the end of the cultivation cycle approaches, which was also analyzed by Oliveira & Scivittaro (2011) in neutral day cultivars.

Regarding the mean volume of the pseudofruits throughout the growing cycle (Figure 3), the cultivar Albion presented higher values, differing from Aromas, but corresponding to San Andreas. Martins (2010) and Carvalho (2013) verified that the fruits produced by Albion differ from those produced by Aromas, since they present higher average mass, indicating a higher fruit volume for the first cultivar, confirming the data found in this study.

* Means followed by the same letter do not differ by Tukey test at 5%.
The percentage distribution of non-marketable pseudofruits (%NTP) was significant for the second, fourth and fifth evaluation and for the total accumulated production of the cycle (Figure 4). In the second evaluation, the cultivar Albion obtained the lowest percentage of non-marketable pseudofruits, differing from the cultivar Aromas, but being statistically equal to the cultivar San Andreas. For the fourth evaluation, San Andreas was the cultivar that produced the lowest percentage of non-marketable pseudofruits, not differing from Albion. In the fifth evaluation, there was a general tendency among the cultivars to increase the percentage of non-marketable pseudofruits, however, Albion differed from San Andreas by the lower production of non-marketable fruits. In the percentage of NTP for the total cycle, Albion stands out over the two cultivars tested with the lowest production percentage of fruits with mass less than 6 g or damaged by pests and/or diseases.

* Means followed by the same letter do not differ by Tukey test at 5%.

Figure 3 - Volume of pseudofruits.

Figure 4 - Percentage of unmarketable pseudofruits.
Martins (2010), in a study carried out in Pelotas, testing Albion and Aromas and other five cultivars, showed no statistical difference between Albion and the cultivar with the lowest percentage of non-marketable fruits. It should be noted that the percentages found here for this variable (5.31% and 9.39% for Albion and Aromas, respectively) are considerably lower than those found in the work conducted in Pelotas. The reduction of fruit mass and, consequently, increase of the percentage of non-marketable pseudofruits can be observed after November (Figure 4), due to the effect of the reduced number of achenes present in the quaternary flowers that give rise to the pseudofruits at the end of the cycle (Santos et al., 2003), and the exhaustion of the plants at the end of the production cycle.

For the soluble solids content (SS), the cultivar Albion was superior to Aromas, not differing from San Andreas (Table 2). Carvalho (2013) found similar data evaluating the quality of strawberries in the region of Pelotas-RS. Antunes (2013), in turn, observed superiority of the cultivar Albion over San Andreas, differing from that found in this work.

Table 2 - Soluble solids (SS), titratable acidity (TA), SS/TA ratio and pH of cultivars Albion, Aromas and San Andreas, conducted in organic system produaço.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>SS</th>
<th>TA</th>
<th>SS/TA</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albion</td>
<td>5.73 a*</td>
<td>1.21 a</td>
<td>4.78 a</td>
<td>3.93 a</td>
</tr>
<tr>
<td>Aromas</td>
<td>4.50 b</td>
<td>1.38 a</td>
<td>3.29 b</td>
<td>3.83 a</td>
</tr>
<tr>
<td>San Andreas</td>
<td>5.00 ab</td>
<td>1.20 a</td>
<td>4.22 ab</td>
<td>3.03 b</td>
</tr>
<tr>
<td>CV (%)</td>
<td>7.70</td>
<td>10.16</td>
<td>10.35</td>
<td>4.27</td>
</tr>
</tbody>
</table>

* Treatments with average not followed by the same letter in the column differ by Tukey test at 5% probability of error.

Regarding titratable acidity (TA), the data submitted to analysis of variance were not significant. Notwithstanding, regarding the SS/TA ratio (Table 2), Albion was highlighted in relation to Aromas, not differing from San Andreas, corroborating the results found by Antunes (2013). The results obtained for this ratio follow the same distribution of the values found for SS. This is due to the fact that TA has similar values between the cultivars, however, for SS, it is noted a considerable difference, reflecting the superiority of Albion over Aromas. The cultivars Albion and Aromas presented higher pH than San Andreas (Table 2), being superior to the values found by Martins (2010) for the first two cultivars.

Conclusions

The cultivar Aromas, together with the cultivar Albion, showed to be the most adapted to the organic production system. The cultivar Aromas was the one that produced the highest number and the lowest volume of pseudofruits, being indicated for processing. The cultivar Albion, in turn, produced less number of pseudofruits and higher volume, and could be indicated for in natura consumption. In addition, the cultivar Albion obtained greater accumulation of soluble solids and higher SS/TA ratio, being the most indicated for in natura consumption when cultivated in an organic system.

References


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Martins DS (2010) Produção e qualidade de frutas de diferentes cultivares de morangueiro em sistema de produção de base ecológica. UFPEL (Dissertação de Mestrado em Ciências).


