Yield and Quality of Spring-Planted, Day-Neutral Strawberries in a High Tunnel

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Local Fruit Production in Kansas

KC Food Hub Feasibility study found that of the 10 crops cited by interested growers:

- Berries, melons, and apples were the only fruit crops of future interest
Strawberry Production

Formerly, a perennial plant
Commercially grown as annual plants
• Anthesis to harvest (~30-40 days)
• Develop between 3-6 crowns

1. June-bearing cultivars:
2. Modern day-neutrals cultivars:
• Insensitive to photoperiod, initiate buds under various day lengths
• Produce a significant June crop, initiated prior to winter dormancy
• Yield 0.75-1.25 lbs/plant

Figure 1. Yield trends for Logan, Utah, high tunnels 2008 and 2009 data.

(Wohletz Farm Fresh, 2014)

(Rowley et al., 2011)
Strawberries Grown in High Tunnel Production

- Growing season extension & enhanced crop productivity
  - Increased yields, size, soluble solids, branch-crown development, vigor
  - Early and late season prices
- High tunnels in Kansas
- Challenges growing in high tunnels
- Solutions
  - Spring-planted day-neutral cultivars
  - Evaporative Cooling
  - Shade cloth
Research Questions

1. Is it feasible to grow spring-planted day-neutral cultivars in a high tunnel production system in Kansas?

2. Which cultivars perform optimally in a high tunnel production system in Kansas, regarding yield and marketability?

3. What is the quality of the cultivars that perform optimally in a high tunnel at-harvest and throughout storage?

4. What is the effect of the evaporative cooling on the yield and quality?
Materials and Methods

Kansas State University Olathe Horticulture Research and Extension Center (OHREC) during 2014 and 2015

• Three-season high tunnel (200’ x 24’)

= With Evaporative Cooling

= No Evaporative Cooling

1. Albion
2. Evie 2
3. Monterey
4. Portola
5. San Andreas
6. Seascape
Materials and Methods

90-100% red mature fruit harvested 1-2x/week

• Separated based on marketability, counted and weighed fruit
  1. Total Yield*
     • Weight (lbs/plant)
     • Size (oz./plant)
     • Number (fruit/plant)
  2. Marketable Yield
     • Weight (lbs/plant)
     • Size (oz./plant)
     • Number (fruit/plant)
  3. Marketability
     • Weight (%)
     • Size (%)
Materials and Methods

Early Season: 5/1/2014 – 6/31/2014
Mid Season: 7/1/2014 – 8/14/2014
Late Season: 8/15/2014 – 10/6/2014
Materials and Methods

Early Season: 5/31/2015 – 6/31/2015
Mid Season: 7/1/2015 – 8/14/2015
Late Season: 8/15/2015 – 10/6/2015
Materials and Methods

Fruit harvest 1-2x/week and brought into the lab for at-harvest and postharvest quality analysis 4x in both 2014 and 2015
- Sorted and stored at 3°C and 90-95% relative humidity
- Three replications with four fruit/rep.

• Nutritional Quality
  - Total Phenolic content, and antioxidant capacity with FRAP and ORAC

• Physical Quality
  - Texture, Firmness and Color (L* = lightness; a* = redness)

• Sensorial Quality
  - Soluble Solids Content (°Brix) and Titratable Acidity

• Respiration Rate (mg CO₂/kg-h)
• Moisture Loss (%)
• Overall Visual Quality (AUC)*
## Results

### Strawberry Fruit Yield Six Day-Neutral Cultivars at OHREC in 2014 and 2015

<table>
<thead>
<tr>
<th></th>
<th>Total Fruit Yield</th>
<th>Marketability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight (lbs/plant)</td>
<td>Size (oz.)</td>
</tr>
<tr>
<td><strong>2014</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albion</td>
<td>0.85 bc</td>
<td>0.37 ab</td>
</tr>
<tr>
<td>Evie 2</td>
<td>1.16 ab</td>
<td>0.31 cd</td>
</tr>
<tr>
<td>Monterey</td>
<td>0.88 bc</td>
<td>0.34 bc</td>
</tr>
<tr>
<td>Portola</td>
<td>1.33 a</td>
<td>0.39 a</td>
</tr>
<tr>
<td>San Andreas</td>
<td>0.72 c</td>
<td>0.39 a</td>
</tr>
<tr>
<td>Seascape</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F value</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R-square</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Season Mean</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2015</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albion</td>
<td>0.63 b</td>
<td>0.26 bc</td>
</tr>
<tr>
<td>Evie 2</td>
<td>0.82 ab</td>
<td>0.25 bc</td>
</tr>
<tr>
<td>Monterey</td>
<td>0.67 b</td>
<td>0.26 bc</td>
</tr>
<tr>
<td>Portola</td>
<td>1.12 a</td>
<td>0.31 a</td>
</tr>
<tr>
<td>San Andreas</td>
<td>0.62 b</td>
<td>0.28 ab</td>
</tr>
<tr>
<td>Seascape</td>
<td>0.72 b</td>
<td>0.22 c</td>
</tr>
<tr>
<td><strong>F value</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R-square</strong></td>
<td></td>
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<tr>
<td><strong>Season Mean</strong></td>
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</tr>
</tbody>
</table>

‘Portola’ produced a significantly high yield in both 2014 and 2015, in terms of weight, size, and marketability.
Results

**Total fruit yield by weight (lbs/plant)** studied at early-, mid-, and late-season production throughout 2014 and 2015

Mid-season production was highest yielding weeks (by weight)

Every cultivar besides ‘San Andreas’ fell within desired range 0.75-1.25lbs/plant in 2014

‘Portola’ and ‘Evie 2’ obtained desired yield results in 2015
Results

**Total fruit size** (oz./fruit) at early-, mid-, and late-season production throughout 2014 and 2015

Fruit size was largest in the early season

Every cultivar produced desired sizes 0.28 – 0.50 oz/fruit in 2014

‘Portola’ and ‘San Andreas’ fell produced desired sizes 0.28 – 0.50 oz/fruit in 2015
Results

Marketability (%) studied at early-, mid-, and late-season production throughout 2014 and 2015

High marketability (%) both growing seasons

Figure A- Early Season
Figure B- Mid-Season
Figure C- Late Season
The antioxidant capacity of 6 day-neutral strawberry cultivars studied using **ORAC** (μM TE/100g FW), **FRAP** (μM TE/100g FW), and **Total Phenolic method** (GAE/kg FW).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>ORAC (μM TE/100g FW)</th>
<th>FRAP (μM TE/100g FW)</th>
<th>Total Phenolic (GAE/kg FW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albion</td>
<td>3645.43 c</td>
<td>2112.92 a</td>
<td>228.27 ab</td>
</tr>
<tr>
<td>Evie 2</td>
<td>4644.67 a</td>
<td>2057.88 a</td>
<td>242.73 a</td>
</tr>
<tr>
<td>Monterey</td>
<td>3799.74 bc</td>
<td>2191.45 a</td>
<td>236.78 ab</td>
</tr>
<tr>
<td>Portola</td>
<td>2290.47 d</td>
<td>1742.38 ab</td>
<td>146.95 c</td>
</tr>
<tr>
<td>San Andreas</td>
<td>3665.22 bc</td>
<td>1743.22 a</td>
<td>219.80 ab</td>
</tr>
<tr>
<td>Seascape</td>
<td>4339.50 ab</td>
<td>1758.49 a</td>
<td>215.77 b</td>
</tr>
</tbody>
</table>

Means marked with the same letter do not differ at P≤0.05.

Student t-test procedure.

All cultivars within the acceptable antioxidant values by ORAC (1540-6973 μM TE/100g FW), FRAP, and Total Phenolic (171-218 GAE/kg-FW)
Results

Effect of cultivar and weather on **firmness (force [g])** of the fruit of 6 day-neutral strawberry cultivars studied during storage.

Texture of ‘San Andreas’, ‘Monterey’, ‘Portola’, and ‘Albion’ fruit was significantly more firm than ‘Seascape’ and ‘Evie 2’
Results

Physical quality parameter of color index (L*) throughout storage

Texture of ‘San Andreas’, ‘Monterey’, ‘Portola’, and ‘Albion’ fruit was significantly more firm than ‘Seascape’ and ‘Evie 2’
### Results

Parameter means of **soluble solids content** (SSC), **Titratable Acidity** (%TA)* at-harvest

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>SSC(°Brix)</th>
<th>Titratable Acidity (%TA)</th>
<th>SSC/%TA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albion</td>
<td>7.77 a</td>
<td>0.934 ab</td>
<td>8.32</td>
</tr>
<tr>
<td>Evie 2</td>
<td>6.46 bc</td>
<td>0.877 bc</td>
<td>7.36</td>
</tr>
<tr>
<td>Monterey</td>
<td>7.65 a</td>
<td>0.831 cd</td>
<td>9.21</td>
</tr>
<tr>
<td>Portola</td>
<td>6.33 c</td>
<td>0.811 d</td>
<td>7.81</td>
</tr>
<tr>
<td>San Andreas</td>
<td>7.12 ab</td>
<td>0.842 cd</td>
<td>8.46</td>
</tr>
<tr>
<td>Seascape</td>
<td>7.19 a</td>
<td>0.927 a</td>
<td>7.76</td>
</tr>
</tbody>
</table>

'Albion' and 'Monterey' resulted in significantly high SSC and general flavor than other cultivars.

Means marked with the same letter do not differ at P<0.05. Student t-test procedure.
Overall visual quality parameter (AUC) of 6 day-neutral cultivars throughout their storage life.

Overall Visual Quality of ‘San Andreas’, ‘Albion’, ‘Monterey’, and ‘Portola’ was significantly higher than ‘Seascape’ and ‘Evie 2’
Conclusion

1. Growing spring-planted day-neutral cultivars within the high tunnel system is feasible based on desired weight (lbs/plant) and berry size (oz/fruit)

2. ‘Portola’ and ‘Evie 2’ were significant in total weight, size, and number in both 2014 and 2015
   • All studied cultivars produced high marketability (%) both production years with the exception of a low ‘Evie 2’ in 2015

3. Identified 6 day-neutral cultivars that lasted 7-8 days throughout storage
   • Based on the organoleptic and nutritional parameters: Fruit with the highest soluble solids content were the darkest and corresponded to those cultivars with the lowest L* and a*
   • ‘Albion’ and ‘Monterey’ contain high levels of SSC and phytochemical properties
   • Based on the physical quality and overall visual quality: ‘Albion’, ‘Monterey’, ‘Portola’, and ‘San Andreas’ all performed significantly higher

4. Evaporative cooling requires further research to eliminate weather effect
Acknowledgements

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Questions?