Gala quality: Review of 2021 harvest season and recommendations for 2022

July 28, 2022

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School of Integrative Plant Science

Ithaca

New York
Acknowledgements for funding of 2021 harvest experiments

• NY Apple Research Development Program
• Valent BioSciences
• Multi-state Hatch funding

And the many wonderful grower and storage cooperators!!!!
The major storage disorders

Stem end flesh browning                                      Flesh browning                                    Core browning

Minor disorders: greasiness, stem end cracking, shriveling, decay
Three main experiments

1. Effects of ReTain and timing of application
2. Effects of ReTain, oxygen concentration, storage temperature, and delayed CA
3. Regional study of 0.5% oxygen and storage temperature on storage quality

Plus DA reading relationships with disorder incidence
1. Effects of ReTain and timing of application

Brookfield strain (commercial farm in Wayne County)

ReTain treatments:

- Trt 1. Untreated control
- Trt 2. ReTain half pouch at 21 dbh
- Trt 3. ReTain half pouch at 21 dbh + 7 dbh
- Trt 4. ReTain half pouch at 21 dbh + 3 dbh
- Trt 5. ReTain full pouch at 7 dbh
- Trt 6. ReTain full pouch at 3 dbh

Objective was to assess effects of later applications to minimize effects on red color development

- Early season resulted in harvest 3, rather than 4, weeks before anticipated harvest.
- Two harvests rather than three harvests
Experimental details

• Commercially colored fruit only
• 4 sets of replicate trees per treatment
• **No postharvest 1-MCP** because of focus on ReTain results
• Storage temperature – 33°F
• Storage atmosphere – **2% oxygen**/1% carbon dioxide (applied 1 day after harvest following overnight cooling)
• Storage periods – 5 and 9 months plus 7 days at 68°F
At harvest

H1: Sept 14
H2: Sept 21
Trt 2. ReTain half pouch at 21 dbh
At harvest and after 7 days at 68°F

<table>
<thead>
<tr>
<th>IEC (ppm)</th>
<th>Trt 1: Control</th>
<th>Trt 2: ReTain half pouch/A at 21 dbh</th>
<th>Trt 3: ReTain half pouch/A @ 21 dbh + 7 dbh</th>
<th>Trt 4: ReTain half pouch/A @21 dbh + 3 dbh</th>
<th>Trt 5: ReTain full pouch/A @ 7 dbh</th>
<th>Trt. 6 ReTain full pouch/A @ 3 dbh</th>
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</thead>
<tbody>
<tr>
<td>TRT</td>
<td>Sept 14</td>
<td>Sept 21</td>
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<td>D 1</td>
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<tr>
<td>1</td>
<td>3.59 c</td>
<td>57.36 a</td>
<td>4.05 c</td>
<td>45.39 b</td>
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<tr>
<td>2</td>
<td>0.52 c</td>
<td>0.82 c</td>
<td>0.83 c</td>
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<td>0.21 c</td>
<td>0.59 c</td>
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<td>0.36 c</td>
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<table>
<thead>
<tr>
<th>Firmness (lb)</th>
<th>Trt 1: Control</th>
<th>Trt 2: ReTain half pouch/A at 21 dbh</th>
<th>Trt 3: ReTain half pouch/A @ 21 dbh + 7 dbh</th>
<th>Trt 4: ReTain half pouch/A @21 dbh + 3 dbh</th>
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<td>14.1 d</td>
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<tr>
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High numbers = greener fruit.

<table>
<thead>
<tr>
<th>TRT</th>
<th>SPI</th>
<th>DA reading</th>
<th>SSC (%)</th>
<th>TA (%)</th>
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<td>Sept 14</td>
<td>Sept 21</td>
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Trt 1: Control
Trt 2: ReTain half pouch/A at 21 dbh
Trt 3: ReTain half pouch/A @ 21 dbh + 7 dbh
Trt 4: ReTain half pouch/A @21 dbh + 3 dbh
Trt 5: ReTain full pouch/A @ 7 dbh
Trt 6 ReTain full pouch/A @ 3 dbh
Storage quality
SEFB (%)  
5 months + 7 d

Sept 14

Sept 21
SEFB (%)  
9 months + 7 d

Sept 14

Sept 21

Trt 1: Control
Trt 2: Retain half pouch/A at 21 dbh
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Trt 5: Retain full pouch/A at 7 dbh
Trt 6: Retain full pouch/A at 3 dbh
Flesh firmness (lb)  
5 months + 1 d  

Sept 14  

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<tbody>
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<td>a</td>
<td>b</td>
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Sept 21  

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</tbody>
</table>

Remember – no 1-MCP
Flesh firmness (lb)  
5 months + 7 d

Sept 14

Sept 21

<table>
<thead>
<tr>
<th>Trt 1: Control</th>
<th>H1: 16.6 lb a</th>
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<tbody>
<tr>
<td>Trt 2: ReTain half pouch/A at 21 dbh</td>
<td>H2: 15.5 lb b</td>
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Flesh firmness (lb) 9 months + 1 d

Sept 14

10 11 12 13 14 15 16 17 18
1 2 3 4 5 6
b ab a a ab ab

Sept 21

10 11 12 13 14 15 16 17 18
1 2 3 4 5 6
c ab ab a bc ab

H1: 15.5 lb a
H2: 14.5 lb b

Trt 1: Control
Trt 2: ReTain half pouch/A at 21 dbh
Trt 3: ReTain half pouch/A @ 21 dbh + 7 dbh
Trt 4: ReTain half pouch/A @ 21 dbh + 3 dbh
Trt 5: ReTain full pouch/A @ 7 dbh
Trt 6: ReTain full pouch/A @ 3 dbh
Flesh firmness (lb)  
9 months + 7 d

Sept 14

Sept 21

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<tr>
<td></td>
<td>H1: 15.8 lb a</td>
<td>H2: 14.7 lb b</td>
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Trt 6: ReTain full pouch/A @ 3 dbh

H1: 15.8 lb a
H2: 14.7 lb b
**I_{AD} value**

5 months + 7 d

### Sept 14

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H1: 0.22 a  
H2: 0.18 b

### Sept 21

<table>
<thead>
<tr>
<th>c</th>
<th>a</th>
<th>ab</th>
<th>a</th>
<th>a</th>
<th>bc</th>
<th>c</th>
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<tbody>
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</tbody>
</table>
\[ I_{AD} \text{ value} \]
9 months + 7 d

Sept 14

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</table>

H1: 0.24 a
H2: 0.17 b

Sept 21

Cornell CALS College of Agriculture and Life Sciences
5 months - Harvest dates combined

<table>
<thead>
<tr>
<th>SSC (%)</th>
<th>TA (%)</th>
<th>Greasiness (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>ab</td>
<td>a</td>
</tr>
<tr>
<td>ab</td>
<td>ab</td>
<td>ab</td>
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<tr>
<td>b</td>
<td>ab</td>
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<td>a</td>
</tr>
<tr>
<td>ab</td>
<td>b</td>
<td>ab</td>
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</table>

Graphs showing the data comparison for SSC, TA, and Greasiness.
9 months

No treatment effects on SSC, TA

![Bar chart showing greasiness (%) with categories: a, c, c, c, b, ab. Categories 1 and 6 have significant differences.](chart-image-url)
Brief comparison with last year
At harvest

ReTain effects similar regardless of application timing for IEC (lower than control) and flesh firmness (higher than control).

But effects of late Retain on SPI, loss of green color, and inhibition of yellowing less than earlier application.
Summary for expt 1

After storage

SEFB – inhibition of browning greater with earlier than late application at 6 and 9 months.

Flesh firmness similar for all ReTain timings and all greater than the control at 6 months. However, benefit decreases over storage time and shelf life.

Loss of green color affected greatly by treatment timing at harvest 2 compared with harvest 1.
Conclusions

USE OF PGRS IS STRONGLY RECOMMENDED!

A significant weapon against SEFB as well as post-storage benefits on firmness.
2. Effects of ReTain, oxygen concentration, storage temperature, and delayed CA

Brookfield strain (commercial farm in Wayne County)

ReTain treatments:
• Trt 1. Untreated control
• Trt 2. ReTain half pouch at 21 dbh
• Trt 3. ReTain full pouch at 7 dbh

• All fruit treated with 1-MCP after overnight cooling
• 2% oxygen compared with 0.5% oxygen (1% carbon dioxide)
• 33°F compared with 38°F
• Delay 7 d and 21 d after cooling and storage
• 4 replicates
SEFB (%): 33°F - 6 months + 7 days

2 % oxygen

0.5 % oxygen

2%: 73 a
0.5%: 25 b
SEFB (%) : 38°F - 6 months + 7 days

2 % oxygen

0.5 % oxygen

2%: 23 a
0.5%: 0.02 b
SEFB (%): 33°F - 9 months + 7 days

2 % oxygen

0.5 % oxygen

2%: 83 a
0.5%: 30 b
SEFB (%): 38°F - 9 months + 7 days

2% oxygen

0.5% oxygen

2%: 87 a
0.5%: 5 b
Firmness (lb): 33°F - 6 months + 7 days

2 % oxygen

2%: 15.7 lb

0.5 % oxygen

0.5%: 16.7 lb

21d delay  7d delay  7d delay  21d delay  7d delay  21d delay
control Retain 3 wbh Retain 1 wbh

7d delay  21d delay  7d delay  21d delay  7d delay  21d delay
control Retain 3 wbh Retain 1 wbh

10 11 12 13 14 15 16 17 18
Firmness (lb): 38°F - 6 months + 7 days

2% oxygen

0.5% oxygen

2%: 15.3 lb b
0.5%: 16.3 lb a
Firmness (lb): 33°F - 9 months + 7 days

2 % oxygen

0.5 % oxygen

2%: 14.2 lb
0.5%: 15.1 lb
Firmness (lb): 38°F - 9 months + 7 days

2 % oxygen

0.5 % oxygen

2%: 13.0 lb b
0.5%: 15.7 lb a
Comparisons of temperatures
SEFB (%) at 0.5 % oxygen – 6 months

33°F

100
90
80
70
60
50
40
30
20
10
0

ab a b ab ab ab

7 d delay 21 d delay
Control
7 d delay 21 d delay
ReTain 3 wbh
7 d delay 21 d delay
ReTain 1 wbh

38°F

100
90
80
70
60
50
40
30
20
10
0

NS

7 d delay 21 d delay
Control
7 d delay 21 d delay
ReTain 3 wbh
7 d delay 21 d delay
ReTain 1 wbh
SEFB (%) at 0.5 % oxygen – 9 months

33°F

38°F

Control 7 d delay 21 d delay Control 7 d delay 21 d delay
ReTain 3 wbh 7 d delay 21 d delay ReTain 1 wbh 7 d delay 21 d delay

bc a c ab bc bc

bc a c ab bc bc
• Delays between harvest and CA storage are detrimental and do not mimic ‘conditioning.

• Up to 7 day delay and storage at 2% oxygen and 1% carbon dioxide maintained low SEFB if storage temperature was 38°F (not 33°F) for 6 but not 9 months.
Summary for expt 2

- Flesh browning development greatly decreased by 0.5% oxygen and 1% carbon dioxide at 33°F and to a greater extent at 38°F.

- No ‘cost’ in terms of firmness at 38°F compared with 33°F. [including after 7 day shelf life (68°F) – all fruit treated with 1-MCP.]
USE OF PGRS IS STRONGLY RECOMMENDED!

38°F rather than 33°F

0.5% oxygen/1% carbon dioxide when achievable

2% oxygen/1% carbon dioxide has relatively limited storage potential

Each factor is additive – maturity, ReTain, oxygen, 38°F storage temperature
3. Regional study of 0.5% oxygen and storage temperature on storage quality

- HV (8/27), WNY west (9/9), WNY east (9/13), Champlain (9/17)
- 6 blocks in each region x 4 replicates
- All fruit treated with 1-MCP
- 0.5% oxygen initiated 7 d after harvest and cooling
- 33°F and 38°F
- 8 months storage
## Preharvest treatments

<table>
<thead>
<tr>
<th>Orch. Block</th>
<th>HV (8/26)</th>
<th>WNY - west</th>
<th>WNY - east</th>
<th>Champlain</th>
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<td>PGR</td>
<td>Strain</td>
<td>PGR</td>
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<tr>
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<td>Galaxy</td>
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<td>2</td>
<td>Buckeye</td>
<td>½ R, 2 wk</td>
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<tr>
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<td>3.9b</td>
<td>3.5cd</td>
<td>4.9c</td>
<td>4.1bc</td>
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<td>2.8d</td>
<td>6.1ab</td>
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<tr>
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<td>4.3bc</td>
<td>6.6a</td>
<td>5.9a</td>
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<tr>
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<td>4.0b</td>
<td>3.5cd</td>
<td>6.5a</td>
<td>5.9a</td>
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</tbody>
</table>
## Firmness (lb)

<table>
<thead>
<tr>
<th></th>
<th>HV</th>
<th>WNY-W</th>
<th>WNY-E</th>
<th>CH</th>
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<tbody>
<tr>
<td></td>
<td>18.9a</td>
<td>15.4d</td>
<td>15.2d</td>
<td>17.9a</td>
</tr>
<tr>
<td></td>
<td>18.2ab</td>
<td>16.1cd</td>
<td>16.5cd</td>
<td>18.8a</td>
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<tr>
<td></td>
<td>18.1ab</td>
<td>16.9bc</td>
<td>16.0bc</td>
<td>18.0a</td>
</tr>
<tr>
<td></td>
<td>16.7c</td>
<td>18.3a</td>
<td>14.7a</td>
<td>18.7a</td>
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<tr>
<td></td>
<td>18.5ab</td>
<td>17.6ab</td>
<td>14.4ab</td>
<td>15.2b</td>
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<tr>
<td></td>
<td>17.5bc</td>
<td>18.4a</td>
<td>15.4a</td>
<td>16.0b</td>
</tr>
</tbody>
</table>
After storage for 8 months
SEFB (%)
Hudson Valley

33F

38F
SEFB (%)  
WNY west

---

**33F**

- O1: 50%
- O2: 70%
- O3: 20%
- O4: 10%
- O5: 10%
- O6: 10%

**38F**

- O1: 0%
- O2: 30%
- O3: 10%
- O4: 10%
- O5: 10%
- O6: 20%
FB (%)
WNY east

<table>
<thead>
<tr>
<th>Year</th>
<th>FB (%)</th>
<th>Year</th>
<th>FB (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1</td>
<td>33F</td>
<td>O1</td>
<td>38F</td>
</tr>
<tr>
<td>O2</td>
<td>38F</td>
<td>O2</td>
<td></td>
</tr>
<tr>
<td>O3</td>
<td>40F</td>
<td>O3</td>
<td></td>
</tr>
<tr>
<td>O4</td>
<td>40F</td>
<td>O4</td>
<td></td>
</tr>
<tr>
<td>O5</td>
<td>40F</td>
<td>O5</td>
<td></td>
</tr>
<tr>
<td>O6</td>
<td>40F</td>
<td>O6</td>
<td></td>
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</tbody>
</table>
HV: Firmness (lb)

<table>
<thead>
<tr>
<th></th>
<th>1 d</th>
<th>7 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>33F</td>
<td>15.9</td>
<td>15.8b</td>
</tr>
<tr>
<td>38F</td>
<td>16.1</td>
<td>16.4a</td>
</tr>
</tbody>
</table>
WNY-W: Firmness (lb)
WNY-E: Firmness (lb)
Champlain: Firmness (lb)
### Relationship with mineral?

33F because of highest incidences.

Overall significant but weak correlation with K.

Variable in specific regions, with strongest in Champlain:

- Positively with N, B, P, P/Ca, P+Mg/Ca
- Negatively with Mn, Mg, Mg/Ca

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (%)</td>
<td>-0.0754</td>
<td>0.4654</td>
</tr>
<tr>
<td>N (%)</td>
<td>0.0758</td>
<td>0.4631</td>
</tr>
<tr>
<td>P</td>
<td>-0.1749</td>
<td>0.0883</td>
</tr>
<tr>
<td>K</td>
<td>-0.2558</td>
<td>0.0119</td>
</tr>
<tr>
<td>Mg</td>
<td>-0.1883</td>
<td>0.0661</td>
</tr>
<tr>
<td>Ca</td>
<td>0.1597</td>
<td>0.12</td>
</tr>
<tr>
<td>P/Ca</td>
<td>-0.0922</td>
<td>0.3766</td>
</tr>
<tr>
<td>K/Ca</td>
<td>-0.0985</td>
<td>0.3451</td>
</tr>
<tr>
<td>Mg/Ca</td>
<td>-0.0896</td>
<td>0.3903</td>
</tr>
<tr>
<td>(P+K)/Ca</td>
<td>-0.098</td>
<td>0.3476</td>
</tr>
<tr>
<td>(P+Mg)/Ca</td>
<td>-0.0919</td>
<td>0.3784</td>
</tr>
<tr>
<td>(K+Mg)/Ca</td>
<td>-0.0982</td>
<td>0.3466</td>
</tr>
<tr>
<td>(P+K+Mg)/Ca</td>
<td>-0.0977</td>
<td>0.3488</td>
</tr>
</tbody>
</table>
Relationship with fruit maturity?

Regression coefficient higher at 33°F than at 38°F because of more FB.

<table>
<thead>
<tr>
<th></th>
<th>33°F</th>
<th>P value</th>
<th>38°F</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC</td>
<td>0.4</td>
<td>0.005</td>
<td>0.2</td>
<td>0.04</td>
</tr>
<tr>
<td>Firmness</td>
<td>0.8 &lt;.0001</td>
<td></td>
<td>0.4 0.001</td>
<td></td>
</tr>
<tr>
<td>SSC</td>
<td>0.01</td>
<td>0.284</td>
<td>0.006</td>
<td>0.71</td>
</tr>
<tr>
<td>TA</td>
<td>0.003</td>
<td>0.06</td>
<td>0.002</td>
<td>0.84</td>
</tr>
<tr>
<td>SPI</td>
<td>0.8 &lt;.0001</td>
<td></td>
<td>0.3 0.005</td>
<td></td>
</tr>
<tr>
<td>IAD</td>
<td>0.5 0.0002</td>
<td></td>
<td>0.3 0.009</td>
<td></td>
</tr>
<tr>
<td>L*(D65)</td>
<td>0.04</td>
<td>1.03</td>
<td>0.06</td>
<td>0.26</td>
</tr>
<tr>
<td>a*(D65)</td>
<td>0.3 0.007</td>
<td></td>
<td>0.09</td>
<td>0.14</td>
</tr>
<tr>
<td>b*(D65)</td>
<td>0.3 0.003</td>
<td></td>
<td>0.14</td>
<td>0.07</td>
</tr>
<tr>
<td>Fruit weight</td>
<td>0.137</td>
<td>0.1836</td>
<td>0.001</td>
<td>0.849</td>
</tr>
</tbody>
</table>
Correlations for Firmness, SPI and I$_{AD}$ value – 33°F

WNY1 = west; WNY2 = east.
Correlations for fruit storage at 38°F are less clear cut because of lower % disorder.
Harvest incidences to minimize risk (using 33°F)

- SPI less than 4
- $I_{AD}$ values greater than 0.4-0.5
- Firmness greater than 17 lb.
Comparing with 2020 harvest: WNY – 10 months – 33°F

A bit more variation
Summary for expt 3

- PGR effects reinforced but variations.
- No strong mineral relationships
- SPI clearly an indicator.
- $I_{AD}$ values are indicators but within regions.
- 0.5% oxygen at 38F is a strong recommendation for late storing Gala apples.
- Temperature effects on firmness seem small
  - Note softer fruit associated with browning in many cases.
Additional experiment

• Trees stripped and split into available DA index categories.
• Description: untreated fruit or fruit from T2 (ReTain 3 wbh) from H1 were classified at harvest by DA meter based on 0.2 difference.

• Storage: 5 months + 7d in CA 2% O₂/ 1% CO₂ at 33°F
SEFB (%) 5m+ d7
Firmness (lb) 5m+ d7
Major conclusions and recommendations
Strongly recommended

- PGR use – with appropriate timing.
- Harvest indices based on SPI and I_{AD} values.
- 1-MCP treatment.
- Early harvest for long-term storage (even though size is sacrificed).
- 1-2% oxygen and 1% carbon dioxide for standard CA.
- 0.5% oxygen and 1% carbon dioxide if facilities allow.
- 38°F storage temperature.
Questions?

What do we need to build confidence in our findings?
Questions

• Does 1-MCP make SEFB worse?
• How important is the carbon dioxide concentration?
• Have you ever seen injury in Gala fruit that you believe is caused by carbon dioxide?
No and ‘no’ and no

Different % CO₂ at 2% O₂

No injury that we recognize as CO₂ injury
Questions

• Do I need to use DCA equipment?
• What type of DCA equipment do you recommend?
• What about even lower oxygen, e.g., 0.4% say at 38°F?
Questions

• What fruit can I store at 33°F?
• What about lower chilling injury risk in the warmer regions? Does that apply to SEFB?
• Hey – if 38°F is good, what about 36? What about 42?
• What maturity should I harvest Gala?
• Is 1-MCP necessary with low oxygen?

• What varieties respond best to DCA use?
Questions from Chat box?