

Gala storage – practical options for improving quality

Chris Watkins

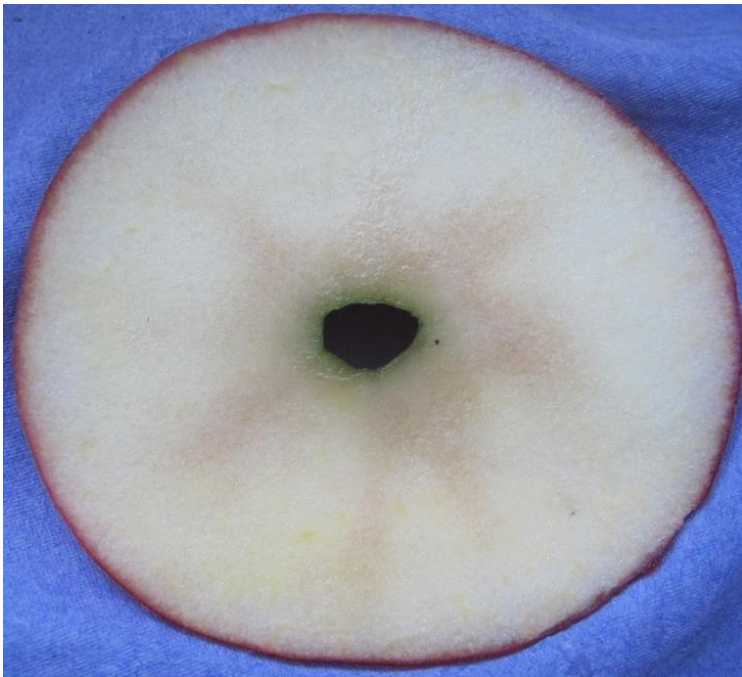
Cornell University

Ithaca, NY



The major storage disorders

Stem end flesh browning



Flesh browning



Core browning



Minor disorders: greasiness, stem end cracking, shriveling, decay

Gala Recommendations

Results are derived for New York. Any changes to management of Gala should be guided by relevant regional university personnel or consultants.

PGR applied at the correct time are critical for long term storage

Store at 38F (will benefit fruit without PGR treatment)

Postharvest 1-MCP recommended if fruit are treated with a PGR.

0.5% oxygen (1% carbon dioxide) recommended for long term storage

2% oxygen (1% carbon dioxide) for standard CA, although lower concentrations are okay. PGR!

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Updated Recommendations for Long-Term Controlled Atmosphere Storage of Gala Apples

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Keywords: Gala, post harvest flesh browning, fruit quality, controlled atmosphere storage, plant growth regulators

Storage of Gala apples has become challenging as fruit plantings have increased, and as a consequence increasingly long storage times are required to market the crop. Physiological disorders that can develop during storage include stem end flesh browning (SEFB), flesh browning (FB) and core browning (Figure 1). As with most physiological disorders, incidences are highly variable across different orchard blocks. Browning of Gala typically starts in the stem end of the fruit (hence the name stem end flesh browning) but develops through the entire fruit. Both SEFB and FB are flesh breakdown disorders.

The standard recommendation for controlled atmosphere (CA) storage of Gala has been 2% oxygen and 2% carbon dioxide at 32-33°F for many years. The carbon dioxide recommendation was recently reduced to 1%. However, high levels of loss to SEFB and FB have led to a multi-year study to identify management practices that will reduce or eliminate fruit losses due to the disorder. We have investigated several factors that affect flesh browning, but the critical ones are strain, fruit maturity, plant growth regulators, storage temperature and oxygen concentration. Our conclusion is that a combination of management practices is essential for control of FB disorders of Gala apples.

Two experiments are presented here to illustrate the involvement of these factors.

a half-rate of ReTain (0.25 g L⁻¹ = 0.033 oz per gallon) 21 days before the first harvest. Spray materials were

prepared by mixing with 0.1% Silwet L-77 (Helena Chemical Company, Collierville, TN). The spray treatment was applied in the early morning using a CO₂ pressurized backpack sprayer (Bellspray, Opelousas, LA) fitted with a Tee Jet 8004VS flat fan nozzle (Spraying Systems, Wheaton, IL).

Fruit were harvested from four trees per replicate on September 7, 14 and 21. After harvest, the fruit were transported to the postharvest laboratory at Cornell University. 1-Methylcyclopropene (1-MCP) was applied at a concentration of 1 ppm for 24 hours after overnight cooling. The fruit were stored in controlled atmospheres of 2% O₂ / 1% CO₂ or DCA 0.5% O₂ / 1% CO₂ at either 33°F or 38°F 8-days after harvest. Fruit quality was assessed at harvest, and after 9 months plus 7 days at 68°F, following standard procedures.

Experiment 2: In 2021, fruit from 24 orchard blocks (6 HV, 12 WNY, 6 CH) were harvested during the optimal harvest periods for CA storage within each growing region. Four replicates of fruit were stored in 0.5% oxygen/1% carbon dioxide at either

This research was supported by the New York Apple Research and Development Program

Preharvest treatment of fruit with plant growth regulators with subsequent storage of 1-MCP-treated fruit at low oxygen and at 38°F is recommended for long term storage of Gala apples.

ReTain, storage atmospheres and storage temperature.

1. Control
2. ReTain half pouch/A at 21 dbh (8/17)

Harvested 9/7, 9/14, 9/21

- *Storage treatments*

Two storage atmospheres: 2% O₂/1% CO₂ 0.5% O₂/1% CO₂

Two temperatures: 33°F 38°F

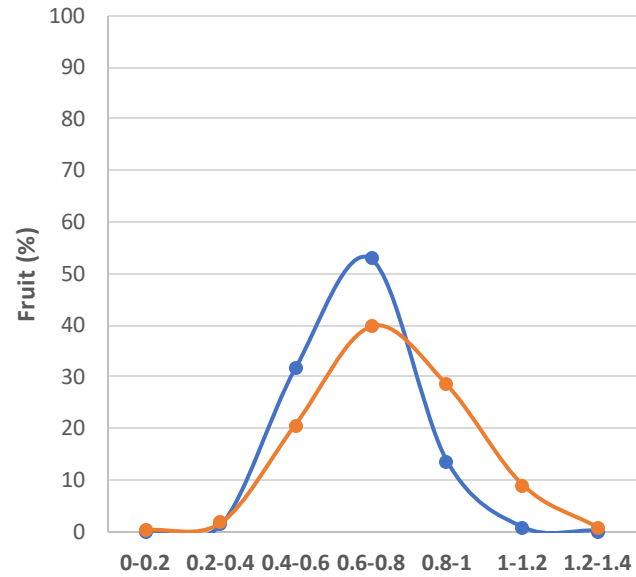
CA initiated 8 days after harvest

- Fruit stored for 9 months

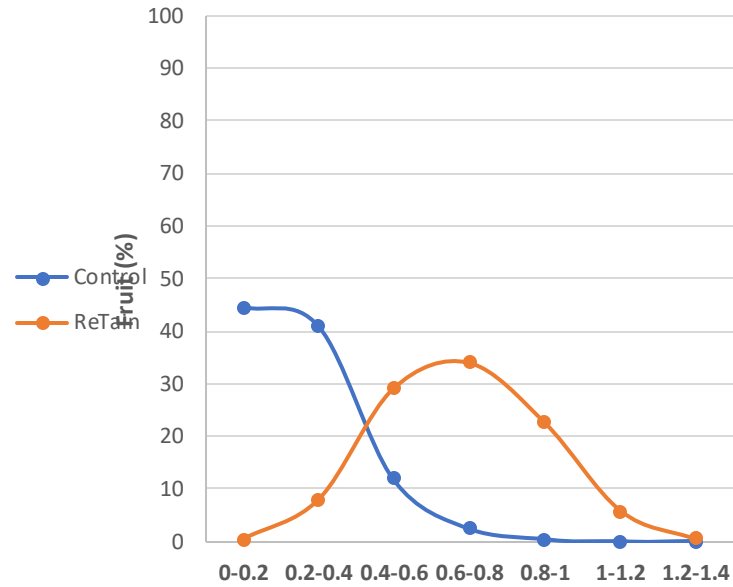
Harvest and ReTain effects on distribution of fruit by I_{AD} value 2201 (21 d ReTain)

9/7, 9/14, 9/21

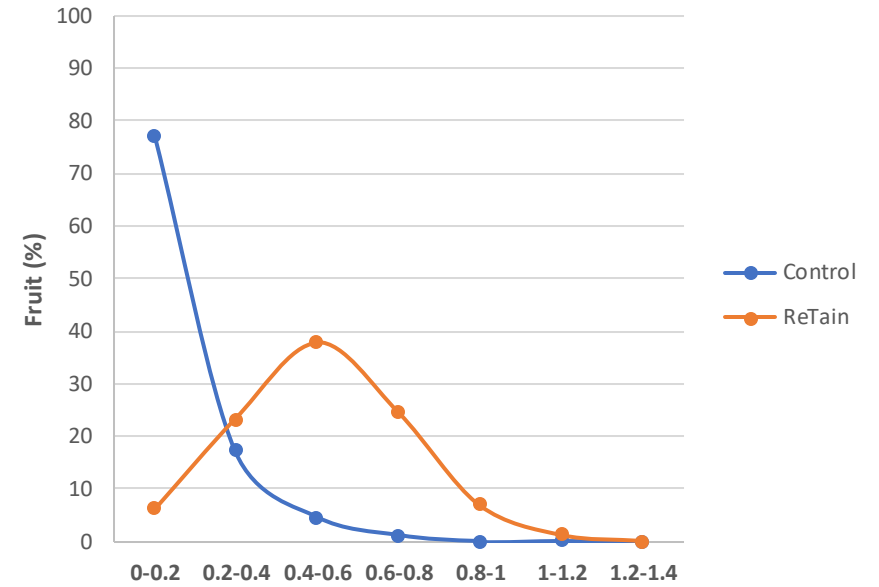
H1



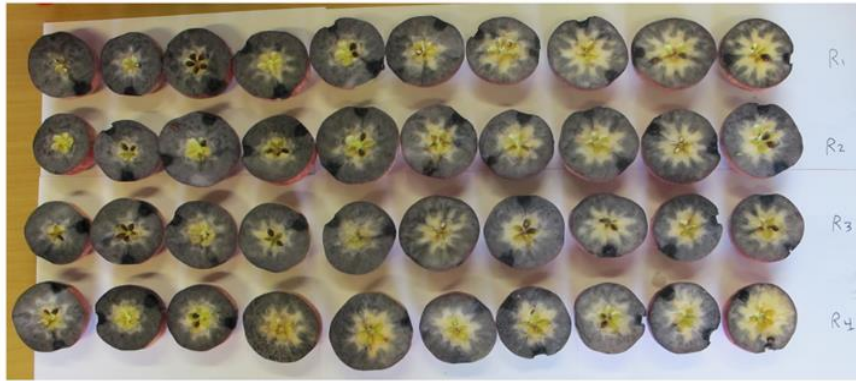
H2



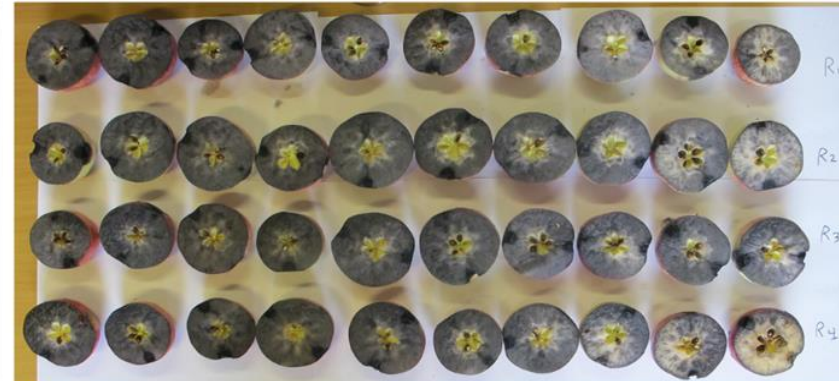
H3



'Gala' control- H1- 9/7/2022



'Gala'- ReTain- H1- 9/7/2022



"Gala" control- H2- 9/14/2022



"Gala" ReTain- H2- 9/14/2022



"Gala" control- H3- 9/21/2022

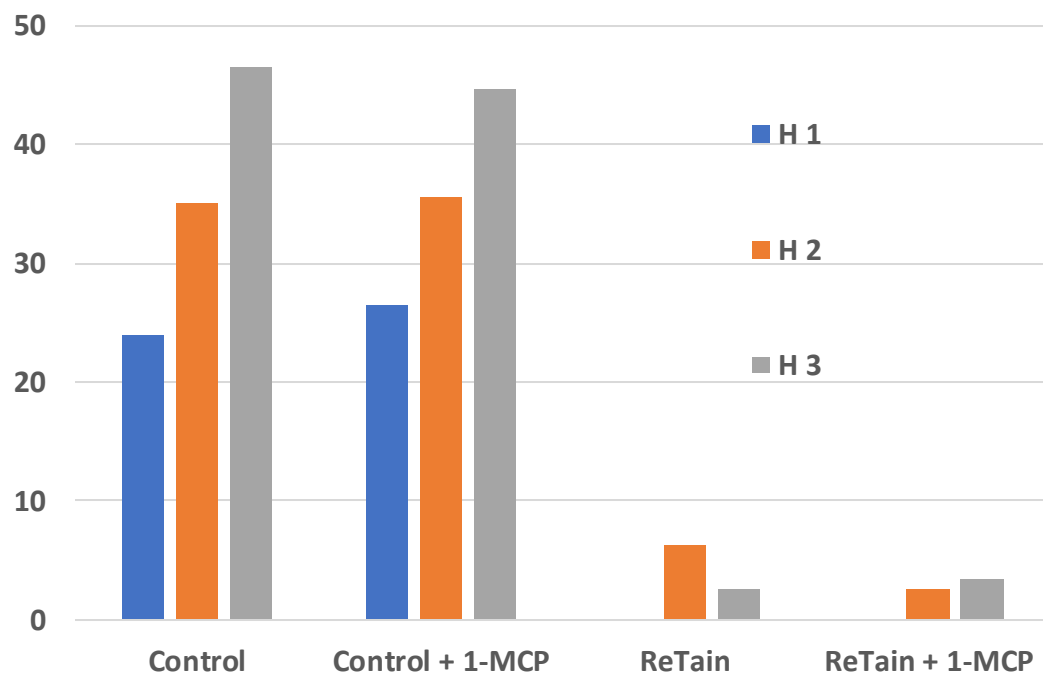


"Gala" ReTain- H3- 9/21/2022

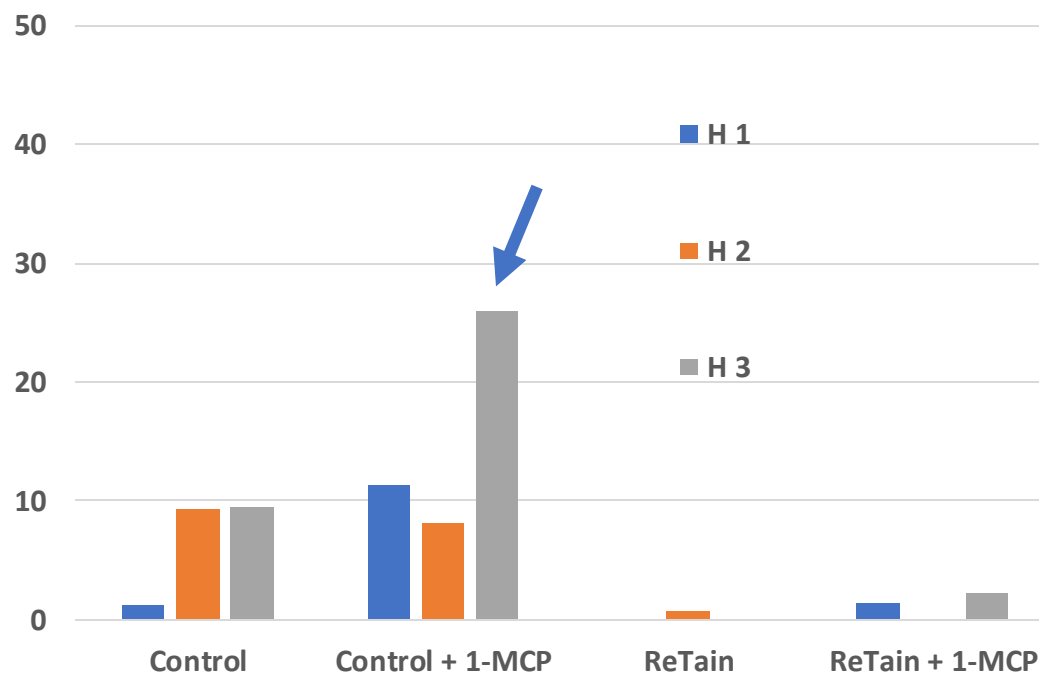


FB (%)

2% oxygen 33F



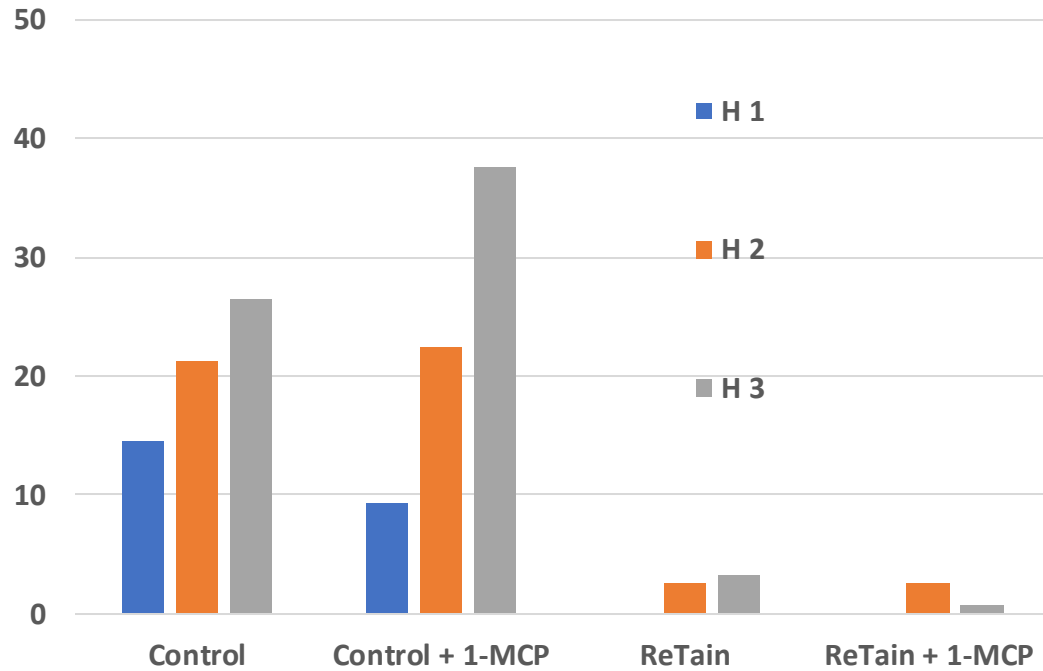
2% oxygen 38F



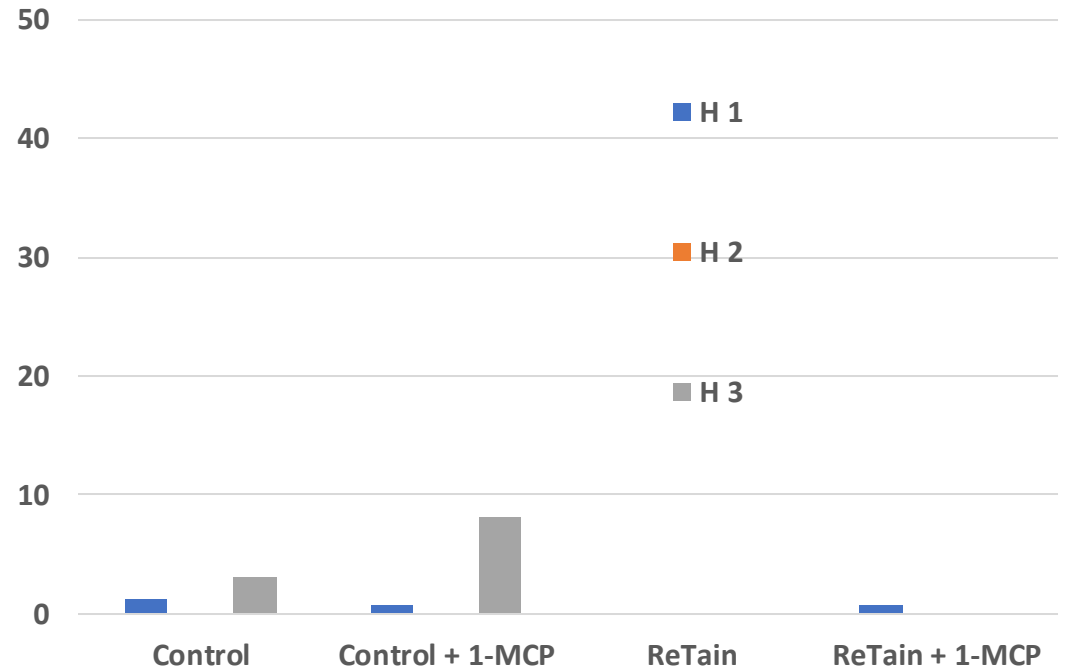
Large benefit of ReTain even at 2% oxygen; Browning lower at 38F than at 33F; Harvest date effect for Control fruit but not for ReTain-treated fruit; 1-MCP effect for Control fruit but not for ReTain-treated fruit

FB (%)

0.5% oxygen 33F



0.5% oxygen 38F



0.5% oxygen lower than 2% oxygen; ReTain effect still evident, especially at 33F; Harvest date effect evident for Control fruit, but less so for ReTain-treated fruit.

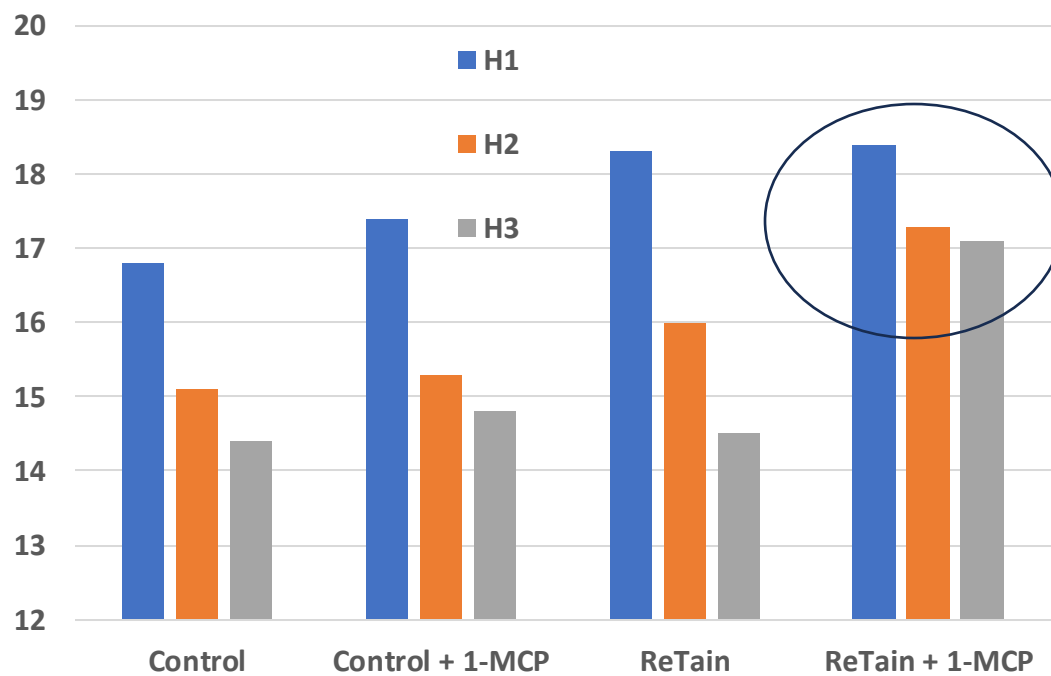
FB summary

Lower incidence:

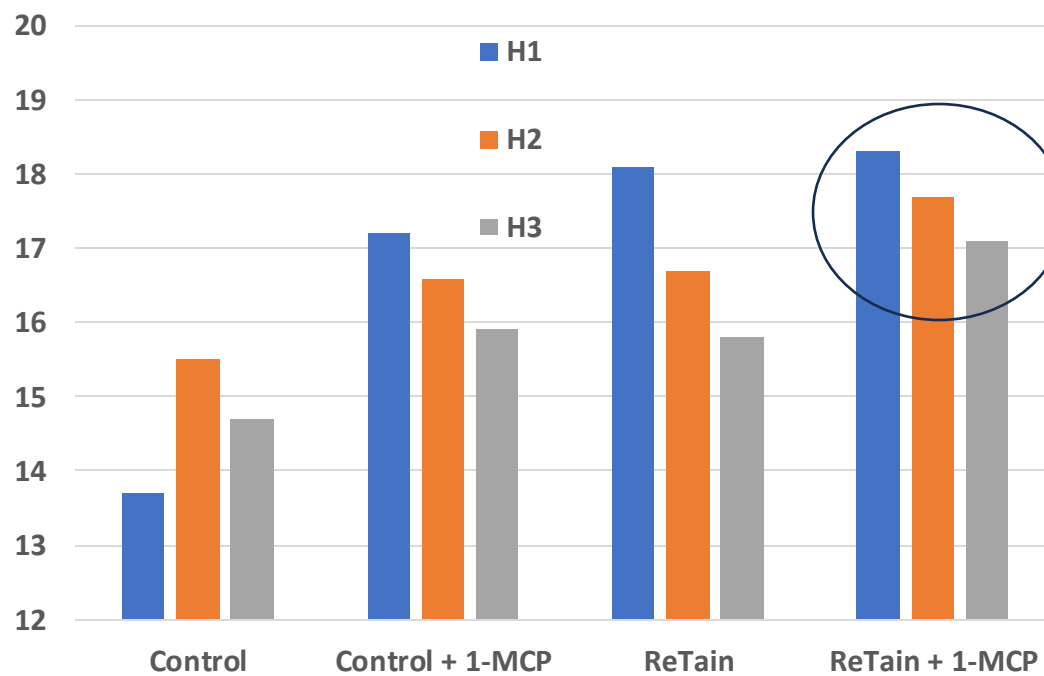
- At 38F than at 33F.
- In 0.5% oxygen than at 2.0% oxygen.
- In ReTain-treated than untreated control fruit.
- In ReTain treated fruit even at 2% oxygen at 38F

Firmness (lb)

2% oxygen 33F



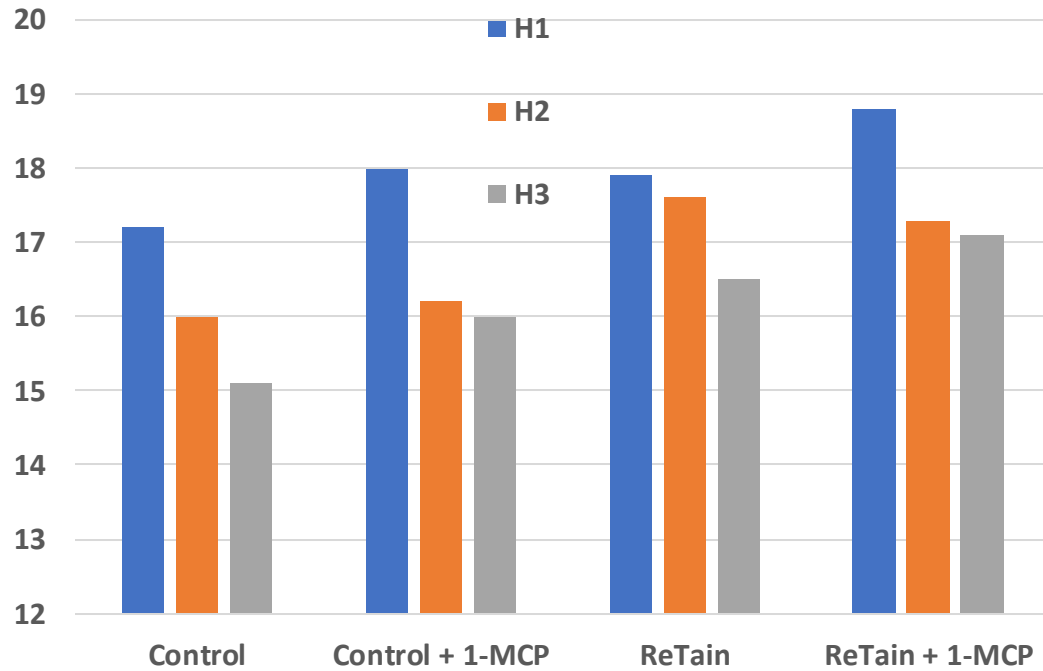
2% oxygen 38F



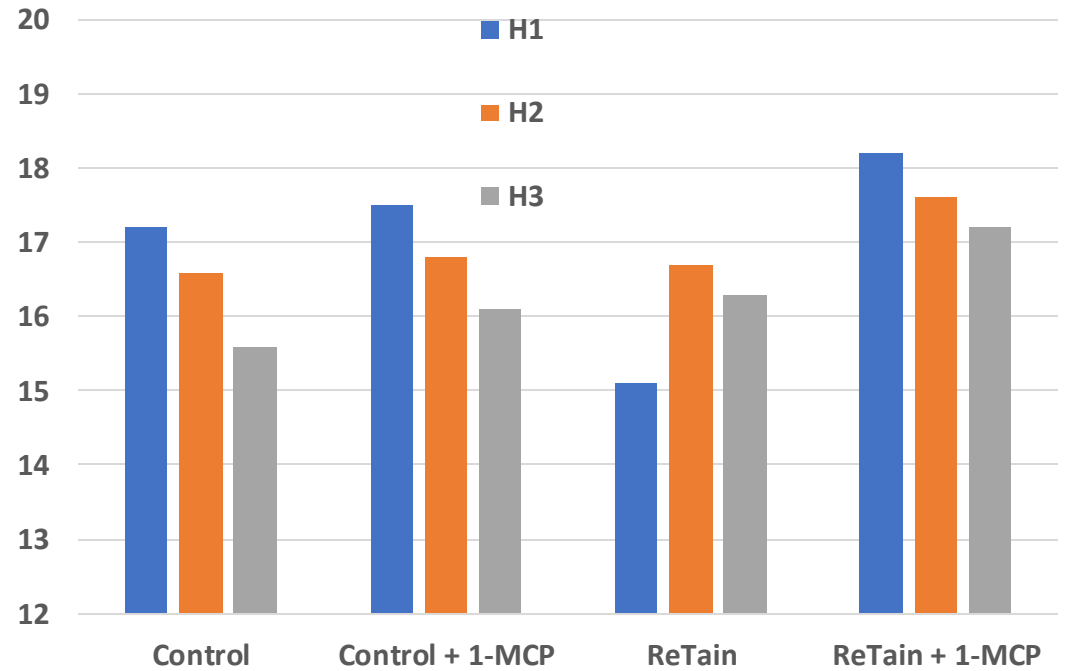
ReTain treated fruit always firmer and responsive to 1-MCP

Firmness (lb)

0.5% oxygen 33F



0.5% oxygen 38F



ReTain treated fruit firmer and responsive to 1-MCP, although less marked than with 2% oxygen.

Main effects of treatment - 9 months plus 7 days at 68F

Treatment	IEC (ppm)	Firmness (lb)	I _{AD} value	SSC (%)	TA (% malic acid)
H1	11.7b	17.4a	0.39a	13.6	0.61a
H2	5.5b	16.6b	0.26b	11.9	0.28b
H3	50.3a	15.9c	0.19c	11.4	0.30b
2% oxygen	43.7a	16.4b	0.27b	11.7	0.38b
0.5% oxygen	1.3b	16.9a	0.29a	12.8	0.41a
33F	9.8b	16.6	0.28	11.8	0.41a
38F	35.2a	16.6	0.28	12.8	0.38b
Control	82.5a	15.7c	0.16b	11.6	0.40ab
Control + 1-MCP	1.4b	16.5b	0.17b	11.8	0.42a
ReTain	5.2b	16.6b	0.38a	14.0	0.37b
ReTain + 1-MCP	0.9b	17.7a	0.41a	11.8	0.39ab

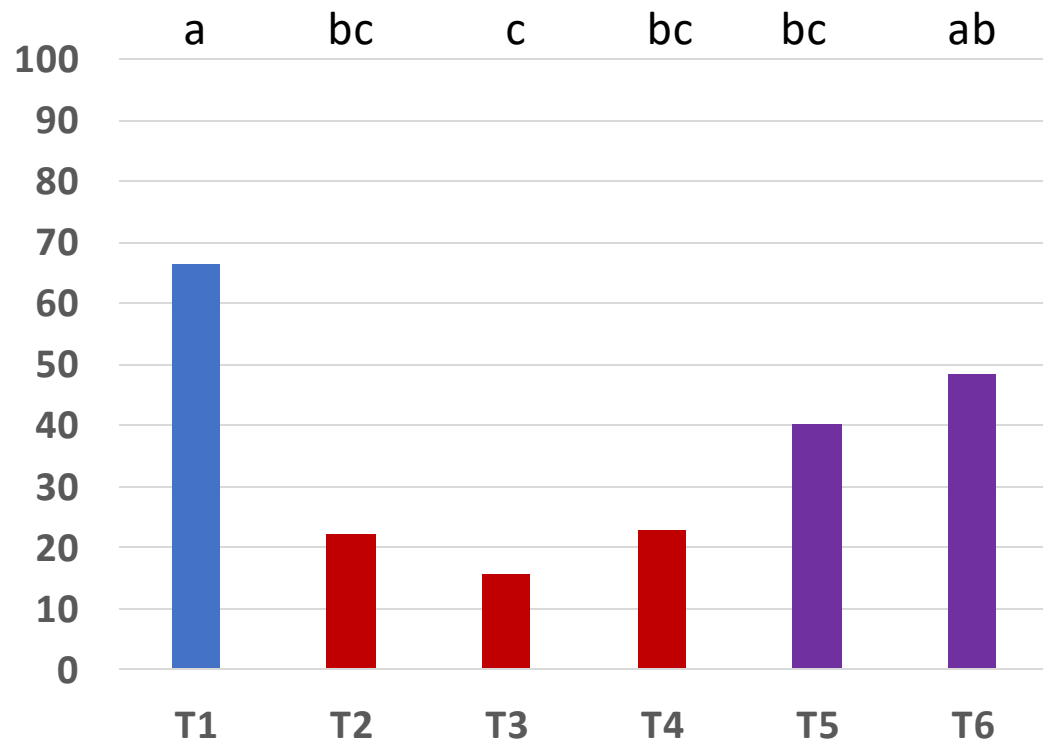
Timing of ReTain and Harvista applications

- **TRT 1. Control**
- **TRT 2. ReTain half pouch/A at 21 dbh**
- **TRT3. 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**

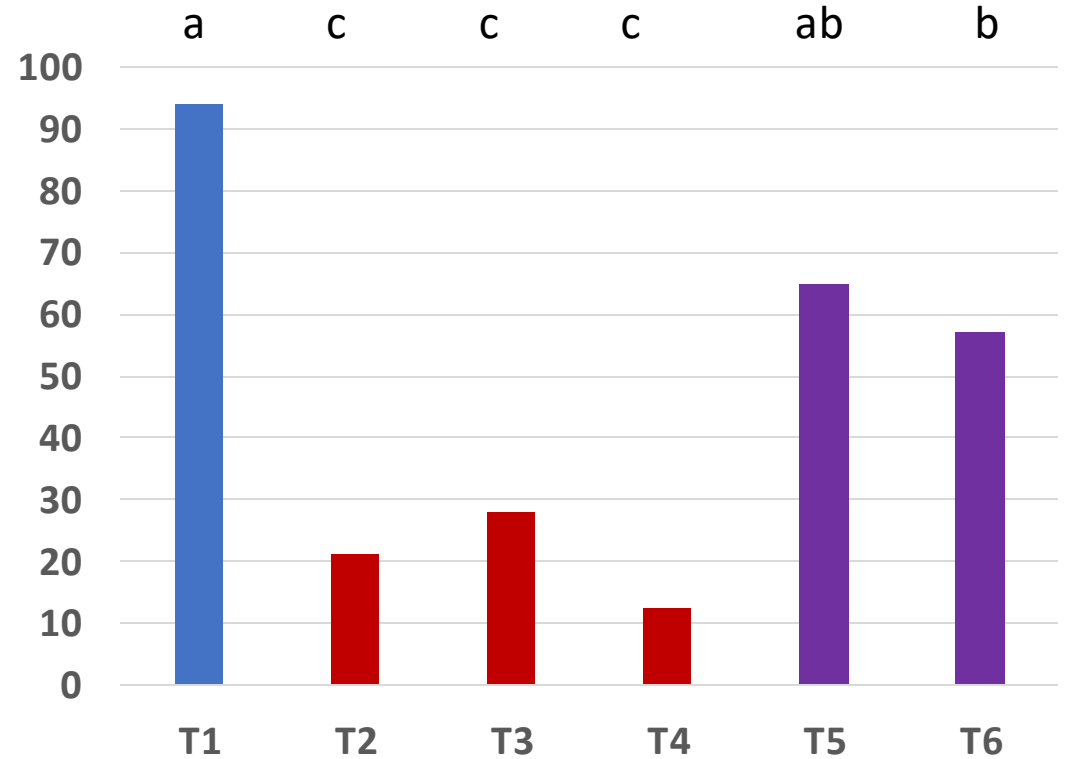
Flesh browning (%)

- H1 and H2 combined (no statistical difference)

5 months



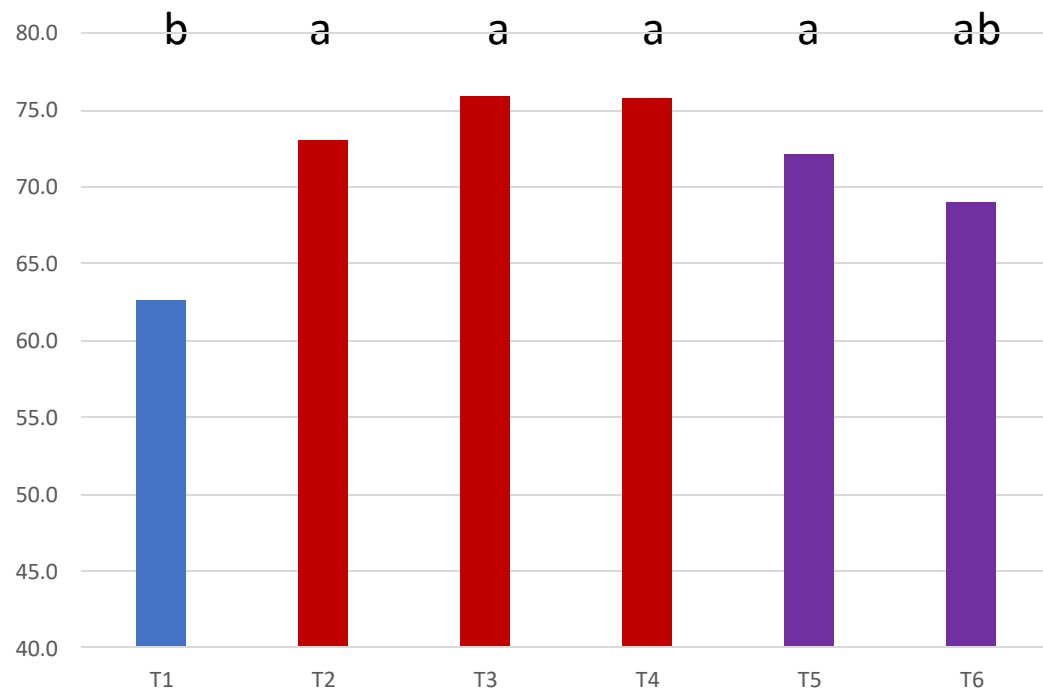
9 months



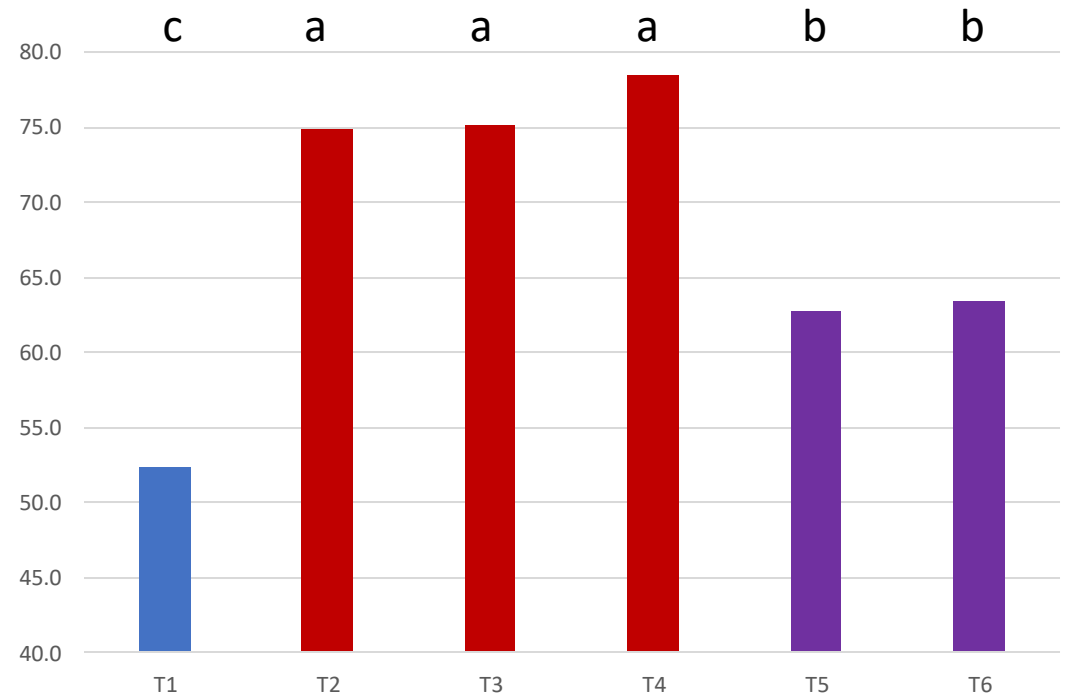
Firmness (N)

- H1 and H2 combined (no statistical difference)

5 months



9 months



Harvista Field treatments

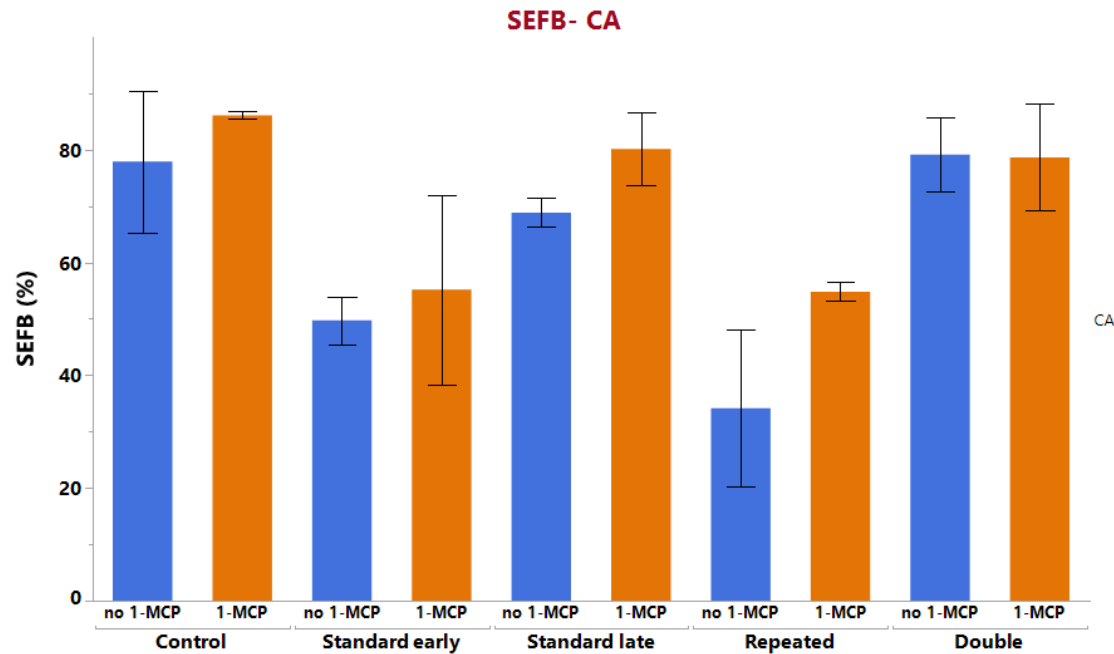
1. No Harvista (control)
2. 60 g rate 2 weeks before harvest (std early)
3. 60 g rate 1 week before harvest (std late)
4. 60 g rate 1 & 2 weeks before harvest (repeat)
5. 120 g rate 1 week before harvest (double late)

Harvest and storage procedures

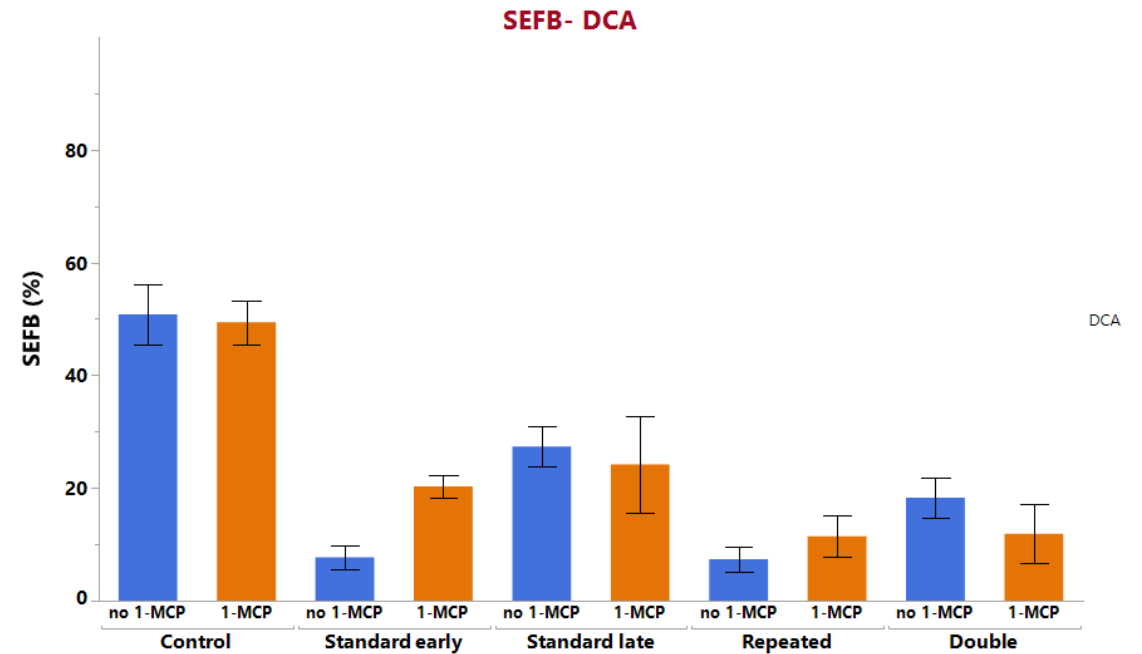
- Gala harvested twice to commercial color standards
- Fruit untreated or treated with postharvest 1-MCP
- Storage conditions - air, CA and DCA **(33°F)**

Flesh browning (%)

CA



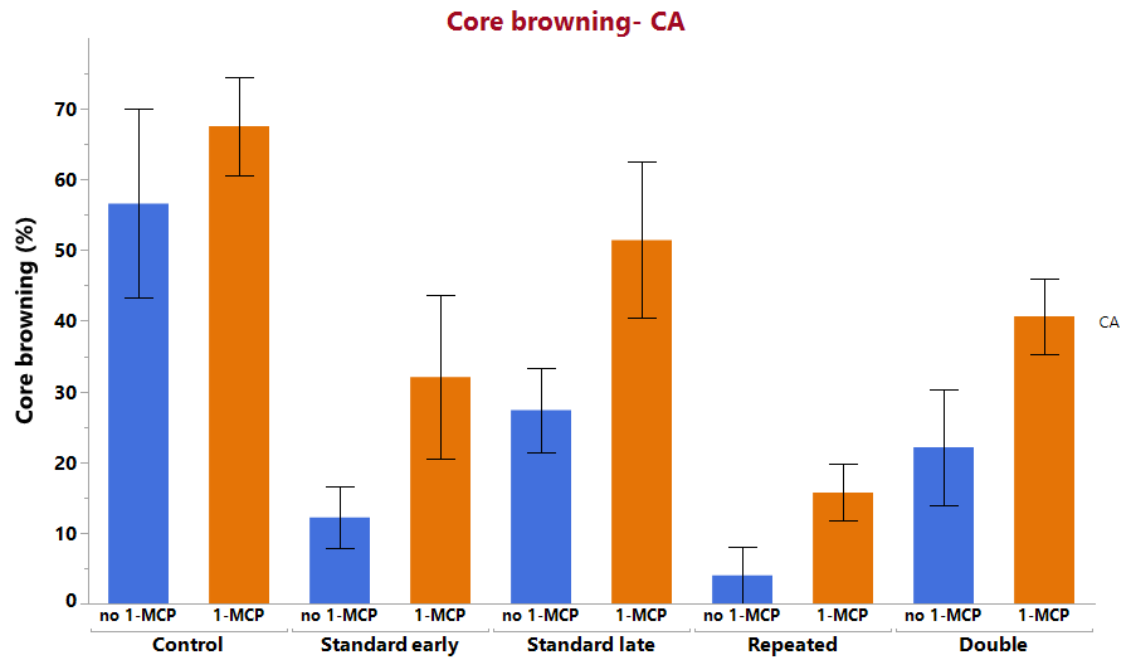
'DCA'



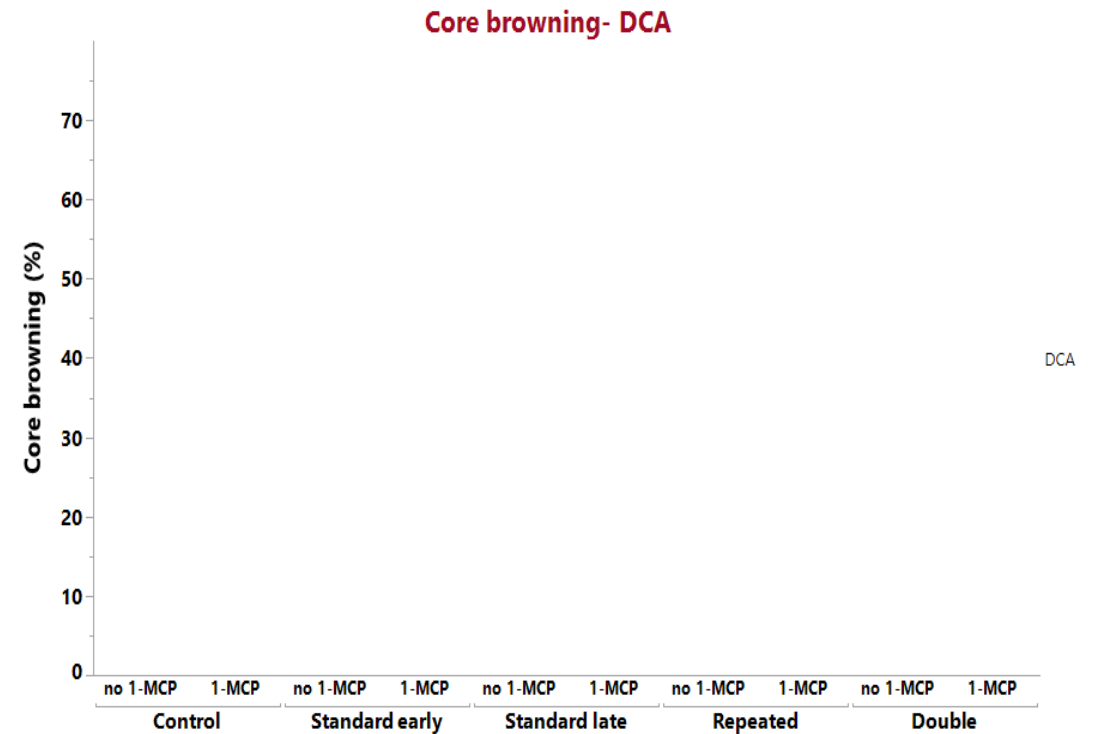
Critical importance of PGRs reinforced;

Disorders: Core browning

CA

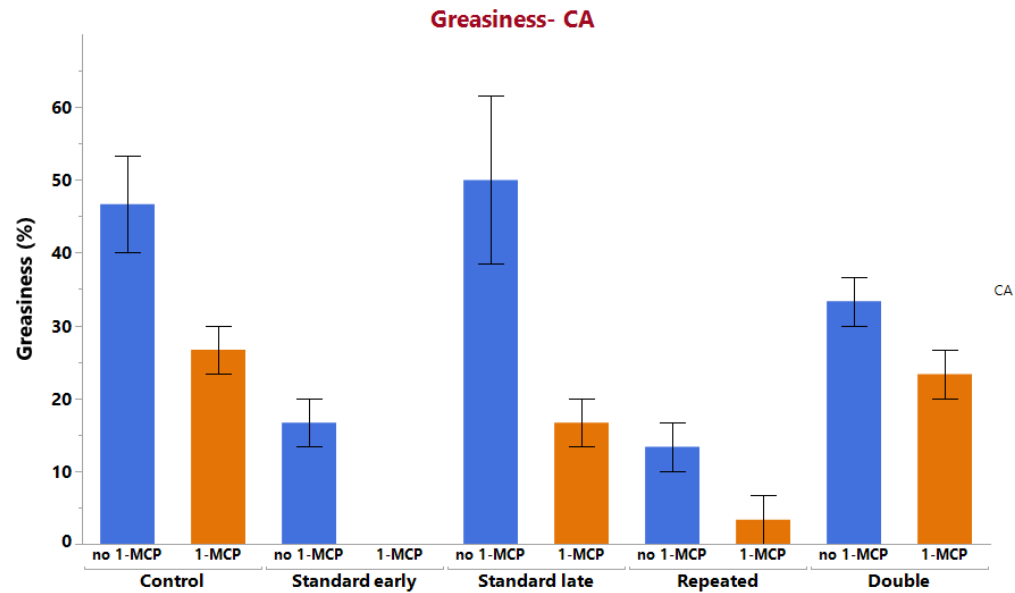


'DCA'

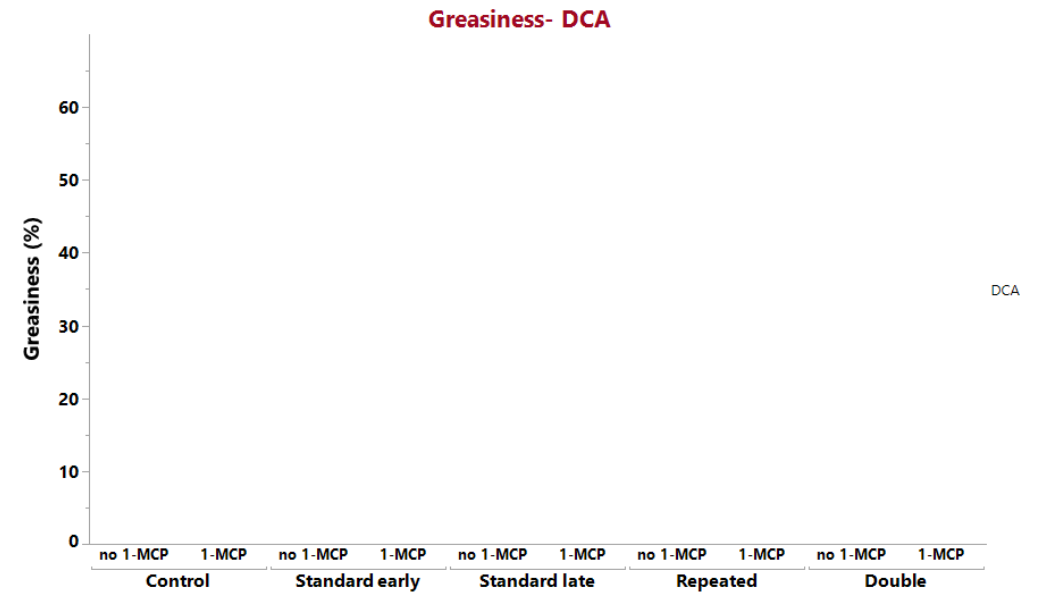


Disorders: Greasiness

CA



'DCA'



Storage operators have to know if
fruit treated with PGRs!

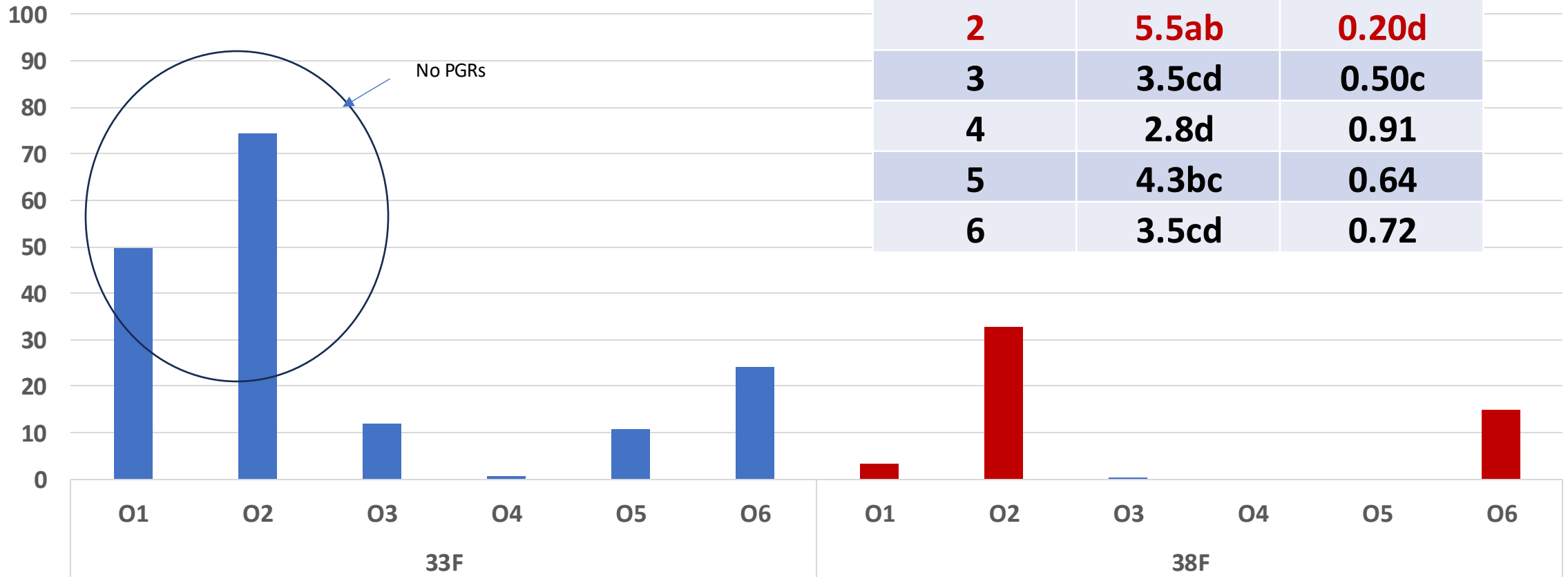
Reinforced by next set of results

Regional results

- Picked at start of CA window in all regions.
- 0.5% oxygen at 33F or 38F
- 8-9 months storage

FB (%)

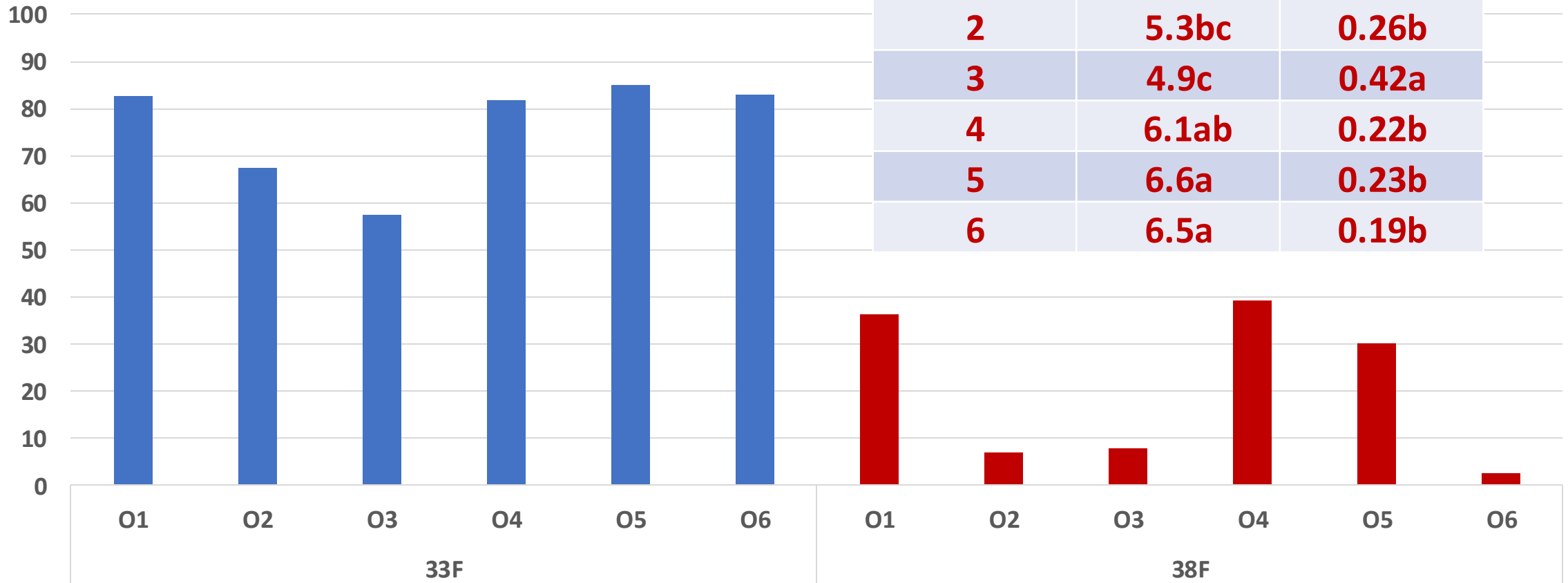
WNY west



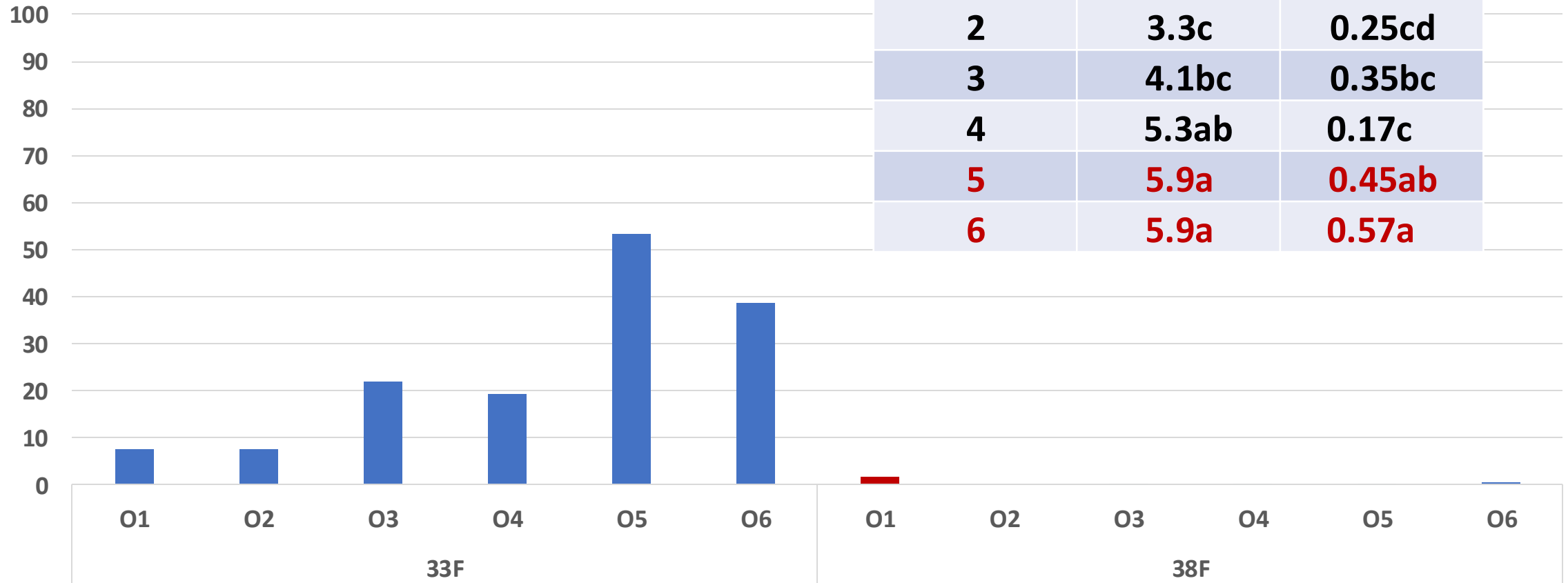
Orchard #	SPI	I _{AD} value
1	6.0a	0.31d
2	5.5ab	0.20d
3	3.5cd	0.50c
4	2.8d	0.91
5	4.3bc	0.64
6	3.5cd	0.72

FB (%)

WNY east (ReTain or Harvista)



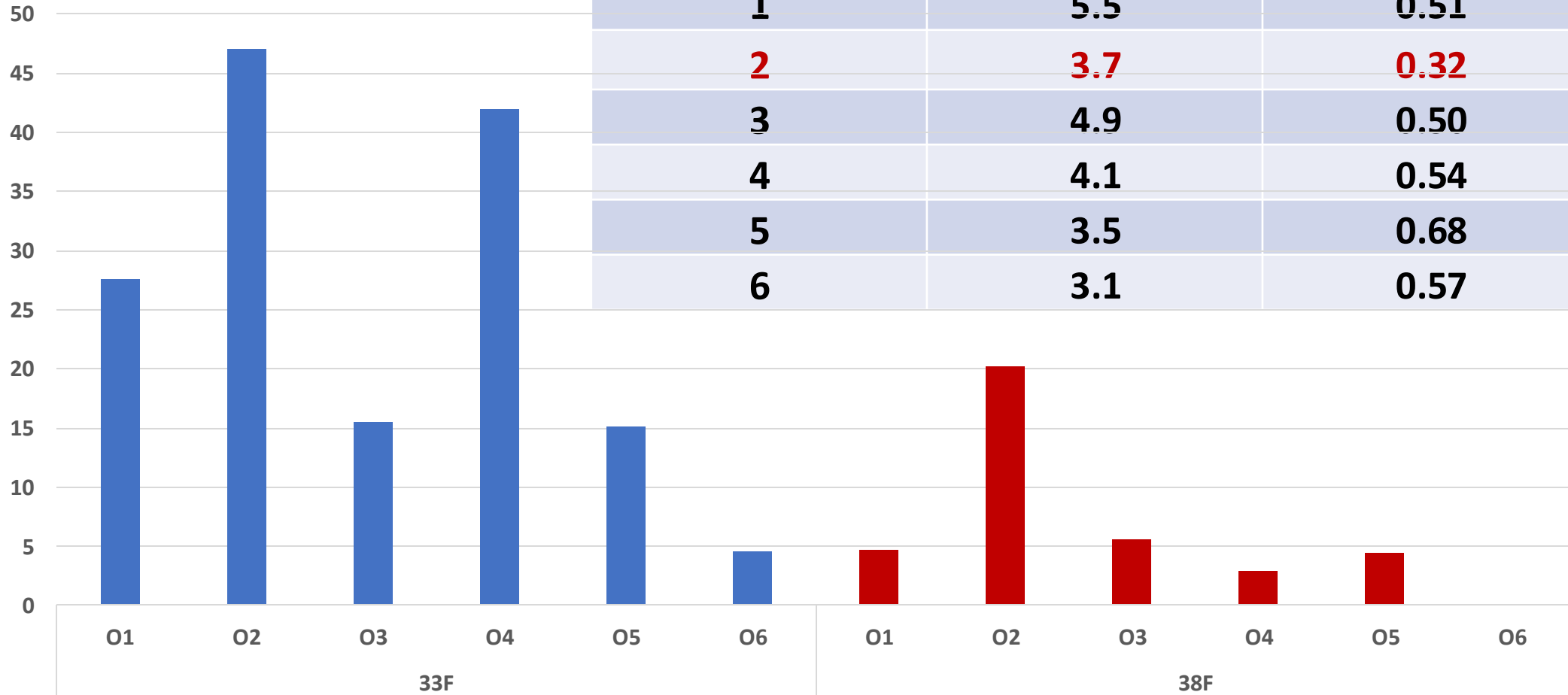
FB (%) Champlain



Orchard #	SPI	I _{AD} value
1	3.3c	0.50a
2	3.3c	0.25cd
3	4.1bc	0.35bc
4	5.3ab	0.17c
5	5.9a	0.45ab
6	5.9a	0.57a

SEFB (%)

WNY west



The impact of other variables.

- Oxygen concentration
- Carbon dioxide concentration
- 1-MCP
- Conditioning
- Delayed CA
- **Maturity**

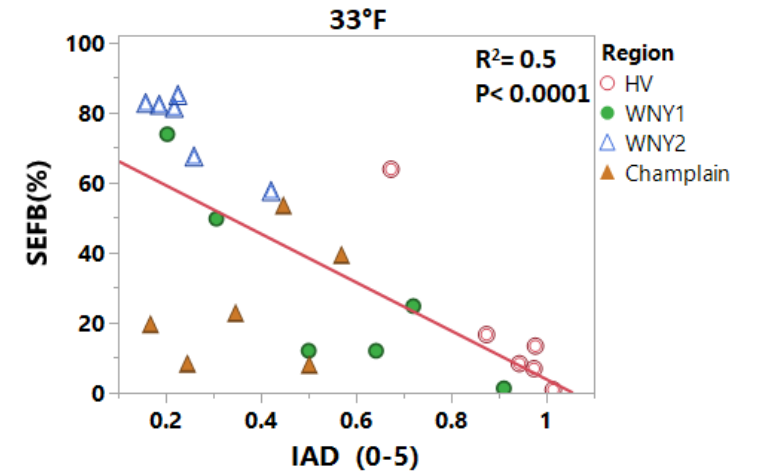
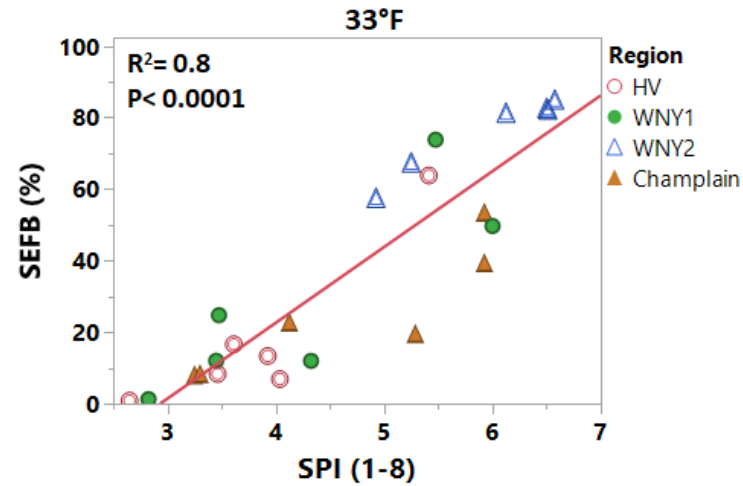
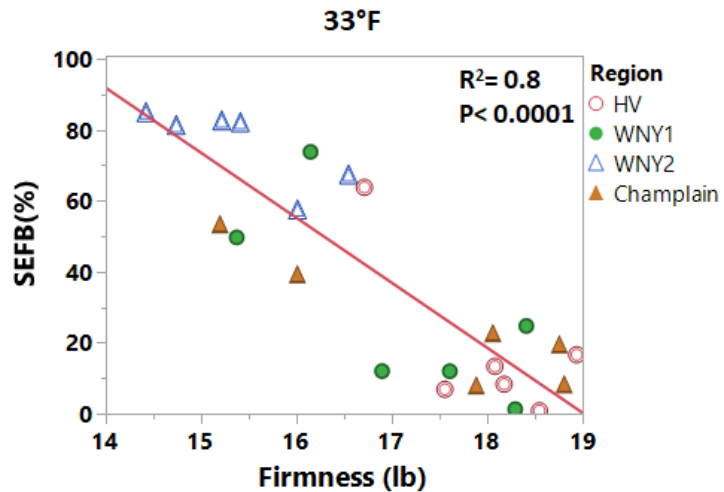
Maturity

SPI and I_{AD} values at least partial indication of risk.

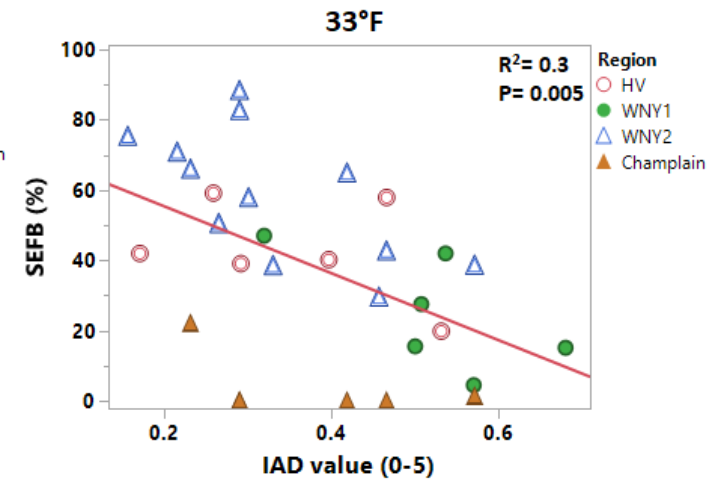
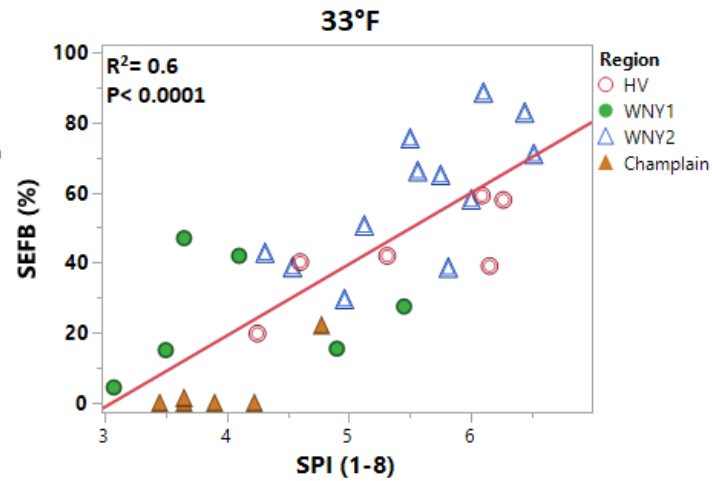
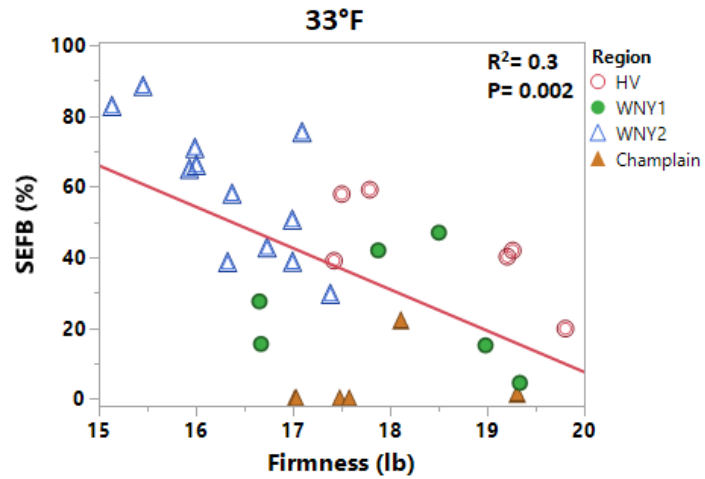
- SPI < 4.0
- I_{AD} value > 0.4 (but regional)?

We use 33F as without FB we cannot develop correlations to predict FB risk.

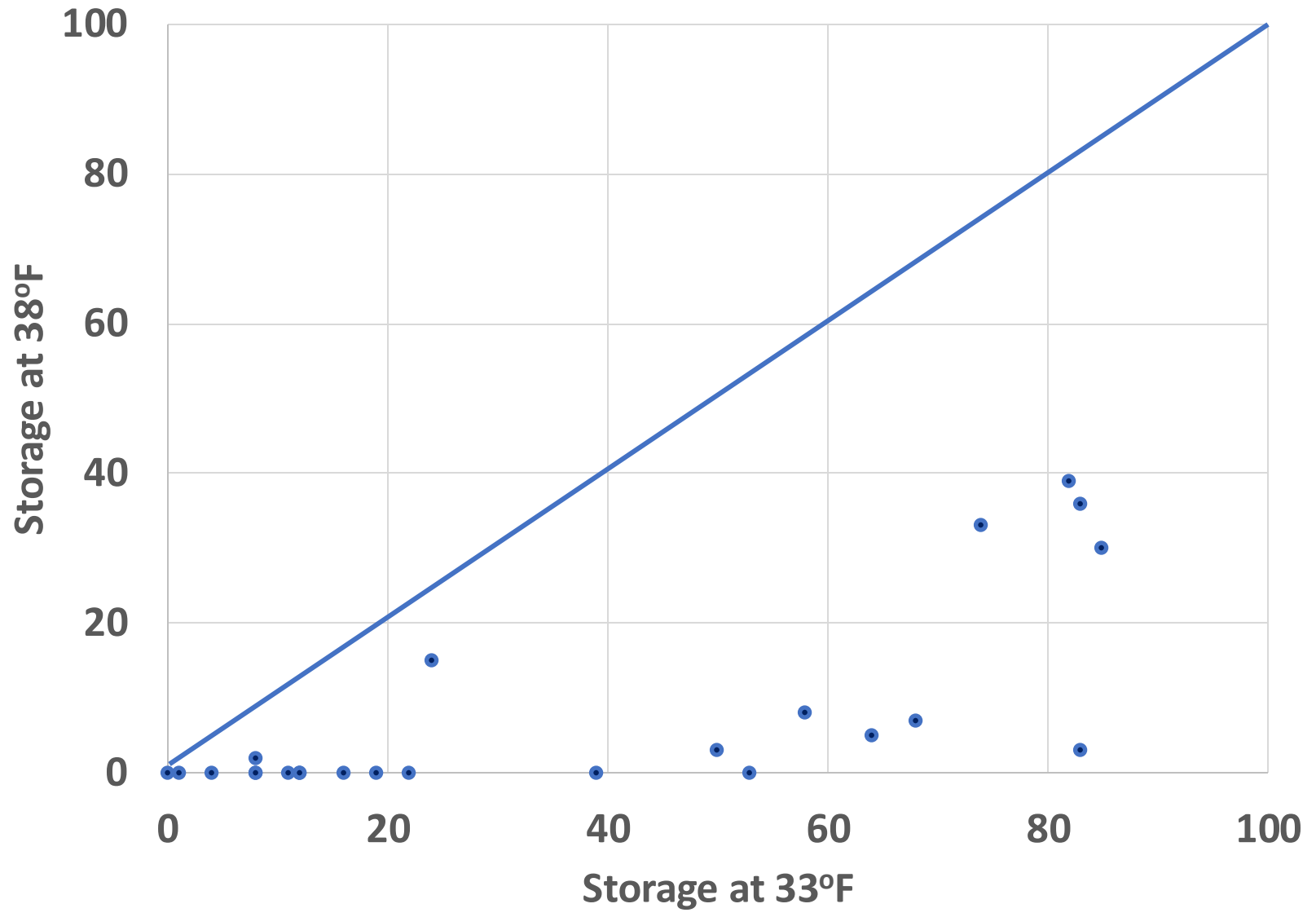
Correlations for Firmness, SPI and I_{AD} value – 33°F 2021 harvest



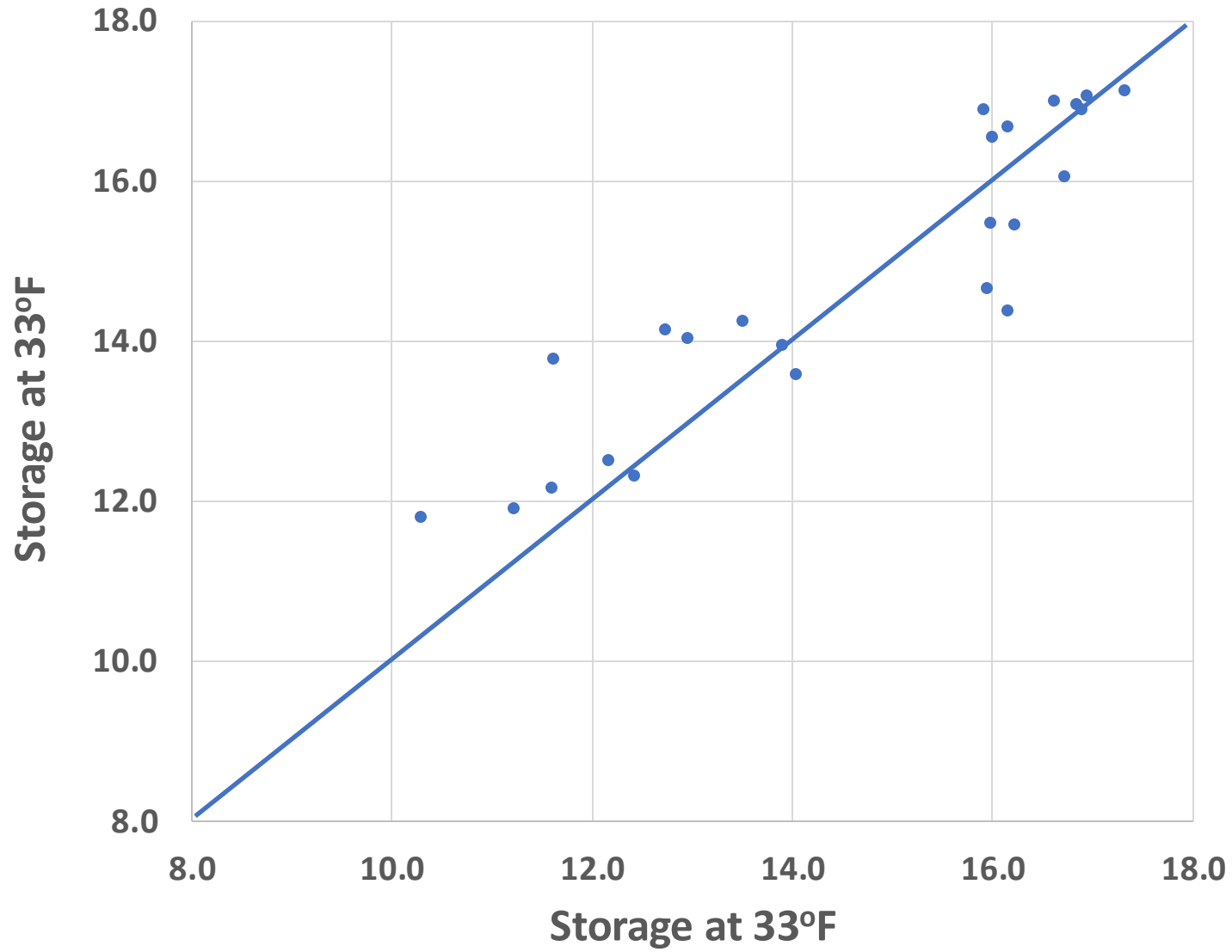
Correlations for Firmness, SPI and I_{AD} value – 33°F 2022 harvest



Flesh browning (%)



Flesh firmness (lb)



Recommendations

Sensory

PGR applied at the correct time are critical for long term storage

Store at 38F (will benefit fruit without PGR treatment)

Postharvest 1-MCP recommended if fruit are treated with a PGR.

0.5% oxygen (1% carbon dioxide) recommended for long term storage

2% oxygen (1% carbon dioxide) for standard CA, although lower concentrations are okay. PGR!