

# 'Quo Vadis' – long term CA storage regimes of Cripps' Pink apples and fruit quality



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- Internal browning (IB) of Cripps' Pink apples is a worldwide tendency
- Costs South African industry millions of Rands in revenue
- The types of IB have been verified:
  - Radial
  - Diffuse
  - Combination
  - CO<sub>2</sub>/ cavities
  - Misshapen fruit



# Radial browning



# Diffuse browning





# Combination browning



# CO<sub>2</sub> cavities core





# CO<sub>2</sub> cavities



# Misshapen







- Internal browning (IB) of Cripps' Pink apples is a worldwide tendency
- Has cost the South African industry millions of Rands in revenue
- The types of IB in this cultivar have been verified (Radial, Diffuse, Combination, CO<sub>2</sub>/ cavities and misshapen fruit browning)
- **Storage regimes have been adapted; fruit stored above 0 °C and for shorter-term CA storage (max 4-5 months)**
- **However, longer-term CA storage (7-9 months) still a risk for IB**

# Risk factors



IB has its potential determined by:

## Pre-harvest factors:

- Growing region
- Orchard factors
- Seasonal climatic variables
- Harvest maturity

## Postharvest factors:

- Cooling rate
- 1-MCP treatment
- CA conditions
- Storage temperature
- Storage time

# Risk factors



- Step cooling has proven to reduce stress on fruit
- This trial tested a successful step cooling regime, in conjunction with 1-MCP (SmartFresh<sup>SM</sup>) to reduce IB potential





# Materials and methods



<b>Areas:</b>	<b>Ceres and Grabouw</b>
<b>Populations:</b>	10 (5 per area)
<b>Harvest maturity:</b>	Optimum (30 - 40% starch breakdown)
<b>1-MCP (SmartFresh<sup>SM</sup>):</b>	Within 7 days
<b>Cooling regimes:</b>	(5 treatments to follow)

# Ceres (KBV) & Grabouw (Elgin)



# Materials and methods



<b>Areas:</b>	<b>Ceres and Grabouw</b>
<b>Populations:</b>	<b>10 (5 per area)</b>
<b>Harvest maturity:</b>	<b>Aimed for optimum (30 - 40% starch)</b>
<b>1-MCP (SmartFresh<sup>SM</sup>):</b>	<b>With or without; within 7 days</b>
<b>Cooling regimes:</b>	<b>(5 Treatments)</b>



# Treatments



April (Harvest)	1-MCP (7 days)	30 days	30 days	30 days	Sept	Jan (Open CA)
T1 (US)	+	4 °C	3 °C	2 °C	1 °C	1 °C
T2 (US)	+	3 °C	2 °C	1 °C	1 °C	1 °C
T3 (Comm.)	+	14 days 2 °C	14 days 1 °C	0.5 °C	1 °C	1 °C
T4 (US)	+	1 °C	1 °C	1 °C	1 °C	1 °C
T5 (US)	—	1 °C	1 °C	1 °C	1 °C	1 °C

# Examinations



- Full maturity at time of harvest
- After 9 months CA
- After 4 weeks RA at -0.5 °C
- After 7 days shelf life at 20.0 °C

***NOTE:***

***Data two-way factorial: Farm x Treatment***

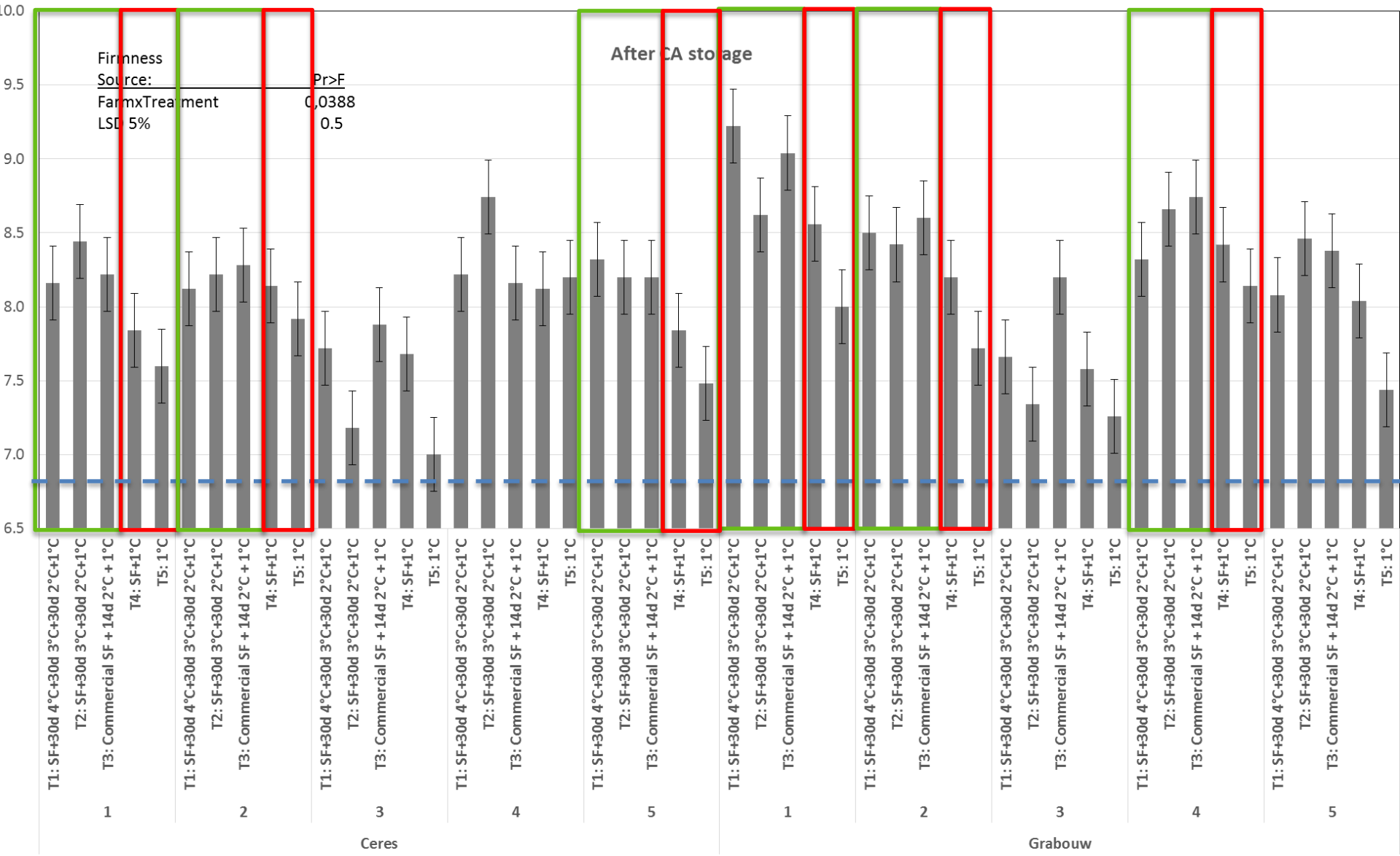
# Maturity at harvest (2018-19 season; Year 2 )



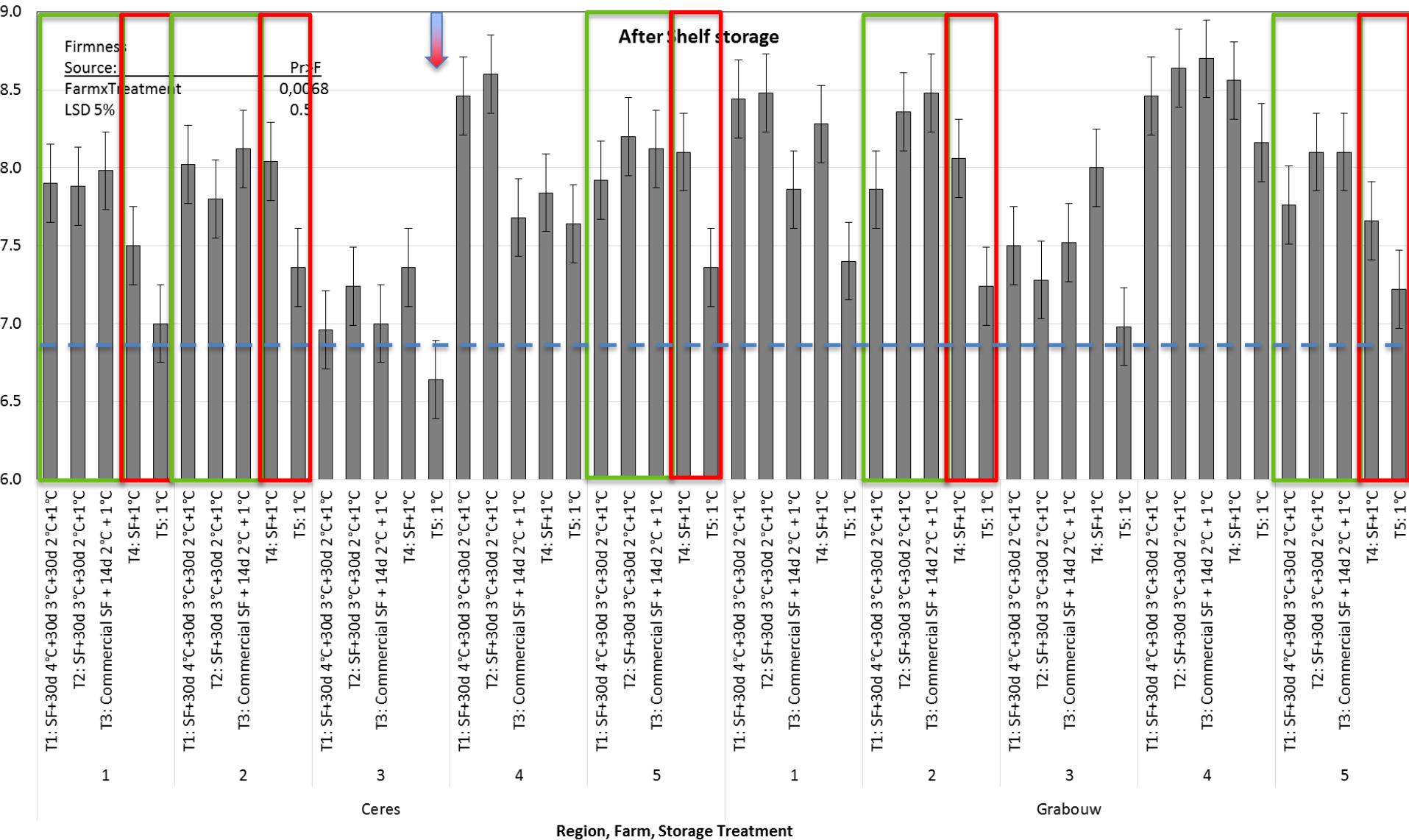
Factors: Farm:	Region:	Firmness (kg)	Background Colour (Chart index) <sup>1</sup>	Blush Colour Intensity (PI 16) <sup>2</sup>	Blush Colour (%) <sup>3</sup>	TSS (%)	TA (%)	Starch (%)	Internal Ethylene (µL/L)	Internal CO <sub>2</sub> (%)	Internal O <sub>2</sub> (%)
1	Ceres	8.66bc	3.0bc	9.1abc	59.3a	14.1bc	0.77bc	49.1bc	0.0b	1.5c	12.9a
2		8.10e	2.9cd	9.0abc	48.3bc	11.8f	0.60de	53.3ab	0.0b	1.7bc	12.9a
3		8.36cde	3.1ab	10.3a	58.8a	13.8bcd	0.64d	63.3a	6.5a	1.6bc	12.8b
4		8.34de	2.9cd	8.3bc	52.2abc	12.6e	0.54ef	34.7de	0.0b	1.5c	13.0a
5		8.52bcd	3.0bc	8.7bc	54.0ab	12.4ef	0.50f	42.6cd	0.0b	1.4c	12.9a
1	Grabouw/ Elgin	9.20a	3.0bc	7.8c	45.9bc	13.4d	0.73c	26.5e	0.0b	1.8bc	12.7bc
2		9.26a	2.8d	8.1c	44.5c	14.3b	0.65d	27.1e	0.0b	2.1ab	12.7bc
3		8.52bcd	2.6e	8.0c	44.6c	13.7cd	0.72c	25.0e	0.0b	1.8bc	12.6c
4		9.08a	3.2a	9.8ab	48.1bc	16.8a	0.94a	31.2e	0.0b	1.8bc	12.7bc
5		8.70b	3.1ab	9.3abc	58.1a	14.0bc	0.81b	30.1e	0.0b	2.5a	12.6c
<i>Source of Variation</i>		<i>Pr&gt;F</i>									
Farm		<.0001	<.0001	0.0417	0.0008	<.0001	<.0001	<.0001	0.0015	0.0094	<.0001



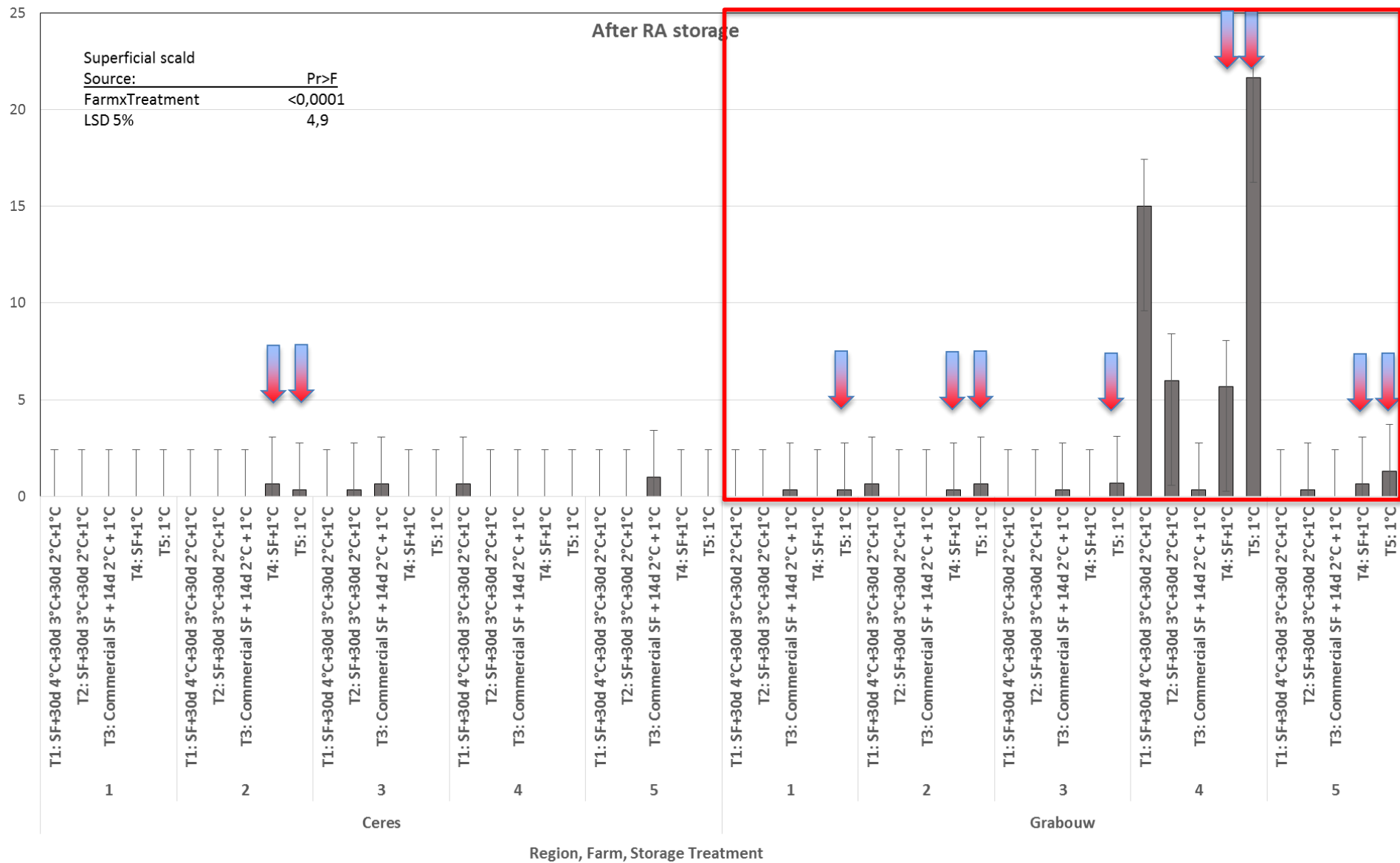
# Firmness - after CA



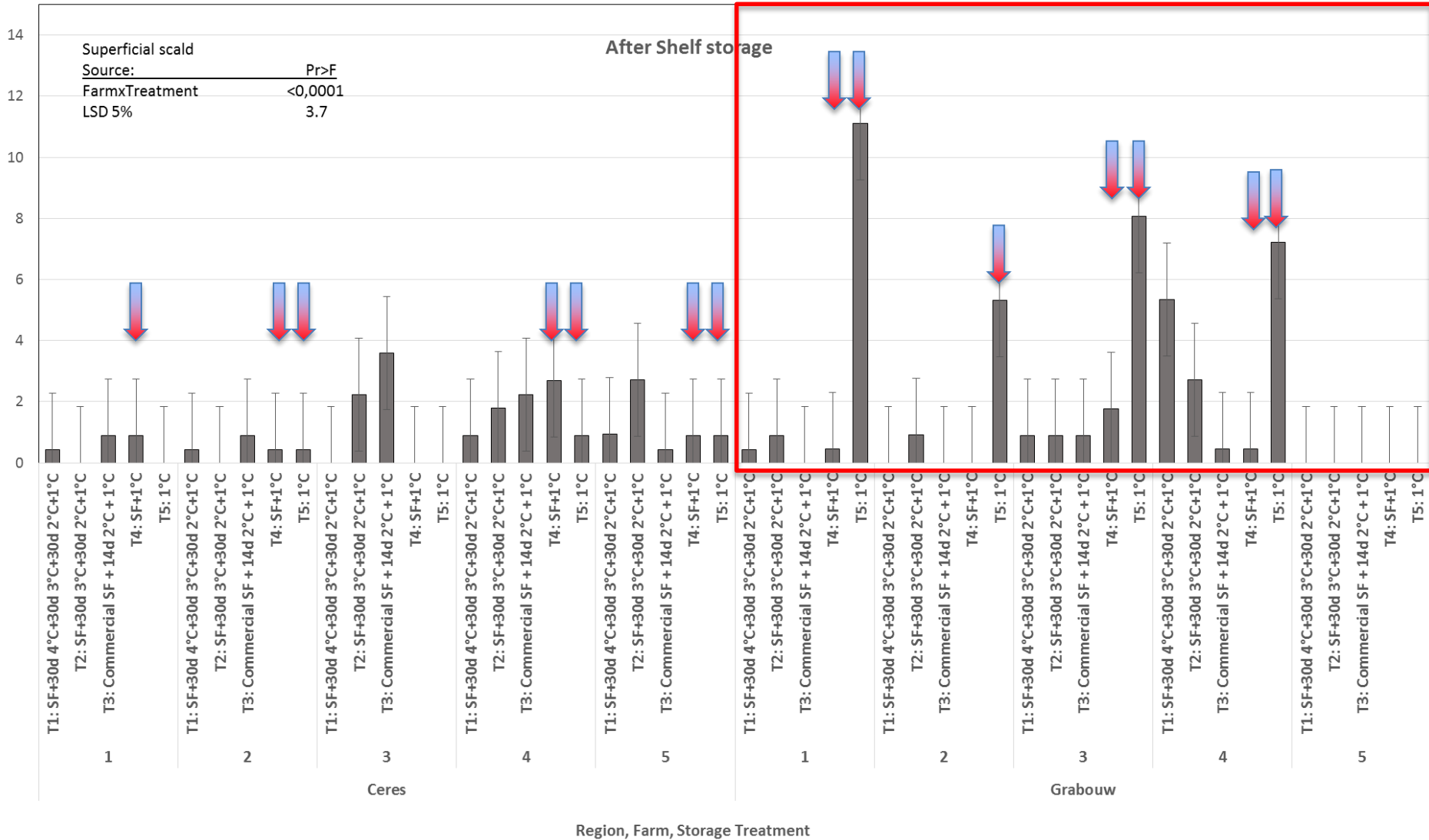
# Firmness - after Shelf



# Superficial scald - after RA



# Superficial scald - after shelf



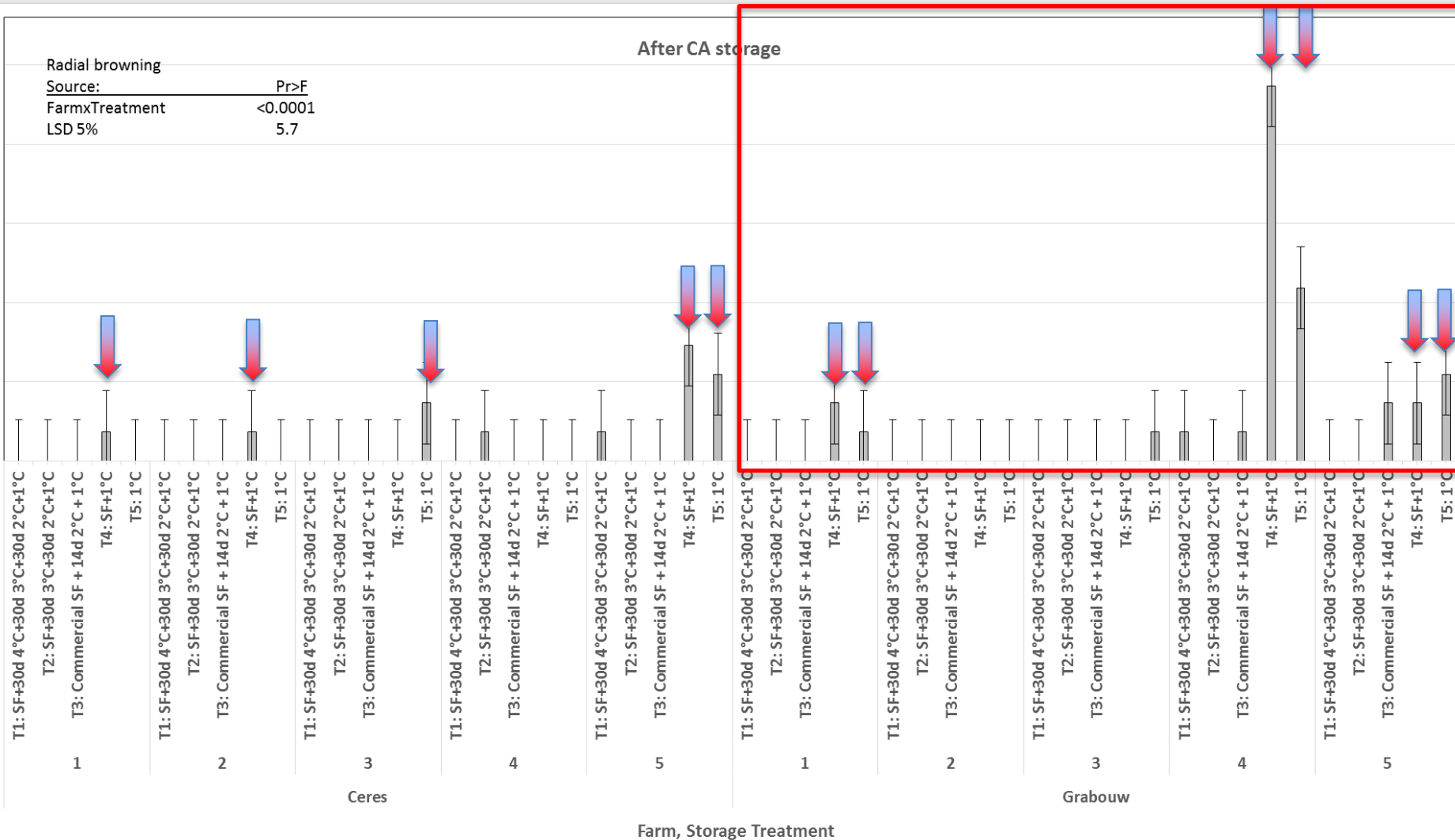


# Radial browning - after CA

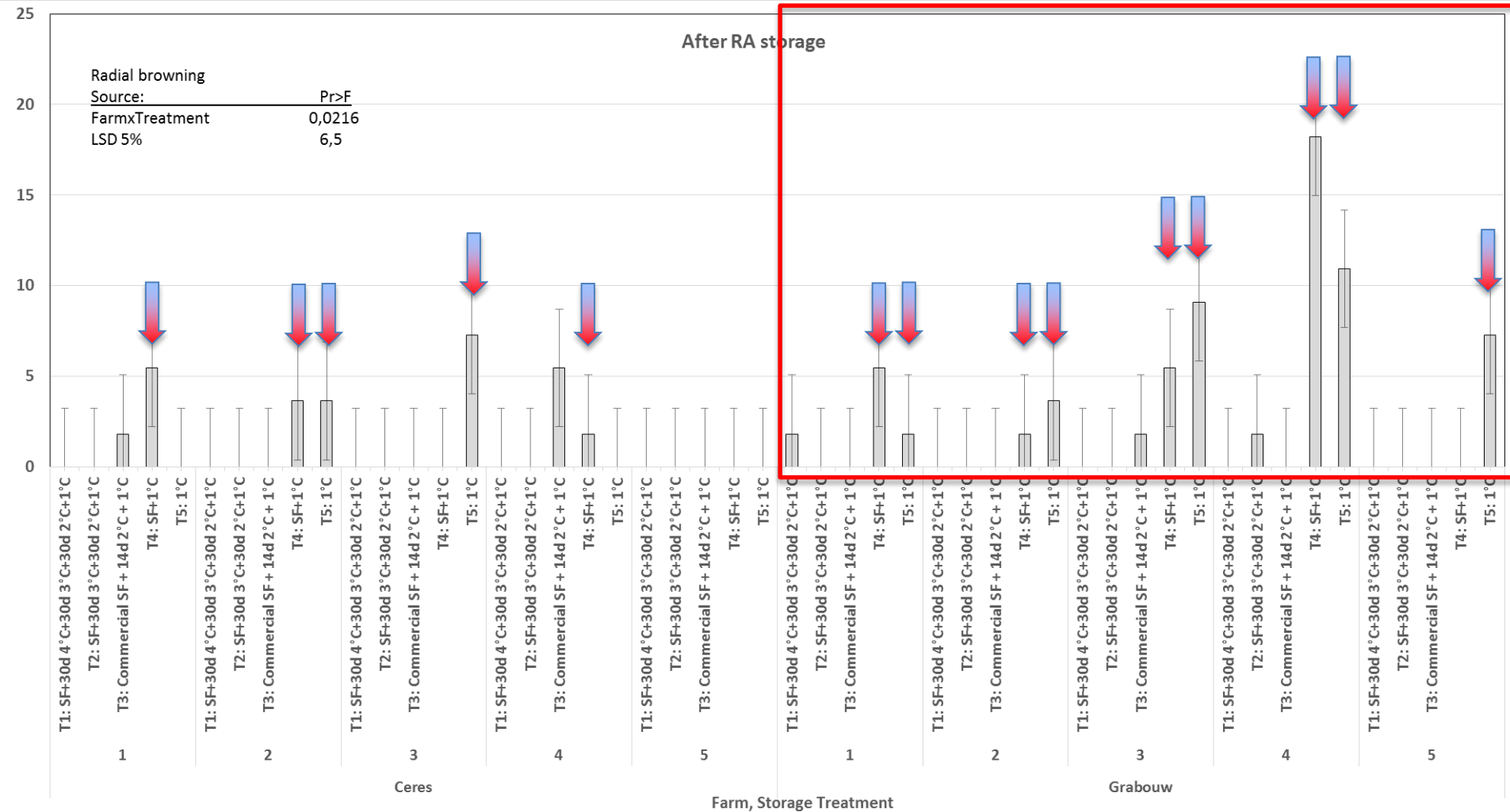


After CA storage

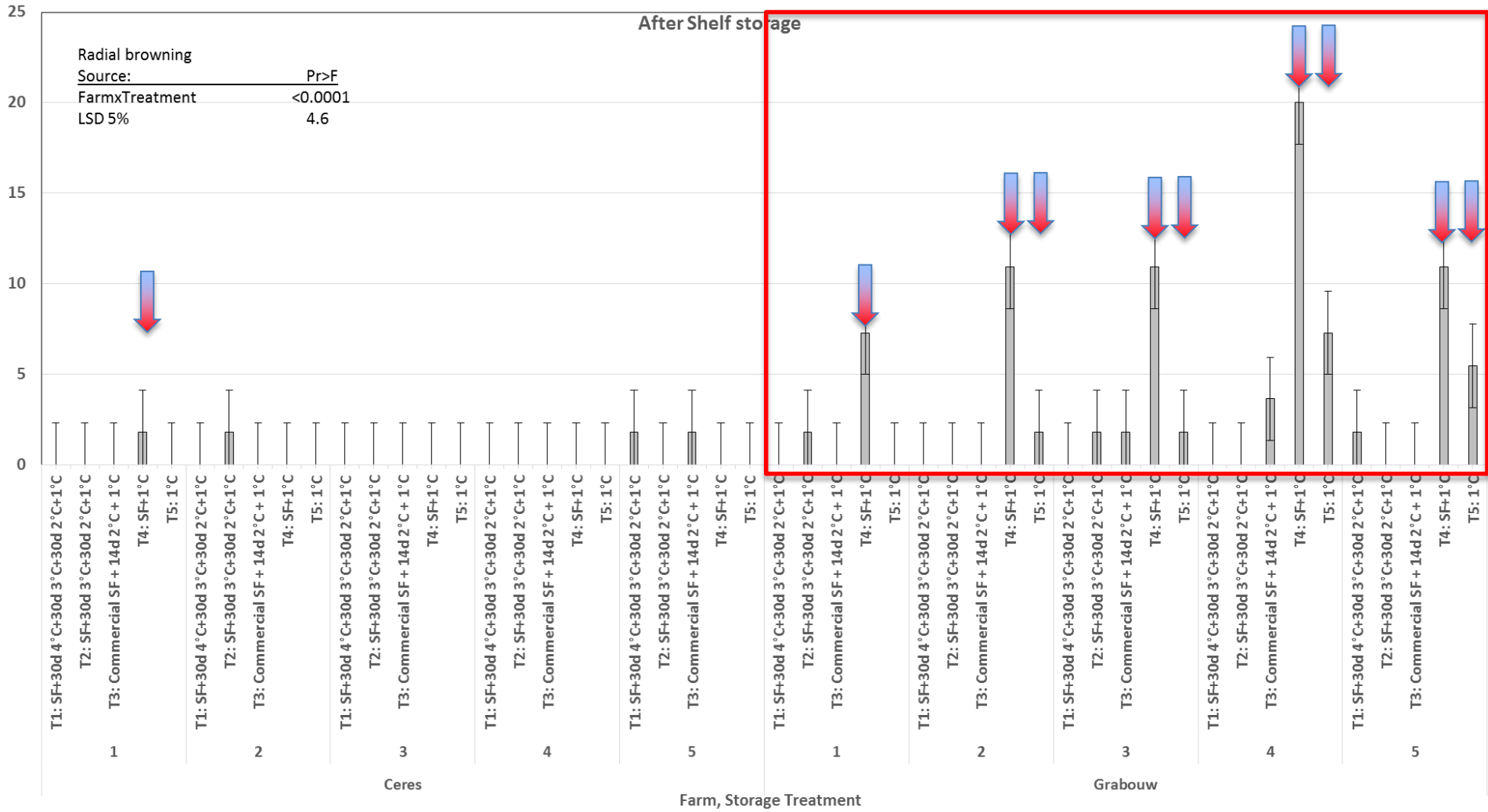
Radial browning  
 Source: Pr>F  
 FarmxTreatment <0.0001  
 LSD 5% 5.7



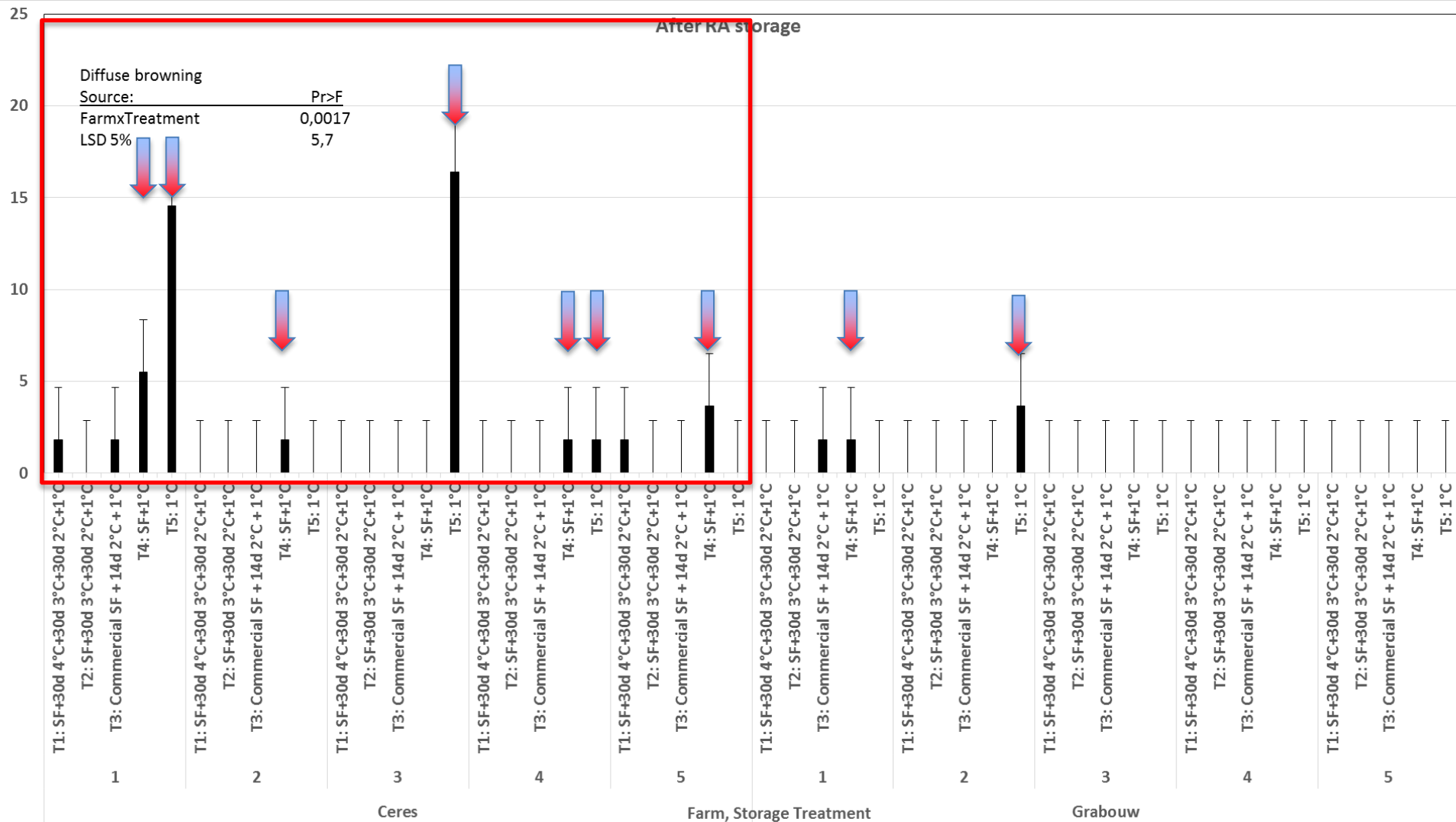
# Radial browning - after RA



# Radial browning - after Shelf



# Diffuse browning - after RA





# Other parameters – after CA



Treatment	TA (%)	Internal CO <sub>2</sub> (%)	Decay flesh (%)	Diffuse browning (%)	Combination browning (%)
T1: SF+30d 4°C+30d 3°C+30d 2°C+1°C	0.49a	1.1c	0.6b	0.0b	0.0
T2: SF+30d 3°C+30d 2°C+1°C	0.49a	1.4ab	0.9b	0.0b	0.0
T3: Commercial SF + 14d 2°C + 1°C	0.50a	1.3bc	1.0b	0.0b	0.0
T4: SF+1°C	0.48a	1.5a	1.0b	1.3a	0.2
T5: 1°C	0.45b	1.5a	2.0a	1.1a	1.5
<i>Source of variation</i>			<i>Pr&gt;F</i>		
Farm	<0.0001	<0.0001	0.0026	0.1068	0.3100
Treatment	<0.0001	<0.0001	0.0069	0.0025	0.1008
FarmxTreatment	0.2064	0.9997	0.9897	0.3081	0.7805

# Other parameters – after RA



Treatment	Firmness (kg)	Background			Internal Ethylene ( $\mu\text{L/L}$ )	Internal CO <sub>2</sub> (%)	Light diffuse browning (%)	Light combination browning (%)	Combination browning (%)
		Colour (Chart index) <sup>1</sup>	TSS (%)	TA (%)					
T1: SF+30d 4°C+30d 3°C+30d 2°C+1°C	8.33a	2.98	13.6b	0.50a	0.0b	1.1ab	2.4b	1.3bc	0.0b
T2: SF+30d 3°C+30d 2°C+1°C	8.32ab	2.97	13.6b	0.50a	0.1b	1.0b	1.5b	0.4c	0.0b
T3: Commercial SF + 14d 2°C + 1°C	8.26ab	3.01	13.8a	0.50a	0.2b	1.0b	2.7b	1.6abc	0.0b
T4: SF+1°C	8.15b	2.96	13.5b	0.47b	0.5b	1.3a	3.5b	3.6a	3.8a
T5: 1°C	7.63c	3.06	13.3c	0.44c	11.0a	1.3a	7.3a	3.1ab	3.3a
<i>Source of variation</i>					<i>Pr&gt;F</i>				
Farm	<0.0001	0.0653	<0.0001	<0.0001	0.1332	0.1325	0.0559	0.2925	0.0031
Treatment	<0.0001	0.4344	<0.0001	<0.0001	<0.0001	0.0025	0.0006	0.0158	<0.0001
FarmxTreatment	0.1851	0.9794	0.3355	0.0682	0.1283	0.7347	0.1935	0.8678	0.1722

# Radial browning



# Light radial browning





# Diffuse browning



# Light diffuse browning



# Other parameters – after RA



Treatment	Firmness (kg)	Background			Internal Ethylene ( $\mu\text{L/L}$ )	Internal CO <sub>2</sub> (%)	Light diffuse browning (%)	Light combination browning (%)	Combination browning (%)
		Colour (Chart index) <sup>1</sup>	TSS (%)	TA (%)					
T1: SF+30d 4°C+30d 3°C+30d 2°C+1°C	8.33a	2.98	13.6b	0.50a	0.0b	1.1ab	2.4b	1.3bc	0.0b
T2: SF+30d 3°C+30d 2°C+1°C	8.32ab	2.97	13.6b	0.50a	0.1b	1.0b	1.5b	0.4c	0.0b
T3: Commercial SF + 14d 2°C + 1°C	8.26ab	3.01	13.8a	0.50a	0.2b	1.0b	2.7b	1.6abc	0.0b
T4: SF+1°C	8.15b	2.96	13.5b	0.47b	0.5b	1.3a	3.5b	3.6a	3.8a
T5: 1°C	7.63c	3.06	13.3c	0.44c	11.0a	1.3a	7.3a	3.1ab	3.3a
<i>Source of variation</i>					<i>Pr&gt;F</i>				
Farm	<0.0001	0.0653	<0.0001	<0.0001	0.1332	0.1325	0.0559	0.2925	0.0031
Treatment	<0.0001	0.4344	<0.0001	<0.0001	<0.0001	0.0025	0.0006	0.0158	<0.0001
FarmxTreatment	0.1851	0.9794	0.3355	0.0682	0.1283	0.7347	0.1935	0.8678	0.1722

# Other parameters – after Shelf



Treatment	Firmness (kg)	TSS (%)	TA (%)	Internal Ethylene (μL/L)	Internal CO <sub>2</sub> (%)	Diffuse browning (%)	Combination browning (%)
T1: SF+30d 4°C+30d 3°C+30d 2°C+1°C	7.9a	13.7b	0.45ab	1.3b	0.92bc	1.1b	0.4
T2: SF+30d 3°C+30d 2°C+1°C	8.1a	13.6b	0.46ab	0.5b	0.86c	1.5b	0.2
T3: Commercial SF + 14d 2°C + 1°C	8.0a	14.0a	0.47a	0.6b	0.88bc	2.0b	0.4
T4: SF+1°C	7.9a	13.5bc	0.44b	0.3b	1.02b	5.3a	2.2
T5: 1°C	7.3b	13.4c	0.41c	58.4a	1.34a	6.2a	2.0
<i>Source of variation</i>				<i>Pr&gt;F</i>			
Farm	<0.0001	<0.0001	<0.0001	0.1714	0.4897	<0.0001	0.0679
Treatment	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
FarmxTreatment	0.0068	0.6934	0.1364	0.0503	0.4944	0.6710	0.2033

# Key results



- Storing for up to 9 months CA is certainly not recommended at this stage (high superficial scald & IB in high risk year)
- These conditions were followed for trial purposes only to get treatment differences and it identified possible risk protocols not to be followed commercially
- Area differences were possibly due to harvest maturity differences



# Key results



- 2017-2018 ([Year 1](#)) Low risk
- 2018-2019 ([Year 2](#)) High risk - clear treatment differences
- A risk for IB (radial and diffuse) and fruit quality if not step cooled (starting at 3 °C)
- A risk of radial was identified if not step cooled and subjected to 1-MCP
- A risk for radial browning seems linked to less mature fruit
- Diffuse browning related to over maturity and low storage temperature, substantiate previous results
- The 2019-2020 ([Year 3](#)) Currently in storage



# Conclusion



Compiled by Store-it Group for HORTGRO Science

May 2019, Version 2

## 'Cripps' Pink' Best Practice

### 1. Correct harvest maturity (for long term storage)

- Starch breakdown: optimum 20-30% and < 40%. Can be released at 15% depending on other parameters.
  - Firmness: > 7.8 kg (11.1 mm tip) as they have to arrive in UK at 6.8 kg.
  - Total soluble solids (TSS): advisable to be above 12.5% (13% at reception)
  - Titratable acidity: 0.75 – 0.55%
- NOTE: Maturity is the biggest factor in diffuse browning development after storage. Post-optimum harvested fruit should never be stored long-term.*

### 2. Reduce variability

- Orchards ranked 4 weeks before harvest on maturity and then pre-delivery samples to determine ripening rate and storability.
- Market fruit from orchards with faster ripening rates first and do not store in CA.
- Inside and outside canopy fruit maturity differences need to be determined.
- The outside, well-coloured fruit will be harvested first due to block colour standard of 40% (some markets 60%).
- The inside pale fruit will be left for last in order to potentially colour up. Consider leaf-stripping after first pick when sunburn risk has diminished. Rather consider reflective mulching should sunburn be a risk.
- These inside canopy fruit may be riper (even at the first pick) and should not be stored in CA / longer than 12 weeks.
- Depending on the size of the first pick, the second pick may be put into CA / long term storage depending on the starch breakdown.
- Avoid extended periods between picks / long picking window.
- Do not harvest after 50% starch breakdown for CA storage purposes longer than 12 weeks. May be fine for RA and RA + 1-MCP and short-term CA storage.

### 3. Long term storage - orchard history ranking

- Age of trees - do not store fruit from young trees longer than 12 weeks.
- Light crop load fruit may be more susceptible to disorders / earlier ripening.
- Irrigation status (under or over irrigation may result in faster ripening rates and poor storability).
- Soil types (sandy soil orchard fruit tend to ripen faster).
- Mineral nutrition (important in storage quality / ripening rate).
- History of progressive defects and ripening rates pre-harvest of each orchard.
- Grafted trees may also have a higher internal browning risk due to increased stress.
- Fruit that received any type of stress during the season should be sold within 6 weeks.

# Thank You!



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