‘Cripps’ Pink’ internal browning and long term storage - what has been learnt

- H Tayler, E Crouch, D Viljoen

Rational

- Internal browning (IB) of Cripps' Pink apples is a worldwide tendency
- Cost South African industry millions of Rands in revenue
- The types of IB have been verified:
  - Radial
  - Diffuse
  - Combination
  - CO_2 cavities
  - Misshapen fruit

Radial browning

Diffuse browning

Combination browning

CO_2 cavities core

CO_2 cavities flesh

Misshapen

Rational

- Internal browning (IB) of Cripps' Pink apples 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_2 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 determined by:

Pre-harvest factors:

- Orchard factors
- Seasonal climatic variables
- Harvest maturity

Postharvest factors:

- Cooling rate
- 1-MCP application
- CA/ DCA conditions
- Storage temperature
- Storage duration

A possible solution?

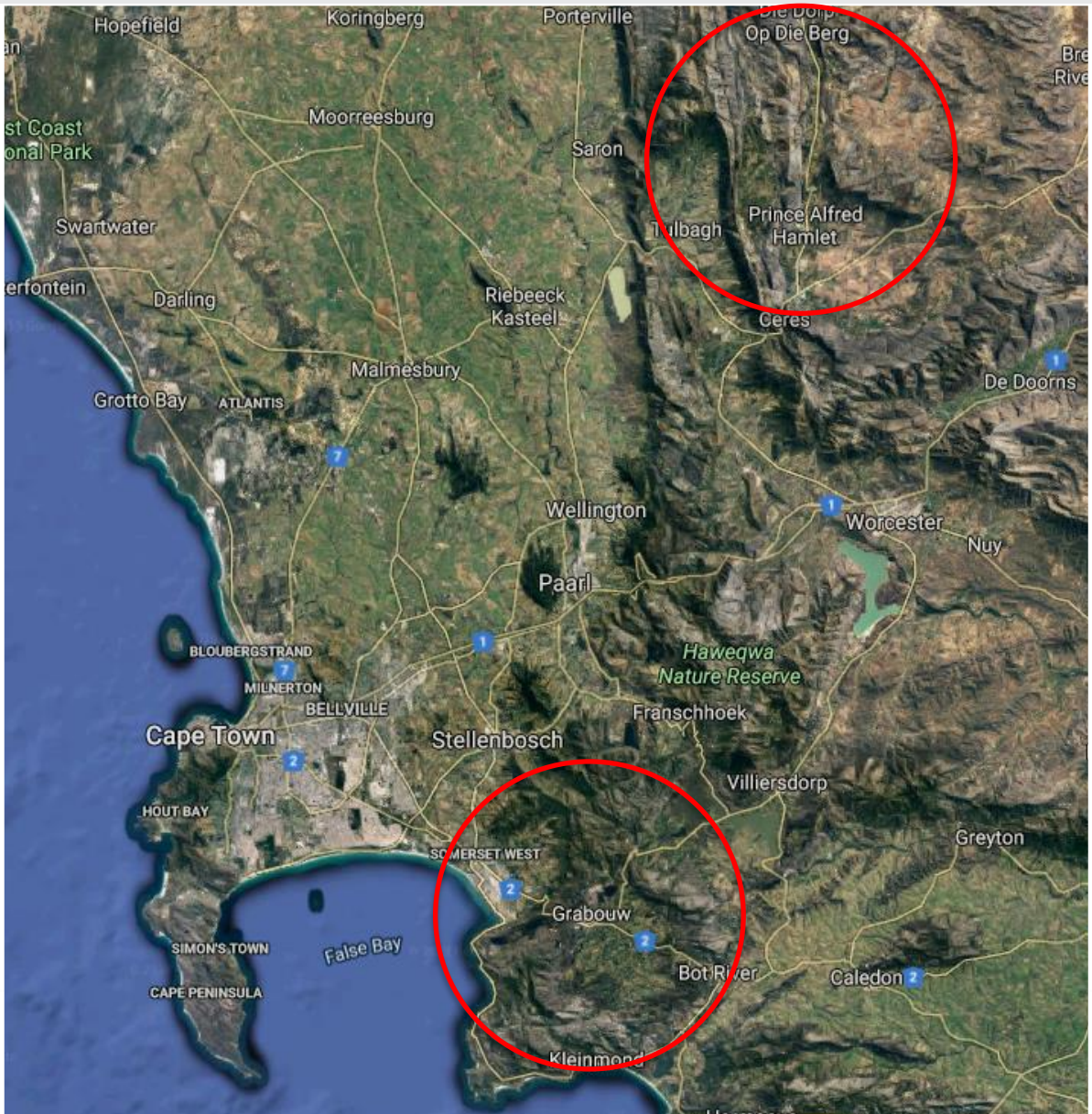
- **Step cooling has proven to reduce stress on fruit**

- **This trial tested a successful step cooling regime, in conjunction with 1-MCP to reduce IB potential**

Materials and methods

Areas:	**Ceres and Grabouw**
Populations:	10 (5 per area)
Harvest maturity:	Aimed for 30 - 40% SB
1-MCP:	Within 7 days
Cooling regimes:	5 treatments

Ceres (KBV) & Grabouw



Materials and methods

Areas:	**Ceres and Grabouw**
Populations:	**10 (5 per area)**
Harvest maturity:	**Aimed for 30 - 40% SB**
1-MCP:	**Within 7 days**
Cooling regimes:	**5 treatments (to follow)**

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

1. **Full maturity at time of harvest**
2. **After 9 months CA (1.5% O_2; 0.5% CO_2)**
3. **After 4 weeks RA at -0.5 °C**
4. **After 7 days shelf life at 20 °C**

What has been learnt?

1. **Harvest at optimum maturity**

2. **Apply 1-MCP**

3. **Step cool**

1. Harvest at optimum maturity

Maturity at harvest (2017-18 season; Year 1)

	Farm	Firmness (kg)	Background Colour (Chart index)	Blush Colour Intensity (PI 16)	Blush Colour (%)	TSS (%)	TA (%)	Starch (%)	Internal Ethylene (µL/L)
Ceres	1	8.3	3.2	7.5	62.9	14.5	0.60	65.8	0.9
	2	7.4	2.8	5.0	46.7	11.8	0.47	59.6	1.1
	3	8.4	2.8	5.7	47.5	12.4	0.57	49.1	0.9
	4	7.4	2.6	3.8	42.8	13.6	0.57	52.8	1.3
	5	8.4	3.0	6.9	56.3	12.6	0.60	41.8	1.5
Grabouw	1	8.0	3.0	5.3	53.4	12.0	0.52	38.1	0.3
	2	8.1	3.2	6.6	57.9	12.6	0.55	35.3	0.5
	3	8.8	3.2	5.2	44.0	12.8	0.55	25.2	0.6
	4	8.7	3.8	6.2	63.4	12.1	0.68	27.3	0.4
	5	8.3	3.1	6.6	55.6	11.9	0.58	30.2	0.6

NOTE:

A low risk commercial browning year

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

	Farm	Firmness (kg)	Background Colour (Chart index)	Blush Colour Intensity (Pl 16)	Blush Colour (%)	TSS (%)	TA (%)	Starch (%)	Internal Ethylene (µL/L)
Ceres	1	8.7	3.0	9.1	59.3	14.1	0.77	49.1	0.0
	2	8.1	2.9	9.0	48.3	11.8	0.60	53.3	0.0
	3	8.4	3.1	10.3	58.8	13.8	0.64	63.3	6.5
	4	8.3	2.9	8.3	52.2	12.6	0.54	34.7	0.0
	5	8.5	3.0	8.7	54.0	12.4	0.50	42.6	0.0
Grabouw	1	9.2	3.0	7.8	45.9	13.4	0.73	26.5	0.0
	2	9.3	2.8	8.1	44.5	14.3	0.65	27.1	0.0
	3	8.5	2.6	8.0	44.6	13.7	0.72	25.0	0.0
	4	9.1	3.2	9.8	48.1	16.8	0.94	31.2	0.0
	5	8.7	3.1	9.3	58.1	14.0	0.81	30.1	0.0

NOTE:
A high risk commercial browning year

Maturity at harvest (2019-20 season; Year 3)

	Farm	Firmness (kg)	Background Colour (Chart index)	Blush Colour Intensity (PI 16)	Blush Colour (%)	TSS (%)	TA (%)	Starch (%)	Internal Ethylene (µL/L)
Ceres	1	8.6	2.6	5.3	35.1	14.3	0.73	39.0	0.0
	2	8.0	2.4	2.6	16.9	12.2	0.64	36.0	0.0
	3	7.8	2.4	3.6	28.5	13.2	0.73	33.0	0.0
	4	8.3	2.7	5.8	39.3	13.9	0.62	35.0	0.0
	5	8.8	2.9	4.7	31.5	12.8	0.53	41.0	3.1
Grabouw	1	8.4	2.3	3.0	19.5	12.2	0.65	39.0	0.0
	2	8.6	2.8	5.6	33.4	13.8	0.87	34.0	0.0
	3	8.6	2.4	2.9	13.9	12.5	0.62	30.0	0.0
	4	8.6	2.6	3.1	15.7	12.5	0.68	39.0	0.0
	5	8.6	2.6	2.8	16.5	12.8	0.68	33.0	0.0

NOTE:
A high risk commercial browning year

Starch (2017-2019 seasons; Year 1-3)

		Low risk	High risk	High risk
	Farm	2017	2018	2019
Ceres	1	65.8	49.1	39.0
	2	59.6	53.3	36.0
	3	49.1	63.3	33.0
	4	52.8	34.7	35.0
	5	41.8	42.6	41.0
Grabouw	1	38.1	26.5	39.0
	2	35.3	27.1	34.0
	3	25.2	25.0	30.0
	4	27.3	31.2	39.0
	5	30.2	30.1	33.0
		Low IB	High IB	Low IB

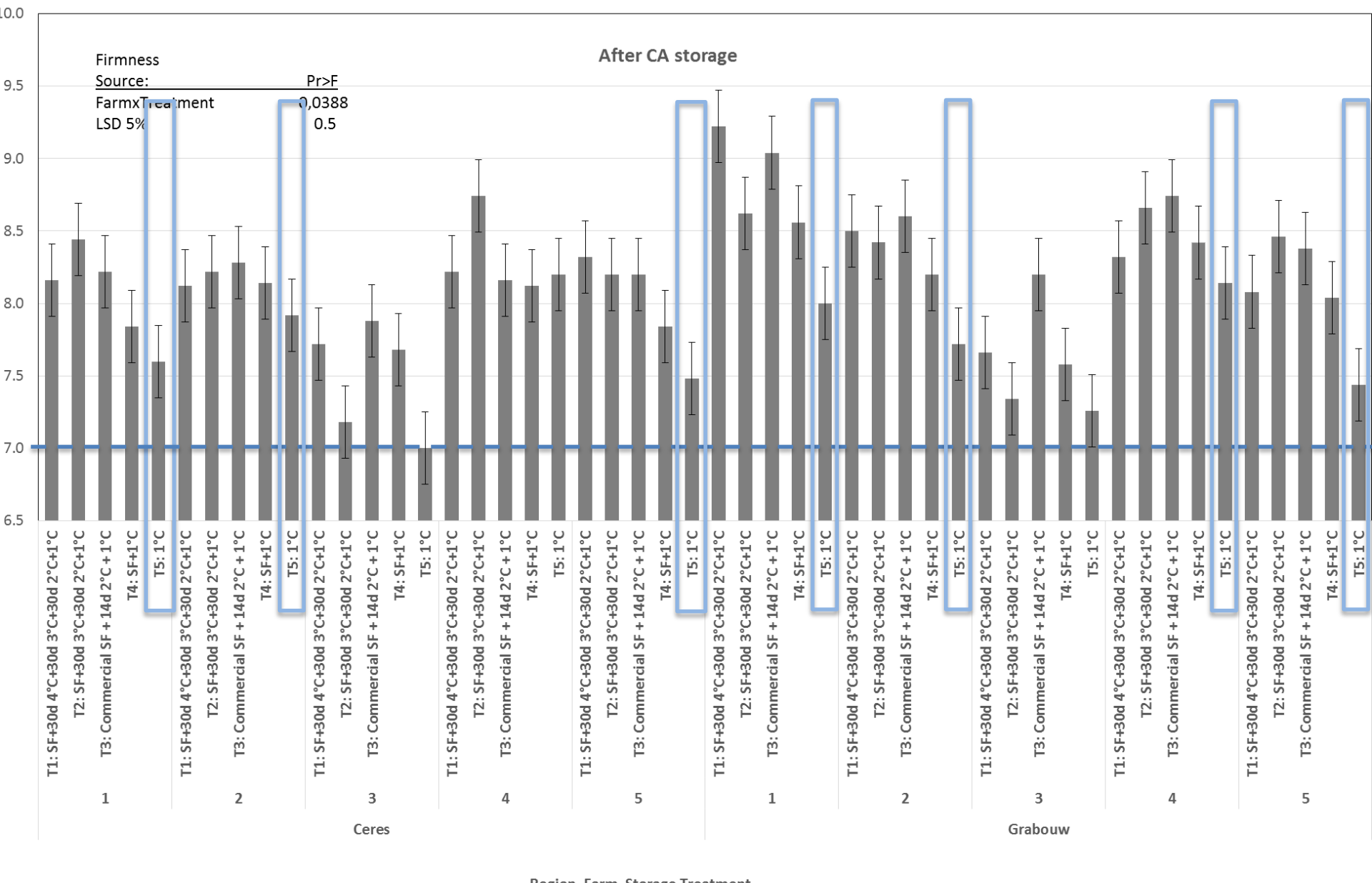
2. Apply 1-MCP

Firmness at harvest (2017-2019 seasons; Year 1-3)

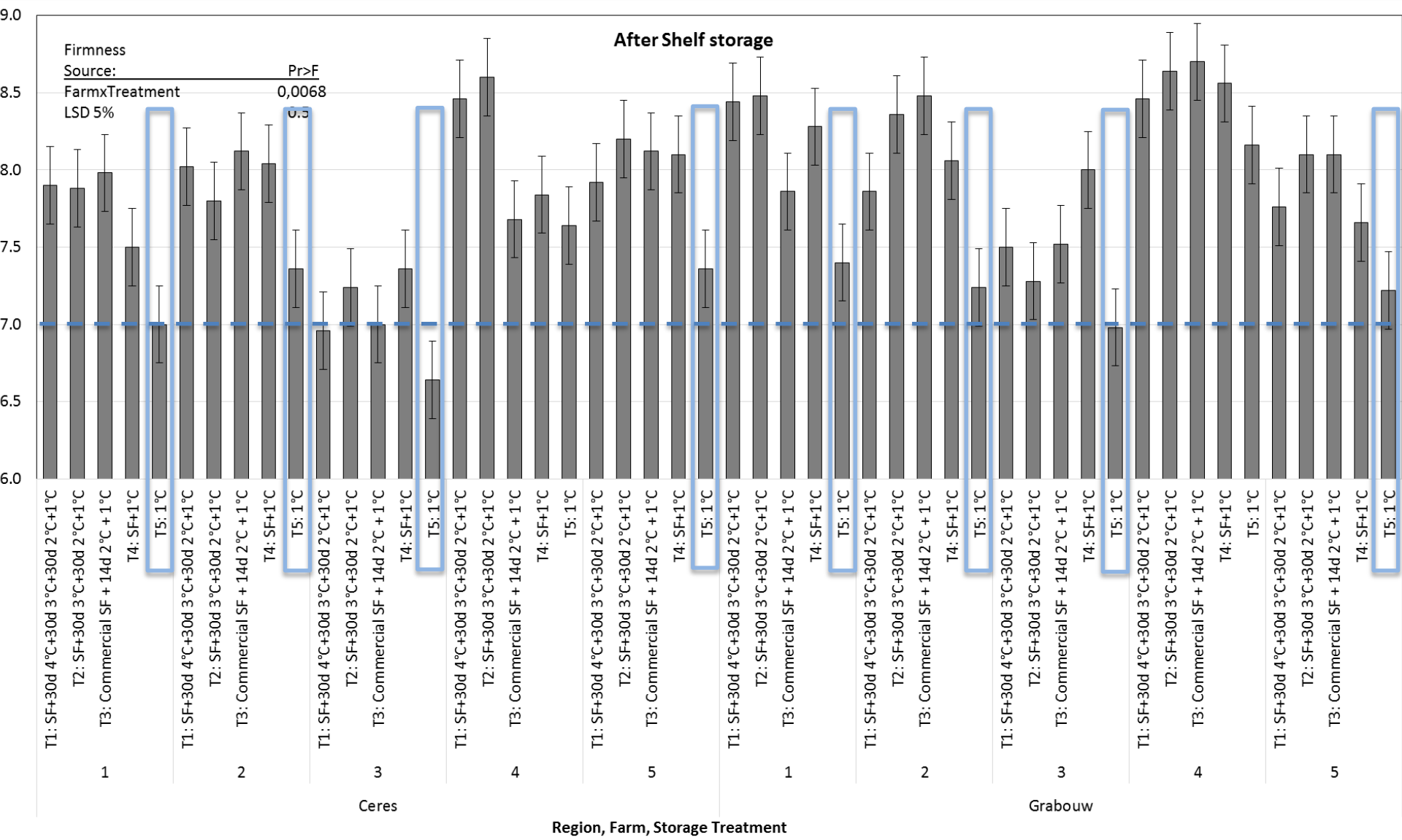
	Farm	2017	2018	2019
Ceres	1	8.3	8.7	8.6
	2	7.4	8.1	8.0
	3	8.4	8.4	7.8
	4	7.4	8.3	8.3
	5	8.4	8.5	8.8
Grabouw	1	8.0	9.2	8.4
	2	8.1	9.3	8.6
	3	8.8	8.5	8.6
	4	8.7	9.1	8.6
	5	8.3	8.7	8.6

2018-19; Year 2

Firmness - after CA (2018-19; Year 2)

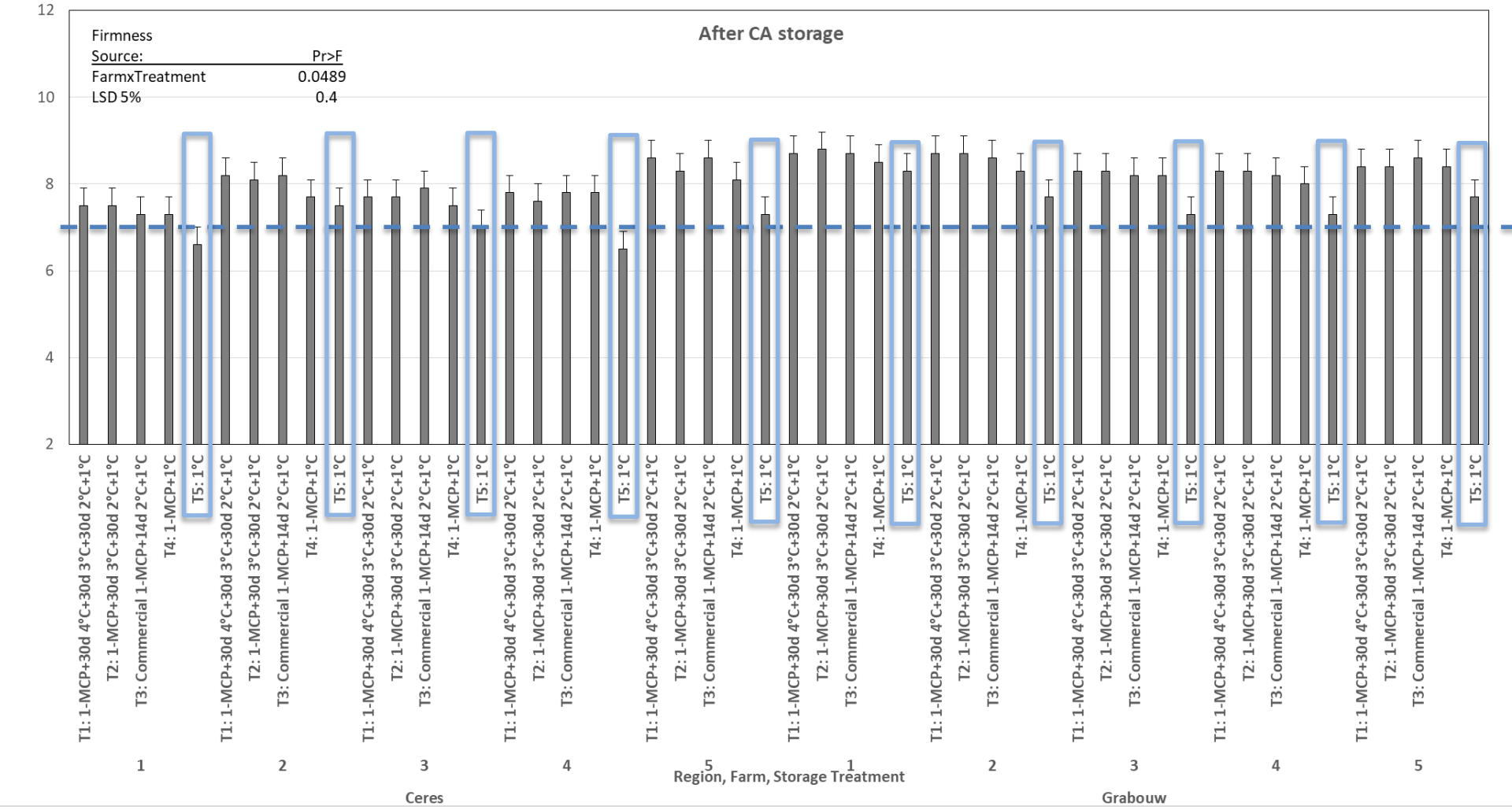


Firmness - after Shelf (2018-19; Year 2)

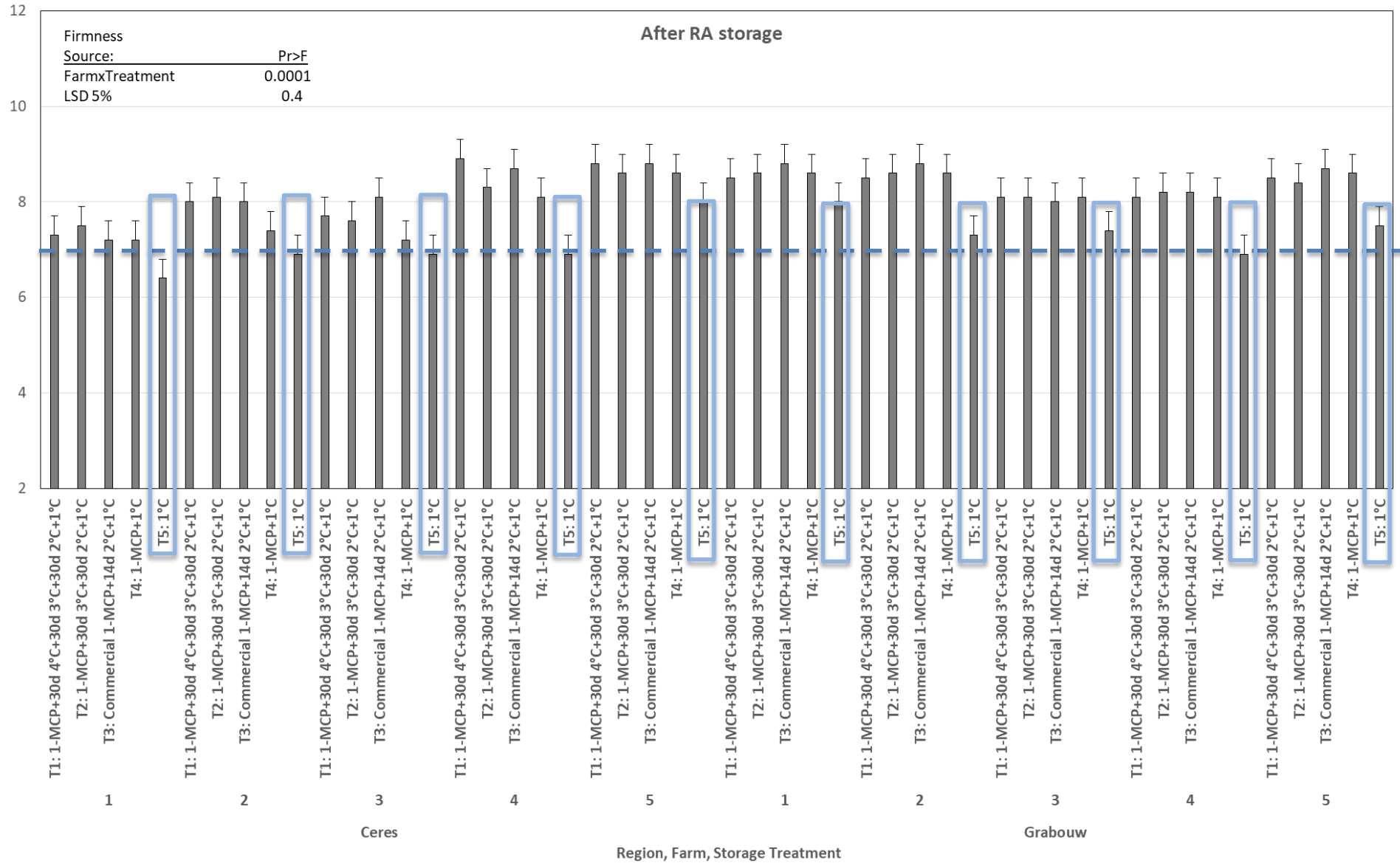


2019-20; Year 3

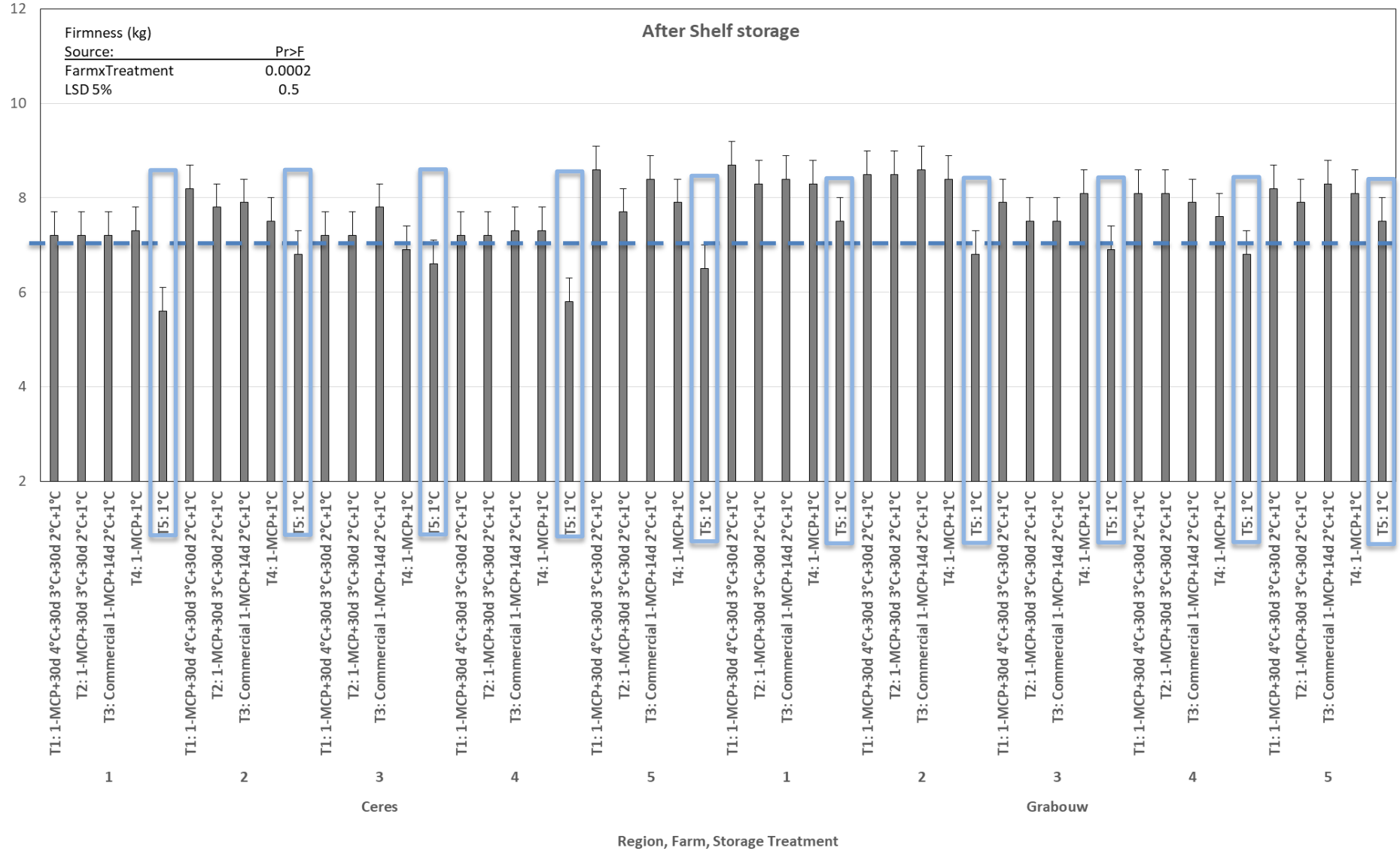
Firmness - after CA (2019-20; Year 3)



Firmness - after RA (2019-20; Year 3)



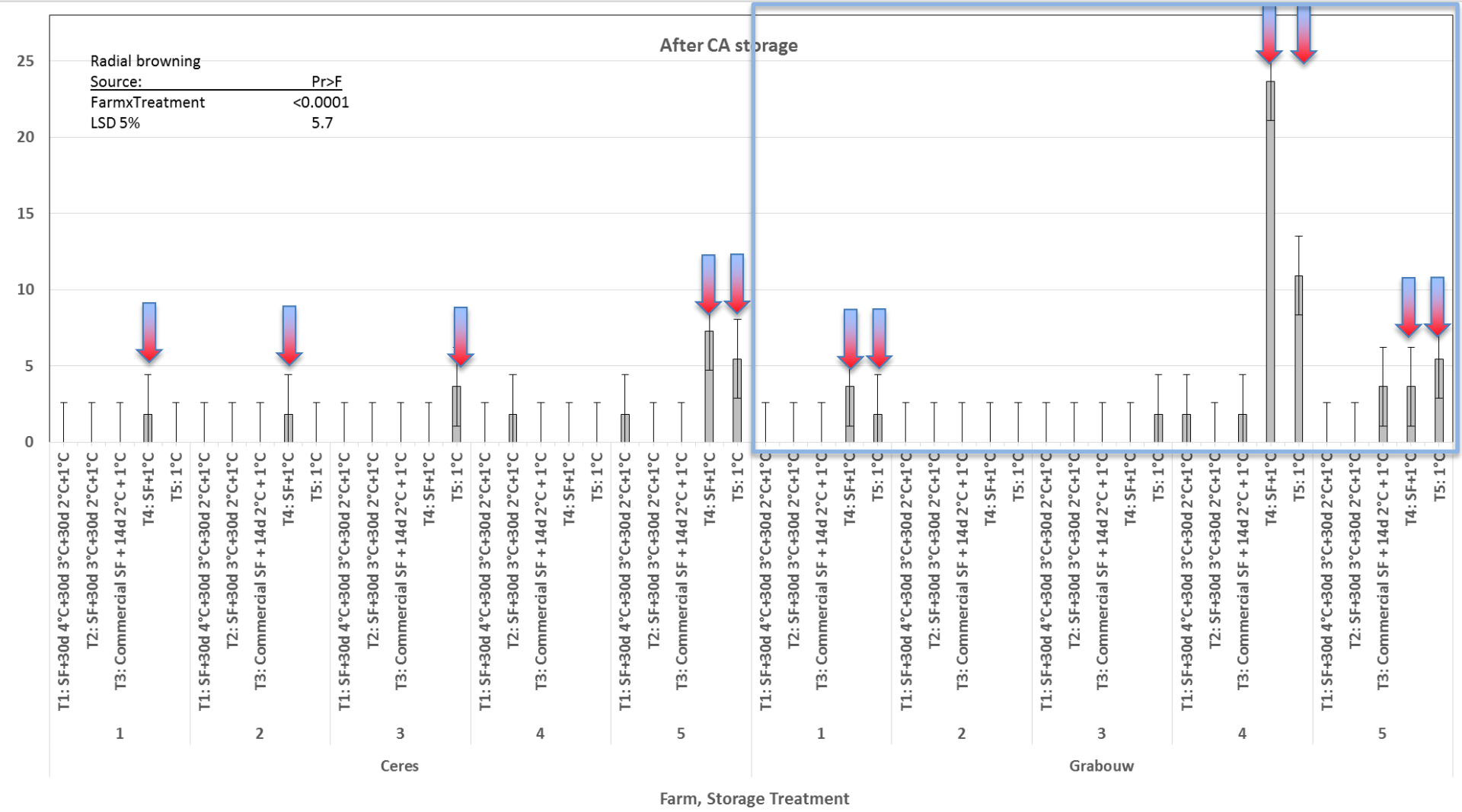
Firmness - after Shelf (2019-20; Year 3)



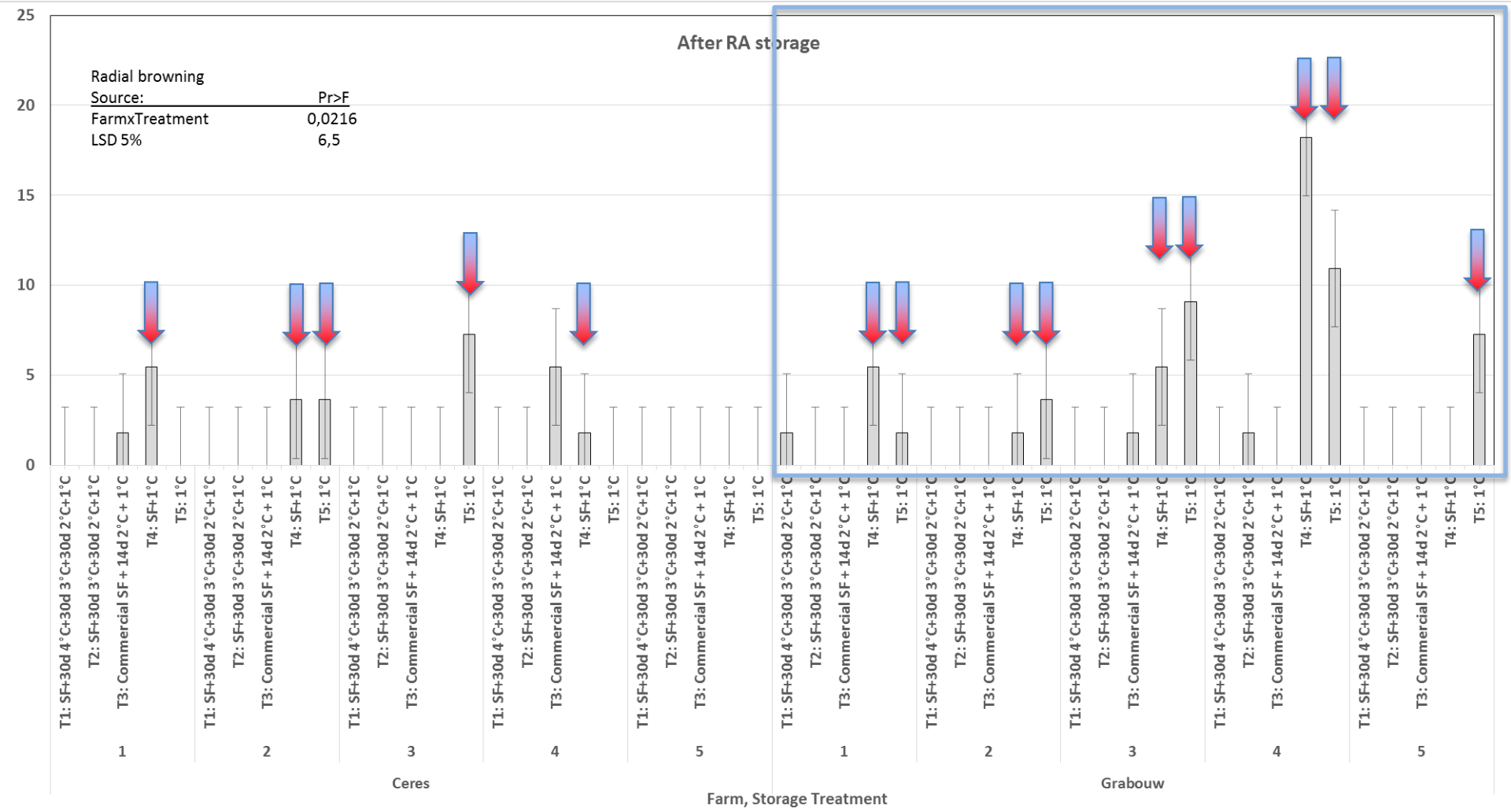
3. Step cool

2018-19; Year 2

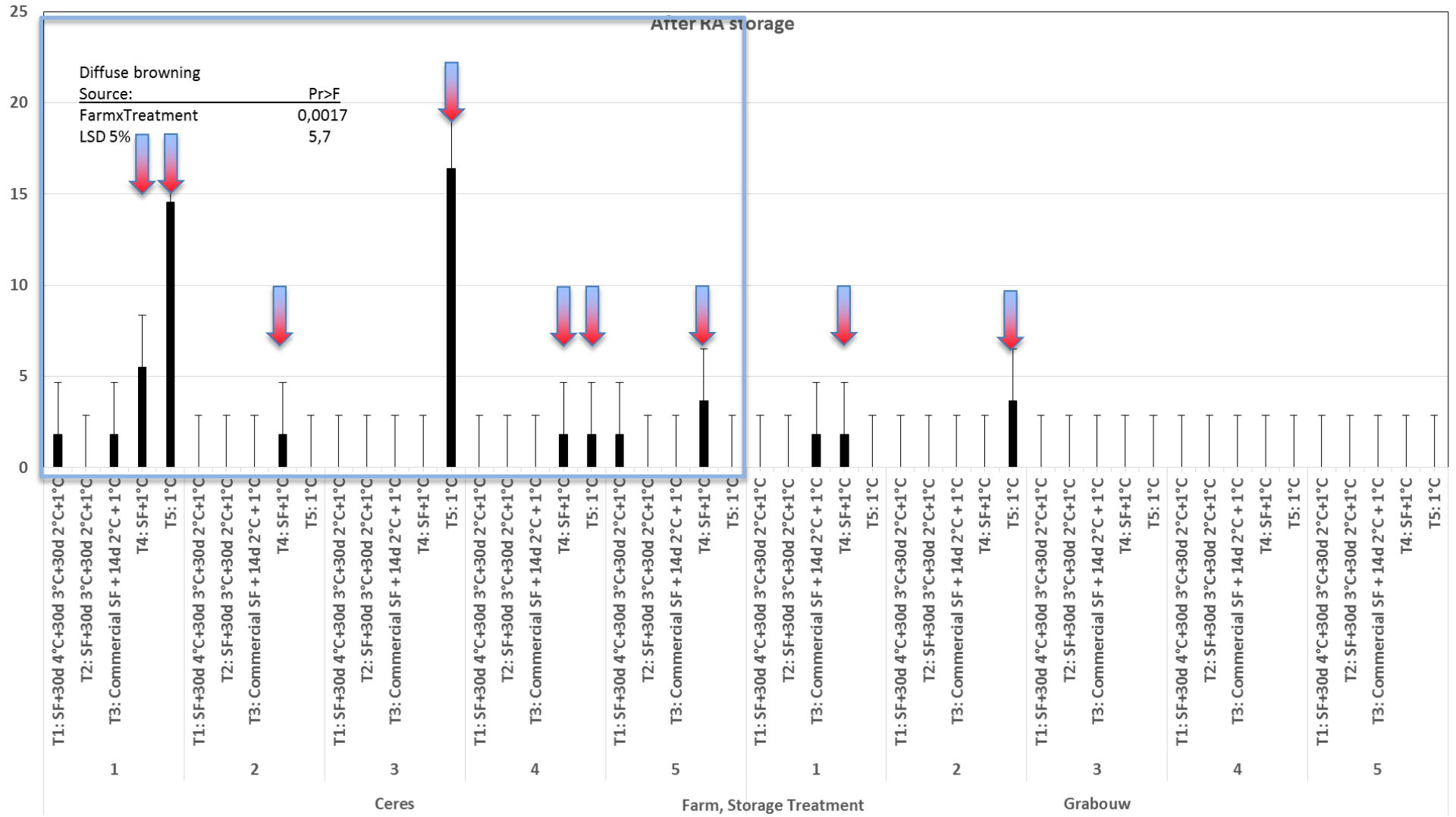
Radial browning - after CA (2018-19; Year 2)



Radial browning - after RA (2018-19; Year 2)

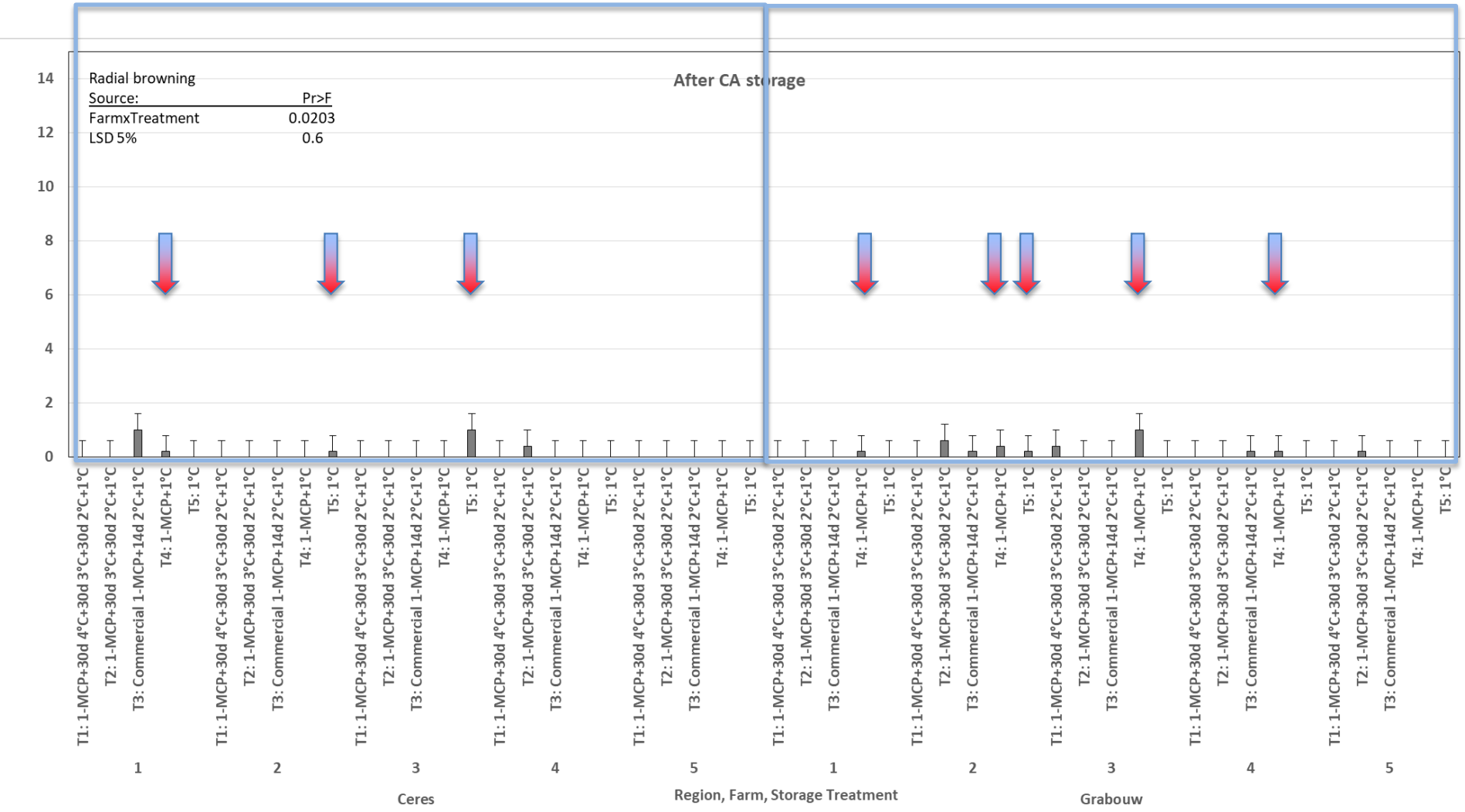


Diffuse browning - after RA (2018-19; Year 2)

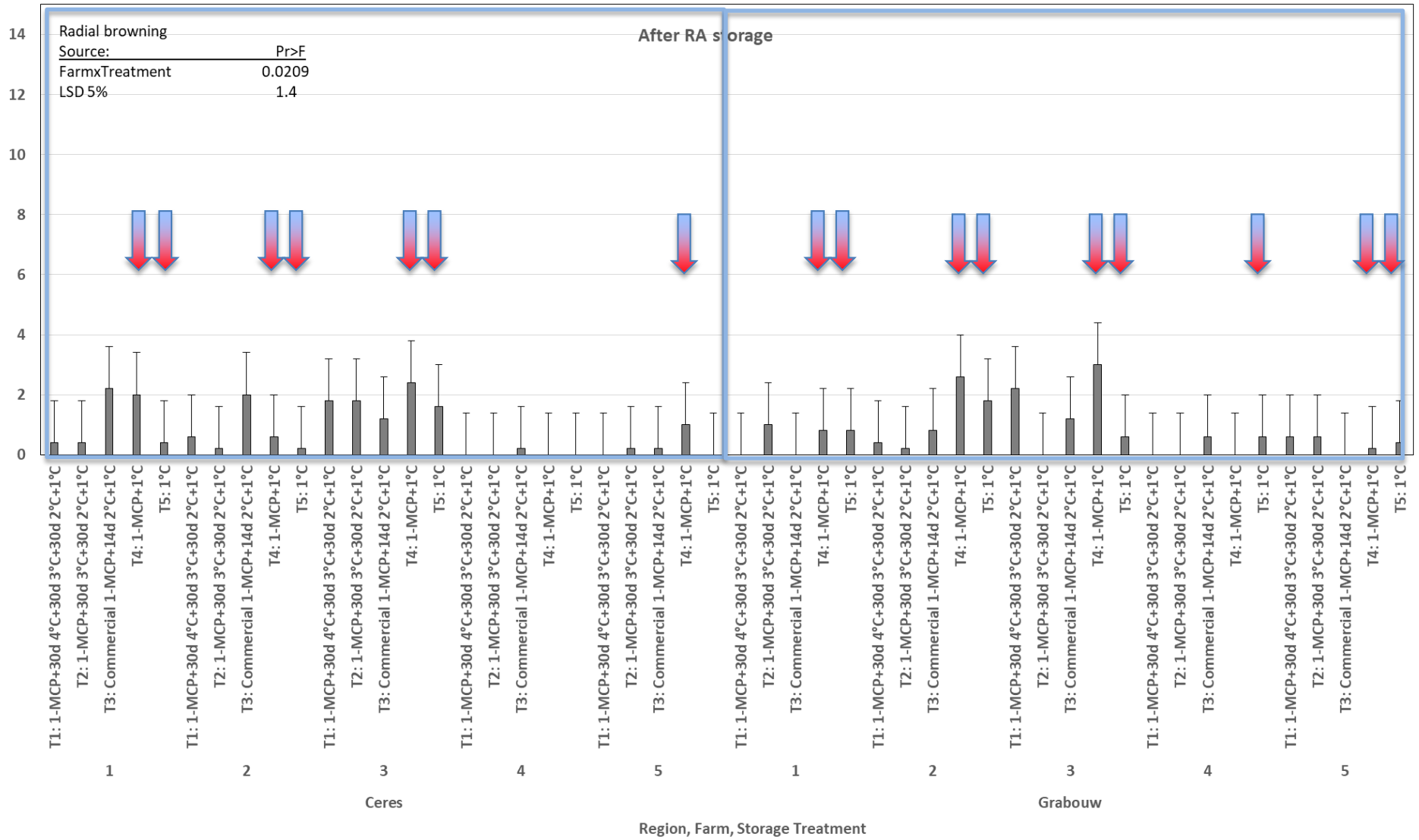


2019-20; Year 3

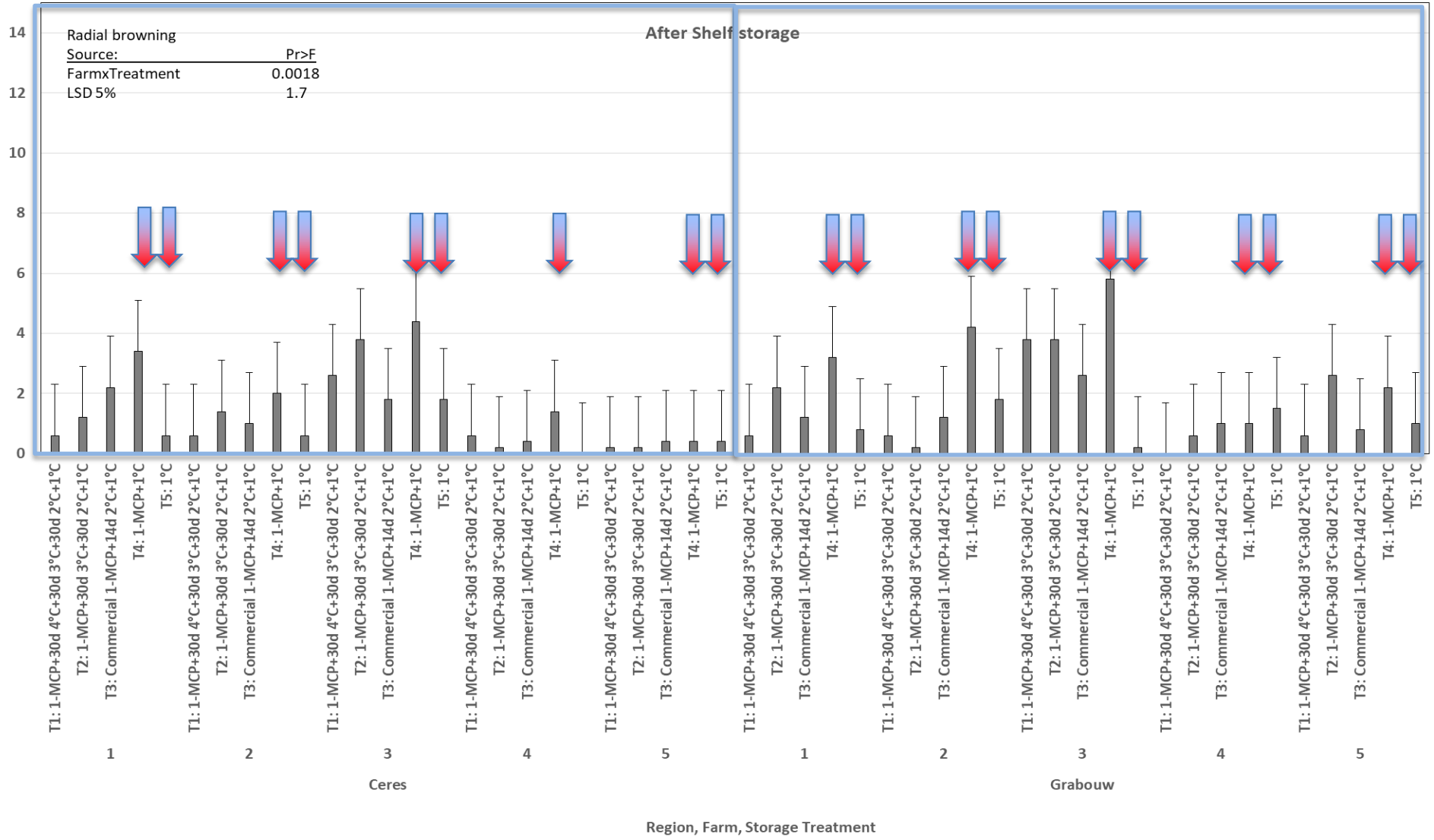
Radial browning - after CA (2019-20; Year 3)



Radial browning - after RA (2019-20; Year 3)



Radial browning - after Shelf (2019-20; Year 3)



Key results

- **Storing for up to 9 months CA is not recommended**

  (IB risk in high risk years)

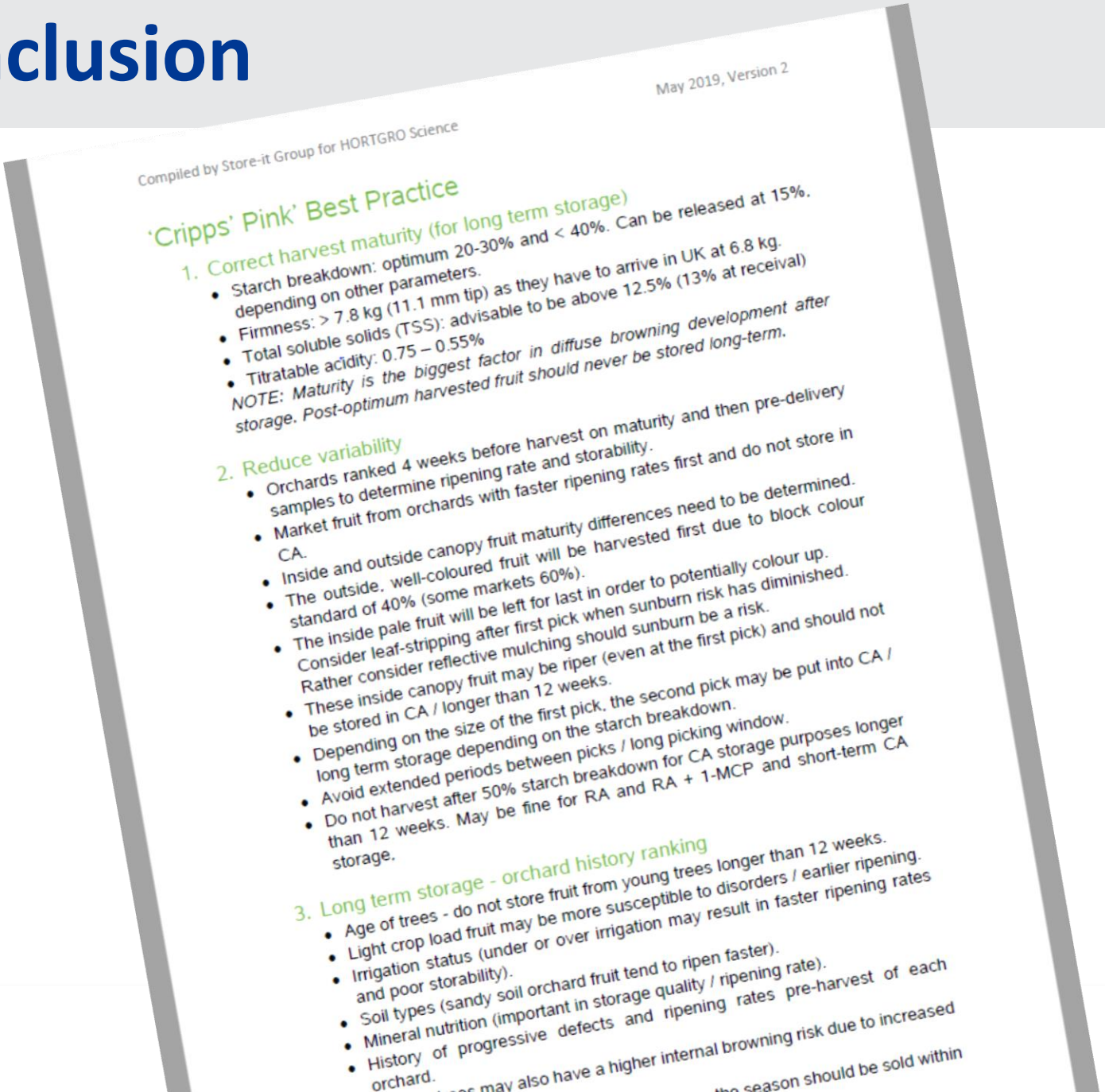
- **These conditions were followed for trial purposes only to get treatment differences and it identified possible risk protocols not to be followed commercially**

- **Area differences possibly due to harvest maturity**

Key results

- 2017-2018 (Year 1) Low risk year
- 2018-2019 (Year 2) High risk year - 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) High risk year - low IB incidence (HMI: 30-40%)

Conclusion



Compiled by Store-it Group for HORTGRO Science

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'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 receival)
- 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.

...es may also have a higher internal browning risk due to increased

...the season should be sold within

Thank You!

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‘Cripps’ Pink’ internal browning

and long term storage - what has been learnt

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