Modern Canopy Management and Training Strategies

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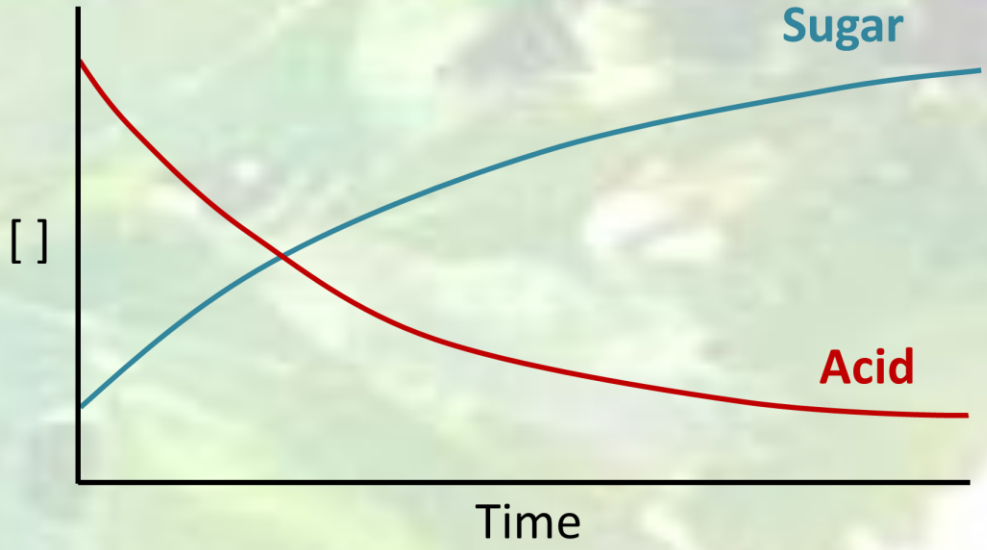
TEXAS A&M AGRILIFE EXTENSION

Leaf Removal to Regulate Fruit Ripening

Texas A&M AgriLife Extension

RIPENING PARAMETERS

- Technological ripening parameters
  - Sugars, organic acids



- Phenolic maturity
  - Quantity and quality of tannins, pigments
- Flavour and aromatic ripeness
  - Typical varietal flavour and olfactory features

CLIMATE RELATED CHALLENGES

- Accelerated maturation
- Earlier harvest dates
- Phenolic maturity slower than sugar accumulation
- Anthocyanin synthesis repressed

EXCESSIVELY FAST SUGAR ACCUMULATION

- High alcohol content
- Stuck fermentation
- Unwanted by-products
- Inhibition of malolactic fermentation

LEAF REMOVAL

- Sugar accumulation rate dependent on ratio of leaf area to fruit weight (LA/FW)
- Slower sugar accumulation by reducing leaf area

AIM

- Quantify the impacts of different leaf removal techniques on the canopy architecture and ripening of Cabernet Sauvignon in a hot Australian climate

↓

- Provide vineyard managers with a canopy management strategy to regulate sugar accumulation, phenolic maturity, and flavour ripeness

SITE DETAILS

- Irrigated commercial vineyard in McLaren Vale winegrowing region
- 12-year-old planting of CS clone CW44
- 110 Richter rootstock
- North-South row orientation
- 3 m x 2 m inter-row intra-row
- Sprawl canopy
- Spur-pruned, 40 nodes/vine

TREATMENTS: LEAF PLUCKING AROUND FRUITZONE

- Leaves removed from basal portion of shoots
- Reduces photosynthetic area
- Increases sunlight exposure and air circulation

- Can lead to higher temperatures and severe UV exposure
  - harmful sunburns
  - inhibition of biosynthesis of phenolic compounds

TREATMENTS: LEAF PLUCKING APICAL TO BUNCHES

- Reduces leaf photosynthetic area while maintaining canopy shade around bunch zone
- Prior study demonstrated potential to delay optimal TSS accumulation by ~ two weeks

Palliotti et al. 2013

TREATMENTS: TRIMMING

- Reduces leaf photosynthetic area while maintaining canopy shade
- Prior study delayed harvest date of Grenache by two weeks
- Same TSS and higher anthocyanin concentration

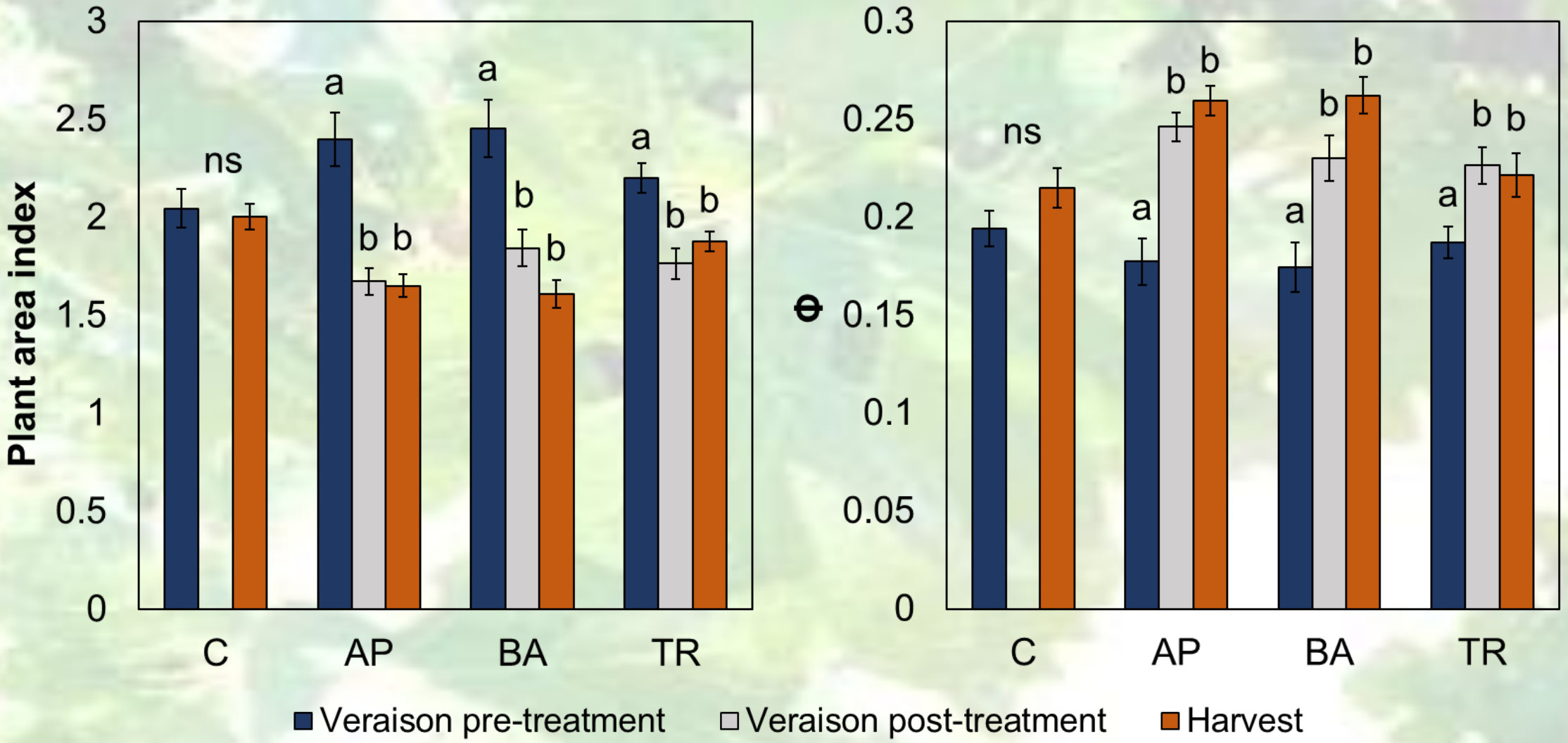
Martínez de Toda et al. 2014

MEASUREMENTS: CANOPY ARCHITECTURE

- Analysis using VitiCanopy app
- **Plant area index (PAI)**
  - Total one-sided area of plant tissue per unit ground surface area
- **Porosity (Φ)**
  - Light penetration through the canopy

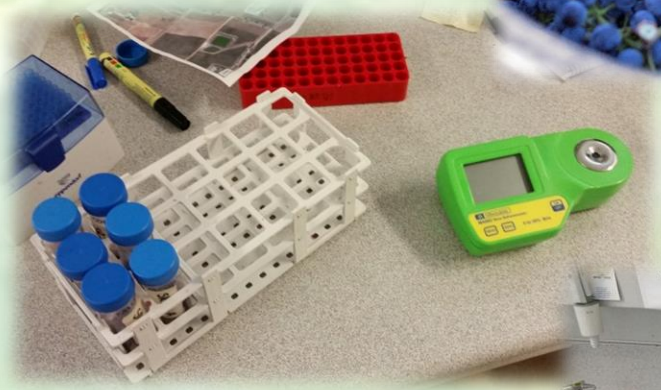
De Bei et al. 2016

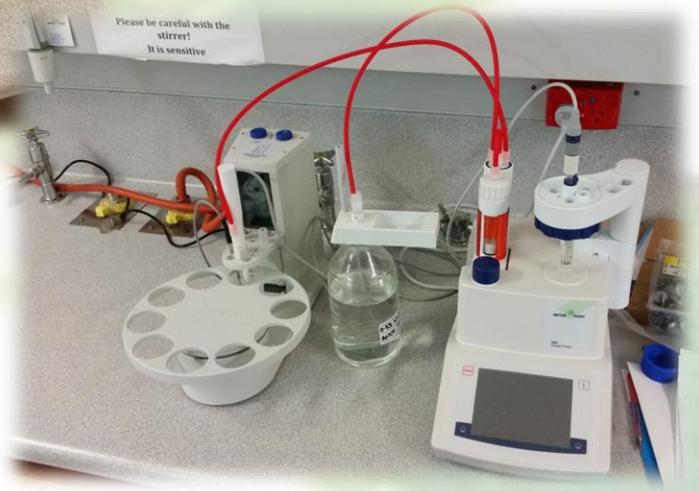
RESULTS: CANOPY ARCHITECTURE



MEASUREMENTS: YIELD PARAMETERS AND MATURITY ASSESSMENTS

- Yield per vine
- Bunch number
- Berry weight
- Total soluble solids (TSS)
- pH, TA
- Total anthocyanins, phenolics, total tannins

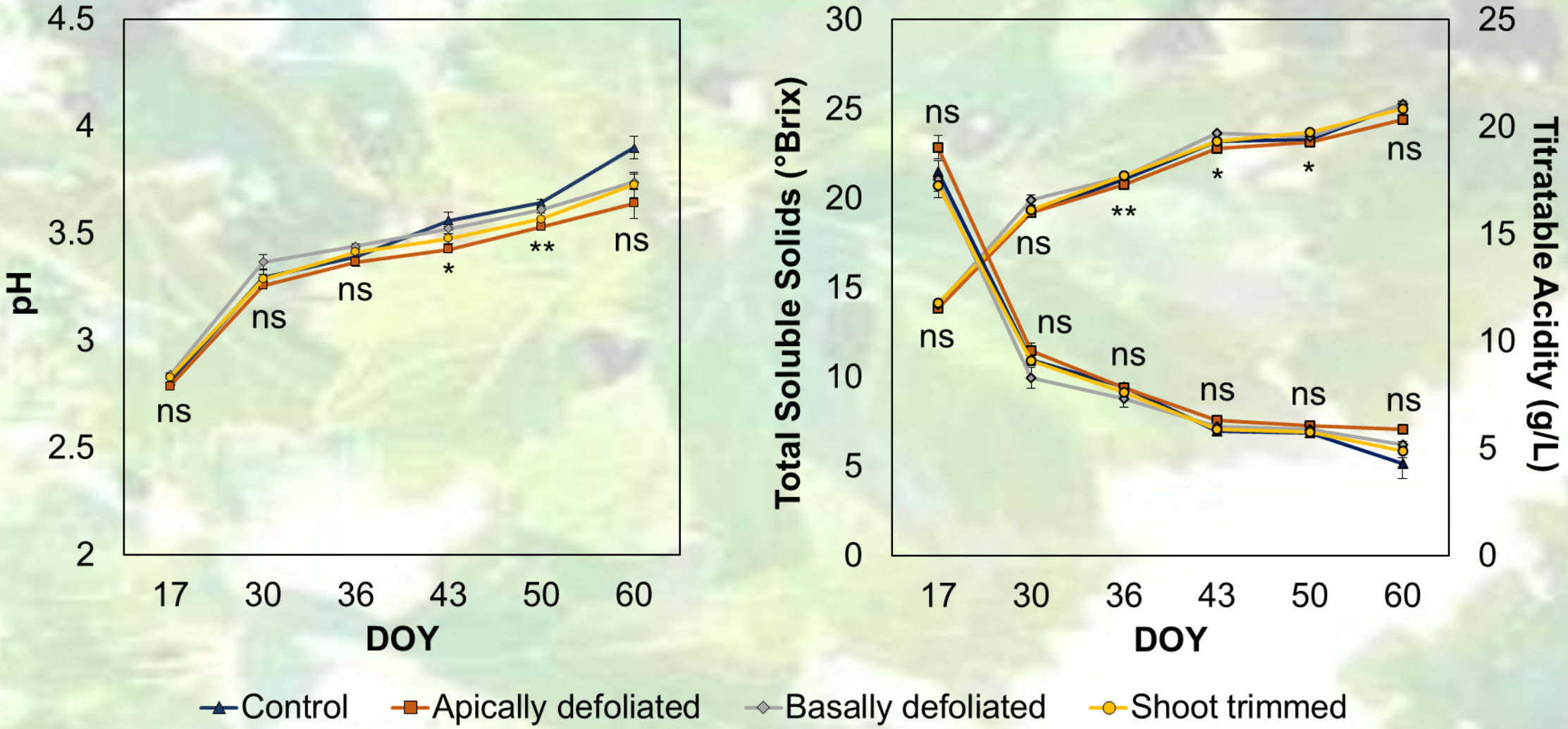




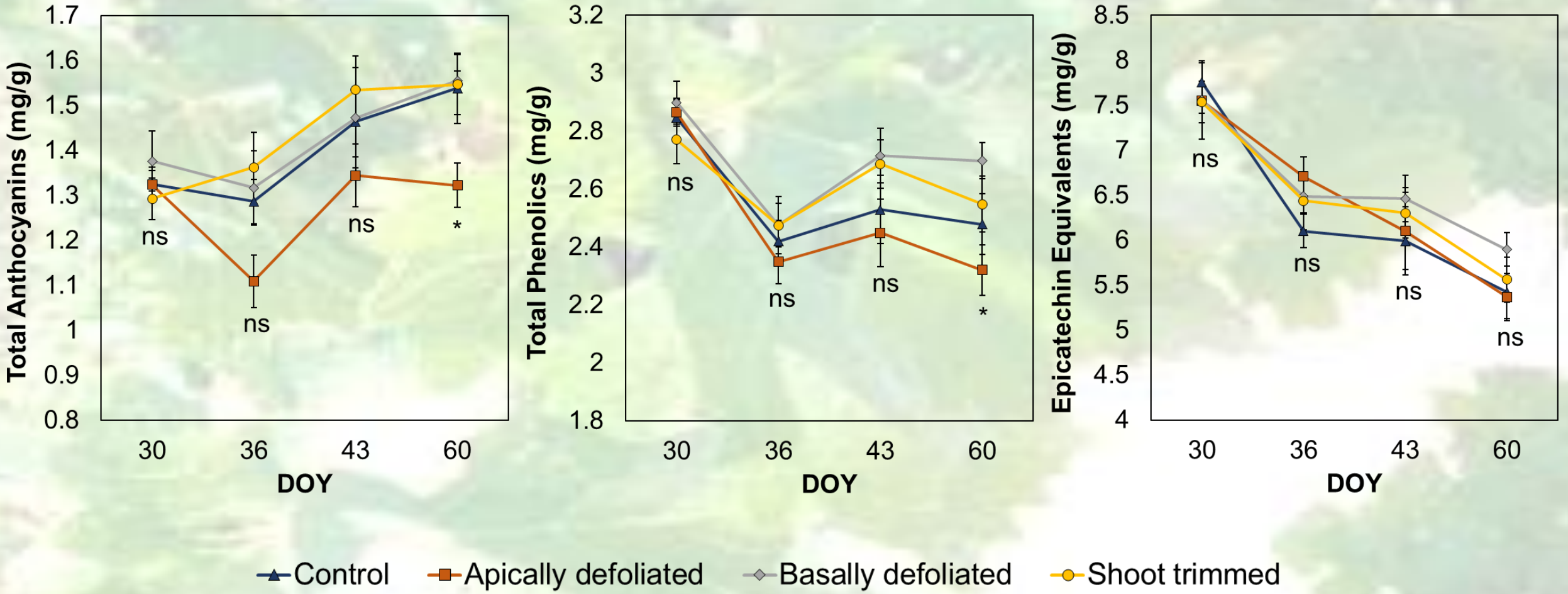
RESULTS: YIELD AND COMPONENTS

Treatment	Yield (kg/m)	Bunch no. (no./m)	Bunch Weight (g)	Berry Weight (g)	LA/Y (m^2/kg)
Control	**2.4** ± 0.7	**32** ± 6.9	**72.8** ± 10.1	**0.78** ± 0.05	**2.6** ± 0.8
Apical leaf removal	**3.3** ± 1.2	**40** ± 5.5	**80.5** ± 25.2	**0.89** ± 0.06	**1.5** ± 0.4
Basal leaf removal	**2.5** ± 1.2	**32** ± 12.1	**75.2** ± 10.9	**0.88** ± 0.12	**2.1** ± 1.0
Shoot trimming	**2.6** ± 0.6	**32** ± 7.5	**81.1** ± 12.3	**0.83** ± 0.03	**2.2** ± 0.7
Significance	ns	ns	ns	ns	**0.018**

RESULTS: TECHNOLOGICAL RIPENESS



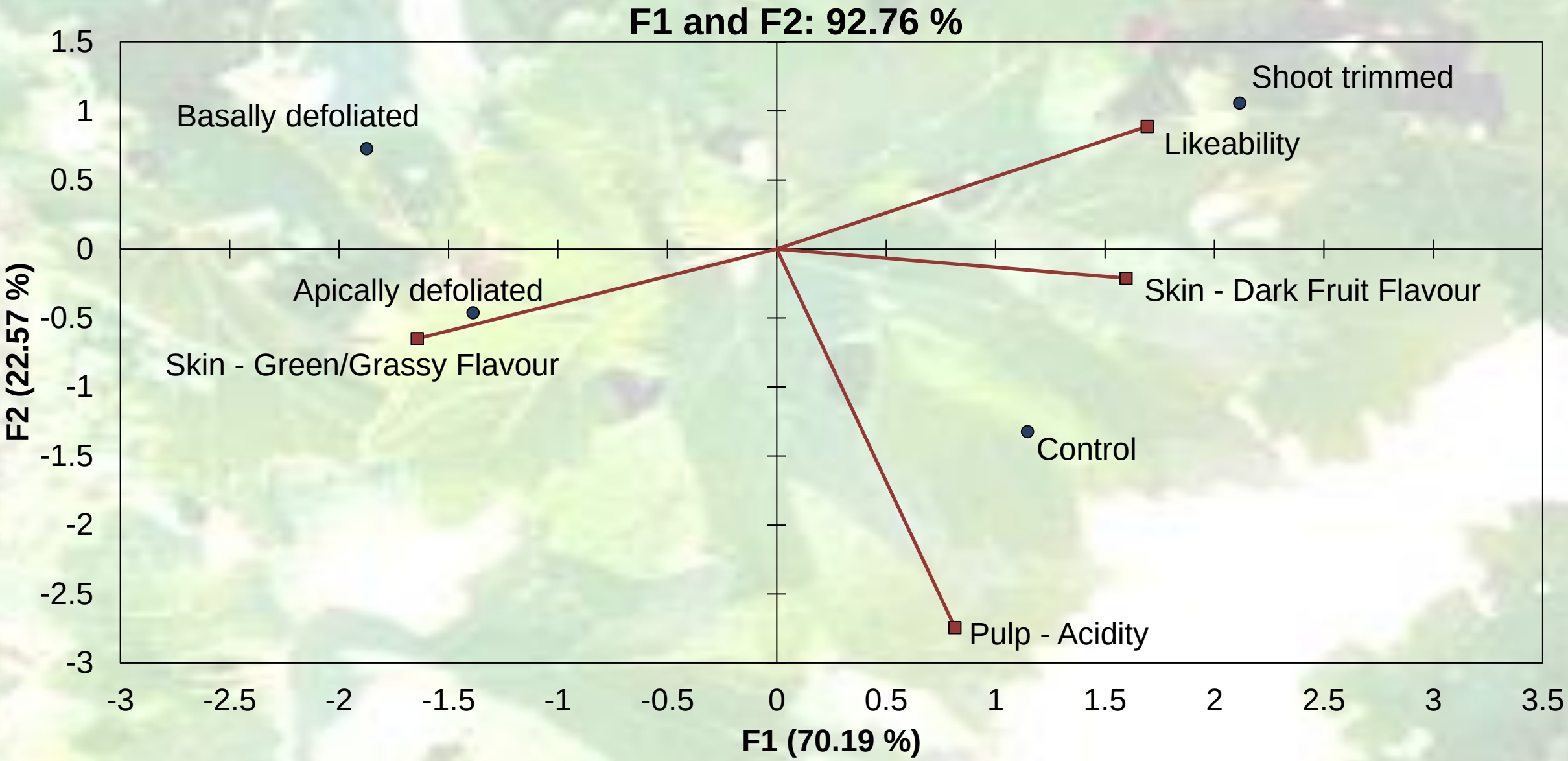
RESULTS: ANTHOCYANINS, PHENOLICS, TANNINS



MEASUREMENTS: BERRY SENSORY ASSESSMENT

- Assessed characteristics of skin, pulp and seeds
- Conducted by 11 trained panellists

RESULTS: BERRY SENSORY ASSESSMENT



CONCLUSIONS

- Results did not indicate decrease in the rate of grape sugar accumulation as a result of investigated defoliation techniques
- Despite decrease in PAI, increase in Φ for all treatments
- Wide vineyard spacing, hot climate, non-light limiting environment likely contributing factors

Cordon Establishment Techniques for Long-Term Vineyard Management

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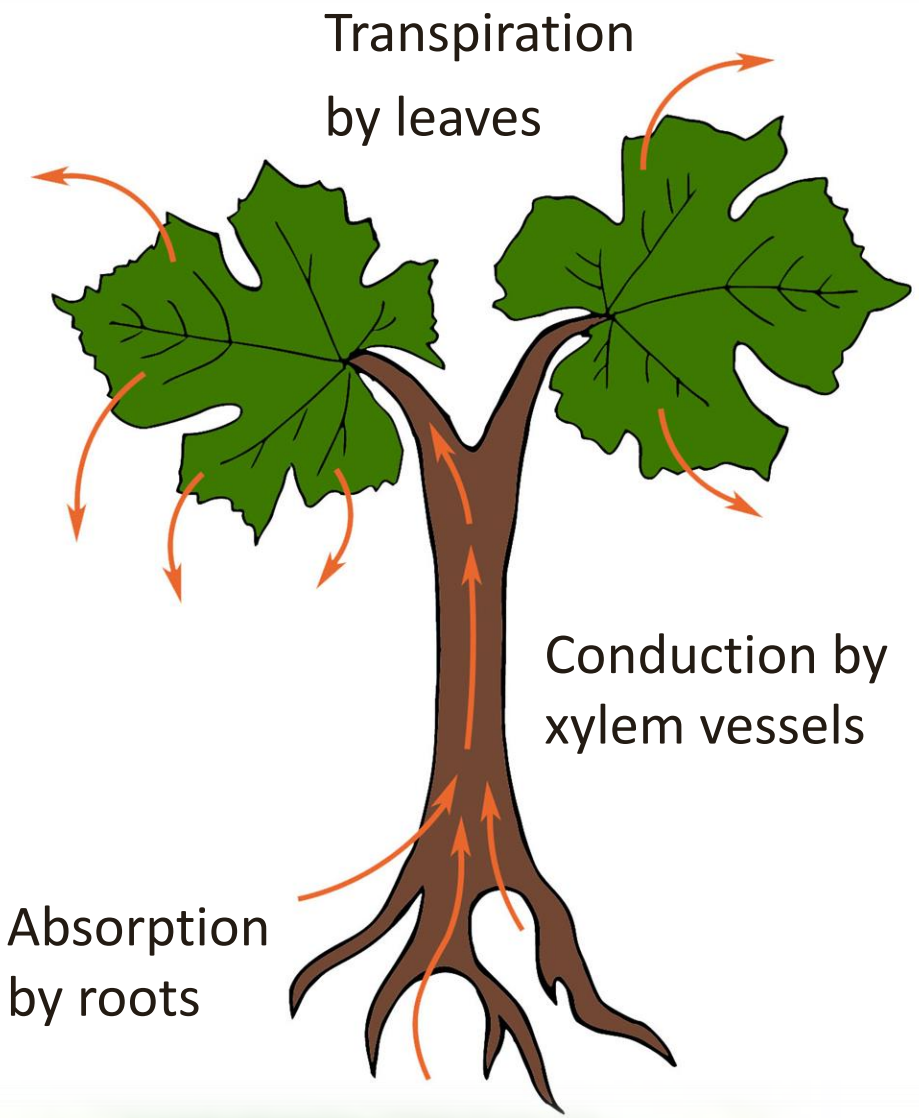
VINEYARD DECLINE

- Soil pathogens
- Trunk diseases
- Viruses
- Water status
- Environmental
- Other problems arising from poor management decisions…

Atallah et al. 2011, Credi and Babini 1997, Rahman et al. 2008, Rolshausen et al. 2010, Sosnowski and McCarthy 2017, White 2015

STRANGULATION OF THE CORDON

COHESION-TENSION THEORY



XYLEM MORPHOLOGY

- Conductivity determined by size and structure of vessels
- Impacted by water availability

CARBOHYDRATE RESERVE STATUS

- Water deficit may inhibit vegetative growth and photosynthesis
- Could lead to a reduction in carbohydrate reserves

TIGHT WRAPPING

- Fast and cost efficient
- Provides additional support
- Reduces the risk of rolling
- Mitigates the need for foliage wires

CONSTRICTION AND GIRDLING

- Constriction applied on olive trees led to reduction in vegetative growth
- Lower stem water potential
- Reduction in vigour observed after girdling

TRUNK DISEASE SUSCEPTIBILITY

- Severity of symptoms may be more influenced by climatic factors than vineyard practices
- May be more likely to express symptoms when health is compromised by stress

Sosnowski et al. 2007,
Van Niekerk et al. 2011

AIM

- To quantify the impacts of different cordon establishment techniques on vine health and longevity

HYPOTHESIS

- Wrapping developing cordon arms tightly around the cordon wire will cause a constriction of the vascular system, becoming worse over time and disrupting the flow of water and nutrients

SITE DETAILS

SITE 1

- **Cultivar: Cabernet Sauvignon**
- Clone: WA Cape Selection
- Rootstock: 1103 Paulsen
- **Vine Age: 4 years**
- Orientation: North-South
- Inter-row spacing: 3 m
- Intra-row spacing: 2 m
- Foliage wire height: 12 cm

SITE 2

- **Cultivar: Shiraz**
- Clone: BVRC12
- Rootstock: Own roots
- **Vine Age: 21 years**
- Orientation: North-South
- Inter-row spacing: 2.8 m
- Intra-row spacing: 1.8 m
- Foliage wire height: 30 cm

TRUNK DISEASE SURVEY

- 10 vineyard sites
- Cordons ranging from 14-24 years old
- Varying degrees of cordon strangulation

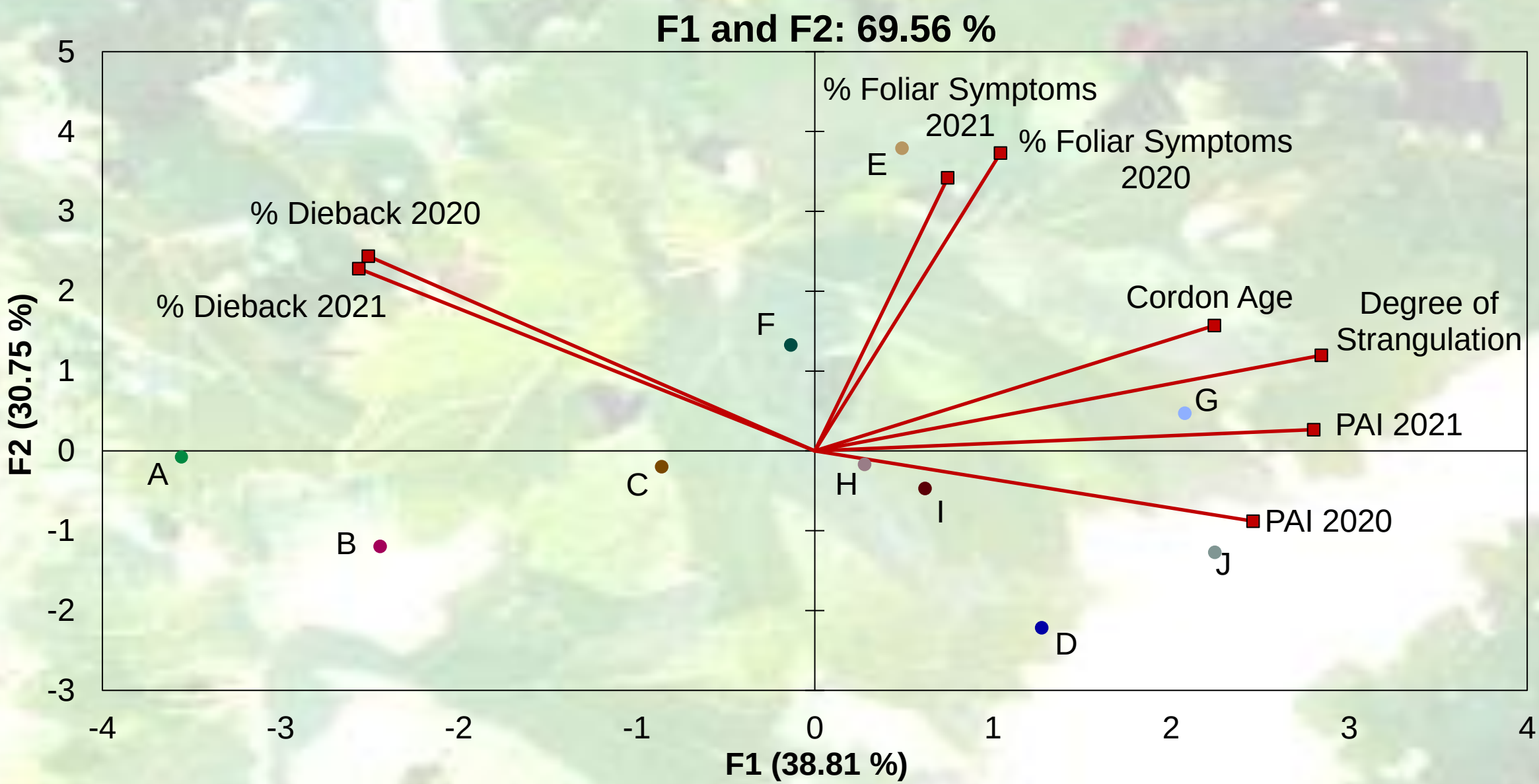
0	no strangulation	
1	minimal strangulation	
2	moderate strangulation	
3	severe strangulation	
4	very severe strangulation	

MEASUREMENTS: DIEBACK, DISEASE SUSCEPTIBILITY

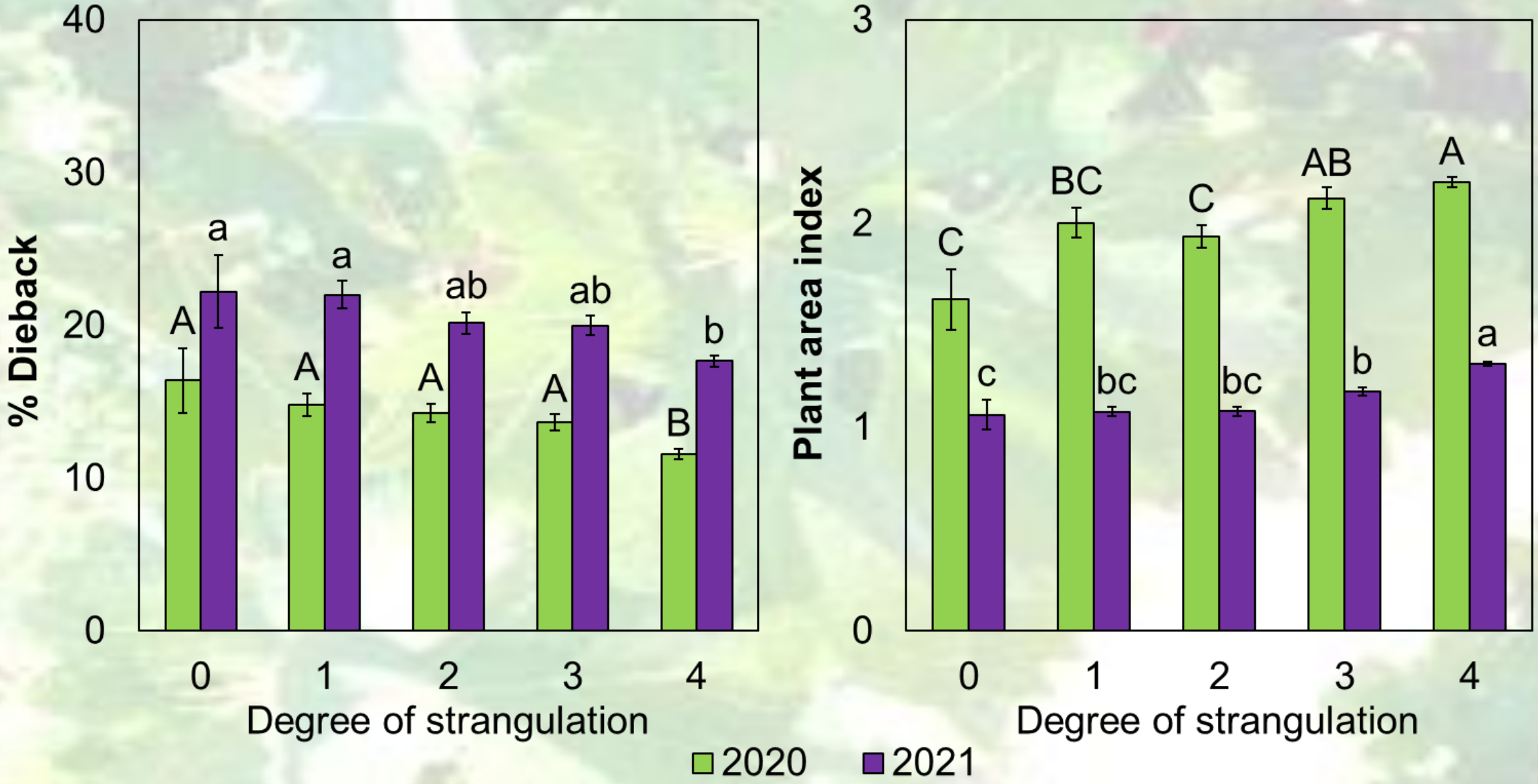
- **Cordon dieback**
  - 0-to-100%
- ***Eutypa* dieback foliar symptoms**
  - 0-to-100%
  - stunted shoots with chlorotic and yellow leaves
- **Degree of cordon strangulation**
  - 0-to-4

Carter 1991

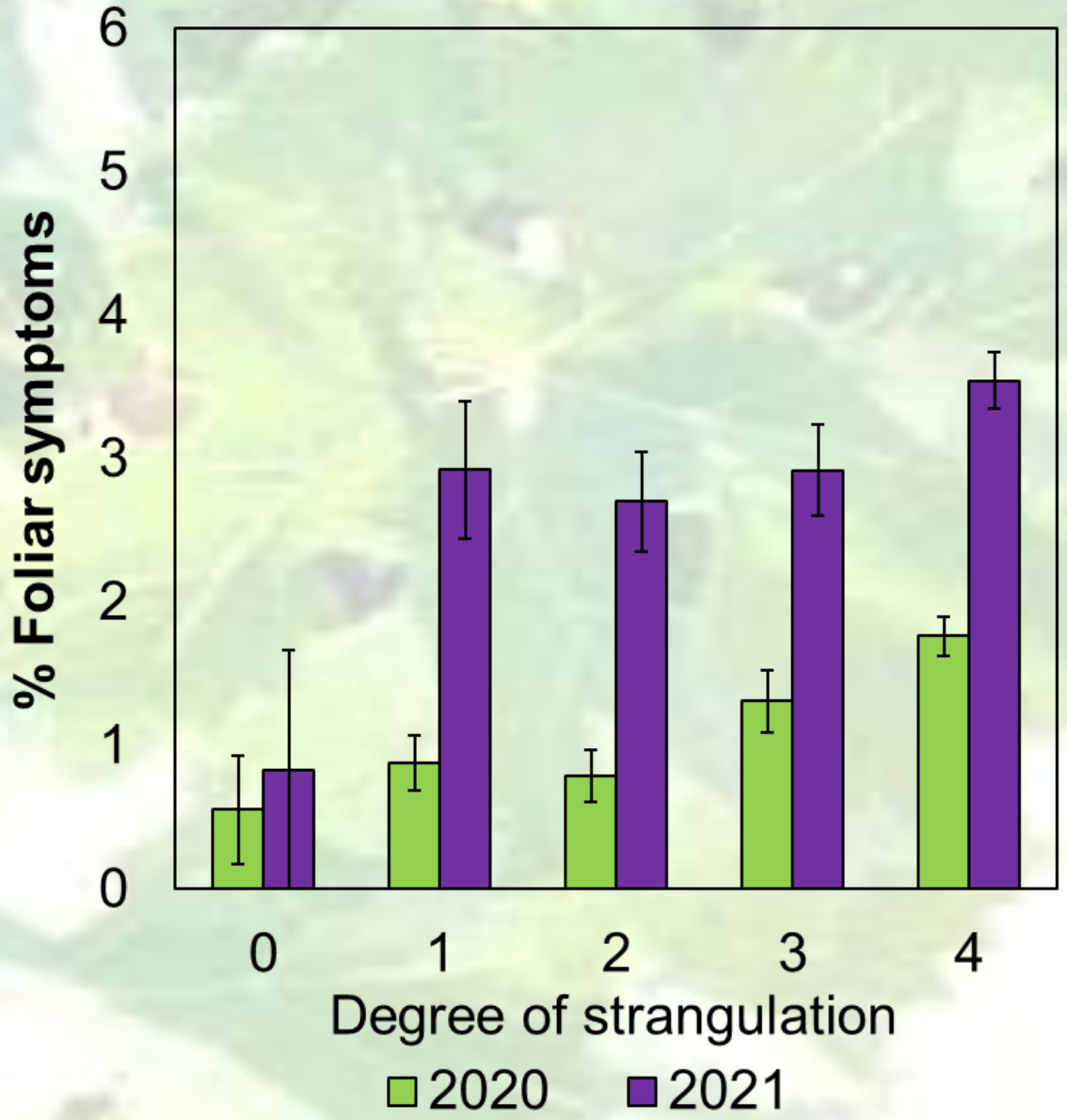
RESULTS: DISEASE SURVEY



RESULTS: DIEBACK, PLANT AREA INDEX



RESULTS: FOLIAR SYMPTOMS



TREATMENTS: TIGHTLY WRAPPED

- Wrapped tightly around the cordon wire
- Standard industry practice

TREATMENTS: PLACED ON TOP OF WIRE

- Placed on top of the wire
- Tied in place at three or four locations

TREATMENTS: WOVEN THROUGH CLIP SYSTEM

- Woven through plastic clip system
- Centred between parallel cordon wires

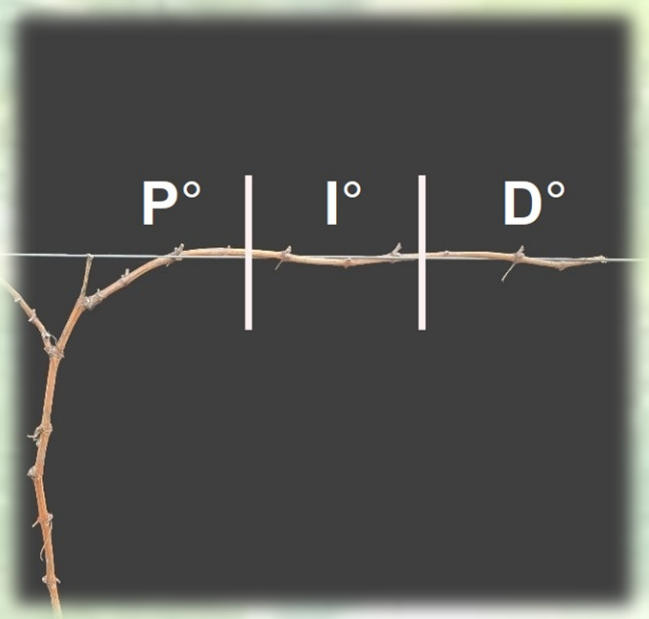
TREATMENTS: S-BEND

- Wrapped around two parallel cordon wires
- Loose, s-shaped bend

NEWSOM TWIST

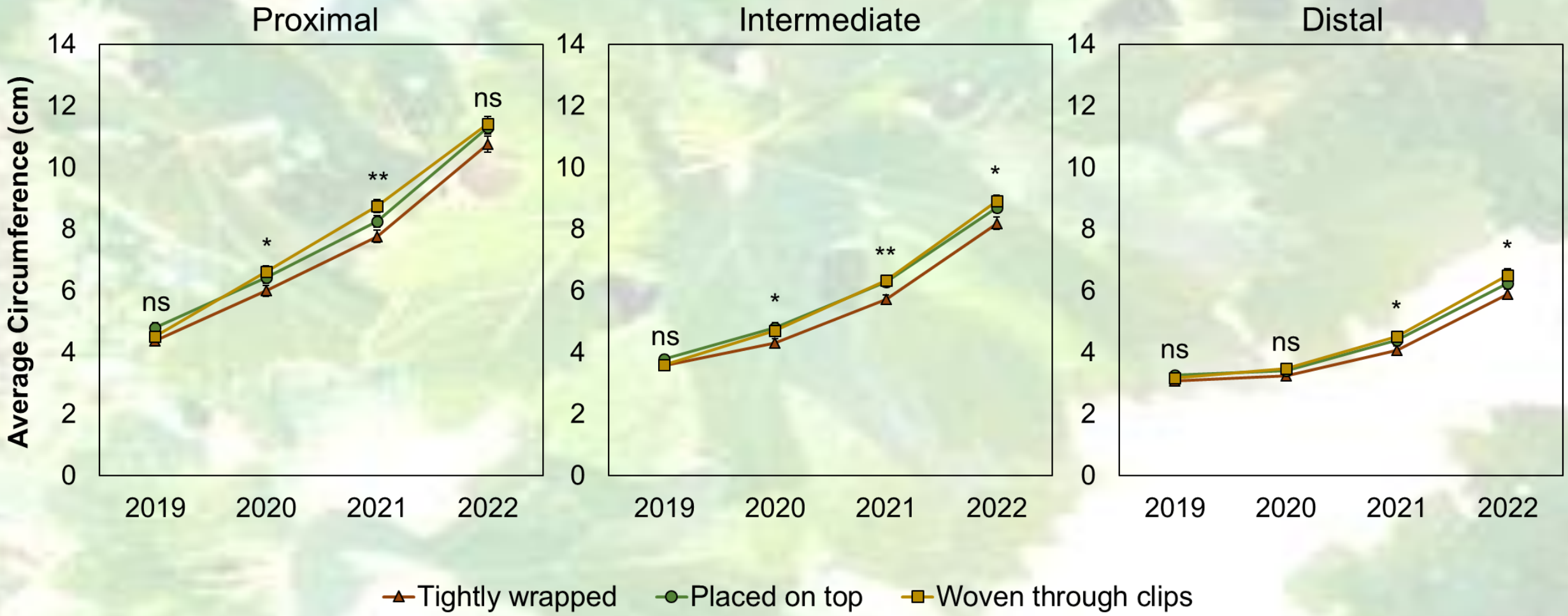
MEASUREMENTS: VEGETATIVE GROWTH

- Pruning weight
- Cordon circumference
- Plant area index (PAI)



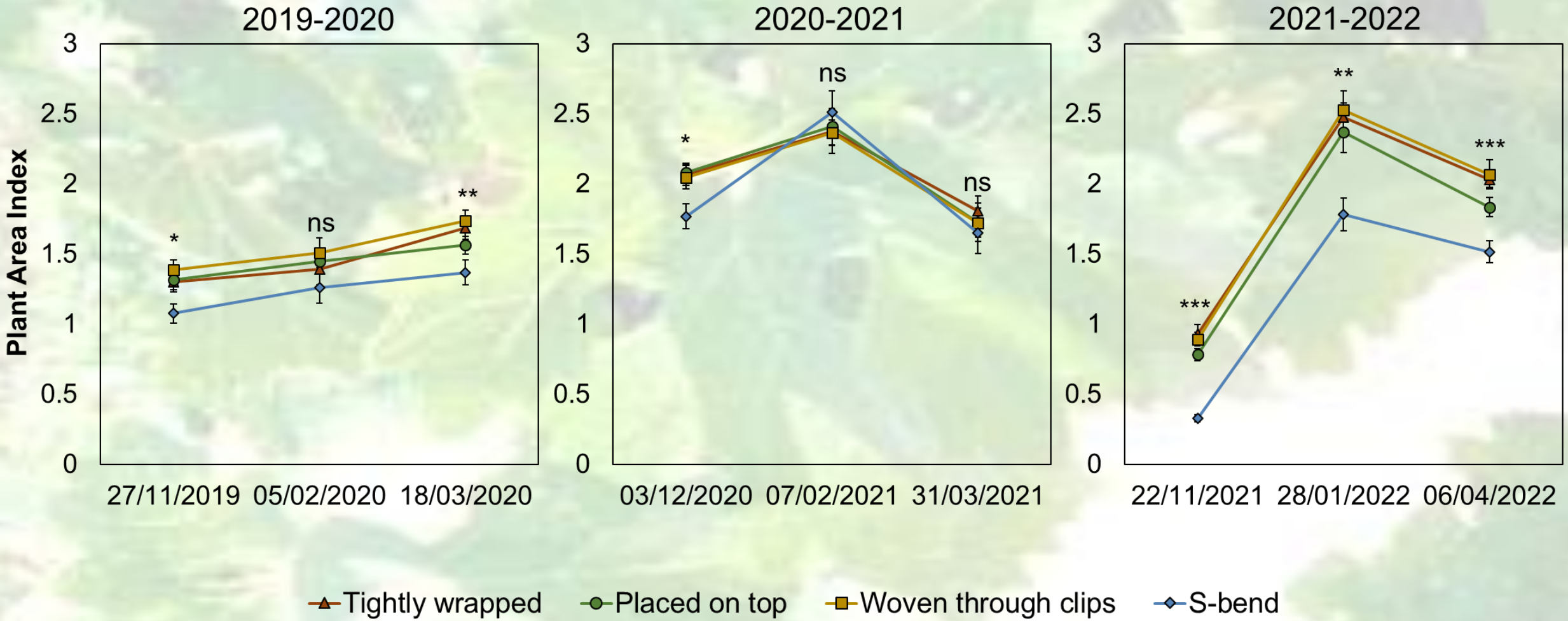
RESULTS: CORDON CIRCUMFERENCE

4-YEAR-OLD CABERNET SAUVIGNON



RESULTS: PLANT AREA INDEX

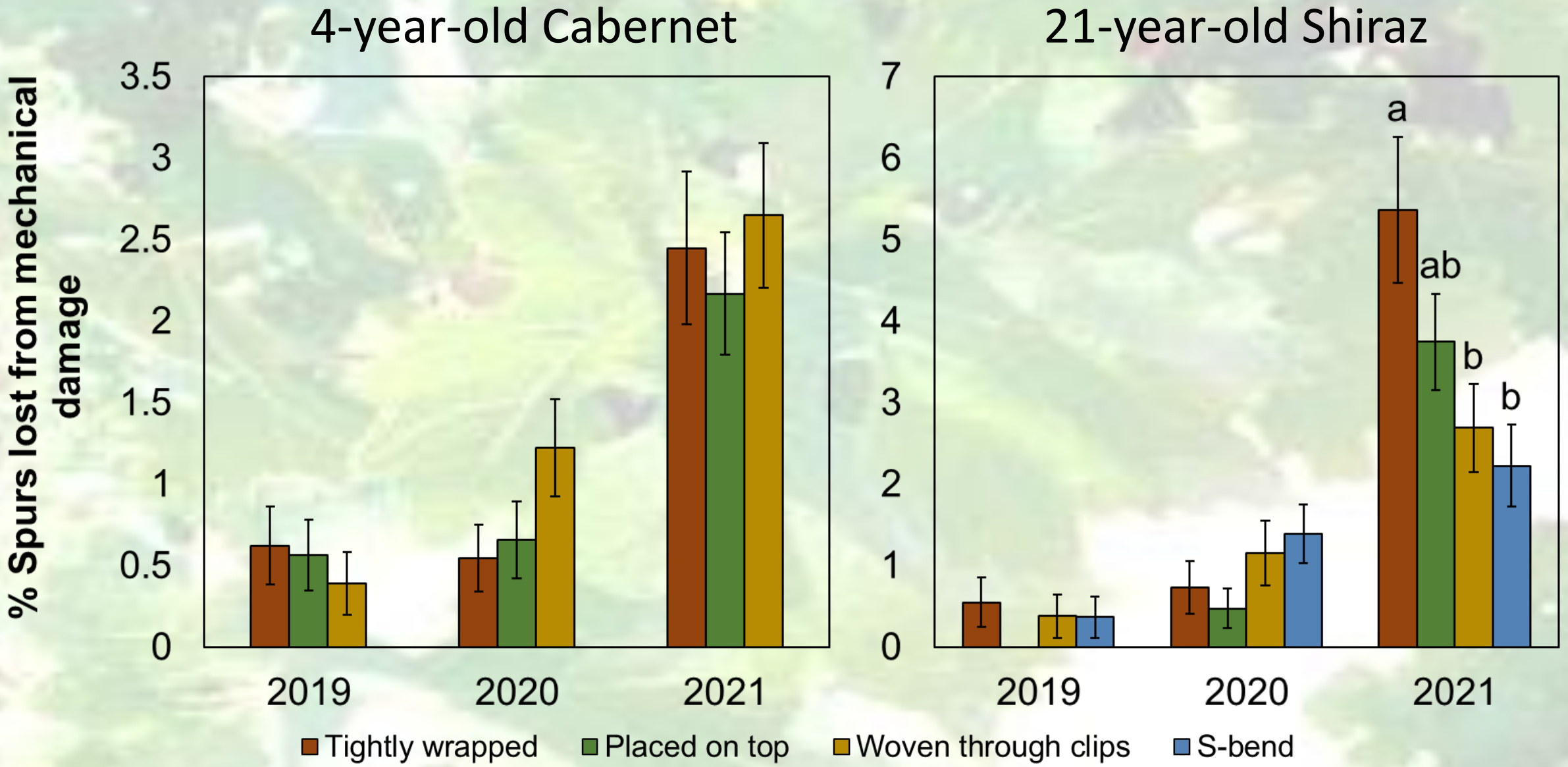
21-YEAR-OLD SHIRAZ



MEASUREMENTS: MECHANICAL DAMAGE

- Survey conducted after mechanical harvest
- 0–to-100% scale based on number of spur positions

RESULTS: MECHANICAL DAMAGE

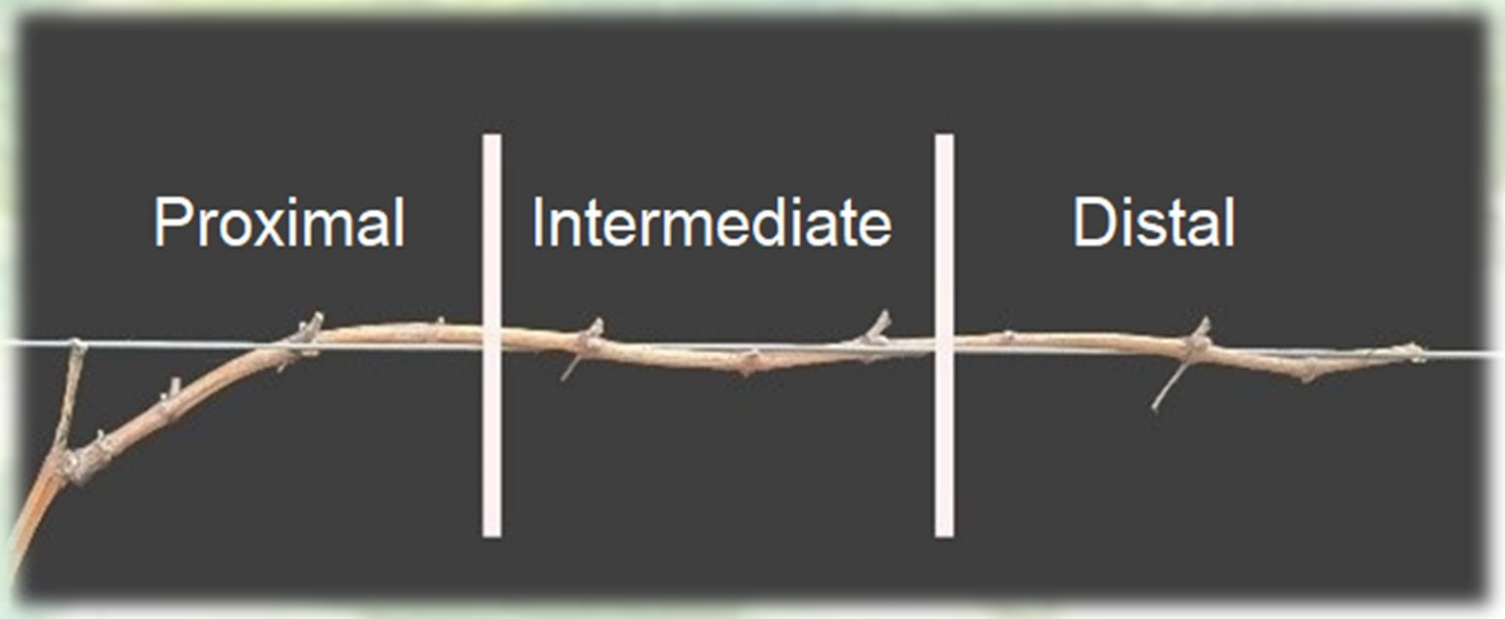


MEASUREMENTS: CARBOHYDRATE STATUS

- Non-structural carbohydrate (NSC) status measured from cane samples collected during dormancy
- Enzymatic assay following methods outlined by Edwards et al. (2010)

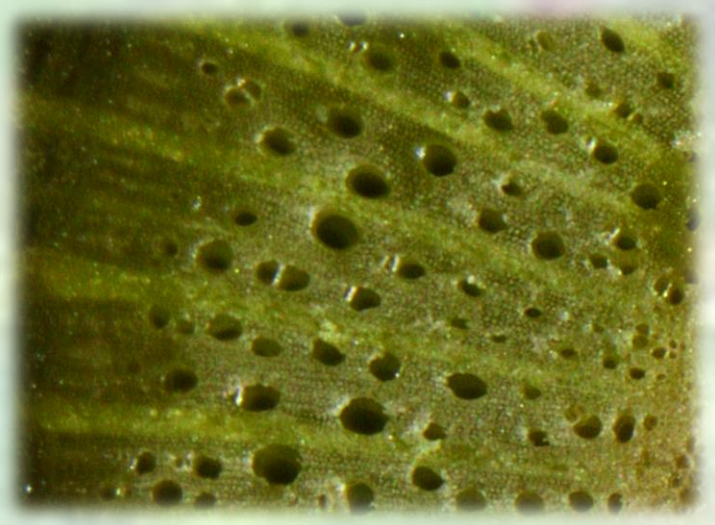
RESULTS: CARBOHYDRATE STATUS

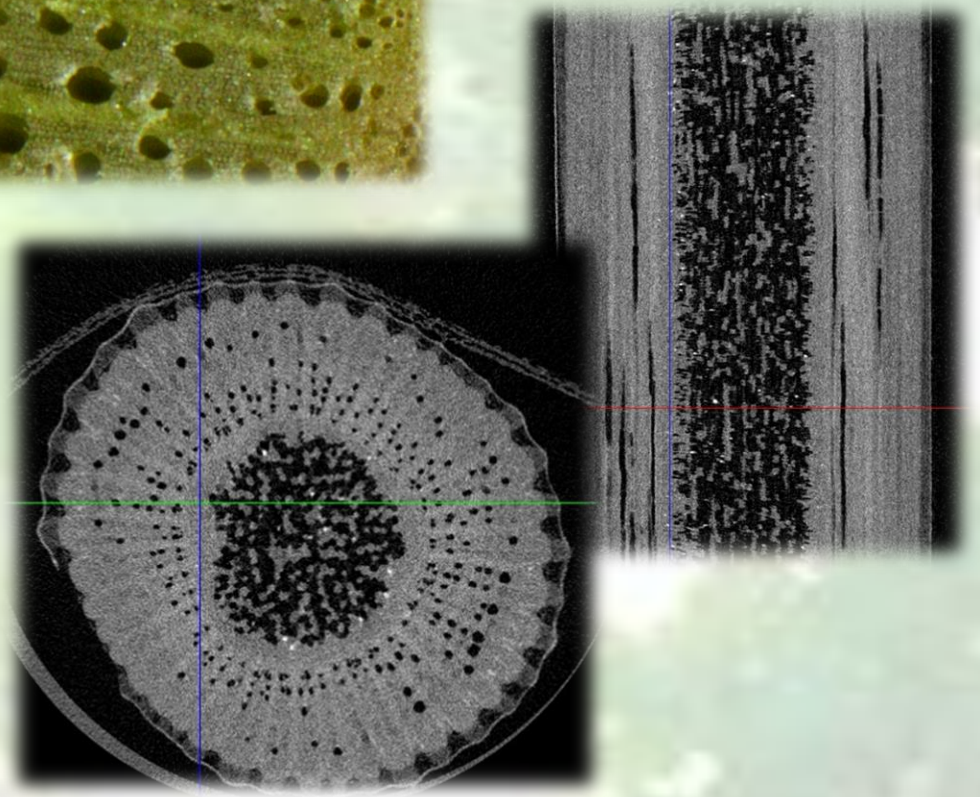
- If low in one arm section, likely to be low in all arm sections
- Suggests treatments did not restrict movement along arms



MEASUREMENTS: MICROSCOPY

- **Nikon Stereo microscope**
  - Vessel diameter
  - Cross-sectional vessel density
- **Bruker SkyScan micro-CT**
  - Volume of xylem conduits
  - Cross-sectional vessel density
  - Vessel thickness
  - Connectivity density
  - Theoretical specific hydraulic conductivity (K_s)

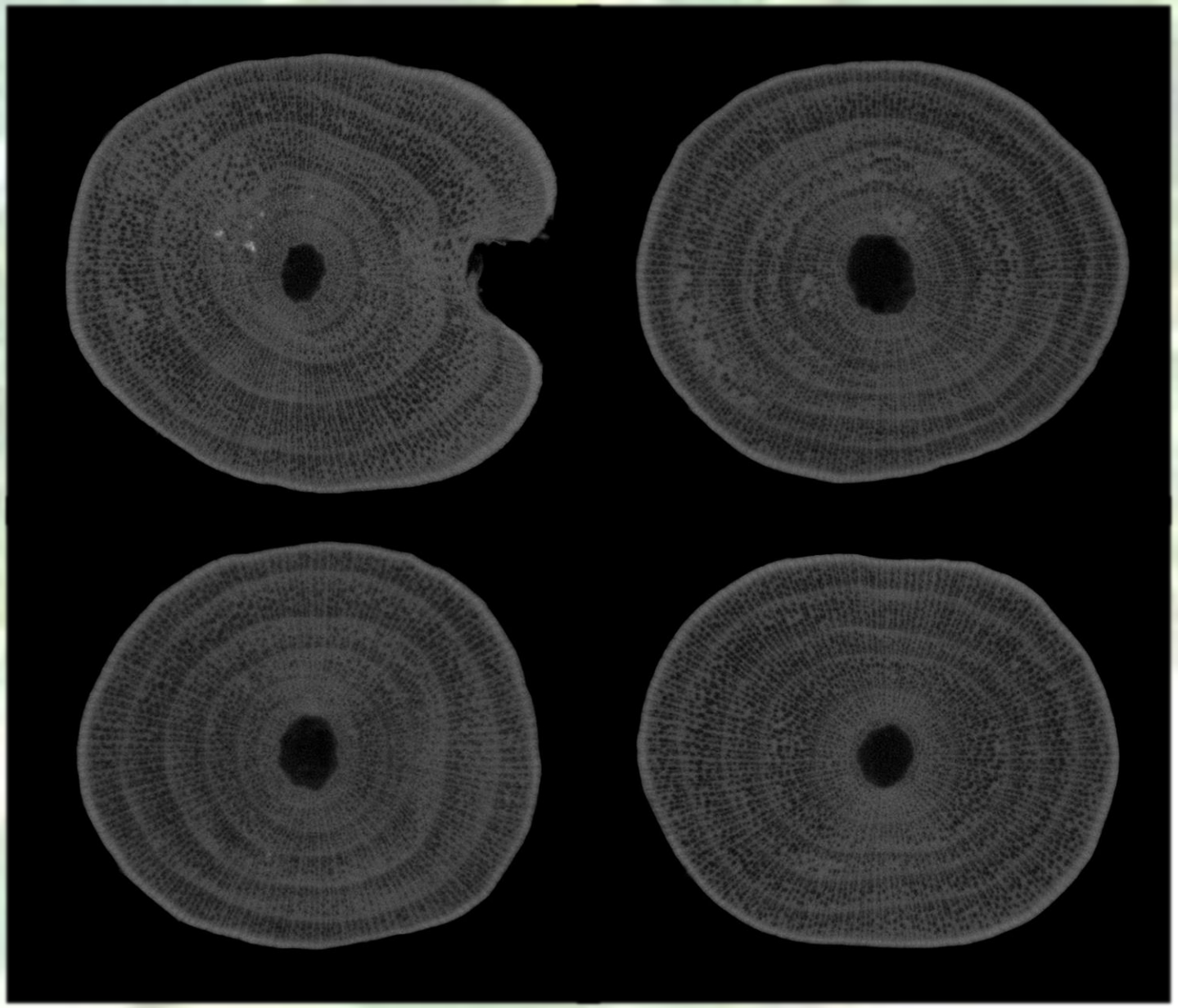




RESULTS: MICRO-CT OF WHOLE CORDONS

Tightly wrapped

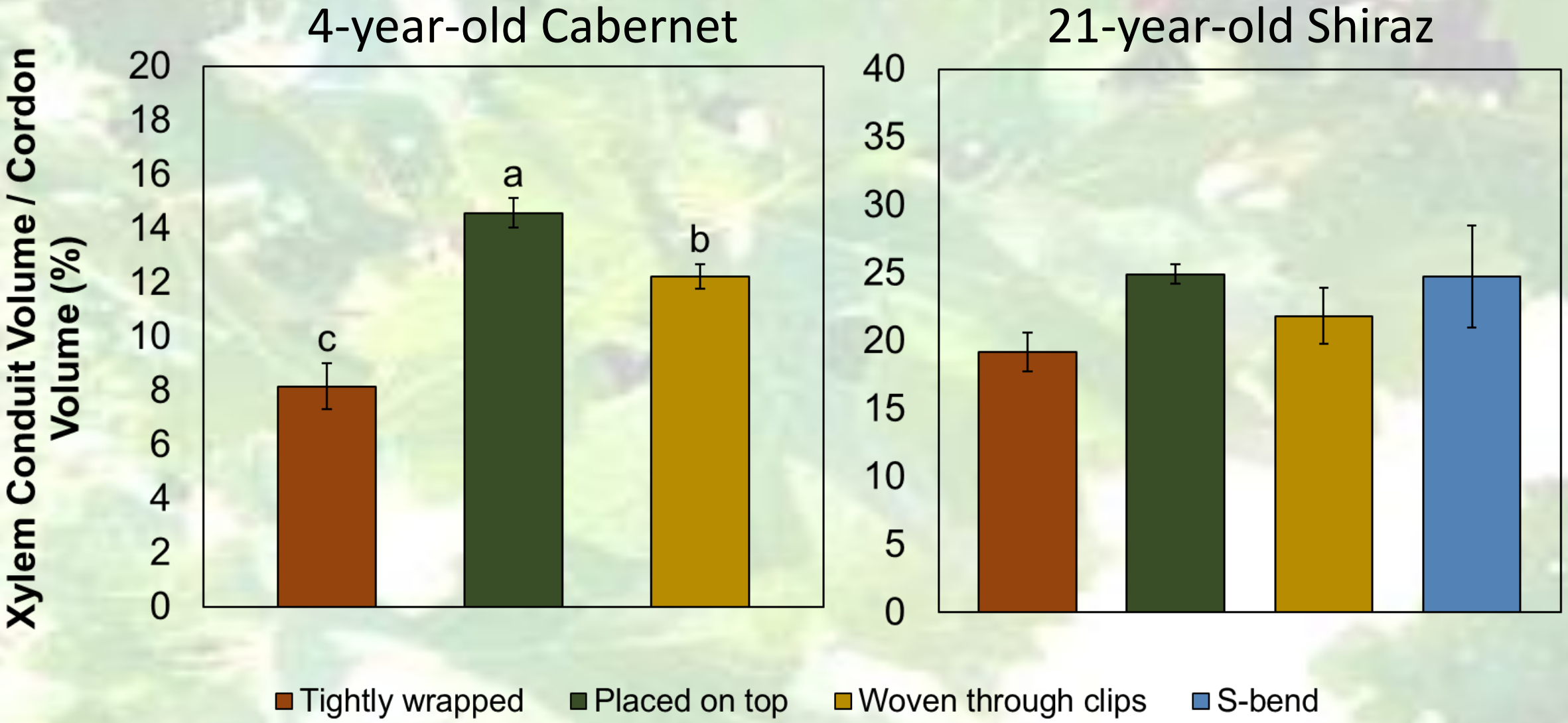
Placed on top



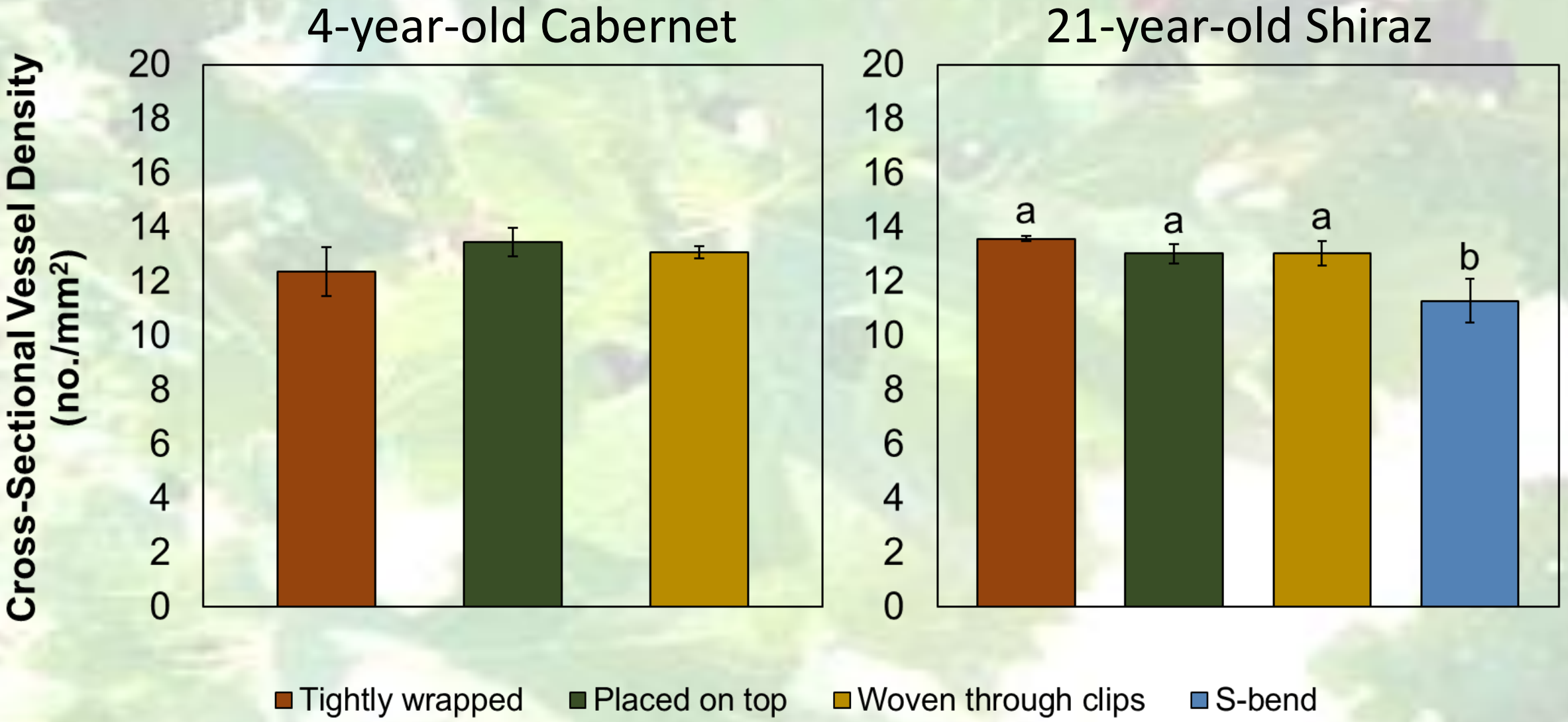
Woven through clips

S-bend

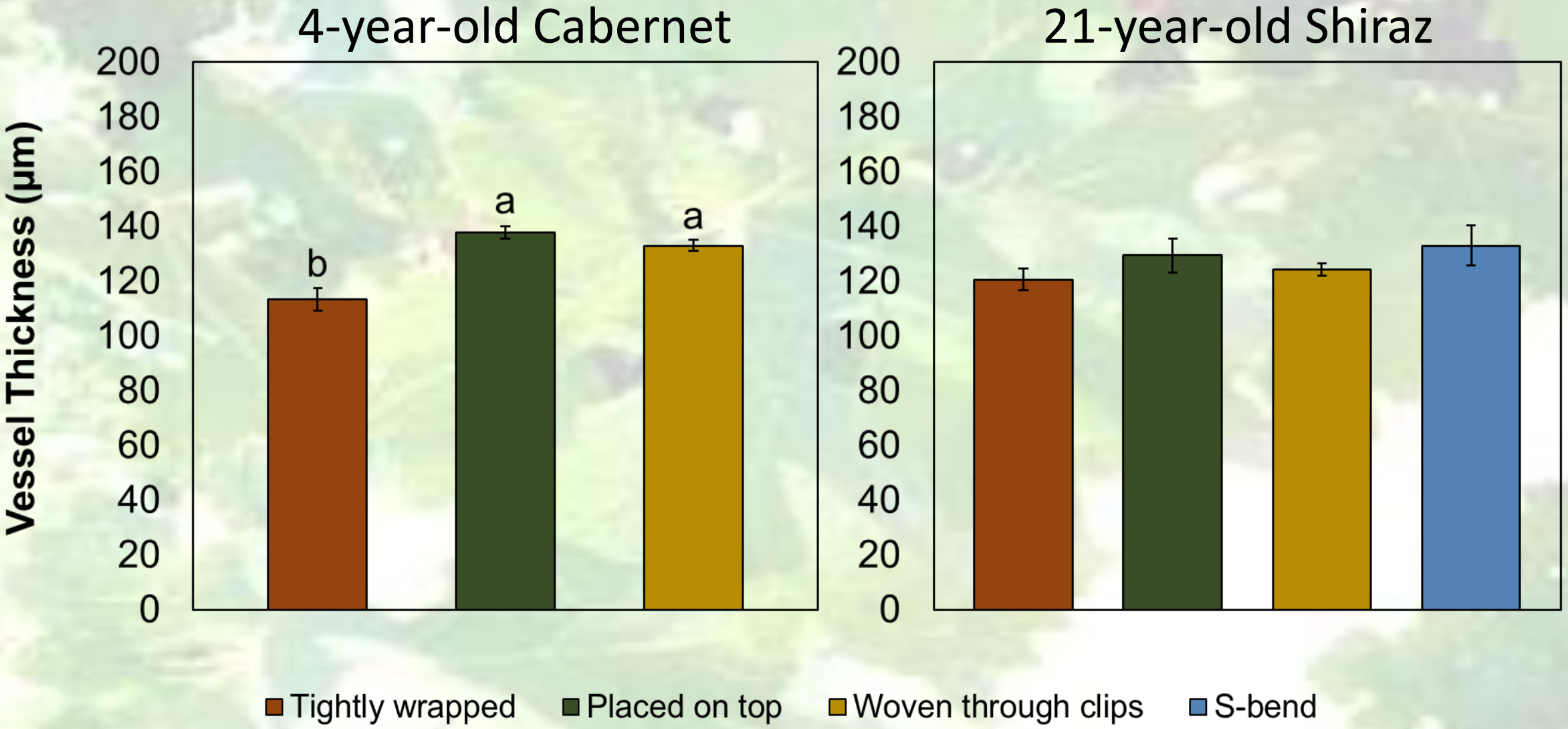
RESULTS: XYLEM CONDUIT VOLUME



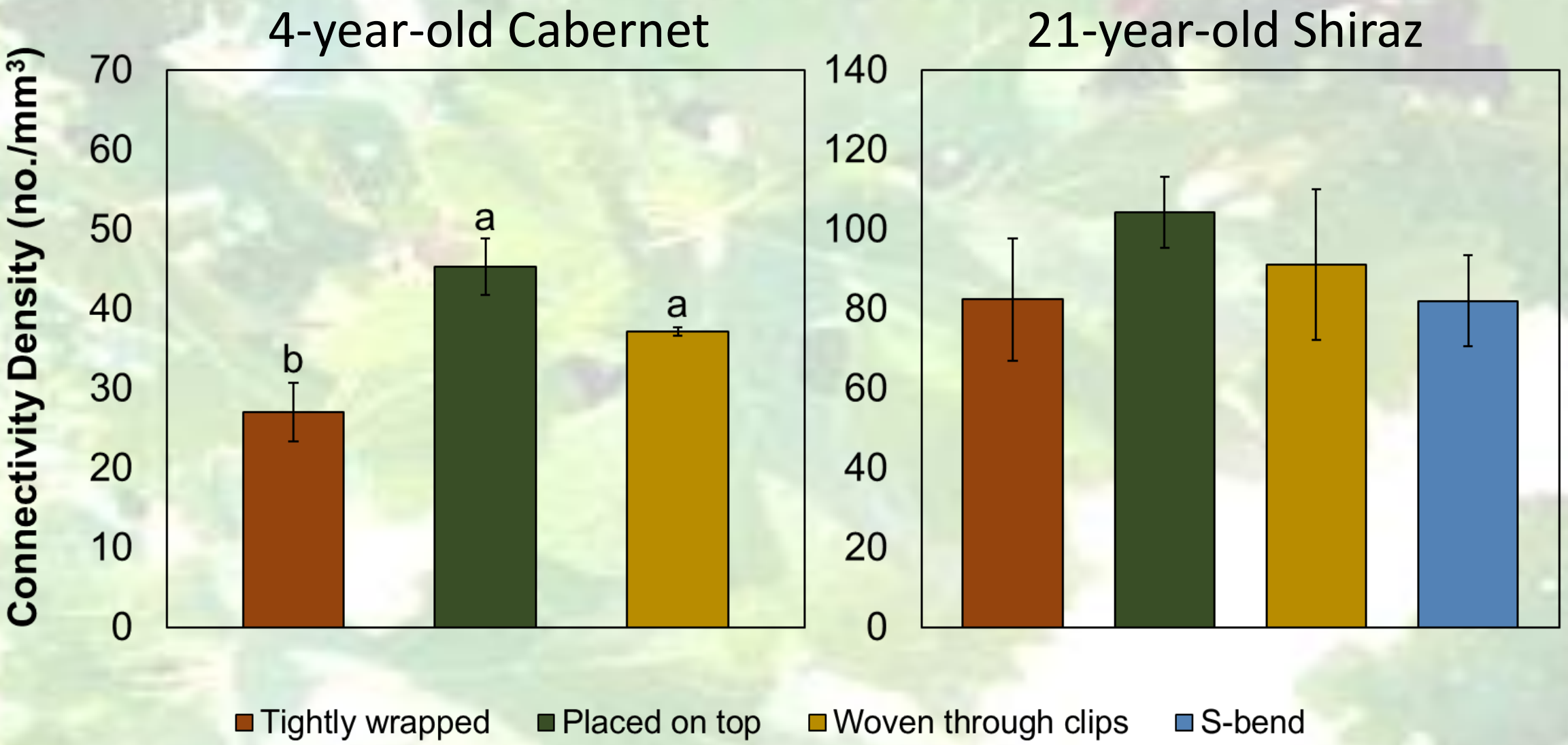
RESULTS: CROSS-SECTIONAL VESSEL DENSITY



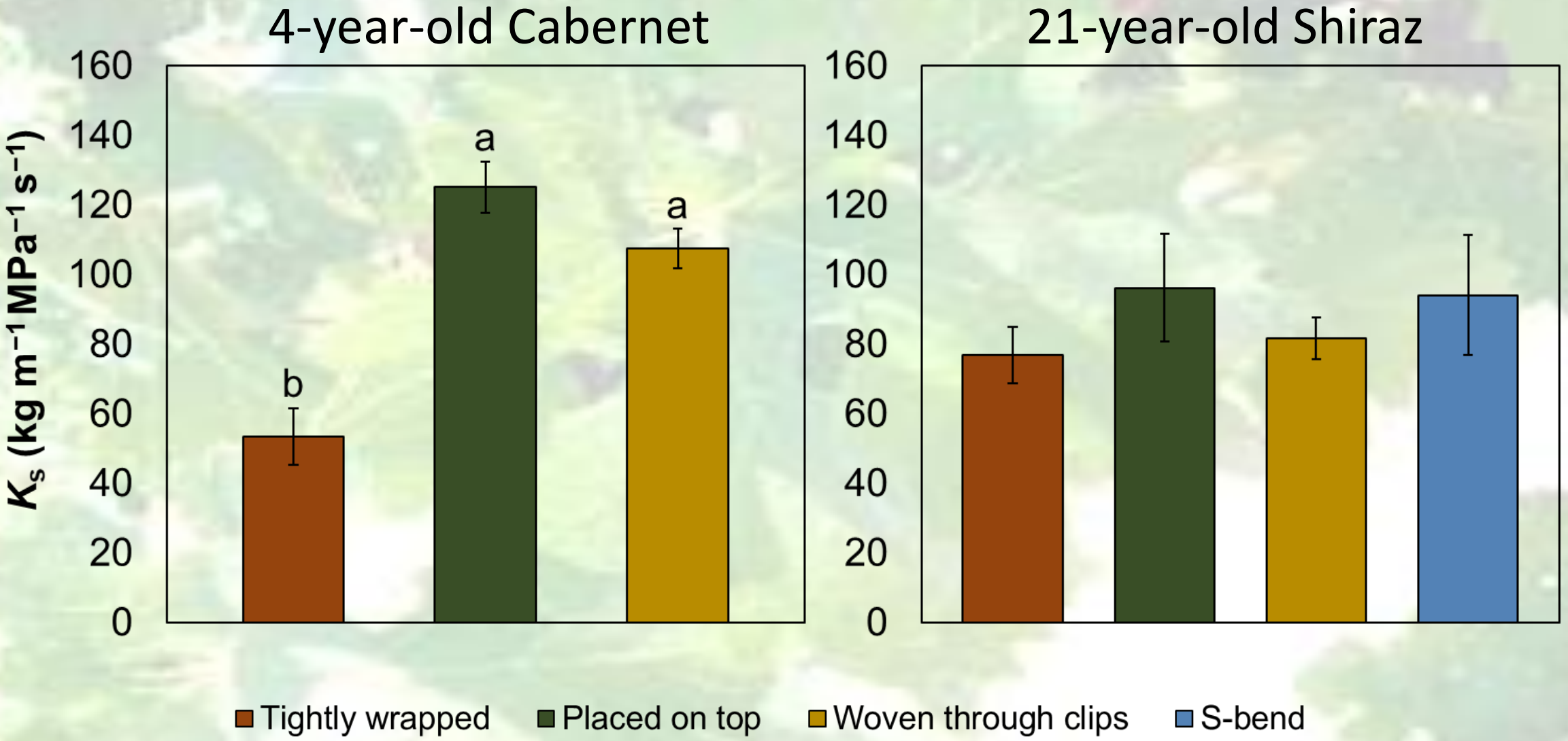
RESULTS: VESSEL THICKNESS



RESULTS: CONNECTIVITY DENSITY



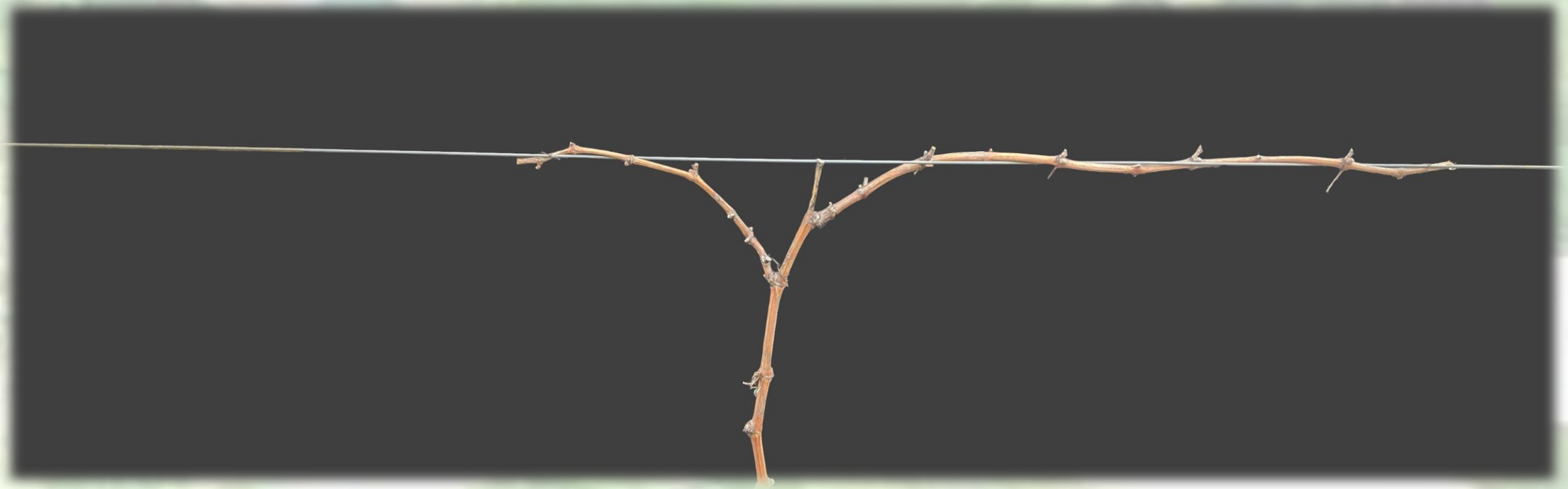
RESULTS: THEORETICAL SPECIFIC HYDRAULIC CONDUCTIVITY (K_s)



CONCLUSION

- **Negative impact on vegetative growth**
  - Reduced circumferences of arm sections
  - Lower intermediate and distal pruning weights
- **Capacity for normal hydraulic function compromised**
  - Lower xylem conduit volume
  - Thinner vessels
  - Less connections between vessels
  - Lower theoretical conductivity

TREATMENTS: LENGTH ADJUSTMENT



- Encourages uniform budburst and shoot growth?

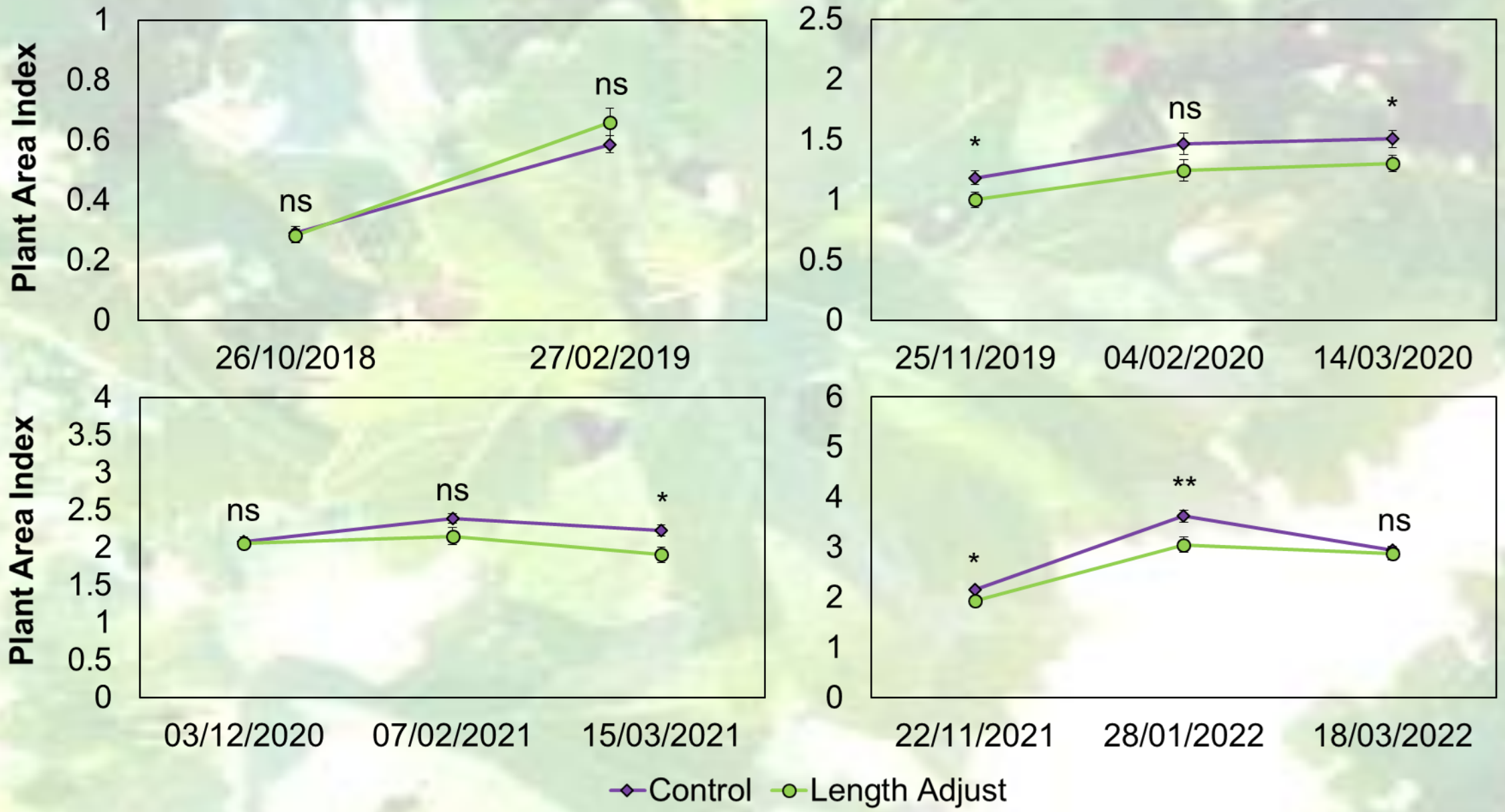
RESULTS: PRUNING WEIGHT

Year	Treatment	Proximal Pruning Weight (kg/m)	Intermediate Pruning Weight (kg/m)	Distal Pruning Weight (kg/m)	Total Pruning Weight (kg/m)
2019	Control	0.20 ± 0.10	0.15 ± 0.08	0.31 ± 0.27	0.26 ± 0.16
	Length Adjust	0.20 ± 0.08	0.38 ± 0.16		0.38 ± 0.16
	p value	ns	**<0.0001**		ns
2020	Control	0.84 ± 0.30	0.45 ± 0.24	0.56 ± 0.25	0.63 ± 0.21
	Length Adjust	0.69 ± 0.31	0.47 ± 0.20	0.55 ± 0.25	0.57 ± 0.17
	p value	ns	ns	ns	ns
2021	Control	1.07 ± 0.42	1.01 ± 0.49	1.28 ± 0.54	1.12 ± 0.37
	Length Adjust	0.97 ± 0.33	0.83 ± 0.23	1.17 ± 0.40	0.99 ± 0.20
	p value	ns	ns	ns	ns
2022	Control	2.09 ± 1.20	1.70 ± 0.82	2.51 ± 1.38	2.11 ± 1.00
	Length Adjust	1.84 ± 1.31	1.58 ± 1.04	2.17 ± 1.58	1.88 ± 1.19
	p value	ns	ns	ns	ns

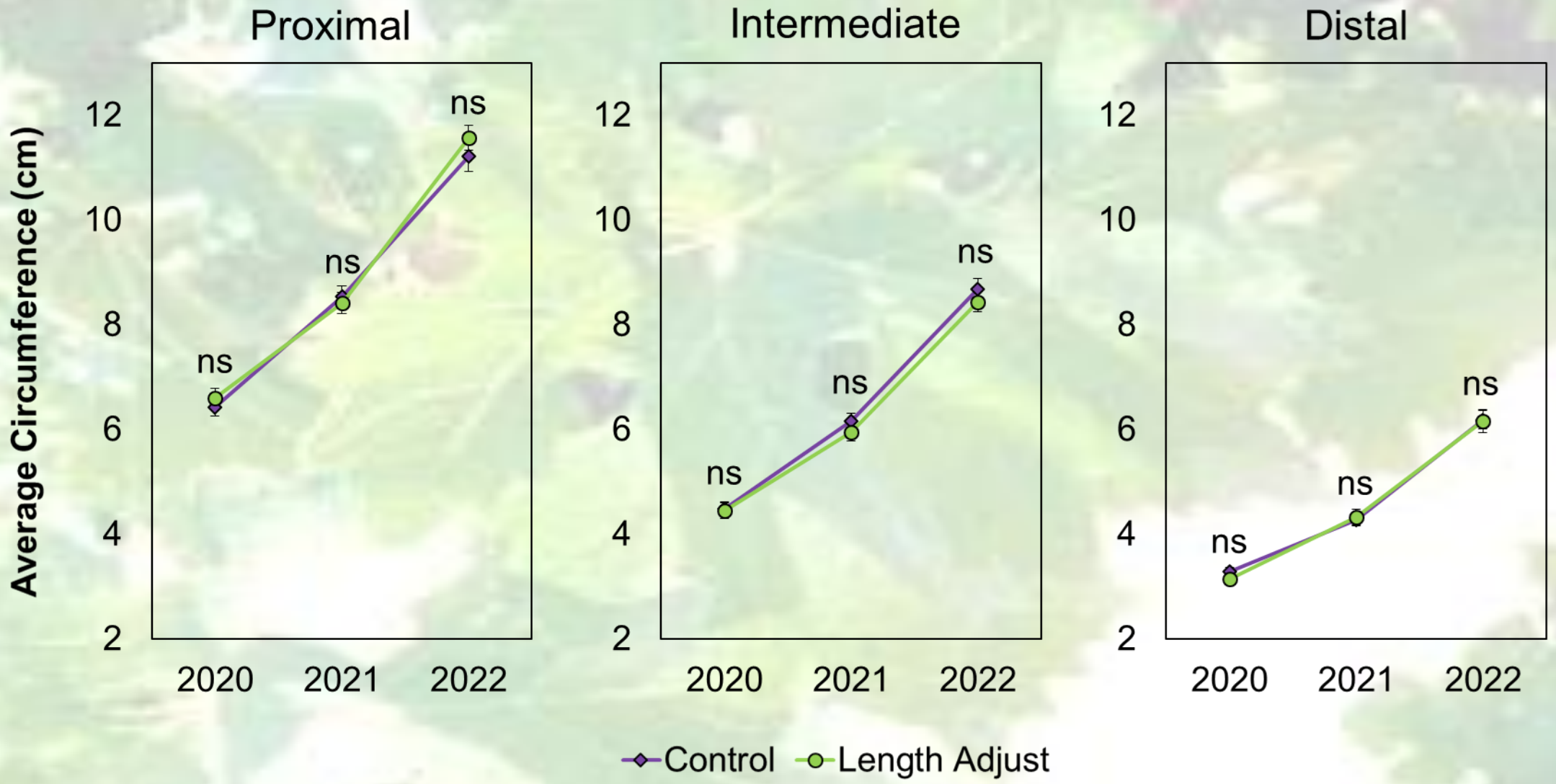
RESULTS: CANE NUMBER/WEIGHT

Year	Treatment	Proximal		Intermediate		Distal	
		Cane no. (no./m)	Cane Weight (g)	Cane no. (no./m)	Cane Weight (g)	Cane no. (no./m)	Cane Weight (g)
2019	Control	10.5 ± 2.8	20.9 ± 12.6	10.8 ± 3.6	16.4 ± 11.8	12.4 ± 3.5	24.2 ± 16.5
	Length Adjust	10.8 ± 3.8	22.6 ± 17.1	13.9 ± 3.2	27.7 ± 10.6		
	p value	ns	ns	**0.027**	**0.014**		
2020	Control	16.3 ± 2.6	51.7 ± 16.0	12.4 ± 3.7	35.1 ± 10.6	14.4 ± 2.9	37.9 ± 14.7
	Length Adjust	15.9 ± 3.6	42.3 ± 15.3	13.5 ± 3.8	34.6 ± 10.6	11.0 ± 2.9	49.1 ± 16.7
	p value	ns	ns	ns	ns	**0.004**	ns
2021	Control	18.3 ± 4.3	58.3 ± 15.4	20.0 ± 3.9	49.6 ± 19.1	22.0 ± 4.3	56.9 ± 19.1
	Length Adjust	18.0 ± 3.2	54.2 ± 17.6	20.5 ± 4.2	40.8 ± 9.8	21.9 ± 2.9	53.0 ± 16.5
	p value	ns	ns	ns	ns	ns	ns
2022	Control	26.3 ± 8.5	84.2 ± 55.8	23.3 ± 4.7	74.4 ± 36.4	30.4 ± 5.4	83.3 ± 46.5
	Length Adjust	23.7 ± 6.5	77.8 ± 57.7	24.8 ± 6.3	64.4 ± 41.7	28.9 ± 4.9	71.0 ± 44.0
	p value	ns	ns	ns	ns	ns	ns

RESULTS: PLANT AREA INDEX



RESULTS: CORDON CIRCUMFERENCE



CONCLUSION

- **Successful in encouraging vegetative growth during first growing season**
  - More shoots and greater pruning weight
  - Especially in middle of arms
  - No reduction in cordon circumference
- **No long-term beneficial response?**
  - Further research could be aimed at lower vigour setting

Questions?

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Texas A&M AgriLife Extension

Modern Drought Management for the Health and Longevity of Perennial Horticulture Plants

Texas A&M AgriLife Extension

Australian Government
Department of Agriculture, Fisheries and Forestry

Future Drought Fund

SA DROUGHT HUB

Mallee Regional Innovation Centre

THE UNIVERSITY of ADELAIDE

SOUTHERN NSW Innovation Hub
SUSTAINABLE AGRICULTURE, LANDSCAPES AND COMMUNITIES

Charles Sturt University

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Government of South Australia
Department of Primary Industries and Regions

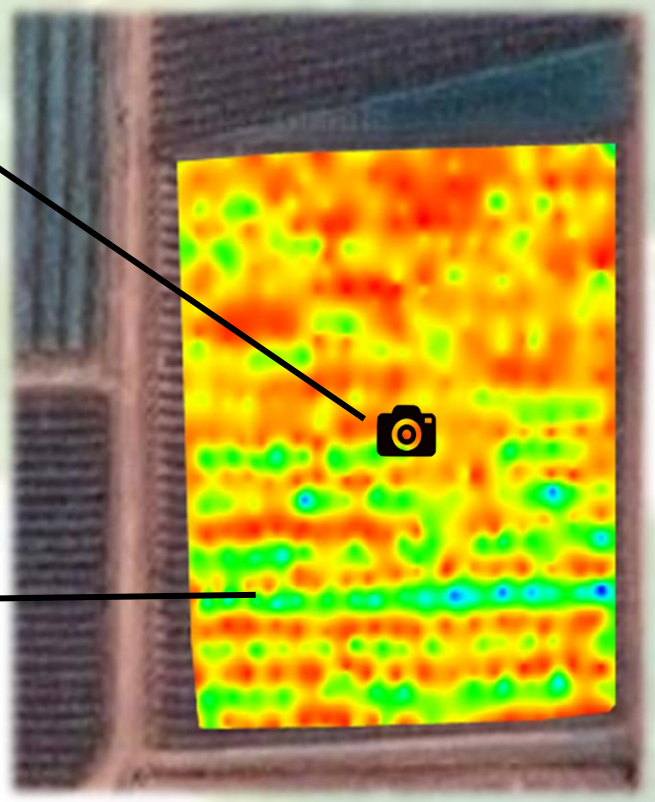
Wine Australia

BOOSTING DROUGHT PREPAREDNESS

- Network of validation and demonstration sites
- Grower interviews
- Co-design

NEW AND PRE-EXISTING SENSORS

- Weather station
  - Air temperature
  - Evapotranspiration
  - Precipitation
  - Relative Humidity
  - Solar radiation
  - Wind speed
- Soil moisture
- Soil temperature
- Irrigation
- Plant area index

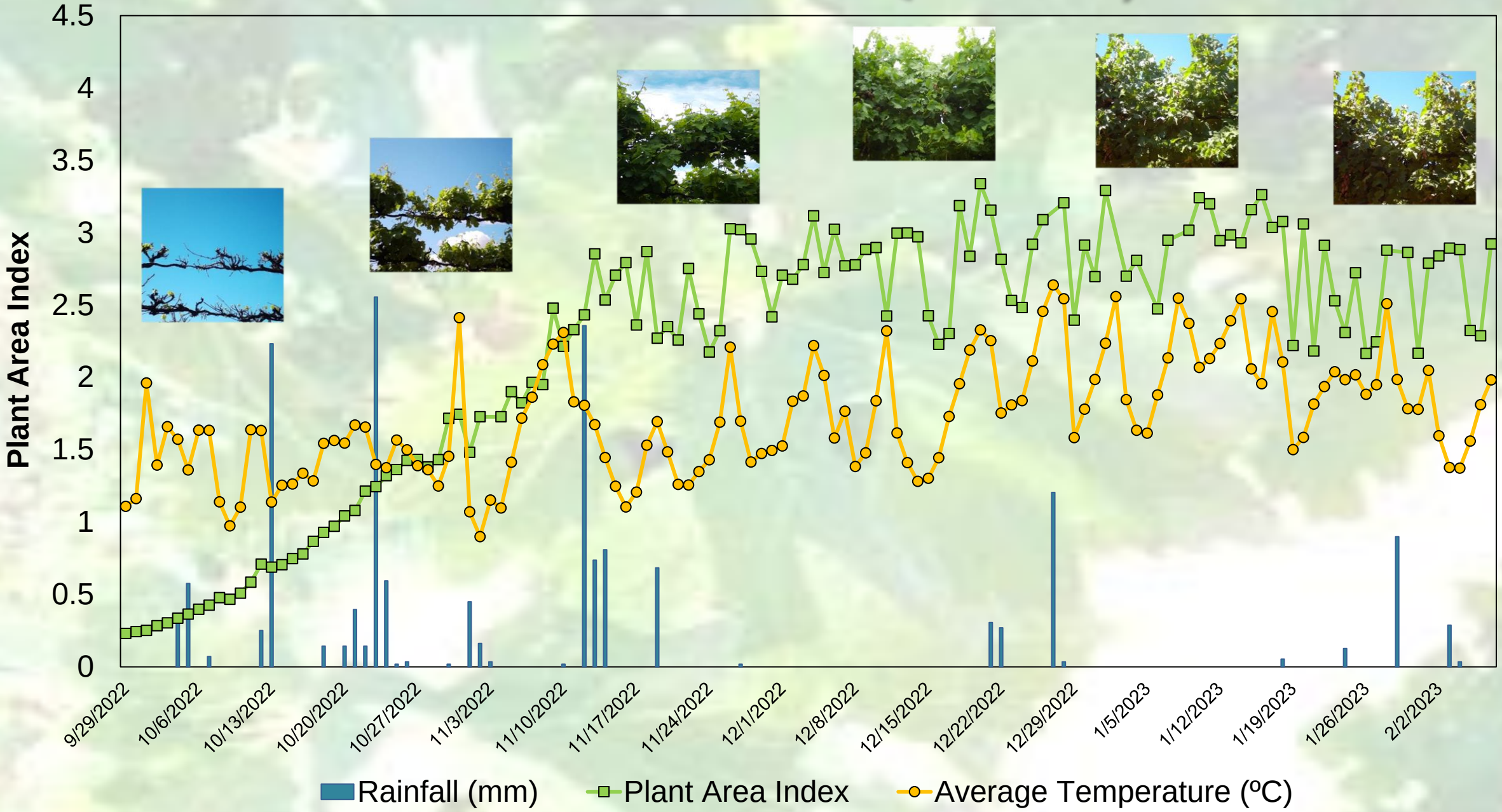


CITRUS: GRIFFITH, NSW

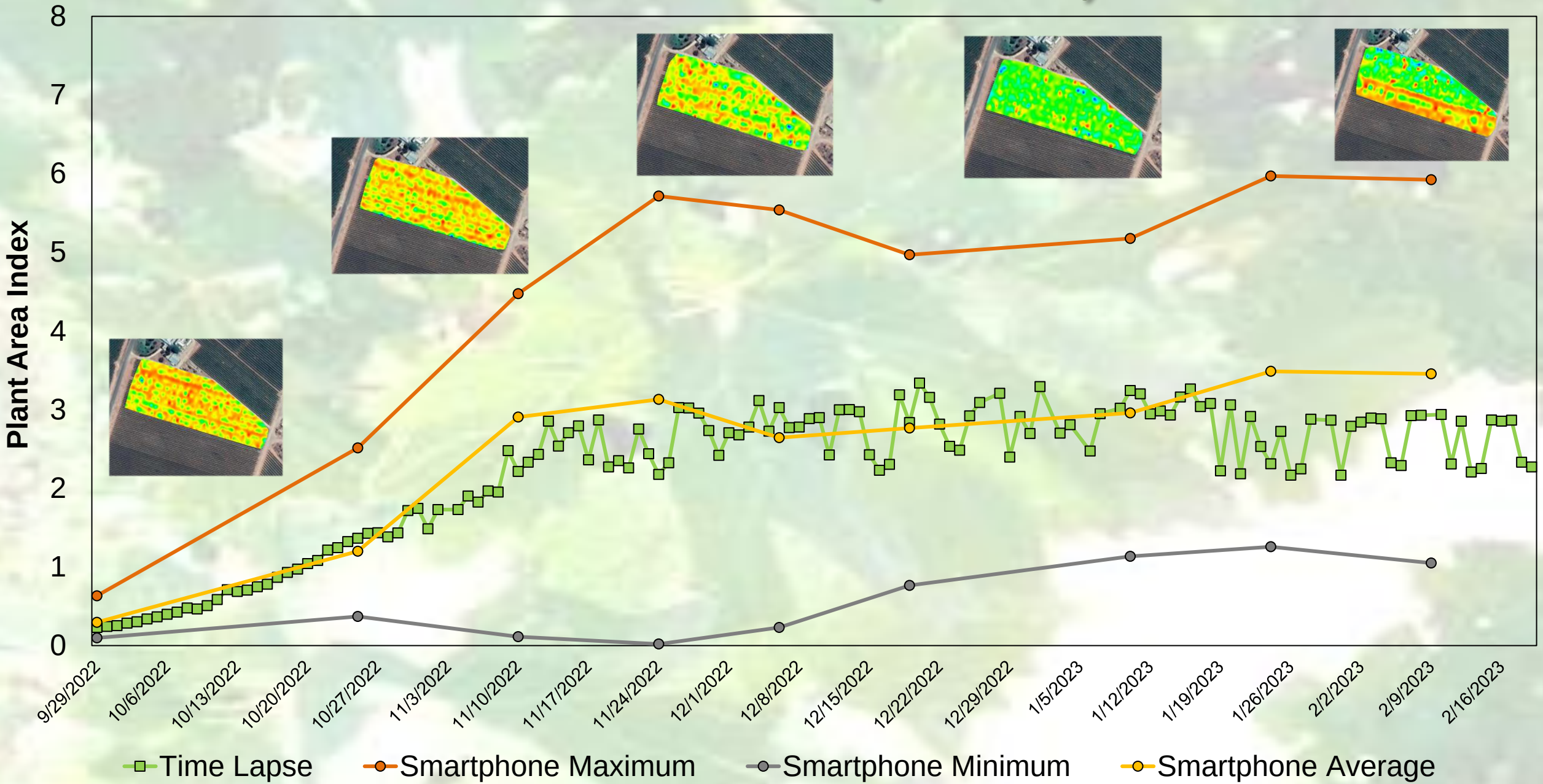





TEMPRANILLO: QUALCO, SA



TEMPRANILLO: QUALCO, SA



Tempranillo House Soil Moisture Content

VIEW: GRAPH | TABLE
DISPLAY: 20 | Max | SCALE Y
MODE: INDIVIDUAL | AVERAGE | STACKED
RANGE: 2D | 1W | 2W | 1M | 3M | 6M | 1Y
FROM: 22/02/2023 LATEST
PERIOD: « »

22nd Feb 2023 – 28th Feb 2023

10cm 20cm 30cm 40cm 60cm 80cm Rainfall

IRRIGATION RAINFALL COMMENTS

Value (hrs) 28/02/2023 1:47pm CREATE

IRRIGATION ENTERED AS: mm | hrs

IRRIGATION CONVERSION FACTOR: 1.50

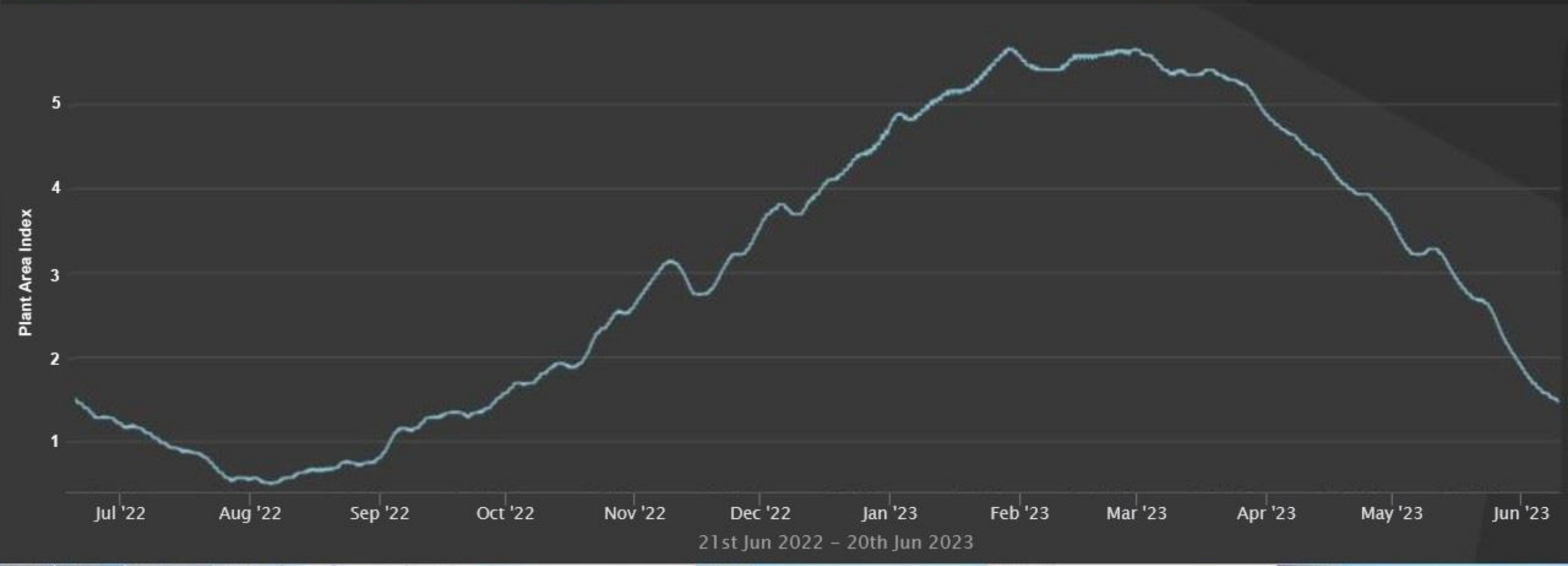
VIEW GRAPH TABLE

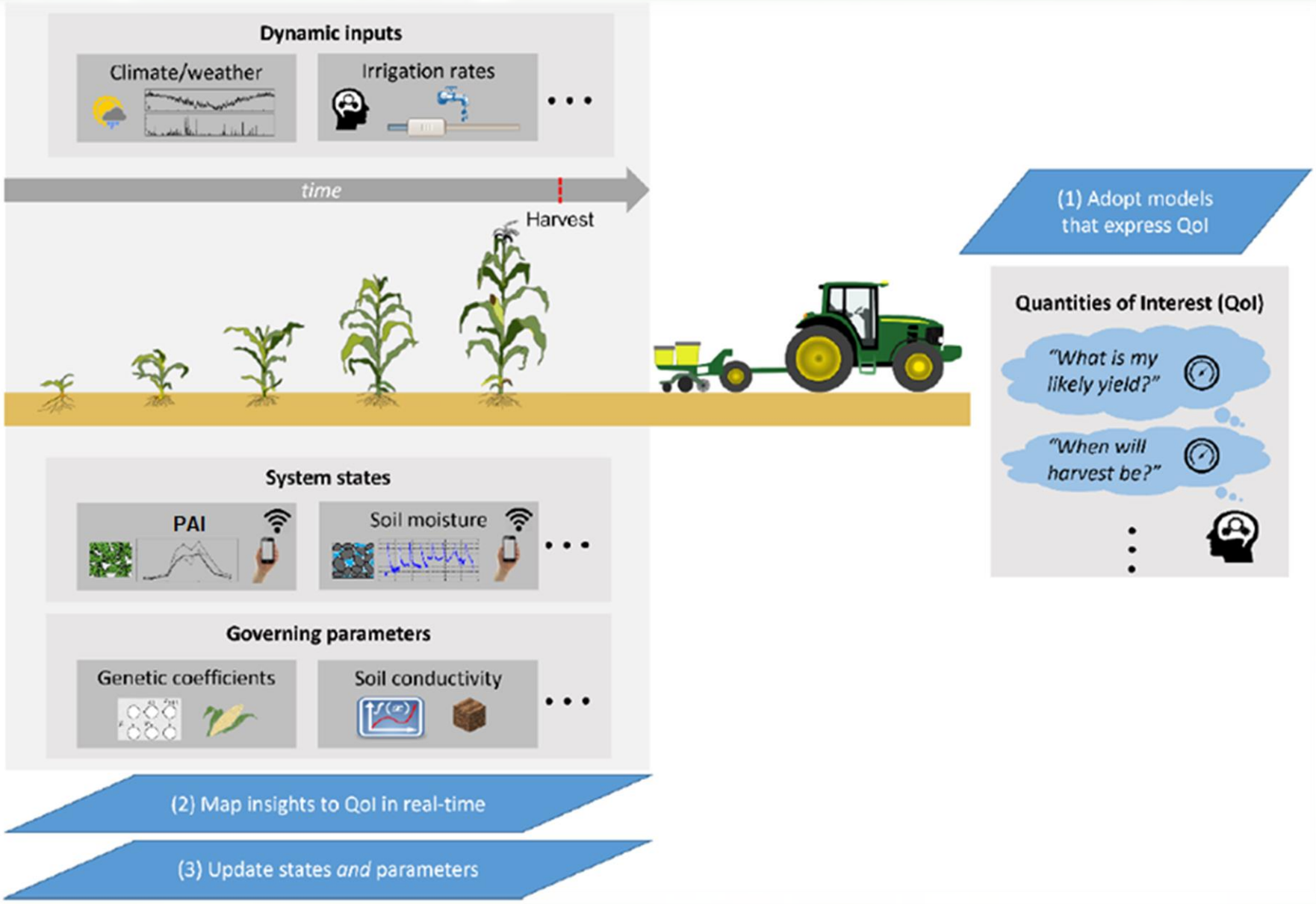
DISPLAY Min Max SCALE Y

MODE INDIVIDUAL AVERAGE STACKED

RANGE 2D 1W 2W 1M 3M 6M 1Y

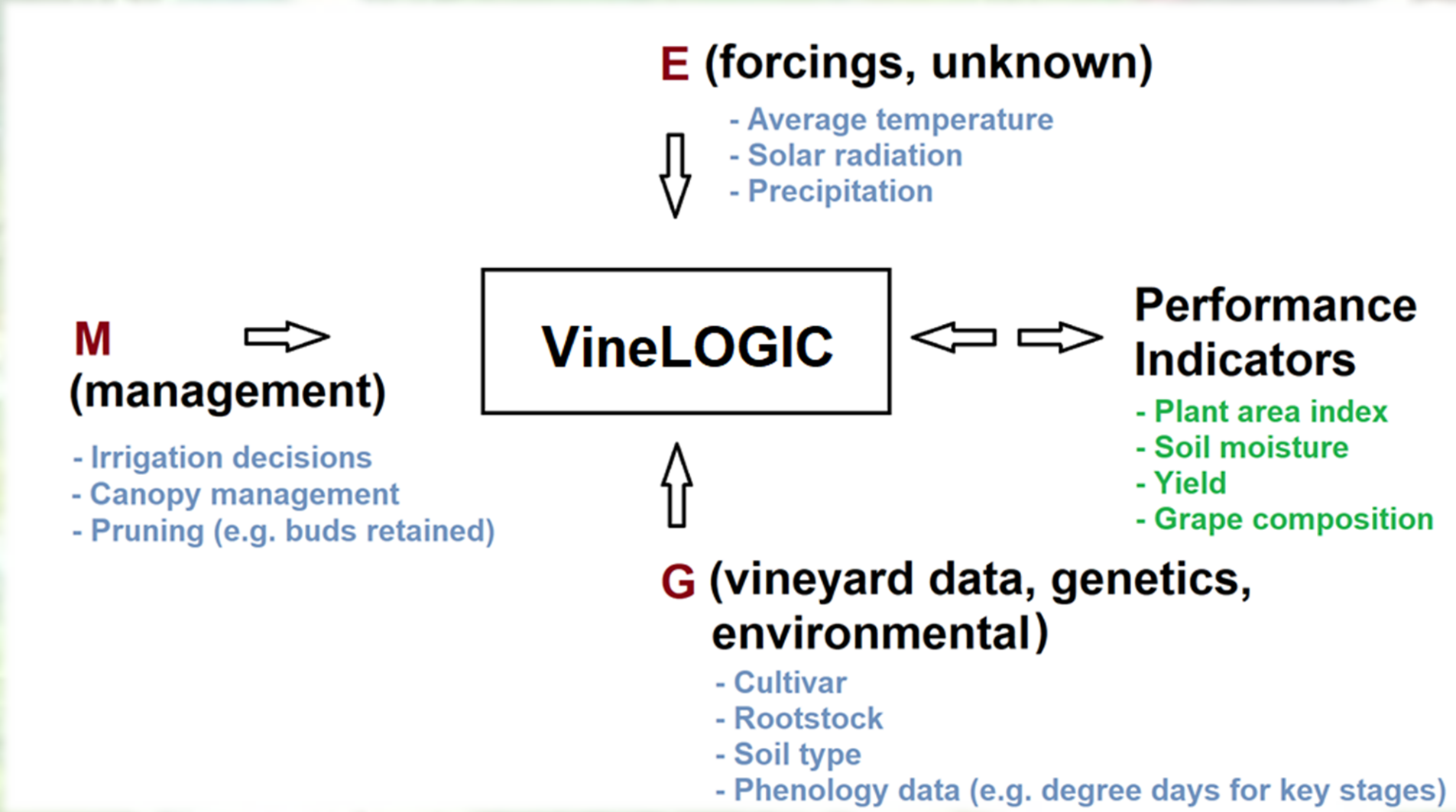
FROM 21/06/2022 LATEST

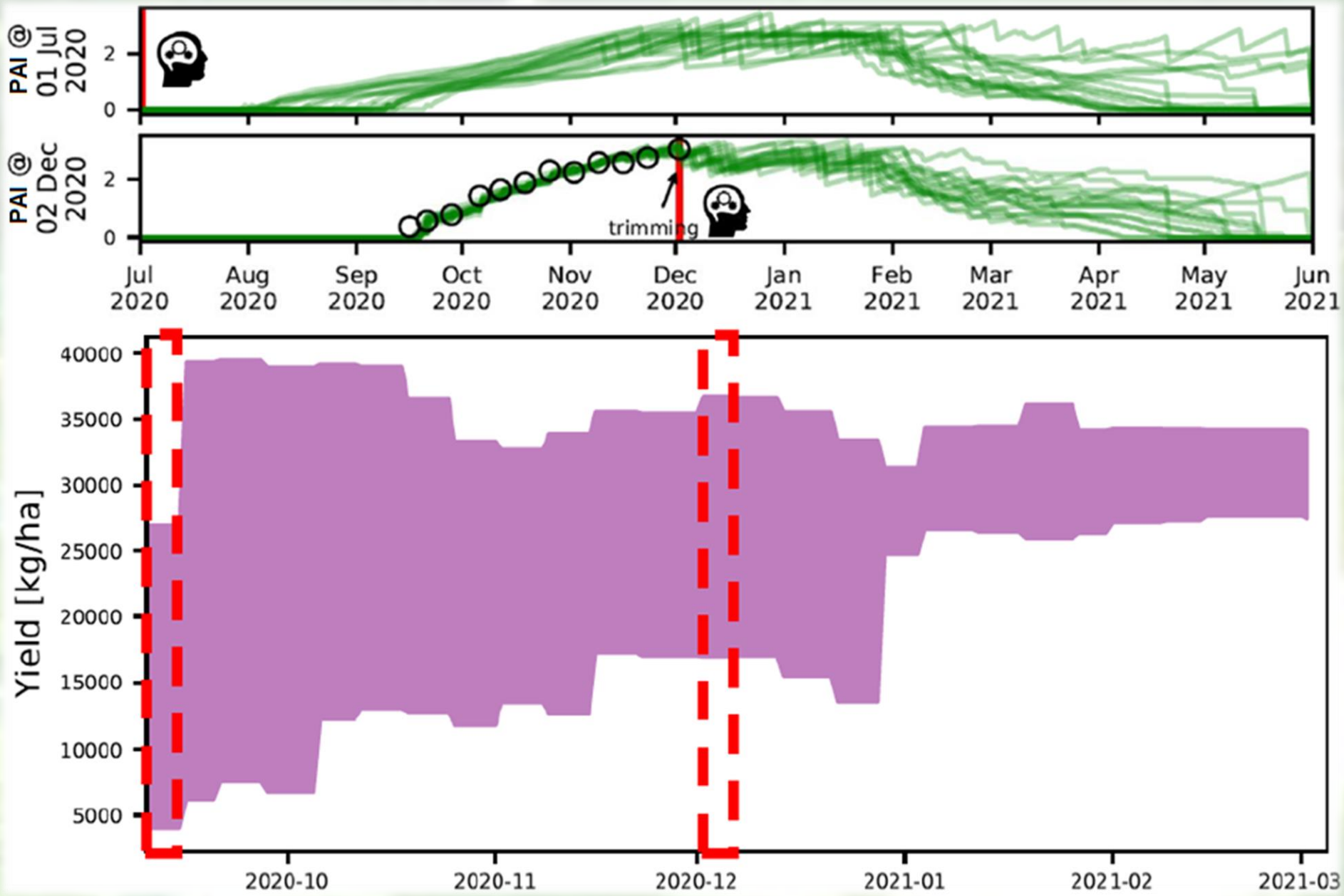




Credit: Knowling, M

VineLOGIC: A MODEL OF GRAPEVINE GROWTH DEVELOPMENT





Credit: Knowling, M

WHERE DO WE GO FROM HERE?

- Real time PAI data available on platform with other data streams

  - Assess grower's attitudes in regard to this possibility

- Process modelling using captured data to determine efficiency gain if any from this new data stream

- Evaluate the use of multiple cameras within single sites/blocks to capture variability

Questions?

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Texas A&M AgriLife Extension