Photo by Stefan Els

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

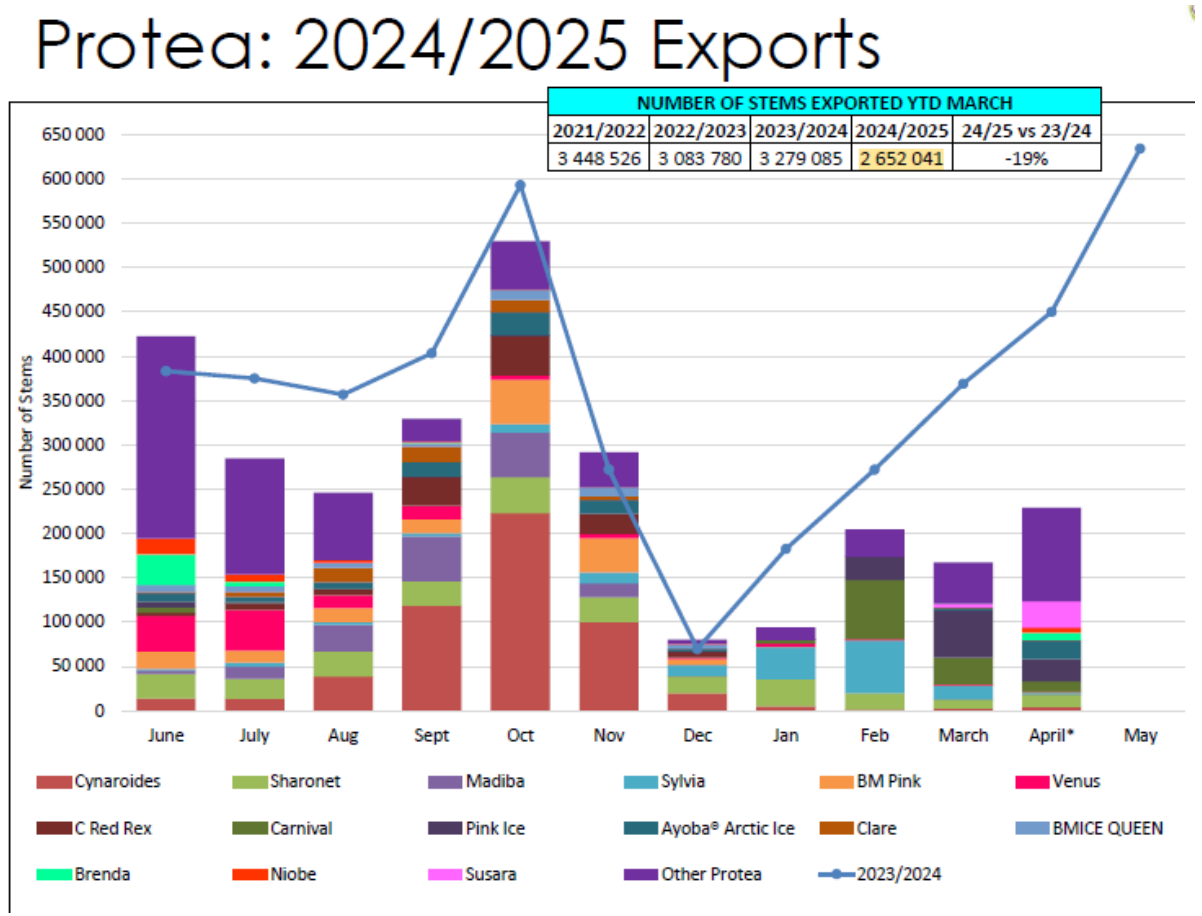
Developing nutrient management strategies for *Protea cynaroides* and *Leucospermum* informed by phenological stages

Andrea Slabber with Dr Aleysia Kleinert, Dr Lynn Hoffman and Dr Eugenie-Lien Louw

CAPE FLORA SOUTH AFRICA

Industry background

- *Protea* and *Leucospermum* are major contributors to the Cape floriculture export industry – total R1 bilj (2023)
- Approx. 7.5 mil *Protea* stems and 14.5 mil *Leucospermum* stems exported during 2024/2025
- Increasing international demand and competition require consistent, high-quality yields – maintaining quality through international shipping
- Main importers:
  - EU – 72%
  - Far East – 16%
  - Middle East – 5%



Variety	2021/2022 Export	2022/2023 Export	2023/2024 Export	3 yr Average	2024/2025 Est
Succession	5 393 007	5 802 953	5 094 888	5 430 283	5 471 487
Total Leucospermum in loose stems	14 962 969	14 338 599	14 369 704	14 557 091	14 782 725
Stems in Bouquets	266 964	244 280	260 626	257 290	652 502
Total Leucospermum	15 229 933	14 582 879	14 630 330	14 814 381	15 435 227

Production evolution

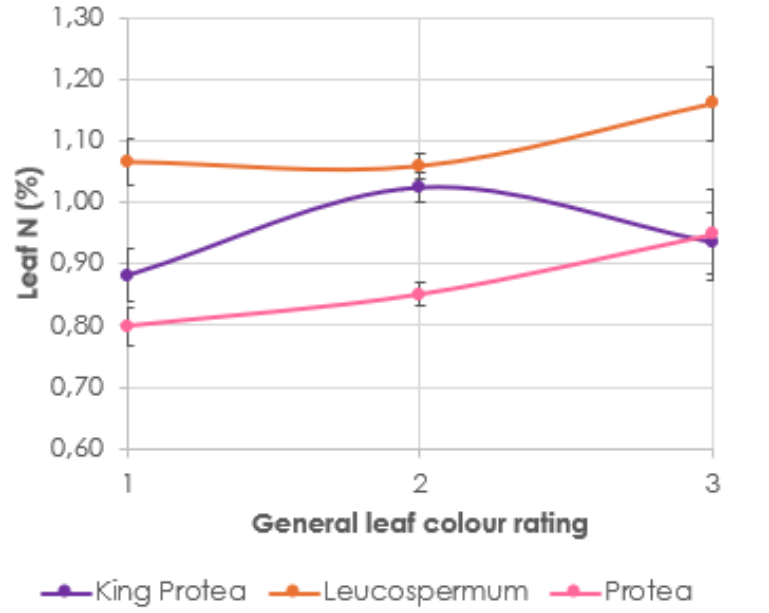
- Adaptation to native soils does not necessarily ensure optimal growth and yield
- Shift from wild harvesting/minimal-input systems to irrigated and fertilized production systems
- Nutrient balance is essential for flower quality and productivity
- Early detection of nutrient deficiencies or excesses can prevent negative physiological effects
- Crop nutritional status can be assessed using:
  - Soil analysis
  - Leaf tissue analysis

Problem statement:

"Existing leaf analysis standards for *Protea* and *Leucospermum* are **inconsistent**, and the effects of **phenological stage** and **shoot type** on leaf nutrient levels remain unclear."

- Cape Flora *Protea*, *Leucodendron* and *Leucospermum* leaf norm establishment project
  - Boundary line approach
    - Leaf nutrient concentration vs performance variable : yield, flower quality, growth etc.
- Different rec. sampling times – confounding effects
  - Dr Eugienie-Lien: late-March to early-May across all cultivars
  - Varying results between different genera:
    - Macronutrient relationships
    - Leaf colour rating (indicator of vigour)

- **Current project: investigate stability of leaf nutrient levels across seasons, correlated with phenological development**



Aims and Objectives

Contribute robust leaf norm standards of *Protea cynaroides* “Lei Momi” and *Leucospermum* “Succession” for the Cape Flora industry, resembling data utilized by fruit industries.

- Determine relationship between phenological stage and leaf nutrient levels
- Determine the possible effect of sampling from vegetative vs reproductive shoots on leaf nutrient levels
- Investigate the impact of nutrient supply on floral structure quality and vase life

Thesis Layout

- General introduction
- Literature review:
  - **The nutritional requirements of *Protea* and *Leucospermum* in all production areas, not limited to South Africa**
- Ch 1: Seasonal variation in leaf nutrient concentrations during phenological development of *Protea* and *Leucospermum*
- Ch 2: Effects of reproductive status and shoot growth characteristics on leaf nutrient interpretation in *Protea* and *Leucospermum*
- Ch 3: Physiological and postharvest responses of *Leucospermum* ‘Succession' to contrasting nutrient supply regimes

1. Field leaf analysis tracking phenology

2. Controlled nutrient regime pot trial

3. Nutrient regime relation to flower quality and vase life

Study sites: Leucospermum "Succession"

- Piketberg: TBC
- Stellenbosch: Rainbow's End
- Welgevallen experimental farm

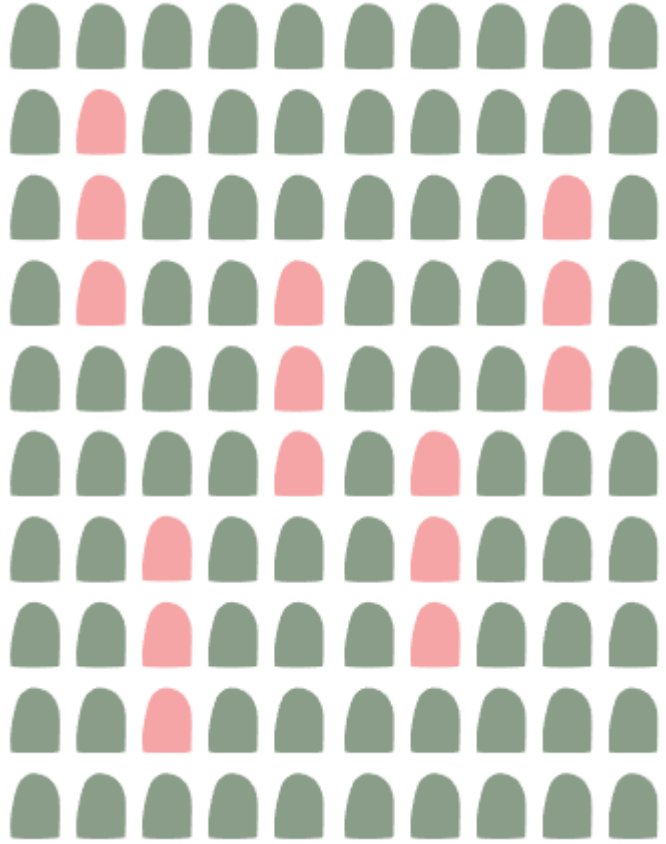
Study Sites: Protea "Lei momi"

- *Piketberg: TBC*
- *Stellenbosch: Boschendal*

TRIAL 1: FIELD LEAF ANALYSIS TRACKING PHENOLOGY

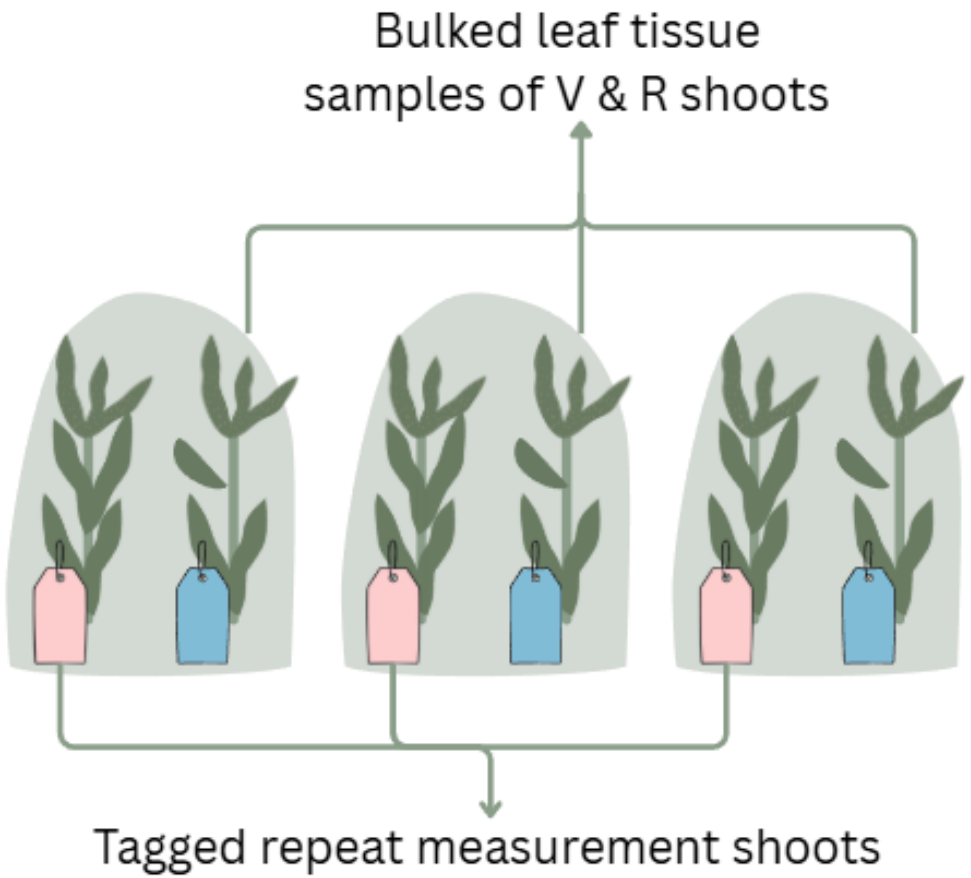
Experimental design

- Completely randomized design:
  - *Leucospermum*:
    - R/V: 5 groups x 3 plants – 15 plants total
  - *Protea*:
    - R/V: 5 groups x 3 plants – 15 total
    - *V: 4 groups x 3 plants – 12 total
  - Group = experimental unit
- *Protea* and *Leucospermums* in rows of 4-5, separated by road
  - No sampling from edge rows – prevent edge effect
  - Healthy, strong plants

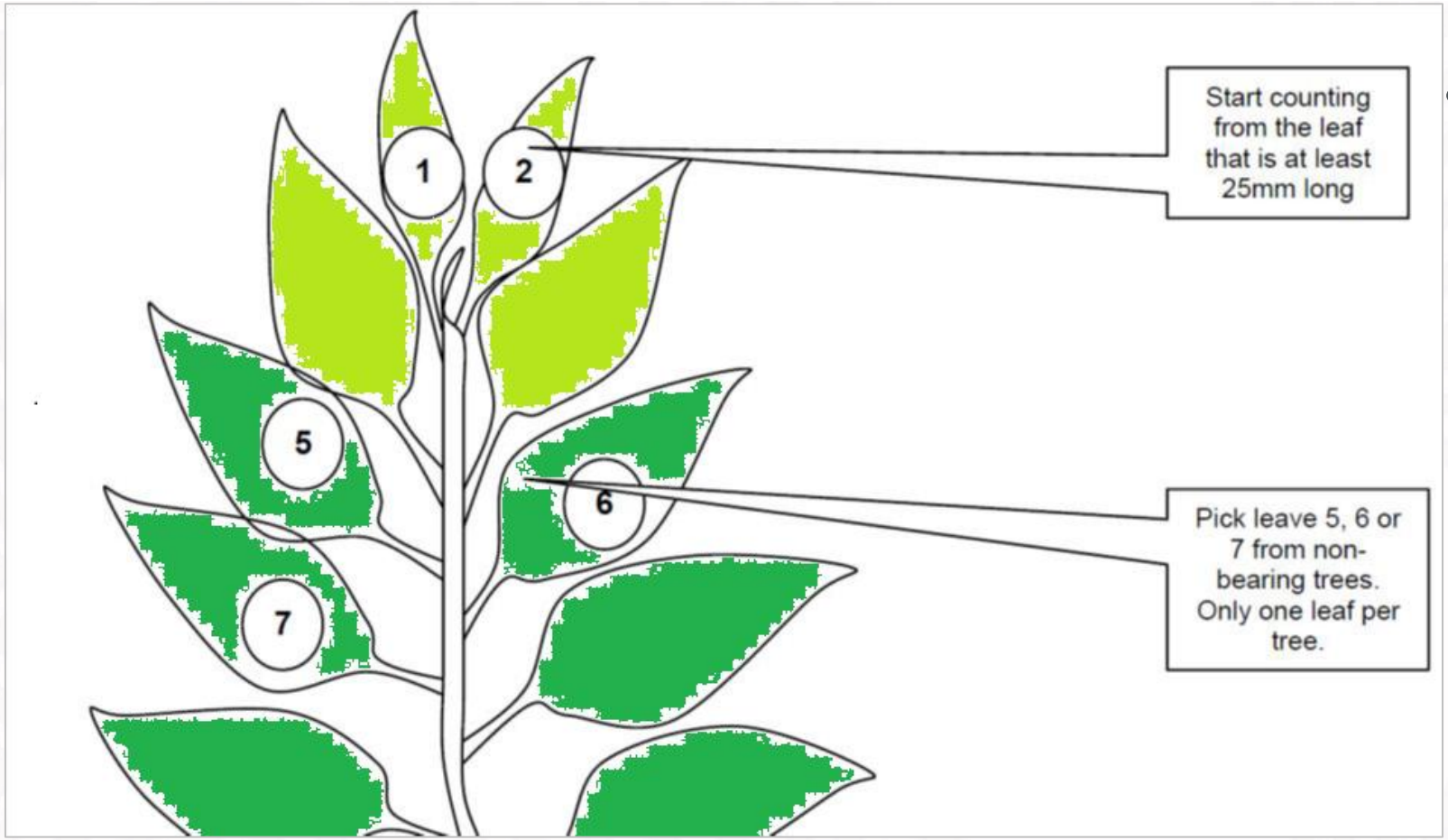


Experimental design: ‘Succession’

- Repeat measurements: 3 shoots tagged/plant:
  - Stem diameter and shoot length
  - Chlorophyll fluorescence
  - Flowers harvested and nutritionally analysed
- Leaf sampling from 12 tagged stems
  - 1 leaf/stem; 2 stems/plant/sampling point
  - Bulked across group → sufficient material and prevent excessive sampling per plant
  - **Sampled stems untagged to prevent future sampling**
  - Analysis of: N, P, K , Ca, Mg, Na, S, Mn, Fe, Zn, Cu, B
- Retagging occurs after each harvesting period



Leaf sampling protocol according to Dr. Eugienie-Lien Louw

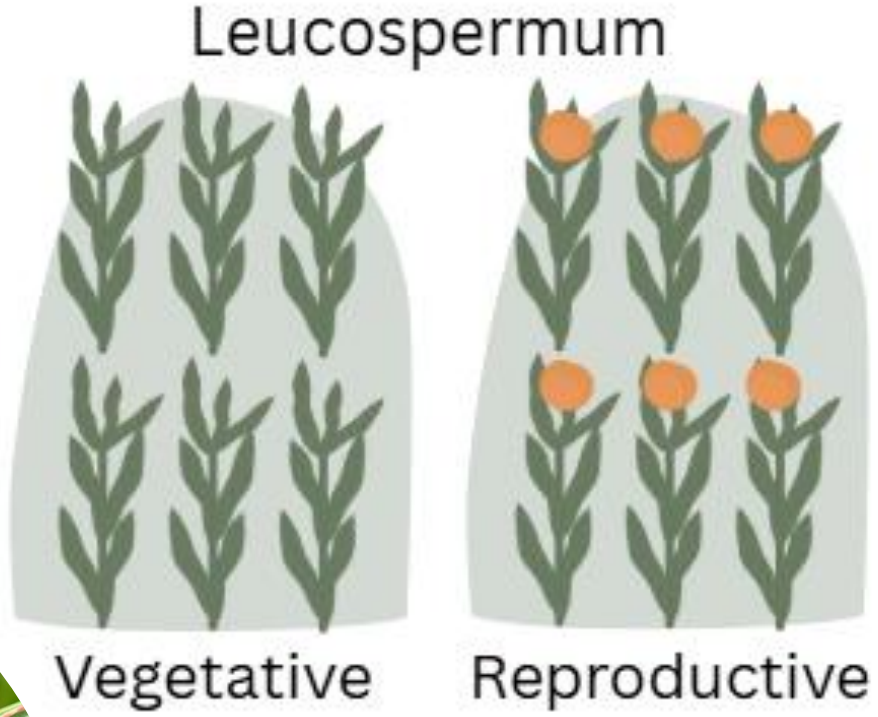


- Adaptations to the protocol:
  - Sampling from bearing (R) and non-bearing (V) shoots
  - Sample two leaves per *Leucospermum* plant to obtain sufficient biomass

Dr Louw recommended leaf sampling method – Cape Flora proposal document

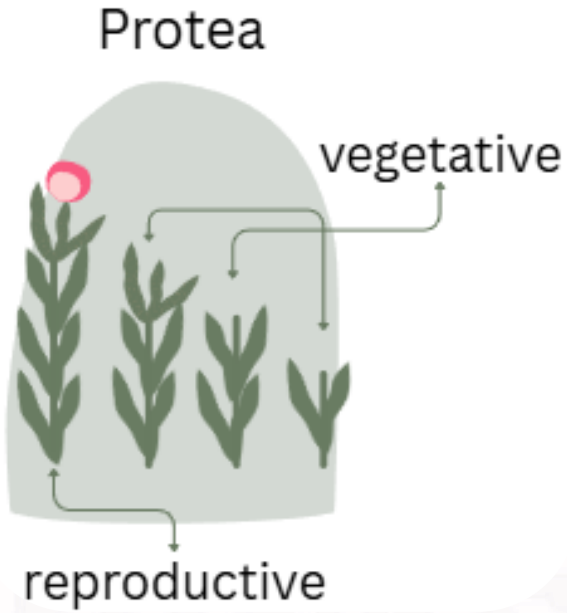
Leucospermum variability and shoot tagging

- Take into account the variability of shoot types
- Leucospermum are SD plants
  - relatively synchronous flowering
  - most of the shoots will be on the same phenological stage and overall exhibit much less variability.
- Choose strong shoots
  - Log length and thickness
  - Currently all reproductive
    - formation of flower bud



Protea shoot variability and tagging

- Theory: *Protea* shoots can occur at different phenological stages on the same plant.
  - Floral initiation min 4 flushes: spring, summer, autumn, and 2nd spring
    - R shoots with 4 flushes → current flowering season.
    - V shoots with a single flush → vegetative development
- Reality at the Boschendal farm:
  - Mature flowering plants predominantly R shoots.
    - Simultaneous V and R shoots the exception
  - Younger V saplings interspersed

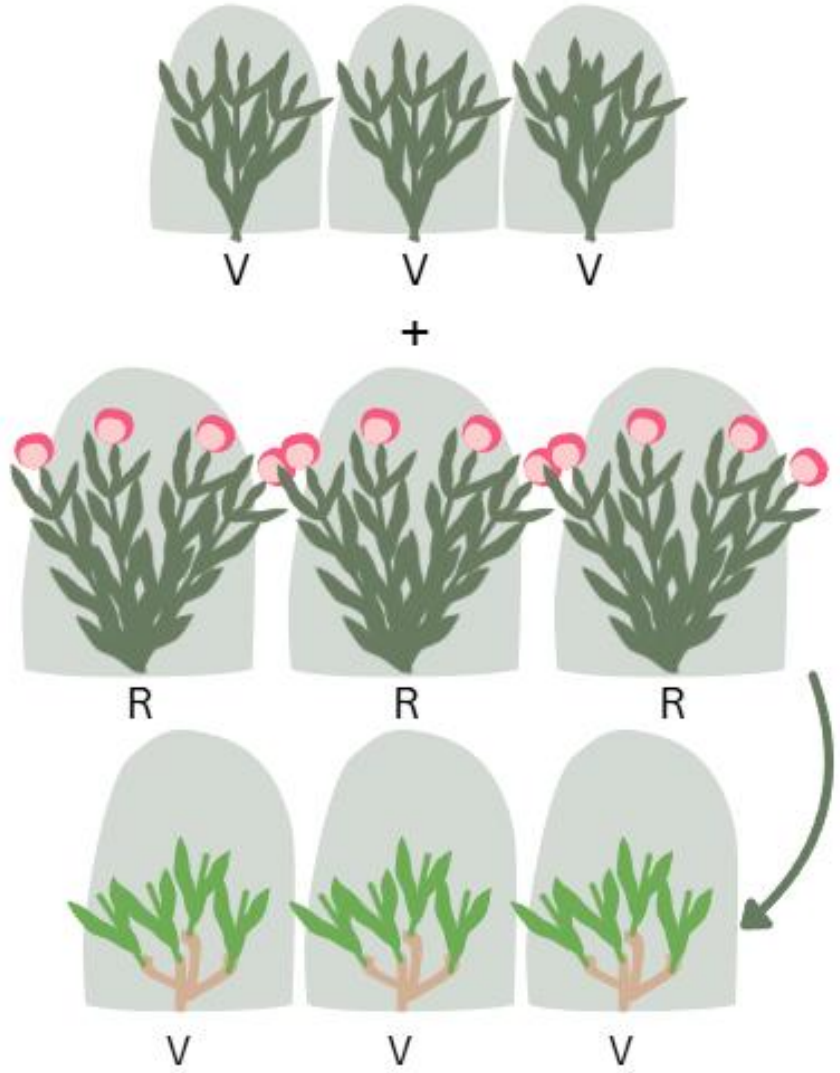


Vegetative sapling

Reproductive mature plant

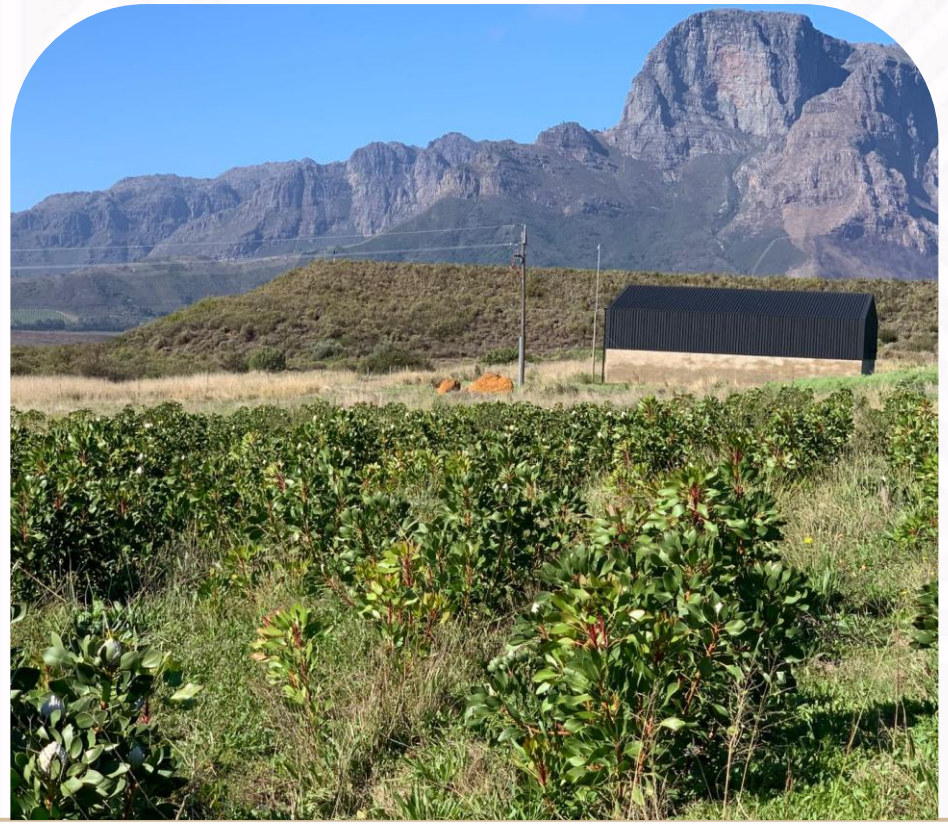
Protea shoot variability and tagging

- Current tagging approach:
  - R shoots (mature flowering plants) + V shoots (younger saplings)
  - After harvest, newly developing single-flush shoots will be tagged.
    - Monitor through phenological development into R stems.
- Why tag V sapling shoots now?
  - Baseline V shoot nutrient + growth data.
  - Comparative data for post-harvest V shoot development.



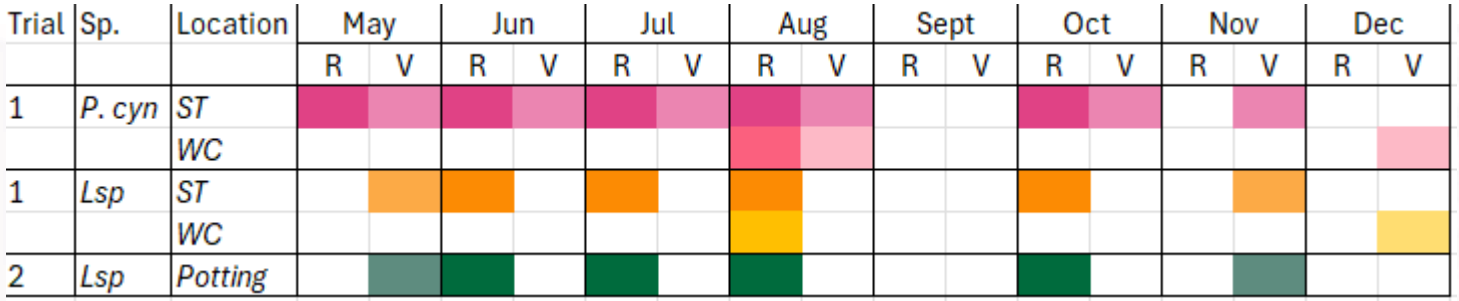
Experimental Design: Proteas

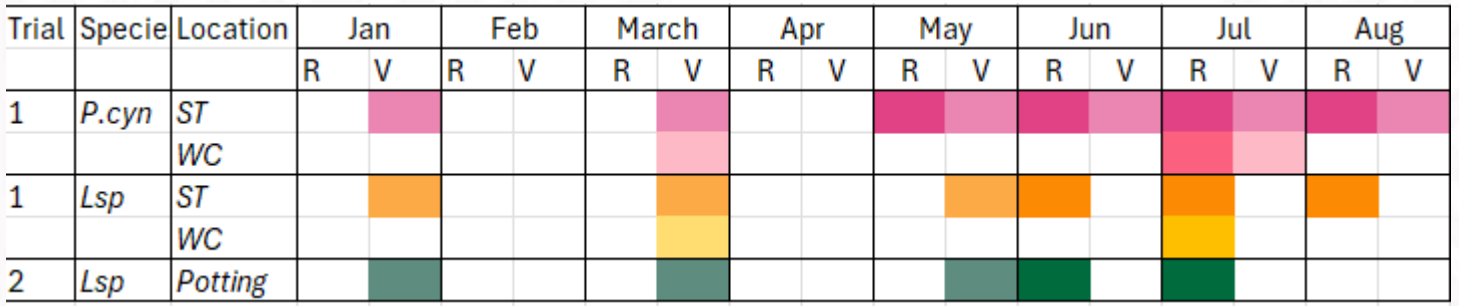
- Repeat measurements: 1 shoot (V/R) tagged/plant:
  - Stem diameter and shoot length
  - Chlorophyll fluorescence
  - Flowers harvested and nutritionally analysed
- Leaf sampling from 5 stems per plant
  - 1 leaf per stem; 1 stem per plant per sampling point
  - Bulked across group
  - **Sampled stems untagged**
  - Analysis of: N, P, K , Ca, Mg, Na, S, Mn, Fe, Zn, Cu, B
- Additional measurements:
  - #shoots on plant; #shoots reproductive
  - #growth flushes and flush length
- Retagging occurs after each harvesting period

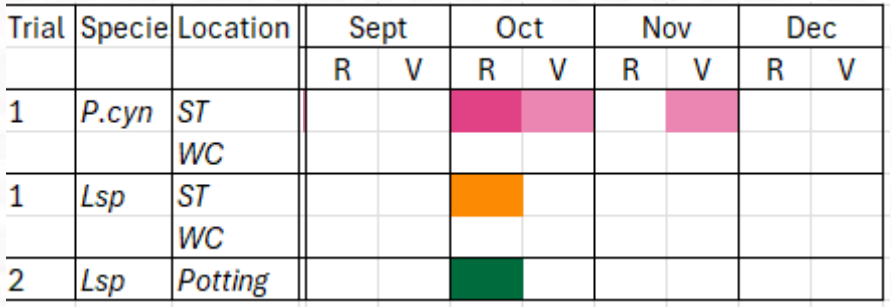


Timeline

- Protea cynaroides:
  - West Coast: 4 sampling time points – 30 samples
  - Stellenbosch: 12 sampling time points - 90 samples
- Leucospermum:
  - West Coast: 4 sampling time points - 20 samples
  - Stellenbosch: 11 sampling time points - 55 samples



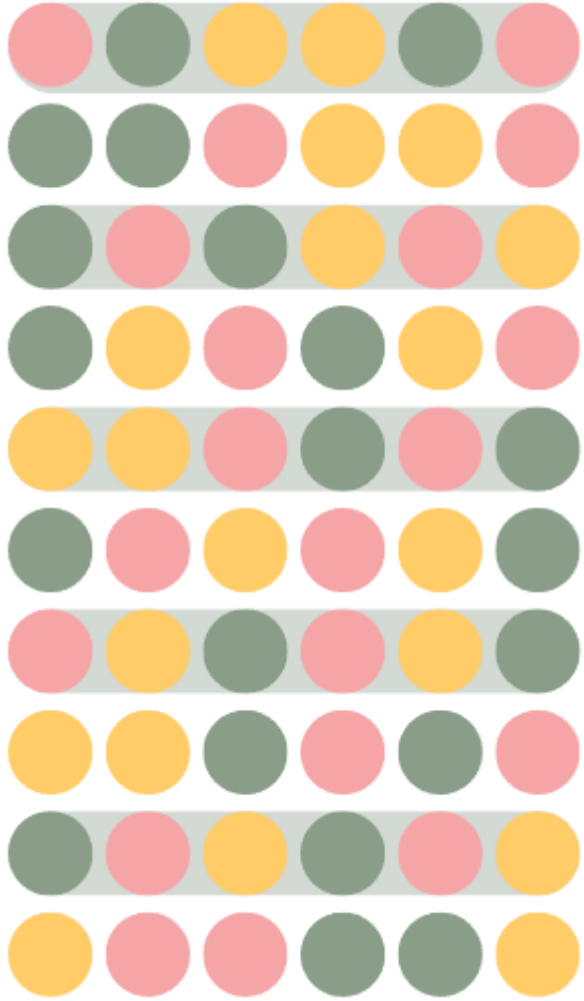




TRIAL 2: CONTROLLED NUTRIENT REGIME IN POTTED PLANTS

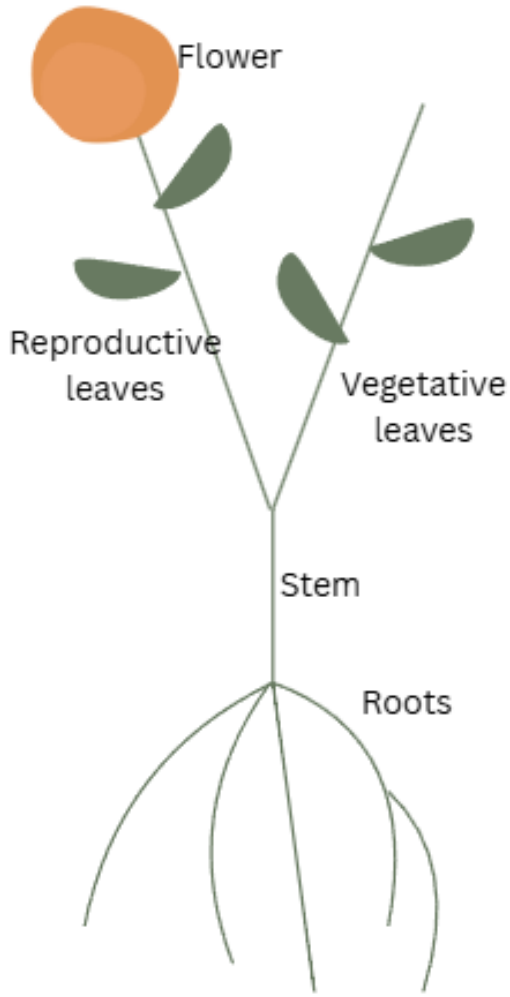
Experimental design

- Randomized block design: 3 treatments randomized within a block, consisting of 6 plants
  - 10 rows representing blocks – 60 plants total
  - 2 replicates of each treatment within a block
- Treatments
  - 3 nutrient regime concentrations: 0.5x, 1x, 2x[fertilizer]
  - Granular fertilizer added to potting mix at the start of the trial
    - Gradual release during irrigation or rainfall



Experimental design: Measurements

- Repeat measurements: 3 shoots (V / R) tagged/plant:
  - Shoot diameter and length
  - Track phenological development
- Leaf sampling from similar stems (2-3 leaves/plant)
  - Bulked
- Destructive harvest of plant parts at end of trial
  - 12 plants: 4 plants per treatment
  - Biomass allocation
  - Nutrient analysis of subsamples
  - Carbohydrate analysis of plant parts
- Correlate nutrient status with nutrient regimes, shoot characteristics, phenological development and DM accumulation



Timeline

- Similar timeline to trial 1 *Leucospermum* sampling dates.
  - 10 sampling points
- Destructive harvest will most likely occur in next year July.
  - 4 plants/treatment
  - 4 plants x 3 treatments x 5 plant parts = 60 samples

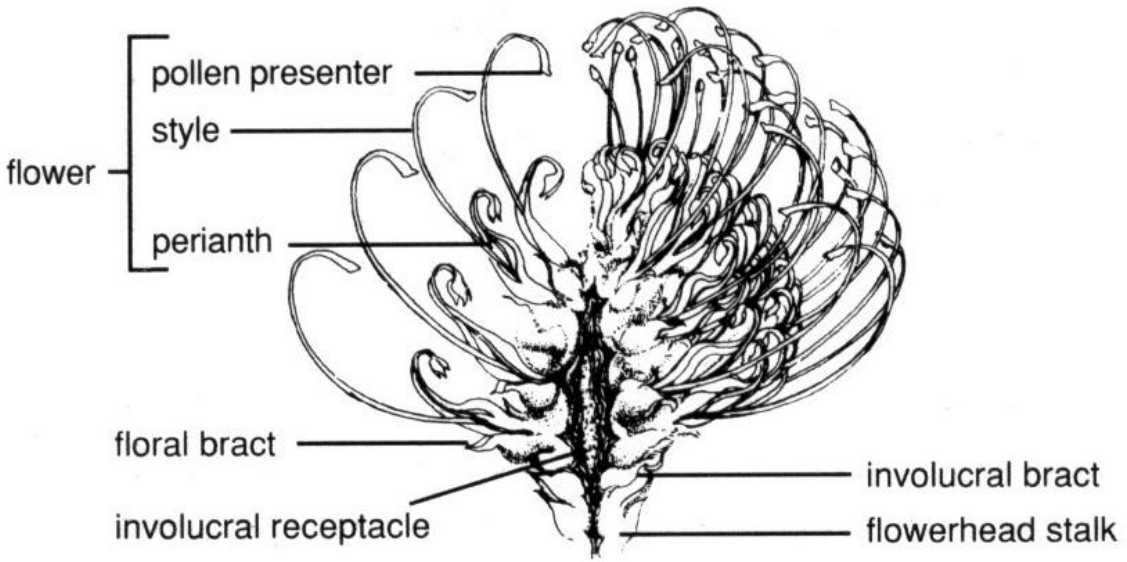
Trial	Sp.	Location	May		Jun		Jul		Aug		Sept		Oct		Nov		Dec	
			R	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V
1	*P. cyn*	*ST*																
		WC																
1	*Lsp*	*ST*																
		WC																
2	*Lsp*	*Potting*																

Trial	Specie	Location	Jan		Feb		March		Apr		May		Jun		Jul		Aug	
			R	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V
1	*P.cyn*	*ST*																
		WC																
1	*Lsp*	*ST*																
		WC																
2	*Lsp*	*Potting*																

TRIAL 3: INFLUENCE OF FERTILIZER LEVELS ON FLOWER COMPOSITION

Experimental design

- Done in conjunction with trial 2:
  - Additional 4 plants/treatment (flowerheads only) – 12 samples
  - Flowerheads bulked across individual plant
    - Subset kept for vase life investigation
  - Assess flowerhead as whole + individual parts
- Measurement of total DM, nutrient content, carbohydrate analysis of flower structures
  - Investigate as indicator of nutrient status
  - #R shoots, flower weight, composition…
- Correlation study with vase life
  - Monitor degradation in quality



STATISTICS

- ANOVA – to determine difference
  - Between sampling timepoints
  - Between phenological stages
  - Between shoot types
  - Between plant structures
  - Between farms
  - Between nutrient regime
- Correlation analysis and regression models – to determine relationships
  - Nutrient status and :
    - shoot characteristics
    - Phenology
    - Nutrient regime
- Multivariate analysis – complex analysis
  - Nutrient regime x floral structure nutrient status/biomass x vase life
  - Nutrient regime x carbohydrate analysis x floral nutrient status

Conclusion

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

- Leaf nutrient interpretation in Protea and Leucospermum may be influenced by phenology, shoot type, and seasonal variation.
  - Current sampling recommendations may not fully account for these sources of variability.
- This study will investigate:
  - seasonal nutrient dynamics,
  - differences between vegetative and reproductive shoots,
  - and the effects of nutrient supply on floral quality and vase life.
- Contributions:
  - improved leaf sampling protocols
  - nutrient management strategies for commercial cut-flower production
  - more robust leaf norm data

References

Bezuidenhout, Eugenie-Lien. “Effect of Temperature on the Growth, Physiology and Flowering of Protea Cv. Pink Ice.” Stellenbosch University, 2010.

Crous, Pedro W., Sandra Denman, Joanne E. Taylor, Lizeth Swart, and Mary E. Palm. Cultivation and Diseases of Proteaceae: Leucadendron, Leucospermum and Protea. CBS Biodiversity Series 2. Centraalbureau voor Schimmelcultures, 2004.

Fernández-Falcón, M., M. Hernández, C. E. Alvarez, and A. A. Borges. “Variation in Nutrition along Time and Relative Chlorophyll Content of Leucospermum Cordifolium Cv. ‘High Gold’, and Their Relationship with Chlorotic Sypmptoms.” Scientia Horticulturae 107, no. 4 (2006): 373–79. https://doi.org/10.1016/j.scienta.2005.08.009.

Hattingh, Naomi. “Manipulation of Flowering in Protea Cynaroides Cv. Arctic Ice.” Stellenbosch University, 2021.

Hoffman, Eleanor Wilhelmina. “FLOWER INITIATION AND DEVELOPMENT OF PROTEA CV. CARNIVAL”. Stellenbosch University. n.d.

Kalra, Yash P. and Soil and Plant Analysis Council, eds. Handbook of Reference Methods for Plant Analysis. CRC Press, 1998

Malan, Gerhard. Protea Verbouing: Van Konsep tot Karton. SUN MeDIA, 2012.

Sedgley, Margaret, Richard A. Criley, J. H. Coetzee, G. M. Littlejohn, Jaacov Ben-Jaacov, and Anver Silber. Proteaceous Ornamentals. Scripta Horticulturae 5. John Wiley & Sons, Inc. ISHS, 2007.

Van Zyl, Maria Helena. “Chilling Injury and the Control Thereof in Selected Leucadendron Cultivars.” Stellenbosch University, 2025.

Viljoen, Nina. CFSA AGM: Exports, Local, Estimates. Cape Flora, 2025. Montarone, M., M. Ziegler, N. Dridi, and S. Voisin. “COMPARISON OF MINERAL REQUIREMENTS OF SOME CULTIVARS IN TWO PROTEACEAE GENERA.” Acta Horticulturae, no. 602 (March 2003): 103–11. https://doi.org/10.17660/ActaHortic.2003.602.14.

Vivier, Marlie. “Control of Flowering Time in Protea Cv. Pink Ice.” Stellenbosch University, 2013.

Stellenbosch
UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT

Thank you!