

Gamma irradiance as a tool for intra-varietal (cultivar) improvement

Investigating the effects on the cluster, canopy, and grape traits of three Pinotage clones

Presented by: Alexandra Bald

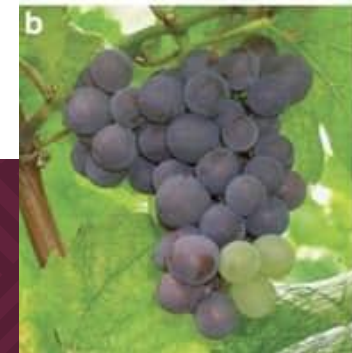
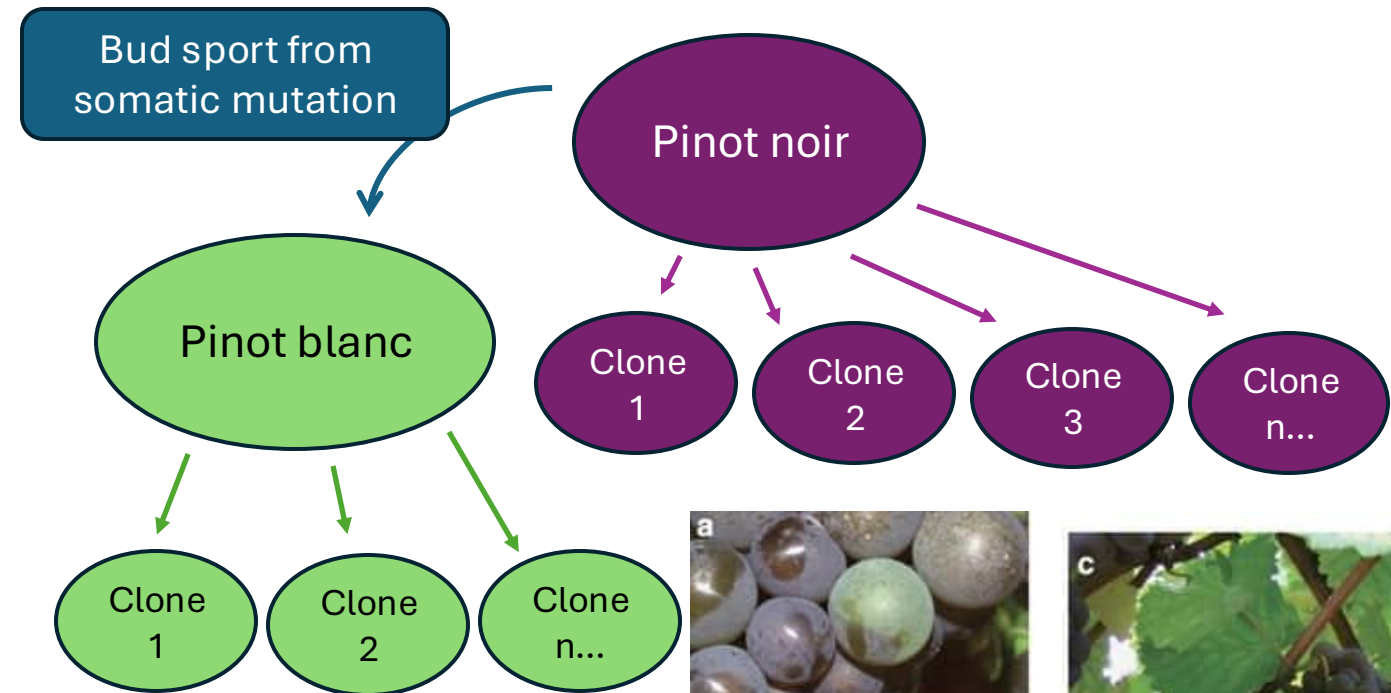
Supervisors: Prof Melané Vivier, Ms Phyllis Burger

Affiliations: SAGWRI, Stellenbosch University

Agricultural Research Council (ARC), Infruitec-Nietvoorbij

Grapevine intra-varietal diversity

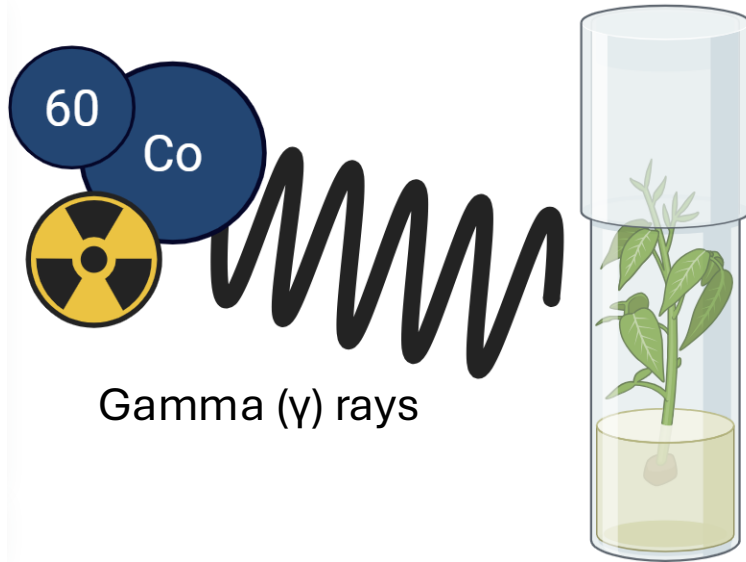
- Grapevine cultivars composed of numerous clones
- **Variation**
 - **Somatic**
 - Natural or induced
 - Mutations occur during growth or through mutagenesis
 - **Somaclonal**
 - *In vitro* culturing process
- **Phenotypic/ genotypic variation**
 - Viticultural traits (vigour, yield)
 - Grape and wine quality traits
 - Pest or disease resistance



(Pelsy, 2010)

Induced mutation using gamma irradiation

A long-standing crop improvement tool



- Gamma irradiation encourages natural-like variation (non-GMO or gene editing).
- Not subject to regulatory approval processes for transgenic or gene-edited plants.
- Unlocks the potential that is already possible within the variety.
- Still the same cultivar, but potential for new strengths.

(Created with Biorender)

Pinotage: a young red-wine cultivar with limited clonal diversity

Pinot Noir X Cinsault Noir (Hermitage)

Clone	Origin	Year selected	Viticultural and Wine remarks
Pi 45	Vititec/ Bellevue	1981	Average yield and vigour, Good quality wine
Pi 48	Vititec/ Slaley	1966	Average yield and vigour, Good quality wine
Pi 50	Meerendal	1976	Removed due to virus infection of source material.
Pi 6	Kanonkop	1996	Average yield and vigour, Good quality wine
Pi 7	Warwick	1996	Average yield and vigour, Good quality wine



Cabernet Sauvignon and Chardonnay have **43 registered clones** each as of 2020

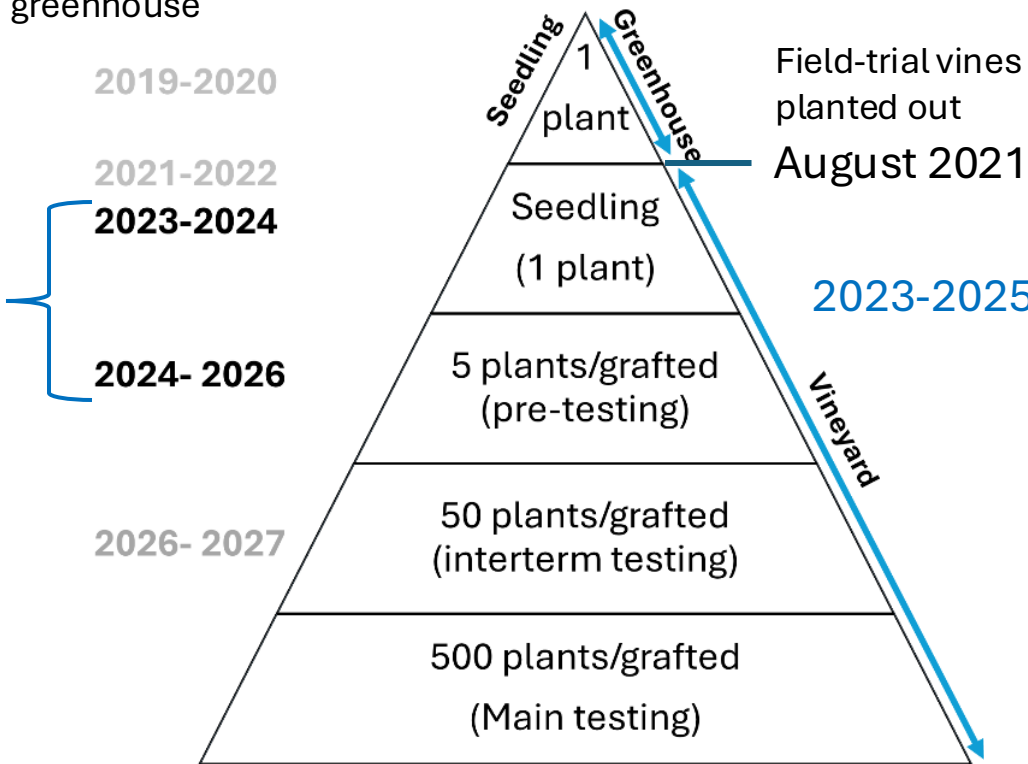
Desirable characteristics
Fruit-driven aromatics and flavours
Yield and quality in marginal soils

Room for improvement
Fast fermentation rate
Unbalanced sugar-to-acid ratio
Fast ripening progression

(Pohl, 2023 [MSc Thesis]; Pinotage Association, accessed 2024; Goussard, 2008; Vine Improvement Association, 2020)

The Pinotage Diversity Project

0, 10, 20 and 30 Gy
 Generation and recovery
 of *in vitro* plants
 Hardening off in
 greenhouse



2021-2022 (Ms Monje Pohl MSc study)

Similarity/ Dissimilarity
 scoring to unirradiated
 clones

Morpho-colorimetric analysis
 Phenological scoring
 Trunk circumference measurements

2023-2025 (Ms Alexandra Bald PhD study)

Population size for field trial planted in 2021*						
Clone	No irradiation	Irradiation				Total
	Control (0 Gy)	10 Gy	15 Gy	20 Gy	30 Gy	
7	30	36	66	63	0	195
45	30	32	36	42	2	142
48	30	27	46	60	0	163
Total	90	95	148	165	2	500
Total	Population size for field trial planted in 2022** = 800					

*This population has been subjected to analysis since planting.

**This population has not yet been comprehensively analysed.

SA Wine Project P04000060

Project leaders:

Prof Melané Vivier

Ms Phyllis Burger (ARC Nietvoorbij)

Plant materials used in this study

***Field trial population planted (self-rooted)** at the Agricultural Research Council (ARC) Nietvoorbij farm

****Commercial Pinotage clonal controls grafted to Richter 110 rootstocks** planted at the Welgevallen Experimental farm



		*Field trial population		
Clone	**Grafted controls	Number of unirradiated vines	Number of irradiated vines	Total number of vines
PI 7	10	30	165	195
PI 45	10	30	111	141
PI 48	10	30	132	162
Total	30	90	408	498

Phenotyping

2022/2023, 2023/2024 and 2024/2025 growing seasons

Season 1 harvest - 28 February 2023

Seasons 2 and 3 - Ripeness monitoring and harvest at optimal ripeness (24-26° Brix for Pinotage)

Season 3 (2024/2025) - quantitative data collection for individuals with differing cluster architectures

Qualitative



Quantitative



¹ Descriptors for Grapevine (*Vitis* spp.), IPGRI, UPOV & OIV (1997).

² Own scale developed based on extremes of phenotypes observed.

Trait	Description	
Bunch traits		
Bunch density ¹		Visual compactness of bunches according to OIV-204.
Bunch size ²		The visual size of the bunches of the plant.
Bunch shape ²		The visual shape of the bunches of the plant.
Berry traits		
Berry skin colour ²	2023	The visual berry skin colour.
	2024	The number of berries displaying each berry skin colour.
Berry flesh colour ¹	2023	Visual berry flesh colour according to OIV-231.
	2024	The number of berries displaying each berry flesh colour according to OIV-231.
Seed colour ²	2023	The average seed colour per plant.
	2024	The number of berries displaying varying seed colours.
Number of seeds ²	2023	The average number of seeds per plant.
	2024	The number of berries displaying varying seed numbers.
Berry shape ¹	2023	Visual berry shape according to OIV-223.
	2024	The number of berries displaying each berry shape according to OIV-223.
Canopy traits		
Growth habit ¹		The visual growth habit of the plant according to OIV-006.
Plant size ²		The visual plant height.
Agronomic traits		
Bunches per plant		Total number of bunches of each plant.
Berry weight		Total weight of 50 berries (g).
Yield per plant		Total grape production (kg) (2024 only).
Trunk circumference (mm)		The quantitative measurement of the trunk circumference (30 cm above the soil level) (2023; 2024).
Shoots per plant		Total number of shoots of each plant (2024 only).
Pruning weight		Total pruning fresh weight (kg) (winter 2024).

Field trial phenotypical observations

Berry skin colour



Red-grey



Yellow-green



Berry flesh colour



5

Slightly pigmented



7

Moderately pigmented



9

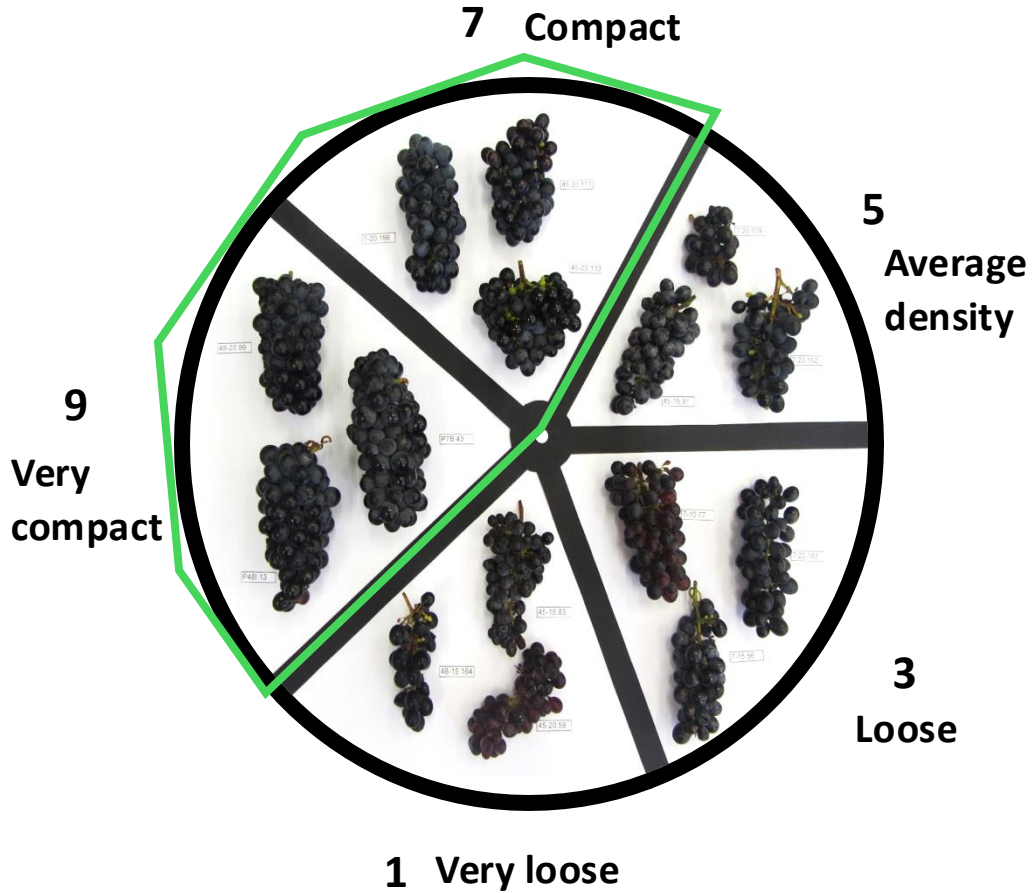
Highly pigmented



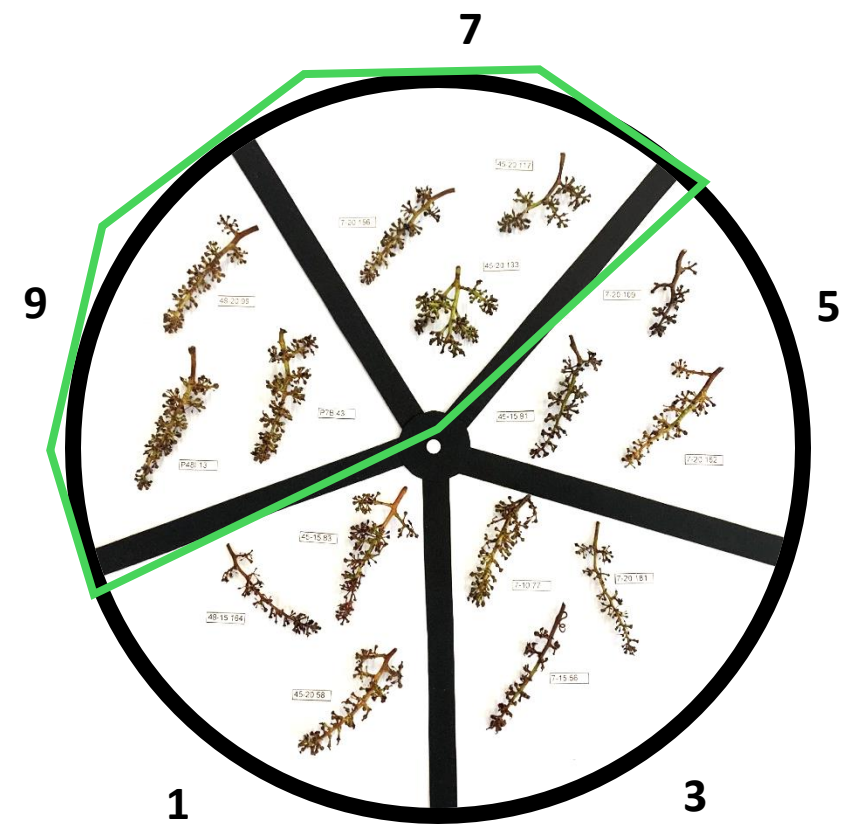
A white Pinotage?

Field trial phenotypical observations

Bunch compactness



Very loose clusters in the vineyard



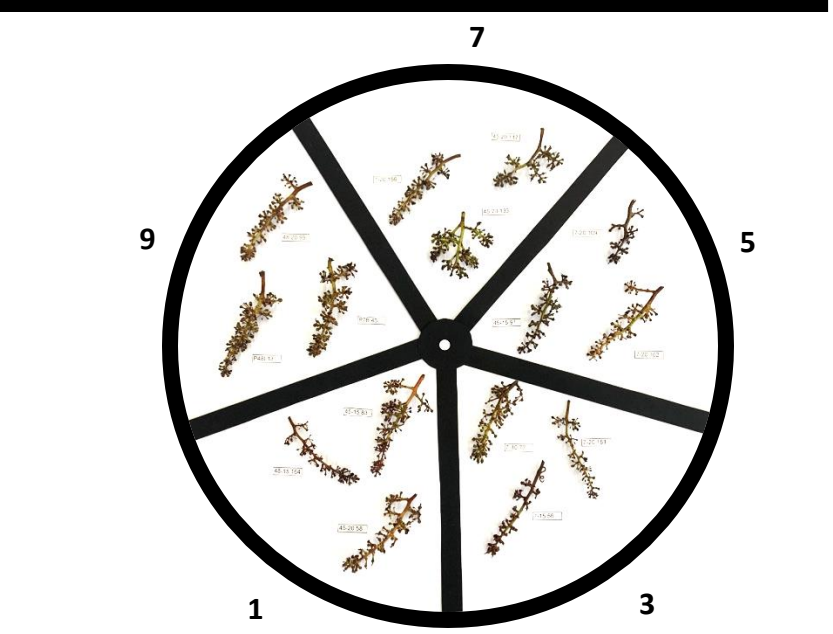
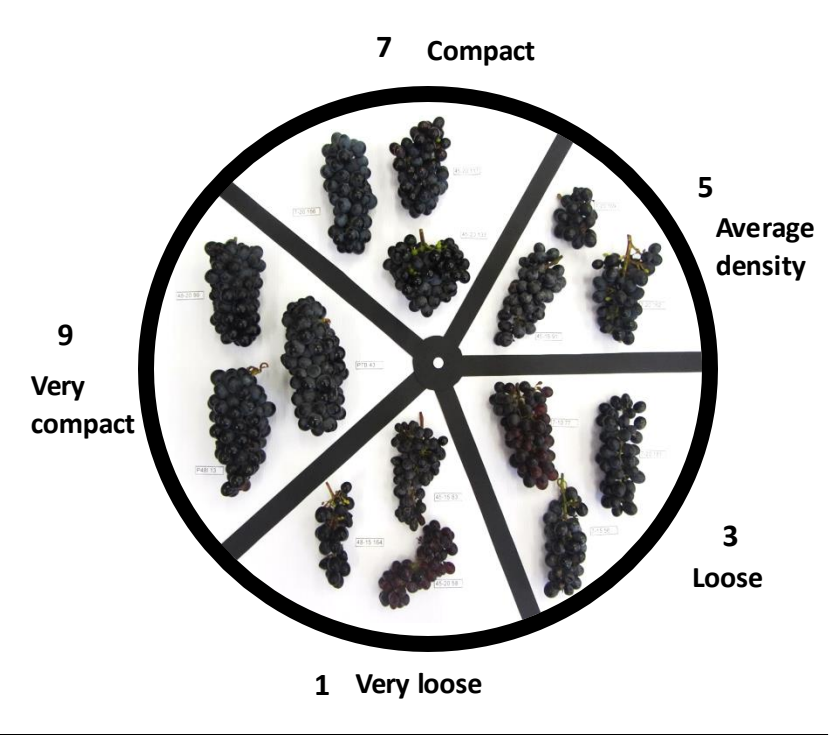
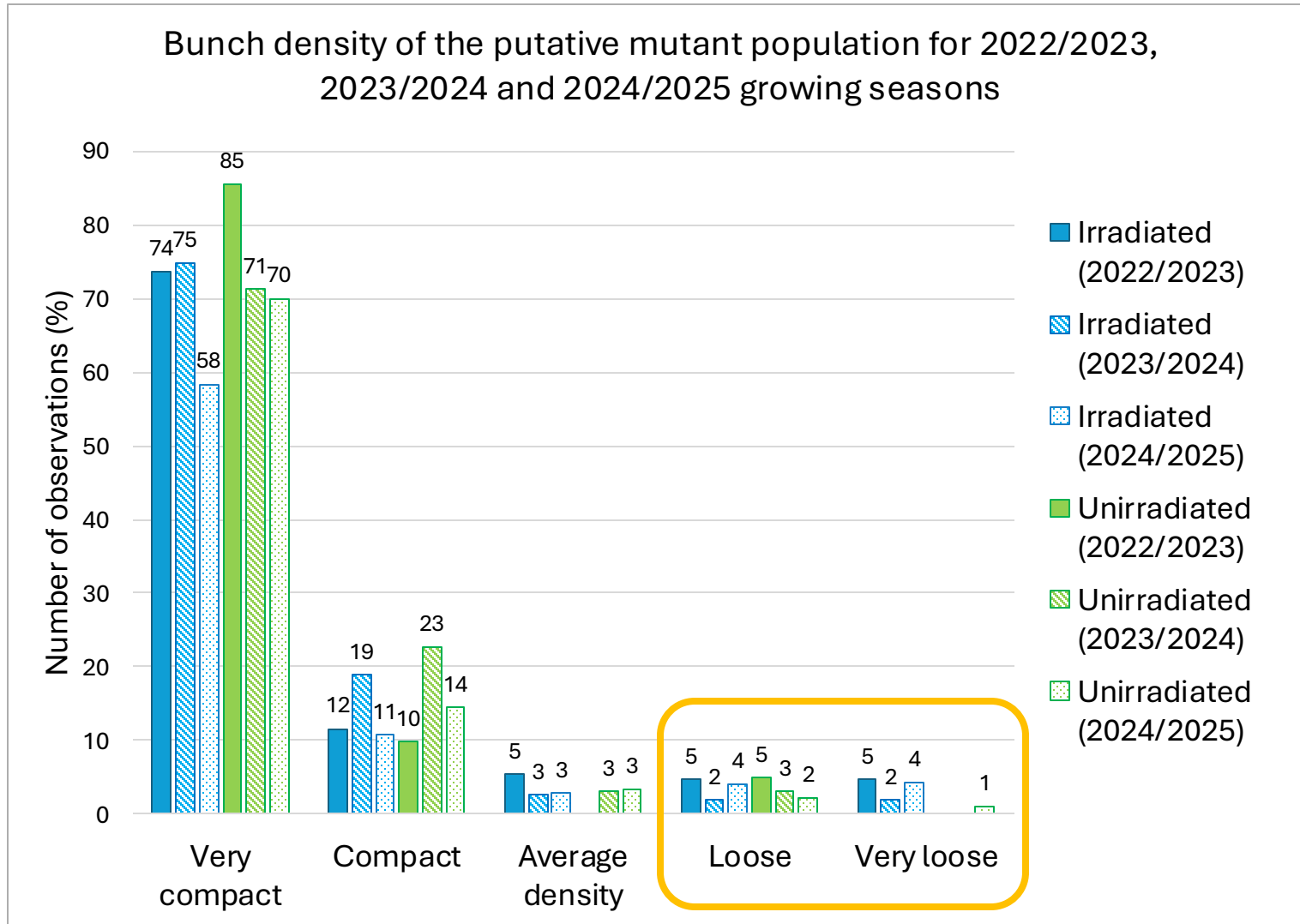
Rachis architecture once berries removed

Berry size



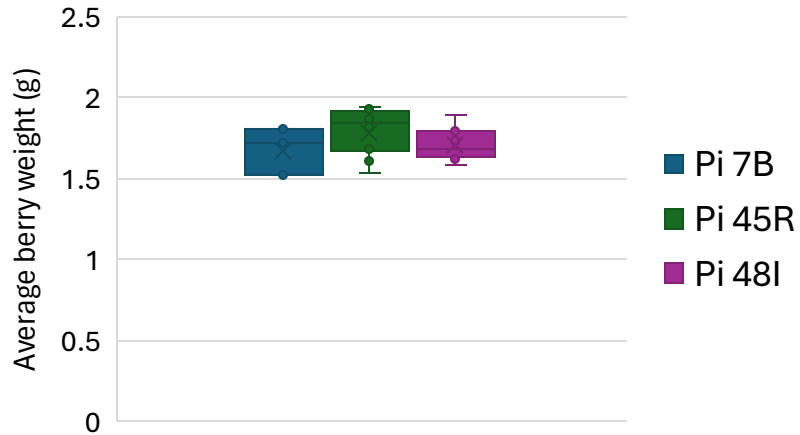
Bunch compactness (3 seasons)

2022/2023 (n= 170)
 2023/2024 (n= 334)
 2024/2025 (n=424)



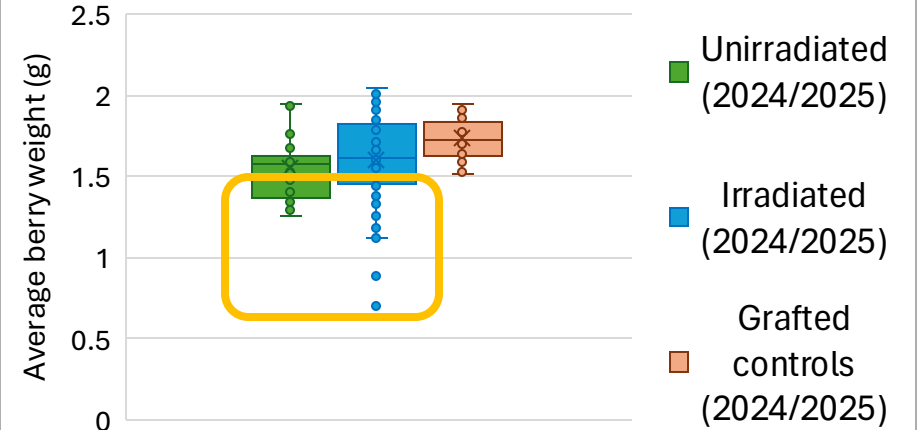
Diversity in berry weight and size

Berry weight (**commercial Pinotage clonal controls**) for the 2024/2025 season

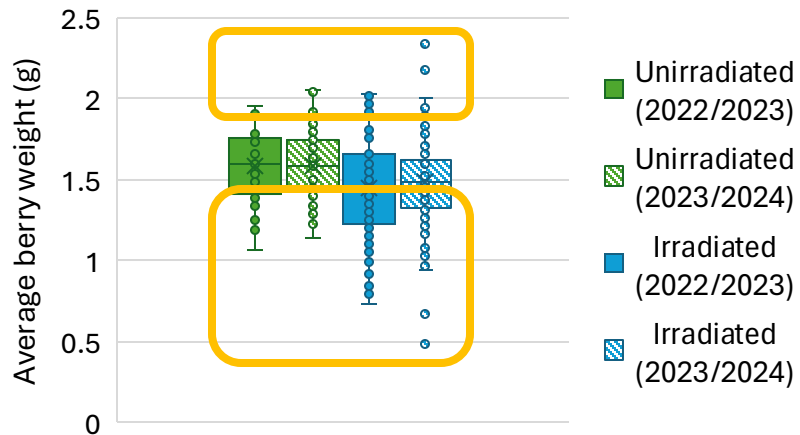


Altered skin: pulp ratios
Implications for juice quality impact factors

Berry weight for the **self-rooted mutant Pinotage population** and grafted commercial clonal controls (2024/2025 season)



Berry weight for the **putative mutant Pinotage population** (2022/2023 and 2023/2024 seasons)

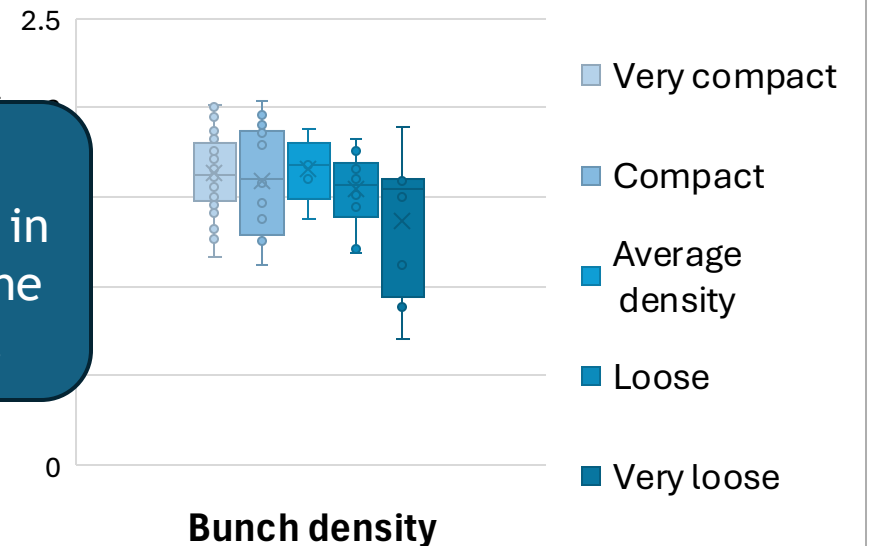


Looser clusters

The irradiated vines exhibited a wider diversity in berry weight compared to the unirradiated control vines.

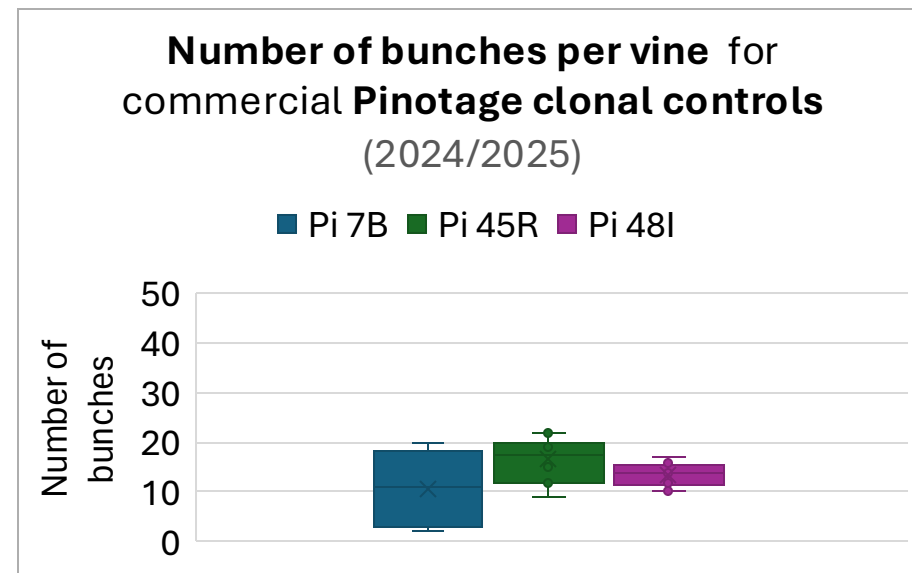
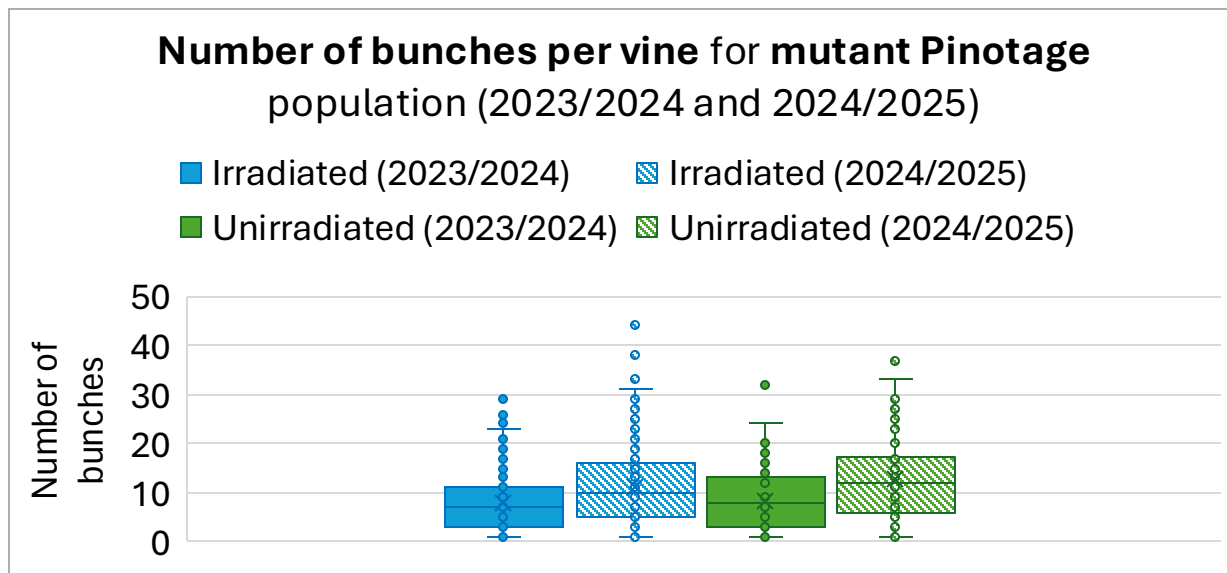
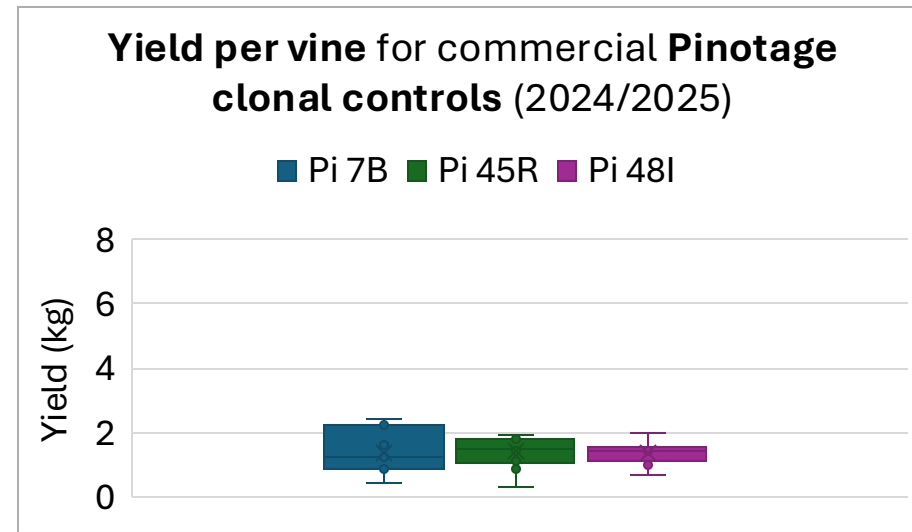
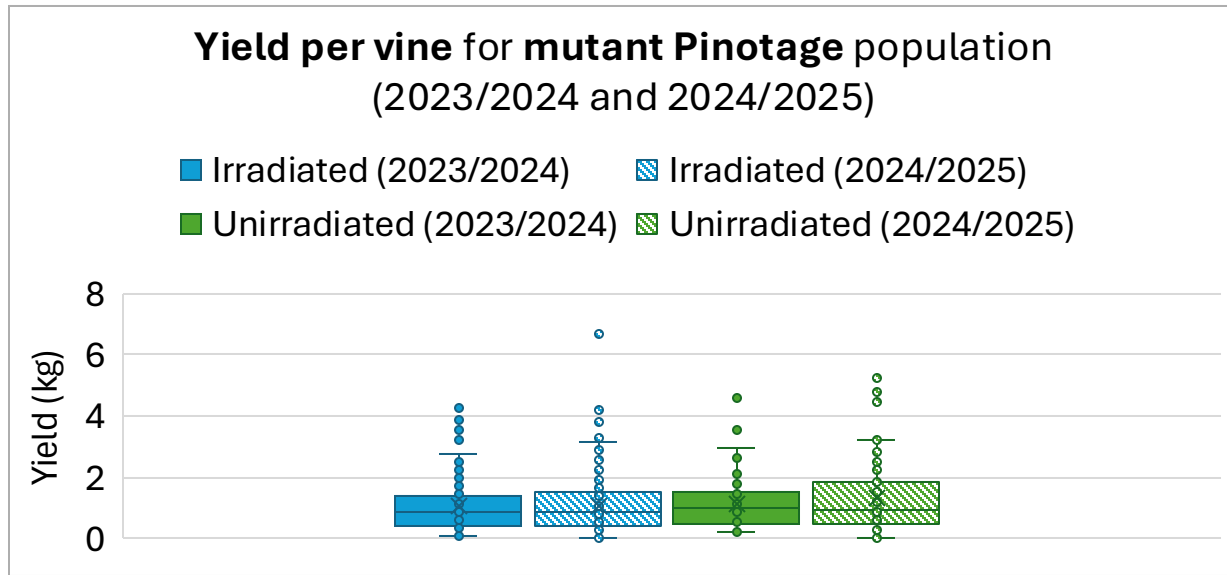


Berry weight for a subset of vines from the **putative mutant Pinotage population** (2024/2025 season)



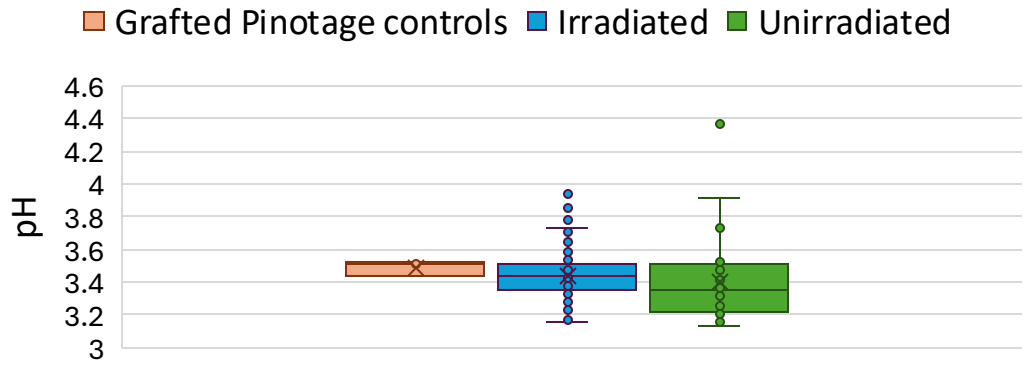
Bunch density

Opportunity for increased yield per vine

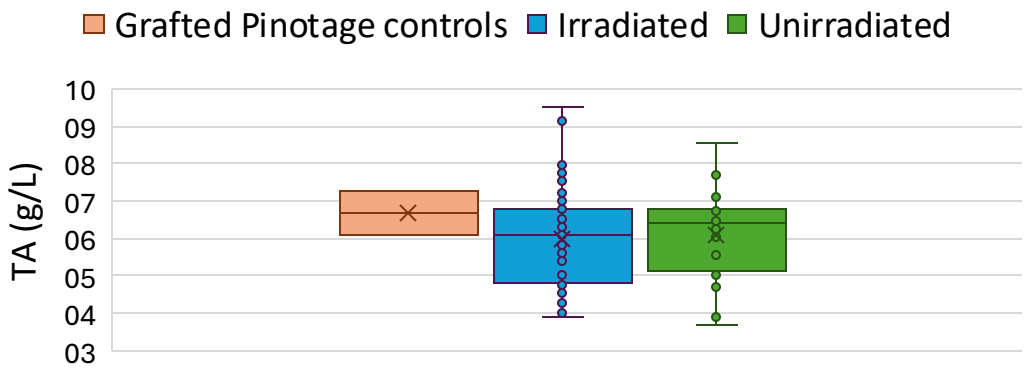


Grape chemical parameters at harvest

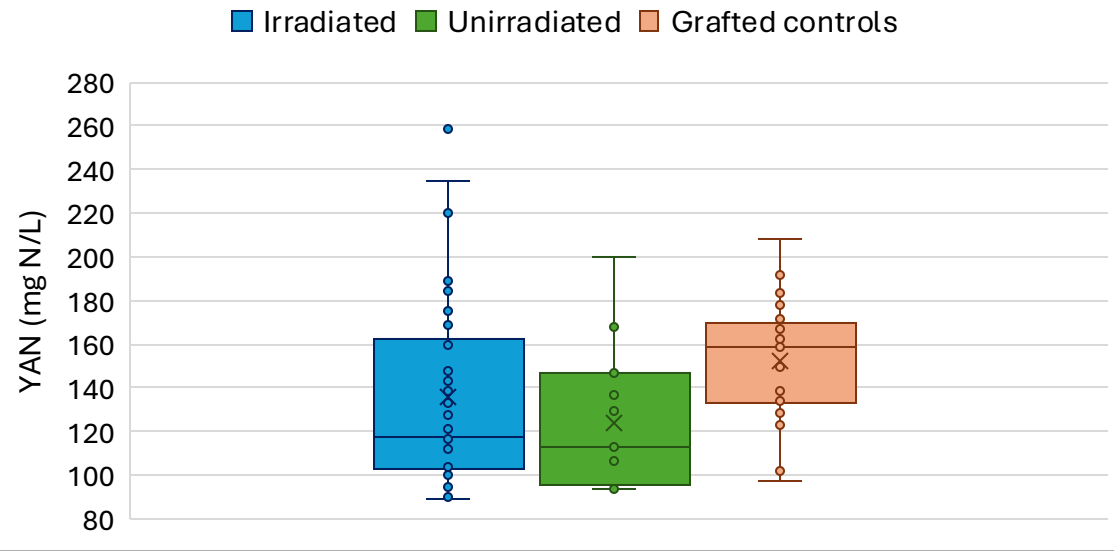
pH of grape juice for the 2023/2024 growing season



Titratable acidity (TA) of grape juice for the 2023/2024 growing season



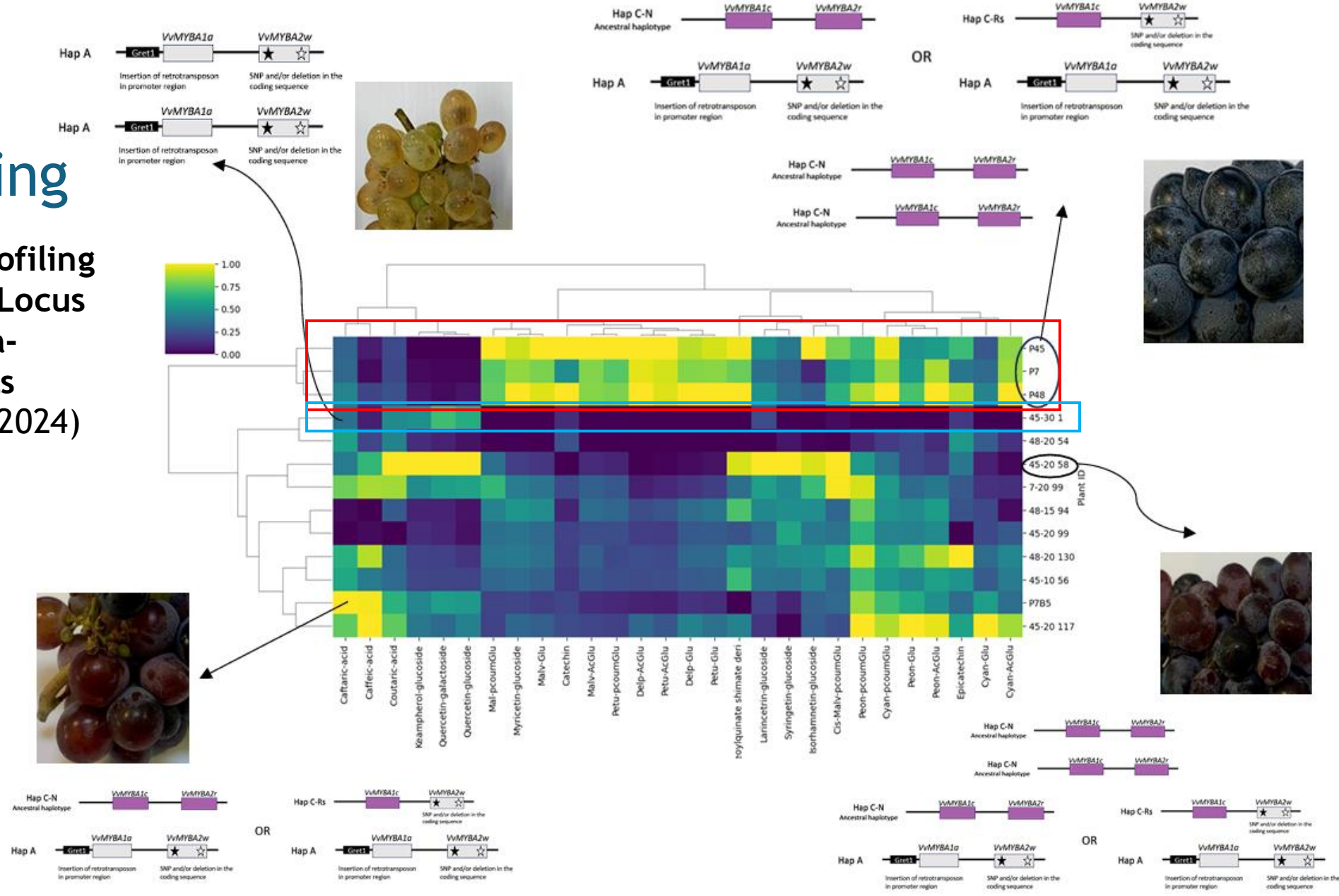
Yeast assimilable nitrogen (YAN) for putative mutant and grafted commercial Pinotage vines for 2024/2025 season



Lower TA and pH at harvest have the potential to slow down the rate of fermentation and improve phenolic extraction during the winemaking process.

Phenolic profiling

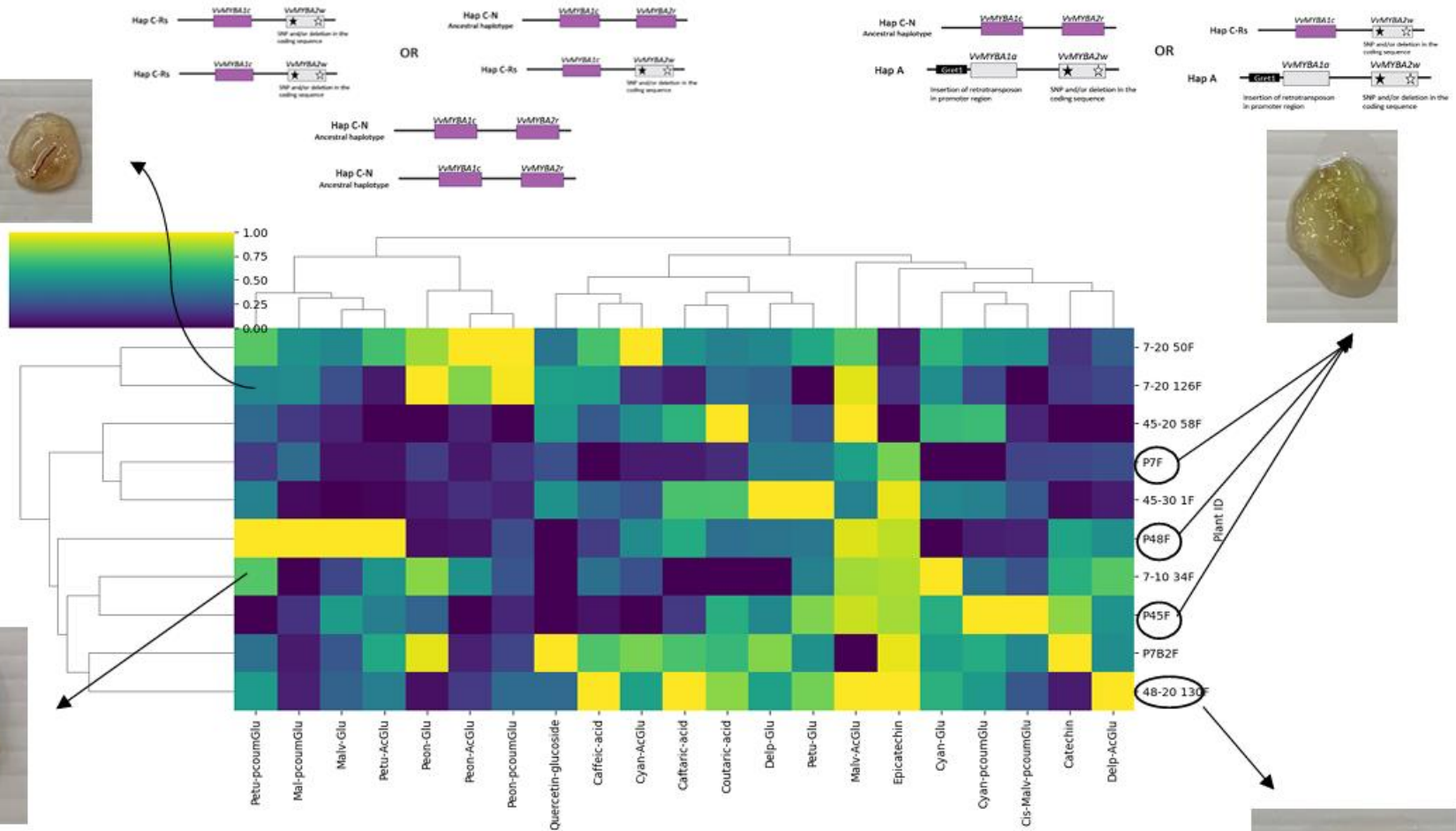
Genetic and Chemical Profiling of the Grapevine Colour Locus in a population of gamma-irradiated Pinotage plants
T Padayachy (MSc Thesis, 2024)



Phenolic profiling

Genetic and Chemical Profiling of the Grapevine Colour Locus in a population of gamma-irradiated Pinotage plants
T Padayachy (MSc Thesis, 2024)

Phenolic profiling (2024/2025 and 2025/2026 seasons)
Controlled for TSS content (Brix). Pinot noir as a reference against which selections can be made.



Detailed phenological characterisation

Modified E-L scoring system (Coombe, 1995)
2023/2024 and 2024/2025 growing seasons

Trait	Description
Phenological traits	
Budburst	Date when first leaf tissue is visible in the bud (E-L Stage 4).
Flowering	Date when 50% of flower caps are off (E-L Stage 23).
Véraison	Date when berries begin to change colour and enlarge (E-L Stage 35).
Harvest	Date when berries are harvest-ripe (E-L Stage 38).



4

Bud burst



23

Full bloom



Véraison

35



Harvest-
ripe

38

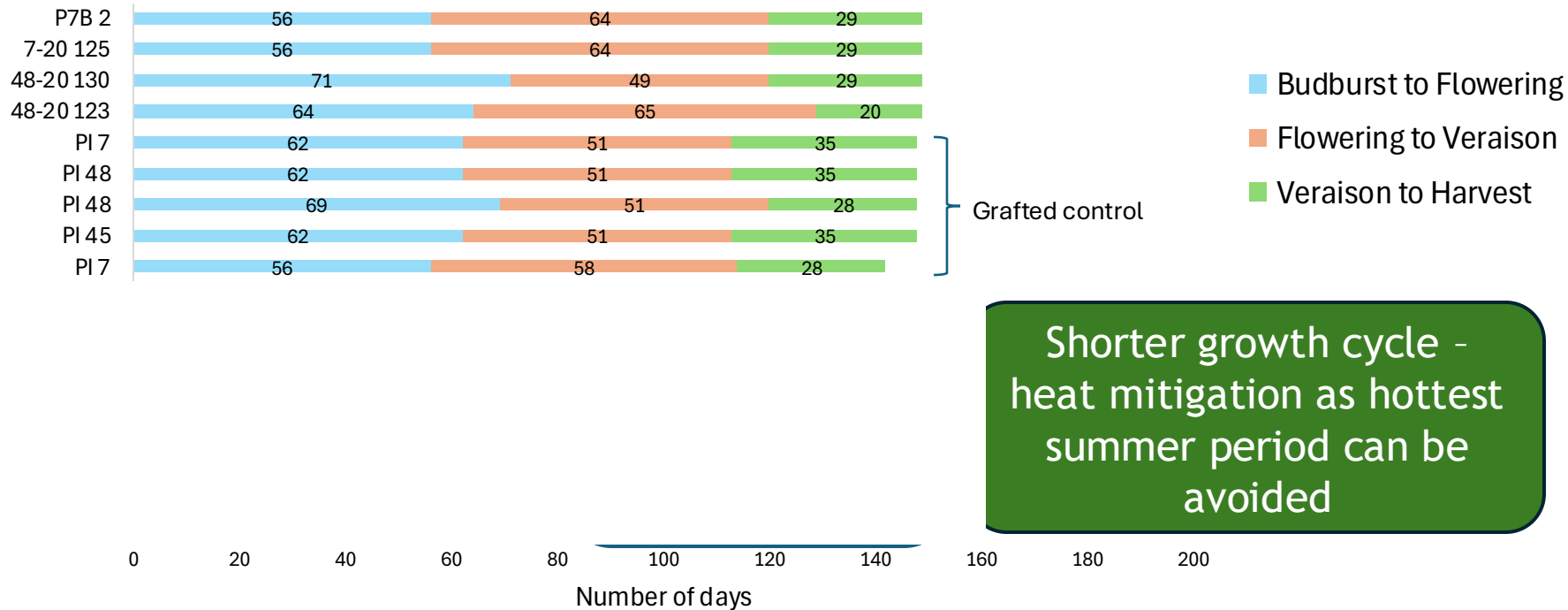
Major phenological developmental stages (2023/2024 season)

45-15 74
Clone-Irradiation level Plant
number

Longer ripening period -
potentially promote
balanced phenolic
accumulation

R 16 (Unirradiated)
(Grafted control)

Increased diversity in the
phenological progression
and ripening period was
observed in the putative
mutant population,
particularly in the
véraison-to-harvest
period.



Grafted control

Shorter growth cycle -
heat mitigation as hottest
summer period can be
avoided

Selections for future research

- **
- Early harvest - late January
 - Mid/ Mid-late harvest - February/ late February to March
 - Late harvest - early March

Clone	Irradiation level (Gy)	Cluster architecture	Berry size, shape or colouration	Ripening period **	Chemical traits	Yield and vigour
7	10	Very loose	Small berries			
	15			Late harvest, long ripening (9 weeks)		
	15			Late harvest, long ripening (8 weeks)	Low TA (~4.4 g/L)	
	20	Very loose	Small berries	Early harvest		
	20		Altered berry shape	Early harvest		
	20			Mid-late harvest	Low TA (~5.6 g/L)	High yield and vigour
	20			Mid-late harvest	Low TA (~5.3 g/L)	High yield and vigour
45	10		Flesh pigment	Late harvest, long ripening	Low TA (~4.5 g/L)	
	10			Mid-harvest, long ripening		High yield
	15			Late harvest, long ripening (11 weeks)		
	20					High yield (6 kg) and high vigour
	30	Very compact	Yellow-green berries			Good yield
48	10			Late harvest, long ripening (9 weeks)	Low TA (~4 g/L)	Good yield
	10			Mid-late harvest, long ripening	Low TA (~5.4 g/L)	
	10		Large berries			High yield
	15	Loose	Small berries			Good yield and vigour
	15	Very loose			High YAN (260 mg/L)	High vigour
	20			Late harvest	Low TA (~3.75 g/L)	

Conclusion and future outlooks

- Gamma irradiance protocol successfully increased the diversity in numerous viticultural and oenological traits
 - Berry skin and flesh colour, bunch compactness, yield and number of bunches per vine, phenological timing and ripening window, as well as basic chemical parameters (TA, pH and YAN) and the polyphenolic profile.
- Proof-of-concept study
 - Potential for application on other cultivars to better enhance their expression in a South African climate.
- Gamma irradiation is non-GMO, allowing immediate adoption for clonal diversity improvement.

Acknowledgments

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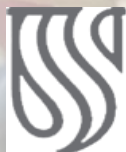
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Cellar team

CA Lab





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South African
Grape and Wine
Research Institute

Thank you
Enkosi
Dankie