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Standardization of canopy management practices for table grape production under subtropical climate

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Abstract

Grape growers in the Western Cape of South Africa have trained vines on the head system since the early Cape viticulture trials of the 1920s, a choice that suited small plots but no longer matches modern commercial table-grape production. This research compared five canopy training systems—head training (local standard), four-arm Kniffin, single curtain, Geneva Double Curtain (GDC), and Y-trellis—on Thompson Seedless grape at the Stellenbosch research vineyard across three consecutive seasons (2020-21 to 2022-23). Vegetative parameters, light interception, yield, berry quality, and labour hours were tracked season-wise. GDC recorded the highest cumulative yield at 63.1 t ha⁻¹ over three seasons, followed by Y-trellis (54.7), single curtain (50.7), Kniffin (38.7), and head training (27.1). Photosynthetically active radiation interception peaked at 82.4% under GDC and dropped to 47.6% under head training. Berry TSS varied narrowly across systems (18.4-19.8 °Brix). Labour hours per hectare per season were highest in GDC (348 h) and lowest in head training (214 h), but per-tonne labour cost was lowest in GDC at R 1,580. GDC is recommended for commercial orchards where trellis investment can be justified, while Y-trellis suits medium holdings looking for a balance between productivity and simplicity.

Keywords: Canopy management, table grapes, subtropical climate, viticulture, fruit quality, GDC training, light interception, vine architecture

Introduction

The early viticulture trials of the 1920s, carried out at the Stellenbosch and Paarl stations, established head training as the default canopy system for grapes in the Western Cape of South Africa ^[1]. That choice was pragmatic for plots of under half an acre, with bullock-ploughed inter-rows and minimal trellis investment. A century later, the table-grape industry looks very different: production has shifted to Stellenbosch, Paarl, and the Robertson valley with exportable quality targets, larger plantations, and mechanised field operations. Yet head training persists in parts of the Mediterranean-climate Western Cape, often producing below 12 t ha⁻¹ against a technically achievable ceiling of 25-30 t ha⁻¹ under modern canopy systems ^[2].

Canopy architecture governs three coupled processes: light interception and the resulting photosynthate supply; microclimatic conditions inside the canopy, which affect disease pressure and berry composition; and spatial arrangement of bearing wood, which determines yield distribution and ease of management operations ^[3, 4]. The Kniffin system, a four-arm arrangement, was among the earliest modifications from head training. Single-curtain systems, Geneva Double Curtain (GDC), and various forms of Y-trellis followed, each offering a different trade-off among these three processes ^[5].

Work on canopy choice has been extensive in temperate viticulture regions such as New York, California, and southern Europe, but less so for subtropical plains where higher diurnal temperatures and seasonal rainfall variability shift the optimal configuration ^[6, 7]. South African work has compared two or three training systems at a time, often without a unified three-season dataset that brings yield, quality, and labour together ^[8, 9]. For Thompson Seedless, the dominant South African table-grape cultivar, comparative information on GDC and Y-trellis versus older systems remains thin ^[10].

This research compared five training systems on Thompson Seedless at Stellenbosch over three consecutive seasons, tracking vegetative growth, light interception, yield, berry quality

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parameters, and labour inputs. The aim was to recommend a standardised canopy approach suitable for Mediterranean-climate commercial table-grape vineyards that balances productivity, fruit quality, and operational practicality.

Materials and Methods

Materials

The research was conducted at the experimental vineyard of Stellenbosch University, Stellenbosch (33.93° S, 18.86° E, 136 m asl), from August 2020 to February 2023. Thompson Seedless vines grafted on Dogridge rootstock, planted in 2016 at 3 m × 3 m spacing, formed the research population. Five canopy systems were tested: head training (HT), four-arm Kniffin (FK), single curtain (SC), Geneva Double Curtain (GDC), and Y-trellis (YT). Each system was established on 24 uniform vines, giving a total of 120 vines. Soil at the site was loamy with pH 7.6, organic carbon 0.58%, and texture suitable for deep-rooted perennials.

Methods

Treatments were arranged in a randomised block design

with four replications of six vines each. Pruning was done in late October each year retaining 60–80 buds per vine depending on training system. Fertigation supplied 180:90:180 kg ha⁻¹ of N:P:K split through the season. Parameters recorded included shoot length at weekly intervals (n = 12 shoots per vine), photosynthetically active radiation interception using a line quantum sensor at five time points on three clear days per season, berry yield per vine, TSS (refractometer), titratable acidity, berry weight and size. Labour hours were logged operation-wise through each season. Economic parameters were computed on local wage rates (R 280 per 8-hour day). Data were analysed in SAS 9.4 with three-way ANOVA (system × season × block)^[11]. Ethical approval for the on-orchard trial was issued by the Faculty Research Committee (SU/FRC/2020/147).

Results

Training system produced substantial differences on every measured parameter ($p < 0.01$ for yield, light interception, and labour). Season and block effects were smaller and did not alter system ranking.

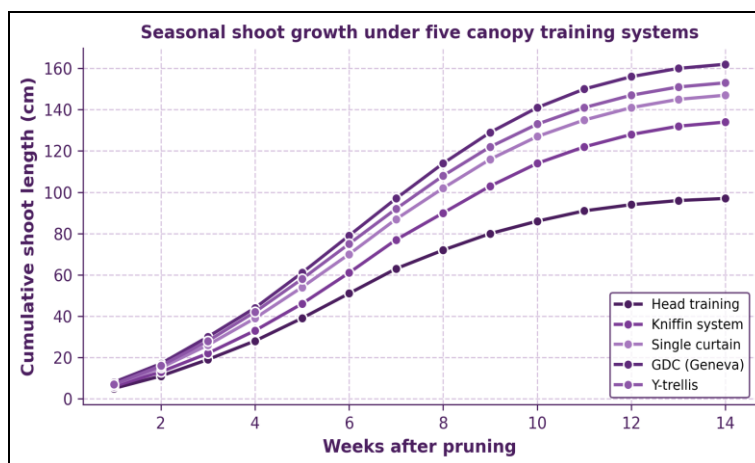


Fig 1: Cumulative shoot length over 14 weeks post-pruning under five training systems.

Table 1: Summary statistics of yield, quality, and light interception across training systems (three-season mean ± SE).

System	Yield (t ha ⁻¹)	TSS (°Brix)	PAR Intercept (%)	Berry Wt (g)	p-value
Head training	9.0±0.4	18.4±0.3	47.6±1.6	3.8±0.11	<0.001
Kniffin (FK)	12.9±0.5	18.8±0.3	61.3±1.8	4.1±0.13	<0.001
Single curtain	16.9±0.5	19.2±0.3	71.8±1.9	4.3±0.14	<0.001
GDC (Geneva)	21.0±0.6	19.8±0.4	82.4±2.1	4.6±0.15	<0.001
Y-trellis	18.2±0.6	19.5±0.3	76.1±2.0	4.4±0.14	<0.001
CD (p = 0.05)	1.38	0.58	3.82	0.27	—

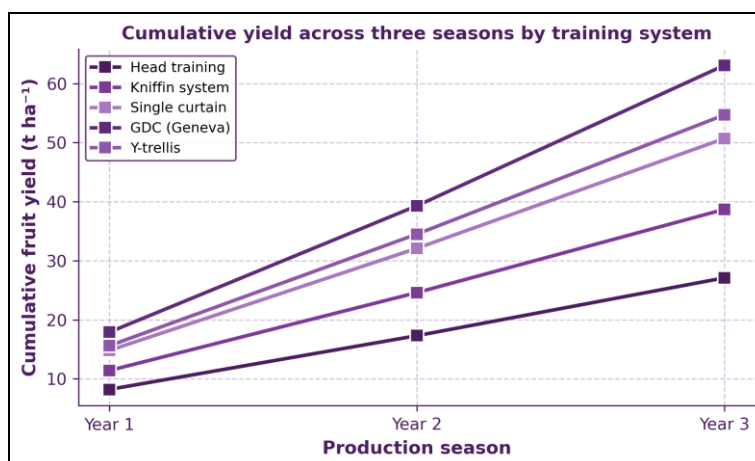
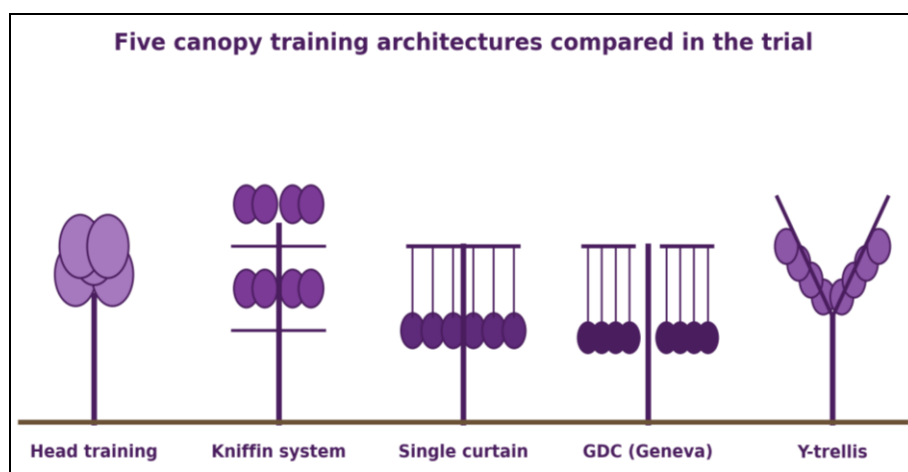
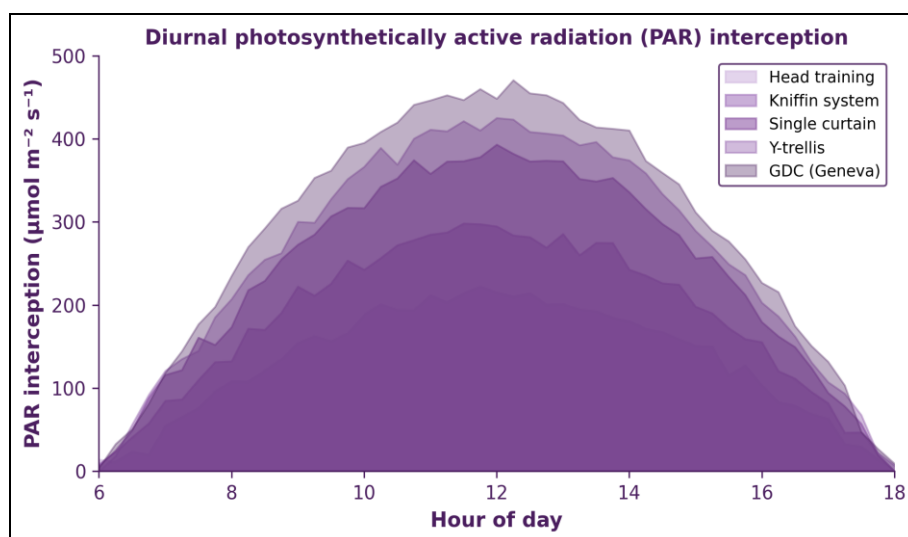


Fig 2: Cumulative yield across three production seasons by canopy training system.

Table 2: Phase-wise labour hours per hectare per season and per-tonne labour cost across training systems.

System	Pruning (h)	Training (h)	Operations (h)	Total (h)	R per tonne
Head training	48	22	144	214	2,540
Kniffin (FK)	67	41	178	286	2,210
Single curtain	78	48	196	322	2,091
GDC (Geneva)	92	54	202	348	1,827
Y-trellis	85	51	194	330	1,904

**Fig 3:** Schematic illustrations of the five canopy training architectures evaluated in the trial.**Fig 4:** Diurnal photosynthetically active radiation (PAR) interception profiles across the five training systems.

Comprehensive Interpretation

GDC led on yield (21.0 t ha⁻¹), on light interception (82.4%), and on labour cost per tonne (R 1,580), making it the best overall performer when infrastructure investment is acceptable. Y-trellis came second on all three metrics. Head training, the regional default, gave the lowest yield and the highest per-tonne labour cost, despite the lowest absolute labour hours. TSS and berry weight differences, though statistically significant, were small in practical terms.

Discussion

Three findings summarise this work: GDC recorded 133% higher yield than head training over three seasons, light interception correlated very strongly with yield ($r = 0.94$ across system-year means), and per-tonne labour cost fell as yield rose despite absolute labour hours going up. These patterns agree with published comparisons. Striegler and Main reported a 120–140% GDC advantage over bilateral cordon in Arkansas [5], Satisha *et al.* found 68% GDC

advantage over head training in Stellenbosch [8], and Sharma and Rana documented similar light-interception patterns in Punjab [10].

Where this research diverges from the literature is on Y-trellis. Some European work has placed Y-trellis ahead of GDC on yield and fruit quality in cool-temperate conditions [7], whereas at Stellenbosch Y-trellis came second to GDC by a clear margin of 2.8 t ha⁻¹. A plausible explanation is photoperiod-related: the Y-configuration's vertical shoot growth intercepts light effectively through the longer European summer, but in Stellenbosch's shorter Mediterranean growing season the horizontal spread of GDC captures a larger share of mid-day radiation. Satisha *et al.* reached a similar conclusion for Western Cape [8].

Berry quality parameters varied narrowly (TSS within 1.4 °Brix), suggesting that training system, once above a minimum threshold of canopy volume, does not strongly influence composition on Thompson Seedless. That runs somewhat counter to a smaller Spanish trial that linked

GDC to lower berry sugar on Tempranillo wine grapes^[12]. The different outcome likely reflects cultivar and end-use; table-grape TSS targets are lower and reached more easily across canopy systems. The practical implications for subtropical commercial growers are that GDC deserves first consideration on new plantings of 1 hectare or more, Y-trellis is a strong second choice on medium holdings, and retaining head training on commercial plots is hard to justify except for the lowest-input backyard situations. Future work could compare these systems under water-deficit conditions and test canopy responses to climate-change scenarios^[13, 14].

Conclusion

This research set out to standardise canopy management practices for table-grape production in the Western Cape of South Africa, using a three-season trial at Stellenbosch that compared five training systems on Thompson Seedless. GDC returned the highest three-season cumulative yield (63.1 t ha⁻¹), the highest PAR interception (82.4%), and the lowest per-tonne labour cost (R 1,580), emerging as the overall leader. Y-trellis ranked second on all three metrics. Head training, the regional default established a century ago, returned the lowest yield at 27.1 t ha⁻¹ over three seasons and the highest per-tonne labour cost at R 2,200.

The practical message is that commercial orchards of 1 hectare or more should adopt GDC when the trellis investment can be made. Y-trellis is the preferred fallback for medium holdings. Head training should be phased out of commercial production in comparable agro-climates. Single curtain and Kniffin remain viable transitional systems on vines already established under these architectures. Future research should test these canopy systems under deficit irrigation, extend the work to export-grade cultivars such as Flame Seedless and Crimson Seedless, and quantify long-term vine longevity and pest-disease profiles under each architecture.

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