



Enhancing Irrigation Water Use Efficiency for Sustainable Macadamia Production in South Africa

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INTRODUCTION

- South African macadamia orchards are rapidly expanding driven by rising global demand for nuts
- Mostly irrigated orchards → increased pressure on limited water resources in a periodically water-scarce region
- Need to enhance **irrigation water use efficiency (IWUE*)** for sustainable macadamia production

Irrigation Water Use Efficiency (IWUE)

$$\text{IWUE} [\text{kg m}^{-3}] = \frac{\text{yield}_{\text{IRR}}}{\text{IRR}}$$

$\text{yield}_{\text{IRR}}$ = yield under irrigation level IRR [kg ha^{-1}]

IRR = amount of irrigation [$\text{m}^3 \text{ha}^{-1}$]



- This study explores **two main pathways to enhance IWUE** of macadamia orchards:
 1. **Increasing yields** by addressing yield-limiting factors
 2. **Reducing water use** through optimized irrigation management

RESULTS & DISCUSSION

Pathway 1: Historical macadamia yield analysis

- Yield data from 247 macadamia orchards along an altitudinal gradient
- 12 years (2010-2021)
- Additional information on orchard characteristics, soil and climate data

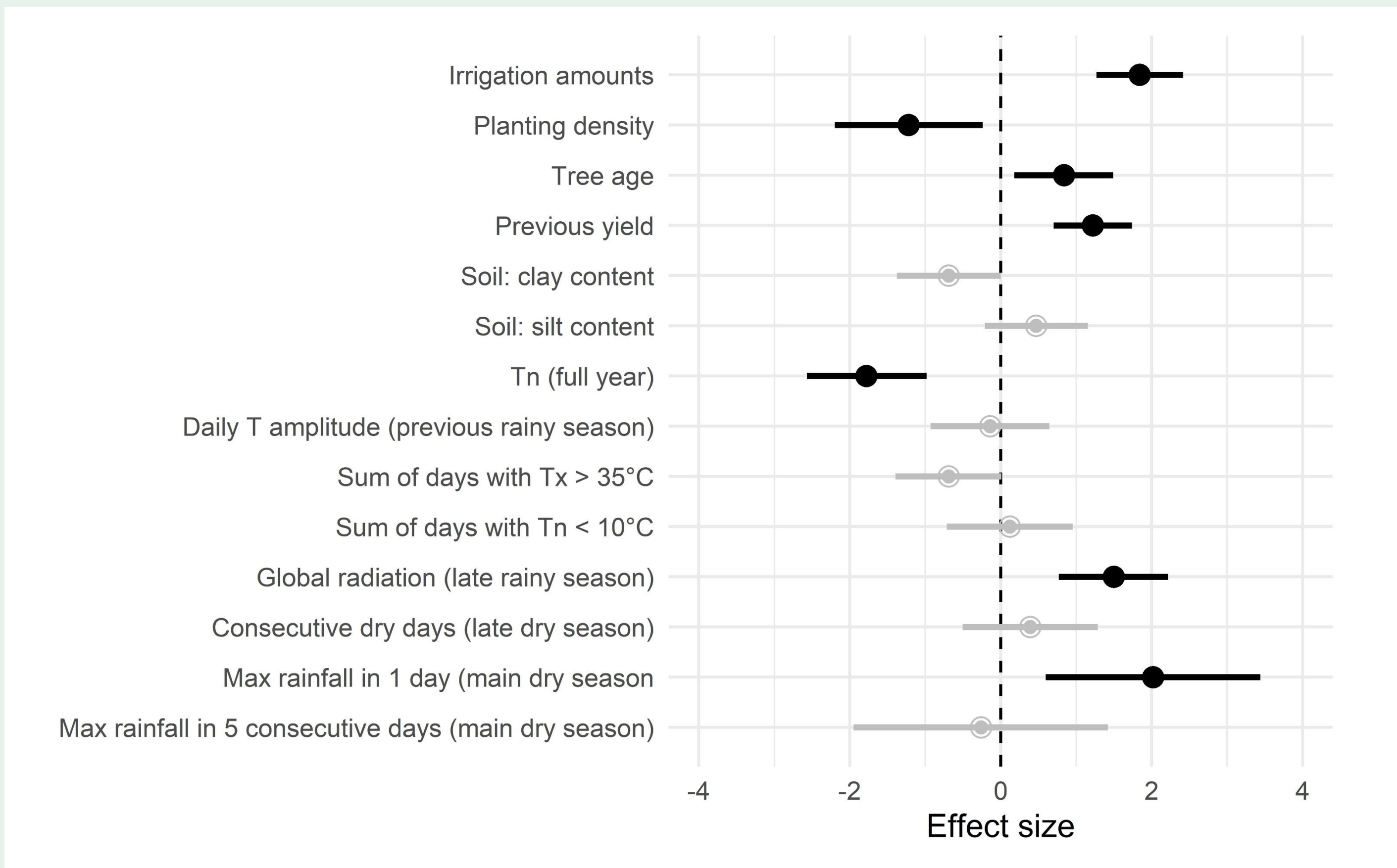


Fig. 1: Effect size of irrigation amounts, orchard characteristics, soil and climatic variables on annual macadamia yields as a result of a linear mixed-effects model. All continuous variables were scaled. Filled black circles indicate significant variables ($p < 0.05$). Source: Bringhenti et al. (2023)

- Relative effect of irrigation amounts is equal or lower than the effects of climatic variables (Fig. 1) → Although beneficial, **irrigation alone cannot counteract adverse climatic effects on yields**

Pathway 2: Macadamia water use experiment

- Two full years of data collection (Fig. 2) on microclimate (temperature, VPD, global radiation, wind speed, rainfall), soil water content, sap flux density and daily tree water use
- 20 monitored trees belonging to different cultivars ('Beaumont' and 'HAES 849') and age classes (intermediate and full bearing)



Fig. 2: On-farm measurement of microclimatic parameters, soil water content, and sap flux density. Source: Bringhenti et al. (2025)

Mean daily water use (mm per day)	Rainy season		Dry season	
	'Beaumont'	'HAES 849'	'Beaumont'	'HAES 849'
Intermediate-bearing	0.5 A,a	0.7 A,b	0.4 A,a	0.6 A,b
Full-bearing trees	0.9 B,a	1.1 B,b	0.8 B,ab	0.9 B,ab

Capital and small letters indicate significant differences ($p < 0.05$) between tree age class and cultivars, respectively.

- Macadamia water use depends on tree age, cultivar and microclimate
- **Low water requirements** → Macadamia trees are water-conservative
- Evidence of **over-irrigation** of South African macadamia orchards driven by conservative industry irrigation guidelines

CONCLUSIONS

- **Reduction of unproductive water use** is the best strategy to enhance IWUE in South African macadamia orchards
- Additional constraints on water availability due to climate change, increased competition, and tightening water regulations → Maximization of IWUE over absolute yield to maintain profitability
- **Regulated Deficit Irrigation (RDI*)** could be a promising strategy (but more research needed)
- Complementary efforts needed to sustainably boost yields through genetic improvement and smart orchard management practices (pruning to enhance light infiltration)

Regulated Deficit Irrigation (RDI)

- Strategic application of irrigation water to crops below full water requirements, without causing severe yield reductions
- Timing of water stress application is critical (varying crop sensitivity at different phenological stages)
- RDI is widely adopted in dry regions and receiving increasing global attention

References:

- Bringhenti, T., Joubert, E., Abdulai, I., Hoffmann, M.P., Moriondo, M., Taylor, P.J., Rötter, R.P. (2023). Effects of environmental drivers and irrigation on yields of macadamia orchards along an altitudinal gradient in South Africa. *Scientia Horticulturae*, 321, 112326.
- Bringhenti, T., Moriondo, M., Abdulai, I., Joubert, E., Rötter, R.P., Taylor, P.J., Hoffmann, M.P. (2025). Adopting and evaluating a simple model for macadamia tree transpiration in periodically water-scarce subtropical regions. *Scientia Horticulturae*, 341, 113970.

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