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"Reconcile land system changes
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Enhancing irrigation water use efficiency for sustainable macadamia production in South Africa

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Abstract

Macadamia, a high-value tree nut crop, is experiencing rising global demand, with South Africa currently the world's leading producer. However, the rapid expansion of macadamia orchards is contributing to increased irrigation water use in a region already facing freshwater scarcity, a situation that will be further exacerbated by projected rapid population growth and climate change. Enhancing irrigation water use efficiency (IWUE)–defined here as crop yield per unit of irrigation water applied–is therefore essential for sustainable macadamia production and the long-term conservation of water resources.

This study explores two complementary strategies to enhance IWUE in macadamia orchards: (i) increasing yields by addressing yield-limiting factors, and (ii) reducing water use through optimised irrigation management. To this end, we present findings from a combination of a historical yield analysis of 144 orchards along an altitudinal gradient, and a comprehensive two-year water use experiment conducted on commercial farms in the sub-humid, subtropical fruit-growing region of Levubu, South Africa. Among the proposed strategies, results indicate that reducing unproductive water use offers the greatest potential for improving IWUE. This recommendation is supported by several key factors: the relatively low water requirements of macadamia trees, widespread orchard over-irrigation driven by conservative industry guidelines, and increasing constraints on water availability due to climate change and tightening water regulations.

As competition for water will intensify, economic pressures are expected to shift macadamia growers' priorities toward maximising IWUE over absolute yield to maintain profitability. In this context, *regulated deficit irrigation* presents a promising solution, enabling significant water savings with minimal impact on yield. We also highlight the need for complementary efforts to sustainably boost yields, including genetic improvement and smart orchard management practices that enhance light infiltration, a key yield-determining factor in macadamia cultivation.

Overall, our findings demonstrate that using limited water resources more efficiently—by applying less irrigation more strategically and without compromising macadamia yields—is

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both achievable and imperative for promoting both economic and environmental sustainability.

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