Rainfall Regime and Optimal Root Distribution in the Australian Perennial Grass, *Austrodanthonia caespitosa* (Gaudich.)

A thesis submitted in fulfilment of the degree of Doctor of Philosophy in the School of Earth and Environmental Sciences at the University of Adelaide.

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ABSTRACT

This study aimed to determine whether rainfall regime has driven differentiation in the Australian perennial grass, *Austrodanthonia caespitosa*, resulting in local ecotypes possessing characters, such as deep rootedness or summer activity, that may be particularly useful in reducing deep drainage for salinity mitigation, or whether the species shows a plastic response in root growth to soil water distribution.Rainfall regime varies within a given annual rainfall because size and ditribution of rainfall event vary. This can have an important effect on soil water distribution, both spatially and temporally. This study investigates the relationship between rainfall regime and the structure of root systems in local populations of *Austrodanthonia caespitosa* (Gaudich.), Firstly, it examined a number of indices useful in quantifying variation in small-scale rainfall regime, including seasonal bias, event size, event frequency, and the clustering of events, as well as how rainfall event size may be changing over time across Australia. The variation in soil water distribution that results from different rainfall regimes is expected to interact with root distribution in plants, either acting as a selective force and driving genotypic differentiation in response to soil water availability, or through plasticity in root placement. The relationship between rainfall regime and root depth distribution was examined in *Austrodanthonia caespitosa* (Gaudich.), or white-top wallaby grass, a perennial grass common across southern Australia.

Growth and reproductive traits of plants grown from seeds collected from across the range of this species under a single rainfall regime were compared and correlated with

the rainfall indices and soil type in order to establish possible abiotic explanations for trait variability. Phenological characters were found to be particularly variable between ecotypes, but high local variation between ecotypes suggested factors operating on a spatial scale smaller than the rainfall gradients are responsible for population differentiation.

In order to investigate the interaction between rainfall event size and root depth, an experiment was conducted to investigate plant response to watering pulse size and frequency, with plants grown under a range of controlled watering regimes, and root depth distribution compared. The primary response in root growth was plastic, with shallow roots being developed under small, frequent events, and deep roots developed under large, infrequent waterings. Differences between ecotypes were less important, and there was no interaction between ecotype and watering treatment, indicating the same degree of plasticity in all ecotypes.

Plants from a range of populations were grown under a controlled climate, first under winter conditions, then under summer conditions, with summer water withheld from half the plants, in order to determine the response to summer watering and summer drought. Plants that were watered over summer showed a strong growth response, increasing shoot biomass significantly. This effect was particularly strong in South Australian populations, which was unexpected as they originate from a region with low, unpredictable summer rainfall. Root depth was not strongly influenced by summer watering treatment.

Finally, an evolutionary algorithm model was constructed in order to examine optimal

plant traits under a variety of rainfall regimes. The model highlighted the importance of the interaction between rainfall regime and soil type in determining optimal root placement. Variable root cost with depth was also found to be an important trade-off to be considered, with high root loss in the surface soil layers, due to high temperatures, making a shallow rooted strategy less efficient than if root costs were equal throughout the root system.

Overall, no ecotypes of *A.caespitosa* could be identified that had characters particularly suited to deep drainage reduction, as the drought tolerant nature of the species, and the dormancy during times of drought, may lead to low overall water use. However, it may be a useful native component in pasture systems, due to its strong growth response to summer rainfall, a characteristic found to be particularly strong in a number of South Australian ecotypes.

3. STATEMENT

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being made available in all forms of media, now or hereafter known.

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