

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

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Grant James Williamson

B. Env. Sc (Hons) University of Adelaide

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1. TABLE OF CONTENTS

1.....TABLE OF CONTENTS	1-3
2.....ABSTRACT	2-11
3.....STATEMENT	3-14
4.....ACKNOWLEDGEMENTS	4-15
5.....TABLE OF FIGURES	5-16
6.....INTRODUCTION	6-28
6.1. Climate.....	6-29
6.2. Plant Root Distribution.....	6-35
6.3. Root distribution, soil water and climate.....	6-39
6.4. Plasticity.....	6-48
6.5. Australian Grasses.....	6-51
6.6. Use of Australian grasses in salinity control.....	6-54
6.7. Aims.....	6-57
7.....RAINFALL PATTERNS IN AUSTRALIA	7-59

7.1.	Introduction.....	7-59
7.2.	Methods.....	7-63
	Data Sources and Maps.....	7-63
	Walsh and Lawler seasonality index.....	7-65
	Vector seasonality	7-65
	τ (Tau) event-size index.....	7-67
	Gap-size index	7-69
	Markov probability and event length.....	7-69
7.3.	Results.....	7-70
	Walsh & Lawler Seasonality Index	7-70
	Vector Seasonality	7-71
	τ (Tau) event-size index.....	7-73
	Gap-size index	7-77
	Markov (1,1) probability and event length	7-80
	τ event-size index change over time	7-84
	Significant correlations of τ event-size with time.....	7-87

7.4.	Discussion.....	7-90
7.5.	Conclusion	7-96
8.....	NATURAL RAIN POPULATION COMPARISON	8-98
8.1.	Introduction.....	8-98
8.2.	Methods	8-103
8.3.	Results.....	8-106
	Phenology	8-106
	Growth	8-108
8.4.	Discussion.....	8-112
	Conclusion	8-117
9.....	PULSE-SIZE GLASSHOUSE EXPERIMENT	9-118
9.1.	Introduction.....	9-118
9.2.	Methods	9-123
9.3.	Results.....	9-128
9.4.	Discussion.....	9-136
9.5.	Conclusion	9-143

10. SEASONAL WATERING COMPARISON	10-145
10.1. Introduction.....	10-145
10.2. Methods.....	10-150
10.3. Results.....	10-153
10.4. Discussion	10-161
10.5. Conclusion	10-169
11. EVOLUTIONARY ALGORITHM MODEL	11-170
11.1. Introduction.....	11-170
11.2. Methods.....	11-179
Model structure	11-179
Daily plant growth loop	11-184
Water infiltration.....	11-185
Soil water diffusion.....	11-186
Respiration.....	11-186
Photosynthesis and assimilation	11-187
Water availability and usage.....	11-189

Assimilation and Biomass Allocation.....	11-191
Evaporation.....	11-192
Plant reproduction.....	11-193
Soils	11-196
Simulation Experiments.....	11-197
11.3. Results.....	11-207
Gene shifts and selection	11-207
Soil moisture regime.....	11-212
Pulse Size and Interval, and Soil Texture	11-217
Seasonal Rainfall Bias and Soil Texture.....	11-222
Total Weekly Rainfall.....	11-228
Daily Rainfall Record Data.....	11-233
Respiration functions	11-235
11.4. Discussion.....	11-241
Model Gene Shifts and Soil Moisture.....	11-241
Pulse size / frequency	11-244

Seasonality	11-247
Total Weekly Rainfall.....	11-250
Daily Rainfall Data	11-252
Respiration	11-253
Soil Surface Area	11-254
Conclusion	11-256
12. DISCUSSION	12-258
12.1. Plasticity and Genotypic Differentiation	12-258
12.2. Rainfall Event Size	12-263
12.3. Interpulse Length and Event Frequency	12-268
12.4. Seasonality	12-269
12.5. Soil Type	12-273
12.6. Deep Drainage Reduction and Utility.....	12-275
12.7. Conclusion	12-277
13. REFERENCES	13-279
14. APPENDIX A – SEED COLLECTION	14-299

14.1.	Austrodanthonia caespitosa Seed Collection.....	14-299
14.2.	Collection and processing of Austrodanthonia caespitosa seed	14-304
15. .APPENDIX B – PILOT STUDIES AND MINOR EXPERIMENTS		15-310
15.1.	Pilot “Colander” study.....	15-310
	Introduction.....	15-310
	Methods	15-311
	Results.....	15-313
	Discussion.....	15-319
	Conclusion	15-320
15.2.	Ecophysiology pilot study	15-320
	Introduction.....	15-320
	Methods	15-321
	Results.....	15-322
	Discussion.....	15-331
	Conclusion	15-333
15.3.	Water Use Efficiency Determination.....	15-333

Introduction.....	15-333
Methods.....	15-334
Results.....	15-335
Discussion	15-337
Conclusion	15-337
16. APPENDIX C – INCOMPLETE AND FAILED EXPERIMENTS	16-338
16.1. Pilot seminal root growth angles.....	16-338
Introduction.....	16-338
Methods.....	16-339
Results.....	16-339
Conclusion	16-340
16.2. Paddock experiment.....	16-340
Introduction.....	16-340
Methods.....	16-341
17. MODEL SOURCE CODE	17-343

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 distribution of rainfall events 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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5. TABLE OF FIGURES

Figure 1- Walsh and Lawler seasonality index across Australia	7-71
Figure 2 - Vector seasonality index across Australia.....	7-72
Figure 3 - Correlation between Walsh and Lawler index and vector magnitude index. Both indices are dimensionless.....	7-73
Figure 4 - t (Tau) event-size index across Australia	7-75
Figure 5 - t (Tau) event-size index across Australia for the summer half year	7-76
Figure 6 - t (Tau) event-size index across Australia for the winter half year	7-77
Figure 7 - Gap-size index across Australia	7-78
Figure 8 - Gap-size index across Australia for the summer half year	7-79
Figure 9 - Gap-size index across Australia for the winter half year	7-80
Figure 10 - Markov (1,1) probability across Australia.	7-81
Figure 11 - Markov (1,1) probability across Australia for the summer half-year.	7-82
Figure 12 - Markov (1,1) probability across Australia for the winter half-year.	7-83
Figure 13 - Average pulse length (days) across Australia	7-84
Figure 14 - Trend in τ -statistic across Australia, 1920 – 2000, indicating change in	

rainfall event size bias. + = trend towards larger events, - = trend towards smaller events, O = no significant change.	7-85
Figure 15 - Trend in t during summer across Australia, 1920 – 2000.....	7-86
Figure 16 - Trend in τ during winter across Australia, 1920 – 2000	7-87
Figure 17- Number of days after planting when first flowering was observed for populations in the natural rainfall experiment*	8-106
Figure 18 - Lifespan of plants from day of planting for populations in the natural rainfall experiment*	8-106
Figure 19 - Number of days between flowering and death for populations in the natural rainfall experiment*	8-106
Figure 20 - Linear regression of time from flowering to dormancy versus time from planting to dormancy.	8-107
Figure 21 - Dry shoot mass for populations in the natural rainfall experiment*.....	8-108
Figure 22 - Total dry root mass for populations in the natural rainfall experiment*.....	8-108
Figure 23 - Top:bottom root mass ratio for populations in the natural rainfall experiment*	8-108
Figure 24 - Root mass in top soil layer for populations in the natural rainfall	

experiment*	8-110
Figure 25 - Root mass in bottom soil layer for populations in the natural rainfall	
experiment*	8-110
Figure 26 - Root:shoot mass ratio for populations in the natural rainfall experiment*...8-	
110	
Figure 27 - NMS Ordination of measured plant characters, overload with joint plot of	
environmental variables. Stress = 6.64. State 1 = SA, 2 = Vic, 3 = NSW.....8-111	
Figure 28 - Differences in dry shoot mass between populations for pulse-size	
experiment*	9-128
Figure 29 - Difference in total dry root mass between watering treatments for the pulse-	
size experiment*	9-128
Figure 30 - Difference in total dry root mass between populations for the pulse-size	
experiment*	9-128
Figure 31 - Difference in total dry biomass between populations for the pulse-size	
experiment*	9-130
Figure 32 - Difference in root:shoot ratio between watering treatments for the pulse-	
size experiment*	9-130
Figure 33 - Difference in top:bottom root mass ratio between watering treatments in the	
pulse-size experiment*	9-130

Figure 34 - Difference in top:bottom root length ratio between watering treatments in the pulse-size experiment*.....	9-132
Figure 35 - Difference in total root length between watering treatments in the pulse-size experiment*.....	9-132
Figure 36 - Difference in total root length between populations in the pulse-size experiment*.....	9-132
Figure 37 - Difference in fractal dimension between watering treatments for roots in the top soil layer in the pulse-size experiment*.....	9-134
Figure 38 - Difference in fractal dimension between populations for roots in the top soil layer in the pulse-size experiment*.....	9-134
Figure 39 - Difference in fractal dimension between populations for roots in the bottom soil layer in the pulse-size experiment*.....	9-134
Figure 40 - Root length versus fractal dimension in the top soil layer.....	9-135
Figure 41 - Root length versus fractal dimension in the bottom soil layer.....	9-136
Figure 42 - Dry shoot mass at harvest by population in the seasonal watering experiment*.....	10-153
Figure 43 - Dry root mass by population in the seasonal watering experiment*.....	10-153
Figure 44 - Total dry mass by population in the seasonal watering experiment*.....	10-153

Figure 45 - Root:shoot ratio for watering treatments and populations in seasonal watering experiment. Error bars indicate standard error, and asterisk indicates a difference between watering treatments for the same population as indicated by a Tukey HSD test.....	10-155
Figure 46 - Top:bottom root ratio by watering treatment in the seasonal watering experiment*	10-156
Figure 47 - Top:bottom root ratio by population in the seasonal watering experiment*	10-156
Figure 48 - Winter shoot dry mass by population in the seasonal watering experiment*	10-156
Figure 49 - Summer shoot growth for watering treatments and populations in seasonal watering experiment. Error bars indicate standard error, and asterisks indicate a difference between watering treatments for the same population as indicated by a Tukey HSD test.....	10-158
Figure 50 - Summer shoot growth as percentage of total for watering treatments and populations in the seasonal watering experiment. Error bars indicate standard error, and asterisks indicate a difference between watering treatments for the same population as indicated by a Tukey HSD test.	10-159
Figure 51 - PSII quantum efficiency (F_q'/F_m') before and after a watering event in the seasonal watering experiment*	10-160

Figure 52 - PSII quantum efficiency (F_q/F_m') for populations in the seasonal watering experiment*.	10-160
Figure 53 - Total dry mass per mL of water supplied for watering treatments in the seasonal watering experiment*.	10-160
Figure 54 - Simplified flux diagram of water and photosynthesis model, with soil water storage on the left, and plant biomass allocation on the right.	11-183
Figure 55 - Shift in value of RD1 gene, a gene under strong selective pressure, over 150 model generations.	11-208
Figure 56 - Shift in value of WUE gene, a gene where higher values always produce greater growth, over 150 model generations.	11-209
Figure 57 - Change in the number of different genotypes of the RD0 gene in the population over 100 generations. Dashed lines indicate standard error.	11-210
Figure 58 - Shift in value of Germ_T gene, a gene under no selective pressure, over 150 model generations.	11-211
Figure 59 - Soil water content in three soil layers over one year of model execution, with a 10mm rainfall event every seven days.	11-212
Figure 60 - Soil water content in three soil layers over one year of model execution, with a 20mm rainfall event every 14 days.	11-213
Figure 61 - Soil water content in three soil layers over one year of model execution,	

5mm per seven days in the summer half-year, and 15mm per seven days in the winter half-year.	11-214
Figure 62 - Soil water content in three soil layers over one year of model execution, using daily rainfall data from site SA002, year 1956.	11-215
Figure 63 - Soil water content in three soil layers over one year of model execution, using daily rainfall data from site NSW005, year 1970.....	11-216
Figure 64 - Optimal RD0 gene value across a gradient in water pulse frequency, for loam, sand, and clay soils.	11-217
Figure 65 - Optimal RD1 gene value across a gradient in water pulse frequency, for loam, sand, and clay soils.	11-218
Figure 66 - Optimal RS gene value across a gradient in water pulse frequency, for loam, sand, and clay soils. Dashed line indicates standard error.	11-219
Figure 67 - Total dry weight across a gradient in water pulse frequency, for loam, sand, and clay soils.....	11-220
Figure 68 - Proportion of biomass allocated to shoot and root layers across a gradient in water pulse frequency, for loam soil.....	11-221
Figure 69 - Proportion of biomass allocated to shoot and root layers across a gradient in water pulse frequency, for clay soil.	11-221
Figure 70 - Proportion of biomass allocated to shoot and root layers across a gradient in	

water pulse frequency, for sand soil.	11-221
Figure 71 - Optimal RD0 gene value across a gradient in seasonal rainfall bias, for loam, sand, and clay soils.	11-222
Figure 72 - Optimal RD1 gene value across a gradient in seasonal rainfall bias, for loam, sand, and clay soils.	11-223
Figure 73 - Optimal RS gene value across a gradient in seasonal rainfall bias, for loam, sand, and clay soils.	11-224
Figure 74 - Total dry weight across a gradient in seasonal rainfall bias, for loam, sand, and clay soils.....	11-225
Figure 75 - Proportion of biomass allocated to shoot and root layers across a gradient in seasonal rainfall bias, for loam soil.	11-226
Figure 76 - Proportion of biomass allocated to shoot and root layers across a gradient in seasonal rainfall bias, for clay soil.....	11-226
Figure 77 - Proportion of biomass allocated to shoot and root layers across a gradient in seasonal rainfall bias, for sand soil.	11-226
Figure 78 - Deep drainage loss across a gradient in winter rainfall bias for sand soil..	11-227
Figure 79 - Optimal RD0 gene value across a gradient in total rainfall, with a seven day pulse interval, for loam soil.	11-228

Figure 80 - Optimal RD1 gene value across a gradient in total rainfall, with a seven day pulse interval, for loam soil.11-229

Figure 81 - Optimal RS gene value across a gradient in total rainfall, with a seven day pulse interval, for loam soil.11-230

Figure 82 -Total dry weight across a gradient in total rainfall, with a seven day pulse interval, for loam soil.11-231

Figure 83 - Proportion of biomass allocated to shoot and root layers across a gradient in total rainfall per seven days, for loam soil.11-232

Figure 84 - Proportional biomass allocation to shoots and root layers, for rainfall records data for seed collection sites.11-233

Figure 85 - Optimal RD0 gene value across a gradient in water pulse frequency, for different respiration functions in loam soil.....11-235

Figure 86 - Optimal RD1 gene value across a gradient in water pulse frequency, for different respiration functions in loam soil.....11-235

Figure 87 - Optimal RS gene value across a gradient in water pulse frequency, for different respiration functions in loam soil.....11-235

Figure 88 - Total dry weight across a gradient in water pulse frequency, for different respiration functions in loam soil.....11-236

Figure 89 - Proportional biomass allocation across a gradient in water pulse frequency,

for three respiration functions.....	11-237
Figure 90 - Optimal RD0 gene value across a range of soil surface areas, in loam soil.	11-238
Figure 91 - Optimal RD1 gene value across a range of soil surface areas, in loam soil.	11-238
Figure 92 - Optimal RS gene value across a range of soil surface areas, in loam soil.	11-238
Figure 93 - Total dry weight across a range of soil surface areas, in loam soil.....	11-239
Figure 94 - Proportional biomass allocation to shoots and root layers, across a gradient in soil surface area for loam soil.	11-240
Figure 95- Seed collection locations in South Australia, Victoria and New South Wales.	14-309
Figure 96 - Shallow and deep root counts for populations in colander pilot study.	15-314
Figure 97 - Shallow:deep root ratio for populations in colander pilot study.	15-315
Figure 98 - Root mass for populations in colander pilot study.....	15-316
Figure 99 - Shoot mass for populations in colander pilot study.	15-317
Figure 100 - Root:Shoot ratio for populations in colander pilot study.	15-318

Figure 101 - Total biomass for populations in the colander pilot study.	15-319
Figure 102 - Length of longest leaf over time for pulsed treatment	15-323
Figure 103 - Length of longest leaf over time for constant watering treatment	15-323
Figure 104 - Final longest leaf length for population and watering treatment	15-324
Figure 105 - Leaf count over time for pulsed watering treatment	15-325
Figure 106 - Leaf count over time for constant watering treatment	15-326
Figure 107- Final leaf count for population and watering treatment	15-327
Figure 108 - PSII quantum efficiency (Fq'/Fm') for population NSW004	15-328
Figure 109 - PSII quantum efficiency (Fq'/Fm') for population NSW005	15-328
Figure 110 - PSII quantum efficiency (Fq'/Fm') for population SA020	15-329
Figure 111 - PSII quantum efficiency (Fq'/Fm') for population SA023	15-329
Figure 112 - PSII quantum efficiency (Fq'/Fm') for population VIC003	15-330
Figure 113 - Fq'/Fm' at day 27 for populations and watering treatments	15-331
Figure 114 - Linear regression of dry weight per mL of water available for <i>Austrodanthonia caespitosa</i>	15-336

