

Development of a novel crop-pasture system for mixed farms in the higher rainfall zone of southern Australia

A thesis submitted for the degree of Doctor of Philosophy

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Table of Contents

Table of Contents	I
List of Figures	IV
List of Tables	VI
Abstract of Thesis	IX
Declaration	XI
Acknowledgments	XII
Chapter 1. General Introduction	- 1 -
Chapter 2. Literature Review	- 4 -
2.1 Introduction	- 4 -
2.2 Higher rainfall farming systems of southern Australia	- 4 -
2.3 Limitations to production and opportunities in the focus region	- 5 -
2.4 Water balance in soils	- 8 -
2.5 Water use of annual systems in higher rainfall zones	- 9 -
2.6 Importance of new agriculture systems in the higher rainfall zone	- 10 -
2.7 Integrating livestock and cropping to improve productivity.....	- 12 -
2.8 Integrating perennial pastures into cropping systems	- 14 -
2.9 Intercropping perennial pastures and annual grain crops.....	- 15 -
2.10 Intercropping benefits.....	- 16 -
2.11 Intercrop species competition	- 17 -
2.12 Row intercropping.....	- 19 -
2.13 Selection of crop and pasture intercrop species	- 20 -
2.14 Assessing the productivity and economics of intercropping systems.....	- 21 -
2.15 Longer-term assessment of intercropping systems.....	- 23 -
2.16 Summary	- 23 -
Chapter 3. Material and Methods	- 26 -
3.1 Experimental site.....	- 26 -
3.2 Soil type.....	- 30 -
3.3 Experimental design	- 31 -
3.4 Agronomy.....	- 36 -
3.5 Measurements taken	- 36 -
3.5.1 Plant numbers	- 36 -
3.5.2 Crop and pasture production	- 37 -

3.5.3	Crop grain yield measurements	- 37 -
3.5.4	Soil water measurement.....	- 38 -
3.5.5	Leaf Area Index (LAI) and plant height measurement.....	- 39 -
3.5.6	Land Equivalent Ratio (LER)	- 39 -
3.5.7	Statistical analysis.....	- 40 -
Chapter 4.	Intercropping and Grain Crops	- 41 -
4.1	Introduction.....	- 41 -
4.2	Materials and Methods	- 42 -
4.3	Results	- 42 -
4.3.1	Crop grain yields	- 42 -
4.3.2	Crop dry matter production.....	- 44 -
4.3.3	Grain quality	- 49 -
4.3.4	Grain yield components.....	- 52 -
4.4	Discussion.....	- 62 -
Chapter 5.	Intercropping and Pastures	- 69 -
5.1	Introduction.....	- 69 -
5.2	Materials and Methods	- 70 -
5.3	Results	- 70 -
5.3.1	Pasture dry matter yields.....	- 70 -
5.3.2	Pasture plant populations.....	- 78 -
5.3.3	Land Equivalent Ratios (LER).....	- 83 -
5.4	Discussion.....	- 86 -
Chapter 6.	Intercropping competition for resources: Light and Water	- 92 -
6.1	Introduction.....	- 92 -
6.2	Materials and Methods	- 93 -
6.3	Results	- 93 -
6.3.1	Soil moisture and root depth.....	- 93 -
6.3.2	<i>Leaf Area Index (LAI)</i>	- 104 -
6.3.3	<i>Plant height</i>	- 108 -
6.4	Discussion.....	- 111 -
Chapter 7.	Effect of grazing on intercrop production	- 117 -
7.1	Introduction.....	- 117 -
7.2	Materials and Methods	- 118 -
7.3	Results	- 120 -

7.3.1	Crop grain yields	- 120 -
7.3.2	Crop dry matter production	- 121 -
7.3.3	Grain quality	- 123 -
7.3.4	Grain yield components.....	- 124 -
7.3.5	Pasture dry matter yields	- 127 -
7.3.6	Species selection	- 130 -
7.3.7	Soil moisture.....	- 132 -
7.3.8	Plant height	- 136 -
7.3.9	Land Equivalent Ratios (LER)	- 138 -
7.4	Discussion.....	- 140 -
Chapter 8.	Intercropping in a farm business.....	- 146 -
8.1	Introduction	- 146 -
8.2	Materials and Methods	- 148 -
8.3	Results.....	- 151 -
8.3.1	Comparison of APSIM simulations and actual measurements	- 151 -
8.3.2	Gross margin comparison between monoculture and intercrops	- 157 -
8.4	Discussion.....	- 164 -
Chapter 9.	General Discussion	- 170 -
Chapter 10.	References	- 176 -
Chapter 11.	Appendix.....	- 186 -

NOTE:

Pagination of the digital copy does not correspond
with the pagination of the print copy

List of Figures

Figure 1-1 Structure of thesis	- 3 -
Figure 2-1 Rainfall zones of Australia (Australian Government: Bureau of Meteorology 2011)	- 5 -
Figure 2-2 Potential areas for dryland lucerne in Western Australia, South Australia, Victoria and New South Wales. Source: (Robertson 2006)	- 7 -
Figure 2-3 Movement of water away from the root zone in Raised Bed Cropping	- 11 -
Figure 2-4 Different intercrop sowing arrangements □- species 1, pasture ● – species 2, crop	- 16 -
Figure 3-1 Location of experimental site at Benayeo, Victoria Source: (The South Australian Tourism Commission 2011)	- 27 -
Figure 3-2 Site soil profile, the pit is located 200m from trial site	- 27 -
Figure 3-3 1. Sample depths for drained upper limit 2. Sample depths for crop lower limit 3. Sample depths for nutrients and soil characteristics	- 31 -
Figure 3-4 Row arrangements of monoculture, intercrop and half monoculture treatments	- 33 -
Figure 3-5 Treatment rotations per plot from 2006-08 in site 1	- 34 -
Figure 3-6 Treatment rotations per plot from 2007-2008 in site 2	- 35 -
Figure 3-7 TDR probe locations for monoculture and intercrop treatments	- 38 -
Figure 4-1 (a) Wheat, (b) lupin, (c) canola plants as a percentage of monoculture at site 1 and 2 from 2006-08	- 52 -
Figure 4-2 Grain yield and plant numbers/m ² in years ◆ 2006, ◆ 2007 and ■ 2008 at site 1 of (a) wheat, (b) lupin, (c) canola and site 2 (d) wheat.....	- 53 -
Figure 5-1 Plant numbers as a proportion of monoculture a) site 1 lucerne b) site 1 chicory and c) site 2 lucerne and chicory	- 80 -
Figure 5-2 Yield and plant number in years ◆ 2006, ■ 2007 and ▲ 2008, site 1 a) chicory b) lucerne..	- 82 -
Figure 5-3 Yield and plant numbers in years ◆ 2007 and ■ 2008, site 2 a) chicory b) lucerne	- 82 -
Figure 6-1 Soil moisture (Volumetric Water Content (%)) between 0-15cm at site 1 on 5 dates in 2007 .	- 96 -
Figure 6-2 Soil moisture (Volumetric Water Content (%)) between 0-35cm at site 1 on 4 dates in 2007 .	- 97 -
Figure 6-3 Soil moisture (Volumetric Water Content (%)) between 0-15cm at site 1 on 6 dates in 2008 .	- 98 -
Figure 6-4 Soil moisture (Volumetric Water Content (%)) between 0-35cm at site 1 on 6 dates in 2008 .	- 99 -
Figure 6-5 Soil moisture (Volumetric Water Content (%)) between 0-15cm at site 2 on 6 dates in 2007-	100 -
Figure 6-6 Soil moisture treatment effect (Volumetric Water Content (%)) between 0-35cm at site 2 in 2007	101 -
Figure 6-7 Soil moisture (Volumetric Water Content (%)) between 0-15cm at site 2 for 7 dates in 2008-	102 -
Figure 6-8 Soil moisture (Volumetric Water Content (%)) between 0-35cm at site 2 for 7 dates in 2008-	103 -

Figure 6-9 Shading effects in canola-chicory intercrop in September 2007.	107 -
Figure 7-1 The grazing trial site showing paddock divisions (brown) under the grazing treatments, the number of sheep and watering points in August at site 2 in 2008	119 -
Figure 7-2 Wheat crop dry matter and yield at (a) anthesis (b) maturity and wheat grain yield for ♦ grazed and ■ un-grazed treatments	122 -
Figure 7-3 Wheat grain yield (t/ha) and (a) Heads per m ² (b) TGW (c) Grains per m ² . Grazed wheat = ♦ Un-grazed wheat = ■	126 -
Figure 7-4 Treatment by grazing soil moisture measurements taken from 0-15cm at Site 2 in 2008	133 -
Figure 7-5 Date by treatment soil moisture measurements for grazing treatments, taken from 0-15cm at Site 2 in 2008.....	134 -
Figure 7-6 Date by treatment soil moisture measurements for grazing treatments, taken from 0-35cm at Site 2 in 2008.....	135 -
Figure 7-7 Wheat plant height measurements for grazed and un-grazed treatments.....	137 -
Figure 7-8 Plant height (cm) of (a) lucerne and (b) chicory grazed and un-grazed treatments.....	137 -
Figure 8-1 (a) Gross margin (\$/ha) for wheat intercrops and the monoculture components (b) plus 20% grain and dry matter yields (c) minus 20% grain and dry matter yields.....	159 -
Figure 8-2 Gross margin(\$/ha) for lupin intercrops and the monoculture components (b) plus 20% grain and dry matter yields (c) minus 20% grain and dry matter yields.	160 -
Figure 8-3 Gross margin(\$/ha) for canola intercrops and the monoculture components (b) plus 20% grain and dry matter yields (c) minus 20% grain and dry matter yields.....	161 -
Figure 8-4 Average gross margin (\$/ha) for intercrop and monoculture components, plus 20% and minus 20% of the grain and pasture dry matter yield	162 -
Figure 8-5 Gross margins (\$/ha) for Site 2 in 2008, grazed and ungrazed treatments	163 -

List of Tables

Table 2-1 Mean average in and out of growing season rainfall (mm) for locations in the higher rainfall zones of southern Australia	- 7 -
Table 2-2 Median average rainfall (mm) for locations in the higher rainfall zones of southern Australia....	- 8 -
Table 2-3 Depletion of soil water (mm) for spring wheat, canola and lucerne in selected soil layers in the post-anthesis period from 2001-2003. Average of measurements from 2001-2003.....	- 9 -
Table 2-4 The amount of plant-available water (mm) remaining in the profile after various crop and pasture treatments.....	- 10 -
Table 2-5 Summary of grain yields (kg/ha) from grazed and un-grazed grain crops	- 13 -
Table 2-6 Economic comparison of grazed and un-grazed grain crops	- 14 -
Table 3-1 Physical and chemical properties of the soil from 0-90cm, taken December 2008, Site 1	- 28 -
Table 3-2 Physical and chemical properties of the soil from 0-90cm, taken December 2008, Site 2.....	- 29 -
Table 3-3 Monthly rainfall and rainfall days summary for 2006-2008	- 30 -
Table 3-4 Treatments and years of inclusion from 2006-08 in site 1.....	- 33 -
Table 4-1 Mean wheat, lupin and canola grain yields (t/ha) from site 1 and 2 in years 2006-08.....	- 43 -
Table 4-2 Mean wheat yield (kg/ha) of standard and high seeding rates, site 1 2006	- 43 -
Table 4-3 Dry matter (kg/ha) of wheat treatments in site 1 and 2 in years 2006-08	- 46 -
Table 4-4 Dry matter (kg/ha) of lupin treatments in site 1 in years 2006-08.....	- 47 -
Table 4-5 Dry matter (kg/ha) of canola treatments in site 1 in years 2006-08	- 48 -
Table 4-6 Wheat screenings (%) for treatments at site 1 and 2 in years 2006-08	- 49 -
Table 4-7 Wheat and lupin grain protein (%) and canola oil (%) at site 1 and 2 in 2006-08	- 51 -
Table 4-8 Tiller numbers (including main) for wheat treatments at site 1 and 2 in 2008	- 54 -
Table 4-9 Unviable wheat head numbers per m ² measured at maturity at site 1 and 2 in 2008	- 54 -
Table 4-10 Wheat heads per m ² for treatments at site 1 and 2 in 2008	- 55 -
Table 4-11 Lupin pods per m ² for treatments at site 1 in 2006 and 2008	- 55 -
Table 4-12 Wheat, lupin and canola 1000 grain weight (gm) for treatments at sites 1 and 2 in 2006-08 .	- 57 -
Table 4-13 Wheat grains per head for treatments at site 1 and 2 in 2007-08.....	- 59 -
Table 4-14 Wheat spikelets per head for treatments at site 1 and 2 in 2007-08.....	- 59 -
Table 4-15 Wheat grains per spikelet for treatments at sites 1 and 2 in 2007-08.....	- 59 -
Table 4-16 Lupin pod and branch number per order for 2007 and 2008	- 61 -
Table 5-1 Pasture dry matter yield (kg/ha), in-growing season, out-of-growing season and the annual total at site 1 in 2006-08	- 72 -

Table 5-2 Pasture dry matter yield (kg/ha), in-growing season, out-of-growing season and the annual total at site 2 in 2007-08	- 73 -
Table 5-3 Pasture dry matter (t/ha) measurements for the 12 month season at site 1 in 2006-08	- 75 -
Table 5-4 Pasture dry matter (t/ha) measurements for the 12 month season at site 2 in 2007-08	- 77 -
Table 5-5 Pasture plant counts (number of plants/m ²) at site 1	- 79 -
Table 5-6 Pasture plant counts (number of plants/m ²) at site 2	- 79 -
Table 5-7 Crop grain yield and pasture dry matter yield (amount available for livestock consumption) expressed as Land Equivalent Ratio (LER) at site 1 and site 2 in years 2006-08	- 84 -
Table 5-8 Crop and pasture dry matter yields, in-growing season and annual total, expressed as Land Equivalent Ratio (LER) at site 1 and site 2 in years 2006-08	- 85 -
Table 6-1 Soil moisture (mm) between 0-35cm at site 1 from 28/7/2008 to 20/10/2008	- 99 -
Table 6-2 Leaf Area Index (LAI) over time at site 1 in 2006	- 105 -
Table 6-3 Leaf Area Index (LAI) over time at site 1 in 2007	- 106 -
Table 6-4 Leaf Area Index (LAI) over time at site 2 in 2007	- 107 -
Table 6-5 Plant height (cm) of monoculture and intercrop grain crops at site 1 in 2006 and 2008	- 109 -
Table 6-6 Plant height (cm) of monoculture and intercrop grain crops at site 2 in 2008	- 109 -
Table 6-7 Plant height (cm) of monoculture and intercrop pastures at site 1 in 2006 and 2008	- 110 -
Table 6-8 Plant height (cm) of monoculture and intercrop pastures at site 2 in 2008	- 110 -
Table 7-1 Wheat grain yield (t/ha) of grazed and un-grazed monoculture and intercrop treatments	- 120 -
Table 7-2 Wheat dry matter (kg/ha) production of grazed and un-grazed treatments for each collection point during the crop growing season	- 121 -
Table 7-3 Cumulative (including dry matter removed by grazing) wheat dry matter (kg/ha) production of grazed and un-grazed treatments for each collection point during the crop growing season	- 122 -
Table 7-4 Wheat screenings (%) and protein (%) for grazed and un-grazed monoculture and intercrop treatments	- 123 -
Table 7-5 Wheat grain yield components including, tillers, heads/m ² , 1000 grain weight (g), grains/head, spikelets/head and grains/spikelet, for grazed and un-grazed treatments	- 125 -
Table 7-6 Seasonal and annual dry matter production of grazed and un-grazed pasture treatments	- 128 -
Table 7-7 Dry matter measurements for grazed and un-grazed treatments, taken for the 2008 season	- 129 -
Table 7-8 Grazing preferences (amount consumed of each species) show as a proportion of the starting value dry matter for each grazing	- 131 -
Table 7-9 Growing season and annual total LERs, based on dry matter production, for grazed and un-grazed treatments	- 139 -

Table 7-10 Economic LERs, based on wheat grain yield and crop and pasture dry matter available for stock consumption (excluding stubble), for grazed and un-grazed treatments - 139 -

Table 8-1 Species, cultivar and sowing density (plants/m²) used in APSIM simulations - 148 -

Table 8-2 Monoculture wheat, lupin and canola grain yield (t/ha) and dry matter (kg/ha) comparison between simulation and observation in 2006-08..... - 151 -

Table 8-3 Monoculture lucerne dry matter (kg/ha) comparison between simulation and observation in 2006-08 - 152 -

Table 8-4 Grain yield (t/ha) and crop dry matter (kg/ha) and the percent reduction (%) of the monoculture for wheat, lupin and canola intercropped with lucerne in 2006-08..... - 154 -

Table 8-5 Wheat, lupin, canola and lucerne plant height (cm) when grown in intercrop in 2006 and 2008..... - 154 -

Table 8-6 Lucerne dry matter (kg/ha) and percent reduction (%) of the lucerne monoculture for each measurement date and annual total, when grown in intercrop with wheat, lupin and canola in 2006-08- 155 -

Table 8-7 Average gross margin return of a two year cereal (wheat), one year canola and one year legume (lupin) rotation for monoculture crop and intercrops also compared to the average gross margin of lucerne and chicory - 162 -

Abstract of Thesis

The use of annual-based pasture and/or annual crops is now common practice in the higher rainfall regions of southern Australia where livestock grazing is the traditional practice. The lower water use of these annual-based systems, compared with systems based on perennial pastures, exacerbates issues of waterlogging, rising watertables and salinity in these regions. For environmental reasons farming systems used in the higher rainfall regions should target the use of more perennials in the landscape, but this should not be done at the expense of farm productivity or profitability. Intercropping, where the pasture component of the system is a perennial species, may provide the opportunity to maintain or improve farm productivity whilst delivering favourable environmental outcomes. A study of crop/perennial pasture intercrops is the core investigation undertaken in this thesis. Perennial pasture species lucerne (*Medicago sativa*) and chicory (*Cichorium intybus*) were established and maintained for three seasons with annually sown (2006-08 seasons) crop species (wheat (*Triticum aestivum*), lupin (*Lupinus angustifolius*) and canola (*Brassica napus*)), in a double skip row arrangement. These intercrops were compared for production, resource use and farm productivity with the individual crops and pastures grown as monocultures.

Yields of grain crops were reduced when grown in intercrop with lucerne and chicory. Grain yield reductions ranged from 0-46% for wheat, 45-74% for lupins and 8-83% for canola. Pasture dry matter was also reduced when intercropped, ranging from 0-78% for lucerne and 19-78% for chicory. Despite the reduction in crop and pasture production, the Land Equivalent Ratio (LER) (used as a measure of the productivity of the intercropping system) ranged from 0.71-1.66, with all intercrop combinations over-yielding (LER 1.01 - 1.66) in favourable growing seasons.

With soil moisture becoming limited during September/October (measured using Time Domain Reflectometry), the grain yield components of wheat heads/m², number of lupin branches/plant, pod number/plant and pasture dry matter were reduced by competition. Lucerne intercrops gave higher yield penalties to the companion species, attributed to greater competition for soil moisture between the component species. Higher soil moisture (9-25mm) for monoculture chicory, compared to monoculture lucerne, indicates chicory growing in intercrop was not likely to compete as strongly for water as lucerne. Plant height and Leaf Area Index (LAI) measurements were taken to assess light capture and showed minimal incidence of light competition in the intercrops. As a result, it was concluded that competition for water was the main resource competition responsible for yield reductions in intercrops.

The Agricultural Production System Simulator (APSIM) model was used to try to assess longer-term intercrop productivity. The model was satisfactory in simulating monoculture crop production; however there was poor agreement for monoculture lucerne production and this subsequently affected the modelled agreement with intercrop production. Notwithstanding these discrepancies, some of the modelled data and extrapolated data were used to produce a medium-term productivity dataset for economic analysis. Economically, the intercrops were found to have higher gross margin returns than monoculture pastures, and lower gross margins of \$39-55/ha when compared to monoculture crops. Despite yield reductions in the intercrop components, intercropping increased productivity compared to growing the components as monoculture stands. It also provided an environmental benefit of retaining perennial pastures in the system, and produced comparable economic returns to the growing of monocultures stands/swards.

Declaration

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 to Penny Roberts Craig 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.

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The use of sheep in a grazing experiment as reported in Chapter 7 was approved by the University of Adelaide Animal Ethics Committee, project number S-038-2008.

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