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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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/m^2, 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

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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.

Roberts Craig, P, Coventry, D & Hocking Edwards, J 2010, 'A comparison of land equivalent ratios and water use in lucerne and chicory based intercrops ', paper presented to 15th Australian Agronomy Conference, Christchurch, New Zealand.

Roberts Craig, P, Coventry, D & Hocking Edwards, J 2010, ' A comparison of lucerne and chicory based intercrops and competition effects', paper presented to 15th Australian Agronomy Conference, Christchurch, New Zealand.

Roberts Craig, P & Coventry, D 2008, ' The integration of novel forage and grain systems in southern Australia', paper presented to 14th Australian Agronomy Conference, Adelaide, South Australia.

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