Lucerne production and water-use in the Mallee

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Abstract

The four-year study found little difference in the production performance of an annual medic and lucerne based pasture-wheat rotation. Total biomass production over the 2 year pasture phase and the subsequent grain yields were similar and limited by seasonal constraints not treatments (growing season rainfall 90 – 208 mm, grain yield 0.1 – 2 t/ha). The positive outcomes of including lucerne in the rotation were improved availability of forage with high nutritive value and increased water use. However there is a perceived risk of achieving successful lucerne establishment with the associated cost of failure in the low rainfall cropping regions. Increased management requirements to ensure persistence is also a consideration for the broad acre cereal farmer, as is the need to maintain a reasonably intensive livestock enterprise to ensure the economic viability.

Key Words

Lucerne, rain-fed, cereal, rotation.

Introduction

An opportunity to address rising saline water tables and salinity is based around replacing annual crops and pastures with perennial plants to increase total annual water-use. Latta *et al.* (2001) measured increased water-use, pasture and crop productivity over a 3-year lucerne, 2-year crop rotation in the low rainfall Western Australian cropping belt. They found the opportunity to grow a lucerne phase within the cropping rotation had numerous potential benefits. Mopping up excess soil water in response to summer rain events, additional soil nitrogen, control of summer weeds, high quality summer forage, and soil stabilisation

Lucerne was seen as a valuable addition to Mallee farming systems in the 1950s and 1960s. McClelland and Wells (1968) measured increased wheat yields and grain protein contents on sandy soils following 2 years lucerne compared with wheat following 2 years annual pasture. The aim of this research was to reassess those earlier outcomes and compare the productivity and water balance of perennial and annual pasture crop rotations. The experiment was commenced in April 2004 and completed in December 2007.

Methods

Design

The experiment was established at the DPI, Victoria, Mallee Research Station (142? E, 35? S) on a Mallee sandy loam calcarasol. Two 3-year rotations were compared: annual medic-annual medic/chemical fallow-wheat (rotation A) and lucerne-lucerne-wheat (rotation B). Comparative rotations were commenced in both 2004 and 2005 providing 2 cycles and finishing in 2006 and 2007 respectively. Each rotation was preceded by a wheat crop in 2003 and 2004. Plot sizes were 20 m by 21 m.

On 1 July 2004 and 16 June 2005 lucerne (*Medicago sativa* cv. Hunterfield) was sown at 2 kg/ha, annual medic (*Medicago truncatula* c.v. Caliph) and (*Medicago tornata* cv Toreador) at 4 kg/ha. On 11 May 2006 and 9 May 2007 *Triticum aestivum* cv. Yitpi was sown at 70 kg/ha. Fertiliser at a rate of 12 kg of P/ha was applied to all wheat plots at sowing, no N was applied and no P was applied to the lucerne or annual medic plots at sowing or in subsequent pasture or pasture/fallow years. Glyphosate @ 1.2 L/ha (450 g a.i./L) was applied pre-seeding of all pastures and wheat. In the pasture establishment years Verdict @ 0.1 L/ha (520 g a.i./L) was applied to both the lucerne and annual medic. The annual medic was chemically desiccated on 1 September 2005 and 23 August 2006 with Glyphosate @ 1.2 L/ha (450 g a.i./L) in preparation for the 2006 and 2007 wheat. The lucerne was removed on 5 April 2006 and 2 February 2007 with 24D-amine @ 2 L/ha (625 g a.i./L). Bromoxynil @ 1.4 L/ha (500 g a.i./L) and Hoegrass @ 1 L/ha (500 g a.i./L) was applied to all the wheat plots in both 2006 and 2007.

Measurements

Pasture plant density and biomass

In 2004, established densities of lucerne and annual medic were recorded on 24 August. In 2005 the regenerated and 2005 sown annual medic and 2004 established lucerne plant counts were recorded on 28 July. The 2005 sown lucerne densities were measured on 3 October. In 2006 the 2005 established lucerne and annual medic plant densities were counted on 13 June. Measurements were based on ten 0.2 m^2 quadrats/plot.

The DM yield of the lucerne and annual medic was estimated from harvesting five 0.2 m^2 quadrats/plot using blade shears. The samples were bulked, oven-dried at 60? C to constant weight then weighed at each sampling time. All non-legume and dead herbage was removed from samples prior to drying. Live herbage DM yield was recorded on 31 August, 5 October and 13 December 2004 and in 2005 on the 4 February, 28 July, 13 September, 3 and 31 October. In 2006 the regenerated 2005 sown annual medic was sampled on 11 August, the 2005 sown lucerne on 13 June, 23 October and 23 November.

Crop production

Wheat grain yield was measured at maturity using a Kingaroy plot harvester on 27 November 2006 and 20 November 2007. Grain protein content was measured using infrared reflectance.

Soil water content

Soil water was measured 7 times from August (site 1) 2004 to December 2007, using a neutron moisture meter (Hydroprobe 503, 16 second counts). Two polyvinyl chloride access tubes with the lower ends sealed (50-mm external diameter) were installed in each plot. Readings were taken to 1 m at depths of 0.2, 0.4, 0.6 and 0.8 (0-1 m), 1.25, 1.5 and 1.75 m (1-2 m), and 2.5 m (2-3 m). Surface measurement were estimated from the 0.2 m reading The calibrations of the neutron moisture meter were taken from O'Connell *et al.* (2003). The linear regression of soil moisture on count ratio data had an adjusted r^2 value of 0.9 (O'Connell *et al.* 2003).

Statistical analysis

Analysis of variance (ANOVA) using Genstat 5 (Genstat, 2002) was carried out on plant biomass, grain yields and grain protein content. Soil water measurements were analysed following a general analysis of variance, with treatment x time as the treatment structure, replicate/time as the block structure. This took account of the correlation between measurements on successive occasions at the same site in the field plot. The soil water content analysis included data from all reading depths. The results presented (0-3 m) correctly represent the extent of the 0.2 and 2.5 m neutron moisture meter readings.

Results

Annual growing season and total rainfall over the 4 year study was below long term average in all but the 2007 annual rainfall (Table 1).

Table 1. Monthly, growing season (GSR) annual (2004, 2005, 2006, 2007) and long-term average rain (LTA) (mm)

?	J	F	M	A	M	J	J	A	S	O	N	D	GSR	Annual
2004	5	1	3	2	12	26	26	44	20	8	52	76	138	275
2005	41	4	2	6	1	53	23	36	31	68	14	11	208	290
2006	22	1	13	22	14	2	37	1	14	0	19	28	90	173
2007	77	1	20	81	51	22	34	12	11	5	35	25	135	375
LTA	20	26	22	23	32	30	33	35	32	35	27	22	230	337

The total biomass and grain yields in response to the treatments were similar over the two 3 course rotations (Table 2a and b). However, lucerne biomass was available at more occasions than the annual medic biomass over the 2004/05 and 2005/06 pasture phases (Figure 1).

Table 2a and b. 2004/05/06 (a) and 2005/06/07 (b) pasture plant establishment (plts/m^2) total pasture biomass (tDM/ha) and grain yield (t/ha) and grain protein (%) in response to lucerne and annual medic pasture phases

(a) 2004	2005	2006	2004	2004/05	2006	
			plts/m^2	tDM/ha	t/ha	%
Establish lucerne	Lucerne	Wheat	17	3.1	0.1	16.4
Annual medic	Annual medic/Fallow	Wheat	42	2.3	0.2	16.2

(b) 2005	2006	2007	2005	2005/06	2007	
Establish lucerne	Lucerne	Wheat	28	2.5	1.9	12.2
Annual medic	Annual medic/Fallow	Wheat	85	3	2	12.5

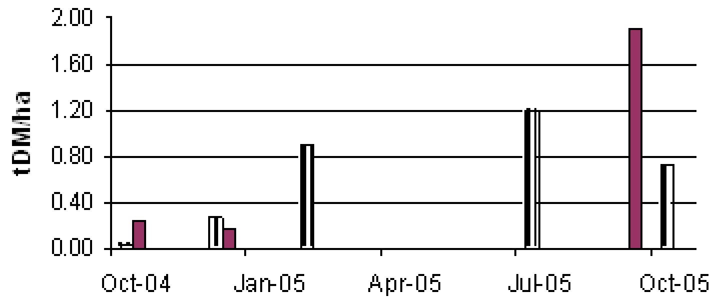

Figure 1. Lucerne ║ and annual medic ▌ biomass (t DM/ha) during the 2004 and 2005 pasture phase

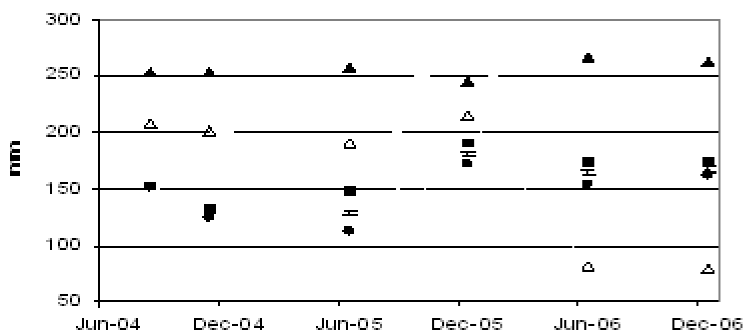

Figure 2. Soil water content (mm) in response to a lucerne-lucerne/fallow-wheat ● and an annual medic-annual medic/fallow-wheat ■ rotation measured at 0-1 m from August 2004 to December 2006. Lsd (P=0.05) I. Soil water content means of both treatments in the 1-2 ∆ and 2-3 m▲ soil profile are also presented.

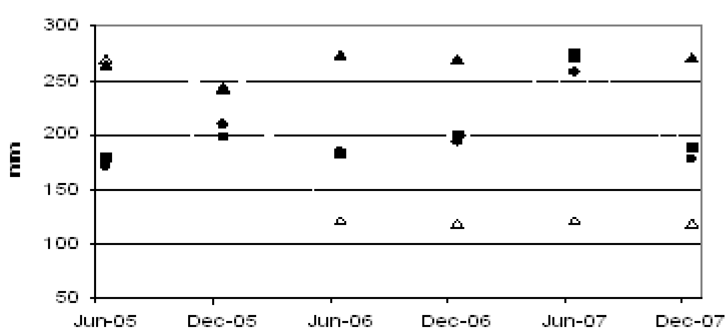

Figure 3. Soil water content (mm) in response to a lucerne-lucerne/fallow-wheat ● and an annual medic-annual medic/fallow-wheat ■ rotation measured at 0-1 m from June 2005 to December 2007. Lsd (P=0.05) nsd. Soil water content mean of both treatments at 1-2 ∆ and 2-3 m▲ are also presented.

The soil water content in the surface 1 m was less throughout 2005 and 2006 as a result of lucerne sown in 2004 (Figure 2). However in the 2005 sown pasture the soil water content in the 0-1 m profile under lucerne was similar to the annual medic treatment throughout the 3 year rotation (Fig. 3). There was no treatment difference in soil water contents below 1 m although the mean reduction in the 1-2 m profile between December 2005 and June 2006 was >100 mm with some increase in the 2-3 m profile (Figures 2 and 3).

Discussion

Latta *et al.* (2001) found the most productive lucerne rotation was two or three years lucerne followed by a maximum 3 years of field crops, two to three growing seasons for effective weed management and two summers for reducing soil water content. The benefits for subsequent field crops was most pronounced in the first 2 years before benefits from the lucerne phase; improved soil structure, soil N and weed control dissipated. The wheat yield and grain protein contents following lucerne in both 2006 and 2007 were similar as when following an annual pasture phase.

In this study the lucerne reduced the soil water content in comparison to the annual pasture/fallow treatments in the second summer after establishment as reported by Latta *et al,* (2001). However there were indications that there was some recharge of soil water from the 1-2 m profile to the 2-3 m profile between December 2005 and June 2006. There was no measured biomass production during this period and no soil water content difference between the lucerne and annual treatments below 1 m. This decline in soil water content was measured during a period of below average rainfall. The reduction of approximately 100 mm irrespective of treatment with the increase in the 2-3 m profile of approximately 50 mm suggests some downward movement through the profile, resulting in water being stored below the root zone, recharge.

The period between December 2006 and January 2007 when approximately 300 mm rainfall was recorded resulted in a 50 mm measured increase in soil water content in the 0-1 m soil profile. However there was no measured increase below 1 m. Soil water content had returned to pre-December 2006 levels by December 2007 and the increased soil water was either used over the 2007 growing season or evaporated.

The study has found little difference in the performance of the rotations evaluated, the potential benefits attributed to lucerne of improved weed competition, N fixation and soil structure were not reflected in improved grain yields, and commencing the fallow at a later date for the lucerne than the annual medic was not reflected in reduced grain yields. The positive outcomes were the improved availability of high quality forage and increased water use. It provides improved confidence to commercially trial alternative cropping rotations to address sustainability issues in the Mallee.

Acknowledgements

Technical support from Ron Sly and Jordan Harker

Funding support from National Action Plan through the Mallee CMA and the CRC for Plant-based management of dryland salinity.

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