Comparing newly established lucerne with annual pastures in south - east Western Australia

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ABSTRACT

This study compares soil water content and biomass production of a first and second year lucerne pasture with an annual pasture. The results of this work show that an established lucerne pasture will increase biomass production compared to an annual pasture by up to 2 times over a growing season in the Esperance region of Western Australia. Measured soil water content under lucerne was up to 51mm less than under the annual pasture from the autumn following establishment. However, wireweed present on the annual pasture treatments reduced the comparative difference between treatments. Summer rain in 1999 refilled the buffer of dry soil in the profile, created by the lucerne. The extra moisture was then utilised by the lucerne pasture to increase pasture production.

KEY WORDS

lucerne, annual pasture, biomass, soil water

INTRODUCTION

A dryland lucerne (*Medicago sativa*) production system is being evaluated in the wheatbelt of Western Australia as an alternative to annual pasture leys. To control rising saline water tables in the agricultural regions of Western Australia, it has been indicated (3) that manipulation of existing systems will not be sufficient, but that the development of new farming systems, which include a considerable area of deep-rooted perennial species, will be required. These new systems however, will still need to be both practical and profitable (3). Lucerne is the only currently available perennial option considered suitable for inclusion in a cropping based farming system.

Studies in the Great Southern region of Western Australia (4) have found that lucerne reduced soil water content by up to 100 mm over a three-year pasture phase, while improving pasture and subsequent crop productivity.

The benefits of lucerne to a grazing enterprise and its ability to outcompete many weedy species are well documented (1, 4, 7). While work done in Victoria (2) has shown the economic benefits of lucerne to grain growers from increased grain yields and protein, these benefits and the potential benefits to sustainability from controlling rising water tables and salinity are yet to be proven in the wider WA agricultural region.

MATERIALS AND METHODS

The experiments were conducted at Cascade and Wittenoom Hills near Esperance, (34?S, 122?E) Western Australia. The Wittenoom Hills site is a sand over domed clay (Parmango soil group) topsoil pH 4.8, $CaCl_2$. The Cascade site is a shallow sand over gray clay (Scaddan sand, Dg 3.43 (6)) topsoil pH 5.8, $CaCl_2$. The experiments were sown to lucerne cv. Trifecta 5kg/ha and subterranean clover (*Trifolium subterranean)* cv. Dalkeith 5kg/ha in June 1998. At sowing the sites were fertilised with 120kg/ha of Super Phos. Plots were 12 x 20 m and arranged in a randomised block design with 3 replications.

Lucerne and sub-clover plant density were counted in 1998 and 1999 at both sites, and lucerne in March 2000, using a randomly placed 0.25 m quadrat, 8 times on each plot.

Comparative pasture growth rates were estimated by taking above ground, biomass dry matter (DM) samples every 6 to 8 weeks from November 1998 to March 2000 using a randomly placed 0.25 m quadrat, 4 times on each plot. Plots were not grazed for the duration of the experiment. Following sampling the plots were mown to a height of 2 cm to simulate grazing. Clippings were left on the plots in order to return similar amounts of N to the soil as would grazing animals.

A PVC access tube with its lower end sealed, was installed in the centre of each plot. Stored soil water in the profile was measured with a neutron moisture meter every 4 to 6 weeks, from October 1998 to April 2000. Readings were taken at eight depths (10-150 cm in 20 cm graduations). They were then separated into three groups 10-30 cm, 50-70 cm and 90-150 cm based on soil description. The volumetric content of free water was calculated using soil bulk density and gravimetric soil water measurements.

RESULTS

Rainfall

Average annual rainfall at both sites is approximately 375 mm with 75% occurring during the April to November growing season. The April to November rainfall was below average at Wittenoom Hills in 1998 and at both sites at in 1999. The December to March rain at both sites (>200 mm in 1998/1999 and >350 mm in 1999/2000) was well above average (Tables 1 and 2).

Plant Densities

More than 40 lucerne plants/m^2 were established in 1998 at both sites, more than 30 lucerne plants/m^2 remained in March 2000. Sub-clover plant densities of around 50 plants/m^2 established in 1998. In 1999 <20 plants were present during the growing season as a result of an early autumn germination and subsequent seedling loss.

Pasture Production

Biomass production of the lucerne pasture in the establishment year was less than the annual pasture at both sites during the 1998 April to November period. The lucerne increased biomass production by about 40% during the same period in 1999 compared to the annual pasture (Tables 1 and 2). However, there was a very low component of legumes in the annual pasture. At both sites the December to March production from lucerne was >2.5 t/ha in 1998/1999 compared to 1 to 3 t/ha of unpalatable wireweed (*Polygonum aviculare*) produced on the annual pasture plots. In the December to March period of 1999/2000 4.7 t/ha of lucerne was produced at Wittenoom Hills and 2.3 t/ha at Cascades compared to <0.6 t/ha of pasture on the annual plots.

Table 1. Rainfall (mm) and pasture biomass (t/ha) dry-matter from the lucerne and annual pasture treatments at Cascade.

	April - Nov 1998		Dec - March 1998/99		April - Nov 1999		Dec - March 1999/00	
Rainfall	379		257		270		412	
Pasture Component	Lucerne	Annual	Lucerne	Annual	Lucerne	Annual	Lucerne	Annual
Lucerne	0.44		2.72		2.21		2.34	
Sub-clover		1.42		0.00		0.16		0.00

Grass	0.08	0.10	0.00	0.20	0.30	1.01	0.09	0.01
Wireweed	0.01	0.00	0.01	1.07	0.07	0.30	0.13	0.58
Total biomass	0.53	1.52	2.73	1.27	2.58	1.47	2.56	0.59
l.s.d. (*P*=0.05)	0.65		0.9		0.85		1.46	

Table 2. Rainfall (mm) and pasture biomass (t/ha) dry-matter from the lucerne and annual pasture treatments at Wittenoom Hills.

	April - Nov 1998		Dec - March 1998/99		April - Nov 1999		Dec - March 1999/00	
Rainfall	280		236		290		355	
Pasture Component	Lucerne	Annual	Lucerne	Annual	Lucerne	Annual	Lucerne	Annual
Lucerne	0.36		2.70		2.05		4.69	
Sub-clover	0.05	0.50		0.00		0.40		0.00
Grass	0.09	0.56	0.00	0.37	0.31	1.09	0.03	0.01
Wireweed	0.05	0.23	0.01	2.82	0.32	0.23	0.02	0.17
Total biomass	0.55	1.29	2.71	3.19	2.68	1.72	4.74	0.18
l.s.d. (*P*=0.05)	0.13		nsd.		0.53		0.86	

Stored Soil Water

At the Cascade site there was less water stored under lucerne than the annual pasture from March 1999 with a maximum difference of 45 mm in January 2000. Wireweed populations reduced stored soil water under the annual pasture plots from April to December 1999 compared to the previous year when wireweed was not present. At the Wittenoom Hills site there was less water stored under lucerne than the annual pasture from July to September 1999 and again in January and April 2000 with a maximum deficit of 51 mm in January 2000.

Figures 1 and 2 present soil water content under lucerne and annual pasture in the 10-150 cm soil profile at Cascade and Wittenoom Hills. Three depth segments (10-30, 50-70 and 90-150 cm) within the 10-150 cm are also included. The results were similar at both sites. At 10 and 30 cm there was no difference between treatments throughout the study. There was less water stored at 50 and 70 cm under lucerne from April to July 1999, in November 1999, and January and April 2000. At 90 to 150 cm reductions occurred under lucerne in January and April 2000.

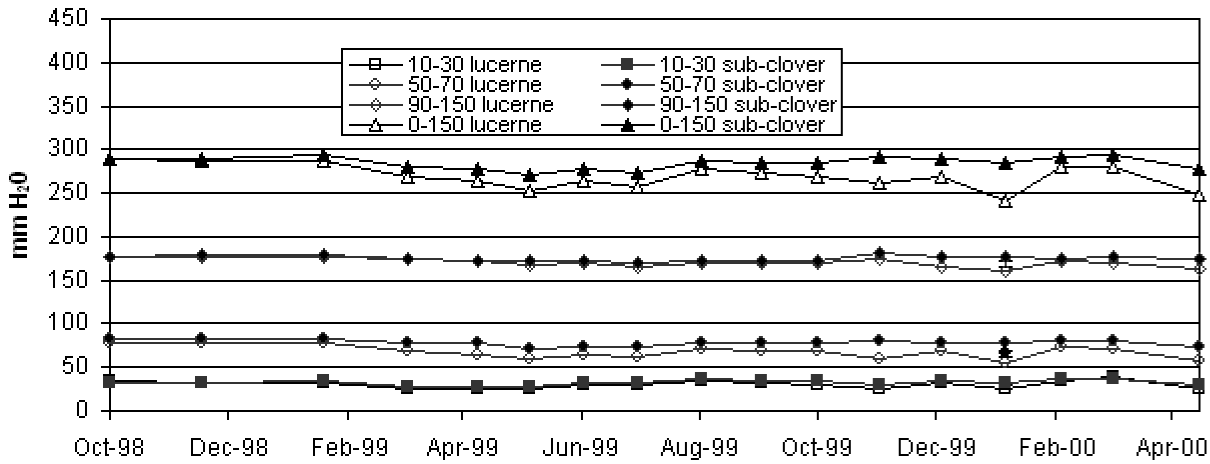

Figure 1: Soil water storage measured at 4 depths (10-30, 50-70, 90-150 and 0-150 cm) under lucerne and sub-clover pastures at Cascade. Error bars are shown for l.s.d. (P=0.05).

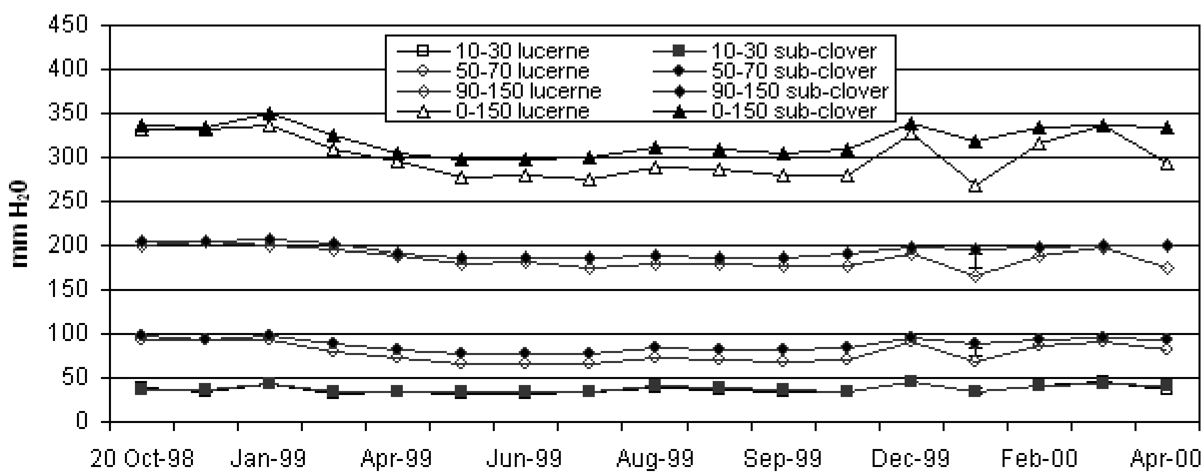

Figure 2: Soil water storage measured at 3 depths (10-30, 50-70, 90-150 and 0-150 cm) under lucerne and sub-clover pastures at Wittenoom Hills. Error bars are shown for l.s.d. (P=0.05).

DISCUSSION

The outcomes from this study are applicable to an area of almost 1 million hectares of medium to low rainfall mixed cereal-livestock farming systems in the Esperance region of Western Australia. The particular soil types selected for the study are directly representative of more than 60% of that area. It has been shown that lucerne is capable of exploring below 90 cm to access stored soil water on these soils and of responding to summer rainfall by producing large amounts of dry matter.

An established lucerne pasture was shown to almost double total annual biomass production compared to an annual legume pasture during both the April to November and summer periods, as well as reducing soil water content by more than 40mm in its second summer. This supports findings from a similar study by Latta, *et. al.* (4), in the south-west, Great Southern region, of Western Australia.

The comparative production improvement of the lucerne is probably due in part to low sub-clover plant densities and poor associated annual legume production. Sub-clover densities of 50 plants/m^2 in 1998 and 20 plants /m^2 in 1999 were far below required numbers. Summer rain and dry autumn conditions caused premature germination and loss of seedlings in 1999. The plant density of lucerne was >30 plants/m^2 throughout the study, which is considered near to optimum in this region (4).

While this study found similar results to Latta *et. al.*(4) in regard to biomass production, the results from this study in terms of soil water content differed from the previous work, due to well above average rain during both 1998/1999 and 1999/2000 summer-autumn periods. In the summer of 1998/1999 both sites experienced over 60% of their annual rainfall. In 1999/2000 Cascade experienced more than its average annual rainfall during the December to March period while Wittenoom Hills received 90% of its annual rainfall. This meant the dry soil buffers created by lucerne were refilled. However the lucerne rapidly depleted these again, showing an ability to respond quickly to out-of-season rainfall.

The presence of the bi-annual wireweed leading into the second summer on the annual pasture plots may have reduced comparative differences in stored soil water between treatments. A benefit from the lucerne pasture measured in this study was the effective wireweed competition presented in the biomass results. This agrees with previous work by Dowling *et. al.* (1) that found that perennial pastures, with proper grazing management, can out-compete a number of weedy species.

The study to this stage has given some indication that lucerne can make a contribution to the control of rising saline water tables. A soil water storage deficit of 40 to 50 mm is unlikely to have any impact on reducing recharge and run-off when large, unpredictable, episodic rainfall events such as those experienced in the summers of 1998/1999 and 1999/2000 occur (5). However, these are extreme rainfall events, which are infrequent, occurring generally only once in a hundred years.

Schroder *et. al.* (7) also found that while recharge would be lower where a pasture contained a perennial, some recharge would still occur. Natural vegetation doesn't use all the water that falls, especially in extreme rainfall events. The reduction in stored soil water, under lucerne, of 40-50mm observed in this experiment could result in significantly less drainage under more usual rainfall conditions. Therefore, lucerne can make an important contribution to the prevention of saline water tables even if it doesn't solve the problem completely.

The results indicate that there are potential production benefits for a grazing enterprise from the inclusion of lucerne in the Esperance region of WA. Successfully established lucerne will increase the reliability of the legume component in the pastures, with the potential to subsequently benefit the cropping component in the whole farm system.

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