Soil water availability and root distribution in rainfed and irrigated lucerne

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ABSTRACT

Lucerne is being widely promoted in Southern Australia for de-watering subsoils to minimise deep drainage and reduce the spread of dryland salinity. However, the productivity and profitability of lucerne-enterprises will largely drive the adoption of lucerne by farmers. Information comparing the productivity of lucerne with annual medic-based pastures is needed to give farmers confidence in switching from annual to perennial pastures. This research aims to quantify the productivity of lucerne in a Mediterranean climate on a duplex soil. Irrigation treatments have been included to assess the potential production of lucerne in the absence of soil water constraints. Given the highly variable distribution of summer rainfall in southern Australia this experimental approach will be complemented with future work using simulation modelling to predict the range of potential production for lucerne.

INTRODUCTION

The aim of this study was to investigate the direct and residual effects of summer irrigation on root distribution and water uptake in lucerne.

MATERIALS AND METHODS

Three treatments were imposed within a one-year-old lucerne stand of winter active variety Sceptre at Roseworthy Campus, SA. The area has an average annual rainfall of 450 mm with about 120 mm occurring in the summer period (Nov-March). During summer two types of irrigation system were used to supply some plots with a limited amount of water (less than pan evaporation) whilst other plots were left unirrigated (rainfed). Overhead sprinkler (surface) and sub-surface drip treatments applied 641 and 479 mm water respectively during mid-December 1999 to end of March 2000. Soil water extraction patterns were observed fortnightly using a Neutron Meter. Root length density was measured twice per year. Shoot biomass was harvested six times during this period at 10% flowering or at initiation of new shoot growth from the crown. WUE was calculated as total seasonal shoot production divided by total water received (rainfall plus irrigation).

RESULTS

Rainfall was below normal during the summer period resulting in lower shoot biomass production (2.5 t/ha) in the rainfed than in the irrigated treatments, with highest production from the surface irrigation

Table 1. Water use efficiency of lucerne in relation to (a) water applied during a summer period and (b) stored soil moisture and rainfall during a following winter (residual) period.

	(a) Summer irrigation period (Dec-March)		
Treatment	Rainfed	Sub-surface	Surface
Water applied (mm)	0	479	641
Rainfall (mm)	96	96	96

Production (kg/ha)	2500	8900	10171
WUE (kg/ha/mm)	26	15.48	14.62
		(b) Winter residual period (Apr-Nov)	
Stored soil moisture(mm)	62	132	119
Rainfall (mm**)**	350	350	350
Production (kg/ha)	5044	8867	8702
WUE (kg/ha/mm)	12.18	18.39	18.16
Overall WUE	**16.91**	**19.25**	**17.62**

treatment (10.2 t/ha). However, water use efficiency (WUE) was substantially higher in the rainfed treatment (Table 1). During the winter residual period the soil moisture stored at depth in the sub-surface pre-treatment was less prone to evaporation, thus resulting in better outcomes in form of shoot biomass and WUE (Table 1), even though the water applied was less than for the surface pre-treatment.

Root length density (RLD), particularly at depth in sub-surface and surface treatments, was higher than in the rainfed treatment during both winter and summer periods, thus increasing utilisation of soil moisture deeper in the soil profile by lucerne in these irrigation treatments (Table 2).

Table 2. Root length density (RLD, cm. cm^{-3}) and water use (WU, mm) for lucerne during a winter (residual) period (1/10/2000) following different water supply treatments during the previous summer period.

Previous Treatment	Rainfed		Sub-surface		Surface	
Depth (cm)	RLD	WU	RLD	WU	RLD	WU
0-10		0.4		0		0
10-20	4.38	0.7	4.31	1.3	4.78	0.1
20-40	2.25	13.8	2.68	12	2.64	13
40-60	2.12	4.4	2.52	7.8	2.65	11

60-80	0.76	-0.4	1.22	3.2	0.94	3
80-100	0.26	0	0.47	1.4	0.64	0.8
100-140	0.06	0	0.45	0.8	0.18	0.8
140-180		0		1.6		0
180-220		0		0		-0.4
TOTAL		18.9		28.1		27

DISCUSSION

Irrigation of lucerne, regardless of whether it was surface or sub-surface application of water, improved yields for the summer period, although WUE was higher for this period in the rainfed treatment probably due to losses of applied water from the irrigated areas via evaporation. However, WUE for the winter residual period was improved for both the previously irrigated treatments due to stored soil moisture at depth (132 mm in sub-surface and 119 mm in surface irrigation treatments).

Consideration of overall shoot biomass production and WUE for the two periods combined demonstrated that sub-surface application of water was more efficient than overhead sprinkler application. Similar efficiency for sub-surface irrigation has been reported by Ayars et al.(5).

During the winter (residual) period less evaporation in conjunction with additional root production, in relation to stored soil moisture deeper in the soil profile of the sub-surface treatment, apparently played a key role in the better utilisation of soil water and ultimately in production of shoot biomass. These results are also supported by the work of Abdul-Jabbar (1) on lucerne.

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References

1. Abdul-Jabbar, A.S., Sammis, T.W. and Lugg, D.G. 1982. Irri. Sci. 3, 197-207.

2. Cawood, R. and McDonald, G. 1996. Climate of South Eastern Australia. *In*: 'Climate, Temperature and Crop Production in South-eastern Australia'. (Ed. R. Cawood). pp.21-32 Work and Turner Pty Ltd: Melbourne

3. Lolicato, S.J. 2000. Aust. J. Exp. Agric. 40, 37-45.

4. Probert, M.E., Robertson, M.J., Poulton, P.L., Carberry, P.S., Weston, E.J. and Lehane, K.J. 1998. *Proceedings 9th Australian Agronomy Conference*, Wagga Wagga, pp247-50.

5. Ayars, J.E., Phene, C.J., Hutamacher, R.B., Davis, K.R. Schoneman, R.A., Vail, S.S. and Mead, R.M. 1999. Agric. Water. Management. 42, 1-27.