Where should lucerne be grown in the Western Australian cropping zone?

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Abstract

Lucerne has been promoted throughout the dryland agricultural regions of Western Australia, resulting in its widespread on-farm evaluation by the farming community. Much of this development is in conflict with economic and environmental simulation studies that suggested that lucerne would only be productive in the higher rainfall, southern regions of WA. However, rising saline water tables and associated dryland salinity requires immediate attention and lucerne is considered the best available option to increase water-use in the WA grain-belt. This study has shown that lucerne established successfully on >90% of farms over a wide range of annual rainfalls and soil types previously considered unsuitable. Results from field experiments in the central agricultural region found that lucerne used up to 50 mm more water than annual pastures. However, lucerne production and stand life, as well as subsequent crop yields, declined in dry seasons compared with an annual pasture-crop rotation. The paper concludes where land protection is the primary concern, short phases of lucerne in rotation with field crops supports the continued expansion of lucerne. To ensure improved production and economic outcomes the previous research conclusions remain valid.

Key Words

Plant densities, production, water-use, rotations

Introduction

Two million hectares of the Western Australian agricultural landscape are currently impacted on by waterlogging and associated dryland salinity. McFarlane and Williamson (1) suggested that the affected area will almost double over the next 15 – 20 years and in all probability will increase to more than six million hectares during the latter part of the 21st century.

An opportunity to address rising saline water tables is based around replacing annual crops and pastures with perennial plants to increase total annual water-use. Research has shown lucerne to be productive and persistent in the higher rainfall southern and coastal regions. Latta *et al*. (2) measured increased water-use, pasture and crop productivity over a three-year lucerne, two-year crop rotation. Ward *et al*. (3) reported a significant reduction in the amount of water that leaked past the root zone of lucerne compared with an annual pasture. Both these studies showed a soil water deficit “buffer” had developed following a lucerne phase which allowed 1 – 2 year cropping before water table recharge recommenced.

Lucerne is currently recommended throughout the 300 – 600 mm WA agricultural zone, on well-drained soils with a pH of 4.8 ($CaCl_2$) and greater. More than 400 farmers have or are currently evaluating lucerne as a forage and for inclusion in cropping rotations (4). However, Hill *et al.* (5) estimated that lucerne was adapted to only 42% of south-western Australia, most of which is in the higher rainfall southern regions, where the probability of intense summer droughts is lower. In support of Hill *et al*., Bathgate and Pannell (6) found that the economic benefits from lucerne were only evident in response to significant summer and autumn rainfall events, which were more probable in the south. The second variable, which may preclude the widespread use of lucerne in WA, is the extent of acid soils and their impact on lucerne production and persistence. Approximately 80% of WA wheatbelt soils are described as neutral to acidic (7). This may in fact considerably reduce the estimated area that is suitable for lucerne.

This paper presents research and survey results from the 300 – 400 mm rainfall zone of the central and northern agricultural regions to help establish the validity of recommending lucerne in these regions.

Minimum performance criteria included the persistence of an adequate density of lucerne plants to increase water use over a pasture phase of 2-4 years and to produce forage and subsequent crop yields equal to those of an annual pasture phase.

Methods

Between 1998 – 2002, 200 commercial sowing of lucerne were monitored. Fifty-three of these were in the northern agricultural regions (latitudes 28 - 32?S). Establishment and subsequent persistence comparisons were made between northern and southern latitudes, rainfall isohyets, soil description and pH levels.

Experiments were established at Quairading (32?S, 118?E) on a duplex soil (Dy 4.83) in 1998 and on a gravelly sand (KS-Uc 4.21) in 1999 (8). The pHs ($CaCl_2$) at 10 and 50 cm depths were 4.8 and 6.8 (duplex soil), 4.3 and 5.2 (sandy gravel) respectively. Comparative measurements of lucerne and sub-clover on the duplex soil, and sub-clover and serradella pastures on the gravelly sand, were taken from 1998 to 2001. They included soil water content (0.1-1.5 m), measured with a neutron moisture meter (9), lucerne persistence, pasture biomass production and subsequent grain yield and quality following 2 and 3 years of lucerne- and annual-based pastures.

Results

Rainfall

Significant events from 1998 to 2001 that affected the whole region included a wet 1999/2000 summer, low growing-season rainfall in both 2000 and 2001 and no rain throughout the 2000/2001 summer. Annual rainfall at the Quairading site in 1998 was 361 mm (282 mm from May-October) 557 mm in 1999 (328 mm May-October) 344 mm in 2000 (170 mm May-October) and 237 mm in 2001 (184 mm May-October).

Commercial lucerne stands

The impact of climatic conditions in the northern agricultural region is presented by comparing 53 commercial lucerne stands established in this region between 1998 to 2002 with 147 commercial lucerne stands monitored throughout the southern region, latitudes 33? - 35?S (Table 1).

Table 1. Lucerne stands (%) with >15 plants/m^2 at establishment, and mean densities (plants/m^2) at and one year after establishment in the northern and southern agricultural regions of WA.

	Stands with >15 plants/m^2 established (%)	Lucerne density at establishment (no./m^2)	Lucerne density after one year (no./m^2)
Northern region	89	64	16
Southern region	92	64	28

Table 2. Lucerne densities (plants/m^2) at and one year after establishment in response to rainfall and soil pH values in the northern region.

	Annual rainfall (mm)	Soil pH ($CaCl_2$)

	<350	>350	<4.8	>4.8
Establishment density	42	73	64	64
One year after establishment	17	10	23	15

Lucerne densities in the northern region declined by 75% and by 56% in the southern region over the first year (Table 1). Increasing rainfall and decreasing acidity had a greater impact on establishment densities than lucerne established on drier and more acidic soils in the northern region (Table 2) although neither variable affected densities one year after establishment significantly. The surface textures (gravel, sand, loam or clay) of the different soil types had no effect on establishment and one year after sowing densities.

Rotation studies

More than 30 lucerne plants/m^2 established at both Quairading sites. As a result of no significant rainfall between October 2000 and April 2001, significant plant losses occurred at these sites over the 2000-2001 summer as average plant densities declined from 35 to 7 plants/m^2.

Table 3. Comparative yearly pasture production (t DM/ha) for 1999 and 2000, and wheat grain yields (t/ha) and protein contents (%) in 2001 on the gravelly sand site.

	Pasture 1999/2000	Pasture 2000/2001	Wheat 2001	
	t DM/ha	t DM/ha	t/ha	(%)
Lucerne	4.1	2.3	1.1	12.4
Sub-clover	3.7	1.4	0.6	9.0
Cadiz serradella	6.4	3.1	1.1	9.6
LSD(P=0.05)	0.8	1.5	0.5	1.1

Table 4. Comparative soil water content (mm$H_2$0/1.5 m soil profile) under 3 pastures species from September 1999 to April 2001 on the gravelly sand site.

	September 1999	April 2000	September 2000	April 2001
Lucerne	178	128	116	84
Sub-clover	162	135	121	116
Cadiz serradella	152	131	118	109

LSD(P=0.05)	21.9	ns	ns	21.9

Lucerne grown on the gravelly sand produced less total annual biomass than Cadiz serradella in the establishment year but yielded similarly in the second year. Wheat grain yield following the lucerne was similar to that following the Cadiz serradella but with a higher grain protein content (Table 3). Compared with the sub-clover pasture the lucerne produced similar pasture biomass but higher subsequent grain yield and grain quality. The lucerne dried the surface 1.5 m of the soil profile to a greater extent than the annual pastures during the second summer after establishment while the Cadiz serradella dried the soil profile to a greater extent than lucerne during the establishment year in 1999 (Table 4).

Table 5. Comparative lucerne and sub-clover dry matter yields (t DM/ha) in 1998/99, 1999/00 and 2000/01 on the duplex soil site.

	Pasture 1998/99	Pasture 1999/00	Pasture 1999/00
	t DM/ha	t DM/ha	t DM/ha
Lucerne	0.7	5.2	1.2
Sub-clover	0.7	6.2	1.1
LSD(P=0.05)	ns	0.5	ns

Table 6. Comparative grain yields (t/ha) and protein contents (%) of the first wheat crop following 2 and 3 years of lucerne and sub-clover pasture, and of the second wheat crop following 2 years of pasture.

	1st wheat following 2 years of pasture		1st wheat following 3 years of pasture		2nd wheat crop after 2 years of pasture	
	Yield t/ha	Protein %	Yield t/ha	Protein %	Yield t/ha	Protein %
Lucerne	0.5	13.9	1.4	13.4	1.3	11.6
Sub-clover	0.7	15.2	1.8	12.3	1.3	11.9
LSD(P=0.05)	ns	1.0	0.3	1.0	ns	ns

Lucerne produced similar or less biomass than the sub-clover pasture over the 3-year pasture phase (Table 5). The wheat following the lucerne pasture produced similar or lower yields and similar, less or greater protein levels than the wheat crops following the annual pasture (Table 6).

Table 7. Comparative soil water contents (mmH_2O/1.5 m soil profile) under lucerne and sub-clover pastures, from September 1998 to September 2001, on the duplex soil site.

	Sept 98	April 99	Sept 99	April 00	Sept 00	April 01	Sept 01
Lucerne	295	248	284	195	197	180	201
Sub-clover	309	297	385	251	253	248	255
LSD(P=0.05)	ns	ns	ns	50	52	62	43

The lucerne pasture and subsequent wheat crop reduced soil water contents by 50 – 60 mm compared with the annual pasture-wheat rotation from the second summer following establishment (Table 7).

Conclusion

Much emphasis has been placed on introducing perennials into WA farming systems to address encroaching salinity. This study has shown that lucerne can be successfully established in the central and northern wheat-belt, irrespective of soil properties or the historical rainfall zone. It will most likely use more water than an annual pasture and provide a greater soil water deficit by the end of the second summer after establishment. With October – May rain it will provide valuable out-of-season forage for livestock. The studies of Hill *et al.* (5) and McFarlane and Williamson (6) were correct when they suggested that lucerne had a limited agronomic and economic role in WA due to environmental constraints. However, their view that the role of lucerne was restricted to the higher rainfall southern regions never fully accounted for the primary aim of introducing perennials, the control of rising saline water tables and the associated economic cost.

This study has shown lucerne to be no more productive than serradella on acidic deep gravelly sand or sub-clover on duplex soil in the central wheat-belt. Low rainfall cropping seasons also resulted in similar or lower wheat yields following lucerne compared with those following annuals. This is due to soil water deficits and/or lucerne escapees competing with the crop. The summer drought of 2000/2001 reduced lucerne stand densities from 64 to 16 plants/m^2 after only one year and from >30 to <10 plants/m^2 after 2 and 3 years. Latta *et al.* (10) suggested that lucerne densities of 15 – 20 plants/m^2 were required to optimise pasture production, weed competition and water-use potential.

As the decline in lucerne densities is largely due to soil water deficits, it can be argued that lucerne has achieved its primary aim. However, to recommend lucerne in this environment several establishment and management strategies are recommended to improve it’s economic potential. They include sowing at 2 kg/ha in alternate rows with a companion field crop to compensate for the low production in the establishment year. Secondly to remove lucerne in the spring prior to returning to crop to allow available soil nitrogen and soil water to accumulate. Further research into the use of low-density stands is also required to help overcome the limitations imposed by soil type and rainfall patterns in the lower rainfall regions of Western Australia.

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