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The economics of lucerne as an option for dryland salinity control in low rainfall environments.

Michele John[A], Ross Kingwell[B], Andrew Bathgate[C] and David Pannell[A]

[A] University of Western Australia
[B] University of Western Australia/Agriculture Western Australia
[C] Agriculture Western Australia

Abstract

The replanting of trees and other high water use perennial plant options has been the major focus of dryland salinity management in recent times. Hydrologists have indicated that unless these options are taken up on a very large scale, little can be done to control ongoing land salinisation in southern Australia. The scale of the problem is further exacerbated with very few economic options for salinity management in low rainfall agricultural environments (< 350mm/year) which in Western Australia includes 40-50% of our agricultural areas.

Phase farming with lucerne (Medicago sativa L.) is an increasingly noted option for dryland salinity management in Australia. The benefits of phase farming systems with lucerne is currently considered to offer both hydrologic and economic benefits for sustainable farming systems. In many areas it may be profitable to change farming systems in order to achieve recharge reductions and therefore manage salinity at a local scale- suggested to be possible in up to 30% of the agricultural landscape in Western Australia (Pannell et al., 2001).

Our aims in this paper are (a) to review the advantages and disadvantages of lucerne management, (b) to present results from a case study of lucerne in south-west Western Australia by Bathgate and Pannell (2001) and (c) to assess the relevance of the case study findings for environments with lower annual rainfall.

Introduction:

The diversity of soil types, landscape forms, seasonal variations and agricultural systems being used in Australia, suggest there is no one single panacea for salinity management.

Currently, there are few economic plant based options for salinity management in low or medium rainfall environments. Perennial pastures such as lucerne and serradella are currently being increasingly trialled but the economics of these systems are largely dependent on pasture based farming systems. Commercial tree crops like Blue gums and Oil mallees are currently being investigated for their wood and oil production profitability (Bartle, 1999). However, there are few commercial tree crops available for low or medium rainfall environments.

In terms of the effectiveness of these current options, George et al. (1999) and others, have suggested that planting trees in groundwater recharge areas will only lead to significant reductions in water levels, if considerable areas of the catchment (70-80%) are planted in order to mimic both the temporal and spatial distribution of native vegetation leaf area that existed prior to clearing. Stolte et al. (1996) also indicated that tree plantations may only be effective in the short to medium term and only till such time as their root zones are inundated with saline water.

Engineering solutions involving deep drains and shallow interceptor drains are also of limited usefulness. Ferdowsian and Ryder (1997) note that deep drains remove only a fraction of recharge and in many instances are not economical. (Cox, 1988) concludes that shallow interceptor drains can reduce waterlogging and recharge but fail to prevent groundwater level rises. Saline groundwater pumping is another option that is confined to the immediate areas surrounding the treatment and is an expensive practice with significant limitations over the disposal of pumped saline groundwaters (McFarlane et al., 1993).

Phase farming is currently seen to be one of the most promising innovations for salinity management, in its ability to prevent deep drainage whilst allowing for the continuation of conventional agricultural practices. Phase farming (alternating a series of crops with a few years of perennial species) with lucerne utilises the storage capacity of the deep subsoil, allowing it to fill during the cropping years and empty under the perennial phase whilst simultaneously providing a pasture based economic return to the landholder.

Lucerne pasture production has increased significantly in Western Australia in recent years with recent advances in aphid resistance, improved strains of rhizobia with greater acid tolerance and winter active lucerne cultivars. The potential area for lucerne now extends to drier areas of Western Australia as a result of these advances and increasing pressures for high water use farming systems to manage dryland salinity.

Economics of perennials at the farm level

Pannell (1995) described the factors that contribute to the economic benefits and costs of legumes in the farming system. His factor groupings included:

- short-term profit factors
- dynamic factors
- sustainability factors
- risk factors and
- whole-farm factors.

Pannell’s general conclusions about the economics of legumes in southern Australia were that-

- In most circumstances, the optimal farm plan includes a mix of cereals, legume crops and pastures.
- It is important to recognise soil types and target activities accordingly.
- Although legumes can make a valuable contribution to profit, if grown in the wrong rotations or on the wrong soil types they can actually decrease profits.

These conclusions would also apply to perennials. They indicate that no single perennial plant, even if highly successful, is likely to dominate farmland use in most regions. This is because of a combination of factors, including soil type diversity, constraints on availability of machinery and labour, and risk considerations. It will be important to identify circumstances (regions/soil types) in which any new perennial is or is not profitable.

In considering perennials, sustainability factors are of particular interest. Reductions in salinity, waterlogging and for woody perennials, wind erosion, are all potential benefits. There is a tendency among scientists for too much emphasis to be placed on these aspects, to the neglect of more direct determinants of profitability such as the cost and ease of lucerne establishment and management.

Adoption and Management of lucerne:

There are a number of influences upon the adoption of lucerne in phase farming systems.

Firstly, the profitability of livestock enterprises relative to cropping enterprises during much of the 1990's encouraged many farmers to move towards larger cropping systems. Ridley et al. (2000) report that the payback system for perennials pastures is at least 5-7 years in comparison with annual pastures that provide an economic return in 2-3 years.

Secondly, lucerne establishment is significantly more expensive than annual pasture establishment.

Thirdly, crop yield penalties in the first year following lucerne may also be disadvantageous, particularly for farmers in low rainfall environments (Hirth et al., 2000).

In addition to these possible economic disincentives, a number of management issues need to be considered including the fact that lucerne management is more time intensive, particularly in the first year of establishment.

Management:

Dear and Sandral (1999) note that there are a number of principles unique to lucerne pasture management. They are the need to a) optimise seedling development for survival over the first summer and b) achieve the optimum target density in the first year. Lucerne density will vary with rainfall, soil type and whether pure or lucerne/annual legume mixtures are being sown. They suggest that plant populations of 40-50 plants/m^2 in medium to high rainfall environments and 20 plants/m^2 in lower rainfall environments may be sufficient.

Grazing management is also recognised as an important factor in maintaining plant numbers, persistence and hence water use of lucerne over summer. However the role of grazing on lucerne water uptake is not yet fully understood.

Feedback from farmers has indicated that lucerne is often considered a ‘riskier’ pasture to grow as it often has more establishment failures than annual pastures and requires rotational grazing management rather than the commonly practised regime of set-stocking. For farms previously ‘set-stocked’ this may mean additional expensive fencing and more dams and reticulation to provide watering points in each paddock.

In addition, if the economics of lucerne production rely on increased pasture provision (Bathgate and Pannell, 2001), this may mean increases in flock size, increases in the workload of rotational grazing and increased veterinary costs associated with higher sheep densities (Barr and Cary, 2000).

However, Latta, et al. (2000) report that whilst lucerne is considered one of the less tolerant perennial legumes to soil acidity due to the susceptibility of its roots to the presence of aluminium and the inability of the Rhizobium meliloti to survive in acid soils, their research suggests that it may be more climatically adapted and pH tolerant than previously understood.

Lucerne pasture advantages:

Lucerne can benefit the farming system in a number of ways. Higher water use than annual pastures results in less annual recharge, greater nitrogen fixation compared with annual pastures, improved soil structure, higher grain yields and protein levels and the provision of high quality summer feed.

The potential benefits that can flow to following crops, may outweigh the extra management costs for lucerne. Furthermore, lucerne persistence through drought, concerns about rising water tables, salinity, and soil acidification and herbicide resistance and the escalating cost of fertilisers are all likely to be catalysts to encourage adoption (Dear, 1997).

Hirth et al. (2000) report in their trials in a high rainfall environment (600mm) that lucerne was able to supply N to a minimum of two crops when cropping commenced in wet years and to at least three crops when cropping years were average to dry.

Ridley et al. (2000) suggest that following the autumn break, soil water repletion and the potential for less run-off are also enhanced under lucerne compared to annual species. It is speculated that this may be a result of increased macroporosity and hence greater infiltration into the drier soil under lucerne.

Lucerne pasture disadvantages:

Peoples et al. (1998) note that despite lucerne's capacity for consistently high inputs of fixed N, its susceptibility to set stocking and sensitivity to acid and saline soils restricts its use. Other obstacles to lucerne adoption include perceived problems and costs with establishment, additional subdivision and watering costs, the conflict between small paddocks for rotational grazing and large paddocks for cropping, an unwillingness by growers to undertake additional management, and difficulties experienced in removing lucerne prior to cropping (Lodge, 1991).

A further challenge to lucerne is that its deep-rooting habit can dry out the soil profile so effectively that subsequent crop yields may be reduced in years of low rainfall (Ridley, et al. 2000). Therefore the timing of lucerne removal is critical for recharging soil water reserves and to allow time for the mineralisation of N from organic N reserves. McCallum et al (2000) conclude that the risk of significant yield penalties for first or second crops after lucerne was low and predicted through simulation modelling that yield penalties were only likely where pre-anthesis crop growth was large and small yield penalties were expected when rainfall from sowing to maturity was lower than in average years.

Hirth et al. (2000) confirm that the interaction between water supply and N nutrition for crops following lucerne is an important element for crop yields, indicating that with lucerne the timing of its removal prior to a crop phase is critical for both N and soil water availability to following crops. Angus et al. (1998) note that autumn removal of lucerne can lead to N deficiency of the following crop compared with lucerne removed in the previous spring.

Case study

A case study by Bathgate and Pannell (2001) provides a detailed economic analysis of lucerne production in the southern agricultural region of Western Australia. Their research considers the direct costs and benefits of lucerne, its role in the rotational farming system practised in the region, its impacts on other enterprises, and the influence of soil type on its role and economic performance. The study captures whole-farm influences of lucerne on feed availability and machinery usage, as well as its production levels at different times of the year and in different phases of the rotation. The study provides a detailed and comprehensive representation of an integrated production system.

Background

In recent years, Western Australian farmers have shown increasing interest in the potential for lucerne pasture as a means of reducing recharge of the watertable. This is particularly so in the southern regions of the State, where there is a relatively high frequency of summer rainfall and where there is a history of lucerne production (Bee and Laslett, 2001). Lucerne appears to be substantially more effective at preventing recharge than traditional annual crops and pastures (Latta et al. 1998, Ward et al. 2001, Dunin et al., 2000).

Lucerne research in Western Australia has examined the effects of lucerne on soil fertility and subsequent change in cereal yield and grain protein. Nitrogen fixation by lucerne has been found to be similar to annual legumes, and yields and grain protein levels in following cereal crops have increased in some cases (Roy Latta, Agriculture Western Australia, pers. comm., 2000).

An advantage of lucerne over annual pasture species is its ability to provide good quality feed to stock at times when feed quality is most limiting. Typically in Mediterranean-type environments feed quality deteriorates in late summer and autumn, such that growers are required either to provide costly feed supplements or to reduce stock numbers. This is one of the main factors determining the value of the stock enterprise in the agricultural region of Western Australia.

While lucerne has shown potential to provide out of season grazing for stock, its economic value depends also on the cost of providing this feed. Establishment costs of lucerne are high relative to other pastures and there is also a risk of establishment failure (Bee and Laslett, 2001).

Description of the modelling system.

This study focuses on the southern agricultural region of Western Australia, in particular an area known as the 'south-coast sandplain'. The region has a Mediterranean-type climate. Around two thirds of annual rainfall occurs between May and October, followed by summer drought from December to March. Annual rainfall at the two sites studied range from 400mm-500mm per year.

The study uses a static mathematical programming model (MIDAS-Model of an Integrated Dryland Agricultural System- South coast version) which describes biological, physical, technical and managerial aspects of the farming system. It models the inter-year production influences of crop-pasture sequences and the intra-year interdependencies between enterprises. Average production data is used in a year-in-year-out framework, so year-to-year variability (risk) in production and the dynamics of shifting resources between enterprises are not represented. The model selects resource use to maximise profit, subject to managerial, resource and environmental constraints.

The South coast version of MIDAS (SCM) has over 1100 activity options (decision variables) including 24 crop-pasture rotation sequences for each of eight land management units (which are described in Table 1). Production parameters include grain yield, grain quality, grain protein levels (in the case of wheat) and germination rates of pasture. Input costs include fertiliser, chemicals for weed and pest control, machinery costs, labour, crop insurance and seed costs.

Table 1. Description of the land management units represented in the South Coast Model

LMU(a)	Description	Production Periods(b) (T ha^{-1})	Arable (%)	LMU Area (c) Fitzgerald (ha)	LMU Area (c) Esperance (ha)
1	Sandplain duplex (sand depth less than 30 cm)	-	85	200	600
2	Sandplain duplex (sand depth 30 to 80 cm)	0.95	95	200	800
3	Deep sand (sand depth greater than 80 cm)	0.65	60	100	400
4	Sandy loam duplex	-	90	300	0
5	Reddish brown loams	-	90	200	0
6	Red clay loams and clays	-	80	200	0
7	Grey loams and clays	0.75	90	600	0
8	Saline soils	-	15	200	200

(a)Land management unit.

(b)Lucerne production for Period 7 to Period 10 (late summer – autumn).

(c)Assumed areas of each land management unit in two different sub-regions.

The seasonal supply of pasture is described by partitioning the pasture sub-matrix into 10 periods. Periods 1 to 5 describe the rates of pasture growth at different times of the growing season. Growth rate is a function of the feed on offer to livestock at the end of each period. Feed not consumed in a given period is carried forward to the following period. Periods 6 to 10 cover summer and autumn in which the quality of dry feed declines over time.

Other activities represented in MIDAS (SCM) include:

- pasture consumption by sheep at different times of the year
- availability of crop machinery at sowing and harvest time
- yield penalties associated with delayed sowing
- grazing of crop stubble by sheep
- supplementary grain feeding during the feed gap
- selling of sheep
- selling of grain and wool

- bi-monthly cashflow

Risk is not represented in the model. The mathematical solution of the model identifies the farming system which maximises medium-run expected profit. The strategy selected includes rotations for each LMU, sheep flock structure, selling times of sheep and grazing strategies.

Bathgate and Pannell (2001) Model Assumptions:

- Production levels of lucerne assumed in the model were based on averages of trial data from sites in Western Australia during 1997 to 1999 (R. Latta, pers. comm., 1999). It was assumed that during the normal growing season, lucerne pasture was a mixed sward of volunteer annual species and lucerne, and production levels were similar to annual pastures.
- Lucerne was used to provide rotational benefits for subsequent cereal crops (higher yields, lower nitrogen fertilizer requirements) similar to those observed following productive annual legume pastures.
- A discount rate of 10%.
- All of the land would have become salinised after 10 years if left in annual based systems.
- The net profitabiity of production from salinised land was assumed to be 20% of the profitability of non-salinised land.

Grain and wool prices used were those forecast for the next 3 to 5 years by Agriculture Western Australia (I. Wilkinson, pers. comm., 2000; B. Layman, pers. comm., 2000): wheat ASW A\$200 T^{-1}; barley malting grade 1 A\$205 T^{-1}; canola A\$330 T^{-1}; lupins A\$190 T^{-1}; wool 21μ greasy 350c kg^{-1}. All prices were net of all selling costs, including transport. Note that as of June 2000, A\$0.6 = US\$1. The establishment cost of lucerne was estimated to be A\$160 ha. This varies substantially between farms, and does not take into account the risk of establishment failure, which incurs a cost of resowing.

Five new rotations were included in the model for three LMUs (soil types 2, 3 and 7). Each new rotation included a phase of lucerne followed by one or a number of years of crop:

- 4 years lucerne followed by wheat-canola-barley-legume-wheat
- 4 years lucerne followed by wheat
- 3 years lucerne followed by wheat-canola-wheat-barley
- 3 years lucerne followed by wheat-barley
- 3 years lucerne followed by wheat-canola

The model was run for different combinations of wool price, grain prices, establishment costs, summer lucerne production and area of lucerne sown. The values tested for each of these factors are shown in Table 2. The analysis was repeated for two sub-regions, Fitzgerald (in the west) and Esperance (in the east).

Table 2. Values used for each factor examined in the sensitivity analysis.

Factor examined (unit)	Value
Wool price (21μ, c kg^{-1} greasy net on farm(a))	250, 350,450, 500
Wheat price (ASW, A$ T^{-1} net on farm)	140, 160
Barley price (Malting grade 1, A$ T^{-1} net on farm)	145, 165
Canola price (A$ T^{-1} net on farm)	270, 300
Lupin price (A$ T^{-1} net on farm)	135, 155
Establishment costs (A$ ha^{-1})	100, 160
Production of lucerne during periods P7-P10 (% of measured)	40, 100
Area of lucerne sown (ha)	50, 100, 150, 200, 250, 300, 350, 400, 450, 500

(a)'Net on farm' means all charges and tolls have been deducted including transport to receival point or market.

Economic value of lucerne

Bathgate and Pannell’s modelling results are based solely on the direct financial benefits and costs of the alternative enterprises, without accounting for the salinity-related benefits of lucerne. At wool and grain prices expected in the medium term and based on the lower level of summer feed production, lucerne increases farm profit in the Fitzgerald sub-region, but not in the Esperance region (Table 3). The primary reason for this difference is that Esperance includes none of the LMU 7 (grey loams and clays), on which lucerne performs well.

Table 3. Summary of MIDAS (SCM) model results, based on assumption of low cost of lucerne establishment (A$100/ha).

Wool price ($c\ kg^{-1}$ greasy net on farm)	Summer lucerne production (a) (% of measured)	Area of lucerne (ha)	Change in profit (A$'000)	Stocking rate(b) ($sheep\ ha^{-1}$ winter pasture)
Fitzgerald region				
350	40	230	22	6.9
	100	230	31	7.6
500	40	315	35	7.8
	100	315	55	9.9
Esperance region				
350	40	0	0	4.1
	100	138	3	6.0
500	40	323	11	7.1
	100	412	29	8.1

(a) Production of lucerne during periods P7-P10 (% of measured)

(b) Stocking rate is expressed as dry-sheep-equivalents per ha. Without lucerne the stocking rate ranges from 4 to 5.

The rotation selected for LMU 7 in Fitzgerald includes a three-year phase of lucerne followed by wheat, canola, wheat and barley. On the 600 ha of LMU 7 on the model farm, it is profitable to grow 230 ha of lucerne on average (15 percent of the arable area of the farm). Including lucerne on LMU 2 is equally profitable to the current optimal rotation, but only if small areas are grown.

They note a reason for lucerne’s inclusion on LMU 7 is that currently available grain legume crops are relatively unsuited to the heavy soils of this LMU. Lucerne provides a fertility boost that is otherwise only available at a greater income sacrifice.

A second, more important reason is that lucerne provides good quality summer feed at costs competitive with other feed sources such as grain supplements. It thereby enables the stocking rate of the farm (sheep per ha of winter pasture) to be profitably increased above the level of 4 to 5 sheep ha^{-1} which is viable without lucerne (Table 3). Additional income results from higher wool and meat sales while input costs increase to a smaller extent. Table 3 also shows that the profitability of lucerne is very dependent on the level of summer production.

However, profits do not continue to increase with larger areas of lucerne due to the "law of diminishing marginal returns". This is demonstrated in Figure 3, which shows the marginal increase in profit per lucerne hectare at different areas of lucerne. The optimal area of lucerne is where the addition to profit resulting from a marginal increase in area is zero, which, in this example, occurs when there are 230 ha grown annually. At areas greater than 230 ha establishing additional lucerne area reduces profit.

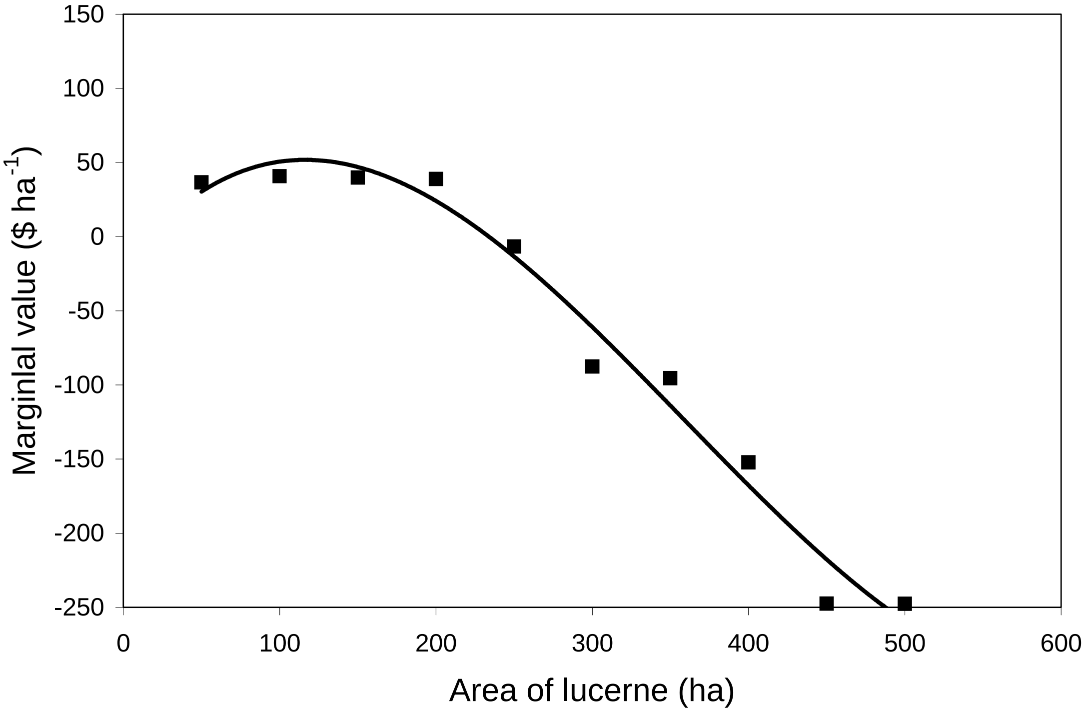

Figure 3. Marginal value of lucerne in Fitzgerald sub-region representative farm (wool 350 c kg^{-1})

The declining marginal value of lucerne occurs for two main reasons. Firstly, to further increase the area of lucerne requires adoption of either less profitable rotations that include a greater proportion of lucerne or additional lucerne being grown on a less suitable LMU. For example, in Figure 3 lucerne has been established on LMU 2 to increase the area above 230 ha. Establishing lucerne on LMU 2 is less profitable than on LMU 7, so much so in this example that profit falls. Secondly, lucerne provides feed at a time when it is relatively scarce. As more lucerne is grown, good quality feed becomes less scarce and other factors begin to limit the extent to which efficiency of livestock production can be improved. The contribution to profit resulting from a marginal increase in lucerne hence is reduced as the area of lucerne increases.

Influence of grain prices, wool price and establishment costs on profitability:

Optimal lucerne area is most sensitive to grain and wool prices and less sensitive to the cost of lucerne establishment, as these costs are spread over the length of the rotation. With more favourable market conditions (lower grain prices, wool price 500 c kg^{-1} greasy and low establishment costs) the optimal area is around 150 ha higher than in Figure 3, bringing lucerne to almost 25 percent of the arable area of the farm. The optimal area of lucerne in the Esperance region is much more sensitive to market conditions. Curve A of Figure 4 shows that with favourable conditions for lucerne the optimal area is 450 ha - 28 percent of the total arable area of the farm. An increase in grain prices leads to a reduction in the optimal lucerne area to around 350 ha (curve B of Figure 4). Where grain prices and costs of establishment are both high the optimal area is 280 ha (curve C of Figure 4). From this point any, adverse change, such as a reduction in the wool price to 450 c kg^{-1}, would make lucerne unprofitable in the Esperance sub-region.

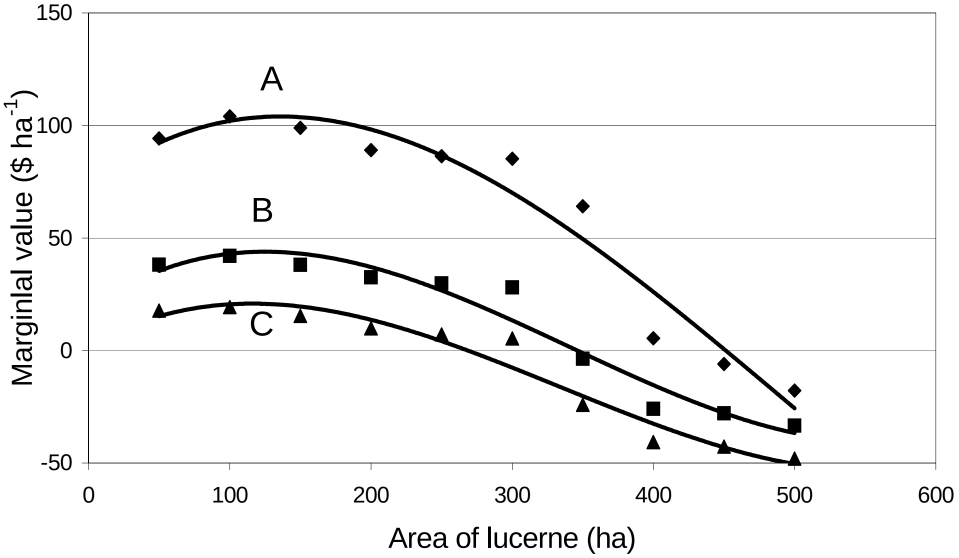

Figure 4. Marginal value of lucerne in Esperance, assuming wool 500 c kg^{-1} (curve A: low grain prices, low establishment cost; curve B: high grain prices, low establishment cost; curve C: high grain prices, high establishment cost)

Impact of lucerne on the spread of salinity

Differences in the productive capacity between farms, the mix of LMUs, farmer management ability, personal preferences and commodity prices will mean more or less lucerne may be established on the south coast, compared to that suggested by the above results. In addition the benefit of reducing the depth of the water table has not been considered so far. If the profitability of each lucerne rotation is increased to represent the value of salinity prevention, then the optimal area of lucerne will increase further. The optimal area of lucerne will be even greater where the economic climate is favourable to livestock. It is hoped that lucerne may provide an effective buffer to offset recharge from a number of subsequent years of crop. If it is fully effective in this, an average lucerne area of 20 percent per annum implies that approximately 40 percent of the farm land may have salinity prevented, or at least delayed.

If risk considerations were modelled, there may be further enhancement of the attractiveness of lucerne. Anecdotal evidence indicates that lucerne production is less affected by below-average rainfall years than are annual crops and pastures. Hence, some costs of livestock agistment or additional feeding or flock re-building can be avoided.

Discussion:

A number of economic, environmental and agronomic benefits are achievable with phase farming of lucerne. Economic and environmental benefits include, management of water tables to prevent or lessen saline degradation and water logging, thereby maintaining land values and future productivity. Agronomic benefits include nitrogen supply and consequently increased crop yields, improved soil conditions due to lucerne assisting with easier weed control. The most significant benefits expected from lucerne pastures arise from the availability of good quality out of season pastures (autumn) and in the improvement of crop yields as a result of increased nitrogen mineralisation.

A few research papers discuss the potential of improved economic returns from lucerne hay or silage production.

Pavelic et al. (1997) used an integrated modelling approach to assess the economic benefit of a number of dryland salinity management options including lucerne pastures. They found that when compared with current land management practices, the economic benefit of perennial pastures was marginal and depended largely on future farm commodity prices (livestock and grain) and discount rates. The effect of livestock prices became increasingly important as the area of recharge reduction increased. Pavelic et al. also noted that in productivity terms, expanding the area of lucerne led to an increase in carrying capacity (DSE) and a reduction in grain yields. They noted that the overall feasibility of lucerne pastures relied heavily on above average livestock prices.

Bathgate and Pannell (2000)'s economic study of lucerne concluded that lucerne's main economic advantage in a medium rainfall environment (450mm) was in providing out of season feed for livestock and that factors such as nitrogen fixation and improved grain yield were of secondary importance in mixed enterprises in medium/high rainfall areas. Their modelling of lucerne profitability indicated that lucernes summer growth could be utilised most efficiently by reducing grain feeding, increasing stocking rate and altering flock structure away from wool to wool and prime lamb production, thereby further increasing the return to lucerne. These benefits largely resulted from a decrease in the cost of supplementary feeding for wool production and from provision of out of season feed to increase stocking rates for production (from 4-5 sheep per ha to 6-9 sheep per ha). Their research also indicated that for the Esperance sandplain in Western Australia, lucerne generated similar levels of profit as continuous crop rotations at low wool prices (<350c/kg greasy). Wool prices above this level may improve farm profit considerably.

Research into grazing return and wheat yield benefits from lucerne pastures in Western Australia to date have largely been based on the last 4-5 seasons, which prior to 2000 have been fairly wet. WA lucerne research has not yet encountered a long-dry period (2-3 years of below average rainfall). Lucerne production in 2000 may be the first year of below average rainfall for DM production. Further dry year analysis is needed in order to determine whether the dry years result in lucerne using up stored soil nitrogen and sub-soil water with less attendant benefits for following crops.

Bathgate and Pannell note that their results cannot be generalised to all of WA or the Eastern states. However they expect that the factors influencing the area devoted to lucerne will be the same:
-area of suitable soil types
-level of summer production and hence summer rainfall

-expected wool and grain prices and
-lucerne establishment costs

The results presented by Bathgate and Pannell are framed by their assumptions, their static modelling approach used and the regional setting of their investigation; a setting which favours livestock production.

However, over 50% of the Western Australian wheatbelt is considered to be a low rainfall environment (<350mm per year) (R.George pers.comm) and dryland salinity is an emerging problem in this environment.

Whilst a wide range of revegetation strategies using perennial species in annual based farming systems exists such as alley farming, intercropping and plantations, their efficacy for controlling salinity and being profitable enterprises largely remains untested. A lucerne perennial pasture integrated into a phase farming system is considered a viable but largely underutilised salinity management strategy for low rainfall environments in Western Australia.

Further research needs to investigate the economics of lucerne in low rainfall environments within a dynamic modelling framework which can test the sensitivity of lucerne production and profitability, to changes in soil types, rainfall, costs of establishment and the influence of tactical approaches to farm management. Dynamic modelling of lucerne will allow review of its place and profitability in cropping dominant low rainfall agricultural systems.

Including risk analysis in the economic modelling of lucerne will also help researchers and farm advisors to better understand the role and value of lucerne in agricultural systems and may assist in determining the level of financial support required to encourage its widespread adoption in managing recharge in the low-medium rainfall environments that make up a large portion of Western Australia's main wheat and sheep producing areas.

Conclusions:

Perennial systems may allow us to maintain the productive potential of agricultural land by greater control of water recharge, soil erosion and water logging. These systems buy time in which to develop more effective and profitable solutions to salinisation.

Research by Bathgate and Pannell (2000) highlights the importance of animal production in determining the profitability of lucerne as a perennial pasture salinity management option. Agronomic research has already highlighted the hydrological benefits of perennial pastures like lucerne in managing recharge and therefore dryland salinity (Lolicato, 2000, Dunin et al. 2000)

Broadscale salinity management involves not just reducing the large influence of salinity on 30% of our agricultural landscape but also the development of economically sustainable farming systems. It is about maintaining the health of 70% of the landscape that will not be significantly affected by salinity, utilising agronomic (recharge), engineering (discharge and recharge) and adaption (PURSL) water management techniques to manage our agricultural lands and protecting the biodiversity and infrastructure assets in these landscapes from the threat of rising water tables and salinisation.

Richard George cited in his W.E. Wood Award 2000 Lecture on dryland salinity, that " no change takes place, no matter how clever the science, without profit, participation and politics. In many ways these are tougher mountains to climb."

In this regard, the economic modelling of salinity management options helps us to understand their feasibility and profitability in an agricultural production environment traditionally based on cropping and annual pasture systems within widely varied landscapes and facing variation in production costs and commodity prices.

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