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Net Benefits from Investing in Lucerne (Medicago sativa) Phase Farming Systems in the Mixed Farming Zone of Northern Victoria[1]

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Abstract. Increases in induced waterlogging and dryland salinization resulting from deep drainage to watertables have been predicted to occur across the mixed farming zone of northern Victoria. Consequently, deep-rooted perennials need to be introduced into farming systems. Lucerne (Medicago sativa) has been found to have a higher level of water extraction than annual crops and pastures. But one of the barriers to farmers adopting cropping with lucerne is that they fear their risk in production will increase and that their economic and financial benefits will be compromised. In this study, farm management systems where lucerne phase farming has replaced cropping with annual legumes were investigated. Changes in profitability and cash flow as a result of making the substitution were calculated and an assessment made of likely increases in business risk for the farming systems.

Introduction

Increasing rates of induced waterlogging and dryland salinization have been predicted to occur across northern Victoria from the Mallee through north-central Victoria to the north-east of the State. The major cause of those problems has been attributed to over-clearing of native woodlands by European settlers over the past 160 years or so (Schofield 1990, Macumber 1991, Hatton and Nulsen 2001). Over-clearing has had the effect of disturbing the pre-existing hydrological balance in the landscape and replacement of trees with shallow rooted annual crops and pastures has led to increasing levels of recharge to ground water. Rising water tables, especially those of a saline nature, have an extremely detrimental effect on the physiology of crops and pastures once they reach levels of 2 metres below ground level. One way to redress the problem of deep drainage to watertables is to introduce deep-rooted perennial plants into the landscape. Lucerne (*Medicago sativa*) is such a plant and has been shown to be effective in restoring hydrological balance in mixed farming areas where average annual rainfalls are less than 600 mm per annum (Angus *et al*. 2001, Hirth *et al*., 2001, Ridley *et al*. 2001).

Apart from having a high water use efficiency, lucerne has been found to be more productive and contributes greater amounts of biologically fixed nitrogen than annual medics or subterranean clover (Peoples *et al*. 1998, Angus 2001). The idea has therefore arisen to substitute lucerne for annual legume pastures in ley-farming systems to improve the productivity of crop production and importantly, to reduce deep drainage of rainfall to water tables thereby protecting the landscape from induced water logging and dryland salinization. This system has generally been described as growing lucerne as a phase of 3 to 4 years in rotation with annual crops.

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Barriers to the adoption of lucerne phase farming

Although previous research has shown that phase farming with lucerne in rotation with crops has a positive environmental benefit by reducing deep drainage to water tables and has the capacity to increase crop yields and quality by increasing the amount of available mineralized nitrogen to successive crops, several barriers have been identified to farmers adopting this seemingly superior system of crop and pasture management. These are: Lucerne is expensive to establish and has a high risk of failure; having established lucerne, it is hard to remove to make way for successive crops; the first crop grown after lucerne does not yield as well as a crop grown after annual legume pasture and a survey of producers as part of this project revealed that many were not convinced that lucerne phase farming provided subsequent economic benefit to their farm businesses.

Aims of this study

The aims of this project were threefold. The first was to provide a description of management strategies that would allow farmers to minimize technical threats in substituting lucerne for annual legumes in their cropping programs. The second was to provide economic and financial information about the likely benefits that could be achieved as a result of changing to phase farming with lucerne. The third aim was to conduct seminars and workshops to provide scientific, technologic and economic information to farming audiences across the study area.

In this paper information is reported about the economic and financial benefits from cropping with lucerne and a risk assessment of substituting lucerne for annual legume pastures.

Economic and financial benefits for cropping with lucerne

The approach taken was to investigate changes in management practices on 13 case study farms where lucerne was substituted for annual legume pasture. From those management changes, benefit:cost analyses were used to calculate resulting changes in profit for a complete pasture-crop rotation (Makeham and Malcolm, 1993, Sinden and Thampapillai, 1995). The method involved discounting future streams of income and costs for the two cropping systems to estimate their net economic benefits. Where the length of the rotations was the same for cropping with lucerne versus cropping with annual legumes, those net economic benefits were stated as net present values (NPV's). But where the length of the rotations differed, the relevant NPV's were converted to annuities. The discount rate used in the calculations was a nominal after tax rate of 15 per cent per annum and an inflation rate of 4 per cent per annum was applied to all values for income and costs in the calculations. Differences in net economic benefits for the two rotational systems, that is, cropping with lucerne instead of with annual legume pastures, was indicated by difference between their NPV's, or the annuities, for the rotations. In doing this, account was taken of the case study farmer's personal risk in changing to lucerne phase farming. The main point to emphasize here is that if the NPV, or annuity, for cropping with lucerne was markedly higher than the NPV, or annuity, for cropping with annual legume pasture, then there would be strong evidence to suggest that it would be a good decision to make the change. This decision would be based on the assumption that access to extra capital was not a limiting resource.

Whilst changes in net economic benefits of the two systems are important, financial characteristics as a result of making the change are as important, or more so, in influencing the decision making process. Financial characteristics relate to differences in cumulative cash flow for the alternative systems and comprise the peak debt arising from changing to cropping with lucerne, the year in which the peak debt occurs, and the time taken (pay-back period) for cash deficits to be repaid from net income. Additionally, a critical factor in influencing the decision to change will be the extra cash available at the end of the rotations.

Previous economic research

Flugge *et al*. (2004) evaluated the economics of substituting lucerne for annual legume pastures in a cropping program that would be applicable for a typical central wheat-belt farm in Western Australia. The models used to carry out the analysis were the central wheat-belt version of MIDAS (Model of an Integrated Dryland Agricultural System) followed by a second model called STEP (Simulated Transitional Economic Planning). Their findings were that farm profit over the whole rotation increased by 3 per cent as a result of including lucerne in the pasture-crop rotation when the livestock activity comprised a self replacing merino flock for wool production. However, increases in farm profit of 23 percent could be achieved if the livestock activity was changed to producing prime lambs from merino ewes or from cross-bred ewes.

Results of this study

This study differed from the work reported by Flugge *et al*. (2004) because they used synthetic information that would apply to a typical central wheat-belt farm in Western Australia for their analyses. In this study, economic and financial analyses and the risk assessment as a result of substituting lucerne for annual legume pastures, was based on actual data and experiences provided by 13 case study farms across northern Victoria.

Table 1 summarizes the results for the 13 case study farms. The details include differences in rotations between cropping with lucerne and cropping with annual legume pasture, differences in livestock activities for the two, changes in profitability and characteristics of the resulting cumulative cash flow from substituting lucerne for annual legume pasture.

Since the contribution to profitability for the various livestock activities has an important influence on overall increases in profitability for the case study farms, average gross margins for them is displayed in Table 2. Those figures are expressed in real terms in year 2004 dollar values.

Table 1: Summary of the results of the 13 case study farms showing differences in rotations between cropping with lucerne and cropping with annual legume pastures, differences in livestock activities for the two, changes in profitability, and characteristics of the resulting cumulative cash flow from substituting lucerne for annual legume pastures.

Location	Cropping with annual legumes	Cropping with lucerne	Annual legume livestock activities	Stocking rate on annual legumes (DSE/ha)	Lucerne pasture livestock activities	Stocking rate on lucerne (DSE/ha)	Difference in net economic benefits (%)	Peak debt ($/ha)	Year of peak debt	Pay-back period (Years)
Underbool	P, F, W	3 yrs lucerne, W,P,W,P,W, P,W,B	Merino ewes and wethers for wool	2.3	Cattle, fattening lambs	2.4	51	217	3	4
Rainbow	W,P,F,W,P,F, W,B,Lu,W	4 yrs lucerne, V,W,C,B,Lu,W	Merino X prime lms, fattening lms.	1.8	Merino X prime lms, fattening lms.	5.4	58	nil	na	na
Wood Wood	P,F,W,F,W	4 yrs lucerne, W,F,W,B	XB ewes prime lms.	1.5	XB ewes prime lms.	3.0	45	nil	na	na
Nyah West	P,P/F,W,F,W	4 yrs lucerne, W,F,B,F,T	Merino X prime lms.	1.5	Merino X prime lms.	3.0	15	191	5	3
Maryborough	4 yrs pasture, W,B,Og	5 yrs lucerne, W,B,Og	Merino flock for wool	7.0	Merino X prime lms.	12.0	45	168	2	2
Wedderburn	5 yrs pasture, W,Og	5 yrs lucerne, W,B,Lu,Bi	Merino flock for wool	7.0	Merino X prime lms.	10.0	84	75	1	1
Bridgewater	2 yrs pasture, W	9 yrs lucerne, C,W,W,C,W,W	Merino wethers	6.0	XB ewes prime lms.	10.0	15	173	2	4
Charlton	5 yrs pasture, C,W,B,Ps,W	4 yrs lucerne, Vh,W,B,W,B	Merino ewes for 1st X ewes	3.1	Merino ewes for 1st X ewes, XB ewes for prime lms.	5.1	43	nil	na	na
Serpentine	4 yrs pasture, W,W,B	4 yrs lucerne, W,W,B	Merino ewes for 1st X ewes, wethers for stores	4.2	Merino ewes for 1st X ewes, wethers for prime lambs	8.1	38	14	1	1
Dookie	3 yrs pasture, C,W,T,C,W, C,T	6 yrs lucerne, W,C,W,Lu,W, VOh,	Merino flock for wool	6.0	Merino flock for wool	12.0	22	294	6	5
Tungamah	4 yrs pasture, W,W,C,W,B	6 yrs lucerne, W,W,C,W,B	Merino flock for wool	9.0	Merino flock for wool	12.5	11	460	1	2
Corowa	4 yrs pasture, W,Lu,W,T	4 yrs lucerne, W,C,W,Lu,W, T	XB ewes for prime lms.	6.0	XB ewes for prime lms.	8.0	36	58	1	2
Chiltern	4 yrs pasture, C,W,T,C,W,T	6 yrs lucerne, Lcn silage, Lcn hay, W,W,C,W,W,T	Cattle for vealers, XB ewes for prime lms.	7.0	Cattle for vealers, XB ewes for prime lms.	12.0	33	541	2	5

B = Barley Bi = Barley intercropped with lucerne Lu = Lupins C = Canola F = Fallow Vh = Vetch for hay VOh = Vetch and Oaten hay
Og = Oats for grain Oh = Oats for hay P = Annual legume pasture Ps = Peas T = Triticale Vgm = Vetch for green manure

Table 2: Contribution of livestock activities to rotation profitability for cropping with lucerne verus cropping with annual legume pastures.

Location	Annual legume livestock activities	Stocking rate on annual legumes (dse/ha)	Gross margin per dse $/dse	Gross margin per hectare $/ha	Lucerne pasture livestock activities	Stocking rate on lucerne (dse/ha)	Gross margin per dse $/dse	Gross margin per hectare $/ha
Underbool	Merino ewes Wethers for wool	2.3 (P) 0.8 (F)	14 19	32 15	Cattle, Fattening lambs	2.4 (L) 2.0 (P)	19 20	46 40
Rainbow	Merino X prime lms, fattening lms.	1.8	20	36	Merino X prime lms, fattening lms.	5.4	27	146
Wood Wood	XB ewes prime lms	1.5	21	32	XB ewes prime lms	3.0	22	66
Nyah West	Merino X prime lms, fattening lms.	1.5	29	44	Merino X prime lms, fattening lms	3.0	34	102
Maryborough	Merino flock for wool	7.0	23	161	Merino X prime lms.	12.0	25	300
Wedderburn	Merino flock for wool	7.0	14	98	Merino X prime lms.	10.0	27	270
Bridgewater	Merino wethers	6.0	23	138	XB ewes prime lms.	10.0	30	300
Charlton	Merino ewes for 1st X ewes	3.1	32	99	Merino ewes for 1st X ewes, XB ewes for prime lms.	5.1	25	128
Serpentine	Merino ewes for 1st X ewes, wethers for stores	4.2	20	84	Merino ewes for 1st X ewes, wethers for prime lambs	8.1	28	227
Dookie	Merino flock for wool	6.0	29	174	Merino flock for wool	12.0	32	384
Tungamah	Merino flock for wool	9.0	32	288	Merino flock for wool	12.5	35	438
Corowa	XB ewes for prime lms.	6.0	23	138	XB ewes for prime lms.	8.0	25	200
Chiltern	Cattle for vealers, XB ewes for prime lms.	3.5 + 3.5	17 20	60 70	Cattle for vealers, XB ewes for prime lms.	6.0 + 6.0	19 21	114 126

P = Annual legume pasture F = Fallow L = Lucerne

Risk assessment

During the data collection process for the various case study farms, the owners were asked to provide details of their rate of success in establishing lucerne compared with their success rate in establishing annual legume pasture. In an attempt to incorporate in some way the expected effects of establishment failure of lucerne *above* what happens when establishing annual legume pasture, the following method was used. In the first year of the alternative rotations (with and without lucerne) the capital investment for establishing pasture as part of the rotation was calculated. For the second and every other successive year of the rotation, the annual expected value of a loss from establishment failure of lucerne above that expected when establishing pasture containing annual legumes was included as a cost. That is, the capital investment for establishment was multiplied by the chances of failure and converted to a nominal value. This is a simple method of handling increases in risk from including lucerne in the rotation. It has the realistic effect of showing that as the risk of failure increased, the NPV's for carrying out the rotation decreased. It was therefore better than ignoring the cost of lucerne to establish in making the comparison in net economic benefits between the two rotational systems. For more on the practical treatment of risk in choosing between different courses of action, see Gigerenzer (2002).

Discussion and conclusions

The results from this study were similar to those of Flugge *et al*.(2004). Both of these studies have shown an increase in profitability from introducing lucerne into a cropping rotation and both showed that for sheep activities, switching from woolgrowing to the production of high valued lambs increased profitability even more. For example, from Table 1, the Wedderburn farm where Merino rams in a self replacing wool producing flock were replaced with White Suffolk rams for the production of prime lambs and the Maryborough farm where Dorset rams for prime lamb production were substituted for Merino rams in a wool producing flock.

The analyses of changes in net economic benefits shown in Table 1 indicated that substituting lucerne for annual legume pastures in the various cropping-pasture rotations was definitely an attractive investment. For all case study farms the net economic benefits for cropping with lucerne was greater than the economic benefits for cropping with annual legume pasture. The smallest increase was for the Tungamah farm where the annuity for the 11 year rotation for cropping with lucerne was $17,650 but the annuity for the 9 year rotation for cropping with annual legume pasture was $15,950.

The case study farm at Nyah West had an annuity for cropping with lucerne of $13,600 and a lower annuity for cropping with annual legume pasture of $11,800. The percentage difference in annuities was the same (15 per cent) for the Bridgewater farm where the annuity for cropping with lucerne was $11,400 compared to the lower annuity for cropping with annual legume pasture of $9,900.

The highest increase in net economic benefits was for the Wedderburn farm. For that farm, the annuity for the 9 year rotation with lucerne was $18,000 whereas the annuity of the 7 year rotation for cropping with annual legume pasture was $9,800.

Overall, for the whole study, 10 out of 13 case study farms had increases in net economic benefits for cropping with lucerne that were more than 20 per cent higher than the net economic benefits achieved from cropping with annual legume pastures.

As was demonstrated in Table 2, the importance of the type of livestock activity used in conjunction with lucerne in the rotation cannot be underestimated. This is because an assumption was made that change from annual legumes to lucerne would be at the start of the rotation. And using a relatively high nominal discount rate of 15 percent per annum meant that profitability in the first 4 or 5 years of the rotation was critical in determining the resulting NPV's for the entire pasture-crop rotation. High profitability of the livestock activity in the early years of the change in pasture species was necessary to pay for the establishment of lucerne and the extra capital invested in extra livestock to use the greater amounts of dry matter produced by lucerne plants. Thus in ranking the case study farms in

order of decreasing increases in rotational profitability after switching to lucerne, farms that stuck with continuing to produce wool as the main product, the Dookie and Tungamah farms, were in the lowest quartile.

Other determinants for increases in livestock profitability after introducing lucerne were an increase in stocking rate to utilize the larger amount of dry matter produced by lucerne plants and a reduction in the cost of supplementary feed. Supplementary feed costs were reduced because lucerne is able to make use of 'out of season' summer and early autumn rains to provide green pasture for livestock instead of having to feed hay or grain as would be the case where annual legumes comprised the pasture phase of the rotation.

The financial analyses displayed in Table 1 too showed a favourable result for making the change in pasture system for most of the case study farms. For 23 per cent of them, there was no peak debt because lucerne was established under a cover crop. For 43 per cent, peak debts ranged between $14 and $217 per hectare. Of the three remaining farms, the peak debts were $294, $460, and $541 per hectare.

Of the 77 per cent of farms that did have a peak debt, 6 or 60 per cent had pay-back periods of 3 years or less. The case study farms at Underbool and Bridgewater had pay-back periods of 4 years whilst the longest pay-back period was 5 years for the case study farms at Dookie and Chiltern

Notwithstanding the increase in the contribution to increased profitability with favourable cash flows from livestock, cropping activities contributed positively too from higher yields and better quality grain. That result was achieved by cropping on soils containing larger amounts of available mineralized nitrates which was the direct benefit achieved by substituting lucerne for annual legume pasture species.

Regarding the perception that the inclusion of lucerne in a rotation increases risk in production. That notion was dispelled by the results of this study. In all the case study farms, the net economic benefits for cropping with lucerne were higher than those for cropping with annual legume pastures. That result was obtained when personal probabilities of the farmers were applied for their expected rate of having an establishment failure with sowing lucerne compared with the rate of failure in sowing annual legume pasture. Additionally, favourable characteristics of resultant cumulative cash flows were achieved by most of the case study farms.

References

Angus, J.F., Gault, R.R., Peoples, M.B., Stapper, M. and Van Herwaarden , A.F. (2001), Soil extraction by dryland crops, annual pastures, and lucerne in south-eastern Australia, *Australian Journal of Agricultural Research* 52 (2).

Angus, J.F. (2001), Nitrogen supply and demand in Australian agriculture, *Australian Journal of Experimental Agriculture*, 41 (3).

Flugge, F., Abadi, A., and Dolling, P. (2004), Lucerne-based pasture for the central wheatbelt rgion of Western Australia – a whole-farm economic analysis, in *Conference Proceedings, Salinity Solutions Working with Science and Society*, Bendigo, Victoria, Australia.

Gigerenzer, G., (2002), *Reckoning with Risk*, Pengiun Books, London, UK.

Hirth, J.R., Haines, P.J., Ridley, A.M., Wilson, K. F. (2001), Lucerne in crop rotations on the Riverine Plains. 2. Biomass and grain yields, water use efficiency, soil nitrogen, and profitability, *Australian Journal of Agricultural Research* 52 (2).

Hatton, T.J. and Nulsen, R.A. (2001), Towards achieving functional ecosystem mimicry with respect to water cycling in south Australian agriculture, in *Agriculture as a Mimic of Natural Ecosystems* (eds). E.C.Lefroy, R.J.Hobbs, M.H.O'Connor and J.S.Pate, Kluwer, Dordrecht, Nederlands.

Macumber, P.J. (1991), *Interaction Between Ground Water and Surface Systems in Northern Victoria*, Department of Conservation and Environment, East Melbourne, Victoria, Australia.

Makeham, J.P. and Malcolm, L.R. (1993), *The Farming Game Now*, Cambridge University Press, Cambridge, UK.

Peoples, M.B., Gault, R.R, Scammell,G.J., Dear, B.S., Virgona, J., Sandral, G.A. Paul, J., Wolfe, E.C. and Angus, J.F. (1998) Effect of pasture management on the contributions of fixed N to the N economy of ley-farming systems, *Australian Journal of Agricultural Research* 49 (3).

Ridley, A.M., Christy, B, Dunin, F.X., Haines, P.J., Wilson K.F., Ellington, A. (2001), Lucerne in crop rotations on the Riverine Plains. 1. The soil water balance, *Australian Journal of Agricultural Research* 52 (2).

Schofield, N.J. (1990), Determining reforestation area and distribution for salinity control, *Hydrologic Science Journal*, 35.

Sinden, J.A. and Thampapillai, D.J. (1995), *Introduction to Benefit-Cost Analysis*, Longman, Australia.