54th Annual Conference, Australian Agricultural & Resource Economics Society,
9-12 February 2010, Adelaide, South Australia

Economics of managing acid soils in dryland mixed cropping systems: comparing gross margins with whole-farm analysis derived using a business process model

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Abstract

A 12-year experiment designed to show the benefits of applying lime to acid soils when growing annual pasture, perennial pasture, and annual crops in rotations with annual or perennial pastures, provides the context for comparing methods of economic analysis. In this study enterprise gross margins are compared with whole-farm cumulative monthly cash flows derived using a business process model.

The current study gave gross margins comparable with those of a recently published study based on the first 12 years of the same field experiment at Book Book near Wagga Wagga in southern NSW (Li et al., 2010). Both gross margin analyses indicated positive results for all treatments. However, because key fixed and capital cost items were not taken into account in the gross margin analysis the financial benefits of the treatments were overstated.

In the whole-farm analysis, a full set of accounts (including fixed and capital costs) was developed for the experimental combinations of prime lamb and dryland cropping enterprises and used to generate a monthly cash flow sequence for each treatment over the 12-year term of the experiment. This full financial analysis, where all costs are included, showed all mixed treatments (cropping and grazing) accumulated unsustainable losses over the period of the trial. The grazing-only treatments generated positive cash lows over the 12 year period, but

accumulated high levels of debt in the initial years. None of these outcomes were predicted by gross margins, which were consistently positive for all treatments.

This paper concludes that the analysis of trial results benefits from interpretation in the context of whole-farm analysis, verified by district experience. Relying on gross margin analysis alone would have supported loss-making outcomes in this trial. This conclusion has important ramifications for analysis of all systems trials.

Introduction

The function of business is to increase the wealth of its owners. The accumulation of earnings as a result of the operation of the business is the primary role of the manager and the usual measure of his success. Business wealth is measured by net worth, which is the sum of the value of the capital and cash assets of the business (Beever and McCarthy 2003). Net worth thus integrates the long-term impact of all business inputs and their variability on both the asset value and accumulated cash flow generated during the lifetime of the business. Cash flow is the main component of business wealth under the control of the farm manager and therefore changes in cash flow are a good measure of both management efficiency and the resulting wealth creation (Fig. 1).

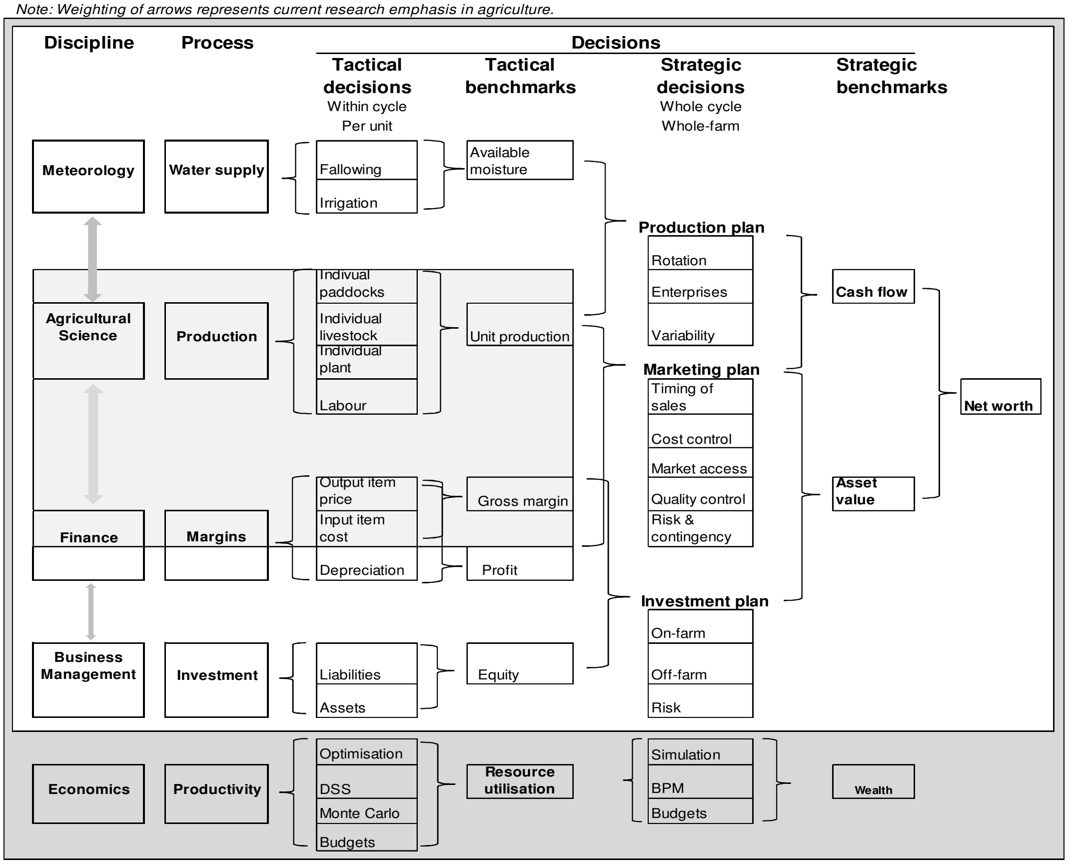
Dryland agriculture is the business of creating wealth from rainfall (Clarke et al. 1995). This wealth is accumulated over time and integrates the effect of all inputs into the business process. It follows that any analysis of the operation of a dryland farm business should include all income and costs generated by the farm business, and encompass the effects of the individual variability of each input over the period being studied. Despite this there are very few studies in the Australian literature which measure the cash and capital components of net worth (Hutchings 2008; Sadras et al. 2003). Most studies only report gross margin or profit.

Gross margins should be limited to within-enterprise comparisons on individual farms; they are not an appropriate or sufficient tool for broader comparisons (Krause and Richardson 1996) . Similarly profit (defined as gross margin less fixed costs and depreciation) is an artificial construct designed to isolate the annual components of business performance but does not include either capital expenditure or personal drawings. These two items together total approximately 20% of total costs of a typical farm (Beever and McCarthy 2003) and together constitute most of the reason that farm businesses operate, which is to earn a living for the farm family, and maintaining the asset base by investment. Both earnings and investment are capital items; ignoring these costs ignores the *raison d-etre* of farm business.

Profit includes depreciation, which is a measure of the decline in the value of assets (usually machinery and infrastructure) with age. However the cost of replacing assets increases with time so that the calculated depreciation usually underestimates the capital cost of replacing farm assets, especially as most farm assets are replaced only slowly (Farmfacts 1991). For these reasons, profit, as defined by the Australian Taxation Department and by ABARE (Australian Bureau of Agriculture and Resource Economics) significantly under-estimates farm expenditure (ABARE 2009) and over-estimates farm financial performance. A study of the financial performance of livestock farms in southern Australia commissioned by MLA (Meat and Livestock Australia) (Goldberg 2008) showed that more than 75% of all producers averaged a negative profit in the five years to 2007, which means that even more farms would have reported a negative cash flow from their farm operations. This is confirmed by the National Australia Bank database of 8,000 farms, which shows that most dryland farmers in eastern Australia generated negative cash flows from their farming operations in the five-year period to 2007. This is not commonly appreciated because most economic analyses report only gross margins or profit, and so underestimate the total costs of running a farm in this region.

Figure 1 is a systems flowchart which links the disciplinary base of farm management with the appropriate key performance indicators (KPI). The chart outlines the small region of the whole dealt with by gross margins analysis; only net worth analysis reports on the individual whole-farm business operation.

Figure 1: The farm management process
Links beween production and wealth creation on farms
Note: Weighting of arrows represents current research emphasis in agriculture.



Farm managers view management as a process; that is a continuous sequence of events linking the effective rainfall to net worth, in which every change occurs as the *consequence* of a preceding change or decision either in the current period or previous periods (McCarthy and Thompson 2007; Schultz 1939; Thompson et al. 1996). Modellers also rely on this causal chain; dynamic modelling would not be possible without this assumption (Cahane 2008). McCown (2001) also recognised that modelling the '*substantive congruity of the process* [of farm management] *has the potential to replace the more theoretical approaches*'. The flow of information in Figure 1 reflects the key concept of consequence or process which is the basis of management decision-making and simulation (Albright and Winston 2005; Antle and Capalbo 2001; Schultz 1939) .

There are two major classifications of decisions represented in Figure 1. Strategic decisions are those which relate to the whole farm and one or more whole production cycles; they therefore are decisions which include all the relevant information available, and because they are made over time, must include variability. These long-term decisions are the most critical for the farm management process (Just 2002). Each key step requiring a strategic (or investment) decision in this process occurs at the junction of two or more disciplinary areas in this schematic; from rainfall to production, from production to finance and from financial output to asset growth. Decision-making at these disciplinary interfaces sets the form of the production, marketing and investment plans and is the key task of management. These interdisciplinary areas are the least understood and require the most judgement (Bamberry et al. 1997; Hardaker et al. 1998; Martin and Woodford 2003).

Strategic decisions such as these can be influenced by concepts of optimum or best practice management, modified by the influence of previous periods, in areas such as affordability, debt, technical and biological limitations to productive capacity. The production, marketing and investment plans chosen by the farmer will depend on his knowledge of these factors, together with his experience, preferences, prejudices and attitude to risk (Vanclay 2004). The outcome of these strategic decisions is measured by changes in the net worth of the whole business (Boehlje 1999).

These critical strategic imperatives are supported by on-going tactical decisions. These constitute the second decision type, which Schultz (1939) terms ‘adjustments’. These adjustments are short-term and re-active during the span of the production process, depending on the scale of the necessary adjustment. They are responses made by management to minimise or recover from the effects of unplanned variability. As shown in Figure 1 they mostly take place within the distinct disciplinary areas and relate to individual units of production, finance or investment within those areas. The results of these tactical responses are measured by a range of short-term or annual key production indicators (KPI). Unlike the strategic benchmarks these tactical benchmarks do not include any measure of time or variability; they relate only to the discipline and year of the response and often include only partial financial analysis. These benchmarks include yield, gross margins, profit and business equity and have provided the historical focus for most agricultural economics research (Beever and McCarthy 2003).

Taken together, these tactical and strategic decision criteria show that a more complex and dynamic modelling system is needed to simulate the process of farming than has often been applied. They assume that a single optimum solution cannot be calculated because of the uncertainty of the future input values, and instead the ideal analysis should produce a range of feasible alternative outcomes from which the manager can choose (Bellotti 2008; Janssen and Ittersum 2007; Malcolm 2004b; Miller et al. 1998). This approach is justified because farmers have disparate goals which change over time (Harwood et al. 1999; Hayman 2004; McCarthy and Thompson 2007) which are influenced by the profitability of their business (Hardaker et al. 1998; Jones et al. 2006; Malcolm 2004b; Mishra et al. 1999; Parton and Cumming 1990) and their experience (Bamberry et al. 1997; Dunn et al. 2001; Nguyen et al. 2004; Vanclay 2004). Farmers can then choose the level of risk which can be tolerated (Boehlje et al. 2000; McCarthy and Thompson 2007). Replacing this range of outcomes with a risk-adjusted optimum solution, as is usually done in economic decision analysis, removes the suitability of the outcome to many of the target audience whilst providing little additional benefit (Lien 2003; Pannell et al. 2000).

For all these reasons this paper uses long-term, whole-farm, financial modelling to re-examine the results of a long-term farming systems trial at Wagga Wagga in southern NSW. Whole-farm cash flow results developed in the present analysis are compared with gross margins from this study and with those from a recent study of the same trial (Li et al. 2010).

Methods

Trial description

The MASTER trial (Managing Acid Soils Through Efficient Rotations) was a large and comprehensive farming system experiment designed to test the impact of liming and perennial pastures on grazing and mixed cropping farming systems. The experiment was purposely sited on some of the most acid soils in the Wagga Wagga area in order to test whether these soils could be improved over time. It must be emphasised that the aim of the trial was to evaluate the long-term effects on soil regeneration under a range of representative farming systems; the opportunity for a full financial analysis of these systems was a secondary benefit. In brief the trial incorporated the following replicated treatments:

Table 1: MASTER trial outline

		Rotation	
Code	**Treament**	**Initial (high lime rate)**	**Stable (maintenance lime rate)**
		1992-1997	1998-2003
APN	Annual pasture, no lime	Annual pasture (AP)	Annual pasture
APY	Annual pasture, lime	Annual pasture	Annual pasture
PPN	Perennial pasture, no lime	Phalaris+cocksfoot + lucerne + sub (PP)	PP
PPY	Perennial pasture, lime	PP	PP
APCN	Annual pasture + crop, no lime	AP/wheat (W)	AP/wheat
APCY	Annual pasture, cropped, lime	AP/wheat (W)	AP/wheat
PPCN	Perennial pasture + crop, no lime	PP/PP/PP/triticale/lupins/wheat	PP/PP/PP/canola/lupins/wheat
PPCY	Perennial pasture + crop, lime	PP/PP/PP/triticale/lupins/wheat	PP/PP/PP/canola/lupins/wheat

Source: Li et al (2010)

The trial was unique in that each phase of each six-year rotation existed every year, enabling a full financial analysis over 12 years. Treatments over the initial six-year period were designed to rapidly reverse the high soil acidity in the site, with lime applications of more than three tonnes per hectare being applied once in this time. An acid-tolerant crop rotation (Table 1) was used in this period. From 1998 to 2003 (referred to as the stable period) lime rates were reduced to approximately 1.5 tonnes per hectare, and canola was introduced into the rotation. Li *et al* (2010) contains a full description of the trial and all results.

Business structure of the model farming systems

Both the original study (Li et al. 2010) and this re-analysis aimed to place these results into the context of a simulated district farm. The essential difference lies in the scope of the financial analysis. Li and his co-authors extended a gross margin analysis of 12 years of trial results to 24 years, and summarised the results as a discounted average for each treatment (farming system) for a farm running 1000 Merino wethers. They then calculated the number of years required to reach break-even gross margin on an accumulated basis.

The present study uses the methods described in Hutchings (2008) to produce both average full-treatment gross margins and accumulated cash flow for the 12-year period of the trial based on a prime lamb enterprise for the grazing component. These results were superimposed on the fixed and capital cost structures of a representative owner-operated district farm of 800 hectares, where these costs were adjusted to reflect the changes in costs and machinery which would be associated with each farming system being trialled.

Capital structure

Land is valued at $3,700/hectare ($1,500/acre) and the infrastructure assumed to be adequate for each farming system. Machinery inventory is adjusted to cope with the cropping enterprises (Table 2) based on realistic clearing sale value for good equipment. Ignoring this difference in inventory value would skew the analysis in favour of the cropping enterprises; it would also ignore the considerable complementarity between the machinery needs of the cropping and grazing enterprises.

Liabilities are adjusted to give opening equities of 80% for the grazing enterprises, and 70% for those which include cropping. This assumption is supported by the NAB database, and reflects the accumulated riskiness of the cropping alternatives. Including this assumption therefore makes the model farms more representative of the farm population.

Table 2: Machinery inventory

ITEM	Grazing	Grazing + Cropping
Tractor	$0	**$8,000**
Tractor	$8,000	**$45,000**
Air Seeder	$8,000	**$45,000**
Augers	$8,400	$8,400
Bins x 3	$0	$3,400
Spray Unit	$8,000	**$12,000**
Grouper	$0	$8,000
Trucks	$0	**$12,000**
Cultivator	$12,000	**$20,000**
Sundry Plant	$4,000	$4,000
Motor Bike	$3,200	$3,200
4x4 Utility XTU 517	$12,000	$12,000
Silos	$14,000	$14,000
Ford Mondeo	$18,000	$18,000
Woolpress	$6,000	**$0** [1]
Shearing and sheep	$4,000	**$2,400**
Workshop	$4,000	**$6,000**
Office	$4,200	$4,200
Total value	**$113,800**	**$225,600**
Annual depreciation at 12% p.a.	$13,656	$27,072

[1] Woolpress supplied by contractor

NB Differences are shown in **bold** type

The cost structure of each treatment has three components: variable, fixed and capital costs. These are shown in Table 3; note that all cost components vary between treatments; any analysis which does not allow for this broad-spectrum variation in total costs, such as gross margin analysis, cannot claim to represent the full treatment effects in this trial.

Table 3: Cost structures

COST OF PRODUCTION $/HA (Stable production period)								
Average of 3 year budget projections	**APN**	**APY**	**PPN**	**PPY**	**APCN**	**APCY**	**PPCN**	**PPCY**
Area utilised	720	720	720	720	720	720	720	720
Crop & Pasture Costs								
Chemical	11	11	42	42	26	26	43	42
Contract		19		19	7	16	5	25
Crop Insurance					4	8	2	3
Fertiliser & Lime	147	220	147	220	147	183	147	183
Seed							16	16
Supplies & Grain Purchased								
Other								
Total crop costs	158	250	189	281	183	232	213	270
Livestock Costs								
Fodder	3	8	117	9	42	4	2	4
Animal Health & Veterinary	20	22	22	24	8	11	7	10
Freight								
Purchases	176	218	198	217	83	108	69	105
Shearing & Crutching	24	25	25	28	9	12	8	12
Other								
Total sheep costs	224	273	362	278	143	135	86	131
Total variable costs	382	522	551	558	326	367	299	401
Fixed Costs								
Machinery (incl. depreciation)	40	40	40	40	78	78	78	78
Labour	6	6	6	6	6	6	6	6
Overheads	39	39	39	39	39	39	39	39
Interest	93	73	50	68	172	145	53	155
Total fixed costs	180	159	136	154	295	269	177	278
Capital Costs								
Drawings + Tax *	96	103	101	106	43	66	46	61
Loan repayments								
Net capital purchases	21	21	21	21	41	41	41	41
Total capital costs	117	124	122	127	84	107	87	102
Total Costs (including depreciation)	**678**	**805**	**808**	**839**	**706**	**743**	**563**	**781**
Less depreciation	19	19	19	19	38	38	38	38
Cost of production per hectare	**659**	**785**	**789**	**820**	**667**	**705**	**525**	**743**

* *Note that income tax can be positive or negative, and this affects the standard living costs of $55,000 p.a.*

1. Physical production

In all cases trial crop yields were used in the analysis.

Livestock numbers in the present study were adjusted to maintain a constant flock size over time for each treatment to equal 90% of the six- year average trial stocking rates on a dry sheep equivalent (DSE) basis (Table 4). The 10% reduction was made to allow for inevitable inefficiencies of managing large numbers over a large area. This mirrors normal farmer practice in deciding the size of the breeding flock, which tend to change only slowly over time. The ewe numbers were set separately for the initial six years establishment period and for the final six years of stable production. An allowance was also made for the value of grazing crops. Whilst this was not a feature of the original trial results it is now accepted practice in the area and allows an additional 1-2 dse/ha/yr on most mixed farms (Hutchings 2009; Kirkegaard et al. 2008; Saul and Kearney 2009).

Table 4: Breeding ewe numbers

Ewe numbers	Initial	Stable	% increase	Av. Effect of crop
APN	3412	5035	48%	
APY	4686	7340	57%	
PPN	3200	4437	39%	
PPY	4822	5889	22%	
APCN	1417	1731	22%	-31%
APCY	1595	2038	28%	-35%
PPCN	1948	1994	2%	-24%
PPCY	2658	2347	-12%	-27%

The number of breeding ewes, calculated on this basis, increased in all treatments with the application of lime in both the initial and stable production periods; in other words the lime showed an immediate effect which increased with time. Even without lime, carrying capacity increased significantly over time, due to the fact that there were three years of low rainfall in the initial period compared with only one in the stable period. Interestingly, based on the average trial stocking rates for each treatment period, the annual pastures carried more sheep than the perennials; this may reflect differences in pasture composition with resulting quality differences, or even a lack of summer rain to promote summer and autumn growth of the perennials. The lower stocking rates for the cropping treatments reflect the point that only 50% of the was area grazed each year, although this was augmented with an estimated contribution from grazing crops. A calculation of the average reduction in the number of ewes carried per hectare between the various grazing treatments and their cropped equivalents (eg comparing APY with APCY)(Table 3) showed that the stocking rate in the annual pastures was reduced by more than 30%, and the reduction due to cropping perennial pastures averaged approximately 25%.

Wool production per head was adjusted to 75% of the trial results, which gives wool production per head consistent with expected values for crossbred ewes. This wool was priced at a constant $2.65/kg, typical of meat sheep fleece values.

Variable costs

a. *Sheep*

These costs varied between $86/ha and $362/ha (Table 3). Surprisingly the grazing treatments had variable costs higher than cropping, mostly due to the cost of purchasing 18-month old Merino x Border Leicester ewes, which were priced at twice the sale price of the older ewes they replaced, a rule of thumb which approximates saleyard values. In general the sheep costs per hectare were determined by the stocking rate, as the individual cost per head, before fodder costs, was identical for all treatments.

Fodder costs were calculated on a per head basis, allowing for the increased requirements in pregnancy at a weaning percentage of 125%. These costs were calculated using the trial data for the number of days sheep were removed from the trial to prevent overgrazing, which is a surrogate for the need for supplementary feeding. Ewes were fed a maintenance ration (adjusted for stage of pregnancy in the autumn period) of 0.95 kg/head/day of 2:1 triticale:lupin ration which was priced at the same value as grain sold from the farm.

b. *Crop*

Crop variable costs ranged from $158/hectare to $281/hectare, including all the fertiliser, lime, seed and weed control costs associated with the pasture (Table 3). If this is allowed the variable cost of cropping was considerably less than grazing, due to the cost of purchasing and feeding sheep.

Crop chemical costs were calculated individually to reflect the weed burden evident on recent inspection. *Vulpia spp*., capeweed and annual ryegrass were the dominant species. As a result these costs varied from the original analysis, especially as the current costing included fungicides to control leaf and root diseases in the crops. In most cases Li *et al* (2010) assumed lower values for these costs.

Fertiliser costs were again set by the trial inputs. These costs included high (15kg/ha) rates of elemental P, and similar amounts of potassium (K). This resulted in a standard application on all treatments every year costing $138/ha at current values, three times the normal fertiliser cost of $45/ha for farms with less acidic subsoils in the district (which do not apply K).

Current lime costs of $70/ha spread were used; once again this site required higher than normal levels as part of the treatment design.

Perennial pasture seed was priced at $110/ha. This is a substantial cost, which had to be met every three years on the PPC treatments. Crop insurance was charged at $2.40/$1000 earned, which is the 80% of the current district rate.

2. *Fixed costs*

Fixed costs varied between $136/ha and $295/ha, largely due to variation in the interest charged on debt. This range of 217% was greater than the range in variable costs (208%), supporting the need to include fixed costs in the analysis.

The machinery costs included fuel, repairs and depreciation. Fuel costs were set at $11,000 for grazing enterprises, rising to $18,000 for cropping treatments. This mirrors local experience, and includes the cost of private transport. Repair costs were set at 6% of the capital value of the machinery (Beever and McCarthy 2003). Depreciation was calculated at an annual rate of 12% of machinery value. In this analysis this cost was paid every year, which is a prerequisite of financial sustainability; this payment also causes the cost of capital replacement to appear in the cash flow and net worth calculations.

An annual allowance of $5,000 was made for casual labour to cover peak demand periods, and holiday caretaking.

3. *Capital costs*

Capital costs include personal costs, income tax, loan repayments and capital purchases. Capital costs varied from $84/ha to $150/ha between treatments, again varying sufficiently to justify their inclusion in any comparative analysis.

Personal costs were set at $55,000 per annum, which is typical of the values used by consultants in regional budgets. This cost can be varied by personal income tax, which can be a credit or debit, depending on the profit or losses made by the farm. Income tax was calculated at an annual rate of 21% (Beever and McCarthy 2003).

4. Cost of production (COP).

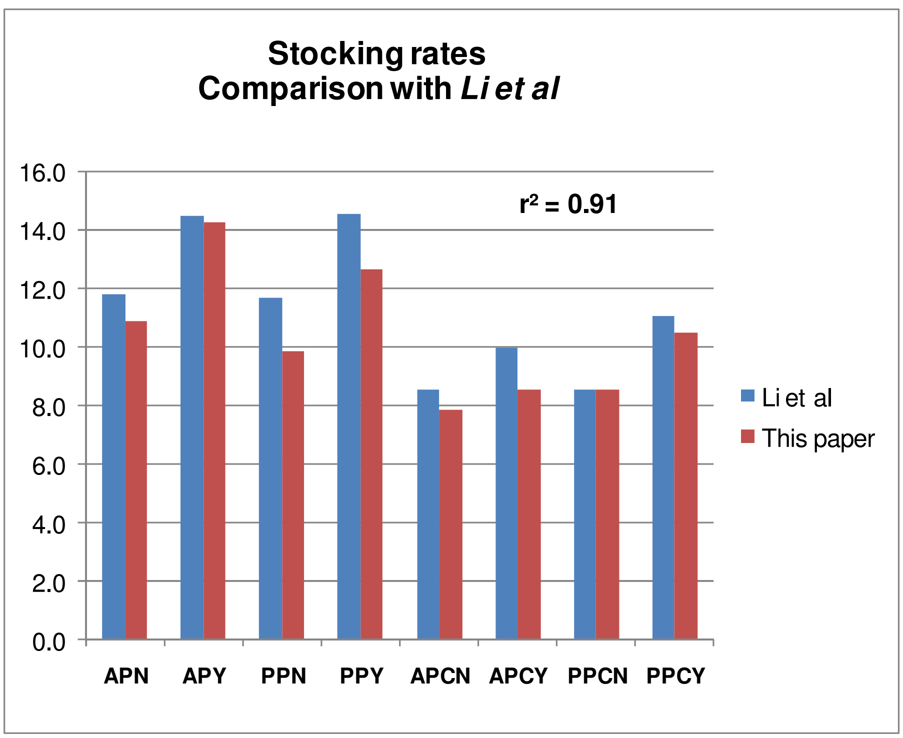
COP varied from $525/ha to $820/ha, a range of $295/ha (Table 3). The correlation between variable costs and total costs was not statistically significant (r^2=0.64, p>20%). This confirms the need for whole-farm analysis in comparing system treatment effects such as in this trial.

These COP figures are higher than district norms. However when adjusted for the additional cost of K fertiliser mentioned above they are typical of farms of this size in the Wagga area (Hutchings 2008).

Results and discussion

There is a tendency for the present study to show lower stocking rates than Li *et al* (2010), because the present study models the size of the breeding flock at 90% of the six-year average treatment stocking rate (Figure 2). There is good agreement between the stocking rates used in the two papers (r^2= 0.91).

Figure 2: Comparison of stocking rates with *Li et al* (2010)



A full comparison of treatment gross margins between the current study and that of Li *et al* (2010) is difficult, because the analyses were based on different sheep enterprises and used different costs. However the rankings on treatment gross margins calculated by Li et al (2010) and the current study show broad agreement (Table 5). The gross margin values reported by Li *et al* are consistently lower because of the lower margins for wool production compared with the prime lamb enterprise used in the current study.

Table 5: Comparison of gross margins from Li *et al* (2010) and the current study for the stable production period.

	Average gross margin $/ha			Rank on gross margin	
Treatment	Li et al[1]	This paper	Difference	Li et al	This paper
PPN	$111	$487	$376	3	1
PPY	$151	$387	$236	1	2
APY	$148	$370	$222	2	3
APN	$107	$341	$234	4	4
PPCY	$91	$176	$85	5	5
APCY	$71	$174	$103	6	6
APCN	$51	$91	$40	8	7
PPCN	$52	-$14	-$66	7	8

[1]Source: Li et al (2010)

Because of the complex financial interactions between enterprises at the variable, fixed and capital cost level, it was not possible, in this study, to separate the average long-term gross margins or cash margins into their individual enterprise components (ie individual crop and livestock gross margins). Figures 3 and 4 therefore show the average margins for both financial measures for the simulated whole-farm accounts built around each treatment.

a. *Gross margins*

Whole-farm gross margins varied from -$14/ha (PPCN) to $406/ha (PPN). The gross margins for each treatment reflect the expected agronomic lime response; that is annual pastures are less constrained by low pH than perennial pastures (Fig. 3). Thus these results confirm the analysis of Li *et al* (2010) and show that, at the gross margin level, all treatments, except annual pasture, more than paid for the lime applied during the stable production period. The annual pasture treatment did not respond sufficiently to cover the cost of liming every sixth year. The reason for the lack of response in the annual pasture in the stable period may be partly due to a carryover effect from the high applications in the initial production period.

This analysis shows that, in this trial, the cash margins from grazing were reduced by the inclusion of cropping enterprises. This result is unexpected and is due to the following factors:

1. The crop yields were low in the experiment, as measured by the potential water-use efficiency (WUE) (Passioura 2004). The WUE for all crops in the trial averaged only 35% (Table 6). The acidic subsoils, lack of nitrogen fertiliser, and summer weed control may have contributed to this difference; however these yields are above average for farms with acidic subsoils (Li, pers.comm.), but well below the 75% WUE expected on less acidic soils in the area.

Table 6: Observed and potential water-use efficiencies (WUE)

Crop	Treatment	Observed WUE kg/mm	Potential WUE kg/mm	% potential
Wheat	APCN	4.3	20.0	21%
	APCY	8.6	20.0	43%
Oats	PPCN	5.1	16.0	32%
	PPCY	6.3	16.0	39%
Triticale	PPCN	6.4	18.0	36%
	PPCY	9.2	18.0	51%
Peas	PPCN	1.1	12.0	9%
	PPCY	2.7	12.0	23%
Lupins	PPCN	4.3	10.0	43%
	PPCY	4.7	10.0	47%
Canola	PPCN	3.4	10.0	34%
	PPCY	4.5	10.0	45%
Wheat	PPCN	4.4	20.0	22%
	PPCY	9.4	20.0	47%
			Average	35%

2. The stocking rates achieved in the cropped treatments were consistently lower than for the pasture treatments, which may be due to the agronomic and financial consequences of regular pasture re-establishment (Table 4).

Figure 3: Average six-year gross margins for all treatments, stable production period

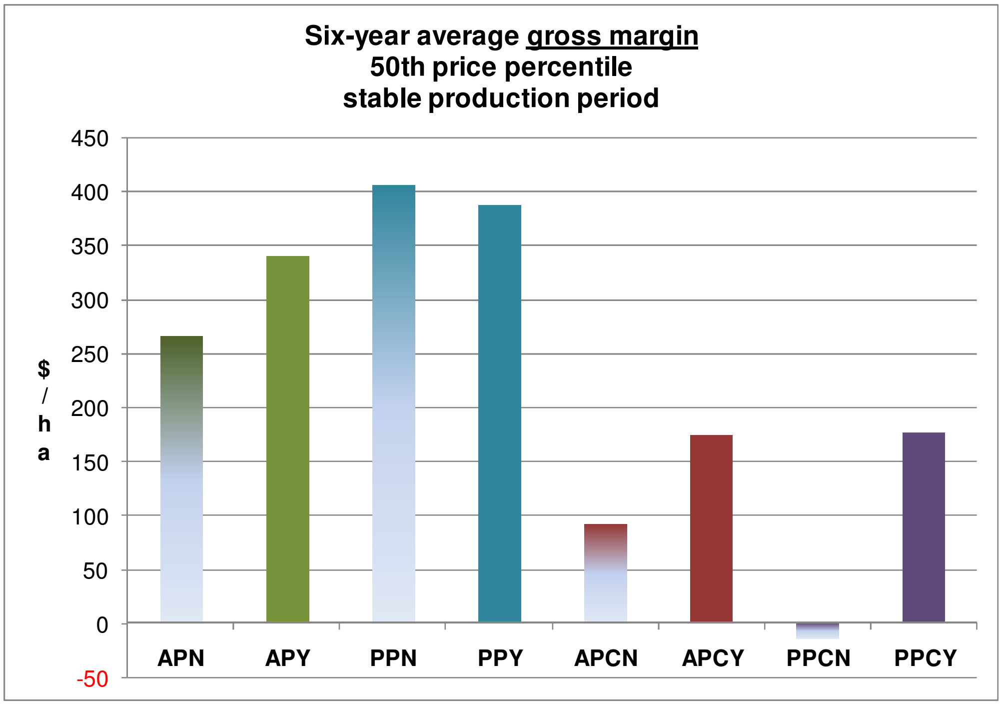
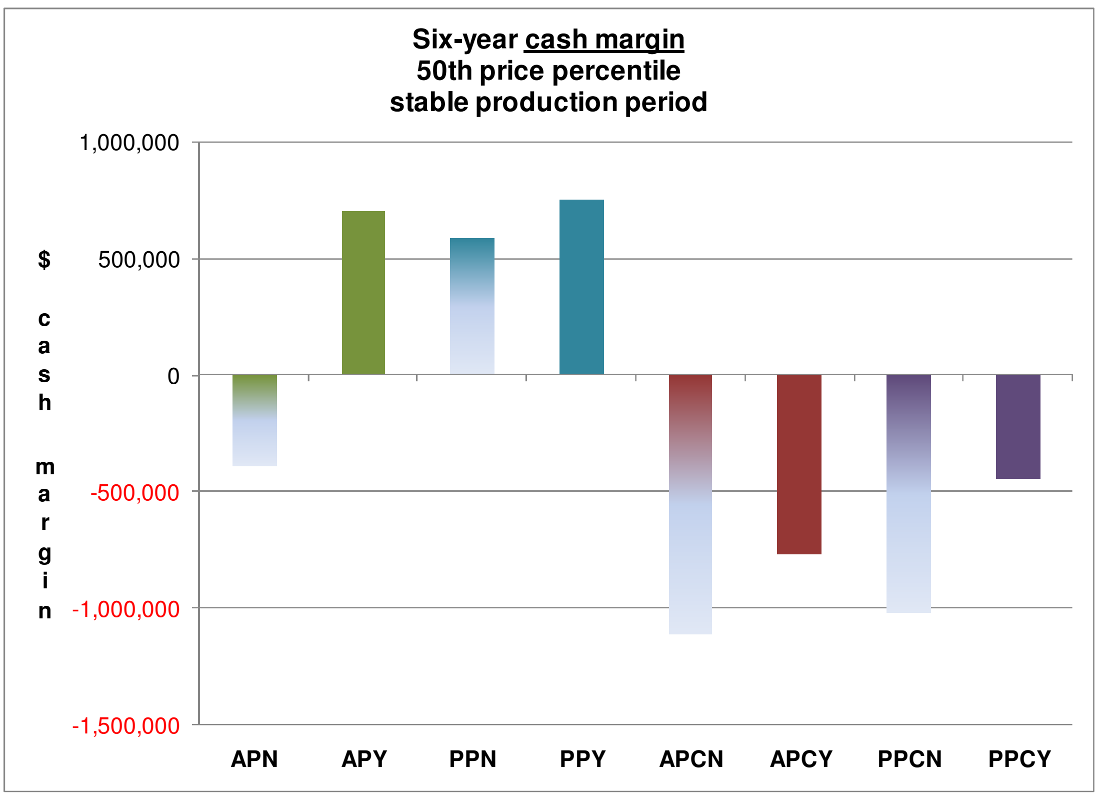
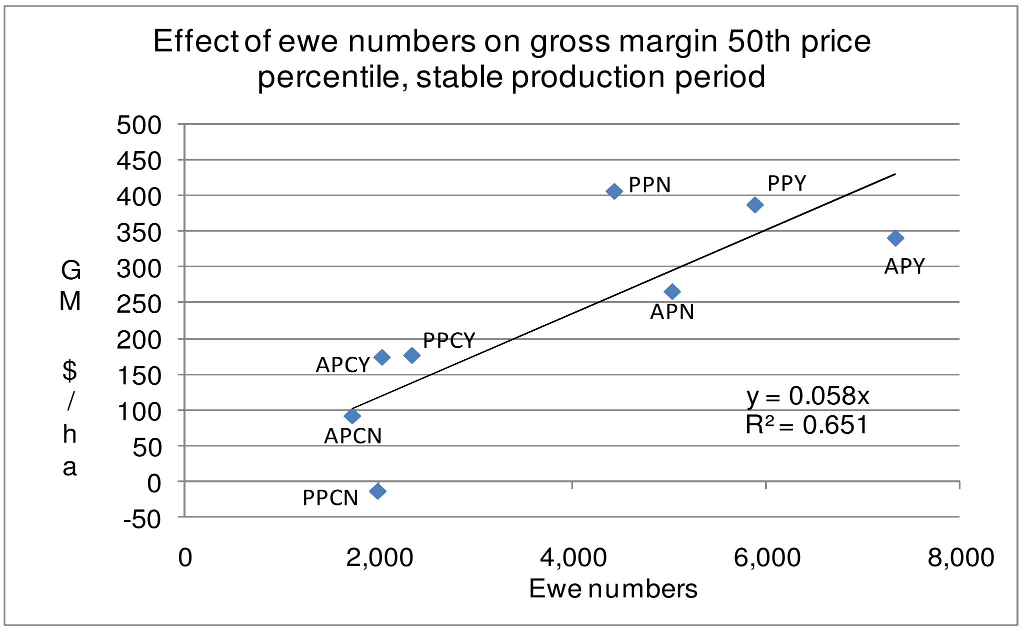


Figure 4: Six-year cash margin, 50th price percentile, stable production period



3. The over-riding cause of the higher margins in the grazed treatments is due to the relatively high gross margins produced by the prime lamb enterprise compared with cropping. This is best illustrated by the fact that the gross margin for all treatments is reasonably well correlated with the total ewe numbers (Fig. 5) determined by the trial results for each treatment. This correlation (r^2=0.65) is surprising given the fact that these gross margins also include the variability arising from seasonal effects, different crop rotations (Table 1) and yields, different pastures and the effect of cropping on stocking rates (Table 4). This level of fit would indicate that the crop enterprises contributed very little to the gross margin during the stable production period.

Figure 5: Effect of ewe numbers on average treatment gross margins



Cash margins

Cash margins are defined as the difference between closing and opening cash balances over the measurement period.

The relative ranking of the various treatments, measured by whole-farm, long-term cash margin, was similar to the gross margin results (Fig. 4). Broadly all grazing-only treatments showed positive cash margins and all cropped treatments showed negative cash margins, for the reasons discussed. All treatments except annual pasture (APN & APY) showed that the increase in performance due to liming more than paid for the cost of applying that lime. The lack of lime response in annual pastures is probably due to the fact that annual pastures are more tolerant of acid soils (Li et al 2010) and also possibly influenced by the carry-over effect of the lime applied during the initial six-year period of the trial.

The most significant difference between gross margin analysis and cumulative whole-farm cash flows was the size of the cash losses sustained by the cropped treatments, which totalled more than $1 million for the APCN and PPCN treatments. In other words, given the low experimental yields, cropping income did not cover the cost of production, even though the cost of production for the cropped treatments was less than for the grazed treatments (Table 3). The reason for the losses must therefore be the lower productivity achieved by the cropped treatments, including reductions in stocking rates, as indicated in Table 4.

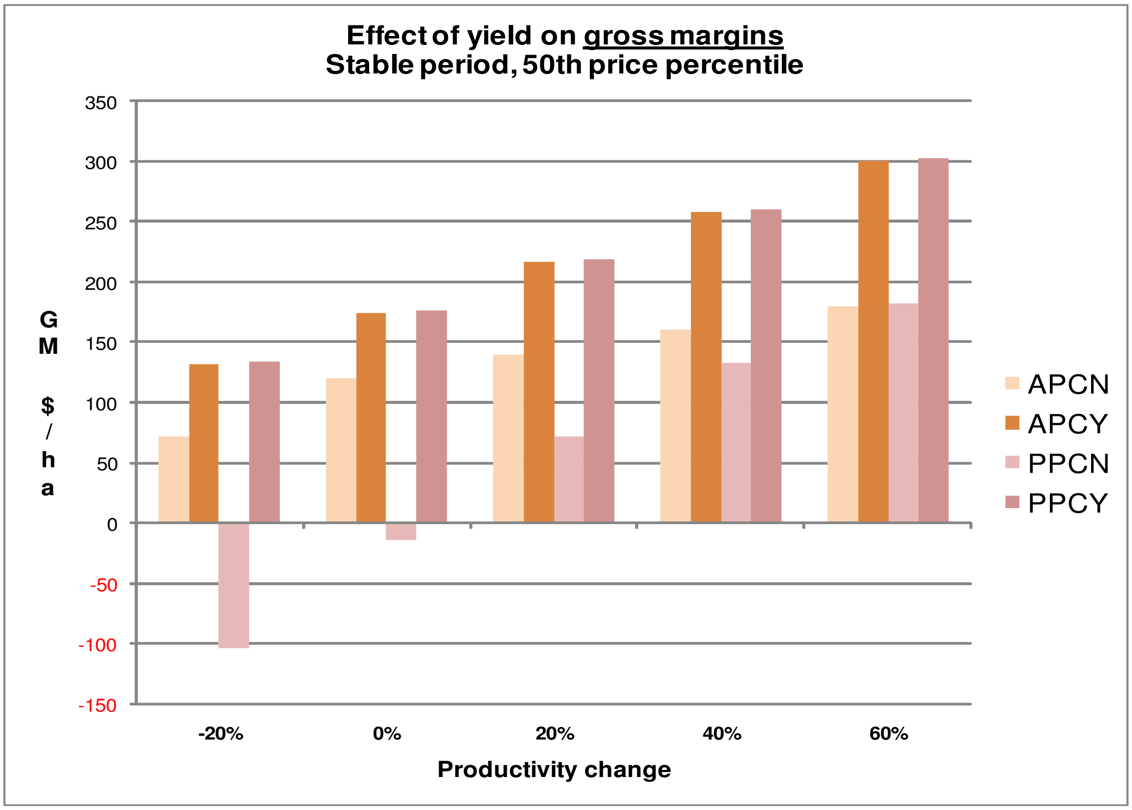
Another notable difference between the treatment rankings on cash margin, compared with gross margins, is the fact that the annual pasture treatments generated a higher cash margin than the perennial pastures. This reflects the lower cost of production (Table 3) of the annual pasture-only treatments (APN & APY). Conversely in the cropped treatments the limed treatments (APCY and PPCY) out-performed the un-limed treatments (APCN and PPCN), an outcome which must reflect a higher productivity in the limed systems, and include the observation (Table 4) that the annual pasture productivity seemed to be more affected by the alternate-year cropping regime (APCN and APCY) than the perennial systems (PPCN and PPCY) where the perennial pasture was maintained for 3 years (Table 1) between cropping phases of the rotation.

Sensitivity analysis

A sensitivity analysis was run incrementing experimental crop yields from -20% to +60%. Ewe numbers were not varied, because the stocking rate for most treatments is already above district norms (Hutchings 2009) and further increases were not considered feasible.

Increasing yields for the cropped treatments generated a significant increase in gross margins. Increases of 60% in crop yields are realistic for farms without subsoil acidity constraints and are necessary to produce yields which are consistent with those achieved by farmers in the region (Hutchings 2009). An increase of 60% in yields increases the wheat yields from less than 3 t/ha to more representative district yields averaging above 4 t/ha. This increase gave gross margins typical for the region (Fig. 6) but still not sufficient to produce positive cash surpluses for any treatment (Fig. 7).

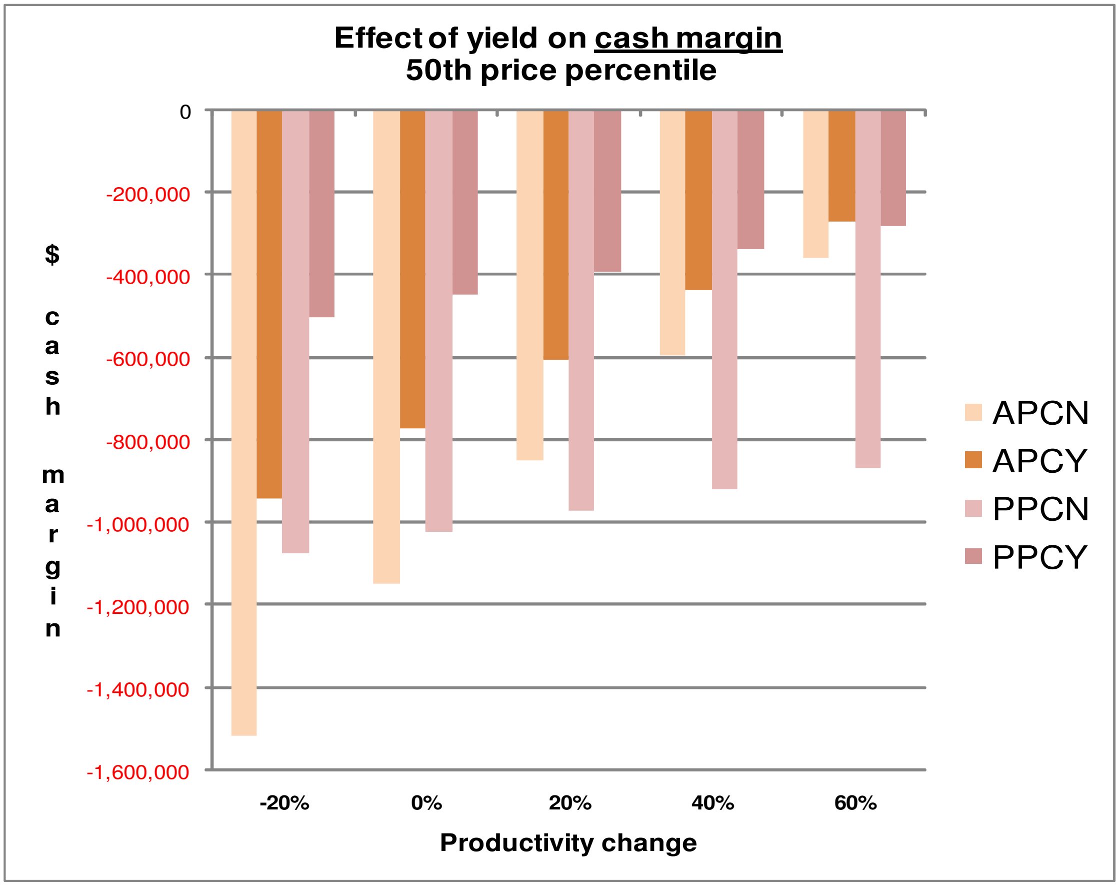
Figure 6: Effect of changing crop yields on treatment gross margins, stable production period



$/ha gross margins 50th percentile prices, stable period

	-20%	0%	20%	40%	60%
APCN	72	120	140	160	180
APCY	131	174	216	259	301
PPCN	-103	-14	72	133	182
PPCY	134	176	219	261	303

Figure 7: Effect of changing crop yields on cash margins, stable production period



$ Cash margin 50th percentile prices, stable period

	-20%	0%	20%	40%	60%
APCN	-1,513,896	-1,148,261	-847,007	-594,844	-356,843
APCY	-938,987	-771,399	-603,968	-436,537	-269,106
PPCN	-1,074,151	-1,022,430	-970,766	-919,102	-867,437
PPCY	-503,186	-447,519	-391,852	-336,185	-280,519

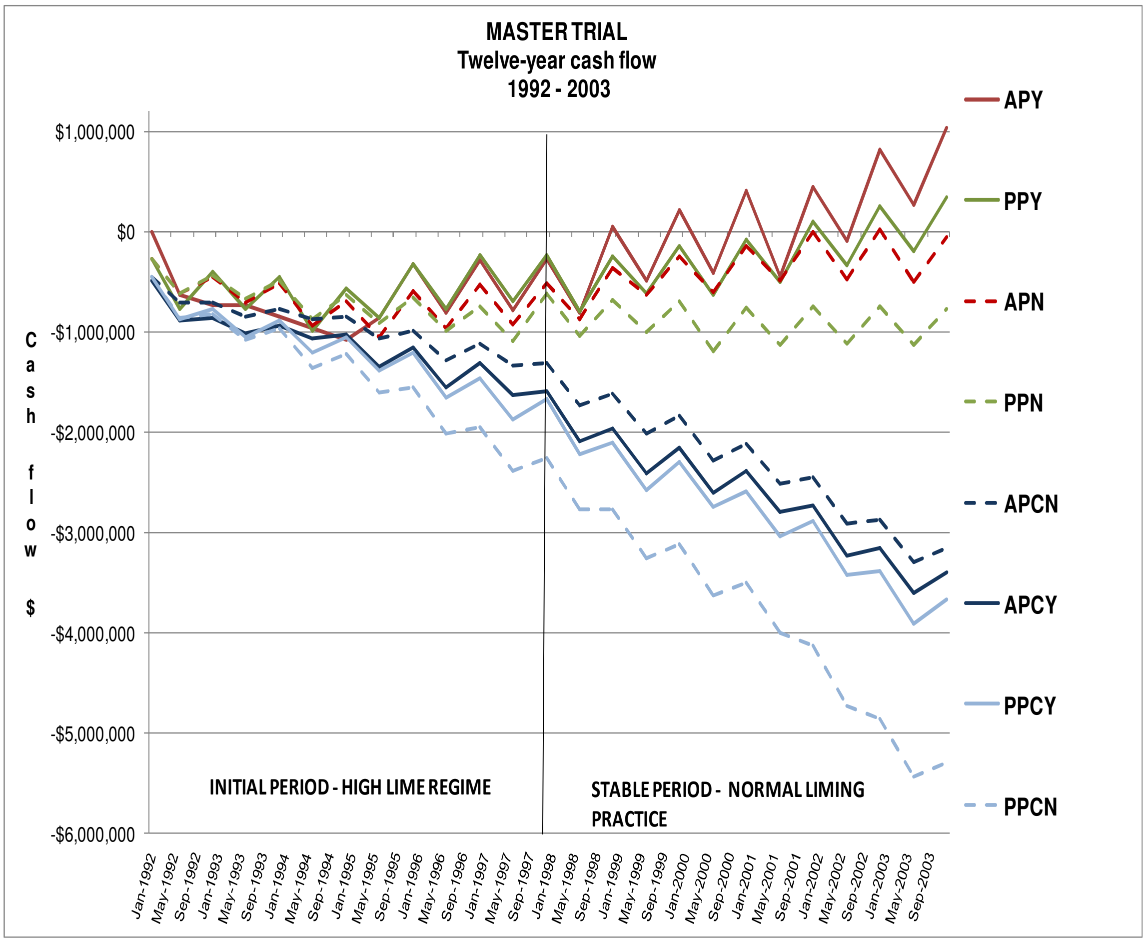
The accumulated losses for the cropped treatments (Fig. 7) were greater for the un-limed treatments (APCN and PPCN). The rate of reduction in these losses varied between the treatments, with the annual treatments improving more rapidly than the perennial treatments due to the higher costs associated with re-sowing perennial pastures, and the slightly lower stocking rates of the perennial systems.

If correct this conclusion questions the viability and feasibility of all these treatments, when applied to farm operations. This is best examined by inspecting the long-term cash flows for the period of the trial.

Long-term cash flows

Figure 8 shows the calculated cash flows for the various treatments for the twelve-year duration of the MASTER trial. This confirms the rankings discussed above, and in addition shows the differences between the initial and stable production periods. This difference is exacerbated by the fact that the sheep numbers were only recalculated in the transition year (1998).

Figure 8: Twelve-year cumulative monthly cash flow for MASTER trial, 50th price percentile



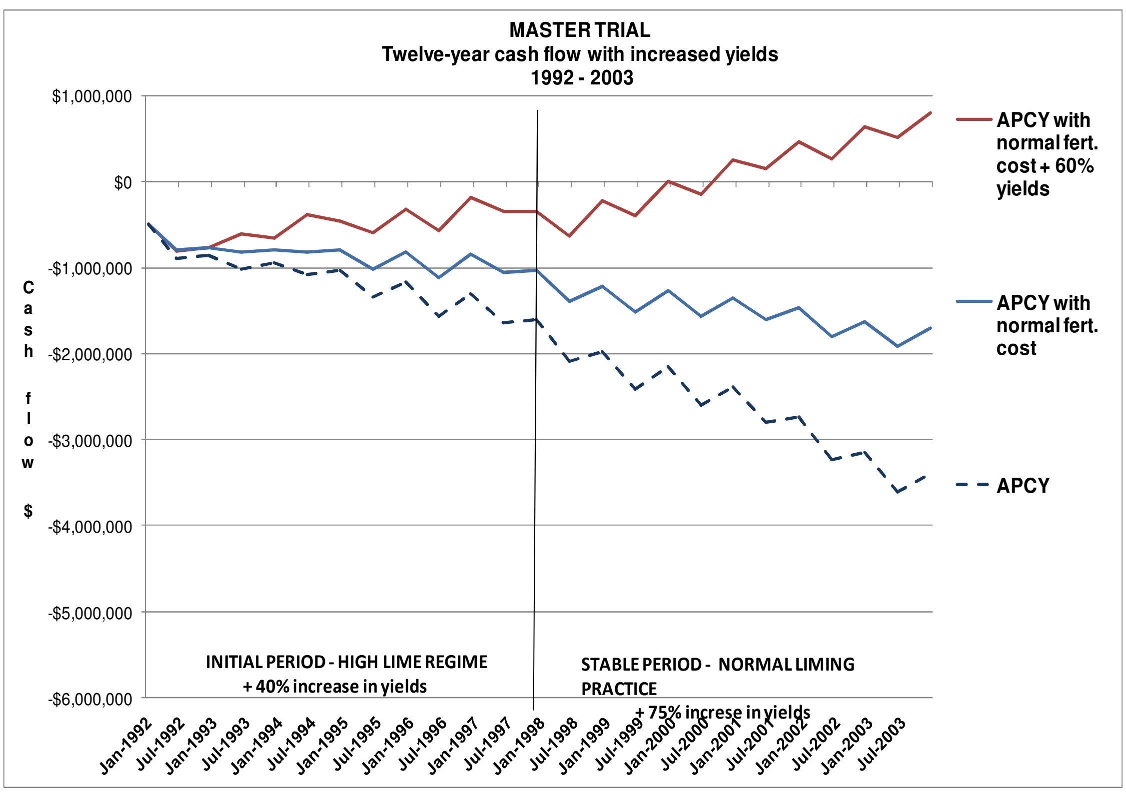
These trends confirm the treatment rankings on cash margin discussed above; they also show the significant increase in overall debt for all treatments during the initial period. Even the grazing treatments, which show positive cash margins over the entire period, would have accumulated additional debt in the vicinity of $1 million in the first three years of the trial. It is significant that this severe limitation to the commercial operations of the simulated farms only became apparent following long-term, whole-farm financial trend analysis.

This level of debt would reduce the business equity to less than 55% of assets for the grazing treatments, a level below the normal lending criteria of most banks (Hutchings 2009). The cropping treatments accumulated debt continuously and exponentially during the entire period of the trial, and would not have been commercially viable as a result. This result is not altered by increasing the yields by 60% (Figure 7), which equates to district norms.

Reconciliation with current farm practice

This result would seem to question the viability of the most common farming systems in the region, represented by the APCY treatment. However most farms in the area have already limed most paddocks at a lower, but still effective, rate than used in the MASTER trial Furthermore most farms do not need, at present, to apply potassium as fertiliser, so that their fertiliser costs would decrease from $138/ha to $45/ha at current prices. Furthermore farms without acidic subsoil constraints achieve 75% WUE (Hutchings 2009), which would approximately double the yields achieved in this trial.

Figure 9: Twelve-year cumulative monthly cash flows adjusted to regional practice



These adjustments are shown incrementally in Figure 9, printed on the same scale as Figure 8 to facilitate comparison. This graph suggests that the normal practice in the region is viable and capable of generating positive cash flows once the cost of the initial lime applications have been absorbed. Furthermore the farm debt increase is supportable over the entire period at average prices and stocking rates, and including actual climatic variability. This result supports current practice in the region and shows that this farming system (annual pasture/wheat) is viable in the long term. It also demonstrates the danger of interpreting trial results without a proper understanding of the physical and financial limitations faced by farm managers in the area.

Conclusion

The present study confirms the analyses of Li et al (2010), showing a similar ranking of the positive gross margin responses to lime applications for all except the annual pasture treatments (APY). However this response, when scaled up to an average 800 ha farm, did not lead to profitable responses for the cropped treatments, which in fact accumulated large and unsustainable losses over the trial period. This outcome demonstrates that gross margins alone, by failing to count all the costs, can lead to erroneous perspectives on the viability of different farming systems.

Gross margins only account for an average 60% of total costs; Table 3 shows that the fixed and capital costs also vary substantially for each production system. Any analysis comparing farming systems will therefore be misleading if it does not include the individual cost of production of each system being studied. These costs must include capital costs, which in this study are mostly greater than the cash margin, and are therefore sufficient to eliminate any cash operating surplus. Cash flow is therefore the only adequate indicator of small business (or farm) performance, because it is the only measure which includes the living costs of the owner-operator, and the cost of maintaining the productive asset. Cash flow is the only measure which describes the viability, resilience and sustainability of the business over time.

Analyses which concentrate purely on costing production (ie gross margin analysis), without undertaking full financial analysis, can support unprofitable farming systems. The consistently poor cash margins produced by the cropped treatments illustrates that pre-conceptions about profitability, based on gross margin analysis, may not always be justified, and could lead to recommendations for loss-making innovations.

Risk is the defining feature of Australian dryland farming systems (Chambers and Quiggin 2000; Malcolm 2004a). It follows than any study which does not include some representative variability in inputs, particularly rainfall, cannot represent the likely system performance. Analyses based on averages cannot measure this variability (Janssen and Ittersum 2007) and do not represent the commercial reality faced by farm businesses. This is demonstrated by the outcome that even the more profitable grazed treatments accumulated unaffordable losses in the initial period of the trial.

A further commercial reality is that cash crises can also arise as a result of compounding losses (Grove et al. 2007). This is apparent in the cost of production for the cropped treatments, where the average interest charges for the loss-making treatments (APCY and APCN) exceed the combined total of the other components of the fixed costs and are greater than the variable costs for livestock (Table 3). The compounding effect of these losses result in the exponential form (both positive and negative) of the long-term cash flows shown above (Fig. 8). Given time, this effect is an important cause of the creation or destruction of wealth and should be included in long-term system analysis; margins should therefore be accumulated rather than averaged.

The fact that this form of financial analysis is common in New Zealand (Martin and Woodford 2003) and America (Boehlje 1999; Just 2002) and is being implemented by at least 70% of non-farm business (Jeston and Nelis 2007) suggests that it should also be more common in Australian agricultural research. This type of analysis is already commonly used by commercial farm business consultants and banks for the benefit of their clients. Perhaps it is time that Australian agricultural economists let theory follow practice in order to develop more relevant analytical systems.

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