Comparing risk for different dairy farm management systems in Taranaki using the Dexcel Whole Farm Model

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Abstract

The approach was to use the Whole Farm Model (WFM) and Taranaki climate to compare a conventional, twice-a-day milking farm system with variations of once-a-day (OAD) milking and high-input systems. The aim was to compare production, return on assets (ROA) and risk as affected by climate and price variability. Simulations were run over 9 different climate years (1995/1996 – 2003/2004). The high-input system had the highest production (1333 kg milksolids (MS)/ha) and highest ROA (10.8%), with variability thereof dampened by a feed buffer of higher quantity and quality that existed because of higher pasture yields (15.8 t dry matter (DM)/ha with 200 kg nitrogen (N)/ha vs. 13.5 t DM/ha with 105 kg N/ha for the other two systems), maize silage and grazing-off. The high-input system was followed by the OAD and conventional systems in terms of production (1068 and 975 kg MS/ha respectively) and ROA (9.8% and 9.2% respectively). Both OAD and conventional systems showed risk values nominally lower than high-input, but both these systems were more severely affected by climatic variability, which lowered the average return and increased the risk relative to the return.

Keywords: climate variability, high input farming, once-a-day milking, return on assets

Introduction

Seasonal variability in pasture growth is one of the main challenges of pasture-based dairying in New Zealand. Seasonal factors like wet winters leading to pasture damage, delayed spring growth when feed demand is high, and summer/autumn droughts may result in variability in milk production and profitability (Verkerk 2002). An underlying goal for most pastoral livestock systems is to cope with environmental and system-generated variation (Beukes *et al.* 2002). Buffering against variation (or risk aversion) may be achieved by conservative stocking policies and tactical use of conserved feeds (Romera *et al.* 2004). Often the evaluation of farm systems with different stocking rates and supplementary feeding strategies are based on the results of farmlet trials spanning over 2-3 years, and then comparisons are made on the basis of production and economic farm surplus (EFS) data only (e.g. Macdonald *et al.* 2001). Comparing different management strategies with the aim of achieving system robustness (high return with low risk) require a more objective evaluation of financial returns, which include risk evaluation by including climate variability over longer terms and payout and supplement price variability.

The Dexcel WFM was developed for simulating the complex and dynamic interactions between climate, management, and cow and pasture production. It lends itself as a useful tool to predict production and economics under different climatic conditions and with different farm management systems in place, and because it can simulate numerous permutations of climate, management and price variability at a fraction of the cost and time of farmlet trials, it can be used to objectively compare different management strategies. The model has been evaluated extensively against trial data (Palliser *et al.* 2001; Lile *et al.* 2002; Wastney *et al.* 2002) including OAD milking (Beukes *et al.* 2004).

Some of the limitations faced by Taranaki dairy farmers in the high altitude region are high pasture utilisation challenges for the early spring, and for the lower lying areas the summer dry spells. Better performing farmers of both regions appear to achieve gains by increasing pasture utilisation via higher stocking rate, while maintaining the same per cow production level and production spread. Increasing the length of the milking season does not appear to be part of the strategy of either group of top performing farmers (Wells *et al.* 1998).

The objective of this study was to use the WFM for the Taranaki region to explore the effect of climate and price variability on production, profit and risk for three typical farm systems: (a) a conventional farm with twice-a-day milking and 3.3 Jerseys/ha, (b) a farm with OAD milking after Christmas, 3.5 Jerseys/ha and more days in milk, and (c) a high-input farm with more N fertilizer, maize silage, grazing-off and 4.2 Jerseys/ha.

Methods

Basic model set-up

The WFM version 8.9.6 was used for this exercise. Pasture growth in the WFM was driven by weather data (daily rainfall, radiation and temperature, supplied by NIWA) from New Plymouth over 9 seasons (1995/

Table 1 Three Taranaki farm systems modelled over 9 seasons (1995/1996 – 2003/2004).

	Conventional	High-Input	OAD
Number of cows	49	63	53
Breed	Jersey	Jersey	Jersey
Stocking rate (cows/ha)	3.3	4.2	3.5
Initial average live weight (kg)	395	395	395
Milking frequency	Twice-a-day	Twice-a-day	Twice-a-day till Christmas, thereafter OAD
Grazing-off	None	66% of the herd for eight weeks	None
Calving dates	6 Aug – 15 Oct	30 Jul – 8 Oct	6 Aug – 15 Oct
Drying-off dates	29 Apr	10 May	30 May
Initial farm cover (kg DM/ha)	2300	2300	2300
N fertilizer (kg/ha)	105	200	105
Initial grass silage stack (t DM/cow)	0.31	0.24	0.33
Other supplement stacks (t DM/cow)	None	0.69 maize silage	None

Table 2 Default capital cost structure used in the model.

Item	Cost
Value of live cow	$700
Land cost/ha	$18000
Share cost/kg MS	$5.40
Cost per dairy	$300000
Cost for all machinery	$80000
Land appreciation rate	4%
Shares appreciation rate	10%
Dairy appreciation rate	-6%
Machinery appreciation rate	-18%
Cow appreciation rate	2%

1996 – 2003/2004), using the pasture growth model of McCall & Bishop-Hurley (2003). "Molly" (Baldwin 1995) (version 4.13) was the cow model used. "Molly" was validated to represent a Jersey cow using trial data from a Taranaki OAD milking trial (Tong *et al.* 2002). The cow model included a function for photoperiod to represent lactation following calving in any season under NZ pastoral conditions (Beukes *et al.* 2005).

A modelled farm of 15 ha with 40 paddocks was set up for a typical Taranaki farm. Information describing this typical Taranaki farm was obtained from Dexcel consulting officers (Hughes & Canton pers. comm. 2005), and included average farm cover at the beginning of the season (1 June), average initial cow live weight, amount of N fertilizer used, calving dates, residuals, conservation period, expected balance date, rotation lengths, planned start of mating and drying-off dates.

Taranaki management systems

The basic farm set-up was adjusted to represent three different low/medium altitude Taranaki farm systems (Table 1). Animal input files were compiled with similar age structures for the three farm systems. Individual cows were initialized in the model depending on age (2, 3, 4+ yrs), live weight and body condition score. Post-partum anoestrus was assumed to be 65 days with cycling every 21 days thereafter. All cows were mated (and assumed to conceive) between 28 October and 30 January when they were cycling.

Economic input data

The WFM simulates a scenario for a year and then uses the production data together with user-defined economic inputs to produce an economic report with a calculated EFS ($/ha) and ROA ((EFS + Capital Gain)/Assets = ROA %). The EFS calculation is adjusted for the differences between farm cover, supplement stacks and cow condition at the end of the simulation compared to the start values.

Input values for Taranaki were derived from economic farm survey data (Dexcel 2005). For the OAD system the net stock income/cow was increased from $102 (default) to $110 to account for the selling of heavier cows and selling them later in the season (Newman pers. comm.). Wages cost/cow decreased from $62 to $57.45 for OAD to account for the freed labour time and the benefits accrued from that in terms of pasture improvement and savings on weekend relief milking (Newman pers. comm. 2005). Further changes to the OAD economic input were animal health costs down from $57/cow to $55/cow, and electricity costs down from $20/cow to $17.18/cow (Canton pers. comm.). Changes to the economic input for the High-Input system were repair and maintenance costs/ha up from $241 (default) to $275, vehicle costs/ha up from $146 to $192, and machinery depreciation rate up from 18% to 25% (Newman pers. comm.). Grass and maize silage used was priced at $200/t DM. This ignored the likely effect of weather on supplementary feed price, and could have resulted in an overestimate of returns for systems with high supplement use during poor seasons. Table 2 summarizes the default capital cost structure used in the model. The limitation of this analysis was that due to a paucity of data, possible differences in capital costs for different systems were not considered e.g. the costs of a feed pad for the High-Input system. This may have led to an overestimate of returns from this system.

Risk report

For the risk report, each system was simulated for each of the 9 seasons. The modelled production for each season together with a set of 100 random combinations of prices were used to calculate 100 possible ROAs for each system for each season. These prices were sampled using the Monte Carlo technique, assuming a normal distribution with price/kg MS average of \$3.90, and standard deviation (SD) of \$1; supplement purchase cost/DM average of \$200, and SD of \$50; and land appreciation rate average of 4%, SD of 5% (Neal *et al.* 2004). From the 900 ROAs/system the average and SD (risk) were calculated. Assuming that the farmer always has the opportunity of investing in a risk free rate of 5% (e.g. government bonds), the farmer can then compare the excess return of a farm system (Average ROA 5% risk free) to the risk, measured with the SD of the ROA. This allows farms to be compared with a Sharpe ratio (as per equation 1), with a higher Sharpe ratio representing a better farm (Hardaker *et al.* 2004).

Sharpe ratio = (Average ROA of farm system – Risk free rate)/SD of ROA Equation 1

Results

The WFM predicted consistently higher MS yield for the High-Input farm over the 9 seasons. Predictions for the OAD system showed the highest comparative stocking rate and supplements fed of the three systems (Table 3).

The High-Input system showed the highest ROA, but also the highest risk (SD). Nevertheless, the excess return/unit risk (Sharpe ratio) for the High-Input system was the most favorable of the three systems (Table 4).

Discussion

The High-Input system had the highest average ROA over the 9 seasons, but with the greatest variability thereof. In the risk analysis, the effect of variability in payout on a system with higher MS yield resulted in a higher risk measurement for the High-Input system. However, this increase in risk was dampened because the High-Input system was better buffered against poor seasons. This buffering can be seen in the fact that the EFS for the High-Input system decreased by 41% from \$2286/ha for the best season (2001/2002) to \$1344/ha for the worst season (2002/2003). For the OAD system this decrease was 50% from \$1890/ha to \$939/ha, and for the Conventional system the decrease was 53% from \$1679/ha to \$794/ha. The High-Input system had a more favourable Sharpe ratio because of better returns and a relatively small increase in risk compared to the other two systems.

The higher returns in the High-Input system resulted from higher production/cow, and consequently a greater efficiency of production (kg MS/t DM). This production was based on cheap and reliable feed from higher N input, and therefore pasture production, grazing-off and maize silage. The buffering not only meant there was a smaller likelihood of the High-Input system running out

Table 3 Predicted averages (± SD) of KPI's for three Taranaki farm systems over nine seasons (1995/1996 – 2003/2004). Values with similar superscripts do not differ significantly at P<0.05.

KPIs	Conventional	High-Input	OAD
MS (kg/ha)	975^{a} ± 14	1333^{b} ± 13	1068^{c} ± 15
MS (kg/cow)	299^{a} ± 4	317^{b} ± 3	302^{c} ± 4
MS (kg/kg LWT)	0.72^{a} ± 0.01	0.75^{b} ± 0.01	0.73^{c} ± 0.01
MS (kg/t DM feed eaten)	73^{a} ± 0.9	75.5^{b} ± 0.7	74.3^{c} ± 0.9
Days in milk/cow	250 ± 0	268 ± 0	282 ± 0
MS for season (kg/cow/day)	1.2^{a} ± 0.02	1.18^{b} ± 0.01	1.07^{c} ± 0.02
Comparative stocking rate (kg LWT/t DM)	98^{a} ± 12	84^{b} ± 7.5	105^{c} ± 12.8
Total pasture grown (t DM/ha)	13.5^{a} ± 1.6	15.8^{b} ± 1.8	13.5^{a} ± 1.6
Supplements fed (kg DM/cow)	371^{a} ± 245	243^{b} ± 216	478^{c} ± 255
Supplements fed (t DM/ha)	1.21^{a} ± 0.8	1.02^{b} ± 0.91	1.69^{c} ± 0.9
Grazing-off (t DM/cow)	0 ± 0	0.3 ± 0	0 ± 0
Pasture eaten (t DM/ha)	11.7^{a} ± 1.0	14.3^{b} ± 1.2	12.0^{a} ± 1.1

Table 4 Risk report for three Taranaki farm systems over nine seasons (1995/1996 – 2003/2004).

	Conventional	High-Input	OAD
Average ROA (%)	9.2	10.8	9.8
SD of ROA (%)	4.96	5.49	5.11
Sharpe ratio	0.847	1.061	0.939

of feed in poor seasons, but the average quality of the feed was also better in poor seasons in the High-Input system. This was demonstrated in the poor season of 2002/2003 (11t DM/ha pasture production) when large quantities of supplements had to be fed to the cows in all three systems, especially over the late summer/autumn period. However, during this time covers were over 2500kg DM/ha in the High-Input system compared to 2300kg DM/ha and lower in the Conventional system. This meant that cows in the High-Input system only required 6 kg DM/cow/day of supplements compared to the 8 kg DM/cow/day in the Conventional system. At this stage supplements fed in the High-Input system consisted of a combination of grass- and maize-silage (approximately 10 and 10.5 MJ ME/kg DM respectively) whereas cows in the Conventional system were fed grass-silage only. The combination of more feed from pasture, smaller quantities of supplements fed per day and better quality supplements fed, allowed the High-Input cows to produce better than their counterparts in the Conventional system. The better production during poor seasons reduced the overall variability of profit in the High-Input system, which was not cancelled by a concomitant increase in risk associated with the cost of this production.

The OAD system showed a better Sharpe ratio compared to the Conventional system. The high comparative stocking rate of the OAD system explains the high demand for supplement feeding, which will increase risk, but the higher production and lower cost of production (average $1.82/kg MS compared to $1.94/kg MS for Conventional) resulted in higher returns compensating for the higher risk. The better pasture utilisation and feed conversion of the OAD system compared to the Conventional system corroborates the trend for higher excess returns per unit risk when these key performance indicators (KPIs) improve.

Farmers who aim to achieve high excess return per unit of risk over the longer term should focus on maximizing pasture growth (within acceptable limits for kg N/ha), increase pasture utilisation, aim for longer lactations (Beukes *et al.* 2004), be prepared to pay for off-farm grazing to get pasture covers up in the early part of the season, and buy-in quality supplements when they run out of pasture. Often late summer/autumn appears to be a critical time and feeding quality silage, like whole-crop cereal silage, could result in increased production compared to when grass silage is fed (Stevens *et al.* 2004).

The next logical step would be to implement the optimisation procedure of the WFM (Neal *et al.* 2004; Neal *et al.* 2005) to explore the combination of management decisions for each of the different farm systems that would provide the farmer with the highest excess returns per unit of risk.

Conclusions

This exercise showed the potential of the WFM to predict ROA and Sharpe Ratio as evaluation criteria for farm systems, because it incorporates variability driven by season and economics. With a variable MS price, systems with higher production show greater variability in ROA. But if high production is achieved at low cost, the higher average ROA compensates for the increase in risk.

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