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A whole farm approach to feed planning and ration balancing using UDDER and CAMDAIRY

J.V. URIBE, W.J. PARKER, C.K.G. DAKE, A. McDONALD[1]

Department of Agricultural and Horticultural Systems Management, Massey University, Palmerston North, New Zealand.

ABSTRACT

The potential of New Zealand cows for milk production remains substantially under-utilised as a consequence of pasture-based feeding systems. One means to increase per cow production is to balance pasture diets to provide the correct quantities and ratios of nutrients to meet target levels of milksolids production, but this needs to be done in a manner which is profitable and consistent with good pasture management. The dairy farm simulation model, UDDER, was used to evaluate supplementation strategies for early and late lactation in order to increase milk yields per cow and the farm gross margin. A sample of diets from UDDER were then tested with a ration balancing model (CAMDAIRY) to identify nutrient limitations to milk production. Undegraded protein (UDP) was limiting in all diets. It was concluded that, ration balancing would be useful aid to feed management on New Zealand dairy farms, but in practice could only be sensibly used if feed and animal monitoring systems are in place to determine the type(s) and period(s) of supple–mentation required.

Keywords: dairy systems; simulation model; UDDER; ration balance; CAMDAIRY.

INTRODUCTION

New Zealand dairy farmers are internationally regarded as being cost effective producers of milk (Murphy 1993) due to the year round *in situ* utilisation of pasture and high labour efficiency. The seasonal dairy systems commonly used have high stocking rates, relative to annual pasture growth and cow requirements, and this often does not allow cows to maximise their intake of pasture except for a 4 to 8 week period from late spring (Edwards & Parker 1994). Consequently, per cow production averages around 280 kg MS/cow (Holmes & Hughes 1993) and lactation lengths are well below those achieved with confined feed systems in the Northern Hemisphere (Edwards and Parker 1994). Scope exists to increase production per cow by improving diet quality and DM intake at critical times of the year (Muller 1993) and by extending the lactation period (Holmes & Hughes 1993). However, the use of supplements other than those derived from pasture for these purposes is limited by feed cost and availability. Likewise, prolonging lactation can increase total milk production in the current lactation but this should not be at the expense of condition score or pasture cover (Gray *et al.* 1992) and hence cow performance over the next lactation (Grainger *et al.* 1982).

One option to profitably increase milk production that has been well-tested in Northern Hemisphere countries is to offer cows a consistent high quality balanced diet throughout lactation (Muller 1993). This technology could be adapted to pasture-based systems, particularly in situations where high levels of milksolids production from pasture are already being achieved. This paper describes an evaluation of ration balancing in the context of New Zealand dairy systems for a case study farm.

METHODOLOGY

Case farm description

The modeling analysis was based on Massey University's No. 4 dairy farm, which has an extensive database of input-output data for seasonal dairying. The farm is located 3 km south west of Palmerston North at an altitude of 40 masl, and receives an average annual rainfall of 1000 mm. It is operated as two management units. The present study was conducted on Lovelock farm, a 90 hectare unit supporting a seasonal dairy herd on mainly ryegrass-white clover pastures. The main soil type is Tokomaru silt loam, which has poor natural drainage and a tendency to dry out during the summer. This constrains early season and summer milk production, respectively, even though extensive tile and mole draining has been undertaken. Stock numbers wintered in 1993 included a herd of 276 milking cows and 44 yearling replacements. Calving starts in early August and through the use of induction is normally completed by the end of September. The herd is dried off on the basis of condition score and pasture availability, usually near the end of April. Approximately 35% of the cows are grazed off the farm for two months during the winter (June and July).

Herd supplementary feed management includes the use of maize silage to milkers at a rate of 3 kg DM/cow/day from early January to mid-February. From mid-February to early April cows are fed a summer crop, usually green fed maize. Winter feeding includes 4 kg DM/cow/day of pasture silage or hay from drying-off until calving.

The UDDER simulation model

UDDER is a whole farm simulation model that predicts herd milk production in 10 day time steps based on

[3]Farms Administration, Massey University, Palmerston North, New Zealand.

specified pasture accumulation rates and management conditions for a case farm (Larcombe 1990a, b). Model predictions include the growth and quality of pasture, animal intake and the partitioning of energy towards milk production, maintenance, growth and pregnancy. Recommendations from ARC (1980) are used to estimate energy partitioning and the cow's requirements for maintenance, pregnancy and growth. The latter are discounted from total energy intake and residual energy is used to predict milk production (Larcombe 1990b).

Physical and management variables for the No. 4 dairy unit, and the costs of the different inputs and the 1993/94 season's milk price ($3.02 kg MS), were entered into UDDER to simulate an "average" year for the farm. The output for this initial simulation was analysed jointly with the farm supervisor and adjustments were made to calibrate model output to "fit" the farm monitoring data (i.e. milk production, pasture cover, condition score) and to produce a "base" model for the farm.

The CAMDAIRY rations balancer

CAMDAIRY is a personal computer model that uses linear programming to formulate rations while satisfying nutrient requirements and other constraints on feeds or nutritional parameters (Irwin and Kellaway 1991). The model includes three main programs for analysing dairy cow rations: maximum profit formulation; least cost formulation; and prediction of performance and profit (Hulme *et al*. 1986). The first two modules are for formulating rations to obtain maximum returns, or to fulfill dairy cow requirements at the minimum cost. The module "prediction of performance and profit" calculates the likely milk output from a specific diet. In analysing a diet the program shows the likely milk production from energy, rumen degraded protein (RDP), undegraded protein (UDP), calcium (Ca) and phosphorus (P). Daily cow requirements are determined from user inputs for animal liveweight, peak milk production potential, cow breed, milkfat concentration, stage of lactation and activity. Other important parameters for the determination of milk production are animal DM intake and the nutritional characteristics of the diet fed. Data from the UDDER simulation output for the No. 4 dairy farm were used as inputs for the CAMDAIRY analysis.

Experimental design

Whole farm strategies to increase milk production by extending lactation were investigated with UDDER using a 4^2 factorial design. The effect of lactation length relative to the base ('average') year by delaying drying off by 10, 20 or 30 days (D010, D020 and D030, respectively) was evaluated for four different supplementary feeding strategies (maize silage in early or late lactation (MSE, MSL) or meal in early or late lactation (MEE, MEL)). Maize silage was assumed to have a DM digestibility of 73% and was fed at 4 kg DM/cow/day. Variables reported from the UDDER output are per cow production, end of year cow condition score (CS) and average pasture cover (APC), and farm gross margin (GM) per cow and per hectare.

The diet 'fed' to the cows in UDDER for the DO30 + MSE (i.e. 30 day longer lactation with maize silage in early lactation) and DO30 + MSL were evaluated for the fourth and 34th weeks of lactation, respectively. Dairy milk yields per cow (kg MS) were estimated for the quantities of energy (MJ ME), protein (RDP and UDP), Ca and P in the diet. In week 4 the diet included either 14.8 kg pasture DM or 10.9 kg pasture + 4 kg maize silage DM. Spring pasture contained 11.8 MJ ME, 240 g CP, 6 g Ca, 4.5 g P per kg DM, and maize silage had either 9.7 or 10.5 MJ ME, 71 g CP, 4 g Ca and 2.5 g P per kgDM. In week 34, DM intake comprised either 10.5 kg pasture DM (10.8 MJ ME, 255 g CP, 4.5 g Ca and 3 g P per kg DM) or 6.5 kg pasture DM and 4.0 kg maize silage DM (with the same nutritional parameters as that offered in the spring).

RESULTS

Whole farm strategies

As could be expected prolonging lactation length for the 'base' situation by delaying drying off increased per cow milk production, but at the expense of cow CS and pasture cover, as summarised in Table 1. Such a system is clearly not physically sustainable. Introducing, either maize silage or meal in early or late lactation for the 10, 20 or 30 day longer lactations improved per cow milk yields, CS and APC relative to the base year, and in all cases increased the GM per cow and per hectare.

The greatest production per cow and GM was achieved for the D030+MSE strategy (180 kg MF/cow and $515/cow v. 162 kg MF/cow and $436/cow for the base option). Maize silage was a superior supplement to meal in terms

TABLE 1: Effect of delaying drying-off dates (10, 20 and 30 days) and different early and late season meal (ME) and maize silage (MS) supplementation strategies in early (E) or late (L) lactation on production per cow, average cow condition score, average pasture cover and gross margin per cow and per hectare. (Note: MS/ha can be derived by multiplying the respective cow data by 2.61 cows/ha).

Simulation option	Milk production (kgMS/cow)	Condition score (units)	Average pasture cover (kg DM/ha)	Gross Margin ($/ cow)	($1 ha)
'Base' year	282	4.6	2837	436	1139
'Base' plus 10 days (DO10)	287	4.5	2731	457	1194
'Base' plus 20 days (DO20)	294	4.4	2618	479	1250
'Base' plus 30 days (DO30)	299	4.3	2493	501	1307
DO10+MEE	296	4.7	2791	449	1173
DO10+MEL	289	4.6	2791	446	1165
DO10+MSE	299	4.9	2915	467	1220
DO10+MSL	289	4.6	2907	447	1167
DO20+MEE	303	4.6	2672	472	1232
DO20+MEL	296	4.5	2702	463	1208
DO20+MSE	306	4.8	2788	491	1281
DO20+MSL	294	4.5	2863	464	1211
DO30+MEE	318	4.5	2545	495	1292
DO30+MEL	301	4.5	2608	480	1252
DO30+MSE	313	4.7	2655	515	1341
DO30+MSL	301	4.4	2823	480	1255

of milk production and financial returns (e.g. D010+MEE vs. D010+MSE milk solids yields per cow were 296 vs. 299 kg, and the GM was $1173/ha vs. $1220/ha). This reflected the lower cost of maize silage.

Ration balance

CAMDAIRY predicted cows fed 14.8 kg of pasture DM during the fourth week of lactation under the current (base) system of management would produce 19.9 li/milk/day, the same value as for UDDER (Table 2). While the amount of RDP in the diet was sufficient to support production of 27.5 li/cow/day, UDP would limit daily output to 18.8 li. Calcium and phosphorus levels were adequate. Cows lost body condition at around 400 g/d to support milk production.

The addition of 4 kg maize silage to the pasture diet in spring would support a slightly lower yield of milk per day than the 'base' system (19.2 vs. 19.9 li/cow/day), because the substituted maize silage had a lower energy density than spring pasture (Table 2). The low concentration of crude protein in maize silage meant that the UDP content of the diet could restrict milk yields to 17.7 li/day. Introducing a higher quality maize silage (10.5 MJME/kgDM) improved predicted daily milk output slightly to 19.9 li/cow/day. Late lactation milk yields were predicted to be 7.8 li/day, but the amount of UDP in the diet was again shown to be marginally limiting (7.2 li/day).

DISCUSSION

Whole farm strategies

Both milk production and GM could be improved at the No. 4 dairy by extending lactation 30 days (i.e. drying off on 31 May) and feeding maize silage at 4 kg DM/cow/day for 50 days in early lactation. Maize silage feeding enabled extra pasture cover (relative to the base situation) to be transferred to the summer, traditionally a dry period with low rates of pasture growth. This enabled end-of-season cow CS (4.7) and pasture cover (2655 kg DM/ha) to be maintained at satisfactory levels for the ensuing lactation. The extra 31 kg MS/cow, represented additional farm income of $18,540 per year, but the UDDER GM calculation did not include the cost of extra labour, or the costs associated with machinery and equipment for feeding silage. The net profit from maize silage feeding is therefore likely to be $2000-3000 per ha less than the GM suggests. On the other hand, UDDER does not predict the effect of supplements on herd reproductive performance. Both calving date and pattern can significantly affect farm returns, through the number of days in milk, level of involuntary culling and need for induction (Lean 1991; McDougall 1993; Parker & Edwards 1994).

Diet balance

The limiting factor to milk production in the pasture diets was UDP. In this respect inclusion of maize silage in the diet of high quality pasture produced a more 'balanced' ration, and this could improve energy utilisation within the rumen (Satter *et al*. 1992). However, inclusion of maize silage also decreased UDP intake and restricted milk yield to a level lower than that for a pasture-only diet. A protein supplement (i.e 'balancer') should therefore be considered to improve UDP intake when maize silage is fed. This is also likely to improve energy partitioning to milk, rather than liveweight gain (Lean 1991). Without the protein supplement, CAMDAIRY suggests cows would loose 200 g/d with the maize silage - pasture diet rather than 400 g/d on the straight pasture diet. A separate CAMDAIRY analysis, for a pasture-maize silage diet with 1 kg DM/cow/day of 'balancer' (13.5 kg MJME/kgDM, 24% CP and 60% UDP of total protein, and total DMI of 16 kg/cow/day), indicated that milk yields could be increased to 21 li/cow/day and liveweight maintained. These analyses suggest that protein metabolism has a major influence on predicted milk yields. The disparity between RDP and UDP predicted milk yields indicates further work is required to define the protein relationships in CAMDAIRY for cows on mainly pasture diets.

TABLE 2: Predicted pasture dry matter intake, change in average condition score and likely milk production (litres/day) for different diet parameters during the 4th and 34th week of lactation for the current system (base) or with maize silage supplementation at No. 4 dairy farm using UDDER and CAMDAIRY.

Model	Cow DMI[1]	ME[2]	RDP[3]	UDP[4]	Ca[5]	P[6]	ACS[7]
			Nutritional parameters in diet (Litres of milk)				
Base year							
UDDER	14.8	19.9					
CAMDAIRY	14.8	19.9	27.5	18.8	41.5	27.2	-.4
Early lactation							
UDDER	14.9	19.2					
CAMDAIRY							
low quality MS	14.9	19.2	23.4	17.7	34.5	24.8	-.2
high quality MS	14.9	19.5	23.4	17.9	34.5	24.8	-.2
Late lactation							
UDDER	10.5	7.8					
CAMDAIRY	10.5	7.8	10.8	7.2	19.9	14.3	.2

[1] = Dry matter intake (kg DM), [2] ME = Metabolisable energy (MJME), [3] RDP = Rumen degradable protein, [4] UDP = Undegradable dietary protein, [5] Ca = Calcium, [6] P = Phosphorus, [7] ACS= Change in average cow condition score (kg per day).

CONCLUSION

The UDDER analysis indicates that there is scope to improve dairy farm profitability through the strategic use of supplements. The supplementary feeding option adopted will depend on the supplement cost: milk price ratio, herd reproduction status, changes in production risk and the availability of suitable feeding out facilities (Parker & Edwards 1994). The introduction of seasonal pricing systems for milk could provide further stimulus for farmers to consider early- and late- lactation supplementation strategies. The CAMDAIRY analysis highlighted the nutritional limitation of the diets adopted for the whole farm simulation and showed that adding supplements (in this case maize silage) on a DM or energy basis without consideration of the overall diet balance, in this case protein fractions, could reduce milk yields and modify energy partitioning. Incorporating a ration balance sub-model into UDDER would therefore be useful from a feed management viewpoint.

The implementation of ration balancing in New Zealand dairy farm management will require a much improved definition of the seasonal variation in pasture quality, in order to fully identify the deficiencies of pasture for milk production at particular periods of the year. Without this information ration balancing can only be carried out by approximation and *ad hoc* reaction to milk responses to different feed mixes tried on farms.

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