Maximising dairy production by using nitrogen fertiliser and calving early

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Abstract

The effects of applying nitrogen (N) fertiliser at 100 kgN/ha as a split application (40 kgN/ha in July/ early August and 60 kgN/ha in October) and of earlier calving (16 July vs 2 August) on milk solids production and farm profitability were evaluated at the Waimate West Demonstration Farm in South Taranaki. Two systems were compared over 3 years: calving on 2 August with no N (LC) and calving on 16 July with N (ECN). In the second and third year calving on 16 July with no N (EC) was also evaluated. All herds were stocked at 4.0 cows/ha. Early calving without N (EC) increased the average lactation length/cow by only 2 days because poorer cow condition and less winter supplements required earlier drying off. Milkfat increased by only 13 kg/ha and protein by 1 kg/ha.

Early calving with N (ECN) increased the average lactation length/cow by 16 days, milkfat by 57 kg/ha and protein by 27 kg/ha. Nitrogen applied in October was more effective (kg milk solids/kg N) at increasing milk solids production (1.08 kg milk solids/kg N) than N applied in late winter (0.56 kg milk solids/kg N). At 4.0 cows/ha and calving on 16 July, the break-even milkfat price for N use was \$3.00/kg fat.

Keywords milk solids, production, nitrogen fertiliser, calving date.

Introduction

In South Taranaki the major limitation to increasing dairy production is low summer rainfall (Roberts & Thomson 1984). Minimising the effects of summer dry spells through the introduction of more drought tolerant species (Thomson & Lagan 1981, Thomson *et al* 1988) or through feeding supplements over summer (Bryant 1983) have not increased production or have proved to be uneconomic. The adverse effects of a summer dry spell could be minimised by calving earlier. Judd *et al* (1990) showed in South Taranaki that severe feed

restrictions would result from earlier calving unless stocking rate was reduced, or pasture growth in late winter/early spring increased.

Information provided by O'Connor & Cumberland (1973), Thomson & Roberts (1982) and Roberts & Thomson (1989) on pasture responses in Taranaki to applications of nitrogen (N) fertiliser, shows that dairying systems may be profitable with the strategic use of N. This would be achieved by overcoming the feed shortage in late winter and increasing the amount of conserved feed for summer, through late winter and mid-spring applications of N fertiliser. Holmes (1982) and Bryant *et al* (1982) concluded that the use of N in NZ dairying is uneconomic. However, Bryant *et al* (1982) did show that the use of N in winter and early spring was profitable if calving earlier at a high stocking rate when feed shortages are severe in early lactation.

In future, dairy companies may develop payment systems to provide incentives for increased production outside the spring flush (Paul 1985). With a payment incentive the strategic use of N, earlier calving and more summer supplements may therefore profitably increase dairy production. To evaluate this hypothesis a demonstration programme was run on the Waimate West Demonstration Farm in South Taranaki over 3 years (1987-1990).

Methods

The soil type is Egmont brown loam (Campbell & Wilde 1970), the altitude 90m above sea level and the mean annual rainfall is 1070mm. Pastures are predominantly old (greater than 30 years) consisting mainly of perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and a small proportion of other grass species including prairie grass (*Bromus catharticus*), cocksfoot (*Dactylis glomerata*) and *Poa annua*. Soil fertility is above average by MAF soil test; ie. pH 5.8-6.0, Olsen P greater than 30 and quick test K greater than 8.

The first year was established solely as a demonstration of two dairying systems: one calving on 2 August at 4.1 cows/ha with no N (LC), the other calving on 20 July with N (ECN) applied in early July and again

in October to maximise the conservation of surplus pasture in late spring/early summer. The trial layout over the 3 years, 1987-1990 is presented in Table 1.

For the ECN **farmlet**, N was applied as urea over two periods, a policy which was adopted for years 1.2 and 3.

Table 1 Trial layout.

	No. Cows	Area (ha)	Stocking rate (cows/ha)	Calving date
1987-88 Season Treatment				
Late calving (LC)	70	17	4.1	2 Aug
Early calving, N (ECN)	70	17	4.1	16 July
1988/90 Season Treatment				
Late calving (CC)	46	12.0	4.0	2 Aug
Early calving (EC)	43	10.8	4.0	16 July
Early calving, N (ECN)	43	10.8	4.0	16 July

Period 1

To maximise the response to N, urea application began early in July at 40 kgN/ha. Nitrogen was applied to all paddocks to meet feed requirements and optimise pasture response to N for that time of year (Roberts & Thomson 1989). Nitrogen was applied when the **herbage** mass of paddocks exceeded 1800 kg DM/ha(45mm), or providing grazing would not occur within 3 weeks, according to the following schedule:

Application date, 2nd week July -% ECN **farmlet** treated, 35; 1st week August, 15; 2nd week August, 15; 3rd week August, 20; 4th week August, 15.

Period 2

From the first week of October, 60 kg N/ha was applied to all paddocks immediately after grazing (residual **herbage** mass approximately 2000 kg DM/ha) to maximise spring growth and increase supplementary feed conserved.

Farmlet Management

All **farmlets** were managed similarly using objective criteria for feed demand, residual **herbage** mass, rotation length and trigger levels for the removal of surplus pasture as either silage or hay (Thomson 1985). Cows were dried off in autumn according to predetermined feed budgets. Feed availability and feed demand were calculated from the current date through to 20 September and drying off dates established to equate the availability of feed with demand and ensure cows calved at a condition score of about 4.5. Budgets were updated fortnightly and particular herds dried off when apparent feed deficits **occurred**.

The extra pasture conserved (ECN-EC) on the ECN **farmlet** was fed out to lactating cows in the ECN herd over summer during periods of pasture shortage. Feed conserved on the LC and EC and that remaining on the ECN **farmlet** was fed to dry cows over winter.

Rotation lengths were similar to normal farm practice. During winter all paddocks were grazed once (So-100 day rotation), a 30-40 day rotation was maintained from calving to late September/early October, then rotation length was shortened to 20-25 days. In late summer/autumn the rotation was lengthened to 30-40 days before drying off.

Farm Costs/Returns

Over the three years the total cost of purchasing and applying N averaged \$1.01/kg N applied. Conservation cost were monitored and the costs of the additional feed conserved on the ECN **farmlet** was calculated at \$0.084/kg DM. Revenue was based on the final payout of the Kiwi Cooperative Dairy Company for the 1990/91 season at: \$2.30/kg milkfat, \$3.838/kg protein and minus \$0.032/litre milk.

Measurements

Year 1

Fortnightly herd test for milk yield, fat % and protein % from calving to December, then at monthly intervals from December to drying off. Using a pasture probe, **herbage** mass was estimated weekly. Average farm cover (kg DM/ha) was calculated using equations of L’Huillier & Thomson (1988).

Year 2 and 3

Herd testing of all cows for milk yield, fat % and protein % 2-weekly from calving to drying off. Throughout lactation **herbage** mass was estimated in all paddocks weekly using the pasture probe and fortnightly over the winter dry period. From this information **herbage** mass before and after grazing and average **farm** cover was calculated and the conservation programme and drying off dates established.

To determine the effect of the two times of N application on milk solids production over the (1988-1990) seasons, each season was divided into 3 periods: calving to 12 October, 12 October to 10 January and 10 January to drying off. Production over each period was averaged for the two years.

During September/October (before any paddock was shut for silage) and in March/April, pastures in all paddocks were sampled immediately before grazing for botanical composition (green grass, clover, weeds and

dead material) and results expressed as percentage of total dry weight.

Results

Milk solids production

The advantage of 96 kg/ha **milkfat** and 50 kg/ha protein (Table 2) in the 1987/88 season to the ECN treatments **was not repeated. Over the next two seasons the advantage** to ECN was 48 kg/ha **milkfat**, 4 kg/ha protein and 73 kg/ha **milkfat**, 33 kg/ha protein in the 1988/89 and 1989/90 seasons respectively. Over the two years of the early vs late calving comparison, the average advantage to early calving was 13 kg/ha **milkfat** and 1 kg/ha protein. Nitrogen (ECN vs EC) increased milk solids by an average 48 kg/ha **milkfat** and 17 kg/ha protein (Table 3).

Table 2 Milk solids production over three years

	LC	EC	ECN
1987/88			
kg fat/ha	556	▪	652
kg protein/ha	410		460
1988/89			
kg fat/ha	564	572	612
kg protein/ha	416	407	420
Lactation days	211	206	228
1989/90			
kg fat/ha	684	700	757
kg protein/ha	509	521	542
Lactation days	242	252	267
Average (3 Seasons)			
kg fat/ha	603	▪	672
kg protein/ha	445	▪	475
Average (2 Seasons)			
kg fat/ha	623	636	684
kg protein/ha	463	464	481
Lactation days	227	229	248

From calving to 12 October, early calving (16 days earlier) increased milk solids production by 27 kg **milkfat**/ha and 10 kg protein/ha (Table 4). Nitrogen further increased production by 14 kg/ha for **milkfat** and 12 kg/ha for protein. Over the period of conservation and when the 60 kgN/ha was applied to the ECN treatment, all treatments produced similar **milkfat** but the ECN treatment produced 13kg/ha less protein, losing all advantage gained from N application in the first period. The EC treatment was dried off the earliest and in terms of lactation days, **lost** all benefit of calving early. The cows in the ECN treatment were milked for an additional 19 days, resulting in an extra 36 kg/ha of **milkfat** and 18kg/ha of protein, compared with production on the EC treatment.

Table 3 Responsiveness of the dairy system to the strategic use of N fertiliser for additional late winter pasture and conserved pasture for summer feed (Average kg milk solids/ha 1988/89, 1989/90 seasons)

	LC	EC	ECN
Calving ▪ 12 October			
kg fat/ha	185	212	226
kg protein/ha	146	156	168
Lactation days	55	71	71
12 October ▪ 10 January			
kg fat/ha	270	268	266
kg protein/ha	198	198	185
Lactation days	91	91	91
10 January ▪ Dry			
kg fat/ha	168	156	192
kg protein/ha	119	110	128
Lactation days	71	67	86
Total			
kg fat/ha	623	636	684
kg protein/ha	463	464	481
Lactation days	217	229	248

Table 4 Advantage of early calving and the application of N fertiliser (average two years).

	Per hectare		
	Early calving (EC-LC)	N fertiliser (ECN-EC)	N and early calving (ECN-LC)
Calving ▪ 12 October			
kg fat	27	14	41
kg protein	10	12	22
Lactation days	16	0	16
12 October ▪ 10 January			
kg fat	-2	-2	-4
kg protein	0	-13	-13
Lactation days	0	0	0
10 Jan-Dry			
kg fat	-12	36	24
kg protein	-9	14	9
Lactation days	-14	19	5
Total gain			
kg fat	13	48	61
kg protein	1	17	18
Lactation days	2	19	21

Table 5 Pasture conserved for each treatment (bale hay equivalents/ha) over three seasons (1987-1990)

	LC	EC	ECN
1987/88	68		96
1988/89	28	36	44
1989/90	44	44	80
Average (3 years)	47		73
Average (2 years)	36	40	62

Table 6 Herbage mass (kg DM/ha) levels before and after grazing for milking cows in spring (calving-1 December) 1988 and 1989.

	LC		EC		ECN	
	kgDM/ha	SE	kgDM/ha	SE	kgDM/ha	SE
1988						
Before grazing	3240	570	3040	580	3270	730
After grazing	1700	370	1700	340	1640	340
1989						
Before grazing	2900	380	2720	450	2800	320
After grazing	1620	170	1620	160	1910	200

Effects on Pasture

Over the three years the amount of feed conserved (Table 5) differed between treatments and between years. Conservation was similar (36-40 bales/ha) on the LC and EC treatments and in each year more feed was conserved on the ECN treatment. There was a small difference between years in the absolute levels of herbage mass before and after grazing during the period of conservation (Table 6) but the differences between treatments within years were small and non-significant.

Table 7 Pasture composition recorded in all paddocks before grazing in spring and summer.

	Spring 1988			Spring 1989		
	Grass	Clover	Dead	Grass	Clover	Dead
LC	69	16	11	50	15	25
EC	72	12	12	55	22	21
ECN	76	11	10	56	15	25

	Summer 1988			Summer 1989		
	Grass	Clover	Dead	Grass	Clover	Dead
LC	58	13	20	46	16	32
EC	61	15	18	44	10	30
ECN	58	12	24	45	15	35

In no period were any of the pasture components significantly different (P<0.05).

Composition of pasture over spring and summer 1988-1990 (Table 7) did not differ between treatments. In spring 1988 the clover content in the LC treatment was 6% and 7% greater than the EC and ECN treatments respectively (P<0.08).

Economic Analysis

For the 1988 to 1990 period the overall benefit to early calving was \$32/ha and the additional benefit to N fertiliser \$19/ha (Table 8).

Discussion

From the last two years' data (Table 8) it can be concluded that applying N had little benefit on farm profitability despite using N strategically to maximise both the pasture DM response and the utilisation of pasture for milk solids production. A similar conclusion was drawn by Holmes (1982) and Bryant *et al* (1982). However, if the results of the first year of the demonstration are included (ECN group produced 96 kg milkfat/ha and 50 kg protein/ha more than the LC group) then a different conclusion may be drawn.

From the more intensive programme in the last two years (Table 4), the proportion of the overall response to the ECN system due to calving earlier, and the proportion due to N, can be estimated. For the 61 kg milkfat/ha response to ECN compared with LC, 21% of the response was due to earlier calving and 79% due to the N. Similarly for protein, 6% of the increase to ECN was due to earlier calving and 94% due to N. Applying this information to the first year it is possible to recalculate the benefits (Table 9) resulting from the three years of application of 100 kg N/ha.

Table 8 Economic assessment of the value (\$/ha) of early calving and the application of N fertiliser (average 1988/89 and 1989/90 seasons)

	Early Calving	N Fertiliser
Returns	13 kg milkfat \$30 1 kg protein \$4 71 litres milk \$-2 Total \$32	46 kg milkfat \$110 17 kg protein \$65 545 litres milk \$-18 Total \$157
costs	Nil	Nitrogen fertiliser \$101 Conservation \$37
Benefit	\$32/ha	\$19/ha

Returns based on the 1990/91 final payout of Kiwi Cooperative Dairy Ltd: \$2.30/kg fat, \$3.838/kg protein, -\$0.032/litre milk.

The re-calculation (Table 9) suggests that the preliminary conclusions (Table 8) could underestimate the benefits due to N.

When initially designing the programme it was felt that the greatest effect of N on milk solids would have resulted from the initial application in July/early August. This however was not the case. The initial application of 40 kg N/ha increased total milk solids (fat + protein) by 26 kg/ha (Table 4), ie. a response of 0.56 kg milk solids/kg N. The increased production from the later application of N (60 kg N/ha) increased milk solids by of 65 kg/ha, i.e. a response of 1.08 kg milk solids/kg N. The response in milk solids production to the later application was achieved through the conservation of additional supplementary feed resulting from the October application of N and the feeding out of the additional supplement to the ECN herd over summer.

An additional 32 bales of hay/ha were conserved and fed out over summer on the ECN **farmlet** compared with the EC **farmlet**. Assuming a bale of hay averages 20 kg DM, the apparent conversion of the additional DM as supplement to milk fat production (440 kg DM fed as supplement: 36 kg **milkfat**) was very high at 12.2 kg **DM/kg milkfat**. From a number of short-term studies, Bryant (1983) calculated a conversion of 66 kg **DM/kg milkfat**. This marked difference in feed conversion efficiency may in part be explained by short term studies not taking into account the effects of supplementary feeding on cow condition and pasture substitution (resulting in higher average farm cover) or by the feed budget approach, allowing herdmanagement to respond to differences in cow condition and farm cover resulting in changes in drying off dates and lactation days. All of these factors were accounted for in the **farmlet** approach.

Table 9 Re-calculation of the overall benefits to using N fertiliser (utilising Year 1 data).

Increase in production in Year 1 due to ECN:	
	96 kg milkfat /ha 50 kg protein/ha.
Increase due to N calculated from ratios established in Years 2 and 3.	
	Milkfat 79% due to N = 75 kg/ha, Year 1 Protein 94% due to N = 47 kg/ha, Year 1
The average response to N over three years:	
	Milkfat 57 kg/ha Protein 27 kg/ha.
Using the data presented for costs and returns presented in Table 8 the overall benefit to using N:	
	\$74/ha at a \$4.50/kg fat equivalent payout.

From Table 9 it can be calculated that **with 4.0 cows/ha** calving on the 16 July in South Taranaki, the **break-even milkfat** payment to applying 100 kg N/ha was **\$3.00/kg milkfat**.

Conclusion

Nitrogen fertiliser can be profitable for dairying in summer dry environments if the management system maximises the effects on pasture growth and fully utilises the additional DM for milk solids production. Calving should be early and N should be applied in July to overcome pasture shortage in early lactation. Nitrogen should be applied again in October to maximise growth for conservation for later feeding out over summer.

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