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Effect of nitrogen fertiliser and concentrate feed on dairy production

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ABSTRACT

Over three dairy seasons (1993/94-1995/96) the input of additional N fertiliser (149 kg N/ha) and dairy meal (570 kg meal/cow) was evaluated in dairy farm systems with calving commencing 20 June. Four farm systems were evaluated: Control LS (no extra N fertiliser, stocking rate, 3.6 cows/ha), NLS (21 kg N/ha after every grazing September to January, 3.6 cows/ha), NHS (N fertiliser same as NLS, 4.2 cows/ha) and NMHS (N fertiliser same as NLS, dairy meal fed at 0.5-3.0 kg/cow/day depending on pasture availability, 4.2 cows/ha). Each farmlet received a base application of 100 kg N/ha; 40 kg N/ha in March and 60 kg N/ha in July.

The additional 146 kg N/ha increased ($P<0.01$) milksolids production by 107 kg/ha, or an additional 0.73 kg MS/kg of N fertiliser applied. The increased milksolids resulted mainly from increased pasture conserved (average of 192 kg DM/cow) which when fed out in summer/early autumn resulted in an increased lactation length of 17 days. A comparison of the NHS and the NMHS treatments showed that the feeding of dairy meal increased ($P<0.01$) milksolids production by 77 kg/cow. An increase of 136 g MS/kg of meal fed. The advantage to meal feeding occurred throughout lactation but more in late lactation where lactation length was extended by 35 days.

The greater proportion of the response to additional feed inputs resulted from an increase in lactation length rather than an increase in production/cow/day.

Keywords: Milksolids production; pastoral farm systems; nitrogen fertiliser; concentrate feeds.

INTRODUCTION

Increases in dairy production on New Zealand research dairies over the past 30 years have been minimal (Bryant, 1990; Thomson, 1989). Through the 1960's and early 1970's rapid increases in milk production occurred as the result of increased use of phosphate and potassium fertilisers and increased stocking rates (Thomson, 1989), but since the adoption of these relatively low cost inputs little further increases have occurred. Farm systems trials utilising N fertiliser, increased pasture production but the resultant increases in milk production were uneconomic under the cost:price ratio for N fertiliser and milk that existed at the time, (Bryant, *et al.*, 1982; Holmes, 1982). However later work by Thomson, *et al.*, (1991) showed N fertiliser to be economic.

Similar to the history of N fertiliser, early work in New Zealand with feeding concentrates to dairy cows, showed relatively small and uneconomic increases in milk production (Hutton and Parker, 1967). As a result, the feeding of concentrates has been actively discouraged. However, farmers concerns about poor production/cow persist and the purchase of feeds off-farm has increased in recent years. In response to this concern, work commenced in 1993 on the Waimate West Demonstration Farm to examine the milksolids response of farmlet systems to additional inputs of N fertiliser and feeding concentrates.

METHOD

The soils, climate and pasture growth pattern for the Waimate West Demonstration Farm have been described by Roberts and Thomson (1984). A previous farm systems trial conducted on the Demonstration Farm by Thomson *et al.* (1991) had shown early calving (15 July vs. 1 August) and the input of 100 kg N fertiliser/ha to increase MS production and farm profitability. The question was then asked if MS could be further increased by calving earlier (20 June), applying additional N fertiliser, or feeding concentrates. During three dairy seasons (1993/94-1995/96) the input of additional N fertiliser (21 kg N/ha applied after every grazing during September to January) and dairy meal (meal fed throughout lactation at a rate varying between 0.5 and 3.0 kg/cow/day depending on pasture availability) was evaluated in dairy farm systems with calving commencing 20 June. Four farm systems were evaluated: Control low stocked - CLS (100 kg N fertiliser/ha, stocking rate, 3.6 cows/ha), N fertiliser low stocked - NLS (100 kg N/ha + 21 kg N/ha after every grazing September to January, 3.6 cows/ha), N fertiliser high stocked - NHS (N fertiliser same as NLS, 4.2 cows/ha) and N fertiliser and meal high stocked - NMHS (N fertiliser same as NLS, dairy meal fed at 0.5-3.0 kg/cow/day depending on pasture availability, 4.2 cows/ha). The dairy meal was a proprietary dairy pellet (Harvey Farms, Top Cow) with a ME value of 11.5 MJ/kg DM and a crude protein content of 11%. Each farmlet received a base application of 100 kg N/ha; 40 kg N/ha in March and 60 kg N/ha in July. The LS farmlets comprised 31 Jersey cows grazing 10, 0.9 ha paddocks and the HS farmlets, 36 Jersey cows grazing the same number of paddocks and area.

The herbage mass for all paddocks was visually assessed weekly using two trained and regularly calibrated

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observers. From the weekly herbage mass estimates; average herbage mass before and after grazing were determined and from these the rate of DM disappearance and net herbage accumulation were calculated. Milk production was measured fortnightly and the milk sub-sampled for analysis of fat, protein and lactose content.

The results were subjected to a least squares analysis of variance for a factorial design, utilising the general linear models procedure of SAS (SAS version 6.08, SAS Institute Inc., Cory, NC, USA) using years as treatment replicates. Comparison for the N Fertiliser response was between LS and NLS, and for a response to meal between NHS and NMHS.

RESULTS

During the three seasons an average of 146 kg N fertiliser/ha/year was applied as additional N and 570 kg/cow/year of meal fed. The application of N fertiliser increased pasture production (Table 1) on average by 1440 kg DM/ha (9.9 kg pasture DM/kg N fertiliser applied). Two thirds of the N fertiliser was applied before 1 December but 75% of the increase in pasture production to N fertiliser occurred after 1 December. The application of N fertiliser increased the amount of pasture conserved for the NLS treatment by 700 kg DM/ha. Increasing stocking rate or feeding concentrate had no effect on pasture production.

TABLE 1: Average net herbage accumulation and DM disappearance over the three years of the project.

Treatment	Pasture production (kg DM/ha) 1 June - Nov. 30	1 Dec. - May 31	Total	Rate of DM disappearance (kg DM/cow/day)
LS	7600 (1850)	7570	15170	11.8
NLS	7950 (2550)	8660	16610	12.4
NHS	7860 (1510)	8320	16180	11.5
NMHS	7870 (1680)	8270	16140	11.0
SED	226	245	383	0.2
Significance	NS	***	**	***

() pasture conserved. kg DM/ha
Level of significance: ** P<0.01, *** P<0.001.

The average rate of pasture DM disappearance over the year was 0.6 kg/cow/day greater for the NLS compared to the LS treatment and lower (0.5 kg/cow/day) for NMHS than NHS.

The increase in pasture production due to the application of N fertiliser and increase in feed input due to meal feeding resulted in increased milk, fat, protein and MS production (Table 2). The feed inputs had little effect on milk composition. Comparing the relative responses to N fertiliser (CLS vs. NLS) and meal (NHS vs. NMHS), N fertiliser increased MS production by 2, 4, and 40% and concentrates by 26, 10 and 115% over the calving to Oct. 1, Oct. 1 to Jan 31 and Jan 31 to drying off periods respectively. The feeding of meal resulted in an increase in MS production/cow/day over each period but the application of N fertiliser had no significant effect on MS production/cow/day (Table 2). Lactation length was increased by 17 days with the application of N fertiliser and by 30 days with meal feeding. During early lactation (calving-Oct. 1) there were 5 more lactation days for the

TABLE 2: Average nitrogen fertiliser and meal inputs, lactation days, milk yield and composition over three dairying seasons (1993/94, 1994/95 and 1995/96) for early (calving to Oct. 1) mid (Oct. 1 to Jan 31) and late (Jan 31 to dry) lactation.

	CLS	NLS	NHS	NMHS	SED	Sig.
Calving to Oct. 1						
N fertiliser (kg N/ha)	0	24	24	24		
Meal (kg/cow)	0	0	0	236		
Lactation days	73	72	69	74		
Milk yield (l/cow)	992	1004	838	1049	41	**
Fat %	5.79	5.87	5.82	5.77	0.07	NS
Protein %	3.99	3.99	3.89	4.02	0.06	NS
Fat yield (kg/cow)	57	59	49	61	2.6	*
Protein yield (kg/cow)	40	40	33	42	2	*
Milksolids (kg/cow)	97	99	82	103	4.5	*
Milksolids (kg/cow/day)	1.34	1.38	1.18	1.41	0.03	**
Oct. 1 to Jan. 31						
N fertiliser (kg N/ha)	0	122	122	122		
Meal (kg/cow)	0	0	0	156		
Lactation days	125	125	125	125		
Milk yield (l/cow)	1513	1552	1459	1603	35	*
Fat %	6.22	6.29	6.3	6.28	0.08	NS
Protein %	4.44	4.47	4.45	4.52	0.07	NS
Fat yield (kg/cow)	94	98	92	101	2.4	*
Protein yield (kg/cow)	67	69	65	72	1.8	**
Milksolids (kg/cow)	161	167	157	173	4.2	*
Milksolids (kg/cow/day)	1.29	1.33	1.26	1.39	0.03	*
Jan. 31 to dry						
N fertiliser (kg N/ha)	0	0	0	0		
Meal (kg/cow)	0	0	0	177		
Lactation days	61	79	46	76		
Milk yield (l/cow)	449	616	290	600	64	**
Fat %	6.82	7.19	7.07	7.09	0.09	*
Protein %	4.88	4.83	4.8	4.94	0.08	NS
Fat yield (kg/cow)	31	44	21	43	4.4	**
Protein yield (kg/cow)	22	30	14	30	3.1	**
Milksolids (kg/cow)	53	74	34	73	7.6	**
Milksolids (kg/cow/day)	0.87	0.96	0.79	0.96	0.09	NS
Total						
N fertiliser (kg N/ha)	0	146	146	146		
Meal (kg/cow)	0	0	0	569		
Lactation days	259	276	240	275		
Milk yield (l/cow)	2954	3172	2587	3252	58	***
Fat %	6.17	6.33	6.23	6.27	0.04	NS
Protein %	4.35	4.39	4.31	4.43	0.03	NS
Fat yield (kg/cow)	182	201	161	204	3.5	***
Protein yield (kg/cow)	129	139	111	144	3	***
Milksolids (kg/cow)	310	340	272	348	6.5	***

Level of significance: * P<0.05, ** P<0.01, *** P<0.001.

NMHS than the NHS herd. Compared with the NMHS herd, the NHS herd had fewer cows cycling (P<0.05) at the commencement of mating and a lower conception to first insemination. The reason for the poorer reproductive performance of the NHS herd was possibly due to underfeeding in early lactation, because from calving to early September, the NHS herd consumed only 8 kg DM/cow/day. With the tighter calving and the extended lactation at the end of the season, meal feeding increased lactation length in total by 35 days.

DISCUSSION

The response in milksolids production to both N fertiliser and concentrate feeding is attributed in part, to an increase in production/cow/day but in the main to an increase in lactation length (Table 2). N fertiliser had no significant effect on daily MS production but feeding meal increased daily MS production throughout the season. All of the N fertiliser and 70% of the meal was put into the systems before January 31, but from February 1 to drying off, 70% of the MS response to N fertiliser and 50% of the response to meal feeding occurred. The responsiveness in the later part of the season to additional N fertiliser was due to two factors:

1, 70% of the increase in pasture production occurring during summer and autumn
2, the conservation of an additional 192 kg DM/cow of silage (Table 1) fed out over January to March at 3-5 kg DM/cow/day.

From information presented in Table 1 on silage made and the average rate of DM disappearance it was calculated that 97% of the response to the additional N fertiliser was utilised as either pasture conserved (0.7 t DM/ha) or increased pasture consumption (0.7 t DM/ha). From the increased feed supply an additional 108 kg MS/ha resulted giving an overall utilisation of 1 kg MS for every extra 13.3 kg DM from N fertiliser boosted pasture, or, 0.73 kg MS/kg N fertiliser applied. The initial application of 100 kg N/ha reported by Thomson *et al.*, (1991) gave a response of 0.65 kg MS/kg of N fertiliser applied. Which shows the MS response to the extra 146 kg N/ha was similar to the initial 100 kg N/ha. The MS response to N fertiliser was greater than responses to additional pasture or pasture supplements fed in early lactation (Bryant and Trigg, 1982), mid and late lactation (Wilson and Davey, 1982) or the total MS response to feeding pasture silage in either early, mid or late lactation Clark (1993). The pasture and MS response to N fertiliser were of similar magnitude to those reported by Penno, *et al.*, (1996).

The feeding of 569 kg of meal/cow increased MS production by 76 kg/cow giving a response efficiency of 134 g MS/kg meal fed. This response was considerably greater than reported by Rogers (1985), Kelloway and Porta (1993) or by Penno *et al.*, (1996). The reason for the greater response to concentrate feeding was in part due to the very early calving (June 20) and the level of underfeeding experienced in early lactation and, to the relatively small amount and strategic manner to which meal was fed throughout lactation. Grainger and Mathews (1989) report an increased response to concentrate feeding at low pasture allowances. In the farm systems study reported by Penno *et al.*, (1996) the amount of feed purchased off-farm for herd 6 (HS herd receiving 200 kg N fertiliser/ha) averaged, 1180 kg DM/cow. For this herd the response efficiency was 90 g MS/kg extra DM fed. A response similar to that reported by Kelloway and Porta (1993) for concentrates fed for a short period but evaluated over the whole lactation.

The information presented by Grainger and Mathews (1989) suggests the effectiveness of any feed input within dairying systems was governed by the level to which the existing pasture was utilised. In this trial pasture utilisation was maintained for all farmlets at a level similar to the CLS farmlet by modifying two farm management practices, the level of pasture conservation and drying off date. The responses achieved were possibly near the physiological limit of the cow to respond to concentrates and would be only achievable on commercial dairies where constant pasture monitoring, feed planning, and intensive pasture utilisation was practised. The use of feed budgets for making drying off decisions was essential to achieving the increases in MS production reported as the major proportion of the response was due to a longer lactation.

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