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Effect of nitrogen fertiliser and supplements on pasture production and milksolids yield from dairy farm systems

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ABSTRACT

Seven farmlets of 6.48 ha grazed by Friesian cows at stocking rates of either 3.24 or 4.48 cows/ha were used to evaluate the effect of high rates of nitrogen fertiliser (N) and rolled maize grain on milksolids (MS) production. Annual applications of 213 and 379 kg N/ha increased annual net herbage accumulation by 3350 and 4650 kg DM/ha respectively. At 3.24 cows/ha extra DM resulted in a three fold increase in pasture conservation, providing silage for use in late lactation, and increasing production by 72 kg MS/cow. The extra pasture reduced the amount of supplement required at 4.48 cows/ha. Offering supplementary feed when cows were over grazing or being under fed resulted in an extra 43g milkfat and 47g milk protein/kg DM at the low stocking rate and 45g milkfat and 36g milk protein/kg DM at the high stocking rate. Responses to extra feed were greatest when used to extend lactation. Increased stocking rates will be necessary to maintain pasture utilisation when large amounts of extra feed are introduced.

Keywords: nitrogen fertiliser; supplementary feeding; pasture; milk production.

INTRODUCTION

High output of milksolids (MS) per hectare is critical to the profitability of dairy farms in New Zealand. Farm systems have evolved which cope with a low and reducing real return for dairy products by becoming more efficient. This has primarily required increased output of milk per unit of land and per labour unit. While mechanisation has allowed large advances in the efficiency of labour use, increased output of MS per unit of land has been restricted by pasture production (Bryant, 1990).

The DRC No 2 Dairy has been involved in continuous research on dairy farm systems since 1945. Output of milksolids per hectare increased from 475 kg/ha in 1945-55 to 980 kgMS/ha in 1968-78. During this period, pasture production was increased by drainage, establishing ryegrass/ white clover pastures, and obtaining optimum soil fertility. Increases in milksolids production per hectare resulted from increasing stocking rates to achieve high rates of pasture utilisation. However, the only substantial lift in the output of milksolids at the DRC No 2 Dairy since 1978 was achieved by grazing replacement heifers off the experimental area (Bryant, 1993). The limiting factor has been annual pasture production. The annual net herbage accumulation of the DRC No 2 Dairy has averaged 15.7 t DM/ ha (14.0 - 17.7 t DM/ha) with no recent upward trend.

New Zealand's leading dairy farmers now require new technology to allow further increases in MS output (Bryant, 1993). Data of Holmes (1982), Bryant *et al.*, (1982) and Thomson *et al.*, (1991) suggest that high rates of nitrogen fertiliser (N) may be profitable at current prices. The use of concentrate supplements has been evaluated in many short term experiments (Kellaway and Porta, 1993), but in few systems trials. The trial reported in this manuscript was initiated to examine the technology necessary to achieve a 30 - 40% increase in output of MS per ha (Bryant, 1993).

MATERIALS AND METHODS

A detailed description of the trial design was given by Harris *et al.*, (1994). Seven farmlets of 6.48 ha were established on the DRC No 2 Dairy 1 June 1993 and stocked with Friesian cows of high genetic merit. Experimental details are contained in Table 1. The low stocking rate (3.24 cows/ ha) was used to investigate the potential of extra feed to increase per cow production. Farmlets 5, 6, and 7 provided information on the increase in productivity when a high stocking rate (4.48 cows/ha) was adopted to utilise additional feed. Target N application rates were 0, 200, and 400 kg N/ha/year at each stocking rate. Purchased supplements were available to all herds, other than the control, and were offered when cows were being underfed (<15 kg DM/cow), or grazing below a post grazing herbage mass thought to impair pasture regrowth (<1800 kg DM/ha). Rolled maize grain was available as a concentrate supplement up to a maximum daily intake of 8 kg DM/cow. Pasture silage produced on a Farmlet was available within that system, but was also purchased if necessary when daily supplementary feed intake exceeded 8 kg DM/cow.

Milk yield and composition was measured each week by herd test; liveweight and condition score were meas-

TABLE 1: Experimental details of Farmlets at the DRC No 2 Dairy

Farmlet	Stocking Rate (cows/Ha)	Nitrogen fertiliser (Kg N/ha)	Bought in Supplement
1	3.24	0	No
2	3.24	0	Yes
3	3.24	200	Yes
4	3.24	400	Yes
5	4.48	0	Yes
6	4.48	200	Yes
7	4.48	400	Yes

ured every 2 weeks after the AM milking. Net herbage accumulation was calculated as the increase in herbage mass on ungrazed paddocks, as determined by weekly calibrated eye assessment. Data are presented as the mean of the 1993-94 and 1994-95 seasons.

RESULTS

The use of N increased net herbage accumulation (Table 2). Applying 213 kg N/ha/year on Farmlets 2 and 6 increased net herbage accumulation by 3350 kg DM/ha (21%), whereas 379 kg N/ha/year on Farmlets 4 and 7 increased it by 4550 kg DM/ha (29%). The average response to N at the low and high application rates was 15.5 and 12.0 kg DM/kg N respectively. Pasture responses to N were extremely seasonal, with 25% of the extra pasture being produced from 1 June to 31 August, and 43% between 1 September and 30 November.

At the low stocking rate, the increases in pasture production increased the amount of surplus pasture conserved as silage in spring. On Farmlets 3 and 4, this additional silage was almost sufficient to meet their total supplementary feed requirements. The other herds all consumed large quantities of bought in supplement, particularly at the high stocking rate. At each stocking rate, the use of supplements decreased with increasing pasture production resulting from increased application rates of N.

At the low stocking rate, extra pasture production and supplementary feed, allowed an increase in annual MS production of up to 72 kgMS/cow (Table 3), mostly achieved after 31 December. Despite the availability of large amounts of extra feed through the spring, the accumulated MS production of Farmlets 2, 3, and 4 was only 7% higher than the control herd at 31 December. After 1 January, the availability of extra feed allowed MS production per cow to be increased by 49%. Much of the extra production per cow can be attributed to additional days in milk. The treatment herds were milked for 288 days, compared to 252 days for cows in the control herd. At the high stocking rate, the availability of extra feed allowed MS production per cow to be maintained, so that the output of milksolids was increased by 696 kg MS/ha (62%).

DISCUSSION

Increasing feed supply by 1670 kg DM/ha at the lower stocking rate increased production by 176 kg MS/ha primarily due to extending lactation length by 37 days (Farmlet 2). Increasing feed supply by a further 2440 kg DM/ha and offering extra feed throughout the season, only increased MS production by a further 44 kg MS/ha (Farmlets 3 and 4). In contrast, increasing the annual feed supply from 15.9 t DM/ha to 25.1 t DM/ha increased MS output by 658 kg MS/ha (59%) when stocking rate was

TABLE 2: Average seasonal and annual net herbage accumulation (kg DM/ha), annual nitrogen fertiliser application rates (kg N/ha), and the response to N for each Farmlet system (kg DM/kg N) for the two years of the trial.

Farmlet	1	2	3	4	5	6	7
Jun - Aug	2467	2072	3219	3626	2264	3095	3201
Sep - Nov	6411	6374	7573	9025	6456	7749	8558
Dec - Feb	5640	5346	6061	6492	5681	6616	6255
Mar - May	1345	1605	1893	1895	2001	2496	2292
Total	15862	15396	18746	21037	16402	19955	20305
Extra pasture			3117	5408		3554	3903
Annual N application			216	381		209	377
N Response			14	14		17	10

TABLE 3: Average annual supplementary feed use, N application rates, silage conservation, and milk production and cow condition data for the two years of the trial.

Herd	1	2	3	4	5	6	7
Stocking rate	3.24	3.24	3.24	3.24	4.48	4.48	4.48
Nitrogen Kg N/ha	0	0	216	381	0	209	377
Silage made (kg DM/cow)	166	91	370	458	0	33	50
Silage fed (kg DM/cow)	150	201	310	320	276	253	248
Grain fed (kg DM/cow)	0	548	139	105	1460	1043	958
Total Supplement (kg DM/cow)	150	749	449	425	1736	1296	1206
Days in milk	252	289	287	289	290	286	288
Production before 31 January							
Milkfat (kg/cow)	139	138	148	151	130	138	141
Milk protein (kg/cow)	105	111	114	120	103	109	110
Production after 31 January							
Milkfat (kg/cow)	61	88	87	85	88	91	91
Milk protein (kg/cow)	42	64	61	63	62	65	64
Annual production							
Milksolids (kgMS/cow)	346	401	410	418	383	403	406
Milksolids (kgMS/ha)	1122	1298	1328	1355	1717	1807	1818
Cow condition (31 May)	4.4	4.5	4.6	4.6	5.1	5.0	5.0

increased by 38% (Farmlets, 5, 6, & 7).

Total response to supplementary feed at the low stocking the rate was 43g milkfat and 47g milk protein/kg DM (Farmlet 2), and 45g milkfat and 36g milk protein/kg DM at the high stocking rate (Farmlet 5). The milksolids response to supplementary feed was consistent between years. Although unmeasured, it would be reasonable to assume the responses to the additional pasture would be less than the response to maize grain. In a similar trial Fraser and Leaver (1988) demonstrated a response of 62g milkfat and 56g milk protein/kg DM when a herd stocked at 2.62 cows/ha was offered 2.2t concentrates/cow was compared to a second herd stocked at 2.13 cows/ha and only offered 0.9t concentrate/cow. Further, a recent trial run at Waimate West in Taranaki measured an annual responses of 132g MS/kg concentrates offered (McCallum *et al.*, 1995). Both trials demonstrated substantially higher responses to additional feed than this experiment.

Large responses in annual MS production to supplements may be achieved if extra feed is used to increase stocking rate, because more pasture may be utilised when it is plentiful. The high concentrate herd reported by Fraser and Leaver (1988) consumed 5% more pasture than the lower stocked low concentrate group. Additional production resulting from increased pasture utilisation is attributed to the use of concentrates. This effect has also been demonstrated on four commercial farms in Victoria where using concentrates and increasing stocking rates achieved a response of 120 g MS/kg DM (Australian Dairy Corporation, 1987). No increase in pasture utilisation was observed in the current work because the control Farmlet was selected to be the optimum stocking rate at the DRC No 2 Dairy under a low input system (Bryant, 1993), and therefore was already achieving a high level of pasture utilisation.

The response to extra feed declines as pasture allowance increases (Kellaway and Porta, 1993). In the example of Waimate West, an early planed start of calving (20 June) and a high stocking rate (4.3 cows/ha) created the situation where the annual feed requirements were in excess of pasture supply. This was demonstrated by the control herd only producing 279 kg MS/cow (McCallum *et al.*, 1995). While a similar situation was created in the current trial on Farmlet 5, the inputs of supplementary feed were three fold greater than those used at Waimate West, to maintain an adequate DM intake throughout the season.

The poor response to additional feeding in early lactation observed in this trial was contrary to the results of Stockdale and Trigg (1989) which showed the largest response to extra feed would be obtained in early lactation. However, few researchers have evaluated supplements within the farm system. Clark (1993) demonstrated that offering 150 kg DM/cow as silage produced a greater response in autumn than in spring or summer. Thomson and Holmes (1995) also demonstrated large MS responses can be attained by using extra feed to extend lactation. Extra feed offered during a pasture deficit will increase milk production, increase cow condition and increase average herbage mass on the farm through substitution (Penno *et al.*, 1995). Offering additional feed in early lactation may only produce a short term effect. Extra herbage mass, and cow condition is of limited value at a time when pasture supply is increasing. In converse, in autumn spared pasture and extra cow condition is likely to be of benefit when pasture supply is declining.

CONCLUSIONS

Nitrogen fertiliser is an effective way of increasing annual pasture production. The greatest responses to extra feed will be obtained by extending lactation length. Because autumn nitrogen responses can be poor in many dairying regions, surplus spring pasture must be transferred to the autumn as high quality conservation. Once a long lactation is achieved, increased stocking rates are necessary to ensure additional feed is effectively utilised.

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