Dairying intensification; production responses and financial implications

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Abstract

Dexcel established a systems trial in June 2001 to investigate the productivity and future environmental consequences of increasing feed input into pasture-based dairy systems. Feed allocation was designed to achieve an identical comparative-stocking rate (85 kg liveweight/t DM) across the six treatments; intensification was achieved by using nitrogen fertiliser, irrigation, and imported feeds. The feed allowance for the 2002-2003 season varied from trial design (56 – 80 kg LW /t DM), and as the feed allowance per cow increased feed utilisation decreased. Milksolids (MS) production per cow for the 2002 – 2003 season ranged from 362 to 436 kg. Increasing stocking rate coupled with supplementary feeding resulted in a large increase (284%) in milksolids production per hectare (1002 kg MS/ha to 2844 kg MS/ha). Relating milksolids production to the area required to supply the feed greatly reduced the marginal increase relative to the control treatment (133%). Milksolids production per cow was high (430 kg MS/cow) for a low input system (treatment C), and a high input system (436 kg MS/cow) that also had high feed conversion efficiency (treatment E). Milksolids payout has a greater effect on the economic farm surplus as the levels of supplement increased. Sensitivity analysis shows that treatment C is less sensitive to changes in milksolids payment. High input systems D and E are competitive at higher milksolids payout, and these systems are affected less by a payout shift when maize silage cost is held at 18 c/kg DM.

Additional key words: pasture utilisation, milking platform, milksolids efficiency.

Introduction

Productivity gains for a pastoral dairy farm are often measured in terms of increased milk production per hectare. Milksolids (MS) per hectare is the product of cows/ha and MS/cow, and increasing either factor (or both) will increase MS/ha. The latter will only be feasible if more feed per hectare, is provided to avoid the negative relationship between stocking rates and production per cow (McMeekan, 1961). Supplement brought onto the farm will support the high stocking rates needed to achieve high levels of pasture utilisation, as well as high per cow milksolids production and high milksolids output per hectare (Stockdale, 1995).

Farmers have developed a range of dairy production systems suitable to the strategic plan of their farm. Systems range from the traditional low input (self contained), to grazing dry stock off, increasing feed grown on farm (e.g. by using irrigation and nitrogen fertiliser), and to importing feed grown off-farm. These variations from the low input self-contained system have developed because:

1. Marginal returns on extra milk are greater than marginal cost of extra feed
2. They allow more profitable use of existing land, cows, plant, and labour
3. They do not incur the risk / cost associated with buying more land.

Milksolids output from a pastoral dairy system is underpinned by pasture yield. Supplement input to a system can be used to control pasture residuals and maintain pasture conditions for optimal growth (Van der Poel, 1997). Additional to the effects on the pasture itself, Deane (1999) maintained that a high stocking rate (SR) (i.e. high feed utilisation) and longer lactation would allow high responses from supplements to be achieved. Supplements can increase the total farm feed supply, and prevent periods of underfeeding of the cows, which would otherwise have been caused by the higher stocking rate. This relates to the effect of supplements on the whole farm system. The MS per cow response can be optimised by high breeding worth cows, which are more effective at converting extra feed into milksolids (Van der Poel, 1997).

There is no single factor that will define a successful system, but rather system components that will interact synergistically. The Resource Efficient Dairying trial was designed to monitor the impact of components on the system as a whole. With particular emphasis on system productivity and environmental consequences of increasing feed inputs into a pastoral based dairy system.

Materials and Methods

Experimental farmlets are located at Scott farm (Dexcel Research Farm), Newstead, Hamilton. Treatment design is based on achieving the same comparative stocking rate (85kg liveweight/t DM). System productivity has been defined to be optimised at this level (Speight, 2002). Feed inputs and stocking rate per hectare are shown in Table 1. The comparative stocking rate is based on an average liveweight of 500kg/cow multiplied by the cows/ha then divided by the total feed provision (Speight, 2002). Treatment C has the replacement heifers grazed on the farmlet; 2.33 cows/ha @500kg, 0.44 heifers/ha @ 300kg =1279 kg LWT/15 tDM = 85 kg LWT/t DM. Treatment herd size is 21 Holstein-Friesian cows, and 200 kg N/ha was applied annually (excluding the low input treatment C).

Treatment herds were established on 1st June 2001, and cows were balanced for age, expected calving date, liveweight, condition score, breeding worth and somatic cell count. Culling is based on 25% replacements entering each herd per year. Treatment B has a standoff pad that is utilised in late winter, early spring. The objective of the standoff pad is to decrease nitrate leaching from the farmlet paddocks, as well as to minimise pugging damage (i.e. protection of the soil structure).

Pasture mass is visually assessed weekly, and calibrated against actual mass. Calibration is achieved from ten quadrats (each 0.2 m^2), four post-grazing and six pre-grazing. The quadrats are cut to ground level with an electric handpiece, washed and oven dried for 48 hours at 105^0 C. Pasture and supplement is sub-sampled for feed quality analysis by near infrared spectrometry (NIRS). Pasture is also sampled quarterly (January, April, July and October) for botanical dissection into perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*), other species and dead matter.

Weekly herd testing (am and pm milking) determines yields of milk and milksolids per cow (milk yield, fat %, protein %). The production per hectare is based on the MS/cow multiplied by the stocking rate of lactating cows. Adding the area required to grow the maize silage and the soy meal that is fed (tonnes per herd) to the grazed area (i.e. the farmlet), gives the total area required to produce the effective milksolids per hectare. Milksolids production for this area is calculated from the total area (farmlet plus cropped area) divided by herd size.

Cow liveweight and condition score are measured fortnightly at a morning milking. Cow health is closely monitored throughout the trial, and a proactive animal husbandry policy is applied across all herds (e.g. in-line dispensing of bloat oil and zinc for prevention of bloat and facial eczema in the critical periods). For the supplemented herds a ration-balancing model based on NRC data (NRC, 1987) is used to ensure that cows are offered appropriate mineral and protein supplements to complement the maize silage input. The only herd to receive a protein supplement is treatment F.

Table 1. Trial design, cow numbers and predicted feed inputs to achieve intensification with a common comparative stocking rate (85 kg LW/t DM).

FARMLET (Treatment)	Feed supply (tonnes DM/ha) Pasture	Supplement	Area (ha)	SR (cows/ha)
A (CONTROL)	17.5		7	3.0
B (Standoff)	17.5		7	3.0
C (Low input)	15.0		9	2.6
D (Supplemented)	17.5	5 MSil	5	3.8
E (Supplemented)	20.5	10 MSil	4	5.2
F (Supplemented)	20.5	15 MSil + 5 S	3	6.9

MSil = maize silage. S = soybean meal. SR = stocking rate is the herd size divided by the farmlet area. E and F farmlets are irrigated during periods of water deficit.

Results

The results are based on the first full year of data (2002 – 2003) from this trial. Annual herbage accumulation ranged from 23,900 to 20,000 kg DM/ha (treatment E and C respectively), and the herbage allowance per cow ranged from 7,725 to 3,228 kg DM/cow (treatment C and F respectively). Visual estimation of pasture mass is a reliable method, but this systems trial imposes the added complexity of scoring paddocks with contrasting pasture composition. It is probable that the pasture mass that was recorded is higher than that actually grown. For this reason it is not possible to define the yield increments that were obtained from the nitrogen and irrigation applications. There were no significant differences in the herbage concentrations of energy, and crude protein between the stocking rates used (2.6 – 7.0 cows/ha). The swards of treatments C, D, E, and F generally contained a higher proportion of white clover (*Trifolium repens*) (Fig. 1), which would be expected to increase their feeding value (Harris *et al.*, 1997).

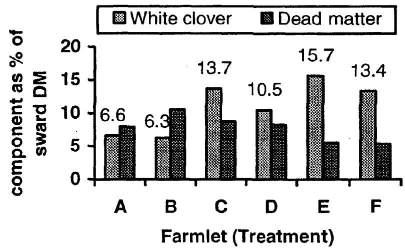

Figure 1. White clover and dead matter contents (% of DM), mean for 2002 - 2003 season.

Milk production

Total seasons milksolids (MS) production varied from 362 to 436 kg MS/cow and MS/ha ranged from 1002 – 2844 kg (Table 2). The range is reduced when the area providing the supplementary feed is allowed for (1002 – 1518 kg MS/ha).

Table 2. Milk production per hectare related to the area required to provide the feed.

Farmlet (Treatment)	A	B	C	D	E	F
Stocking rate (cows/ha)	3.0	3.0	2.3	3.8	5.2	7.0
Farmlet area (ha)	7.05	7.05	8.24	5.48	4.05	3.05
Maize silage (t DM/herd/year)	0.00	0.00	0.00	26.6	49.5	62.5
Maize silage area (ha) @24t DM/ha	0.00	0.00	0.00	1.11	2.06	2.61
Soybean (t DM/herd/year)	0.00	0.00	0.00	0.00	0.00	4.28
Soybean area (ha) @4t DM /ha	0.00	0.00	0.00	0.00	0.00	1.07
Total area (ha)	7.05	7.05	8.24	6.59	6.11	6.73
Milksolids yield (kg/cow)*	380a	362a	430c	412b	436c	406b
Milksolids yield (kg/ha)	1139	1087	1002	1575	2291	2844
Effective milksolids yield (kg/ha)**	1139	1087	1002	1310	1518	1289
Milksolids (relative to Trt A)(%)	100	95	88	115	133	113

*kg MS/cow SED= 14.9, figures with same letters are not significantly different. Effective milksolids yield (kg/ha)** = MS production / actual area required to feed the herd (grazed pasture + cropped area). Results are related to the control treatment (i.e. A = 100%).

The feed input affected the efficiency of milksolids production (Table 3). Total feed allowance is calculated as the total feed grown, plus supplements fed, minus the supplement conserved. Milksolids per cow divided by kg DM/cow calculates efficiency of MS production from the feed allowance.

The quantity of feed that was required by the cows during the year is calculated from their liveweight and milk production, as shown in Table 4. The total values range from 4.6 to 5.1 t DM/cow, and these are expressed as a percentage of the total feed supplied per cow providing an estimate of feed utilisation.

Table 3. Total annual feed provision and milksolids production.

Farmlet (Treatment)	A	B	C	D	E	F
Pasture grown (kg DM/cow)	7335	7548	7725	5303	4595	3228
Grass silage fed (kg DM/cow)	66	90	66	0	0	0
Maize silage fed (kg DM/cow)	0	0	0	1266	2356	2978
Soybean meal fed (kg DM/cow)	0	0	0	0	0	204
Total feed (kg DM/cow)	7401	7638	7791	6569	6951	6410
Pasture silage conserved (kg DM/cow)	299	207	249	0	0	0
Total feed allowance (kg DM/cow)	7102	7431	7542	6569	6951	6410
Liveweight (kg/cow)	464	478	476	463	486	494
Kg LW/t DM	65.3	64.3	63.1	70.5	69.9	77.1
Kg MS/t DM	54	49	57	63	63	63

Table 4. Calculation of annual energy requirements per cow and their feed utilisation (Energetic values derived from McDonald *et al.*,1995)

FARMLET (TREATMENT)	A	B	C	D	E	F
Liveweight (kg/cow)	464	478	476	463	486	494
Maintenance (MJ ME)/cow	21894	22388	223 18	21859	22668	22948
Gestation (MJ ME)/cow	2520	2520	2520	2520	2520	2520
Milk production (MJ ME)/cow	24700	23530	27950	26780	28340	26390
1 CS* loss/gain (MJ ME)/cow	228	228	228	228	228	228
Total MJ ME/cow	49722	49027	53445	51798	54192	52491
DM requirement kg/cow**	4647	4582	4995	4841	5065	4906
Feed provision (kg DM/cow)	7102	7430	7542	6569	6951	6410
Feed utilisation (%)***	65	62	66	74	73	77

*Energetic cost of mobilising and regaining one condition score (CS).
**Assumes average energy value of pasture to be 10.7 MJ ME/kg DM.
***Pasture utilisation is kg DM/cow required divided by kg DM/cow provided.

Financial evaluation of treatments

Economic farm surplus (EFS) for each treatment is presented in Table 5. Analysis has been done for two values for milk payment, and two values for the cost for maize silage. The maize silage costs were taken from ProfitWatch data (Leslie, 1999) and compares maize silage purchased (24 c/kg DM) with that grown by the dairy farmer on a runoff (18 c/kg DM).

Table 5. Economic farm surplus ($/ha), and return on assets (ROA) of treatments at two maize silage costs and milksolids payouts.

	Farmlet (Treatment)					
	A	B	C	D	E	F
Maize cost 24 c/kg/DM						
$3.50 payout	967	814	1327	637	-68	-2699
ROA (%)	6.2	5.6	7.5	4.6	1.3	-7.9
$4.50 payout	2133	1906	2341	2226	2210	79
ROA (%)	10.4	9.5	11.1	10.9	10.0	1.7
Maize cost 18 c/kg/DM						
$3.50 payout	967	814	1327	928	665	-1468
ROA (%)	6.2	5.6	7.5	5.8	4.1	-3.7
$4.50 payout	2113	1906	2341	2516	2944	1310
ROA (%)	10.4	9.5	11.1	12.1	12.8	5.9

Discussion

The pasture quality measures used in this trial (NIRS, and botanical composition) have not revealed a system (treatment) effect, but there was a trend for high per cow production to be associated with high clover content of the swards. L'Huillier (1987) also reported that pasture digestibility increased as the stocking rate increased because severe defoliation of pasture reduced the fibre content, and increased the proportion of clover in the sward (Stockdale & King, 1980).

These results need to be seen in the context of this trial, it being long-term allowing treatment effects to evolve. In this respect it is accepted that a dramatic effect on the pasture characteristics of a treatment farmlet will not be apparent in one milking season, but will become apparent as treatments affect soil and sward factors that impact on pasture productivity and quality (Greenwood *et al.*, 1997; L'Huillier, 1987).

Treatment C had high milk production per cow, but with the lowest stocking rate of all the treatments it had the lowest milksolids/ha. Of the high input systems (D, E and F), treatment 'E' has the highest production per cow, and also relatively high MS per hectare because of its high stocking rate. Treatment C achieved high per cow MS production due to high pasture allowance per cow, but had low feed conversion efficiency (57 kg MS / t DM). Treatment E achieved high per cow, and per hectare production through supplement input that allowed for efficient use of feed grown on the farmlet (74% feed utilisation), and a high feed conversion efficiency (63kg MS/ t DM).

These findings agree with the relationship proposed by Stockdale (1995) that pasture utilisation rates can be high, and cows may be well fed with supplement input. For treatment C to obtain the high DM intake required for their level of production a high pasture allowance (70 kg DM/cow/day) of highly digestible pasture (greater than 10 MJ ME/ kg DM) (Kolver & Muller, 1998) would be required, which this treatment achieved as the average pasture mass was consistently above that of the other treatments. Dalley *et al.* (1999) proposed that this would be associated with an increase in pasture residual levels from 1.8t DM/ha to 2.7t DM/ha to change the allowance from 20 to 70 kg DM/cow/day. Feed utilisation for this treatment of 66% supports this relationship.

These results confirm the principles that a low stocking rate will result in high feed allowance per cow, high DM intake (DMI), high milk production per cow, low feed conversion efficiency, low feed utilisation, and low kg MS/ha (Macdonald *et al.,* 2001). When the stocking rate is increased by the use of imported feeds to supplement the pasture feed resource, DMI and milk production per cow can still be high, but feed conversion efficiency and utilisation will be increased, and result in high kg MS/ha.

A shift in the milksolids payout has a greater effect on the EFS as the levels of supplement increased. Sensitivity analysis showed that the low input system (treatment C) is less sensitive to changes in milksolids payment. High input systems, D and E are competitive at higher milksolids payout, and these systems are affected less by a payout shift when maize silage cost is held at 18 c/kg DM. Return on assets analysis, which was based on a land value of $18,000 per ha follows the same trend as for system EFS. However, if the land value is increased to $37,000 per ha the high input treatment stocked at 5.3 cows/ha shows a higher return in all but one instance (i.e. $3.50/kg MS, and maize costed at 24c/kg DM). Effectively this is comparing system profitability when the base feed resource increases in cost from 6c/kg DM to 11c/kg DM (i.e. land value of $18,000 and $37,000 per ha respectively).

Summary

This long-term trial is designed to identify the future environmental consequences of a range of dairy systems, and to monitor their productive and financial performance. The management of these treatments is effective, generating a wide range in annual milksolids production capability, and an even wider range in production per hectare due to the large range in feed imported to the milking platform. When these aspects are related to the

efficiency of milk production in relation to physical performance, treatment E is consistently high. The low input treatment (C) is a low risk system in relation to financial performance.

These systems are operating across divergent farming philosophies, and market signals may indicate customer preferences. The decision by farmers to adopt a particular system will relate to their personal perspective on environmental issues and to the economic evaluation of the system. While the economic evaluation is based only on one seasons data there are sound economic principles evident.

Intensifying dairy systems with more cows/ha and more maize silage can increase production up to 3000 kg MS/ha on the milking platform. When the area used to grow the maize is included, the production per hectare of intensive systems was increased by additional maize silage input (+ 379 kg MS/ha). However, within the cost/return relationships analysed diminishing returns occurred by intensifying above 5.2 cows/ha and 10 t DM maize silage /ha. The profitability of these systems depended on the payout, base feed value, and the cost of maize silage.

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