Improving performance within feed-to-yield systems

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and

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FOREWORD

The efficient use of resources is of critical importance to a farm's economic and environmental sustainability. Purchased feed is the biggest single cost on most Northern Ireland dairy farms as well as being the main source of phosphorus. Purchased feed also accounts for around 18% of the greenhouse gas emissions of dairy farms (on a CO_2e basis). A "feed-to-yield" approach seeks to bring increased precision to feeding systems and many Northern Ireland dairy farms have adopted this technology.

It was with this in mind that AgriSearch with support from the Department of Agriculture, Environment and Rural Affairs through the Research Challenge Fund commissioned a study involving 30 commercial dairy farms from across Northern Ireland who are operating feed-to-yield systems. A wide range of data was collected from these farms over two years. On behalf of AgriSearch I would like to thank the farms for their participation in this study.

In addition a second research project (also co-funded by DAERA) was commissioned at AFBI Hillsborough which looked in greater detail at strategies to improve individual cow management within feed-to-yield systems.

Jason Rankin
General Manager
AgriSearch

Concentrate feeding systems which involve a feed-to-yield approach are now common on many Northern Ireland dairy farms. This booklet presents results from a number of studies which were undertaken to improve our understanding of these systems.

Part 1

In the first study (Part 1) data were collected from 31 local dairy farms over a 12 month period. On all farms cows were offered a 'basal diet', and additional concentrates were then offered on a feed-to-yield basis.

Most participating farmers adopted a feed rate of 0.45 kg concentrate/kg milk produced above what the basal ration supported.

As concentrate intakes increased, total dry matter intake also increased. However, silage intakes stayed relatively constant across a wide range of concentrate levels (and did not fall off as might have been expected at higher concentrate levels). This broadly supports the assumption that the maintenance plus value assigned to the 'basal diet' is appropriate across a wide range of milk yields.

Milk yields showed a linear increase with increasing concentrate levels, although in reality it was concentrate levels that were 'following' milk yield.

Milk fat % decreased with increasing concentrate levels. Part of this decrease can be explained by a reduction in genetic merit for milk fat %. However, it appears that part was also due to diet.

Milk protein % was not affected by concentrate level during the winter, but did fall at higher concentrate levels during the grazing season.

Fertility performance did not differ between cows offered 'low' or 'high' levels of concentrates.

The amount of concentrates offered per kg milk produced increased at higher concentrate levels, indicating a greater reliance on concentrates at these levels (poorer concentrate use efficiency). This will also have increased farm phosphorus surpluses.

At higher concentrate levels, the value of each kg of milk produced decreased due to the fall in milk fat content. Nevertheless, margin-over-feed costs (£/cow/day) continued to increase at higher concentrate levels, although this increase was very small when milk price was low.

The marginal economic benefit of offering each additional kg of concentrate decreased at higher concentrate levels. When milk prices were very low, the benefit was almost non-existent, and challenges the concept of 'chasing extra litres' at low milk prices.

However, when milk price is high, the highest yielding cows on the study continued to show an economic response to concentrate levels of 17 - 18 kg/cow/day. However, at those and higher concentrate levels, cows move close to a 'metabolic tipping point', with a very real risk of rumen problems unless rations are carefully balanced. In addition it becomes very difficult to meet environmental regulations, especially in relation to phosuphorus, at these high concentrate levels.

The on-farm study also demonstrated the importance of regular calibration of concentrate feeding systems. When feeders on a sub-group of farms were checked, some farms were overfeeding/underfeeding by up to 15% due to feeder inaccuracies.

Part 2

In the second part of the project two feeding studies were conducted at AFBI Hillsborough.

In the first study cows were offered either a 'high' or 'medium' feed value silage, and supplemented with concentrates on a feed-to-yield basis.

As expected, silage intakes were higher, and total intakes tended to be higher with the high feed value silage. Milk protein content was also higher. However, this study was specifically designed to examine the effects of silage quality and concentrate level at an individual cow level.

The results with both silage types were fully aligned with those from the on-farm study. Total dry matter intake continued to increase with increasing concentrate level, while silage dry matter intakes did not decrease with increasing concentrate level.

Milk yield showed a linear increase to concentrate feeding (although in reality concentrates ‘followed’ milk yield). While milk fat content was relatively unaffected by concentrate level (as was observed on some farms in part 1), milk protein content tended to decrease at high concentrate levels, especially with the ‘medium’ feed value silage.

Despite the effects on milk composition not being as large as those observed in the on-farm project, the rate of increase in margin-over-feed costs slowed at higher concentrate levels. This was due in part to poorer milk quality, and to the increasing cost of each kg of the diet with increasing concentrate levels.

This study supports the findings of the on-farm study in demonstrating the need for caution at higher concentrate levels, especially when milk price is low.

The second study examined if individual cow management could be improved within feed-to-yield systems. This study involved three different feed-to-yield approaches. One of these was a ‘conventional’ feed-to-yield system with extra concentrates offered on the basis of milk yield of each cow. With the second strategy, the quantity of concentrates offered was adjusted according to both the milk yield and milk composition of each individual cow. With the third strategy, the quantity of concentrates offered was adjusted according to the milk yield, milk composition and intakes of each cow.

However, adjusting concentrate levels according to milk yield, milk composition and intakes resulted in higher concentrate intakes, but had no effect on total dry matter intakes. While milk yields were not increased, milk protein content increased, reflecting the higher concentrate intakes.

The efficiency of concentrate use was reduced when the concentrate levels were adjusted according to milk yield, milk composition and intakes.

This part of the project also examined the potential of some ‘wearable technologies’ to predict energy balance of individual cows. While this was unsuccessful, this booklet describes some technologies which are currently being developed for use on dairy farms.

The project also examined the potential of mid-infrared spectroscopy (MIR) to predict the energy balance of individual cows. While this work is still ongoing with a larger data set, this technique looks very promising as a method by which to gain a better understanding of the cow.

BACKGROUND

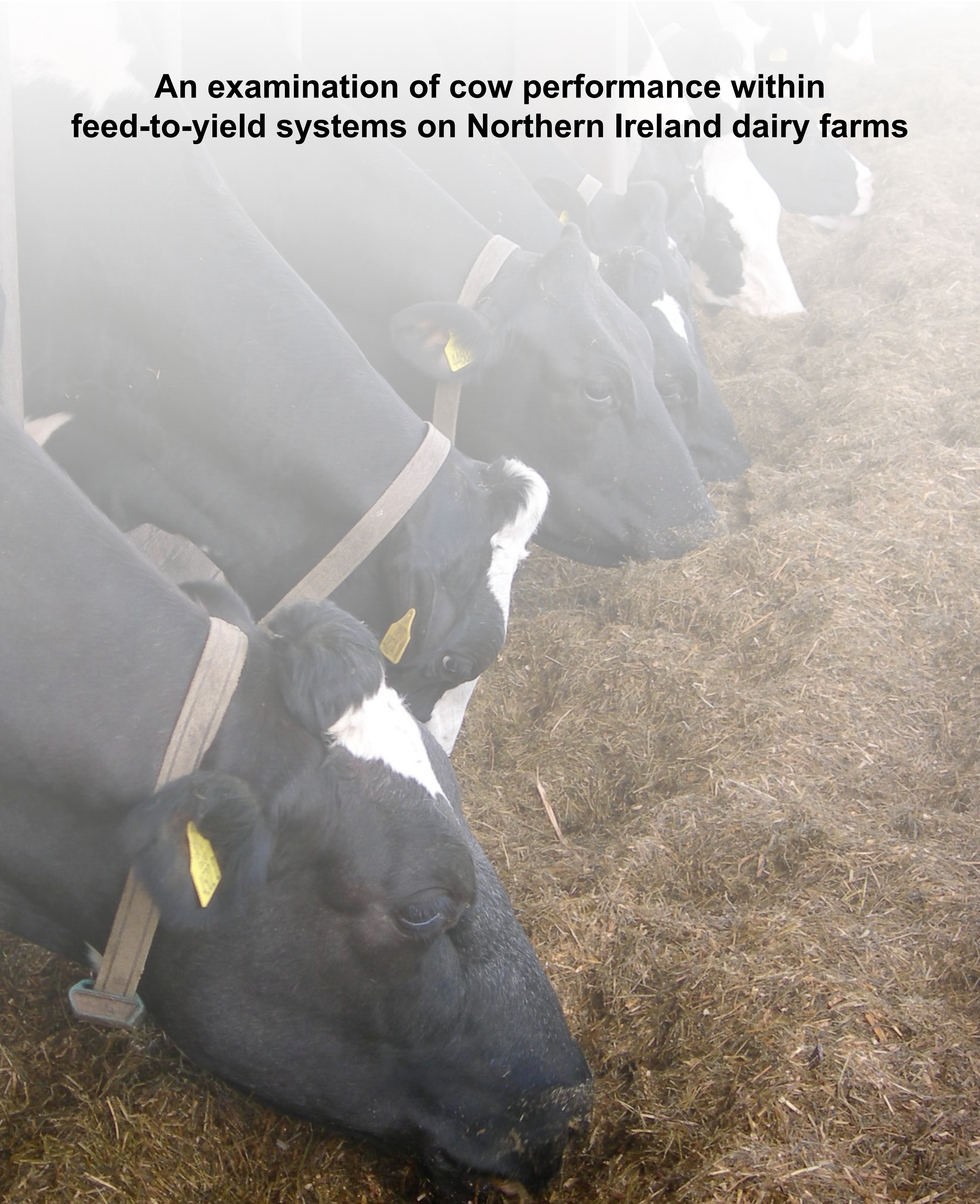
Over the last two decades concentrate feed levels have increased on Northern Ireland dairy farms. However, the efficiency with which concentrates are used on farms is extremely variable, and given that concentrates comprise 60-70% of the variable costs of milk production (CAFRE Benchmarking data), low concentrate use efficiency reduces margins. In addition, inefficient use of concentrates can have a negative environmental impact, especially in relation to phosphorus. Consequently there is considerable pressure to increase the efficiency with which concentrates are used on farms.

Previous studies at AFBI compared a group feeding approach (complete diet feeding) with a feed-to-yield approach. A feed-to-yield approach seeks to bring increased precision to feeding systems by offering more concentrates to higher yielding cows and offering less concentrates to lower yielding cows. However, in general, the results of these studies demonstrated that concentrate allocation strategy (complete diet vs feed-to-yield) had little impact on herd performance when total concentrate inputs over the winter were equal. Nevertheless, when data for individual cows were examined, there was a greater range in intakes and milk production with the feed-to-yield system. In addition, there was a reduction in milk fat content (and milk protein content to a lesser extent) at the high concentrate levels in the feed-to-yield system, and this reduced the value of each kg of milk produced. The latter was an important finding given the widespread adoption of feed-to-yield systems on local dairy farms, and the fact that higher yielding cows may be offered in excess of 15 kg concentrate per day. However, it was unclear if the fall in milk composition at higher concentrate levels was due to cow genetics, or due to the effect of diet on the cow's rumen. In addition, it is unknown if a similar reduction in milk composition is observed on commercial farms.

Furthermore, while a feed-to-yield approach may bring some 'precision' to concentrate feeding, many of the assumptions used are based on an 'average cow'. For example, the approach assumes all cows produce milk with the same fat and protein content, and that all cows consume the same quantity of basal ration. Neither assumption is actually true, and this may lead to individual cows being either overfed or underfed.

To address these issues, DAERA and AgriSearch co-funded two projects which focused on providing a better understanding of feed-to-yield systems, and specifically if precision within these systems could be improved. The first of these projects monitored performance on commercial dairy farms around Northern Ireland (Part 1), while the second project was conducted at AFBI Hillsborough and examined options to improve individual cow management (Part 2).

An examination of cow performance within feed-to-yield systems on Northern Ireland dairy farms



Background: Feed-to-yield concentrate allocation systems are now common-place on local dairy farms, and most modern milking parlours allow a feed-to-yield approach to be adopted using either in-parlour or out-of-parlour feeders. The key principle behind feeding-to-yield is the ability to allow concentrates to be targeted to individual cows according to their milk yields. As a result, these systems have the potential to allow very high levels of concentrates to be offered to individual cows. However, there is no detailed information available on the effects of concentrate levels within feed-to-yield systems on milk yield, milk composition and economic performance. Consequently, this study was undertaken to develop a better understanding of performance within feed-to-yield systems on commercial dairy farms.

The Study: This study was conducted on 31 Northern Ireland dairy farms between August 2018 and August 2019. Participating farms were chosen according to the following criteria:

- Holstein-Friesian herds (18 herds were pedigree registered),
- Herds with a large proportion of cows calving between August 2018 and February 2019,
- Farms with concentrates offered on a feed-to-yield basis,
- Farms with an annual milk yield in excess of 6500 litres,
- Participation in an official milk recording scheme.

Each farm was visited 4-6 times during the course of the study. During each visit silages and concentrates that were being offered were sampled for analysis, and detailed information on feeding practices were collected. Information on milk production and milk composition was obtained from milk recording organisations, with the majority of farms conducting milk recording monthly.

During the week when milk recording was undertaken on each farm, the total concentrate intake for each cow was determined (either from the in-parlour or out-of-parlour feeding system, or based on the feeding assumptions/information from the farm at that time). Total forage intakes were also estimated using intake prediction equations developed by AFBI. In addition, fertility data was recorded by farmers, including, dates of services, pregnancy diagnosis and subsequent calving date.

Data Analysis: Data from the study were divided into two time periods:

- Housed period: for months 2 to 5 of lactation when data was available for all farms (a total of 3,471 cows).
- Grazing period: (May, June and July): during this time only 19 of the farms on the study had cows grazing full-time (a total of 1,556 cows).

During each of the housed and grazing periods data for heifers and cows were examined separately.

Diets offered and feeding systems adopted: The mean composition of the forages offered is summarised in Table 1, with the quality of the grass silages offered generally good. Seventeen of the farms offered an 'alternative forage' (either maize silage or whole crop silage).

On average, the composition (protein and starch content) of the concentrates offered in the basal ration, and through the in-parlour/out-of-parlour feeders (Table 1) were relatively similar.

As expected, the approach to concentrate feeding differed across the farms. On 19 of the farms cows were offered a basal ration containing both forage and concentrate ingredients, prepared using a mixer wagon. On these farms additional concentrates were offered using either an in-parlour feeding system (14 farms) or an out-of-parlour feeding system (1 farm), or both in-parlour and out-of-parlour feeding systems (4 farms).

On the remaining farms cows were offered a 'forage-only' basal ration, with concentrates offered using either an in-parlour feeding system (1 farm) or both in-parlour and out-of-parlour feeding systems (5 farms).

All farms adopted a concentrate 'build-up' period following calving, before moving to a feed-to-yield approach. However, most farms had started offering concentrates on a feed-to-yield basis by day 30 post-calving, although on three farms this did not happen until at least day-60 post-calving (Figure 1).

In addition, the 'feed-rate' settings for the in-parlour or out-of-parlour feeders varied between farms. While the majority of farms used a feed-rate of 0.45 kg concentrate/kg milk, 5 farms used a feed rate lower than 0.45, while 2 farms used a higher feed rate (Figure 2).

Table 1. Mean composition of the forages and concentrates offered across the 26 farms during the housed period.

	Forages			Concentrates	
	Grass silage	Maize silage	Whole crop silage	Offered 'feed-to-yield'	Offered in the 'basal diet'
Oven dry matter (%)	31.9	33.4	39.9		
Crude protein (% DM)	13.9	8.6	8.4	19.3	21.7
Starch (% DM)	0	29.3	24.4	22.8	24.7
Metabolisable energy (MJ/kg DM)	11.3	11.4	10.0		

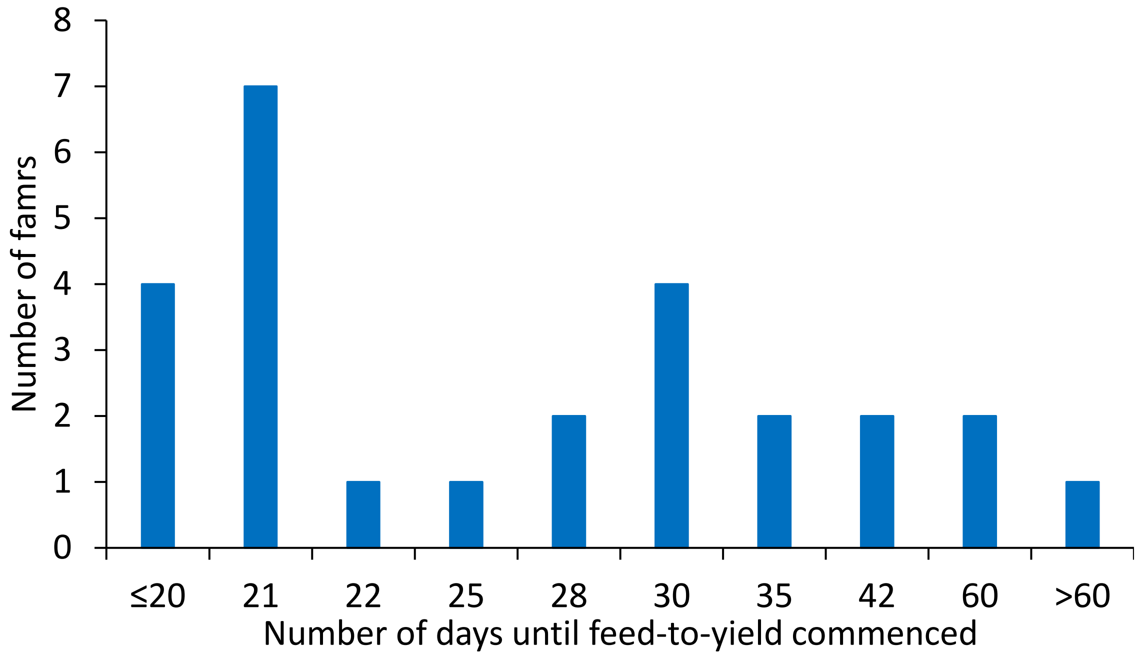


Figure 1. Number of days from calving until farmers started to offer concentrates on a feed-to-yield basis, across the farms.

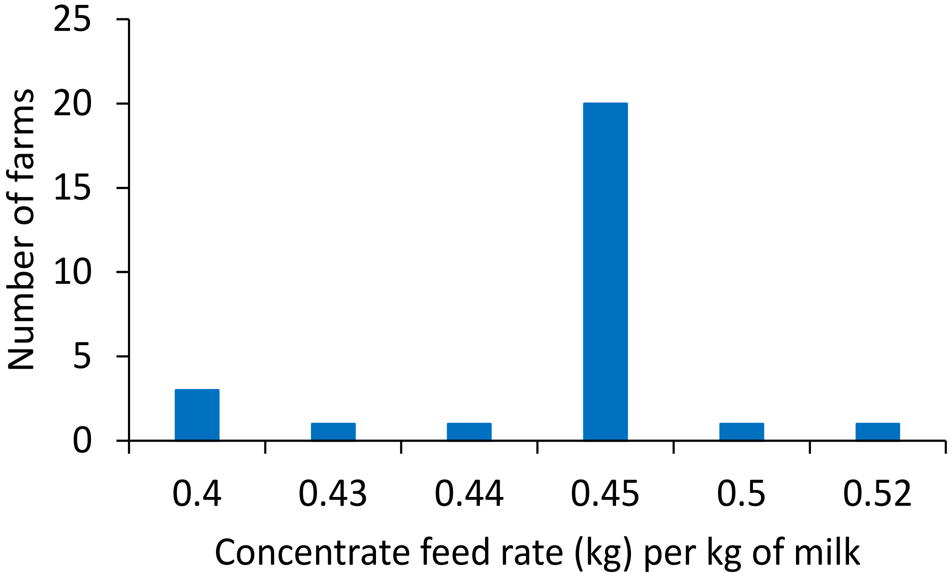


Figure 2. The range of feed-rates (kg concentrate/kg milk) adopted across the farms.

Intakes: As concentrate intakes increased, total dry matter intake also increased, as expected, and as shown in Figures 3a (heifers) and 3b (cows). However, forage intakes showed only a slight decrease with increasing concentrate levels. We would normally expect forage intake to fall off rapidly at higher concentrate levels due to 'substitution' (i.e. cows reducing their forage intake to accommodate the extra concentrates eaten). However, within feed-to-yield systems this does not appear to be the case.

This is explained by the fact that higher yielding cows have a greater overall intake potential than lower yielding cows, and consequently, offering extra concentrates to these higher yielding cows does not dramatically reduce silage intakes. From a practical point of view, the fact that silage DM intake decreased only slightly across the range of concentrate levels examined provides support for a key assumption which is made when cows are managed using a feed-to-yield approach, namely that the 'basal diet' is able to maintain the same level of performance across a wide range of milk yields.

These figures demonstrate another important issue with feed-to-yield systems, namely that the concentrate proportion of the diet increases at higher concentrate levels. For example, with the cows (Figure 3b), at a concentrate intake of 8 kg per day the diet contained 37% concentrate, while at a concentrate intake of 18 kg/day, the diet contained 58% concentrate (DM basis). Similarly, the total diet starch content increased from 12 to 16% (DM basis) across this range of concentrate levels. So higher yielding cows offered high concentrate levels are more likely to experience rumen upset if the ration is not formulated properly.

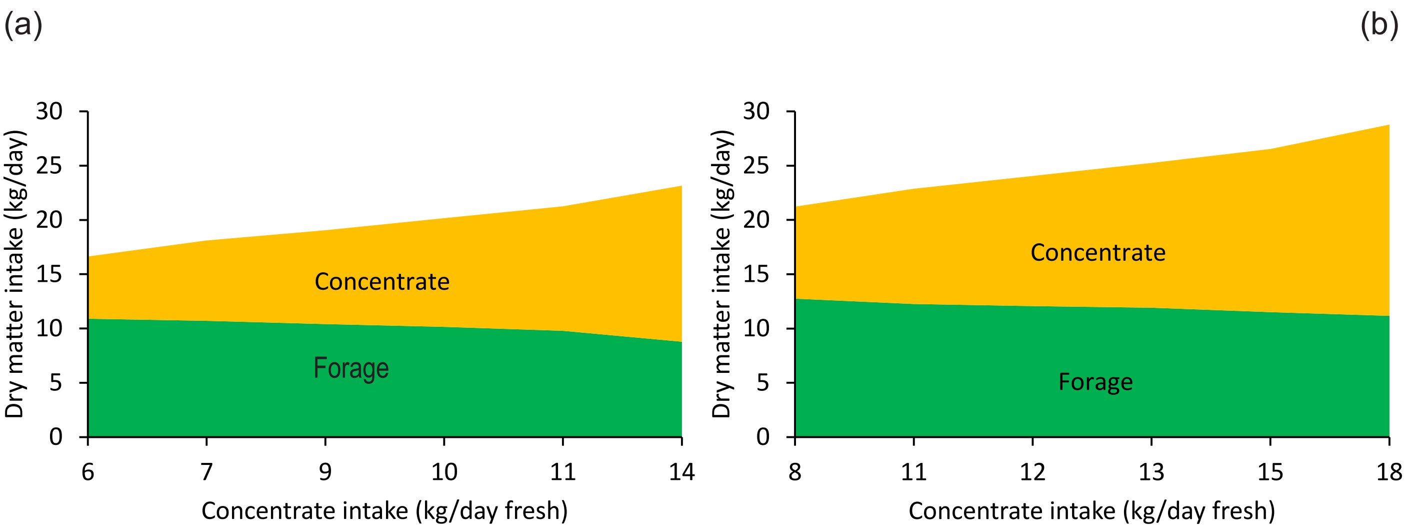


Figure 3. Impact of increasing concentrate intakes on forage and concentrate DM intakes of (a) heifers and (b) cows managed on a feed-to-yield system.

Key Message

Silage intakes stayed relatively constant across a wide range of concentrate levels – this broadly supports the adoption of a single 'Maintenance Plus (M+)' value for cows in a dairy herd offered a common diet (separate values for cows and heifers)

Milk yield: In traditional studies undertaken at AFBI, the milk yield response to additional concentrates began to flatten off at higher concentrate levels. However, within feed-to-yield systems milk yields continue to show a linear increase with increasing concentrate levels in both cows and heifers (Figure 4). This is as expected as the amount of concentrates offered 'follow' the milk yields of the cows. Part of this increase in milk yield can be explained by cow genetics. For example, the mean PTA (Predicted Transmitting Ability) for milk increased from 87 to 266 kg for heifers across the range of concentrate levels examined, while with the cows the mean PTA for milk increased from -52 to 242 kg across the range of concentrates examined. However, genetics explains only part of the differences in yield observed, and it is likely that other factors such as general management, concentrate build-up strategy and differences in forage quality also played a role.

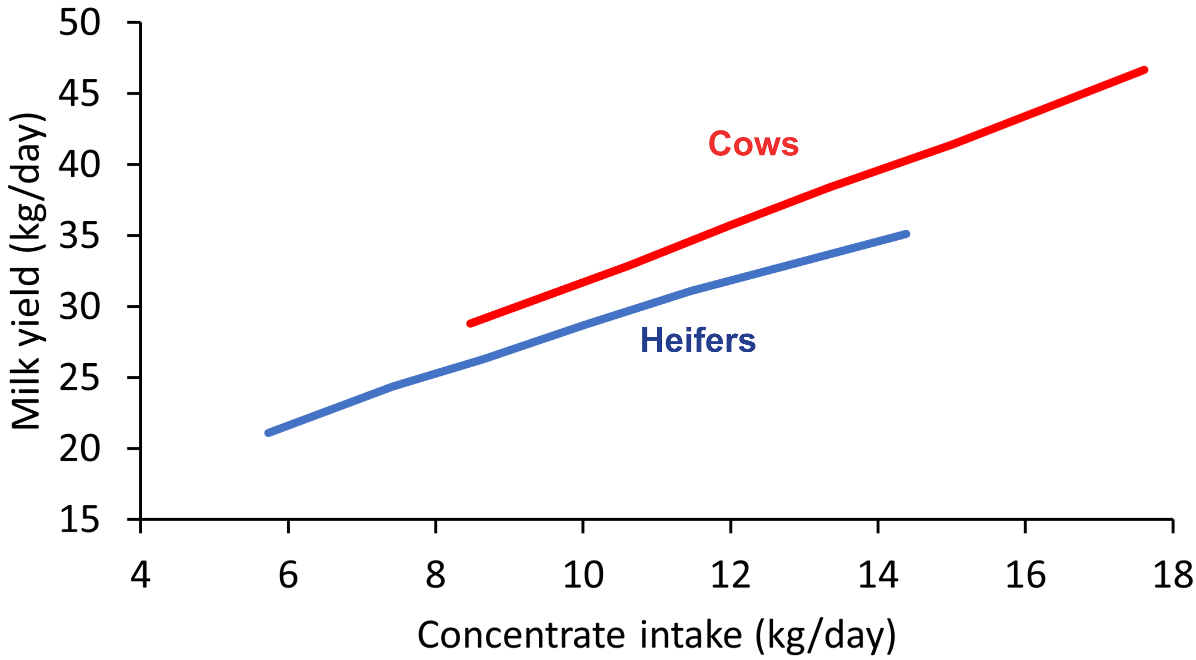


Figure 4. Relationship between concentrate intake and milk yield when concentrates are offered on a feed-to-yield basis

Milk composition: One of the key objectives of this study was to examine the effects of increasing concentrate levels on milk composition. Figure 5 clearly shows that as concentrate levels increased, the fat content of the milk decreased for both cows and heifers. This can again be partly explained by cow genetics. For example, with the heifers the mean PTA for milk fat % decreased from 0.06 to 0.04 % across the range of concentrate levels offered, while with the cows the mean PTA for milk fat % decreased from 0.08 to 0.01 % across the range of concentrates offered. This suggests that farmers with higher yielding herds have placed a greater focus on milk yield than on milk composition, when selecting sires. When we examine this in more detail it appears that genetics can explain between 20 – 50% of the reduction in the milk fat % with the remainder of the reduction in milk fat likely due to diet.

On closer examination of the results, there were a few farms that did not experience as large a decrease in milk composition at higher concentrate levels as others did. The reasons for this were unclear, and it is likely that no single factor was responsible. Nevertheless, contributing factors appear to have included: similar PTA for milk fat% across the concentrate intake levels, the inclusion of alternative forages in the diet, lower than average concentrate intakes, and diets with slightly lower starch contents.

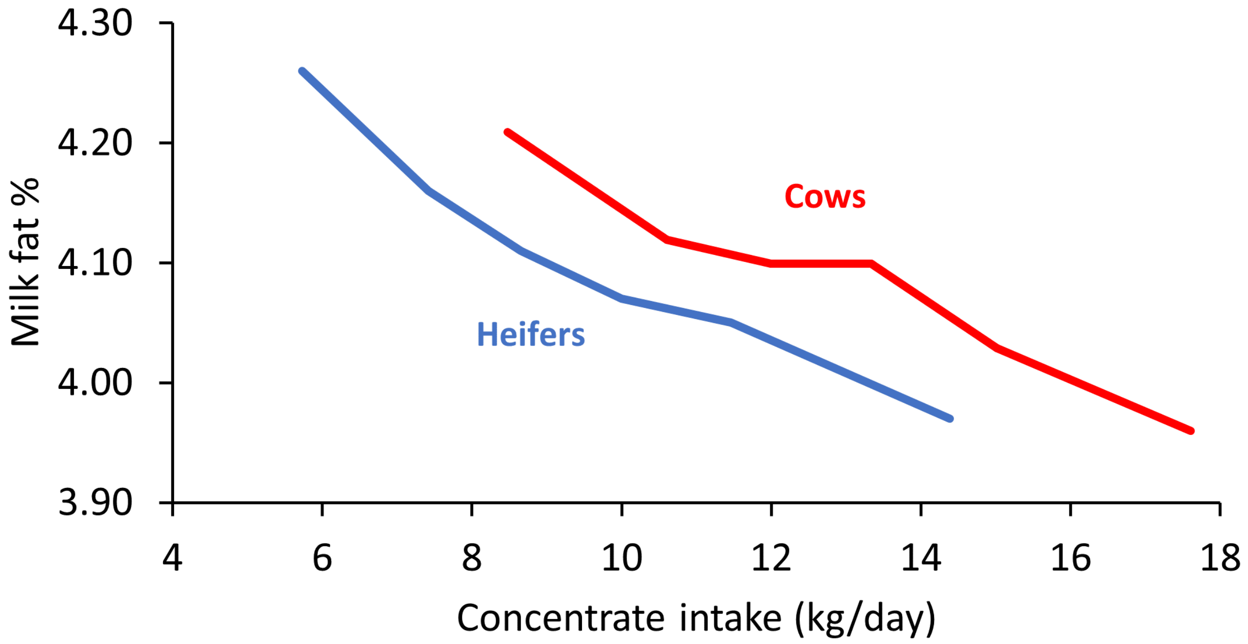


Figure 5. Relationship between concentrate intake and milk fat percentage when concentrates are offered using a feed-to-yield approach.

Key Messages

- On most farms milk fat % decreased at higher concentrate levels. This can be explained in part by cows having a lower PTA for milk fat %, and in part by the impact of diet on rumen function
- Milk protein % was unaffected by concentrate level

In contrast to the decrease in milk fat content observed, milk protein content remained relatively unchanged across the range of concentrate levels in the study (Figure 6). This can be explained in part by the fact that cow genetics for milk protein (PTA protein) changed very little across the range of concentrate levels. It might have been expected that milk protein would improve at higher concentrate levels (reflecting an improved energy balance of the cows), but this was not observed.

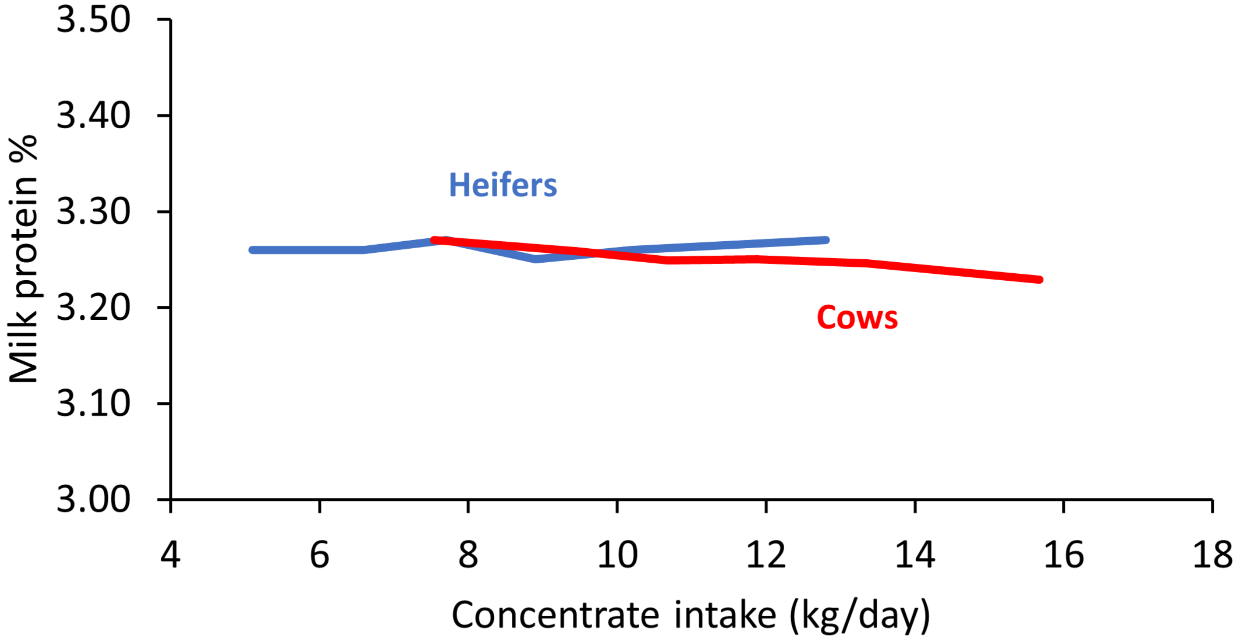


Figure 6. Relationship between concentrate intake and milk protein percentage when concentrates are offered using a feed-to-yield approach.

Efficiency: Two 'efficiency measures' were considered in this study. The first of these examines how much milk is produced per kg of intake (i.e. kg milk per kg DM intake). In both heifers and cows this figure increased from approximately 1.35 – 1.70 kg milk per kg DM intake, across the range of concentrate levels offered (Figure 7), indicating an overall improvement in efficiency at higher concentrate levels. This is because the energy required to 'maintain' the cows body remains fairly constant across a wide range of concentrate levels, and this energy requirement is then diluted as more milk is produced.

The second 'efficiency measure' is 'kg concentrates required to produce each kg milk' (Figure 8). This value also increased as concentrate level increased. However this suggests that concentrate use efficiency has decreased (i.e. cows in the higher concentrate intake bands consumed more concentrate per kg of milk produced, which is undesirable as concentrates are more expensive).

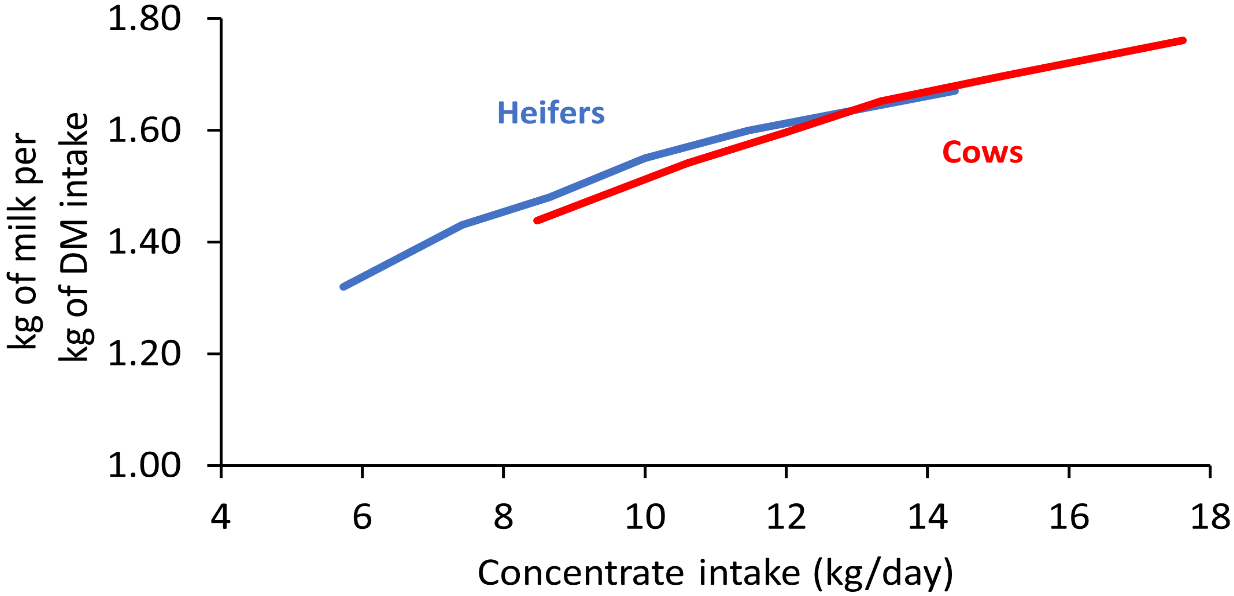


Figure 7. Relationship between concentrate intake and efficiency of milk production (kg of milk per kg of DM intake), when concentrates are offered using a feed-to-yield approach

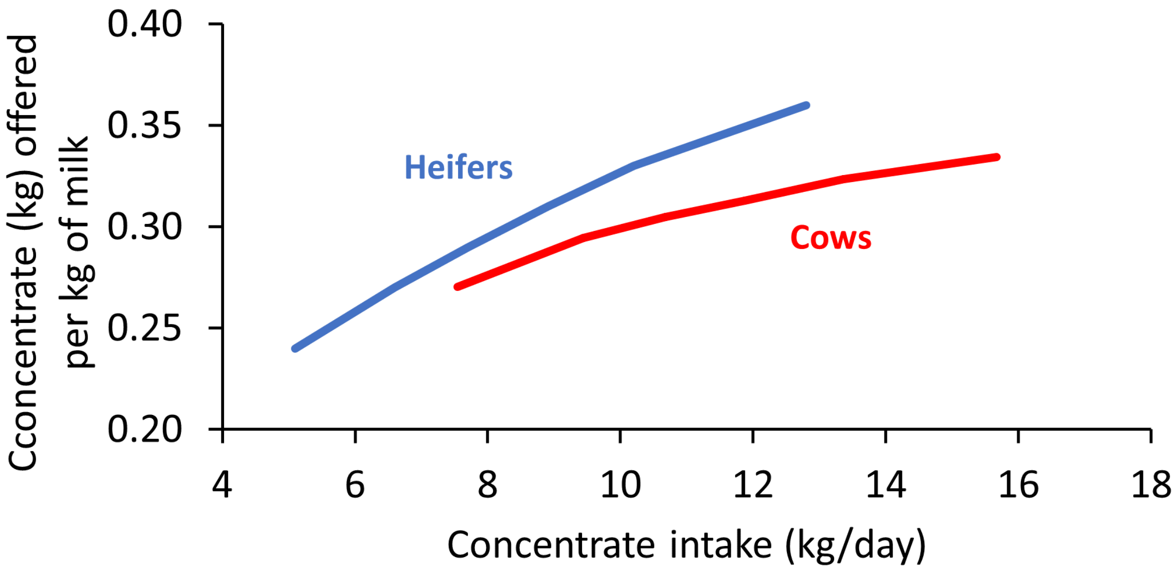


Figure 8. Relationship between concentrate intake and the amount of concentrates offered per kg of milk produced, when concentrates are offered using a feed-to-yield approach.

Fertility outcomes: The effect of concentrate level on fertility was examined separately for cows and heifers (Table 2). In this analysis all cows were divided into one of two groups, namely a ‘Low’ or ‘High’ concentrate group. In general there was no clear impact of concentrate intake level on any of the fertility measures calculated (although cows offered higher levels of concentrate’s had a marginally lower PTA for fertility). Thus, based on the outcomes of this experiment, higher yielding cows (which were offered higher levels of concentrates) did not have poorer fertility than lower yielding cows, when concentrates were offered on a feed-to-yield basis.

Table 2. Effect of concentrate level on fertility outcomes for cows and heifers.

		Concentrate level	
		Low	High
Heifers	Average concentrate intake	7.2 kg/day	11.9 kg/day
	Pregnant to 1st service (%)	39	36
	Pregnant at 100 days post-calving (%)	49	57
	Days to confirmed ‘in-calf’	102	100
	Overall conception rate (%)	90	92
Cows	Average concentrate intake	10.1 kg/day	15.4 kg/day
	Pregnant to 1st service (%)	34	34
	Pregnant at 100 days post-calving (%)	46	45
	Days to confirmed ‘in-calf’	113	110
	Overall conception rate (%)	88	88

Key Message

Fertility was unaffected by concentrate level

Grazing period:
On 19 of the farms some cows grazed full-time during May, June and July, and continued to be offered concentrates on a feed-to-yield basis. Although the project was primarily focused on the winter period, this provided an opportunity to examine trends in milk yields, and in milk fat and protein content for grazing cows offered concentrates on a feed-to-yield basis.

Milk yield and milk composition: Both milk yields and concentrate intakes were lower during the grazing period than during the winter period as cows were in later lactation. The trends in milk yield, and milk fat content were similar to those found during the winter period. For example, milk yield showed a linear increase with increasing concentrate levels (Figure 9), and this again reflects the fact that concentrate feeding 'followed' milk yield (i.e. concentrates were offered according to the yield of milk produced).

Milk fat levels were higher during the grazing period, reflecting the fact that cows were in mid to late lactation at this time. In common with the winter period, milk fat % decreased as concentrate levels increased (Figure 10), with the size of the decrease (from approximstely 4.5% fat to less than 4.0% fat for the cows) almost double that observed during the winter. While part of this reduction can be explained by genetics (decreasing PTA for milk fat %), it is likely that diet is a significant factor. Grazed grass is lower in fibre than grass silage, so if grazing cows are offered a starchy concentrate, milk fat will often fall off quite considerably.

In contrast to the housed period, the protein content of milk from grazing cows decreased with increasing concentrate intake. While this was partly due to cow genetics, the size of this reduction was surprising.

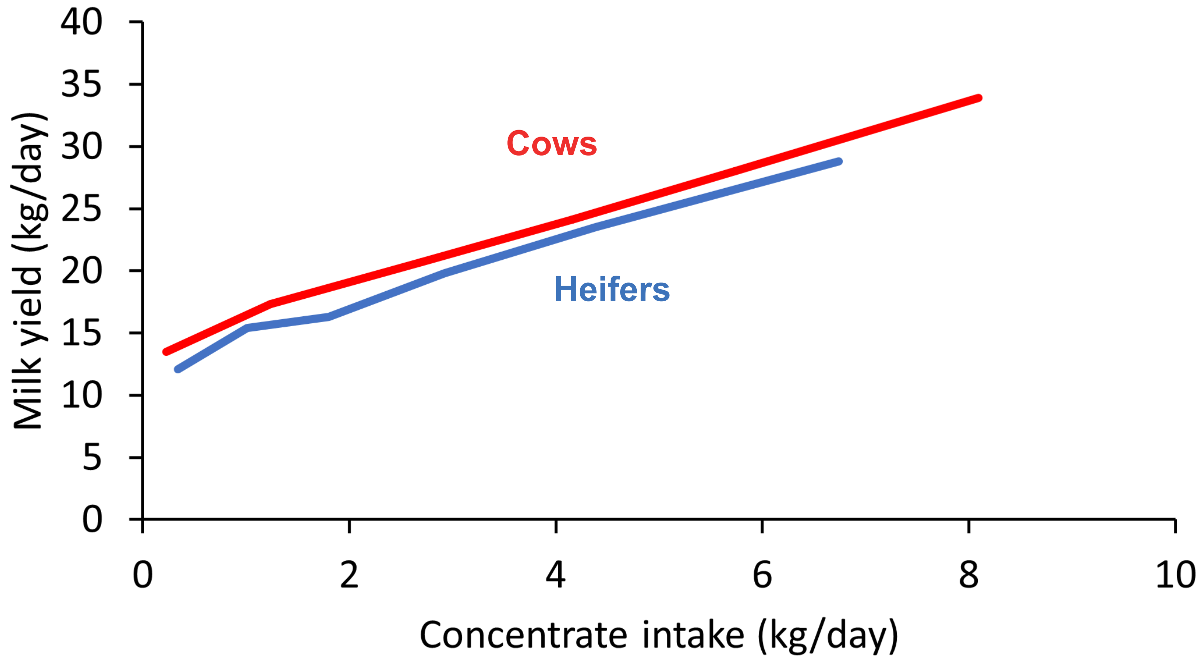


Figure 9. Relationship between concentrate intake and milk yield, when concentrates are offered to grazing cows on a feed-to-yield basis

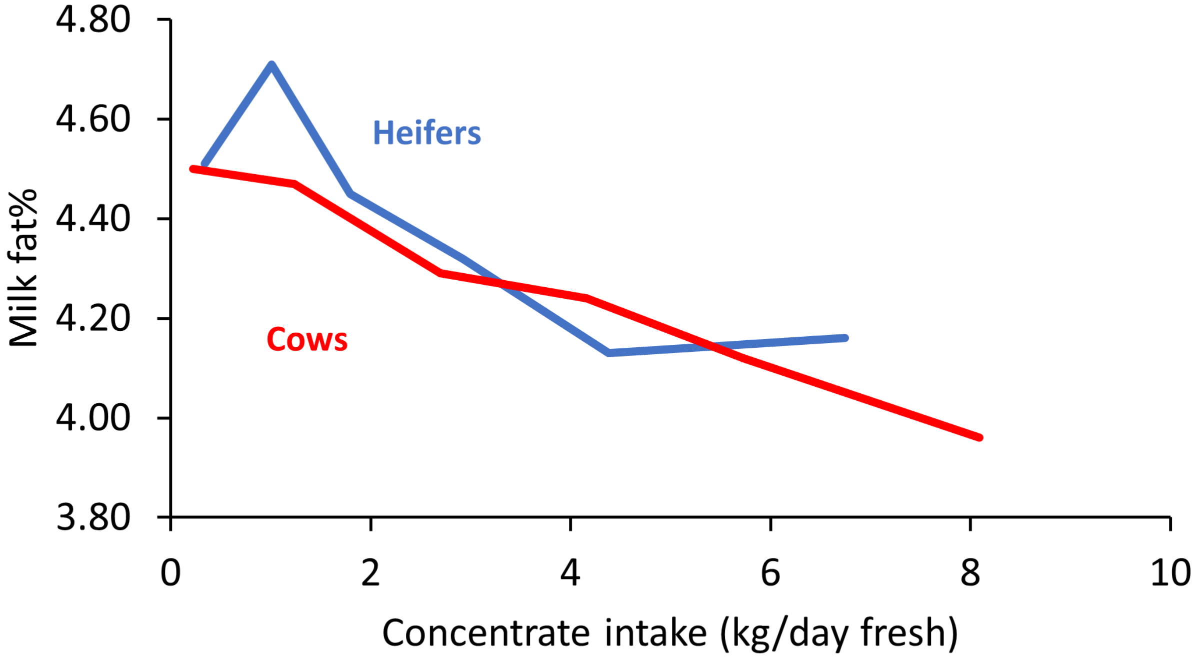


Figure 10. Relationship between concentrate intake and milk fat percentage, when concentrates are offered to grazing cows on a feed-to-yield basis

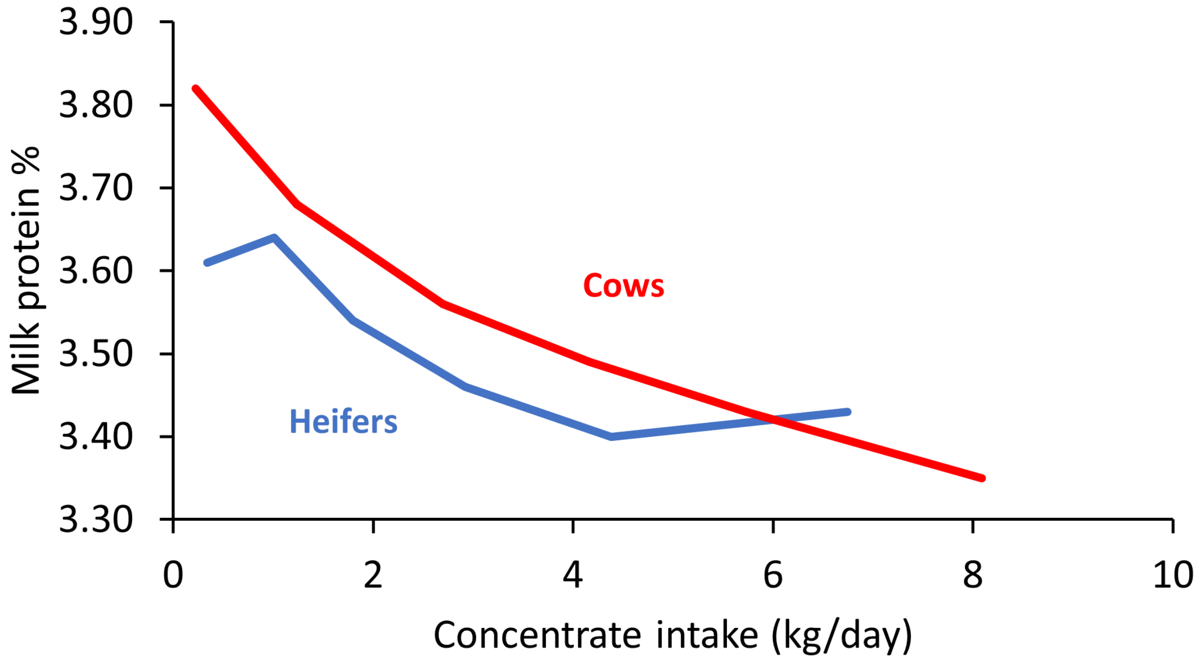


Figure 11. Relationship between concentrate intake and milk protein percentage, when concentrates are offered to grazing cows on a feed-to-yield basis

Key Message

When cows were grazing, both milk fat and milk protein content decreased at higher concentrate levels.

Economic analysis: A key objective of this experiment was to examine the impact of increasing concentrate feed levels within a feed-to-yield system on economic performance. This is important as an earlier AFBI study demonstrated that due to poorer milk composition, the economic performance of some cows offered higher concentrate levels was no better than that of cows offered much lower concentrate levels, especially when milk prices were low. This part of the study was designed to examine if a similar trend was observed on commercial dairy farms, with the analysis restricted to the data from the winter feeding period.

Bonus/deductions: Base level for milk fat was set at 3.85%, with a bonus/deduction of 0.022 pence per 0.01% above or below the base composition. Similarly, base level for milk protein was set at 3.18% with a bonus/deduction of 0.036 per 0.01% above or below the base composition. The impact of concentrate intake on the mean milk price bonus/deduction is presented in Figures 12a (heifers) and 12b (cows). These figures clearly demonstrate the impact of increasing concentrate intake on the value of milk produced. For example with heifers, at a concentrate intake of 4 – 6 kg/day, there was a bonus of 2 pence per kilogramme of milk produced, while at a concentrate intake of 12 – 14 kg/day, the bonus was reduced to 0.2 pence per kg milk. Similarly for cows, at a concentrate intake of 6 – 8 kg/day, there was a bonus of 2.3 pence per kilogramme of milk produced, while at a concentrate intake of 16 - 18 kg/day, there was a deduction of -0.1 pence per kg milk.

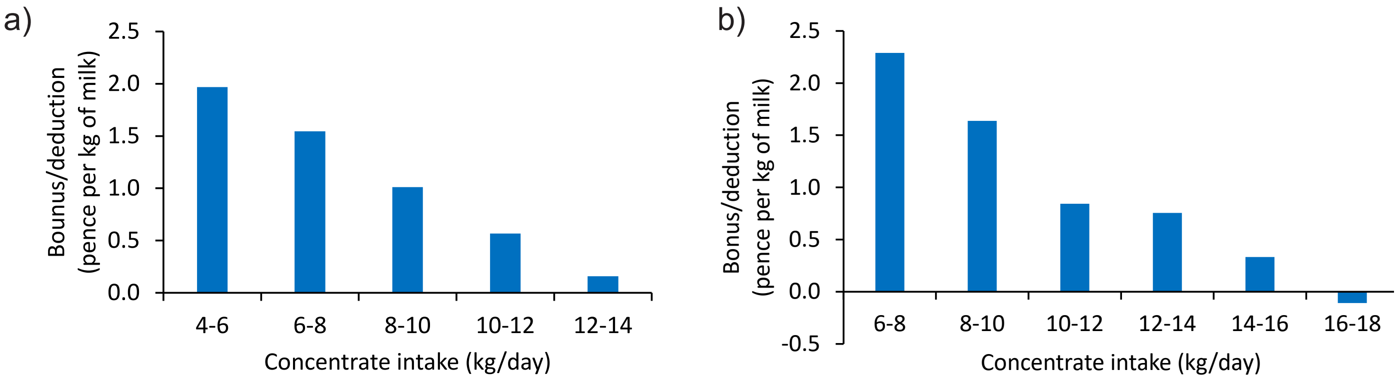


Figure 12. Mean bonus/deduction per kg of milk produced by heifers (a) and cows (b) across the range of concentrate intakes

Margin-over feed costs per cow:

Margin-over-feed costs for each individual cow was determined based on performance data for each cow over the winter feeding period. Feed costs were determined using feed intakes calculated for the housed period, with costs for grass silage, maize silage and whole crop silage assumed as £123, £189, £225/tonne DM, respectively. The cost of concentrates was assumed to be £260/tonne fresh. Margins were modelled at three different milk prices, namely 18, 26 or 34 pence per kg milk.

The effect of concentrate intake on margin-over-feed costs is shown in Figure 13a (heifers) and 13b (cows). At all milk prices margin-over-feed costs (£ per cow per day) continued to increase as concentrate levels increased, however the size of this economic response (the 'marginal response') decreased at higher concentrate levels. This was a result of: 1) The decreasing value of each kg milk produced due to the reduction in compositional bonuses, and, 2) The increasing cost of each kg of diet consumed due to the increasing contribution of concentrates to the diet.

Nevertheless, at a milk price of 34 pence/kg, margins per cow continued to increase even when the highest yielding cows were fed up to 17 – 18 kg concentrate/day. The same pattern was observed when remodelled at a concentrate cost of £300/t, albeit margins were lower. Thus, from an economic perspective, when milk price is high, high concentrate feed levels can make economic sense for the highest yielding cows in the herd. However, at these and higher concentrate levels, cows move close to a 'metabolic tipping point', with a very real risk of rumen problems unless rations are very carefully balanced and managed. In addition, when operating at these high concentrate levels, it becomes increasingly difficult for farms to meet current environmental legislation in relation to phosphorus balances, with this legislation likely to become stricter in the future. The sustainability of milk production systems in which large amounts of 'human edible' cereals are fed to cows is also likely to be challenged long term.

At a moderate milk price (26 pence/kg milk), the benefit of increasing concentrate levels beyond 14 kg/cow/day was much reduced, even for high yielding cows. This benefit was reduced even further when remodelled at a concentrate cost at £300/t.

At an exceptionally low milk price (18 pence/kg milk) the benefits of feeding more than 12 kg concentrates to the highest yielding cows were minimal, and actually became negative at a concentrate cost of £300/t. The latter indicates that farmers should carefully consider the effects of 'chasing extra litres' when milk price is moderate/poor, as for many cows there will be little financial benefit from doing this.

Although feeding additional concentrates at a moderate milk price may increase margins, this may not be the most profitable option by which to produce milk. While it cannot be examined within the current dataset, there is evidence from other research that when silage quality is good, improved margins may be achieved by adopting lower feed rates post peak lactation. This is something that future research should examine.

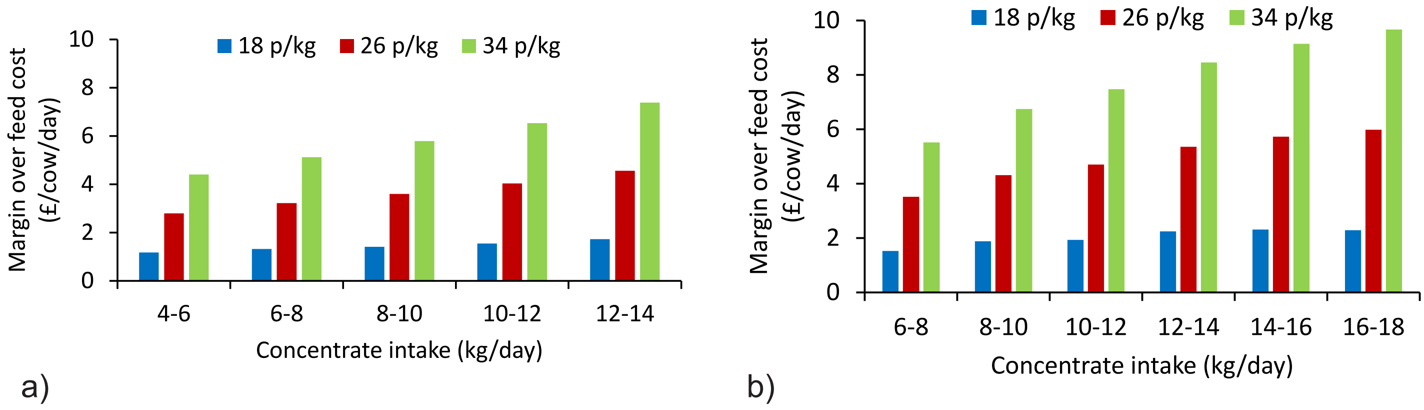


Figure 13. Effect of concentrate intake on margin-over-feed costs (£/cow/day) for (a) heifers and (b) cows at three milk prices.

Key Messages

- At high concentrate levels, the value of each litre of milk decreased due to the fall in milk fat content.
- The marginal economic benefit of offering each additional kg of concentrate decreased at higher concentrate levels due to the fall in value of each litre of milk produced, and the higher cost of each kg of diet consumed.
- When milk prices were very low, the benefit of feeding more than 10 – 12 kg concentrates was almost non-existent, and challenges the concept of ‘chasing extra litres’ at low milk prices.

Feeder checks: As we try to improve individual cow management on farms, one issue that is often overlooked is the accuracy with which concentrate feeding systems (in-parlour and out-of-parlour feeders) actually weigh out concentrates. As part of the on-farm project we took the opportunity to work with a number of farmers to examine feeding system accuracy.

This part of the project was conducted on 16 of the participating farms, with a total of 490 individual feeders tested (between 16 - 48 feeders tested per farm). The test involved allowing a pre-programmed quantity of concentrates (normally between 0.5 – 2.0 kg, depending on the feeder calibration setting) to be dropped from each feeder into a plastic bucket, and then recording the weight of concentrate dropped using a weigh-scale. The difference between the actual weight of concentrate dropped from the feeder, and the target weight that should have been dropped (percent deviation from target), was then calculated. The information on the actual weight of concentrate that was dropped was then used to recalibrate the weigh-cell in each feeder using the inbuilt computer software.

Outcomes: The average deviation of all feeders on each of the 16 farms from the target concentrate feeding level is shown in Figure 14. On average, the feeders on Farms 1 - 7 underfed cows (i.e. the feeders dropped less concentrates than they were supposed to), while feeders on Farms 8 - 16 overfed cows (i.e. the feeders dropped more concentrates than they were supposed to). In the extreme cases (i.e. Farms 1 and 2) the feeders dropped approximately 13 – 14% less concentrates than planned, while on Farm 16 on average the feeders dropped 15% more concentrate than planned.

On most of the remaining farms the average error across all feeders was plus or minus 5%, which most farmers will find acceptable. However, even on these ‘better’ farms the averages did hide problems with individual feeder variations. For example, on Farm 11 one feeder was overfeeding by 100% (i.e. dropping 2 kg instead of 1 kg), while on Farm 4 one feeder was underfeeding by 70% (i.e. dropping 0.3 kg instead of 1 kg).
The impact that these inaccuracies can have on the amount of concentrates offered on a farm can be considerably. For example, if we take the case of a 100-cow herd offering an average of 6.0 kg concentrate per cow per day through in-parlour feeders over a 180 day winter period, the total target concentrate usage is 108 tonnes over the winter. However, based on the feeder-inaccuracies observed, Farm 1 would actually feed only 93 tonnes concentrate, while Farm 16 would actually feed 125 tonnes concentrate, representing underfeeding and overfeeding of 15 tonnes and 17 tonnes respectively (Figure 15).

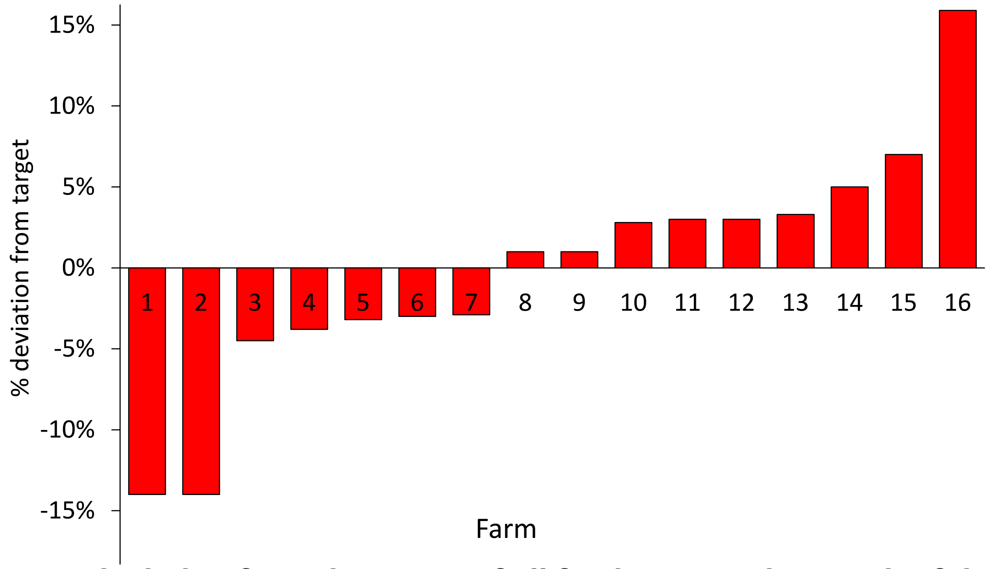


Figure 14. **Average deviation from the target of all feeders tested on each of the 16 farms.**

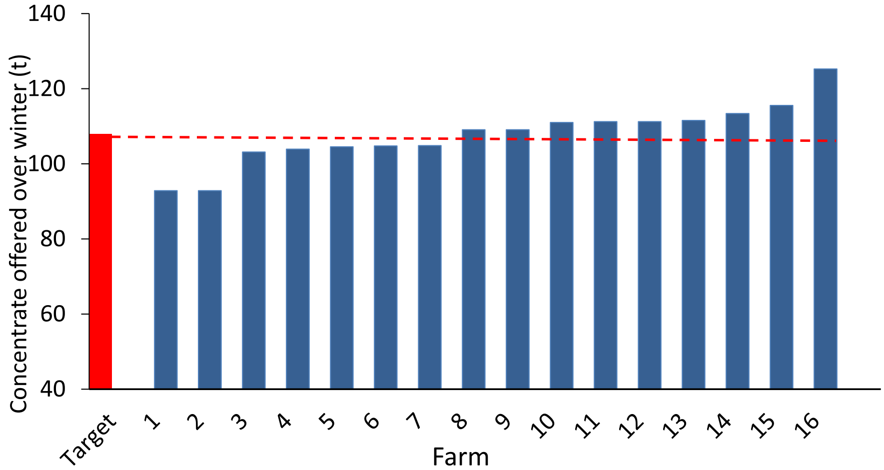


Figure 15. Impact of inaccurate feeders on the total quantity of concentrates that would be fed over a 180-day winter period (100 cows at 6 kg/cow/day)

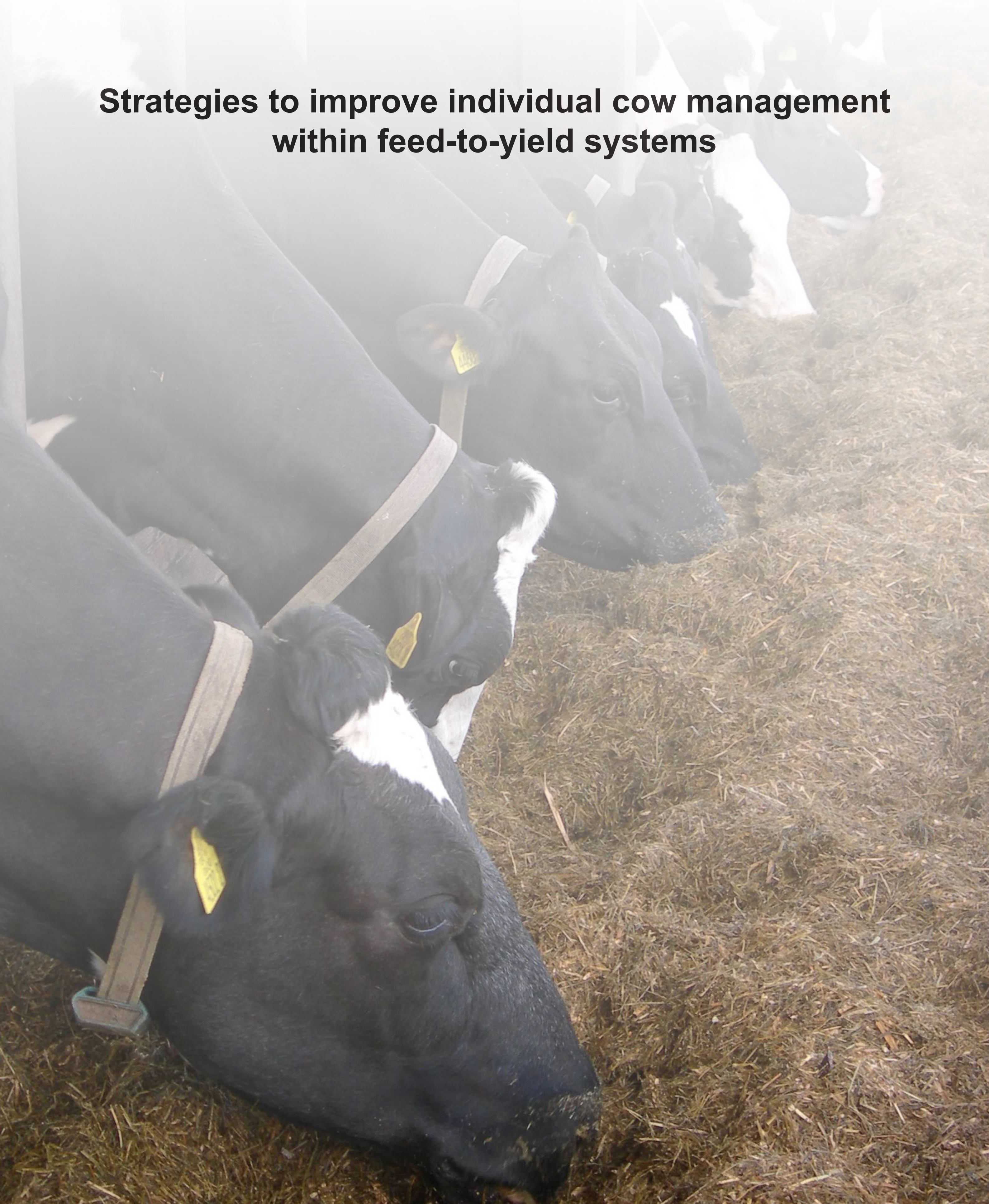
Implications: Unfortunately, poorly calibrated feeders are common on many local dairy farms, and as a result, underfeeding or overfeeding of concentrates is likely to be a significant problem. However, many farmers already check the accuracy of their feeders regularly (some on a weekly basis), and given the cost of concentrate feeds, regular checking is a practice that all farmers should adopt. In addition, different types of concentrates have different densities, and feeders should be recalibrated for each new type of concentrate being fed. Your feeder supplier should be able to advise you on how to calibrate your feeding system, but in general, a simple weight scale, plastic bucket and some of your time is all that is required. Taking time to calibrate your feeders is likely to be time well spent, especially if you wish to bring more accuracy into your feeding systems, and possibly save some money.

Key Message

Concentrate feeding systems (in-parlour and out-of-parlour) on many farms are not accurate – these need to be calibrated regularly to avoid underfeeding and overfeeding of concentrates

Conclusions from Part 1: Within feed-to-yield systems concentrate levels 'follow' the cow's milk yield, meaning the milk yield response to concentrate feeding will be linear. However, on the majority of farms on this study milk fat levels decreased at higher concentrate levels (explained in part by cow genetics and diet), and as a result, the value of each litre of milk produced was reduced. Nevertheless, margin-over-feed costs (£ per cow/day) continued to increase at higher concentrate levels, albeit the increase was very small when milk price was poor. In addition, the marginal economic benefit of feeding an extra 1 kg concentrate decreased considerably at higher concentrate levels, something that farmers should be aware off, while 'chasing extra litres' at low milk prices.

Strategies to improve individual cow management within feed-to-yield systems



BACKGROUND

To improve concentrate use efficiency, many farms have adopted a feed-to-yield approach. Feed-to-yield systems are designed to increase the precision with which concentrates are offered, by targeting concentrates according to the requirements of individual cows based on their milk yield. In practice, a forage or forage-concentrate mix (basal ration) is offered, and this is assumed to supply sufficient nutrients to meet the cow's maintenance energy requirements and to support the production of a given amount of milk (Maintenance Plus, or M+). Additional concentrates are then offered to individual cows on a feed-to-yield basis to support milk production above the yield that the forage/basal ration is assumed to support. Part 2 of this booklet examines strategies to improve individual cow management within feed-to-yield systems. This part of the booklet includes two experiments, together with an examination of how future developments may help improve individual cow management.

Experiment 1 was designed to provide an improved understanding of the responses of individual cows when offered concentrates on a feed-to-yield basis, specifically when the approach is adopted with silages of differing feed values.

Experiment 2 recognised that while a feed-to-yield approach does bring some 'precision' to concentrate feeding, many of the assumptions used are based on an 'average cow'. For example, the approach assumes all cows produce milk with the same fat and protein content, and that all cows consume the same quantity of basal ration. However, neither assumption is true, and this may lead to overfeeding or underfeeding of individual cows. Therefore, Experiment 2 examined if increased precision could be achieved by taking account of differences in individual cow milk composition and intakes, when allocating concentrates on a feed-to-yield basis.

i) Effect of silage quality on the response of individual dairy cows offered concentrates on a feed-to-yield basis

Background: Part 1 of this booklet examined the performance of cows on commercial dairy farms in Northern Ireland when offered concentrates using a 'feed-to-yield' approach. The current experiment, which was undertaken at AFBI, was designed to complement the on-farm study, by examining the impact of adopting a feed-to-yield system on individual cow performance with cows offered silages of different nutritive values.

The study: The study involved 60 Holstein-Friesian dairy cows (40 cows and 20 heifers). Following calving cows were allocated to one of two diets:

- 'High' quality silage mixed with concentrates in a basal ration (supporting Maintenance plus approximately 25 kg milk), plus extra concentrate offered on a feed-to-yield basis through an out-of-parlour feeding system
- 'Medium' quality silage mixed with concentrates in a basal ration (supporting Maintenance plus approximately 18 kg milk), plus extra concentrates offered on a feed-to-yield basis through an out-of-parlour feeding system

With both treatments the silage and concentrates were mixed in a 65 : 35 dry matter ratio in the basal diet. The chemical composition of the two silages offered are presented in Table 3.

Following a three week build up phase after calving, concentrates were offered on a feed-to-yield basis (at 0.45 kg concentrate/kg milk produced above that supported by the basal ration) until 16 weeks post calving.

Table 3. Chemical composition of the two silages offered

	Silage feed value	
	'High'	'Medium'
Dry matter (%)	34	24
Crude protein (% DM)	16.7	12.6
Ammonia nitrogen (% total N)	7.1	8.9
Metabolisable energy (MJ/kg DM)	12.0	10.9

Outcomes: Mean cow performance is presented in Table 4. Cows offered the High quality silage had a higher silage DM intake than cows offered the Medium quality silage, and tended to have a higher total DM intake. However, concentrate intake did not differ between the treatments. Silage quality had no effect on milk yield, although the trend for a higher milk yield with the High quality silage reflected the trend for a higher intake with this treatment. The higher milk protein content with the High quality silage is as expected. Cows offered the High quality silage had an improved energy balance, and this was reflected in these cows having a higher body condition score at the end of the experiment, suggesting that some of the extra energy consumed with this treatment was laid down as body tissue. The quantity of concentrates required to support the production of each kg milk was also higher with the Medium quality silage. In general, these average results are as expected when silages of two different qualities were offered, however the primary objective of this study was to examine individual cow performance.

Table 4. Effect of silage feed value on cow performance, when concentrates are offered on a feed-to-yield basis

	Silage feed value		Significant difference between treatments
	High	Medium	
Silage DM intake (kg/day)	11.3	9.2	Yes
Concentrate DM intake (kg/day)	12.5	13.0	
Total DM intake (kg/day)	23.8	22.2	Almost
Milk yield (kg/day)	39.0	36.6	
Fat (%)	4.03	4.12	
Protein (%)	3.33	3.18	Yes
Fat plus protein yield (kg/d)	2.83	2.66	
Energy balance (MJ/cow/day)	23	7	Yes
End of study body condition score	2.5	2.4	Yes
Concentrates (kg fresh) offered per kg milk yield	0.29	0.32	Yes

Individual cow responses: In Figures 16-19 each individual cow is represented by a circle, blue circles for cows offered the High quality silage and red circles for cows offered the Medium quality silage.

Figure 16 shows the effect of increasing concentrate level on silage DM intake and total DM intake. As concentrate intakes increased, total DM intake also increased (a linear increase) with both silage types, supporting the results from the on-farm study. In addition, silage DM intake also increased (or stayed relatively constant) as concentrate intakes increased. This is in contrast to non feed-to-yield systems where silage intakes would be expected to fall due to 'substitution'. That intakes do not fall off at higher concentrate levels reflects the fact that higher levels of concentrate are offered to higher yielding cows, and these cows have a greater intake capacity. This again lends support to the practice of adopting a single M+ value for all cows in the group. Figure 16 also highlights that at any given concentrate intake, intakes of the cows offered the High feed value silage were greater than intakes of those offered the Medium feed value silage.

As concentrate levels increased, milk yield also increased (Figure 17), with the response linear. However, within feed-to-yield systems it is important to remember that concentrates 'follow' milk yields (e.g. 0.45 kg concentrate/kg milk), so the linear response is very much as expected. At any given concentrate level, milk yields of cows offered the High quality silage are generally higher than those of cows offered the Medium quality silage.

In this study milk fat changed relatively little across the range of concentrate levels examined. This was also observed in a number of the farms participating in the on-farm project. However, there was a definite trend for milk protein to decrease, especially with the medium quality silage. The wide variation in individual cow milk composition is evident from these figures, and yet feed-to-yield systems generally assume a standard milk composition for all cows in a herd.

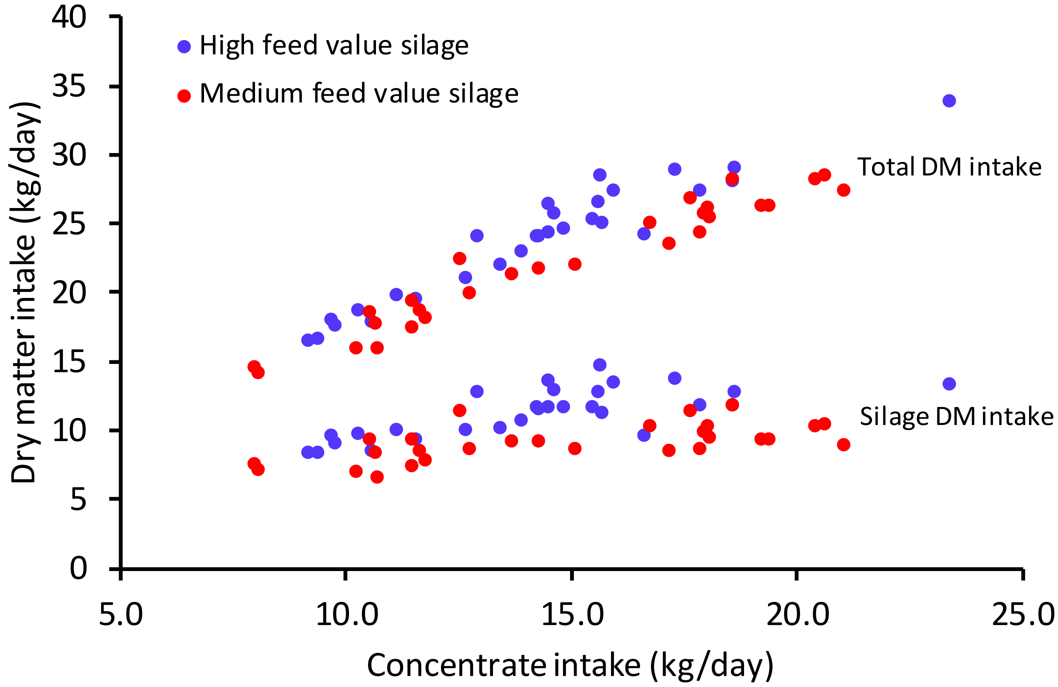


Figure 16. Effect of offering increasing levels of concentrates on a feed-to-yield basis on silage DM intake and total DM intake of individual cows (with a High and Medium feed value silage)

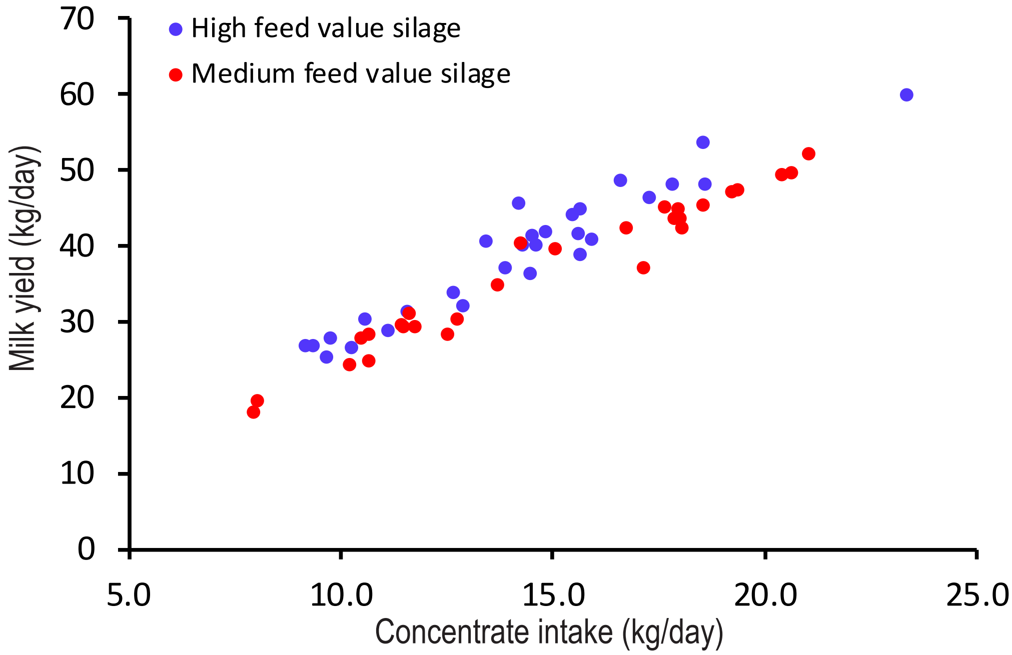


Figure 17. Effect of offering increasing levels of concentrates on a feed-to-yield basis on milk yield of individual cows (with a High and Medium feed value silage)

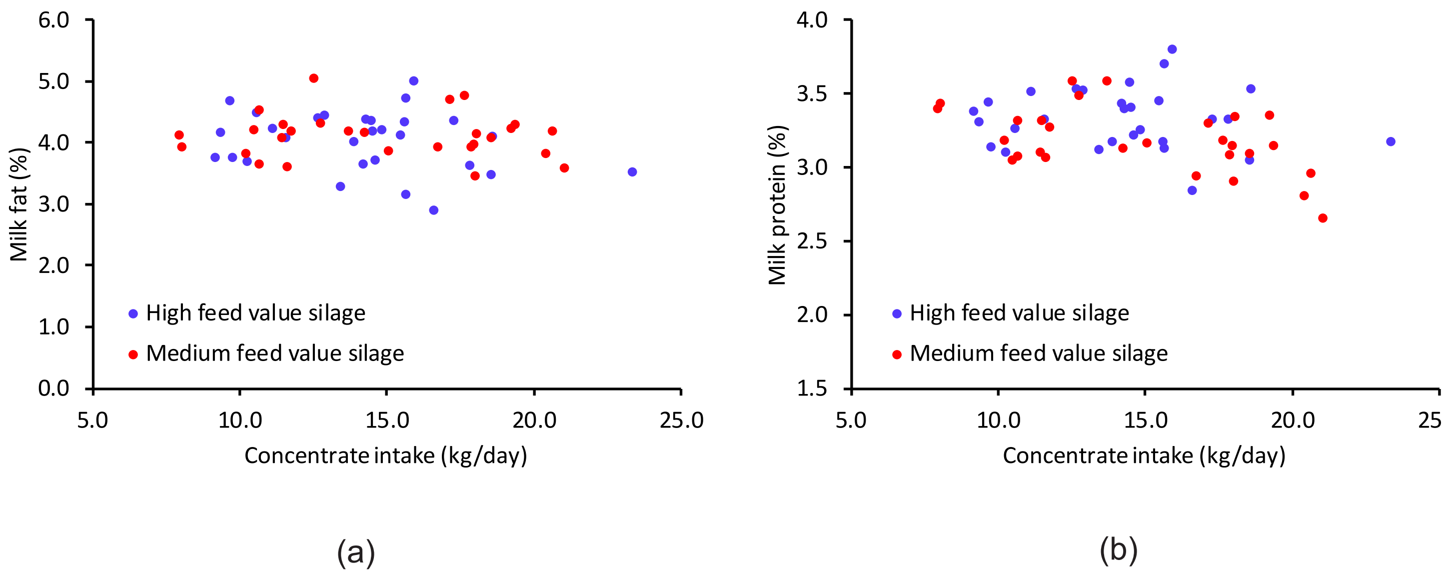


Figure 18. Effect of offering increasing levels of concentrates on a feed-to-yield basis on milk (a) fat % and (b) milk protein % of individual cows (with a High and Medium feed value silage)

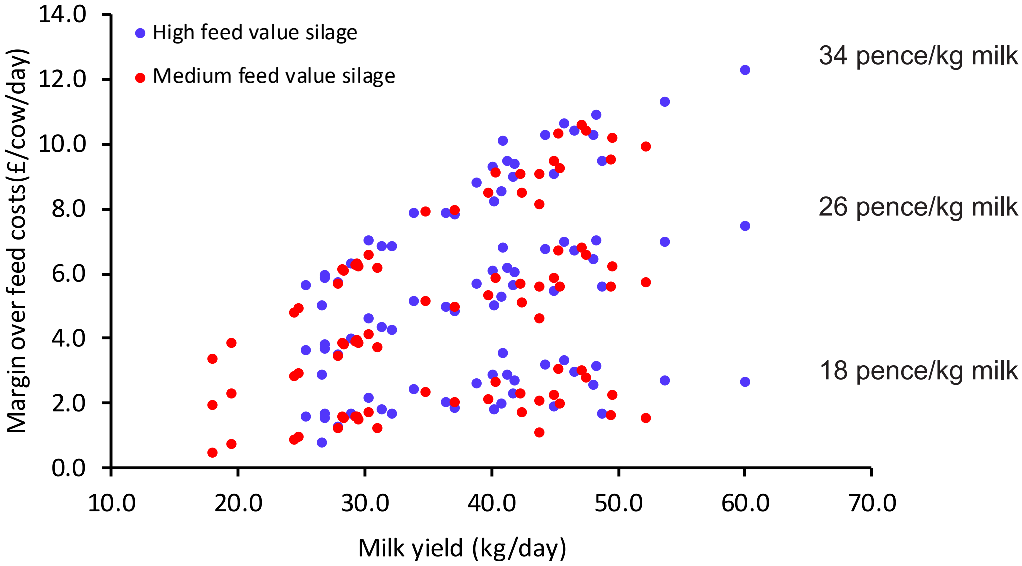


Figure 19. Effect of increasing milk yield on margin-over-feed costs at milk prices of 18, 26 and 34 pence per kg (with a High and Medium feed value silage)

The impact of milk yield level within a feed-to-yield system on margin-over-feed costs is shown in Figure 19 at three different milk prices (18, 26 and 34 pence/kg). The costs adopted for silage, concentrates and the milk price bonus/deduction were the same as used in Part 1 of this booklet. The results of this study are very similar to the outcome of the economic analysis undertaken on the data from the commercial farms, with the marginal economic response decreasing at higher concentrate levels. This is particularly evident at a low milk price (18 pence/kg), where an increase in milk yield beyond 40 kg/cow/day resulted in no real improvement in margin-over-feed costs. Even at a milk price of 26 pence per kg, the increase in margin-over-feed costs was small when milk yields were in excess of 40 kg/day with many individual cows. Part of this is due to the slight reduction in the value of milk produced due to the fall in milk quality at higher concentrate levels. However, in this experiment the main driver of this decline in margin was the increasing cost of the diet with increasing concentrate inclusion level. For example, diet cost increased by an extra 2 - 3 pence per kg DM across the range of concentrate levels in this study. This was especially true for the cows offered the medium quality silage, and this was reflected in generally lower margins at all milk yields with diets based on the medium quality silage.

Conclusion

The results of this study confirm the benefits of higher quality silage in terms of improving intakes, milk protein content and economic performance. However, irrespective of silage quality, the economic benefits of offering additional concentrates was reduced at higher milk yields, even within a feed-to-yield system. When milk prices are poor, ‘pushing for extra litres’ will have little financial benefit.

Key Messages

- Within a feed-to-yield system, there is a linear relationship between milk yield and concentrate intakes
- As concentrate levels increase, silage intakes do not fall off rapidly within a feed-to-yield system
- Irrespective of silage quality, the economic benefits of increasing concentrate levels were small when milk price was poor.

ii) Taking account of individual cow milk composition and intakes when allocating concentrates on a feed-to-yield basis

Background

While offering concentrates using a feed-to-yield approach is designed to improve precision within feeding systems, it largely does this by taking account of individual cow milk yields. However, the findings of Experiment 1, and previous research at AFBI, have shown that there is much variation between individual cows in a herd in relation to milk composition and intakes at any given milk yield. This study was designed to examine if efficiency could be improved by taking account of this cow-to-cow variation when allocating concentrates. For example, cows with improved milk composition may require more concentrates, while cows with poorer composition may require less. In addition, cows with a higher intake may have a greater M+ value than cows with a lower intake. However, it is unclear if benefits will arise if we account for this variation between cows when offering concentrates.

The Study

The study was conducted over a twelve week period, and involved 69 mid-lactation Holstein dairy cows (24 of which were heifers). All cows were offered the same basal ration which consisted of grass silage mixed with concentrate (at a rate of approximately 4.5 kg/cow per day). This ration was mixed using a mixer wagon. All cows were offered additional concentrates on a feed-to-yield basis via an out-of-parlour feeding system. Concentrate feed levels were adjusted weekly according to one of three approaches, as follows:

Conventional feed-to-yield: this treatment followed a conventional feed-to-yield approach. The milk yield supported by the basal ration (M+) was determined based on the average intake of the group of cows on this treatment. Individual cows were then supplemented with concentrates at a rate of 0.43 kg concentrate per kg milk produced in excess of the M+ value. Over the course of the study the average M+ value was 14.4 kg/day for heifers and 20.8 kg/day for cows. Concentrate levels were adjusted each week based on milk yields during the previous week.

Precision 1 (feed-to-yield, with adjustment for milk composition): this approach was similar to the ‘conventional’ treatment above, except with this treatment the concentrate feed level for each cow was adjusted taking account of each individual cow’s milk yield and milk composition. Thus, concentrate levels for cows producing milk with a high fat and protein content were increased to reflect the additional energy required to produce that milk, while concentrate levels for cows producing milk with a poorer composition were reduced. Concentrate levels were adjusted each week based on milk yields and milk composition during the previous week.

Precision 2 (feed-to-yield, with adjustment for milk composition and intakes): as with Precision 1, this treatment also took account of differences in milk yield and milk composition of individual cows. However, this treatment was designed to be even more ‘precise’ in that it also took account of differences in intakes between individual cows. Thus, cows with higher intakes were assigned a higher M+ value while cows with lower intakes were assigned a lower M+ value. Again, concentrate levels were adjusted each week based on milk yields, milk composition and intakes during the previous week.

Outcomes

The results are presented in Table 5, and values with a circle around them were statistically different from the values in the Conventional treatment. Cows managed using the two Precision approaches consumed approximately 1 kg more concentrate per day compared to cows on the Conventional feed-to-yield treatment. However, silage DM intake and total DM intake was unaffected by treatment. Despite the higher concentrate intakes with the two Precision treatments, milk yields with these treatments were not significantly higher than with the Conventional feed-to-yield treatment. However, milk protein content was higher with the two Precision treatments compared to the Conventional treatments, reflecting the higher concentrate levels. In addition, milk fat content tended to be lower in Precision 2 compared to the other two treatments, while cows on Precision 1 had a higher fat plus protein yield (+0.13 kg/day) compared to the other two treatments.

Despite these differences in intakes and milk composition, there was no evidence that any of the estimates of 'efficiency' were improved with the precision feeding approaches. For example, the amount of milk produced per kg of DM intake was almost identical across the three treatments (approximately 1.64 kg milk/kg DM intake). However, if we examine 'concentrate use efficiency', more concentrates were offered per kg of milk (+0.04 kg) within the Precision treatments compared to the Conventional treatment. This indicates that the improved milk composition with the precision treatments required extra concentrates.

Table 5. Effect of three different feed-to-yield strategies on intake, milk production and efficiency measures (values with circles were 'significantly' higher than those for the conventional treatment)

	Treatment		
	Conventional feed-to-yield:	Precision 1: (concentrate level adjusted for milk yield and composition)	Precision 2: (concentrate level adjusted for milk yield, milk composition and intakes)
Silage DM intake (kg/d)	12.4	11.6	11.5
Concentrate DM intake (kg/d)	9.4	10.5	10.3
Total DM intake (kg/d)	21.2	21.8	21.5
Milk yield (kg/d)	32.9	34.5	34.3
Fat (%)	4.51	4.49	4.31
Protein (%)	3.27	3.35	3.31
Fat plus protein yield (kg/d)	2.54	2.69	2.58
Kg milk produced per kg DM intake	1.63	1.65	1.64
Kg concentrate offered per kg milk produced	0.30	0.35	0.34

Adjusting feed rates for milk composition:

As highlighted above, one way that farmers can improve precision at a herd level is by ensuring that the feed rate adopted is appropriate for the composition of milk produced by cows within their herds. However, perhaps the first step is to check that you know the feed rate that your feeder is actually set at! On some farms this may simply the 'default value' or the value that the supplier set it at during installation.

Within the on-farm study outlined in Part 1 of this booklet, the most common feed rate adopted was 0.45 kg concentrate/kg milk. This is broadly based on the concept that a cow requires approximately 5.2 MJ energy to produce a kg of milk, and that a kg of concentrate has a metabolisable energy content of 11.5 MJ/kg fresh weight (5.2 ÷ 11.5 = 0.45). However, this calculation is based on 'standard' milk with a composition of 4% fat and 3% protein. Thus, if the milk produced has a poorer composition than this, a lower feed rate could be adopted, while if milk produced has a higher composition than this, a higher feed rate may be preferred. This is highlighted in Table 6 for milk with a range of compositions. For example, the feed rate for milk with a composition of 3.6% fat and 3.0% protein could be reduced to 0.43, while for milk with a composition of 4.8% fat and 3.4% protein, a feed rate of 0.51 may be preferable.

Table 6. Matrix showing calculated feed rates for milk with a range of fat and protein compositions.

		Fat %				
		3.2	3.6	4.0	4.4	4.8
Protein %	2.6	0.40	0.42	0.44	0.46	0.48
	3.0	0.41	0.43	0.45	0.47	0.50
	3.4	0.42	0.44	0.46	0.49	0.51
	3.8	0.43	0.45	0.48	0.50	0.52

Practical Implications: Feed-to-yield systems are now common on dairy farms in Northern Ireland, and software in most modern milking parlours can facilitate this concentrate feeding approach, either through in-parlour or out-of-parlour concentrate feeding systems. It was expected that allocating concentrates more precisely to individual cows within the current study, by taking account of difference in milk composition and intakes, would result in improved efficiency in concentrate use (i.e. a successful precision concentrate feeding strategy was expected to reduce concentrate inputs while maintaining or improving cow performance). However, this was not the case, and the Precision treatments actually resulted in more concentrates being offered, with only a small improvement in performance and no improvement in efficiency. Thus, the results of this experiment were unexpected, and the reason for this outcome is unclear. Nevertheless, it is recognised that a fall in milk yield in one week within a feed-to-yield system can result in concentrate levels being reduced, and this can drive performance downwards in the long term. Given these results, the adoption of the precision approaches examined in this study cannot be recommended at this time.

Conclusions

The results of this experiment did not demonstrate any efficiency benefits by taking account of individual cow milk composition and intakes. For most farmers, perhaps the most important advice is to ensure that your feed-to-yield approach is accurate at a herd level. This involves using an appropriate M+ value, ensuring that feeders (and milk meters) are properly calibrated, that you know the feed rate setting on your computer, and that it is appropriate for your herd.

Key Messages

- The individual cow 'precision approaches' examined in this study did not improve efficiency
- This suggests it is more important to get things correct at a 'herd level': ensure that your M+ value is appropriate, that feeders and milk meters are calibrated, and that you know the current feed rate setting on your feeding system

Background: 'MIR', or mid-infrared spectroscopy, is the technique used by milk processors and milk recording organisation to predict the fat and protein content of bulk tank milk samples, and milk samples from individual cows. The technique, which is used throughout the world to analyse milk samples, involves shining a light (within the mid-infrared range) through a small sample of milk using a MIR instrument (see photo). Some of the light is absorbed by the molecules in the milk and some is reflected, and a 'spectra' is produced. Using these spectra we are able to predict the fat, protein, lactose and urea content of milk with a high degree of accuracy using a series of calibration equations. For example, Figure 20 shows the spectra for two different cows, and while the lines are similar, there are subtle differences, which indicate that the milk from these two cows differ in composition.

More recently, MIR has been used to predict the type of fat in milk, allowing processor to identify how much of the fat in milk is unsaturated (more health) and how much is saturated (less healthy).

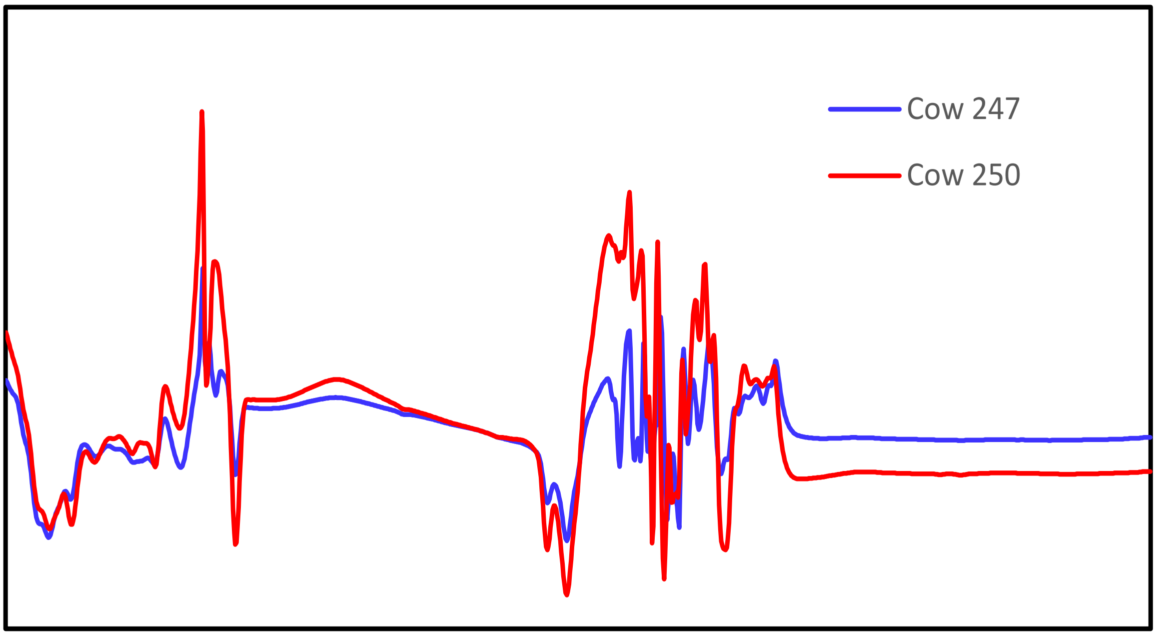


Figure 20. Typical MIR spectra for milk samples from two dairy cows

However, over the last decade research has examined what MIR can tell us about the cow that is producing the milk, and not just about the milk! For example, research is currently evaluating the role of MIR to identify the diet that a cow has been offered (i.e. grass vs. silage). This could be used to validate the 'providence' of milk from a farm (i.e. 'grass fed' milk). Furthermore, MIR has been used to predict a number of difficult-to-measure traits in cows, including energy balance of individual cows. In addition, MIR has been used to identify cows in a herd that are 'metabolically at risk', and which may need special attention. MIR also offers potential to help lessen the environmental footprint of dairying. For example, MIR can be used to predict the methane production of individual cows, and to identify cows which are using nitrogen efficiently (or inefficiently). While most of these prediction equations are still in the development stage, a number of research groups throughout the world, including at AFBI, are currently working in this area.

MIR has a number of benefits, including that it is 'non-invasive' (unlike a blood sample) and that milk samples are readily available from farms (monthly for those involved in milk recording). It looks very likely that in the near future additional information obtained from MIR analysis of milk samples will become increasing important in helping farmers manage the nutrition of their herds, and indeed individual cows, and to help farmers reduce the environmental impact of dairy farming.

Key Message

MIR analysis of milk has the potential to provide information on individual cows that can help improve nutrition and health, and reduce their environmental impact

During the last decade there has been an ‘explosion’ of new technologies developed for use on dairy farms, and this trend will continue in the future. Many of these technologies seek to improve the accuracy with which we manage the nutrition of our dairy herds, and indeed the nutrition of individual cows. In addition, many of these technologies are still under development, and require further improvement, while others are currently being marketed to farmers (sometimes without clear guidance on how to apply their results to make practical management decisions). Furthermore, most manufacturers have developed their products in isolation, and consequently information provided by one product does not integrate with information from another manufacturers product. As a result, the farmer is often left to try to combine outputs from different products to obtain practical management information. If real progress is to be made in the use of these technologies on farms, increased cooperation between different manufacturers is essential, as maximum benefit will only be obtained by integrating data from multiple sources. A number of technologies which have been developed, or which are being developed, are outlined below. Their inclusion does not mean that these technologies are being advocated at present, rather we are just highlighting the current ‘direction of travel’.

Feeding technology: Significant advances have been made in feeder wagon technology, including in their ability to accurately weigh and mix ingredients. However, more recently, NIRS technology (the same technology that is used to analyse silage samples in labs) is being incorporated into feed buckets to analyse ingredients before they are placed in the mixer wagon, and this allows adjustments to be made due to variability in silage dry-matter. In addition, the same technology has also been incorporated into mixer wagons to provide an indicator of the basic nutrient content of the diets being offered.

Predicting intakes: The ability to measure or predict the intakes of individual cows could help improve cow management. For example, if we know the intake of a cow and her milk yield, then we can calculate her energy balance, and this may allow us to make feeding decisions which could improve performance, health and fertility. In addition, we could determine the feed conversion efficiency of each cow, and this would allow us to identify the more efficient cows in the herd.

While it is relatively easy to measure intakes of individual cow on a research farm using ‘feed boxes’, this approach is not feasible on commercial farms. Part of the current project involved developing equations to allow us to predict intakes of individual cows using information that is readily available on farms (i.e. lactation number, days-calved, milk yield and milk composition). This work is still on-going at AFBI, and involves mathematical techniques such as machine learning. Another part of this project examined the use of pedometer data and feeding behaviour data to try to predict intakes, and while this proved to be unsuccessful, other approaches are being examined. For example, research in other institutes is examining the use of cameras and 3D images to ‘measure’ intakes of individual cows.

Rumen function and feeding behaviour: A number of neck collar and ear tag based systems can provide estimates of cow activity, including feeding behaviours. Furthermore, rumen boluses that measure rumen pH, rumen temperature and cow activity are now available. While direct measures of rumen pH and temperature can provide an early warning for disease such as subacute ruminal acidosis (SARA) changes in rumination and eating behaviour can also signal the onset of disease, and allow for early intervention and prevention.

Location sensors: can identify where a cow is in the house (feeding/lying), and provide information on normal feeding behaviour.

Live-weight and body condition scores: Most cows lose live-weight and body condition in early lactation as they mobilise body tissue, and gain it again in later lactation. Measures of these changes can provide an indication of a cow's energy status. Automatic systems which weigh cows and estimate body condition score at each milking are now available, and some software packages now make use of this information within feed rationing systems.

In-line milk sensors: These can provide daily information on the fat and protein content of milk, which can be used to assess the cow's energy status. In addition, sensors are being developed which can detect enzymes in milk, and metabolites such as ketone bodies, which can guide nutritional and health management. Having this information 'real-time' would be much more valuable than monthly milk recording information, which can be 'historical' before the farmer receives it.

Sniffer technology: Emerging 'sniffer' technologies can detect acetone in a cow's breath, and this can be used as an indicator or ketosis. These technologies are currently at the prototype stage but could be placed in milking stalls or feeders for daily monitoring.

Rumen boluses can provide key information on rumen function and detection of subclinical disease.

Key Messages

- Many 'precision technologies' are being developed for use on dairy farms – some of these will have real potential to improve herd management.
- It is likely that maximum benefit will be obtained by integrating data from a range of different sources – however at present most technologies do not 'talk' to each other.

Is it time for a health check of your feed to yield computer system?

Alan Hopps – Senior Dairying Development Adviser, Armagh

Milking parlours with computerised feed to yield systems for the allocation of concentrates have become much more common in recent years. These systems have the potential to greatly improve feed efficiency – if properly monitored and managed. They largely take over the element of control "at the back of the cow" where farmers were very aware of how much they were feeding individual animals in the milking parlour as it was done manually. Where the computer "feeds the cow", there is an element of trust that the computer is doing what it has been programmed to do. How can you check that your herd is being fed according to the feed plan that has been entered into the computer? There are a number of points that are worth checking on your system.

1. Calibration of milk meters – does the milk yield that your computer system returns match what's in the bulk tank? Remember 1000 kgs of milk are the same as 971 litres of milk. If milk yield is being overestimated, then cows will be overfed as well.
2. Calibration of feeders. Concentrates are usually dispensed by feeders on a volume basis. Individual loads of meal can vary in their bulk density. A computer can think that 1kg of feed has been dispensed where in actual fact it might be 1.2kg of meal. Feeders should be weighed and checked regularly to ensure the correct weight of concentrate is being dispensed.
3. If you are carrying out monthly recording of milk and meal for the herd, check that the average milk from forage for the herd corresponds fairly closely with the M+ set for the herd in the computer system.
4. Monitor closely the rate of decline in the milk yield of cows after peak yield. A drop in daily yield of 2 litres of milk per month after peak is typical. A greater decline than this is likely to mean that M+ is set too high for the quality and quantity of forage being offered. Any forage will not deliver results if it is not fed to appetite in the dairy herd.

Is it time for a health check on your feed to yield system?

5. If you can analyse the lactation curve of your herd, it can reveal many issues with the management of the herd – for example:-

- Is there a loss of milk yield when cows are transferred between groups on the farm?
- Is your transition cow management as good as it could be? Major variation in milk yield at around peak yield (50 days in milk on most farms) is a sign that transition management could be poor.
- Are there too many cows still in the milking herd above 250 days in milk with very low yields (< 10 litres)? These cows should be considered for dry off as it is unlikely to be economic to continue milking them.
- A variation of 20 litres between animals at the same "days in milk" is common in many herds.

6. Are cows being fed properly for the milk yield they are producing (usually the average rolling 7 day yield)? On a feed to yield system (with no build up phase or lead feeding after calving), Figure B represents how cows will be fed according to yield. In this graph of milk yield versus meal fed, there are no cows that are "exceptions" to the system. You should always be looking

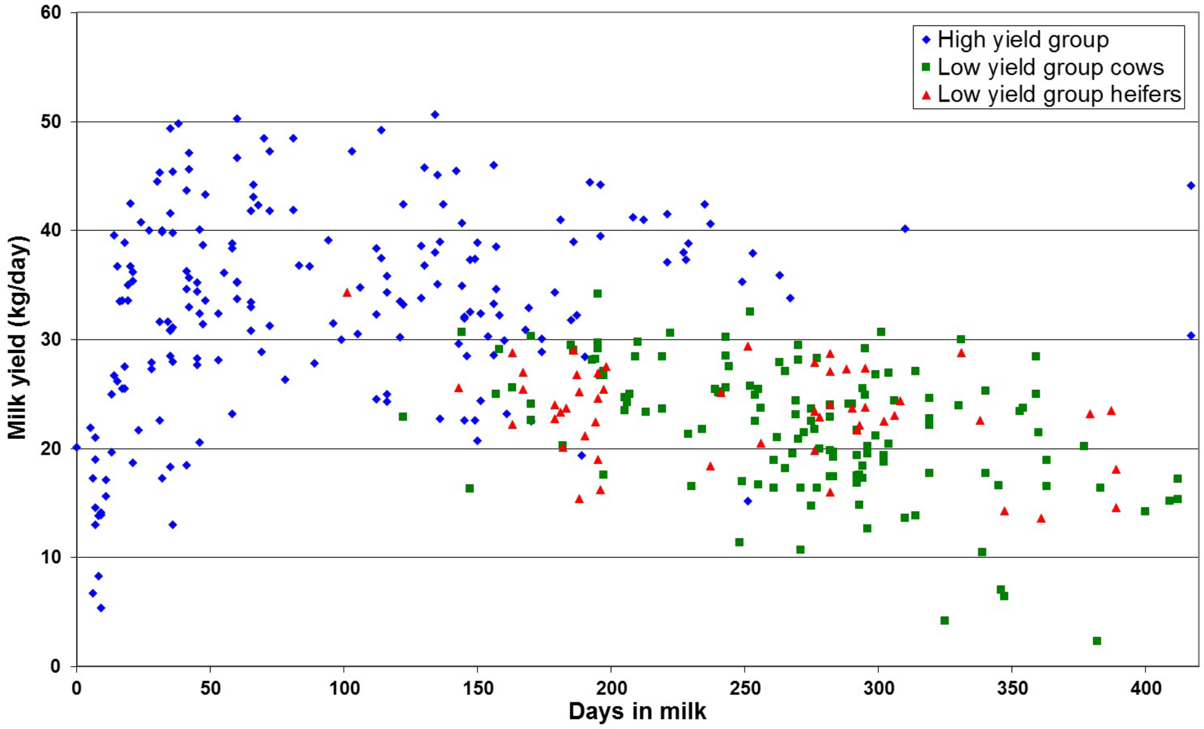


Figure A. Lactation analysis of a large dairy herd with 2 groups of cows housed separately

for cows that are not corresponding to the "lines" – because they are either being over or under fed. Cows to the left of a line like this are being overfed. In many cases, they are the result of lead feeding in the first 50 days of lactation and can be explained. If they are a result of manual 'bonuses' added to an individual cow's ration for some reason, make sure those bonuses are removed again after the need for them has gone. If cows are appearing to the right of the line, they are being underfed. This can be as a result of a wrongly entered group number or another data keying mistake. Check these cows on the system for problems and correct them to ensure that they are fed properly.

7. What is the total concentrate allocation to the highest yielding cows in the herd? Remember to include the concentrate in the mixed ration as well. At total daily concentrate allocations over 14kgs, you should be aware of the higher risk of health issues with these cows and the fact that milk quality may be lower. If you are seeing cow health issues, then the milking parlour should be set to deliver a lower maximum daily feed level across the herd.

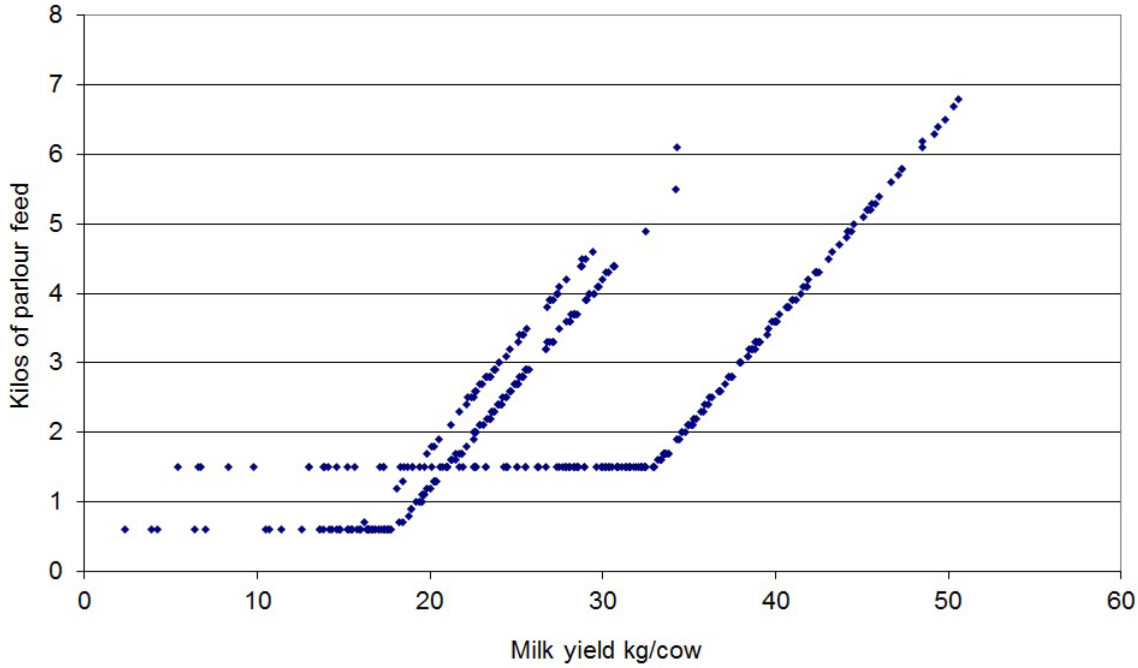


Figure B. Graph showing 2 batches of cows in a cubicle house but 3 batches of animals on the computer – lows are split into cows and heifers.

It's always worth checking your system to ensure that it is delivering the feed you thought it was. Minor errors can accumulate over a period of time and lead to wasted concentrate. There is no point in blaming the computer for problems as it will only ever be as good as the person entering the data and monitoring the results. If you are a member of a Business Development Group, your Dairying Development Adviser can help you analyse your feed to yield system and idenify areas for improvement in your herd.

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Computerised feed to yield systems in milking parlours have become much more common in recent years

NOTES

DAIRY RESEARCH BOOKLETS

- A Comparison On Four Grassland-Based Systems Of Milk Production For Winter Calving High Genetic Merit Dairy Cows
- Dairy Herd Fertility – Examination Of Effects Of Increasing Genetic Merit And Other Herd Factors On Reproductive Performance
- Developing Improved Heifer Rearing Systems
- Reducing Organic Nitrogen Outputs From Dairy Cows and Beef Cattle in Nitrate Vulnerable Zones
- The Effect Of The Type Of Dairy Supplement On The Performance Of The Grazing Dairy Cow
- Are International Dairy Sire Genetic Evaluations Relevant To Milk Production Systems In Northern Ireland?
- Effective Footbathing Of Dairy Cows
- Effects Of Feeding Maize And Whole Crop Silages On The Performance Of Dairy Cows Offered Two Qualities of Silage
- The Effect of Reducing the Protein Content of the Diet on the Performance of Dairy Cows
- Comparisons of Dairy Cow Management Strategies Which Differ in Labour Inputs
- Reducing Phosphorus Levels In Dairy Cow Diets
- The Effect Of Applying Slurry During The Grazing Season On Dairy Cow Performance
- A Comparison Of The Performance Of Holstein-Friesian And Norwegian Red Cows On Northern Ireland Dairy Farms
- The Effect Of A Number Of Novel Supplementation Strategies On Milk Production And Fertility Of High Yielding Dairy Cows
- A Comparison Of The Performance Of Holstein-Friesian And Jersey Crossbred Cows Across A Range Of Northern Ireland Production Systems
- The Effect Of Applying Cattle Slurry As The Sole Source Of Nutrients Over A Four Year Period On The Yield And Persistency Of Seven Perennial Forage Crops

- Grassland Performance And Its Relationship With Profitability On 10 Northern Ireland Dairy Farms
- The Effect Of Offering Concentrates During The Dry Period On Dairy Cow Performance
- Prevalence Of BVD In Northern Ireland Dairy And Suckler Herds
- Developing Improved Concentrate Feeding And Grazing Strategies For Dairy Cows
- The Effect Of Early Lactation Concentrate Build-Up Strategies On Dairy Cow Performance
- A Comparison Of Four Intensive Grassland-Based Systems Of Milk Production
- A Comparison Of Strategies To Improve The Body Condition Score Of Thin Cows In Late Lactation, And Their Effects On Performance During The Subsequent Lactation
- Calf Rearing Essentials
- Zero-Grazing: A Best Practice Guide
- Studies on The Use of Locally Grown Field Beans and Red Clover in Dairy Cow Diets

OTHER PUBLICATIONS

A Comparison Of Confinement And Grazing Systems For Dairy Cows

DISCLAIMER

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