Advancing dairy farming profitability through research

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Abstract

The New Zealand dairy industry recognises that to remain competitive it must continue to invest in research and development. Outcomes from research have ensured year-round provision of low-cost feed from pasture while improving productivity. Some of these advances, discussed in this paper, include the use of white clover in pasture, understanding the impacts of grass endophyte, improved dairy cow nutrition, the use of alternative forage species and nitrogen fertiliser to improve productivity, demonstration of the impact of days-in-milk on profitability, and the use of feed budgeting and appropriate pasture management.

Keywords: dairy, profitability, research and development

Introduction

The dairy industry has a significant impact on the New Zealand economy, being responsible for 21% of our export revenue and 5% of GDP (MAF 2000). Reliant on international trade for 95% of its revenue, the New Zealand dairy industry strives to remain competitive and produce high volume products. The use of new technologies on-farm while maintaining a cost-efficient production structure has, and continues to be, important to the dairy industry. A key element of New Zealand's competitive advantage is the provision year-round of low-cost feed from pasture. Ongoing research into forage, feeding, nutrition and management systems aims to maintain our competitive position. Some of these advances that have increased our understanding and led to changes in on-farm management, are described.

White clover content in pasture

To remain internationally competitive, the New Zealand dairy industry has relied on a cheap, high quality feed source. This has been predominantly a grass-based system complemented with white clover that contributes nitrogen through fixation, improved sward quality, and stimulation of forage intake and utilisation rates of animals (Caradus *et al.* 1995). White clover content of dairy pastures generally ranges from 10–20% but Harris *et al.* (1997) have demonstrated that white clover content needs to be nearer 50–65% to achieve maximum milk production. Increasing clover content from 0 to 50% resulted in significant increases in pasture crude protein and metabolisable energy, which resulted in increased herbage intake and milk yield (Table 1).

Table 1 Change from 0 to 50% white clover, in pasture crude protein and estimated metabolisable energy, cow herbage intake, and milk yield when offered an *ad lib* allowance (50 kg DM/cow/day). (Adapted from Harris *et al.* 1997).

	Pasture containing 0% clover	Degree of change in 50% clover pasture
Crude protein (%)	14.3	+29%
Estimated ME (MJ/kg/DM)	9.5	+11%
Herbage intake (kg DM/cow/day)	12.10	+23%
Milk yield (*l*/cow/day)	10.24	+33%

The benefit of pure white clover swards over pure ryegrass swards in increasing milk production has been demonstrated (Caradus *et al.* 1996). However, given the choice, ruminants are likely to only select up to 70% of their diet as white clover (Parsons *et al.* 1994). This value is similar to the optimum clover content of 50–65% for maximum milk yield. However, the challenge remains of how to provide ryegrass–white clover pastures with a legume content of 50%. One option may be to sow the grass and legume separately in a paddock to allow the grazing animals themselves to achieve the desired proportions (Chapman *et al.* 1996).

The potential of legumes other than white clover in grazed pasture has often been demonstrated but rarely adopted in on-farm management practices. Birdsfoot trefoil (*Lotus corniculatus*) is one such legume which when fed to cows, has been shown to produce 9% more milk than a comparative white clover dominant pasture (Harris *et al.* 1998). Realisation of this potential depends upon the determination of how best to utilise a legume such as birdsfoot trefoil in a dairy farm system.

Grass endophyte

In dairying areas, other than Southland and Westland, perennial ryegrass pastures are infected with the endophyte *Neotyphodium lolii* (Easton 1999). Endophyte is essential for the persistence of ryegrass in the presence of pasture pests, notably Argentine stem weevil and black beetle. The protection of ryegrass from these pests is related to production of a range of alkaloid metabolites by endophyte. Lolitrem B is active against larval feeding by Argentine stem weevil. Ergovaline contributes to ryegrass resistance against black beetle. However, lolitrem B is the major factor causing ryegrass staggers, and ergovaline is responsible for heat stress of animals.

Short-term trials have shown the effects of endophyte on milk production to be small and inconsistent (Thom *et al.* 1999). Longer-term trials have shown a 4% reduction in milk production in spring and a 14% reduction in summer on endophyte-infected compared with endophyte-free pastures (Valentine *et al.* 1993). Comparison of ergovaline-free pasture with ergovaline-containing pasture demonstrated that post-peak milk production (after November) was 24% greater in ergovaline-free pastures (Blackwell & Keogh 1999, 2001). Some of this difference may have been owing to the higher legume content seen in ergovaline-free pastures (Blackwell 1999).

Research has now provided the option for inserting an endophyte, AR1, that does not produce the alkaloids lolitrem B or ergovaline, but does produce peramine and provides resistance to Argentine stem weevil. This endophyte will not cause staggers or heat stress and preliminary trials, as yet unpublished, indicate an advantage in milk production of cows fed ryegrass containing AR1 over those with wild-type endophyte.

Dairy cow nutrition

Changes in nutritional factors associated with changes in pasture quality are considered to result in milk composition variability (Kefford *et al.* 1995). Auldist *et al.* (2000) comparing cows fed pasture or a total mixed ration (TMR), showed that a TMR diet not only increased total milk yield, but also increased lactose concentrations, while lowering casein: total protein ratio, and concentrations of fat and casein. More consistent and better nutrition appears to reduce much of the seasonal variation in milk yield and composition. Research is now being directed to achieve an affordable TMR from forage.

Alternative forage species for dairy production

Perennial ryegrass and white clover are not always the most suitable species for all conditions and environments. Neither are ideal for drought-prone soils where tall fescue may be preferred because of its tolerance to drought, heat, grass grub and Argentine stem weevil (Milne *et al.* 1997). On light soils, prone to summer drought, tall fescue can show a 20% increase in milksolids (MS) over ryegrass. Average rates of milk production decline, post peak, were only 6.7% for tall fescue compared to 11% for ryegrass-fed cows (Milne *et al.* 1997). Other studies have shown 4% and 9% increases in milksolids for tall fescue mixes over ryegrass (Thom *et al.* 1998). Tall fescue on such soils can give more than 150% return on investment per annum. A contributing factor is the higher white clover content of tall fescue compared to ryegrass pastures (34% and 17%, respectively).

Chicory can also produce large quantities of high quality summer feed (Waugh *et al.* 1998). During summer drought, chicory gave similar milk production responses to turnips but had the additional advantage of being a perennial herb suitable for rotational grazing. Milkfat from cows fed chicory has a higher conjugated linoleic acid content than those fed turnips as a summer feed (Thomson *et al.* 1999).

Nitrogen fertiliser

The tactical use of N fertiliser up to 50 kg N/ha per year has long been accepted (Field & Ball 1978). Higher rates were shown to be unprofitable in a large scale dairy trial at the prevailing N cost: milk price ratio (Holmes 1982). This, and other trials, confirmed a widely held view that optimal profitability came from high P fertiliser use to encourage white clover growth and biological N fixation, coupled with zero or low N fertiliser use. By 1990 however, higher milksolid prices in dairying and a greater emphasis on profitability in all animal-based enterprises forced a re-evaluation of N fertiliser use. Dairy farmlet trials in the Waikato (Penno *et al.* 1994) and Taranaki (Thomson *et al.* 1991) led to recommendations for higher N use. Some dairy farmers exceeded 400 kg N/ha per year (Barr 1996) and concerns were expressed about the environmental impact of such high rates. A 4-year trial at Ruakura using N fertiliser rates of 0, 200 and 400 kg/ha per year (Penno *et al.* 1996) provided the opportunity to examine the environmental consequences of N fertiliser use. Ledgard *et al.* (1996) showed that the use of 400 kg N/ha per year led to nitrate levels rapidly exceeding the World Heath Organisation level for drinking water of 11 mg/l. However, the level generally remained below this value at an application rate of 200 kg N/ha per year.

Further research in the same trial by Harris *et al.* (1996) showed that while a rate of 400 kg N/ha per year caused a rapid disappearance of white clover from pastures, 200 kg N/ha per year coupled with high pasture utilisation had little effect on clover levels compared with the control (20 v 24% respectively).

A review by Clark (1997) of all dairy farmlet trials using N fertiliser concluded that there was a poor correlation between Economic Farm Surplus (EFS) per ha and N applied with N application giving an extra $100 EFS/ha. For application rates between 80–150 kg N/ha per year the EFS varied from -$260 to +$350/ha.

Average N fertiliser use by New Zealand dairy farmers in 2000 was 80–100 kg/ha per year. As a result of the above, and other research, farmers are now fully aware of the environmental consequences of high N use and of the need to evaluate decisions in relation to total farm management parameters.

Days-in-milk

From the 1960s until the early 1990s, dairy farm management was based around McMeekan's concept of high stocking rates to utilise a large proportion of the pasture grown. Consequently, little surplus pasture was available for silage, and what was conserved had low feeding value for lactating cows. The concept of maintaining condition score through winter rather than increasing it from a low base meant that cows were dried off early. In addition, there was no technology to achieve a concentrated calving pattern.

A trial in 1992/93 at the Dairying Research Corporation (DRC) fed pasture silage to lactating cows in spring or summer or autumn or in all three seasons (Clark 1993). Extra milk returns from 150 kg DM per cow were $26, $25 and $35 per cow for spring, summer and autumn respectively, and $80 per cow for silage fed in all three seasons. Surprisingly, cows had a greater response to silage in late, compared with early lactation, and this was further enhanced by the autumn supplemented cows milking for longer and therefore, having more days-in-milk. The trial further showed that higher levels of silage feeding, (e.g., 450 kg DM per cow), could also be profitable providing they contributed to extra days-in-milk. This experiment led to greater emphasis being placed on pasture silage quality, costs per kg DM of supplements and methods of increasing days-in-milk.

A larger trial at DRC examined the use of N fertiliser and maize silage supplementation to reach a goal of 1.75 t MS per ha per year (Penno *et al.* 1994, 1996). The success of this trial encouraged farmers to source cheap energy and protein from a variety of sources to ensure that days-in-milk were increased (van der Poel 1996). The importance of days-in-milk led to a re-evaluation of optimum stocking rates for pasture-based dairying (McCall *et al.* 1999; Penno 1999). Currently, the optimum stocking rate for maximum EFS is 85 kg liveweight per t DM.

Work on early summer application of N fertiliser at 50 kg N/ha showed a response of 65 kg milksolids per ha together with increased condition score at drying off (Penno *et al.* 1995). When coupled with a longer rotation length of 40 days N, fertiliser allowed an extra 450 kg DM/ha of pasture to be built up for winter.

The concept of higher feeding value for pasture silage was advanced by a national silage survey (Howse *et al.* 1996) that identified key factors to produce high feeding value of: (a) cutting silage by the first week of November and (b) using spring N fertiliser to generate early surpluses.

An indication of the success of the days-in-milk concept is shown by the increase in milksolids processed in New Zealand from 572 million kgs in 1989/90 to 970 million kgs in 1999/00. This 70% increase was associated with only a 41% increase in cow numbers (LIC Statistics 2000).

Feed budgeting and pasture management

Feed budgeting grew from a need to control the inputs (growth) and outputs (consumption and decay) in a grazed system (Parker 1973). From this reconciliation, both major strategies such as which stock classes to farm and tactical issues such as: fertiliser N application, feed conservation, rotation length, supplementation and destocking, can be driven.

There was an early recognition that feed budgeting required accurate measures of pasture mass. Various methods were used: visual assessment calibrated to ground level cuts, rising plate meters, capacitance probes and pasture cuts at different heights (Piggot 1986; L'Huillier & Thomson 1988). Where indirect measures of height or mass were used they were corrected to pasture DM through calibration equations developed on a local and/or seasonal basis. Whilst all methods led to more confident pasture allocation there were significant differences in the methods and estimations made in different regions by different research stations and consultants. In an attempt to standardise procedures and obtain comparable estimates throughout New Zealand dairy pastures, Thomson *et al.* (1997) conducted an extensive series of comparisons at different sites and in different seasons. They concluded that a consistent estimation of average farm cover and the ranking of paddocks for grazing purposes could be obtained using the rising plate meter and L'Huillier & Thomson's (1988) standard set of calibration equations. Further work for North Island dairy pastures by Thomson and Blackwell (1999) developed a more complex equation that provides specific intercept and regression coefficient values on a daily basis.

Despite the controversy that still exists around seasonal, pasture type and regional variation, there is no doubt that pasture mass estimation is an integral part of pasture management on many farms.

The use of near infrared reflectance spectroscopy (NIRS) has been shown to provide rapid, low cost and accurate estimates of feed composition (Corson *et al.* 1999). However, this technology has yet to make a significant impact in predominantly pastoral systems. However, it is becoming more widely accepted for maize and pasture silage and hay analysis.

As farms become larger and skilled personnel more expensive, there will be a requirement for less labour-intensive methods of monitoring pasture quantity and quality. Recent work on Air Video techniques (Waugh *et al.* 1999) and the Hanna radiometer (Hanna *et al.* 1999) have the potential to provide both estimates, although more research is needed to achieve commercial feasibility.

Concluding comment

It is evident that investment in research has led to significant advances in understanding factors influencing dairy production which in turn, has resulted in technological advances that maintain New Zealand's competitive advantage internationally. These include reinforcing the message of the value of white clover and legumes in general in our pastures; the impact of grass endophyte alkaloids; the dilemma of feeding high breeding worth cows from pasture; the niche positioning of alternative forage species; the tactical use of fertiliser nitrogen; the economic importance of extending days-in-milk; and, the benefits accrued from feed budgeting and astute pasture management.

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