Where to now for forage productivity in dairying?

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Introduction

There is no serious dispute that farmer profitability and national milk production are underpinned by grazed pasture. DairyNZ data shows that the amount of homegrown pasture and crop consumed is the best predictor of profit per hectare (Macdonald and Roche 2023). National feed consumption data shows that approximately 75% of dairy cattle diets are from directly grazed forages (DairyNZ Economic Survey). The importance of high genetic merit cows and management skill in turning the inherent competitive advantage of grazed pasture into profit and production are also well documented (e.g. Macdonald and Roche 2023).

Dairy sector strategies have long envisaged future farmer prosperity and sector competitiveness being achieved by ever increasing forage production, harvested by cows of ever-increasing genetic merit, managed by farmers with ever improving skill and technologies.

Unfortunately, there is growing evidence that grazed pasture harvested in NZ dairy systems is not increasing. In this paper I address the evidence and offer some choices for the future direction of research and farm management. The time scales for these two pathways aren't the same. Farmers looking to adapt to climate change or market conditions need to use the research and plants available now; it's only in a decade that a change in science direction will start to deliver new solutions.

What does the data say?

Trends in pasture production have been recently dissected and synthesised by David Chapman in his Ray Brougham address of 2023 and published in Chapman et al. (2024 submitted). Key points from that paper link data from sector, research farm and plot scale together. There is no national time series of accurate, farm level measurement of pasture yield. However, the simplicity of modern dairy systems and previous research allows back-calculation of the pasture that must have been consumed to meet observed milk solids production.

The longest data set derived from DairyNZ Economic Survey data (Chapman et al. 2024 submitted) suggests that there was a sizeable increase (1600 kg DM/ha) in pasture harvest from 1990-2001, based largely on increased nitrogen (N) fertiliser use and increased stocking rate leading to both greater pasture growth and harvest. Increased genetic merit in cows through this time will have also driven this trend given their higher appetite. Since 2001 the apparent increase is much smaller (c. 500 kg DM/ha) with several possible contributing sources.

Mills and Neal (2021) offer evidence that this plateauing is not a management issue, with both the highest producing farms (90th percentile) and average farms showing static pasture yield in the period 2009-2021.

A longer 1979-2019 timeseries of pasture growth at DairyNZ's Ruakura and Newstead research control farmlets (run under a consistent management protocol) supports these observations. Pasture yield appeared to increase only due to the shift to use of N fertiliser (c. average of 180 kg N/ha/yr) from 1990. As Chapman et al. (2024 submitted) point out, the measured yields are little different from those measured by Mitchell (1960) and Hodgson (1990).

Chapman et al. (2024 submitted) list the potential sources of increased pasture harvest in their work. These include gains from removing limitations to pasture growth (N fertiliser, irrigation), increased stocking rate and plant genetic gain. In addition, I would add increased cow genetic merit and appetite as a driver of feed demand, and increased maize silage cropping on-farm contributing to increased feed supply. Increased apparent pasture yield (derived from increased milk solids) was also measured during the shift from wild-type to novel endophytes in the Northern North Island in the 2000-2003 period (Bluett et al. 2005). It is also important to acknowledge that increased use of bought in feed will have led to substitution (Macdonald and Roche 2023), acting to reduce pasture harvested. Farmlet scale research has demonstrated all these individual factors, other than increased plant genetic gain. But all these proven factors relate to removing limitations to growth, or more efficiently harvesting it. Only plant genetic gain and cropping look to increase yield potential.

The uncertain link in the chain to the dairy sector's pasture ambition is the ability to increase yield potential through plant breeding. The evidence from National Forage Variety Trials (NFVT) is that potential yield of ryegrass is increasing due to plant breeding. The national yield gap between Nui Standard Endophyte and leading perennial ryegrass cultivars is approximately 2t DM/ha, achieved over 40 years this represents gains of the order of 50 kg DM/ha/yr or 0.5% (NZPBRA, 2024). However, this increased potential was not observed

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in the recently completed Forage Value Index (FVI) validation experiment (DairyNZ 2024) nor clearly seen in any other time series of data at research farms, high producing farms or in national averages of pasture harvest.

Most of our major competitors in the dairy export market aren't pasture based, so one aspect of competitive advantage is the productivity in the United States (US) of maize for grain and silage. There is evidence (Jeshke 2023) that maize grain yields are increasing on leading farms in the US in the National Corn Competition (NCC) by 4.7 bu/ha/yr (c.1.5%) as farmers bring genetics, management and competitive instincts together. Average yields and the rate of annual gain in the US is much lower (though still c.1% per year) – suggesting that management skill and increased yield potential are both producing gains. Sources of these gains include the availability of genetically modified (GM) traits in drought tolerance and insect protection, hybrid seed technology, gains in harvest index through conventional and genomic breeding and a large financial input into research.

Within NZ, the evidence for increased yields in maize silage is mixed, being similar to the ryegrass breeding story. Pioneer (2024) report year-on-year gains in plot yields of 300 kg DM/ha/yr (c. 1.5%). However, the Arable Industry Marketing Initiative (AIMI 2023) survey data indicates that on-farm yields have been flat for the previous decade.

So, in the face of this lack of demonstrable progress, competitive pressure from crop-based dairy and uncertainty on pathways to increased productivity, what do farmers, plant breeders and researchers do in their search for greater forage productivity?

Understand what ryegrass breeding for yield has done to plants and system performance

Researchers need to understand what the last 20-30 years of plant breeding has changed in the physiology of ryegrass plants and whether that does translate to increased potential herbage accumulation. This requires physiology and agronomy science at a plant level (for example photosynthetic efficiency), leaf area expansion rate) which then must be scaled up to plots and farm systems. This research should give insights into breeding progress and provide future breeding targets.

At the same time research should further test the farm systems level response to current plant breeding to see if the NFVT data does transfer to increased pasture yield and animal production. A less complicated systems test than the FVI validation experiment (which included clover, supplement feeding and was exposed to drought) is required to take smaller steps from NFVT evidence to farm system performance.

Breed for amenable (and useful) traits

Plant breeders have shown that they can change heading date and seasonality of yield through breeding. These are traits that are useful, and amenable to breeding because they can be measured accurately. We simply must know whether or not breeding for yield potential (measured by improved animal performance) in perennial grasses is possible. To re-frame Parsons et al. (2011) – harvested yield is the target trait, but if you can't measure it directly in ways that allow you to breed for it – then you need a different trait. Plant breeders need a breeding target that does lead directly to the yield trait.

Identifying new traits that will provide future value is another obvious strategy. Climate change adaptation and persistency traits such as heat tolerance or dormancy (as a drought avoidance strategy) are candidates, along with reduced methane, N use efficiency and biological nitrogen inhibition.

Modern breeding techniques such as genomics or gene editing won't help unless we have reliable gene maps and phenotypes in relevant plant material to drive the selection and modification processes.

Act now to capitalise on 20 years of genetic modification research

World leading science has been carried out at AgResearch to produce two GM forage plants (High Lipid or High Metabolisable Energy (ME) ryegrass and High Condensed Tannin white clover). In comparison with the 50% yield gains originally reported from glasshouse trials with High ME ryegrass, the current estimate of 10% increase in ME per hectare alongside reductions in methane and N loss may appear disappointing. However, compared with the observed gains in yield and environmental footprint from conventional ryegrass breeding and other GHG technologies, these gains look attractive.

It is interesting that both these mechanisms involve transferring a gene that stimulates production of compounds that are beneficial for farmers but are also a sink for photosynthesis (Chapman et al. 2024 submitted). Other targets for genetic modification or gene editing might emerge but given the lead times we need to move quickly in synchrony with regulatory change to test the field performance of these plants individually and as a pasture mix.

Change your system

For the last 30 years the easiest route to increased feed production per hectare has been the use of increased N fertiliser. With new regulations and the cost of N fertiliser increasing, the use of N is now declining (FANZ 2023). The second route to increased production has been the use of cropping on the milking or wintering platforms, in particular maize in the North Island and fodder beet in the South Island. This is distinct from importing maize grown by other farmers, although this is an effective strategy for system change.

System trials such as Super P Prototype Farms (Glassey and Roach 2010) and Northland Agricultural Research Farm (NDDT 2018) have tested cropping options. Results usually show an increase in forage harvested and milk solids production from increased cropping. Increases in profit are more variable, and all systems introduce greater complexity. Results from Super P also showed an increase in pasture harvest as a consequence of the rapid renewal cycle of having 25% of the farm renewed every year and benefiting from the 'new grass' effect. Questions remain about the net effect of these systems on GHG emissions with these being dependent on assumptions about soil carbon change. However, for farmers looking to increase physical productivity and produce more milk solids per hectare – this is the best bet option.

Get better at managing your existing pastures

The pasture harvest gap between below average and top farmers indicates scope to improve pasture harvest by better management. This is supported by the work of McCarthy et al. (2014) and DairyNZ (and all its predecessors) who have worked tirelessly to persuade farmers that this gap exists on their farm. Clearly this has been ineffective in raising pasture harvest at a sector level, regardless of the individual gains.

While people are still running farms, it seems unlikely that anything outside a sustained and substantial drop in terms of trade (i.e. milk price relative to input costs) is going to change their core practices at scale. However, it is possible that there is a step-change in technology in train. This is likely to combine virtual fencing, accurate real-time measurement of grazing residuals and AI driven decision rules on initial allocation, expected feed disappearance rate, real-time fence shifting and supplementary feeding.

For dairy farmers this technology package will produce incremental changes. For beef farmers it will be transformational in terms of pasture harvest and system productivity, acknowledging the need for investment in water reticulation.

Conclusions

The dairy sector needs better pastures for both productivity and a reduced footprint. Currently there is a lot of uncertainty about the gains being made in plant breeding and how these will translate into improved farm performance. As a sector and a country, we need to invest in the science, both fundamental and applied, that will resolve the uncertainties, exploit the gains in the pipeline and create new value.

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