Adoption of plantain within New Zealand farming systems

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Abstract: In New Zealand, plantain has been incorporated into the pasture forage base in three ways: as a short-term pure crop; as a major component in "herb mixes" that include clovers and chicory; and as a minor component in perennial grass-based swards. All types are typically grazed in-situ. Given the incentive to optimise the plantain proportion in livestock diet to mitigate nitrogen losses and the observed lack of persistence in grass-dominant pasture over time, there is a need to use various pasture types strategically across a farm system to ensure a long-term sustainable contribution of plantain to feed intake. The inclusion of plantain in the forage base should be relatively straightforward since farmers are already familiar with establishing and managing forage crops and mixed-species pastures. However, there are still technical questions to answer and incentives to implement before we can achieve the region-wide adoption necessary to result in a measurable impact on water quality. The Tararua District, on the east coast of the North Island of New Zealand, represents a useful case study of adoption in a strong dairy farming region. Some underpinning elements for successful adoption were in place: 1) national agronomic experience in using a plantain cultivar released in 1996; and 2) regulatory push in terms of reducing N leaching losses on farms. However, other initiatives were required to see meaningful progress: provision of data from local dairy farm systems, focussed on the impact on forage supply/quality; a targeted extension program by a trusted sector leader agency (DairyNZ); individual farmer risk-taking and leadership in establishing and managing new crops and pastures. After three years, awareness is well embedded in the rural community and approximately 30% of dairy farms within the district have started to use plantain.

Introduction

In New Zealand, since the development of two commercial plantain cultivars in the mid-1990s (Stewart, 1996), plantain has been incorporated into the pasture forage base in different ways: Although early research was with short-term pure crops (Fraser and Rowarth, 1996) commercial use was as a minor component sown at low rates (1-2 kg/ha) in diverse pasture mixes, with a market volume that grew from c. 20 to 80 t/y in the early years (1996-2005).

During the period 2005-2010 plantain was researched and promoted as a major component in "herb mixes" that included clovers and sometimes chicory (Cranston *et al.*, 2015). The effectiveness of this for finishing young stock (Moorhead *et al.*, 2002) and increasing ewe liveweights (Judson *et al.*, 2009) led to an increase in seed sales of the Ceres Tonic cultivar and an increase in market volume to c. 110 t/y. From 2010-2015 pure crop use grew rapidly, to peak at over 300t/y. However, poor sector understanding of its niche and its failure to meet high expectations by farmers led to a market retrenchment to c. 200 t/y by 2015.

More recent inclusion in perennial grass-based swards in the dairy sector (Edwards et al., 2015), as a result of two major national research programmes: "Forages for Reduced Nitrate Leaching" and "Greener Pastures". Since 2015, other seed companies have entered the market with proprietary cultivars, such that market volume is currently c. 250 t/y. Another recent development has been the incorporation of the effects of plantain on animal N excretion into the Overseer® model (Wheeler et al., 2003). This tool has been used by many local regulatory authorities to assess farm N leaching losses for the purpose of granting long-term land use consents.

Adoption barriers

The inclusion of plantain in the forage base on farms should be relatively straightforward: incorporating plantain does not require costly additional infrastructure (c.f. stand-off pads) or a major shift in feed

management (c.f. forage or catch crops). New Zealand pastoral farmers are already very familiar with establishing and managing ley and mixed-species pastures. However, there are still some finer-scale management questions to answer, to achieve the region-wide adoption necessary to result in a measurable impact on water quality. Some of the key barriers to uptake have been:

Weed management. As a dicot herb, plantain shares physiological and phenological characteristics of many of the other dicot herbs (e.g., *Ranunculus* spp, *Rumex* spp., *Senecio* spp.) targeted by the active ingredients in commonly available herbicides. Hence, weed control options are limited, and the common practice of applying 24-D or flumetsulan in early spring to suppress dicot weeds in mixed pastures proved severely damaging to plantain (Gawn *et al.*, 2012). The small size of the potential market for a suitably discriminating herbicide and the high cost of agrichemical registration means that researchers and farmers are restricted to improvising with existing formulations. Some useful candidates have recently emerged, such as bentazone and diuron (PJ Gerard, *pers. comm.*).

Pest management. Between 2010-2015, pure plantain crops in the northern North Island were damaged by plantain moth (*Scopula rubraria/Epyaxa rosearia*), and they are also susceptible to the native grass grub (*Costelytra zealandica*). Pesticides are considered a last resort, because of their non-target and residual effects, but there is some evidence of differences in cultivar susceptibility (Gerard *et al.*, 2018).

Persistence. The prolific seeding capacity of plantain sees it operating as a short-term perennial, which is commonly seen in grass-based mixes where competition from perennial ryegrass is intense (Dodd et al., 2019). Recruitment rates of >300% have been observed in pure crops under ideal conditions of open swards in moist autumns, though only 20% of those plants had established after 6 months. The combination of plantain and perennial clovers is most conducive to plantain persistence, with swards readily maintaining high plantain contents for >5 years (Cranston *et al.*, 2015).

Palatability. Palatability appears to become a problem in cases when poor utilisation leaves old leaves intact for the next grazing rotation, or when leaves age due to longer winter rotations. Optimal grazing management has been well studied for herb-clover mixes in drystock systems (Cranston *et al.*, 2015) but less so for grass-based mixes in cattle/dairy systems. Indications are that plantain prefers a slightly longer round length than perennial ryegrass (Lee *et al.*, 2015), so industry standard recommendations may need to be modified to maintain persistence and palatability of this combination.

Farm-scale implementation

The nitrogen loss driver implies the need to use various pasture types strategically across a farm system to ensure a long-term sustainable contribution to feed intake (Beukes *et al.*, 2014). The nominal target for plantain contribution of the herd's intake is 30%, in line with evidence from farmlet studies (Navarrete *et al.*, 2022) and indoor feeding studies that this is the threshold for statistically verifiable effects on urinary N concentration (Minneé *et al.*, 2020). Of the three pasture types, plantain/clover mixes offer a potentially powerful combination of high-quality feed and high plantain content. However, there is emerging evidence that this sward type has little benefit for reducing N leaching, possibly due to the beneficial effects of plantain being offset by an increase in N fixation and animal N intake and reduced plant N uptake in the cooler seasons with high clover content (S. Navarrete, *pers. comm*). Hence the focus has been a combination of plantain in a pure crop and as a component in grass-based pastures, with aligned research aimed at maximising the persistence of plantain at high levels in the latter (Edwards and Pinxterhuis, 2018).

A simple spreadsheet modelling exercise serves to explore ways of achieving this target, by varying three factors: the proportion of the farm area in pure plantain, the re-grassing rate for introducing plantain in grass-clover swards, and the decay rate of plantain content in those swards (Table 1). The decay rate data have been sourced from the paddock monitoring in the Tararua Plantain Rollout project described in the case study below. The proportion of the farm in pure plantain has the greatest impact towards reaching the nominal 30% target, followed by the effect of good sward management.

Table 1. The effect of sward management, re-grassing rate and proportion of farm sown, in maintaining long-term whole-farm plantain contribution to forage supply.

Decay rate of plantain content	% of farm in plantain forage crop	10	17	25
Moderate (typical management)	5% re-grassing rate	15	20	24
Crop: 90-50-30*	7% re-grassing rate	16	20	24
Mixed pasture: 30-25-20-10*	10% re-grassing rate	17	21	26
Low (best management)	5% re-grassing rate	19	24	29
Crop: 95-70-30*	7% re-grassing rate	21	25	29
Mixed pasture: 50-45-40-20*	10% re-grassing rate	23	27	32

*Figures indicate the year-on-year change in autumn plantain content (%) typically observed.

Case study

The Tararua District, on the east coast of the lower North Island of New Zealand, represents a useful case study of adoption in a strong dairy farming region. Two key underpinning elements were in place: 1) well developed national agronomic experience in using a plantain cultivar (Ceres Tonic) released in 1996; and 2) regulatory push to reduce N leaching losses on farms to obtain long-term land use consents. However, few local dairy farmers had any experience with plantain, and hence other initiatives were required to see meaningful adoption progress:

- provision of data from local dairy farm systems, focussed on the impact on forage supply/quality.
- a targeted extension program by a trusted sector leader agency (https://www.dairynz.co.nz/about-us/regional-projects/tararua-plantain-project/)
- individual farmer risk-taking and leadership in establishing and managing new crops and pastures.

With a small group of willing farmer leaders and the support of an industry-government funding partnership, on-farm monitoring was implemented to address the following farmer questions:

Will the use of plantain impact forage supply? Including plantain in perennial ryegrass/white clover pastures significantly increased annual herbage accumulation (HA) with the greatest effect in summer and autumn (Table 2). Plantain/clover paddocks had similarly higher annual HA, and significantly higher autumn yield. Pure plantain paddocks had lower spring HA than other pasture types and annual yield was similar to ryegrass/clover. Both ryegrass/plantain/clover and plantain/clover paddocks had high plantain contents (30-50%) going into the autumn-winter period of highest N leaching risk.

Will the use of plantain impact forage quality? Inclusion of plantain in grass-based swards had no significant impact digestibility (Table 2), but reduced pasture dry matter %. Plantain/clover and pure plantain swards showed some small reductions in digestibility, largely driven by declines in summer.

What is the best means of establishing plantain to ensure the long-term persistence of its contribution to forage supply? Establishment by spray drilling or cultivating with re-grassing in autumn was the best means of ensuring high plantain contents in grass-based swards, and the swards with higher starting content maintained the highest content for >3 years (Dodd et al., 2023).

How can we effectively assess the contribution of plantain to livestock diet to meet regulatory thresholds? Visual assessments by experienced operators were robust at estimating the contribution of plantain to available dry matter, with correlations >0.9 (Dodd et al., 2023).

After three years of monitoring and extension activity, awareness is well embedded in the rural community and approximately 30% of the 186 unconsented dairy farms within the Tararua district have started to use plantain. Further developments that would likely enhance uptake include:

- Incorporation of additional soil effects of plantain into the Overseer® model, to further reduce modelled nitrate leaching from swards with plantain.
- Practicable solutions to weed and pest management issues.
- Optimisation of companion grasses and grazing management to maintain strong plantain content.

Table 2. Mean effects of sward type on seasonal herbage accumulation (double-trim cage harvests) and pasture quality (NIR analysis) of dairy farm pastures in the Tararua over 3½ years. Different letters within rows indicate significant differences (Fishers LSD, P<0.05).

Pasture type	Ryegrass/clover	Ryegrass/plantain/clover	Plantain/clover	Plantain
Winter yield (kgDM/ha)	1670 a	1860 a	1380 a	1320 a
Spring yield (kgDM/ha)	4260 b	4330 b	4580 b	3310 a
Summer yield (kgDM/ha)	4750 a	5460 a	5070 a	5150 a
Autumn yield (kgDM/ha)	2600 a	3020 ab	4000 c	3310 bc
Annual yield (kgDM/ha)	13280 a	14670 b	15030 b	13090 a
Digestibility (%)	71.3 a	71.8 a	69.0 b	69.0 b
Dry matter (%)	17.8 a	15.2 b	17.2 a	14.5 b

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