Weed ingress and pasture persistence in Bay of Plenty dairy farms: field observations and farmer perceptions

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Abstract Above-ground botanical composition and seedling emergence from the soil seedbank were assessed in 30 Bay of Plenty dairy pastures in spring 2010. Pastures ranged in age ('young': 1–2 years, 'medium': 3–4 years, 'old': 5–6 years) and included those with and without forage herbs (chicory and/or plantain). As pastures aged, there was an increase in the percentage of total dry matter of unsown weed grasses (3%, 8%, 27%) and unsown herbaceous weeds (5%, 18%, 39%) in young, medium and old pastures sown with herbs, respectively. Unsown weed grasses dominated the seedbank and together with herbaceous weeds comprised more than 99% of seedlings that emerged from the seedbank. Farm managers ranked insect pests and climate (e.g. droughts/floods), as the primary factors causing the decline of sown species, while grazing management was perceived as the most important factor that can improve persistence of sown species.

Keywords pasture persistence, weed seedbank, botanical composition.

INTRODUCTION

A decline in pasture quality with age and subsequent weed ingress have been identified as key issues by many New Zealand farmers (Daly et al. 1999; Tozer et al. 2011). Sown species frequently decline in their contribution to pasture performance over a period of several years (Parsons et al. 2010). The absence of regeneration of pasture species may be caused by the failure to develop a seedbank. For example, the seedbank of ryegrass (*Lolium perenne*) does not persist as nearly all seeds germinate in the autumn (Bell 1995).

Overseas studies have shown that increasing the diversity of sown species can have benefits for pasture production and performance, provided the species selected are well adapted to their environment. For example, Sanderson

et al. (2004) showed that pastures with a greater diversity of sown species had greater pasture production and reduced weed pressure during droughts. This is related to their functional characteristics, which determine how plants respond to different climatic variables. One means of increasing the functional diversity of a standard grass-legume mix is by adding the forage herbs chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*), which are deep-rooted and drought-tolerant.

A previous survey was undertaken in spring 2009 to assess the impact of sowing herbs on pasture persistence and weed ingress. The survey included assessments of the above-ground botanical composition and the soil seedbank. Additionally, farmers were asked to name the

key factors contributing to persistence of sown species and their mortality. They were also asked to name key knowledge gaps/information needs regarding pastures. This survey was undertaken in beef and sheep pastures in North Canterbury/Northland and dairy pastures in Waikato/Taranaki. Results from these surveys are reported in Tozer et al. (2010 a, b). This paper reports survey findings from Bay of Plenty dairy pastures in spring 2010.

METHOD

Site selection

Thirty dairy paddocks on a total of 10 dairy farms in the Bay of Plenty were assessed over 7 days during spring 2010. Paddocks were approximately 1.5 ha. On each farm, one to five paddocks were selected to encompass a range in age since renovation (1 to 6 years) and in diversity of the sown mix (grasses + legumes vs grasses + legumes + herbs). Other selection criteria included: knowledge of the original pasture species mix sown, no irrigation and no undersowing since renovation. Most pastures were sown with ryegrass and white clover (*Trifolium repens*) although some were sown with tall fescue (*Schedonorus arundinaceus*) and white clover. Red clover (*T. pratense*) was occasionally included in the mix. Sown herbs included chicory and narrow-leaved plantain.

Survey design

Sowing mix and pasture age were considered as explanatory variables. Fifteen paddocks were selected in which grasses and legumes had been sown, and 15 paddocks in which grasses, legumes and herbs had been sown. The 15 paddocks were further subdivided into 'young' (renovated in the last 1–2 years), 'medium' (3–4 years) and 'old' (5–6 years). This gave five replicates for each sowing mix × age combination.

Botanical composition

Plant species were identified and their percent ground cover visually estimated by the same operator on all occasions, in four 2 m × 2 m randomly placed quadrats in each paddock.

Percentage of total dry matter for sown and unsown grasses, sown and unsown legumes and sown and unsown herbs was also assessed in 20 0.1 m² quadrats in each paddock, in the same area in which percent cover was estimated, using the BOTANAL method (Jones & Hargreaves 1979). This method visually ranks the three most dominant species present in each of the 20 quadrats, with respect to their dry matter contribution. To estimate the contribution of these species to total pasture dry matter, standard multipliers are then used (Jones & Hargreaves 1979).

Soil seedbank assessment

Eighteen of the 30 paddocks were chosen for seedbank assessment (three of the five replicates in each paddock age × diversity treatment combination). Fifteen soil cores (2.5 cm diameter and 7 cm deep) were collected from each paddock. Cores were bulked and the 500 g subsample sieved and placed in a 2 cm layer on trays in a glasshouse. Trays were maintained at ambient temperatures and watered as required to keep the soil moistened to field capacity. Most seedling emergence from the seedbank occurs within the first week using this method (Rahman et al. 1995). Emerged seedlings were identified, then removed, until seedling emergence ceased, after 7 weeks.

Statistical analyses

REML was undertaken using GenStat for Windows 13.2 (2010), with farm as a random effect, on the proportion of total dry matter of the different vegetation classes present, including total sown and unsown species, and sown and unsown grasses, legumes and herbs. Diversity treatment (with/without herbs) and age were the explanatory variables.

Average percent ground cover of the seven overall most dominant species and the percentage of sites at which they were present were tabulated.

Farmer survey

Managers or owners of the farms included in this project were asked the following questions to ascertain their perceptions on factors

associated with pasture persistence and decline following sowing of the species: ‘what are the keys to persistence’, ‘what are the main killers of persistence’ and ‘what are your key pasture research/information needs?’ Respondents could give up to three answers for each question. Responses on ‘keys to persistence’ were categorised according to: grazing management, nutrient management, plant species/cultivar selection, insect pests, soil properties, other management factors and weather. ‘Killers of persistence’ and research needs were similarly categorised. These categories were chosen such that they were as similar as possible to those used for the previous spring surveys in Northland, Waikato, Taranaki and Canterbury (Tozer et al. 2011). The number of responses for each category was presented as a percentage of the total number of responses. Categories were ranked in order of their percentage contribution.

RESULTS
Effects of sowing herbs on proportion of total DM

Sown herbs (chicory and/or plantain) contributed an average of 8% of the total DM where sown. Pastures with sown herbs had a smaller contribution to total DM of sown grass and total sown species in medium and old pastures (Table

1, $P<0.01$). Pastures with sown herbs also had more weeds (total unsown species) in medium and old pastures and more unsown grasses and unsown herbs in old pastures (Table 1, $P<0.001$). Legume content of pastures was not affected by including herbs and contributed approximately 12% of total DM (data not shown, $P>0.05$).

As pastures aged, sown grasses and total sown species content declined while unsown grasses, unsown herbs and total unsown content increased (Table 1, $P<0.001$). There was no detectable effect of pasture age on legume or sown herb content (data not shown, $P>0.05$).

Percentage cover and seedling emergence from the seedbank

Sown grasses were the most prevalent above ground cover, followed by unsown herbs and then sown legumes. Of these, ryegrass ground cover comprised 66% and white clover 11% in paddocks in which they were sown, irrespective of age. Broad-leaved weeds comprised 16% and annual grass weeds less than 5% of total ground cover. These included annual poa (*Poa annua*), broad-leaved dock (*Rumex obtusifolius*), buttercup (*Ranunculus* spp.) and yarrow (*Achillea millefolium*, Table 2).

In contrast to the above ground cover, emergence from the seedbank mainly comprised

Table 1 Mean percentage of total DM for sown and unsown pasture species in young (1–2 years), medium (3–4 years) and old (5–6 years) pastures measured in spring 2010. SEDs and letters following means apply to comparisons between all treatments within a row. *** denotes $P<0.001$, ** denotes $P<0.01$, * denotes $P<0.05$.

Vegetation	+herbs			−herbs			SED	Difference between +/- herbs		
	Young	Med	Old	Young	Med	Old		Young	Med	Old
Sown										
Grasses	66 a	49 b	18 c	73 a	78 a	68 a	7.8	NS	***	***
Total	91 a	71 b	33 c	89 a	85 a	73 b	4.7	NS	**	***
Unsown										
Grasses	3 b	8 b	27 a	6 b	6 b	3 b	5.1	NS	NS	**
Herbs	5 c	18 bc	39 a	6 c	11 c	25 b	6.6	NS	NS	*
Total	9 c	29 b	67 a	10 c	15 c	27 b	4.7	NS	**	***

Table 2 Average cover (%) of the seven most dominant species sampled from 30 pastures and total seedling emergence from soil sampled from 18 pastures, spring 2010. Data are untransformed means $\pm$ SE. Data in parentheses are the percentage of sites at which they were present.

Botanical composition (above ground)		Soil seedbank (below ground)	
Species	Percentage of total ground cover	Species	Percentage of total seedling emergence
Ryegrass	62 $\pm$ 6.3 (97)	Summer grass	50.7 $\pm$ 5.6 (100)
Tall fescue	3 $\pm$ 3.1 (16)	Smooth witch-grass	16.6 $\pm$ 5.0 (78)
Annual poa	3 $\pm$ 1.0 (97)	Crowsfoot grass	2.4 $\pm$ 1.2 (39)
<i>All grasses</i> ¹	68		71.5
White clover	11 $\pm$ 3.1 (97)		
<i>All legumes</i> ¹	12		0.4
Buttercup	4 $\pm$ 2.0 (94)	Broad-leaved plantain	14.9 $\pm$ 3.5 (83)
Broad-leaved dock	4 $\pm$ 0.8 (97)	Amaranthus	3.5 $\pm$ 1.8 (50)
Yarrow	2 $\pm$ 1.4 (50)	Oxalis	2.3 $\pm$ 1.1 (61)
		Broad-leaved dock	1.6 $\pm$ 1.4 (28)
<i>All herbs</i> ¹	16		28.1

¹Totals in italic are based on all seedbank data, not just the seven most prevalent species.

weedy grasses and weedy herbs. Of seedlings that emerged from the seedbank, emergence of the C4 grasses, summer grass (*Digitaria sanguinalis*) and smooth witch-grass (*Panicum dichotomiflorum*), was greatest, followed by broad-leaved plantain (*Plantago major*) and amaranthus (*Amaranthus* spp.). Crowsfoot grass (*Eleusine indica*) and oxalis (*Oxalis* spp.) were also present. Emergence of white clover (0.5%) and narrow-leaved plantain (0.1%) was negligible and there was no emergence of sown grasses (Table 2). The seven most dominant species comprised 89% of ground cover and 92% of seedling emergence from the soil seedbank (Table 2).

Farmer assessments of pasture quality

Farmers identified grazing management and nutrient management as the two most important factors contributing to increased persistence of sown pasture species (Table 3). They also identified insect pests and weather (e.g. droughts), followed by grazing management, as being the three most important factors contributing to loss of persistence (Table 4). Topics identified as key research/information gaps were improving pasture persistence, followed by the need for

independent, on-farm regional trials and information (Table 5).

DISCUSSION

As pastures aged during their first decade, the content of sown species declined and that of weeds increased, which is consistent with previous findings from Northland, Waikato and North Canterbury (Tozer et al. 2010b). Thom et al. (1998) have also shown how ryegrass dry matter (kg DM/ha/year) declines as dairy pastures age. There was an average decline in dry matter production of 27% between the first and second year of their study and a further 6% decline between the second and third year. Contrary to the hypothesis, increasing diversity of sown species did not increase the persistence of sown species or reduce weed ingress; pastures sown with the forage herbs chicory and/or plantain had more weeds and less dry matter of total sown and sown grass species in the older pastures (see Table 1). This is in contrast to the earlier surveys in other regions, where a weak negative relationship was discovered between sown species diversity and weed ingress. For example, in Northland, older pastures sown with

Table 3 Farmer responses to the question “what are the keys to persistence?” Ten farmers took part in the survey and each farmer was allowed to give up to three responses to the question. Values are the number of responses given for each category expressed as a percentage of the nineteen responses that were received in total.

Factor	Percentage of total number of responses
Grazing management (e.g. avoid pugging, undergrazing and overgrazing)	32
Nutrient management (e.g. N application)	24
Plant species / cultivar (e.g. appropriate species selection)	12
Insect pests (e.g. treated seed, right endophyte)	12
Soil properties (including biological activity)	4
Other management factors (appropriate herbicide use)	4
Weather (good rainfall)	12

Table 4 Farmer responses to the question “what are the main killers of persistence?” Ten farmers took part in the survey and each farmer was allowed to give up to three responses to the question. Values are the number of responses given for each category expressed as a percentage of the twenty-four responses that were received in total.

Factor	Percentage of total number of responses
Insect pests (e.g. black beetle (mentioned by 6 farmers))	33
Weather (drought, floods)	33
Grazing management (e.g. undergrazing, overgrazing, pugging, compaction)	22
Nutrient management (soil imbalances and deficiencies)	8
Other management factors (herbicide use and non-target damage)	4

Table 5 Farmer responses to the question “what are your key pasture research/information needs?” Ten farmers took part in the survey and each farmer was allowed to give up to three responses to the question. Values are the number of responses given for each category expressed as a percentage of the twenty responses that were received in total.

Research needs / information gaps	Percentage of total number of responses
Persistence/performance	25
Independent on farm regional trials, demonstrations and information	20
Insects (enhancing biocontrol agents, endophyte persistence)	10
Plant breeding (e.g. better genetics suited to BOP)	10
Mixtures (e.g. alternative species, management of mixtures)	10
Weed control (summer-active grass weeds)	5
Livestock performance (animal health and nutrients)	5
Other (soil biological activity, simple management systems, management of diploids vs tetraploids)	15

the forage herbs chicory and plantain had fewer unsown herbaceous weeds (Tozer et al. 2010b). The survey was not designed to investigate reasons for differences between the treatments in botanical composition. Further research under controlled conditions would be required to determine how sown herbs interact with the other species present in the pasture. Regardless of the reasons, it is clear that there are large regional differences in how diverse pastures perform.

Botanical composition can be assessed using many techniques. Two methods were used in this survey to ensure that species present in the pasture were detected. Percentage cover was assessed using a small number of large quadrats and focused on the area occupied by each species, while the BOTANAL method used a larger number of smaller quadrats. The BOTANAL method assesses contribution to total dry matter, which is an important measure in agronomic studies as it relates to pasture quality and livestock production. While species present were identified using both methods, aggregated data (i.e. sown and unsown vegetation) were based on BOTANAL measurements (Table 1) and individual species data were based on percentage cover measurements (Table 2). This was to better enable comparisons with results from the previous surveys (Tozer et al 2010 a, b).

Soil seedbank assessments demonstrated how unsown herbs (e.g. broad-leaved plantain) and especially summer-active grasses (e.g. summer grass and smooth witch-grass) were prevalent. This is consistent with results from all the other regions surveyed, where weed seedlings dominated the seedbank in spring and there was negligible emergence of sown species, including ryegrass and white clover. It is possible that seeds of sown species such as ryegrass had germinated during autumn prior to soil sampling. Greater emergence of winter-active grass weeds may have occurred if emergence was tested during autumn, when winter-active grasses normally germinate. Nonetheless, results show that the seedbank in spring is dominated by weed seeds and that there is negligible carry-over of the seed of sown species. Some of the farmers interviewed

were making hay to allow ryegrass to set seed and replenish the seedbank in the hope that ryegrass germination and seedling establishment would occur in autumn. Modern grazing management aims to optimise pasture quality and livestock production, and therefore intensive grazing or mowing of pastures after seedhead emergence has led to less ryegrass seed set and fewer seeds entering the seedbank.

Although only a small number of Bay of Plenty farmers were surveyed regarding their perceptions on persistence and key research needs/information gaps, their answers were consistent with other regions surveyed during the previous spring (Tozer et al. 2011). Farmer perceptions in the Bay of Plenty were consistent with those from Northland and Taranaki, where grazing management followed by nutrient management were seen as key factors contributing to persistence of sown species. Farmers in the Bay of Plenty were also in agreement with those from Northland, Waikato, Taranaki and Canterbury in listing insect pests as the main factor leading to poor pasture persistence and Waikato, Taranaki and Canterbury in listing extreme climatic events (droughts, floods) as the second most important factor leading to poor pasture persistence.

Improving pasture persistence was identified as a research priority/information gap by Bay of Plenty farmers. A number of farmers commented that they had persistent ryegrass pastures over 10 years in age with wild-type endophyte. In contrast, they expressed concern over the persistence of their more recently sown pastures and modern cultivars. This was consistent with the field data presented in this paper, which have demonstrated a rapid decline in the persistence of sown species as pastures age. Farmers interviewed frequently expressed their mistrust of claims made in commercial brochures advertising pasture seed. This was corroborated by their ranking of independent trials and information regarding cultivar performance as the next most important research need/information gap. Farmers in Northland, Waikato, Taranaki and North Canterbury also identified pasture persistence and independent trials as the

two most important research needs/information gaps (Tozer et al. 2011).

CONCLUSIONS

There was no evidence in the Bay of Plenty that increasing functional diversity of sown forage herbs reduces weed ingress. Sown pasture components declined significantly during the first 6 years after sowing from an overall average of 90% to 53% of total dry matter, and there was negligible emergence of sown species from the soil seedbank. Farmers believe that grazing management and climate are the main causes of pasture decline. These results give an indication of future research and dissemination priorities. Improving pasture persistence must be a priority that will require a combination of research and better dissemination of existing technologies and knowledge regarding best-practice management.

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