Pasture persistence: farmer observations and field measurements

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Abstract
Information is presented on farmer perceptions and concerns regarding key factors leading to poor persistence of sown pasture species. Forty-seven farmers from four regions viz. Northland (beef, sheep), Waikato (dairy), Taranaki (dairy) and North Canterbury (beef, sheep, deer) were asked for their opinions on the 'keys' to persistence and 'killers' of sown species; i.e., factors leading to a decline in sown species. In all regions, grazing management was perceived to be the most important key to persistence and insect pests the top killer of sown species. Better industry dissemination of existing information and further research on forage herbs and insect pest issues are future requirements. In each region, presence of sown species was also assessed in 30 paddocks belonging to the surveyed farmers. There was a significant decline in pasture chicory presence, but no decline in that of cocksfoot or plantain. Ryegrass, white clover and tall fescue were present in nearly all paddocks in which they were sown. Chicory may be best used as a crop, while plantain shows greater potential for persistence as part of a pasture mix.
Keywords: chicory; farmer survey; information gaps; plantain; research needs

Introduction
'Poor persistence' occurs when the desirable species are replaced by weedy, undesirable species. This can occur through a decline in the population of a sown species or the decline in the expression of a trait within the sown species present in the pasture (Parsons *et al*. 2010). Farmers have recently expressed concern at industry field days and farmer meetings over poor persistence of sown pasture species and particularly perennial ryegrass. Pasture persistence was also ranked as the fourth most important factor in the whole farm system in a survey of 100 beef and sheep farmers in 1997/1998 (Daly *et al.* 1999). Research in Northland, Waikato and North Canterbury pastures demonstrated that there is a decline in the dry matter contribution of sown species as pastures age (Thom *et al.* 1998; Tozer *et al.* 2010b). In a separate paper in this volume Tozer *et al.* (2011) have reviewed the New Zealand literature to determine the factors leading to poor persistence. Assessing farmer perceptions of the factors affecting persistence is also important and will give direction to the pastoral industry when designing research projects and assigning funding. It will also highlight information gaps that can be addressed by effective dissemination of current industry knowledge.

To achieve the above objectives, surveys were conducted in four New Zealand regions to identify what farmers perceived to be the keys to persistence of sown species, killers of sown species and their pasture research/information needs. In addition, paddock surveys were undertaken to assess persistence of the sown species. Here we focus on presence or absence of a species; trends in the content of sown and weedy species in these pastures are reported elsewhere (Tozer *et al.* 2010a; Tozer *et al.* 2010b).

Methods
Research reported here is part of a larger project investigating trends in pasture persistence in Northland (sheep, beef), Waikato (dairy), Taranaki (dairy) and North Canterbury (sheep, beef, deer) pastures. Details of the project are recorded in Tozer *et al*. (2010b).

Sites
In each of the four regions, 10 to 14 farms were selected. This equated to two to three paddocks per farm and 30 paddocks per region and included both organic and conventional farms. Selection criteria were based on age since renewal and diversity of the sown mix (grasses + legumes (15 paddocks) vs. grasses + legumes + forage herbs (15 paddocks)). Paddocks were selected if: 1) the mix sown and year of sowing were known; 2) they were not irrigated (other than effluent spreading on a small number of dairy paddocks); and 3) no under or oversowing had occurred since renewal. Regions selected varied in climate, from Northland that has mild winters and warm, subtropical summers to North Canterbury that has a harsher climate of hot dry summers and cold winters. Paddocks varied in size from smaller 1.5-ha paddocks on dairy farms to much larger sizes (>10 ha) on sheep and beef farms.

Sampling
In spring 2009, presence and identity of sown species

Table 1. Keys to persistence: Percentage of the total number of farmer responses on keys to pasture persistence, in four regions.

Keys to persistence	Percentage of the total number of responses			
	Northland	Waikato	Taranaki	Canterbury
Grazing management (e.g., recovery period, post-grazing height)	55	41	36	46
Pasture establishment (seedbed preparation, sowing date, sowing depth, pre-emergent herbicide use and cropping to control weeds, soil with high organic matter and good structure, fertiliser application and initial grazing management).	10	13	12	11
Nutrient management	14	0	15	7
Plant species/cultivar (selection of appropriate species or cultivar/genetics for location and climatic effects (e.g., summer vs. winter activity, aspect), selection to allow succession of sown species, selection of drought tolerant, vigorous, deep rooting plants)	7	8	12	7
Insect pests (tolerance to insect pests: use of seed coating, endophytes, insecticides)	0	15	6	11
Soil properties (addressing compaction, drainage, iron-pans, aeration, lime, pH and biological activity issues)	3	5	18	0
Other management factors (weed control, don't renew- keep old pastures, use stock supplement, minimise herbicide use)	7	8	0	7
Weather (rainfall, moisture)	3	8	0	11
Total number of farmer responses / total number of farmers surveyed*	28/11	39/14	33/12	28/11

* Each farmer could list up to three keys of persistence.

Table 2. Killers of sown pasture species: Percentage of total number of farmer responses on killers of sown species, in four regions.

Killers of sown species	Percentage of the total number of responses			
	Northland	Waikato	Taranaki	Canterbury
Insect pests (e.g., grass grub, porina, Argentine stem weevil, black beetle, clover flea, clover root weevil, slugs, crickets)	36	44	54	35
Weather (drought, waterlogging, wind, storms, oversowing in a drought)	9	29	31	29
Grazing management (too lax, too early, inadequate recovery period, pugging, overgrazing especially during summer, selective grazing of Merinos, shutting up for hay / silage)	36	18	8	29
Soil-plant interactions (shallow roots, too much nitrogen, pulling, soil fertility)	5	6	8	0
Weeds (annual weeds in seedbank, kikuyu, barley grass, goose grass, using herbicides to control weeds and thereby damaging clovers)	14	3	0	6
Total number of farmer responses / total number of farmers surveyed*	22/11	34/14	13/12	17/11

* Each farmer could list up to three killers of sown species.

was assessed in four, randomly placed, 2 x 2 m quadrats in a 1-ha area of each paddock. Sown grasses included: perennial ryegrass (*Lolium perenne*), tall fescue (*Festuca arundinacea*), cocksfoot (*Dactylis glomerata*), prairie grass and grazing bromes (*Bromus* spp.), timothy (*Phleum pratense*) and phalaris (*Phalaris aquatica*). Sown legumes included white clover (*Trifolium repens*), red clover (*T. pratense*), subterranean clover (*Trifolium subterraneum*), lucerne (*Medicago sativa*) and lotus (*Lotus* spp.), while sown herbs included chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*).

Within each region, the 15 paddocks in each diversity category were subdivided into 'young' (renewed in the last 1 - 3 years), medium (4 - 6 years) and 'old' (7 years or more). This gave five paddocks for each age and diversity category within each region. In Northland, it was not possible to locate sufficient renewed paddocks over 6 years old with known paddock histories. Therefore, young was defined as 1 - 2 years, medium as 3 - 4 years and old as 5 - 6 years.

Table 3. Pasture research needs and information gaps: Percentage of the total number of farmer responses on pasture research needs and information gaps, in four regions.

Research and information needs	Percentage of the total number of responses			
	Northland	Waikato	Taranaki	Canterbuiry
Persistence (including comparison of new and old cultivars)	33	46	37	30
Mixtures (e.g., forage herb establishment in a perennial pasture, dry matter production, quality, palatability, minerals benefits, animal health effects of mixtures, weed control, suitable species to grow with tall fescue, clover growth in a vigorous ryegrass sward)	7	32	19	17
Independent, on-farm regional trials, demonstrations and information	20	3	15	4
Insects and endophyte (insect pest control, endophyte issues, stock management on high endophyte grasses, endophyte interactions with high sugar grasses)	20	0	8	8
Plant breeding (e.g., for drought tolerance and higher metabolisable energy, making sown species more attractive for specific cattle breeds, e.g., Jerseys)	7	3	4	13
Weed control (e.g., kikuyu, cut-leaf geranium, gorse)	7	8	0	9
Grazing management (rotation lengths, impact on root length/growth, optimal post-grazing residuals for different grasses)	7	3	4	0
Livestock performance (on new cultivars and especially high sugar grasses)	0	0	0	13
Organic: effectiveness of fertilisers (seaweed, rock phosphate), comparative (conventional vs. organic) greenhouse gas emissions, pasture quality and regrowth	0	5	7	0
Pasture establishment (spatial separation of plants to reduce competition, reseeding bare patches vs. renewing the whole pasture)	0	0	7	4
Total number of farmer responses / total number of farmers surveyed*	18/11	37/14	27/12	23/11

* Each farmer could list up to three pasture research needs/information gaps.

Table 4. Persistence of chicory, cocksfoot, plantain and red clover, in paddocks in which they were sown (expressed as a percentage of the total number of paddocks sown with the species). Data were averaged over four regions (Northland, Waikato, Taranaki and North Canterbury).

Species	Paddock age				
	Young	Medium	Old	SED	Signif.
Chicory	96.1	66.2	34.0	13.07	***
Cocksfoot	82.4	79.7	87.4	15.83	NS
Plantain	94.6	95.1	75.2	10.24	NS
Red clover	52.2	40.5	36.3	28.71	NS

*** = $P < 0.001$; NS = not significant. Young = 1-3 years, medium = 4-6 years, old = ≥ 7 years for all regions except Northland: Young = 1-2, medium = 3-4 and old = 5-6.

Statistical analysis

A binomial regression fitting age and region was undertaken using GenStat 12.2 (VSN International Ltd., Oxford), on the persistence (presence) of chicory, cocksfoot, plantain and red clover. The number of paddocks sown with other species (phalaris, prairie grass, grazing bromes, timothy, lucerne, lotus and subterranean clover) was insufficient to undertake statistical analyses. Ryegrass, white clover and tall fescue were present in nearly all paddocks where sown, regardless of age; therefore a binomial regression could not be fitted to presence data for these species.

Farmer survey

Managers or owners of the farms on which pastures were sampled, were interviewed for their perceptions on keys to pasture persistence, killers of sown species and key pasture research/information needs. When asked the survey questions: 'what are the keys to persistence', 'what are the killers of persistence' and 'what are your key pasture research / information needs' each farmer was allowed to list up to three keys to persistence, three killers of sown species and three key research/information needs. Information was obtained from a total of 48 farmers: 11 from Northland, 14 from Waikato, 12 from Taranaki and 11 from Canterbury. Responses on keys to persistence were categorised according to: grazing management, pasture establishment, nutrient management, plant species/cultivar selection, insect pests, soil properties and other management factors. Killers of persistence and research needs were similarly categorised. The number of responses for each category

was presented as a percentage of the total number of responses for each region. Categories were ranked in order of their percentage contribution.

Results

Farmer survey

Keys to persistence listed by farmers are presented in Table 1. Farmers interviewed consistently thought that aspects of grazing management (details in Table 1) were the most important keys to pasture persistence, followed by pasture establishment and nutrient management factors.

In all regions, insect pests (e.g., grass grub, black beetle) were listed as the primary killer of sown species. Farmers named climatic factors (e.g., droughts, waterlogging) as the next most likely killer, followed by issues around grazing management (e.g., under or overgrazing, Table 2).

By far the greatest research need/information gap identified by the farmers was improving pasture persistence (Table 3). Farmers are concerned that new cultivars are not lasting in pastures and wanted information on the comparative performance of new and old cultivars. Secondly, issues regarding pasture mixtures were identified as a key research need/ information gap, including information requirements on forage herb establishment and production, control of weeds in pastures containing forage herbs, and performance of mixed swards other than ryegrass/white clover. The third greatest need was for independent, on-farm trials. Farmers also identified needs for further research into plant breeding. They required more information on weed control, best-practice grazing management, livestock performance on new cultivars, comparative performance of organic and conventional agriculture and pasture establishment.

Persistence of sown species

Chicory was sown in 53 of the surveyed paddocks and showed a consistent decline as pastures aged. It was only present in 34% of the 'old' pastures in which it was sown ($P<0.05$, Table 4). There was no difference between regions in persistence of chicory, cocksfoot, plantain or red clover ($P>0.05$, data not shown). There was also no difference between paddocks of different ages in the persistence of cocksfoot, plantain or red clover ($P>0.05$, Table 4). Cocksfoot was sown in 29 of the surveyed paddocks. It was present in 80% or more of the paddocks in which it was sown, regardless of age. Plantain was sown in 46 of the surveyed paddocks and was present in 95% or more of the young and medium aged pastures in which it was sown and over 75% of the old pastures. Red clover was sown in 40 of the surveyed paddocks. While there was a downward trend in red clover as pastures aged, there was much variation in the data and there was no significant difference between pasture ages ($P>0.05$). Ryegrass and white clover were present in all paddocks in which they were sown.

Discussion

Of the four species assessed, chicory was the only species to show a significant decline in persistence as pastures aged from several years to more than 10 years since renewal. Plantain and cocksfoot appeared to be more persistent. For example, plantain was observed in all Waikato paddocks in which it was sown and 11 of 12 Canterbury paddocks, which ranged in age from 1 to 15 years in Waikato and 1 to 10 years in Canterbury. Plantain may, therefore, provide high quality forage for many years when sown as part of a sown pasture mix, while chicory may be best used as a crop in more intensive systems. These results are consistent with farmer comments on chicory persistence; for example, most farmers who had grown chicory found that little chicory remained in rotationally grazed dairy pastures 3-4 years after sowing. This is also consistent with an Australian study in dryland pastures that were rotationally grazed by sheep; there was a large decline in chicory after 3 years (Alemseged *et al.* 2003). In contrast, some of the dairy farmers interviewed commented that commercial plantain cultivars appeared to be spreading around the farm via dung. This is likely, as 58% of plantain seeds germinate after being ingested by and passing through cattle (Hammond, 1982).

While presence of a sown species in the pasture gives an indication of persistence, its contribution to total dry matter is critical with respect to persistence and livestock production. Dry matter contribution of the different vegetation components for these pastures has been assessed and reported in Tozer *et al.* (2010b). In Northland, Waikato and North Canterbury, the contribution of all sown species to total dry matter declined as pastures aged. However, in Taranaki there was no decline in the contribution of all sown species (Tozer *et al.* 2010b).

Farmers identified grazing management (e.g., recovery period), pasture establishment factors (e.g., seedbed preparation) and nutrient management as the most important keys to pasture persistence. This is consistent with a postal survey of 100 beef and sheep farmers in 1997/1998, who listed fertility, followed by drainage and grazing management, as key factors contributing to persistence (Daly *et al.* 1999). Plant species and cultivar selection were also seen as important in this study. Some of the North Canterbury beef, sheep and deer farmers interviewed have experimented with different mixes and found that the traditional ryegrass-white clover pastures were not

persisting in their hot, dry summer environment. These farmers sowed mixes containing several of the following species: prairie grass, grazing brome, cocksfoot, lucerne and white clover and subterranean clovers. Their aim was to allow cocksfoot to gradually fill the gaps left by the mortality of the shorter-living prairie grass and grazing brome, helping to suppress weeds and improve pasture persistence. This was the case in some of the paddocks assessed using these mixes; for example, in 4- and 8-year-old North Canterbury paddocks, the dominant species was cocksfoot, which comprised 72% and 68% of the ground cover, respectively.

In all regions, pasture pests were ranked as the main killer of sown species. Extreme weather, such as droughts, and grazing management ranked as close second and third most frequent killers of sown species. This is consistent with research findings. For example, in Waikato dairy pastures, ryegrass percent ground cover in February 2008, 2009 and 2010 was 55%, 40% and 35% respectively (Tozer *et al.* 2010c). It was thought that the large decline in ryegrass cover between 2008 and 2009 reflected the impact of the 1-in-100-year drought during summer of 2008. During droughts, when feed is scarce and pasture plants are stressed, the impact of overgrazing is more severe and likely to result in mortality of sown species (Kemp & King 2001). However, even without extreme droughts such as occurred in Waikato, ryegrass persistence is an issue (e.g., Tozer *et al.* 2010a). Thom *et al.* (1998) compared the performance of 13 new ryegrass cultivars in Waikato dairy pastures. There was an average decline in dry matter production of 27% between the first and second year of the study and a further 6% decline between the second and third year.

Pasture persistence ranked as the highest research/information need in all regions. While farmers were not asked to define persistence as part of the survey, many expressed the view that sown species should be dominant in the sward of a persistent pasture, contributing significant dry matter up to 10 or more years after it was sown, while sown species in a poorly persisting pasture would only last for several years before undesirable weedy species became dominant. This is consistent with the survey by Daly *et al.* (1999), in which farmers identified persistent pastures as those containing a high level of desirable species and low levels of weeds and low-fertility volunteer species. More recently, Parsons *et al.* (2010) discussed persistence with reference to a decline in the population of a sown species or a decline in the expression of a trait within the sown species present in the pasture. They also propose that loss of persistence may be independent of the cultivars sown but may be related to a loss of the yield benefits that occur after pasture renewal. Pasture assessments associated with this study provide strong evidence that persistence is an issue. For example, in 4 to 6-year-old dairy pastures in Waikato, 35% of the total dry matter comprised unsown, weedy species (Tozer *et al.* 2010b).

Pasture persistence is also related to the second and third issues identified by the farmers. During the interviews, farmers often expressed their dissatisfaction with the persistence of new ryegrass cultivars and their interest in alternative species and mixtures. This may explain why pasture mixtures and especially species alternative to ryegrass and white clover (e.g., tall fescue and red clover) were ranked second as a research/information need. Many beef, sheep and dairy farmers expressed interest in the forage herbs (chicory and plantain) and wanted information on their establishment and management. This interest was indicative of farmers throughout New Zealand, as illustrated by national chicory seed sales over the last few years. For example, Cropmark chicory seed sales increased dramatically from 2007, when approximately 2 tonnes of chicory was sold, to 2009 and 2010 when 25 tonnes were sold. In 2010, supply was unable to meet farmer demand for chicory seed (personal communication, Brendan Arnet, Fonterra).

Current DairyNZ and AgResearch projects are addressing a number of research needs identified by the farmers, including defining optimal defoliation frequency and residual height for chicory and plantain. Previous research and literature reviews undertaken by Prof. P. Kemp and others from Massey University (e.g., Li & Kemp 2005; Li *et al.* 1997; Powell *et al.* 2007) also provide relevant information to address needs identified by the farmers, such as optimal timing of the first grazing after sowing and the number of leaves required for plantain and chicory to survive grazing. Application of this knowledge on farm will improve persistence of these herbs.

Independent information and more on-farm regional trials were ranked as the third greatest research/information need. Farmers interviewed expressed frustration and dissatisfaction with the information provided by commercial companies; they expressed concern that it was not independent and commented that it could not be trusted, based on their experiences with poor persistence of newly sown pastures. The newly established Pasture Renewal Leadership Group, a pastoral industry group established to aid help farmers adopt best practice renewal, can address some of these research and information needs, by ensuring that independent research results are packaged and disseminated to give consistent and relevant messages through the many different industry and commercial groups who provide information for farmers.

Most of the farms assessed were intensively grazed

and had high stocking rates. They were managed to maximise pasture utilisation, livestock production and profit. In some cases, meeting these goals may be at the expense of persistence of the sown species, leading to increasing need for pasture renewal. As input costs associated with pasture renewal increase, (e.g., fertiliser, herbicide), farmers may choose to reduce the intensity of their enterprises and manage their pastures to optimise persistence and long-term profit. Soil Quick Test analyses suggested that nutrients were adequate and not a limiting factor in the growth of the sown species in this survey. These data will be reported in a further paper investigating management practices associated with persistence. Practices such as allowing sown species to set-seed and replenish the seedbank could improve persistence. Some of the farmers interviewed in this study are currently allowing sown species to set seed to address this issue.

Conclusion

Although sample numbers of farmers surveyed were small, there were consistent messages from farmers in all regions. Grazing management was consistently perceived as the most important key to persistence of sown species, while insect pests were perceived as the top killer of sown species. With current industry collaboration, the formation of the Pasture Renewal Leadership Group and Primary Growth Partnership funding, the pastoral industry has the opportunity to address some of the key issues highlighted by these farmers. Key issues include addressing the poor persistence of ryegrass in different regions of New Zealand; the heightened interest of farmers in alternative mixtures and forage species, such as the forage herbs chicory and plantain and the concern over pasture insect pests. Additionally, there needs to be improved dissemination of previous and current research, to ensure that accurate, consistent and independent information is available for farmers.

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