Evaluating perennial ryegrass cultivars: improving testing

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Abstract
The agronomic performance of a range of perennial ryegrass cultivar-endophyte combinations was compared in 16 trials conducted at sites throughout New Zealand. Each trial was run for 3 years according to seed industry evaluation protocols, measuring variables including: dry matter (DM) yield (total annual and seasonal DM yield), ryegrass ground cover at the end of 3 years, susceptibility to plant pulling, and rust incidence. The change in DM yield over the 3-year term of each trial was also analysed. There were significant differences among cultivars in total annual DM yield, and in seasonal DM yield for each of the five periods of the year among which yield was split (winter, early spring, late spring, summer, and autumn). Mean annual yield declined between Year 1 and Year 3 in all regions except Taranaki, by between 0.8 t DM/ha (Canterbury) and 5.3 t DM/ha (Waikato). There were significant region, year, region × year, and cultivar × year interactions in yield change. Significant differences in ground cover score for perennial ryegrass at the end of 3 years were recorded among cultivars. However, these differences did not mirror on-farm observations of ryegrass persistence in the Waikato during the drought of 2007/08, suggesting that the standard trial protocols currently used do not adequately test persistence. It is recommended that industry cultivar testing needs to more accurately assess perennial ryegrass persistence, using new protocols including running trials on commercial farms, for more than 3 years, and using mixed swards. Genetic differences in persistence could be generated more quickly by choosing sites known to challenge perennial ryegrass growth and survival.
Keywords: perennial ryegrass, cultivar evaluation, DM yield, persistence testing, plant pulling, rust

Introduction
New Zealand's ability to produce quality livestock product at internationally competitive prices is based on grazing pastures *in situ*, and the challenge to New Zealand's plant breeding industry is to continually improve pasture production (Clark *et al*. 2001).

Genetic improvement of pasture plants has been pursued for over 85 years (Wratt & Smith 1983), with documented gains in dry matter (DM) production, disease resistance and forage quality (Corkill 1949; Kerr 1987; Easton *et al.* 1989; Easton *et al.* 1997; Woodfield 1999; Easton *et al.* 2001). Genetic gains averaging around 0.5% per year for total annual DM yield (Lee *et al*. 2012) have been demonstrated through small plot trials (Kerr 1987; Pennell *et al.* 1990; Easton *et al.* 2001; Hume *et al.* 2007).

Total annual DM yield of pasture is a key driver of animal performance in pastoral systems (Williams *et al.* 2007). The seasonality of supply is equally important, because it strongly influences the balance between feed supply and demand on a month-by-month basis. Chapman *et al*. (2012) calculated that the economic value of additional dry matter grown varied for dairy systems in different regions of New Zealand. Extra feed in early spring carried high economic value ($0.42–$0.48 per kg additional DM/ha) in all regions, whereas the value of summer feed was lower, and varied according to region ($0.33–$0.40 per kg additional DM/ha in the Waikato and the lower North Island; $0.12–$0.17 per kg additional DM/ha in Canterbury and Southland).

Genetic gains in DM yield identified in plot trials have sometimes proved difficult to capture in animal production trials (Woodward *et al.* 2001; Crush *et al*. 2006). However, small plot trials are a practical, relatively low cost way to evaluate pasture cultivars, and remain the dominant source of information for analysing genotype × environment interactions, and estimating the economic value delivered to farmers through plant breeding (e.g. McEvoy *et al*. 2011; Bryant *et al*. 2012). While many such trials have been conducted in New Zealand over several decades, few data from them have been published. Yet, these data can reveal considerable information about, for example, the relative agronomic performance of different perennial ryegrass types (diploid versus tetraploid; mid-season flowering versus late-season flowering), and interactions between type and growing environment.

The utility of these trials for assessing other important agronomic traits, such as persistence, has not been considered in any depth. More information is required to clarify the discriminatory power of small plot trials for DM yield, and to determine their value in resolving genotype, endophyte and environmental influences on pasture persistence. This information will help improve the value to the farming industry of pasture cultivar evaluation systems in New Zealand.

This paper presents results from small plot trials conducted throughout New Zealand comparing cultivars and breeding lines of perennial ryegrass (*Lolium perenne*), the grass of choice for long-term pastures under fertile conditions in New Zealand (Hunt & Easton 1989; Easton *et al.* 2011). The variables presented include DM yield, ground cover of ryegrass after 3 years, and resistance to plant pulling and rust. Further analysis was undertaken to assess yield stability over the 3-year trials.

Methods

Trial programme

A total of 16 separate perennial ryegrass yield trials, conducted by three different operators, were completed as described in Table 1. Trials were sown in March or April, except those in Southland which were sown in December. For all trials, data were collected from 1 June following sowing through to 31 May, 3 years later. Plots were all maintained as pure ryegrass swards, with herbicides used to control other species. All North Island trials, along with those at Kirwee and Burnham in Canterbury, were rotationally grazed by dairy cows or dairy heifers, whereas the Chertsey, Courtenay and Winton trials were rotationally grazed by sheep. All trials included four replicates (12–15 m^2 plot area) of each cultivar or breeding line, typically arranged in a randomised row-column design. Most trials contained 20 entries, which included a range of named cultivars (some with different endophyte strains) and various breeding lines. Some 67 breeding lines were included in statistical analyses, but are omitted from the results reported here, apart from 'LP534' which was later released as the cultivar 'Trojan'.

Trials were conducted according to New Zealand seed industry standards, as prescribed in the National Forage Variety Trial Protocol (NZPBRA 2010). Trial procedures were independently audited by AsureQuality through field visits every year, and final trial results were checked through independent analyses by VSN (NZ) Ltd, with this also audited by AsureQuality.

Measurements and management

DM yield was assessed on all plots when a mean mass of approximately 3000 kg DM/ha was first reached by one of the entries. Yield was measured by mowing an area of 2.5–3 m^2 to 5 cm height, recording total fresh weight, and then oven-drying a subsample for determination of DM content. The area mown was rotated across three or four discrete non-overlapping positions within each plot. Yield assessment was immediately followed by grazing, after which plots were trimmed, if necessary, to an even post-grazing residual. Grazing was followed by an application of nitrogen-based fertiliser equivalent to approximately 30 kg N/ha. On average each trial was assessed for DM yield 29 times over 3 years.

Results were split into five seasons defined as: winter – June and July; early spring – August and September; late spring – October and November; summer – December to February, and autumn – March to May. Where the growth period for a yield assessment straddled more than one season, the yield was split between seasons based on the proportion of days of growth in each.

Ground cover of perennial ryegrass was assessed at the end of each trial through point analysis (Radcliffe & Mountier 1964). A total of 100 points per plot were checked to estimate the percentage of ground area covered by perennial ryegrass for each trial entry. Assessment was typically conducted 2 weeks following grazing.

The eight trials grazed by cows or heifers, particularly those at Newstead, often exhibited ryegrass plant pulling. On the 22 occasions when pulling occurred, each trial plot was visually scored on a 1–9 scale, with 9 = no pulled plants in the plot. In one trial with very high levels of plant pulling, scoring was stopped after 2 years, as several entries had few intact plants left.

High levels of ryegrass infection with crown rust (*Puccinia coronata*) were observed on seven occasions in five North Island trials. On these occasions, each trial plot was visually assessed and scored on a 1–9 scale for the presence of rust, with 1 = very high levels of rust and 9 = no rust.

Data analysis

To assess stability, or persistency, of DM yield over the 3-year trials, data from the 16 trials were compiled into 909 observations of mean annual yield across trial replicates for each cultivar in each trial, and a factorial ANOVA performed to ascertain yield trends over the 3-year duration of each trial, regional yield differences, and region × year and cultivar × year interactions.

Results and Discussion

DM yield

There were significant differences among cultivars in total annual and seasonal DM yield in all five seasons analysed (Table 2), with yields similar to those in previous ryegrass cultivar comparison work (Easton *et al*. 2001). These differences could be expected to translate to sizeable differences in profitability. For example, in autumn, the range between the lowest and highest diploid cultivars was around 600 kg DM/ha, or about $180/ha if an economic value of $0.30 per kg additional DM/ha is assumed (Chapman *et al*. 2012).

Diploid and tetraploid cultivars are split in Table 2. This is because tetraploids were likely to be disadvantaged in the trial protocol due to greater animal preference for tetraploids compared to diploids, causing harder grazing (O'Donovan & Delaby 2005), lower post-grazing residuals, and lower herbage mass at the time of DM yield assessment (which was implemented for all cultivars once the first cultivar in a trial had reached approximately 3000 kg DM/ha). It is notable that the relative yields of tetraploids were often significantly lower than relative yields of diploids, for example, in early and late spring.

It is also notable that the relative yield of the same cultivar with different endophytes sometimes differed: for example, 'Bronsyn' with NEA6 endophyte ranked significantly higher for total annual DM yield than did 'Bronsyn' with AR1. Endophyte strain effects have been observed in perennial ryegrass for both insect control (Popay & Hume 2011) and animal feeding preference (Edwards *et al.* 1993). In these trials run under "cafeteria" grazing it is not possible to determine whether the greater DM yield of a ryegrass-endophyte combination is due to better growth, improved insect resistance, reduced animal preference and therefore

Table 1: Summary of 16 trial sites split by region.

Region	Sown	Location	Latitude Longitude	Soil type	Altitude a.s.l.	Average rainfall	Operator
Waikato	2003	Cambridge	37°89'S 175°43'E	Kereone silt loam	60 m	1183 mm	Agriseeds
	2005	Newstead	37°78'S 175°36'E	Te Kowhai peaty silt loam	40 m	1200 mm	DairyNZ
	2007	Newstead	37°78'S 175°36'E	Te Rapa silt loam	40 m	1200 mm	DairyNZ
Taranaki	2004	TARS, Whareroa	39°61'S 174°31'E	Egmont black loam	90 m	1100 mm	DairyNZ
	2006	TARS, Whareroa	39°61'S 174°31'E	Egmont black loam	90 m	1100 mm	DairyNZ
	2008	TARS, Whareroa	39°61'S 174°31'E	Egmont black loam	90 m	1100 mm	DairyNZ
Manawatu	2003	Massey No 4 dairy	40°40'S 175°62'E	Tokomaru silt loam	60 m	963 mm	Massey University
	2005	Massey No 1 dairy	40°38'S 175°61'E	Manawatu silt loam	34 m	963 mm	Massey University
	2007	Massey No 4 dairy	40°40'S 175°62'E	Tokomaru silt loam	67 m	963 mm	Massey University
Canterbury	2003	Kirwee	43°49'S 172°19'E	Chertsey silt loam	190 m	805 mm*	Agriseeds
	2003	Courtenay	43°46'S 172°18'E	Hatfield silt loam	190 m	805 mm*	Agriseeds
	2005	Burnham	43°60'S 172°27'E	Lismore silt Loam	150 m	670 mm*	Agriseeds
	2007	Chertsey	43°78'S 171°89'E	Lismore silt Loam	150 m	700 mm*	Agriseeds
	2008	Courtenay	43°46'S 172°18'E	Hatfield silt loam	190 m	805 mm*	Agriseeds
Southland	2007	Winton	46°17'S 168°33'E	Pukemutu silt loam	50 m	1100 mm	Agriseeds
	2008	Winton	46°17'S 168°33'E	Pukemutu silt loam	50 m	1100 mm	Agriseeds

* Canterbury trials all irrigated

decreased grazing pressure, or a combination of these factors.

Popay *et al*. (2003) also observed host genotype × endophyte strain interactions in perennial ryegrass. Further information is required to understand how these interactions occur, and what they mean for pasture performance.

Although Table 2 provides data on the comparative performance of cultivars, actual DM yields are likely to be underestimated. There are two reasons for this: firstly, non-recording of DM yield accumulated between time of assessments and grazing, particularly if grazing was delayed by stock availability or weather; and secondly, DM losses when plots were trimmed after grazing to ensure consistent post-grazing residuals between plots.

Stability of yield

The stability, or persistency, of DM yield over time has been questioned (Easton *et al.* 2011; Parsons *et al.* 2011). Region, year, and the year × region interaction effects were all highly significant in the analysis of yield stability from these trials ($P < 0.001$). On average, Year 3 yield was 1.95 t DM/ha lower than Year 1 yield,

Table 2: Combined analysis of dry matter (DM) yield of diploid and tetraploid cultivars over 16 three-year trials, relative to trial mean = 100%, ranked on total yield. Significance lettering given for 5% LSD. Cultivars must have been in a minimum of three trials to be included.

Entry*	Winter		Early Spring		Late Spring		Summer		Autumn		Total	
Diploid cultivars												
Trojan NEA2	112	a	105	a	103	ac	114	a	110	ab	109	a
Tolosa NEA2	107	ac	100	ag	108	a	109	ac	110	ab	107	ab
Bronsyn NEA6	88	hi	101	af	105	ab	109	ab	112	a	106	ab
Arrow AR1	104	be	104	ac	104	ab	107	bc	106	bd	106	ab
Alto SE	97	eg	98	bg	107	a	109	ab	108	ac	105	ab
Arrow SE	103	be	102	ad	103	ac	107	bc	105	bd	104	bc
Alto AR1	103	be	100	bg	104	ab	106	bd	102	de	103	bc
Matrix SE	104	be	97	cg	101	bd	107	bd	108	ac	103	bd
Extreme AR6	100	ce	102	ae	100	bd	104	bd	109	ab	103	bd
Extreme AR37	103	be	105	a	100	bd	101	cf	104	be	103	bd
One50 AR1	107	ab	99	bg	99	cd	107	bc	104	bd	103	bd
Bronsyn SE	84	i	98	bg	102	ad	106	bd	106	bd	103	bd
Arrow WE	103	be	105	a	106	ab	98	dg	98	ef	102	bd
Impact SE	104	be	90	hi	99	bd	104	be	107	ad	101	bd
Extreme AR1	97	eg	105	ab	98	ce	103	be	98	ef	101	bd
Alto WE	99	df	96	eh	101	ad	102	bf	100	df	101	bd
Revolution AR1	104	be	100	af	101	bd	97	eg	98	ef	100	cd
Bronsyn AR1	93	fh	100	af	100	bd	101	cf	103	ce	100	d
Commando WE	93	gh	107	a	100	bd	92	g	95	f	97	de
Commando AR1	84	i	97	dh	100	bd	93	g	87	g	94	e
Tetraploid cultivars												
Bealey NEA2	106	ac	95	gh	97	de	104	bd	104	bd	100	cd
Banquet II Endo5	104	be	96	fh	96	de	105	bd	103	ce	100	cd
Banquet SE	108	ab	89	i	94	e	95	fg	97	f	95	e
Quartet SE	74	j	77	j	88	f	73	h	81	g	79	f
Mean (kgDM/ha)	1067		1999		3595		4094		2545		13322	
Wald test	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
LSD 5%	9.2		8.3		7.9		10.8		9.9		7.3	

* Endophyte strain is given after cultivar name. SE = Standard or wild-type endophyte. WE= without (nil) endophyte.

ranging from a fall of 3.54 t DM/ha/year in the Waikato trials to a gain of 1.15 t DM between Years 1 and 3 in the Taranaki trials (Table 3). Interestingly, no cultivar × year interaction was detected, indicating that all cultivars in the trials displayed a similar yield decline with time. The variation between regions in rate of yield decline is possibly linked to summer moisture deficit stress as indicated by regional rainfall statistics in Table 3, but this point needs further investigation. The interaction between region and cultivar was also statistically significant ($P<0.05$) and this too warrants further investigation.

Persistence

Pasture persistence has a significant effect on the performance of both dairy (Brazendale *et al.* 2011) and sheep and beef systems (Stevens 2011). The ability of perennial ryegrass to persist across the wide range

Table 3: Analysis of regional mean yield (tonnes DM/ha) and change in yield over time for a subset of 234 annual mean yields of 10 cultivars in 5 regions. Cultivars included in the analysis were 'Alto', 'Arrow', 'Bealey', 'Bronsyn', 'Commando', 'Extreme', 'Matrix', 'One50', 'Revolution' and 'Trojan.'

Region	Year 1	Year 2	Year 3	Change year 1 to year 3	Nov – March rainfall+
Waikato	18.8	18.7	13.5	- 5.34	395 mm
Taranaki	13.8	14.3	14.9	1.15	629 mm
Manawatu	13.9	11.0	10.8	- 3.06	354 mm
Canterbury	12.0	12.1	11.2	- 0.79	214 mm*
Southland	13.0	12.9	11.3	- 1.70	489 mm

+ Mean for 2003 – 2011 years (Taranaki) and 2002 – 2011 (other regions). * Canterbury trials were irrigated.

Table 4: Analysis of ryegrass ground cover at the end of trials for: (1) nine North Island trials from 2003–11, and; (2) two Newstead trials run at the time of 2007/08 drought. Significance lettering given for 5% LSD. (T) = tetraploid. For the North Island data, a minimum of three scores were necessary for a cultivar to be included, except where marked with * (two scores).

Cultivar	Ground cover % **North Island trials**		Cultivar	Ground cover % **Newstead trials**	
Tolosa NEA2*	71	a	Arrow AR1	87	a
Arrow AR1	69	ab	Trojan NEA2	84	ab
Trojan NEA2	68	ac	Alto AR1	84	ab
Bronsyn NEA6	68	ac	Bealey NEA2 (T)	83	ab
Matrix SE	67	ac	Banquet SE (T)	83	ab
Bealey NEA2 (T)	67	ac	One50 AR1	81	ac
Banquet SE (T)	66	ac	Bronsyn AR1	76	bd
One50 AR1	66	ad	Arrow SE	70	cd
Alto AR1	66	ad	Commando AR1	70	cd
Bronsyn AR1	66	ad	Revolution AR1	67	de
Commando AR1	65	ad	Extreme AR37	59	ef
Impact SE	65	ad	Extreme AR6	55	fg
Bronsyn SE	65	ad	Banquet II Endo5 (T)	55	fg
Arrow SE	65	bd	Extreme AR1	50	g
Alto SE	64	bd	F test	<0.001	
Revolution AR1	62	ce	LSD 5%	10.0	
Banquet II Endo5 (T)	62	ce	CV%	8.0	
Extreme AR1*	59	df			
Extreme AR37*	56	ef			
Extreme AR6	54	f			
Wald test	<0.001				
LSD 5%	7.5				
CV%	11.3				

of conditions in which it is used has been questioned (Fraser 1994; Thom *et al.* 1998; Easton *et al.* 2011). Persistence issues have become particularly prominent in the upper North Island in the last 4 years, where factors including summer moisture deficits and black beetle (*Heteronychus arator*) attack have placed pressure on perennial ryegrass pastures (Kelly *et al.* 2011; Tozer *et al.* 2011).

Point analysis to assess the ground cover by ryegrass at the end of each 3-year trial is the prescribed method to assess ryegrass persistence in seed industry protocols (NZPBRA 2010). These data are presented in Table 4 in two ways. Firstly, combined for all the North Island trials, and secondly, for just the two Waikato trials located at Newstead which suffered a severe "1 in 100 year drought" in 2007/08.

The North Island trials are presented because they were conducted under more difficult conditions, with warmer temperatures and less reliable summer rainfall than the South Island sites. Despite this, ground cover differences between cultivars in the North Island were small.

The Newstead trial results in Table 4 also show few differences. Most cultivars containing AR1 endophyte had high ground covers, at odds with what was happened on many farms through this drought period, including farmlet trials at the same site (Thom 2010).

The results from point analysis at the end of these types of small plot trials do not, therefore, appear to assess the persistence of ryegrass cultivars well enough to be representative of a wide range of farms. There are three suggested reasons for this. Firstly, there is careful pasture management of the trials, which is not always replicated on commercial farms, particularly through periods of low pasture growth. Secondly, the plots are sown and kept as pure ryegrass swards with herbicide applications, so are artificially free of white clover and

Table 5: Analysis of 18 ryegrass plant pulling scores from six trials from 2003–11, on a 1 to 9 basis where 9 = no plant pulling. Significance lettering given for 5% LSD. Cultivars must have a minimum of three scores to be included. (T) = tetraploid.

Cultivar	Average plant pulling score*	
Bealey NEA2 (T)	8.0	a
Bronsyn SE	8.0	a
Bronsyn NEA6	7.9	ab
Banquet SE (T)	7.7	ab
One50 AR1	7.7	ac
Bronsyn AR1	7.6	ac
Alto SE	7.5	ad
Arrow SE	7.3	ad
Trojan NEA2	7.2	ae
Commando AR1	7.0	bf
Commando WE	7.0	bf
Impact SE	6.9	cf
Alto AR1	6.9	cf
Arrow AR1	6.8	df
Matrix SE	6.4	ef
Banquet II Endo5 (T)	6.2	f
Extreme AR6	5.3	g
Extreme AR37	5.1	g
Revolution AR1	5.0	g
Extreme AR1	4.4	g
F test	<0.001	
LSD (5%)	0.8	
CV%	10.2	

* Data are combined from six trials: 2004 Whareroa (4 scores), 2005 Newstead (5 scores), 2005 Massey University (1 score), 2005 Burnham (2 scores), 2006 Whareroa (1 score) and 2007 Newstead (5 scores).

Table 6: Analysis of seven rust scores from four trials from 2003–11, on a 1 to 9 basis where 9 = no rust. Significance lettering given for 5% LSD. Cultivars must have a minimum of two scores to be included. (T) = tetraploid.

Entry	Average rust score*	
Extreme AR1	9.0	a
One50 AR1	9.0	a
Extreme AR37	8.7	a
Bealey NEA2 (T)	8.0	ab
Commando AR1	7.8	ab
Extreme AR6	7.8	ac
Arrow AR1	7.1	bd
Bronsyn NEA6	6.7	ce
Trojan NEA2	6.5	cf
Alto AR1	6.5	cf
Alto SE	6.2	df
Bronsyn AR1	6.1	df
Matrix SE	6.1	df
Revolution AR1	5.7	dg
Bronsyn SE	5.6	eg
Banquet II Endo5 (T)	5.3	fg
Impact SE	5.1	g
Quartet SE (T)	4.9	g
Banquet SE (T)	4.6	g
F test	<0.001	
LSD 5%	1.1	
CV%	12.9	

* Data are combined from four trials: 2003 Massey (2 scores), 2004 Whareroa (1 score), 2005 Newstead (2 score) and 2007 Massey University (2 scores).

weed ingression common with poor persistence (Tozer *et al.* 2011). Thirdly, the trials only run for 3 years.

To better assess persistence new evaluation protocols are required to more closely simulate commercial farming conditions, with trials run over a longer time period. One suggestion is to test cultivars in an additional trial series on commercial farms, using mixed swards, on sites known to provide a challenge to perennial ryegrass growth and survival.

Plant pulling

Ryegrass plant "pulling" occurs in some areas of New Zealand, particularly throughout northern North Island peat and light ash soils under cattle grazing (Thom *et al.* 2003) and differences in susceptibility exist between cultivars (Thom *et al.* 1996).

In the trials, plant pulling was distinguished by visual scores of plots, with clear differences in resistance shown between cultivars (Table 5). Plant pulling and ground cover scores for the North Island trials (Table 4) were correlated ($R^2 = 0.76$), indicating that plant loss through pulling caused sustained reductions in ryegrass plant/tiller density .

Prestidge *et al.* (1989) suggested that endophyte strain might affect plant pulling, however, in this case cultivars with multiple endophyte strains ('Alto', 'Arrow', 'Bronsyn', 'Commando' and 'Extreme') exhibited similar levels of plant pulling irrespective of endophyte strain.

Similarly, no relationship between plant pulling and heading date was apparent, with mid-season and late heading cultivars showing both high and low levels of pulling.

Rust

Crown rust (*Puccinia coronata*) is a common pathogen which reduces both the photosynthetic leaf area and the acceptability of foliage to livestock (Easton *et al.* 1989). Crown rust only occurred in the North island trials where higher temperatures and humidity favour its development (Latch & Lancashire 1966), and no rust was seen in Canterbury trials, where stem rust (*Puccinia graminis*) is more prevalent (Easton *et al.* 1989).

Ryegrass cultivars can be selected for improved rust resistance (Easton *et al.* 2002) and significant cultivar differences were identified by visual scoring of plots (Table 6).

Endophyte strain appeared to have little effect on rust resistance, as those cultivars with multiple endophyte strains ('Alto', 'Bronsyn' and 'Extreme') were not significantly different in rust resistance across strains. Similarly, heading date appeared to have no effect with late and mid-season cultivars displaying both high and low levels of rust resistance.

Conclusion

The small plot trials in this programme generated useful comparative information on the potential DM yield and seasonal growth pattern of a range of perennial ryegrass cultivars and breeding lines. They also identified significant differences between ryegrasses in rust resistance and, under dairy cow grazing, in susceptibility to plant pulling.

However, there were limitations associated with the trial methods, the most notable being that they did not reflect the persistence of different cultivars that was seen on many farms in the northern North Island through the same period.

Different trialling methods are needed to better assess ryegrass persistence. One suggestion is to establish "mirror image" trial series on commercial farms, to better simulate "real" farm conditions, sown with ryegrass and white clover, with more typical herbicide usage, and trials run for longer than the industry-norm of 3 years. Persistence differences should emerge more quickly if sites known to provide a challenge to perennial ryegrass growth and survival were chosen for trials.

A better assessment tool for persistence is also needed. One-off point analysis of ryegrass ground cover, as prescribed by industry protocols, is of limited value. Also ryegrass ground cover interacts with plant structure, such that cultivars with fewer, larger tillers tend to have lower ground cover (Neuteboom *et al.* 1988) but their yield may be similar to cultivars with a greater density of smaller tillers (Bahmani *et al.* 2001).

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