Validation of perennial ryegrass cultivar Forage Value Index rankings using independent trial data

C.I. LUDEMANN[1], C.M.WIMS[1] and D.F. CHAPMAN[2],
[1]*DairyNZ, Private Bag 3221, Hamilton 3240, New Zealand*
[2]*DairyNZ, PO Box160, Lincoln University, Lincoln 7647, New Zealand*
cameron.ludemann@dairynz.co.nz

Abstract

The current DairyNZ Forage Value Index (FVI) categorises ryegrass cultivar-endophyte combinations into five, 'star rating' groups for dry matter (DM) yield using data from the National Forage Variety Trial (NFVT) system. However, variability in performance of cultivars between trials raises the question of how cultivars with different star ratings perform against each other under different conditions. The validity of the FVI star rating categories for perennial ryegrass was assessed using cultivar DM yield data from two independent trials outside the NFVT system and under dairy cow grazing with white clover. Results from the trials were used in Monte Carlo simulations to provide a probabilistic determination of the likelihood of high FVI rated cultivars outperforming the low FVI rated cultivars. Results indicate selecting high FVI (5 star) perennial ryegrass cultivars over lower FVI (3 star) cultivars deliver greater contributions to dairy operating profit in over 94% of the simulated iterations for the Waikato and Canterbury.

Keywords: Forage Value Index, *Lolium perenne*, plant breeding, selection, cultivars

Introduction

Since 2012, DairyNZ has published an independent economic index, the DairyNZ Forage Value Index (FVI; www.dairynz.co.nz/fvi), that ranks perennial ryegrass (*Lolium perenne*) cultivar-endophyte combinations based on their expected economic value to New Zealand dairy farmers. Seasonal dry matter (DM) yield data collected from National Forage Variety Trials (NFVT) operated by the New Zealand Plant Breeding and Research Association (NZPBRA), are used to calculate the economic value of the perennial ryegrass cultivars for four regions in New Zealand: Upper North Island, Lower North Island, Upper South Island, and Lower South Island. Based on their expected economic value to dairy farmers, the FVI categorises cultivars by endophyte combinations into five 'star rating' groups in each dairy region. Cultivar-endophyte combinations with a higher star rating are expected to deliver greater economic value to dairy farmers (Chapman *et al.* 2017).

Data from NFVT test differences between perennial ryegrass cultivars grown in monoculture under high nitrogen (N) supply (Lee *et al.* 2012). However, this raises the possibility that cultivar rankings obtained in NFVT could change if trialled under differing management or in the presence of other species such as white clover (Camlin 1981) that may affect whole pasture performance. Furthermore, variability in performance of cultivars between NFVT sites raises the question of how cultivars in different FVI star rating categories perform against each other. Analysis of independent trial data in mixed swards and under grazing can, therefore, be used to test the validity of the FVI star rating categories.

The objective of this research was to assess the validity of the FVI star rating categories, when perennial ryegrass cultivars are grown with white clover and managed under rotational dairy cow grazing in independent trials, using cultivar variability in performance and a probabilistic (Monte Carlo) method of analysis.

Methods

This study utilised field experiments in Waikato (Upper North Island) and Canterbury (Upper South Island), described by Wims *et al.* (2014), in which 24 perennial ryegrass cultivar-endophyte combinations were grown with white clover from May 2013 until May 2016. Based on the 2017 FVI Lists (Ludemann & Peel 2017), the cultivar-endophyte combinations were categorised according to their FVI star rating. A minimum of two cultivars with 3 years of dry matter (DM) yield data were required for a FVI star grouping to be included in this study. Based on these criteria the DM yield data of eleven perennial ryegrass cultivars in Waikato (Upper North Island) and twelve in Canterbury (Upper South Island) were used in this study, and were categorised as being either 5-, 4- or 3-star cultivars for the respective FVI regions (Table 1), according to the published FVI Lists (Ludemann & Peel 2017).

The Waikato field experiment was located at DairyNZ Scott Farm, Hamilton (37°47S, 175°19E; altitude: 40 m a.s.l.; soil type: Bruntwood silt loam) and the Canterbury field experiment was located at the Lincoln University Research Dairy Farm, Lincoln, (43°38S, 172°27E; altitude: 12 m a.s.l.; soil type: Wakanui silt loam over

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a mottled sandy loam phase). The Waikato site was not irrigated, while at the Canterbury site 194 mm, 400 mm and 430 mm of irrigation water was applied in years 1, 2, and 3, respectively, with a centre pivot irrigator. The experiment was sown in a row-column design with four replicates on 26 April 2013 in the Waikato and on 4 April 2013 in Canterbury. Both sites were rotationally grazed by dairy cows when average herbage mass across the experimental area reached 2500-3200 kg DM/ha, to a post-grazing residual of 1500-1750 kg DM/ha. This resulted in 27 grazings during the experiment for the Waikato trial and 28 grazings for the Canterbury trial. Average annual nitrogen fertiliser application rates were 155 kg N/ha and 254 kg N/ha at the Waikato and Canterbury sites, respectively.

Herbage DM yield/ha was estimated for each cultivar directly before each grazing (except for the first grazing at the Waikato site and the first, second and last grazing at the Canterbury site) by cutting one strip (1.5 m wide by 5 m long) from each plot (where each plot had an area of 3 m wide by 11 m long in Waikato, and an area of 4 m wide by 12 m long in Canterbury) using a forage harvester (Haldrup GmbH, Ilshofen, Germany) set to a cutting height of 55 mm above the ground. The fresh weight of the herbage was recorded in the field and a representative subsample of herbage was collected (~800 g). In the laboratory, either duplicate subsamples of approximately 150 g were oven-dried at 95°C (Waikato) or single subsamples of approximately 100 g were oven-dried at 60°C (Canterbury) to constant weight (~ 48 hours). Annual and seasonal herbage DM yield/ha for each cultivar-endophyte combination was calculated for each site and replicate, each year. Five seasons, winter, early-spring, late-spring, summer and autumn, were defined for each location as described by Chapman *et al.* (2017). Yields were then averaged across replicates and years to obtain representative values for each cultivar at each site. Herbage DM yields for each of the FVI star groups represented were calculated as the mean and standard deviation of the cultivars within that group.

Table 1 Forage Value Index star rating (2016/2017) of perennial ryegrass cultivar-endophyte combinations evaluated in the Waikato (Upper North Island-UNI) and Lincoln (Upper South Island-USI) field experiments.

Waikato		Lincoln	
Cultivar	**Star rating (UNI)**	**Cultivar**	**Star rating (USI)**
Alto AR1	3	Abermagic AR1	3
Bealey NEA2	3	Alto AR1	3
Halo AR37	3	Halo AR37	3
One50 AR1	3	One50 AR1	3
Alto AR37	4	Bealey NEA2	4
Arrow AR1	4	Matrix SE	4
Matrix SE	4	Prospect AR37	4
Base AR37	5	Alto AR37	5
One50 AR37	5	Arrow AR1	5
Prospect AR37	5	Base AR37	5
Trojan NEA2	5	One50 AR37	5
		Trojan NEA2	5

The economic value of the cultivar-endophyte combinations were calculated from the seasonal herbage DM yield data collected from the Waikato and Canterbury field experiments using the 2016/2017 FVI economic values (Table 2) and the calculations described by Chapman *et al.* (2017). The difference in economic value for the 3- and 4-star cultivars, compared with the 5-star cultivars, was determined using the means and standard deviations of the seasonal DM yield data from the field experiments. These were calculated probabilistically using @RISK software version 7.5 (Palisade Corporation, Ithaca, NY, USA) over 10 000 iterations of a Monte Carlo simulation. The Monte Carlo simulation method was used because it explicitly highlights the uncertainty in the results as they are calculated with levels of variation included in the outcomes. The method has also been applied to a wide range of applications where a probabilistic approach to estimate future scenarios is applicable (Metropolis 1987).

Results and Discussion

There were insufficient data available from the field experiments to compare the performance of 1- and 2-star FVI rated cultivars. Nonetheless, the analysis presented here provides information on the performance of 3-, 4- and 5-star FVI rated cultivars under simulated dairy farm management in Waikato and Canterbury.

Seasonal and annual DM yields for the cultivars evaluated are presented in Tables 3 and 4. Average annual DM yield was 8452 kg DM/ha and 14 774 kg DM/ha at the Waikato and Canterbury sites, respectively. The greater annual DM yield at the Canterbury site was mainly due to greater late spring (4241 kg DM/ha versus 2176 kg DM/ha) and summer (6100 kg DM/ha versus 3061 kg DM/ha) DM yields. The annual DM yields are comparable with those reported by Chapman *et al.* (2016) for perennial ryegrass-white clover pasture measured using the same technique and managed under dairy cow grazing at the same sites.

Table 2 Forage Value Index economic values (2016/2017) of seasonal herbage dry matter production ($/kg DM) for the Upper North Island (UNI) and Upper South Island (USI).

Dairy Region	Economic value in each season				
	Winter	**Early spring**	**Late spring**	**Summer**	**Autumn**
UNI	0.28	0.45	0.16	0.34	0.35
USI	0.42	0.38	0.28	0.13	0.25

For the cultivars rated as 3, 4 and 5-star in the 2017 FVI lists, average annual DM yields at the Waikato site were 7809 kg DM/ha, 8515 kg DM/ha and 9033 kg DM/ha, respectively. At the Canterbury site, annual DM yields averaged 14 093 kg DM/ha, 14 708 kg DM/ha and 15 521 kg DM/ha for the 3, 4 and 5-star cultivars. The trend of increasing DM yield with star rating was reflected in all seasons at the Canterbury site and in winter, late-spring, and autumn in the Waikato.

The DM yield data of the perennial ryegrass cultivars evaluated in this study were collected from pastures where perennial ryegrass was grown with white clover and managed under rotational dairy cow grazing. Therefore, genotype × environment interactions related to management (Lee *et al.* 2012) and potential species interactions with white clover (Camlin 1981) that may affect herbage dry matter yields have been accounted for in this study.

Results of the Monte Carlo simulations are presented in Figures 1 and 2. Of the 10 000 iterations >94.9% indicated that the group of 5-star cultivars had a greater economic value than a group of 3-star cultivars based on DM yield data collected from the Waikato site. Using DM yields from the Canterbury site, >97.1% of the iterations indicated that the group of 5-star cultivars had a greater economic value than a group of 3-star cultivars. The 5-star cultivars using the Waikato data had greater economic value than the 4-star cultivars in 75.5% of the iterations (Figure 1) and 87.5% of the iterations using the Canterbury data (Figure 2). This analysis indicates that there is a high probability that the relative economic value of perennial cultivars based on performance data collected from NFVT, and their associated FVI rankings, is consistent when cultivars are managed under typical dairy farm conditions i.e. grown in a mixed pasture with white clover and managed under well managed dairy cow grazing.

Farmers, therefore, can be confident that selecting perennial ryegrass cultivars with a high FVI rating (5-star) will deliver greater economic value to their dairy farming business than cultivars with a lower FVI.

Conclusions

This statistical analysis and probability simulations run on two independently grazed, mixed sward yield trials, align strongly with the FVI star rating information. This gives farmers further confidence that selecting high (5-star) FVI perennial ryegrass cultivars over lower FVI cultivars (when accounting for variability in seasonal DM production) will deliver greater economic benefit to dairy farmers. While 5-star cultivars may not always perform better than 3- or 4-star rated cultivars, the probability of this occurring is low based on this study.

Table 3 The mean values (μ) and standard deviations (σ) for seasonal herbage dry matter production (kg DM/ha) of 3-, 4- and 5-star rated perennial ryegrass cultivars from the Waikato (Upper North Island) field experiment.

	Winter	**Early spring**	**Late spring**	**Summer**	**Autumn**	**Annual**
3-star cultivar group μ	823	928	2055	2983	1020	7809
3-star cultivar group σ	76	50	260	382	97	n/a
4-star cultivar group μ	1065	990	2217	2978	1265	8515
4-star cultivar group σ	352	87	214	167	257	n/a
5-star cultivar group μ	1142	956	2255	3224	1456	9033
5-star cultivar group σ	142	95	246	292	372	n/a

Table 4 The mean values (μ) and standard deviations (σ) for seasonal herbage dry matter production (kg DM/ha) of 3-, 4- and 5-star rated perennial ryegrass cultivars from the Lincoln (Upper South Island) field experiment.

	Winter	**Early spring**	**Late spring**	**Summer**	**Autumn**	**Annual**
3-star cultivar group μ	597	718	4120	5818	2840	14093
3-star cultivar group σ	166	119	287	455	156	n/a
4-star cultivar group μ	736	780	4178	6077	2937	14708
4-star cultivar group σ	97	82	341	228	96	n/a
5-star cultivar group μ	794	868	4425	6406	3028	15521
5-star cultivar group σ	149	125	278	358	113	n/a

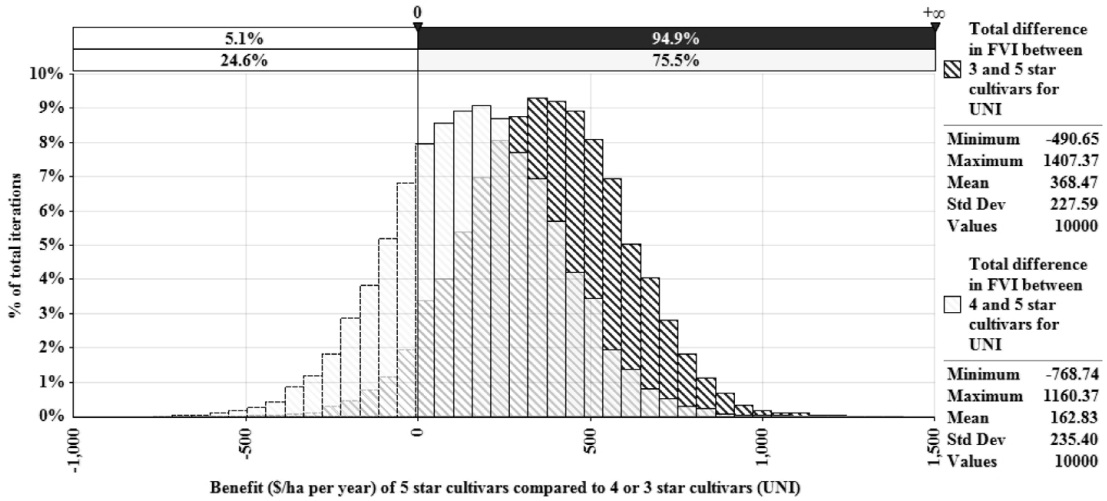

Figure 1 Distribution of the benefits of the group of 5-star perennial ryegrass cultivars as compared with groups of 4- or 3-star rated cultivars using Upper North Island (UNI) field experiment data and 10 000 iterations of a Monte Carlo simulation (values below zero indicate iterations where the 5-star rated cultivars performed worse than the other cultivars).

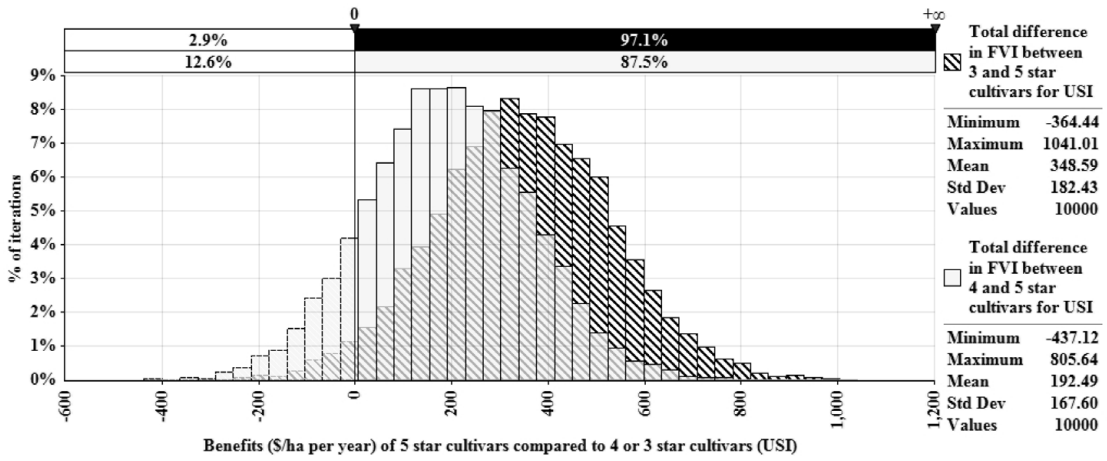

Figure 2 Distribution of the benefits of the group of 5-star perennial ryegrass cultivars as compared to groups of 4- or 3-star rated cultivars using Upper South Island (USI) field experiment data and 10 000 iterations of a Monte Carlo simulation (values below zero indicate iterations where the 5-star rated cultivars performed worse than the other cultivars).

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