

# Changes in estimated value of perennial ryegrass cultivar/endophyte combinations in the DairyNZ Forage Value Index when metabolisable energy contents specific to cultivar groups are included

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## Abstract

Further development of the DairyNZ Forage Value Index (FVI) requires accounting for genetic variation in the nutritive value of ryegrass herbage in addition to the current weightings on dry matter production traits. Performance values for metabolisable energy content (PV ME) have been identified as the most appropriate variables to use for this purpose. In this study an assessment was made of the effect of including cultivar group (mid-heading date diploid, late-heading date diploid and tetraploid) PV ME in FVI ranking calculations of eligible perennial ryegrass (*Lolium perenne*) cultivars. Incorporation of the seasonal ME trait into the FVI has resulted in changes in rankings of those cultivars. Although correlations were strong (0.74 for Upper South Island to 0.92 for Upper North Island) between rankings of cultivars using the current FVI and the FVI with cultivar group PV ME, marked improvements have been made in the rankings of tetraploid cultivars. On-farm persistence implications (not yet included in the FVI) of selecting tetraploid cultivars will need to be included if the ME trait is included in the FVI.

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

## Introduction

DairyNZ Ltd plans to develop its Forage Value Index (FVI) into a more holistic assessment of the relative value of cultivar/endophyte combinations (referred herein as ‘cultivars’ for brevity) for New Zealand dairy farmers. The current DairyNZ FVI ([www.dairynz.co.nz/fvi](http://www.dairynz.co.nz/fvi)) ranks perennial ryegrass (*Lolium perenne*) and short-term (e.g. Italian *Lolium multiflorum*, and hybrid *Lolium boucheanum*) ryegrass cultivars based on performance values for seasonal herbage dry matter yield (PV DM) (Chapman *et al.* 2017). The next trait to be included in the FVI is expected to be performance values for seasonal metabolisable energy content (PV ME) of perennial ryegrasses. Empirical perennial ryegrass ME data are now available at the cultivar group level (‘mid-(season) heading diploid’,

‘late-(season) heading diploid’ and ‘tetraploid’) (Wims *et al.* 2017) for inclusion in the FVI. These data allow a comparison to be made of FVI rankings of cultivars based on the current FVI and an FVI that includes PV ME. The present study was carried out to assess the value of the effect of including cultivar group PV ME in an improved FVI.

## Methods

A comparison of the change in values and FVI rankings (Spearman’s rank correlations) of FVI-eligible (Ludemann 2018) cultivars was made when using two different FVI calculations. The first was that used in the current FVI Lists (Chapman *et al.* 2017) and used PV DM data available for each specific cultivar. The second calculation built on PV DM data by adding PV ME data that reflected differences in cultivar group metabolisable energy content differences. Data from two experiments (Ludemann *et al.* 2017; Wims *et al.*, 2017) were used to calculate PV ME. Briefly, two, 3-year field experiments tested 24 perennial ryegrass cultivars. In addition to cultivar group classification, these cultivars were characterised according to the date at which the cultivar was first measured for performance (as an indicator of the ‘first release age’ of the cultivars). The trial used eight mid-heading diploid cultivars, 11 late-heading diploid cultivars and five tetraploids. Seasonal DM yield and nutritive value measurements were made in the Waikato, upper North Island (UNI) and at Lincoln, upper South Island (USI). ME data collected over the 3 years of the Lincoln and Waikato experiments were used for PV ME.

From Chapman *et al.* (2017), the existing FVI of cultivar ‘i’ in region ‘j’ (UNI or USI), ignoring ME differences, was calculated by summing the products of production values (PV) and economic values (EV) for dry matter yield (DM) over seasons (indexed ‘a’ for winter, early spring, late spring, summer and autumn, respectively) as:

$$FVI^{ij} = \sum (PVDM_a^{ix} \times EVDM_a^j) [1]$$

where  $PVDM_a^{ix}$  is the performance value for dry matter yield for cultivar ‘i’ in region ‘x’ (where ‘x’ is either

the UNI or Rest of New Zealand mega environments as described by Chapman *et al.* 2017) and season ‘a’ with units of kg of DM production over the whole season expressed as a deviation of a base average dry matter production for that region and season, and  $EVDM_a^j$  is the economic value of additional dry matter production expressed as \$ /kg of DM in region ‘j’ and season ‘a’. To evaluate the impacts of adding cultivar group ME performance values, cultivars eligible for FVI listing were assigned PV ME that were the mean of their cultivar group. Thus, a new index denoted FVIME was calculated by adding the summed (over seasons) dollar value of additional seasonal ME performance per cultivar group (‘g’) of the cultivar weighted by cultivar dry matter production in that region and season as follows:

$$FVIME^{ijg} = FVI^{ij} + \sum \left( (LSMDM_a^{ij} \times PVME_a^{gj} \times EVME_a^j) \right) [2]$$

where  $LSMDM_a^{ij}$  is the least square mean value for DM herbage production for cultivar ‘i’ in region ‘j’ and season ‘a’ which is used to weight the value of higher energy content by the total yield across the improved energy content. Calculation of  $LSMDM_a^{ij}$  has been described in more detail by Chapman *et al.* (2017) with measurements taken from a National Forage Variety Trial (NFVT) (Easton *et al.* 2001). The  $PVME_a^{gj}$  in equation [2] is the performance value for ME content of herbage DM assigned to cultivar ‘i’ based on the performance of its cultivar group ‘g’ made up of ‘mid-(season) heading diploids’ (MD), ‘late-(season) heading diploids’ (LD) and ‘tetraploids’ (T), in region ‘j’ and in season ‘a’, calculated as follows:

$$PVME_a^{gj} = LSMME_a^{g,j} - LSMME_{MEa}^{g=MD} [3]$$

The least square mean values for seasonal ME ( $LSMME_a^{g,j}$ ) for each location were calculated using analysis of variance (Proc Mixed ANOVA, SAS 9.3, Cary, NC, USA) for the three cultivar groups as well as ‘non-genetic’ factors known to influence ME such as column, block, year and the cultivar group by year interaction. The ME LSM for the mid-heading diploids (MD) was used as the base from which PVME were expressed, so that PV ME for mid-heading diploids were all zero. Units of PV ME were MJ of ME/kg of DM for the corresponding region, season, and cultivar group.

The  $EVME_a^j$  used in equation [2] are the economic values of additional ME in herbage DM in region ‘j’ and season ‘a’ and were estimated from the change in farm operating profit resulting from a 1 MJ ME/kg DM increase in herbage ME as follows:

$$EVME_a^j = \frac{\Delta \text{operating profit}}{\Delta \text{ME trait}} [4].$$

The same representative dairy farms as described by Chapman *et al.* (2017) were used to simulate the effect

of the increase in ME. The change in farm operating profit on the representative dairy farm from the increase in ME came mainly from a reduction in feed costs and an increase in milk production. The economic values of increasing ME were in the UNI for winter \$0.03, early spring \$0.06, late spring \$0.05, summer \$0.10 and autumn \$0.09 in dollars per additional MJME, and were in the USI for winter \$0.07, early spring \$0.04, late spring \$0.10, summer \$0.08 and autumn \$0.06 (Ludemann 2018).

### Results and Discussion

The PV ME for tetraploid cultivars were positive across all regions and seasons (Table 1). The PV ME for tetraploids were (mean) 0.44 MJME/kg DM in the UNI and 0.51 MJME/kg DM in the USI (Table 1). It is likely that encroachment of weeds in plots of the associated ME field experiment contributed to the UNI tetraploids having a lower PV ME than in the USI, especially in the summer and autumn, as described by Wims *et al.* (2018). Late heading diploid cultivars also had positive PV ME.

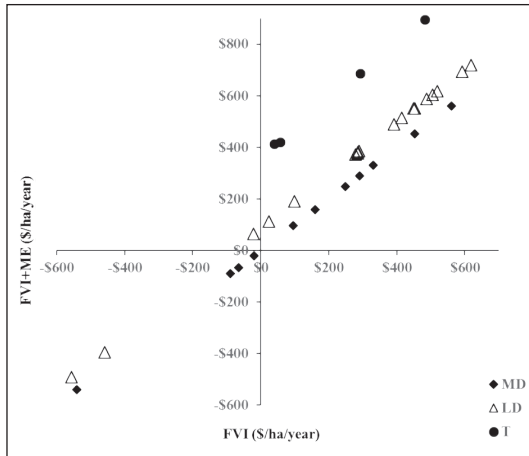
Figures 2 and 3 provide an indication of the change in FVI of each cultivar currently in the FVI using the current FVI equation and the equation with the PV ME (+ME’). The greatest changes in rankings of cultivars when PV ME were included were for the tetraploid cultivars. For instance, Base AR1, Halo AR37, and Ohau AR37 each improved their ranking by 10 places in the UNI. In the USI these same tetraploid cultivars had notable improvements in ranking with Base AR1 improving by 19 places, Halo AR37 by 15 places and Ohau AR37 by 18 places. The correlation between the rankings of cultivars using the current FVI and the ‘FVI+ME’ was 0.92 in the UNI and 0.74 in the USI.

The absolute changes in FVI with the addition of the

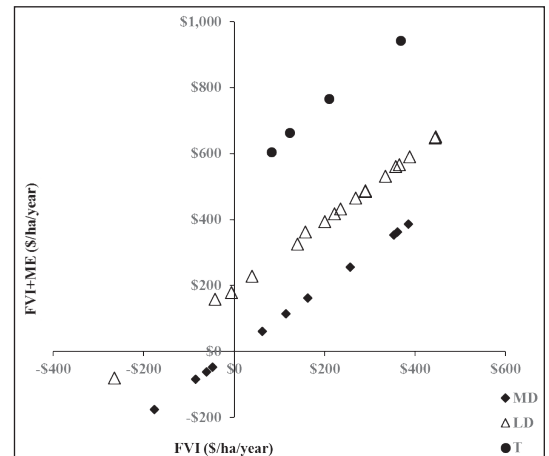
**Table 1** The Upper North Island (UNI) and Upper South Island (USI) performance values for seasonal metabolisable energy content (PV ME) (MJME/kg DM) for mid-season heading diploid (MD), late-season heading diploid (LD) and tetraploid (T) perennial ryegrasses.

Dairy Region/ Grass type	PV ME				
	Winter	Early spring	Late spring	Summer	Autumn
UNI/MD	0	0	0	0	0
UNI/LD	0.09	0.05	0.20	0.06	0.10
UNI/T	0.47	0.42	0.58	0.31	0.40
USI/MD	0	0	0	0	0
USI/LD	0.20	0.20	0.77	0.27*	0.14
USI/T	0.46	0.46	0.63	0.50	0.48

\*Correction made by the authors 10/09/2019



**Figure 1** Differences in Forage Value Index (FVI) between the current FVI and use of the FVI with the performance values for seasonal metabolisable energy trait included (FVI+ME) for mid-heading diploid (MD), late-heading diploid (LD) and tetraploid (T) cultivars of perennial ryegrass in the Upper North Island.



**Figure 2** Differences in Forage Value Index (FVI) between the current FVI and use of the FVI with the performance values for seasonal metabolisable energy trait included (FVI+ME) for mid-heading diploid (MD), late-heading diploid (LD) and tetraploid (T) cultivars of perennial ryegrass in the Upper South Island.

PV ME were greatest in the tetraploid cultivars because of the magnitude of the PV ME used (Tables 1 and 2). The mid-heading diploid cultivars did not change in FVI with the addition of the PV ME because they were assigned zero PV ME (Table 1). The tetraploid cultivars increased their absolute FVI by \$386/ha/year (177% increase) as a mean in the UNI and by \$549/ha/year (280%) in the USI (Table 1). In contrast, the late-heading diploid cultivars had only \$77/ha/year (20%) to \$171/ha/year (68%) increases in FVI with the addition of the PV ME in the UNI and USI, respectively (Table 2).

It is important to note that inclusion of a ‘persistence’ trait in the future may have a negative effect on the FVI of some cultivars. Insufficient independent persistence trial data are currently available to assess what inclusion of persistence might have on the DairyNZ

FVI. However, the Irish Pasture Profit Index (PPI) (the only forage economic index to include seasonal DM, quality and persistence traits) (O’Donovan *et al.* 2016) may offer some insight into the relative effects of including a persistence trait. In that study, inclusion of the persistence trait (based on change in ground score) resulted in a 12% reduction in mean PPI of tetraploids compared with the PPI with only the DM yield and quality (dry matter digestibility) traits included. Some regions of New Zealand have greater insect burdens and drier conditions than in Ireland. Therefore, we can speculate that the effect of including a persistence trait in the DairyNZ FVI will likely be a greater proportionate reduction in overall FVI of tetraploid cultivars as compared with the FVI with seasonal DM and ME reported here.

**Table 2** Differences in Forage Value Index (FVI) between the current FVI and use of the FVI with the performance values for seasonal metabolisable energy trait included (+ME) for three cultivar groups.

Dairy Region <sup>1</sup>	Cultivar Group <sup>2</sup>	FVI (Current)	FV (+ME)	Absolute change in FVI	Percentage change in FVI
UNI	MD	\$260	\$260	\$0	0%
UNI	LD	\$374	\$450	\$77	20%
UNI	T	\$218	\$604	\$386	177%
USI	MD	\$188	\$188	\$0	0%
USI	LD	\$249	\$420	\$171	68%
USI	T	\$196	\$745	\$549	280%

<sup>1</sup> UNI=Upper North Island, and USI=Upper South Island. <sup>2</sup>MD=mid-season heading diploid, LD=late-season heading diploid, and T=tetraploid.

## Conclusions

Incorporation of the seasonal ME trait into the FVI calculations resulted in changes to the rankings of FVI-eligible cultivars. Although, correlations were strong between the rankings of cultivars using the current FVI equation and the equation which included the ME trait, a marked improvement in rankings of tetraploids resulted. Inclusion of the ME trait is an important step toward development of a more holistic estimation of the overall value of cultivars in the FVI. However, if this trait is included, a counter-balancing persistence trait will need to be included with the ME trait in the FVI considering the effect including the ME trait has on rankings of tetraploid cultivars.

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