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Dietary preference of dairy cows for perennial ryegrass cultivars growing with and without white clover

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Abstract

Dietary preference of dairy cows for eight perennial ryegrass cultivars (AberMagic, Alto, Base, Bealey, Commando, Kamo, One50 and Prospect) growing with and without white clover was examined at two vegetative stages (May and October) and one reproductive stage (November). Groups of dairy cows (n = 8) were offered free choice among cultivars growing with or without white clover for 6 to 8 hours. Preference was defined as the relative decreasing rate in sward surface height. Preference was higher for the tetraploid cultivars, Base and Bealey and the high-sugar diploid cultivar, AberMagic (preference ranged from 1.02 to 1.45). Preference was negatively correlated with herbage mass (r = -0.179, P = 0.013), proportion of dead material (r = -0.301, P < 0.001) and neutral detergent fibre (r = -0.287, P < 0.001), and positively correlated with sward surface height (r = 0.386, P < 0.001), ryegrass lamina length (r = 0.233, P = 0.001), tiller mass (r = 0.338, P < 0.001), water-soluble carbohydrate concentration (r = 0.143, P = 0.049) and organic matter digestibility in dry matter (r = 0.312, P < 0.001). Although the proportion of white clover was low (< 7% DM) in all three experiments, the interactions between perennial ryegrass cultivar and the presence of white clover were significant (P = 0.004 at pre-heading stage, P = 0.046 at reproductive stage and P = 0.038 at post-heading stage), with differences among preference for perennial ryegrass cultivars reduced when white clover was present.

Keywords: dietary preference; perennial ryegrass; white clover; interaction

Introduction

An understanding of the dietary preference of grazing animals is important for the efficient utilization of pasture (Rutter et al. 2004). It is also useful for both farmers and breeders to improve animal voluntary intake and performance (Edwards et al. 2008). Preference is exhibited not only for different species (Francis et al. 2006; van Dorland et al. 2006), but also for cultivars of the same species (Shewmaker et al. 2006; Solomon et al. 2014). Previous studies indicated that preference was related to pre-grazing herbage mass, leaf proportion (Solomon et al. 2014) and herbage nutritive value (Smit et al. 2006).

Dietary preference of dairy cows, beef cattle and sheep has been evaluated for perennial ryegrass (*Lolium perenne*) cultivars (Roegiers et al. 1988; Smit et al. 2006). Most of these studies have been carried out using pure perennial ryegrass pastures rather than perennial ryegrass/white clover mixtures. Sowing white clover (*Trifolium repens*) with perennial ryegrass is common in temperate pastures (Peoples & Baldock 2001). The interaction between pasture components can diminish or enhance the differences among perennial ryegrass cultivars (Lee et al. 2012). A small change in white clover percentage could lead to a disproportionate effect on animal production and outweigh the cultivar effect of perennial ryegrass (Hyslop et al. 2000). Hypothetically, including white clover might lead to a change of dietary preference for perennial ryegrass cultivars.

The objectives of this study were (1) to measure the sward structure, morphology, chemical composition and digestibility of herbage, and dietary preference of dairy cows, for eight perennial ryegrass cultivars growing with and without white clover, and (2) to define what herbage characteristics contributed to preference.

Materials and methods

Experimental design

Three grazing preference experiments were conducted when perennial ryegrass reached three growth stages: vegetative, post-heading (autumn 2013); vegetative, pre-heading (early spring 2014); and reproductive (late spring 2014). The pasture was established in March 2012 in a split-plot design with four blocks, with the main-plot factor being white clover (absence or presence) and the sub-plot factor being perennial ryegrass cultivar. A main-plot with an area of 18 m × 28.8 m was fenced using electric wires, resulting in eight paddocks (two levels of the main-factor × four blocks). Each main-plot contained eight adjacent sub-plots (18 m × 3.6 m), consisting of randomly allocated perennial ryegrass cultivars (two tetraploids, Base and Bealey, sown at 28 kg/ha; six diploids, AberMagic, Alto, Commando, Kamo, One50 and Prospect, sown at 20 kg/ha). The white clover used in the experiment was a mixture of cultivar Kopu II and Tribute (sown at 4 kg/ha). Sowing rates of diploid and tetraploid cultivars were designed to generate similar plant populations at establishment. To remove potential bias from previous grazing, management of treatment plots prior to the experiments were standardised by mowing all plots to achieve similar residual heights.

Animal management

In each grazing experiment, sixty-four Friesian × Jersey crossbred dairy cows were randomly divided into eight groups. Each group of eight cows was allocated to one of the main-plots, each containing eight adjacent perennial ryegrass cultivars after morning milking (around 0730). Cows grazed the plots with free access to all eight cultivars for six to eight hours depending on the herbage availability. Cows had *ad libitum* access to water.

Sward measurements

Herbage mass was measured prior to grazing by cutting three 0.2 m^2 quadrats in each sub-plot to ground level with hand shears. A subsample of 50 g fresh weight was taken from each quadrat for botanical composition and morphological analysis. Perennial ryegrass, white clover (in treatments where white clover was present), dead material and weeds were separated by hand. Ten intact perennial ryegrass tillers were selected randomly and the length of the newest fully expanded leaf blades (from ligule to tip) were recorded. All samples were oven-dried at 60°C for 48 h and weighed so the botanic composition could be calculated.

In order to monitor the decrease in sward height during grazing, 30 measurements of perennial ryegrass sward surface height (SSH, excluding headings) were recorded in each sub-plot at 0, 1, 2, 4 and 6 or 8 h after the start of grazing using a sward stick (Jenquip, New Zealand). The height of white clover petiole was recorded using a sward stick before grazing.

Chemical composition and digestibility analysis

Additional herbage samples of 150 g fresh weight were cut to ground level in each sub-plot before grazing. Samples were oven-dried at 60°C for 48 h, weighed and ground through a 1-mm sieve. Ground samples were analysed by NIRS (near infrared reflectance spectroscopy systems 5000, Foss, Maryland, USA) for chemical composition, including the concentrations of organic matter (OM), crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) and water-soluble carbohydrates (WSC) and organic matter digestibility in dry matter (DOMD).

Preference calculation

In this study, preference was defined as the decreasing rate of SSH at the beginning of grazing when herbage availability was ample and constraints associated with diet choices were minimal (Hodgson 1979). As the dietary preference for a food choice can be affected by other choices that the animals have at the same time, preference should be a value relative to the average of all the choices (Hodgson 1979).

A growth model was used to fit the decline in perennial ryegrass SSH at different times during grazing:

$$y = a(1 - e^{-bx})$$

Consequently, the preference, α was calculated as follows:

$$\alpha_i = \frac{y'_{(x=0)_i}}{\sum_j^8 y'_{(x=0)_j}/8}, \qquad j = 1, 2, \cdots 7, 8$$

where y is the accumulative decline in SSH (cm), x is the time after the start of grazing (h), a is the predicted final decline of SSH (cm), b is the fractional decreasing rate of sward height and $y'_{(x=0)i}$ is the SSH decreasing rate at the beginning of grazing ($x = 0$) of cultivar i.

At the beginning of grazing, among all the options the cows had, the faster the SSH decreased, the greater the preference. A preference of 1.00 would be representative of a cultivar if it is exactly intermediate, neither being preferred nor non-preferred.

Statistical analysis

The effects of growing with or without white clover (WC, main-factor), perennial ryegrass cultivar (PRG, sub-factor) and their interactions (WC × PRG) on sward structure, morphology characteristics, chemical composition, digestibility and preference were analysed by ANOVA (SPSS version 22.0) for the each of the three growth stages using a split-plot model. Pearson correlation analysis was performed between the preference and pasture measurements, which were converted to relative values according to the mean within a paddock to enable the comparison among paddocks and growth stages.

Results

Sward structure and morphology

Inclusion of white clover had negligible impact on the sward structure and morphology characteristics (Table 1). The tetraploid cultivars Base and Bealey had lower herbage

Table 1 Sward structure and morphology characteristics of perennial ryegrass pastures growing with and without white clover. P values for main-effect of white clover are shown

	With	Without	S.E.M.	P value
Pre-heading stage				
Sward surface height (cm)	25.2	25.1	0.4	0.903
Herbage mass (DM kg/ha)	3234	3460	166	0.406
Perennial ryegrass (%)	75.4	81.0	0.6	0.008
White clover (%)	6.4	-	-	-
Weeds (%)	1.5	1.8	0.5	0.703
Dead material (%)	16.2	16.8	0.6	0.472
Ryegrass lamina length (cm)	13.1	13.5	0.1	0.055
White clover petiole length (cm)	11.1	-	-	-
Tiller mass (mg)	46.0	56.2	2.0	0.036
Reproductive stage				
Sward surface height (cm)	23.6	24.1	0.4	0.528
Herbage mass (DM kg/ha)	3593	3438	200	0.584
Perennial ryegrass (%)	77.3	80.5	0.8	0.077
White clover (%)	6.8	-	-	-
Weeds (%)	1.4	1.6	0.2	0.435
Dead material (%)	14.5	16.4	0.8	0.114
Ryegrass lamina length (cm)	12.0	13.1	0.5	0.212
White clover petiole length (cm)	12.0	-	-	-
Tiller mass (mg)	55.8	56.7	1.5	0.679
Post-heading stage				
Sward surface height (cm)	18.4	17.5	0.1	0.023
Herbage mass (DM kg/ha)	1370	1399	95	0.846
Perennial ryegrass (%)	71.0	72.8	0.9	0.254
White clover (%)	4.9	-	-	-
Weeds (%)	1.0	0.8	0.3	0.748
Dead material (%)	23.1	26.3	1.1	0.142
Ryegrass lamina length (cm)	15.1	14.0	0.3	0.109
White clover petiole length (cm)	10.2	-	-	-
Tiller mass (mg)	27.2	25.7	0.5	0.127

Table 2 Sward structure and morphology characteristics of eight perennial ryegrass cultivars. P values for sub-effect of perennial ryegrass are shown. Means within rows followed by different subscripts are significantly different according to Duncan (P < 0.05)

	Base	Bealey	AberMagic	Alto	Commando	Kamo	One50	Prospect	S.E.M.	P value
Pre-heading stage										
Sward surface height (cm)	23.1^{d}	22.6^{d}	23.2^{d}	25.0^{c}	28.6^{a}	28.9^{a}	22.7^{d}	26.9^{b}	0.5	<0.001
Herbage mass (DM kg/ha)	2690^{d}	2652^{d}	3194^{c}	3580^{bc}	4135^{a}	3958^{ab}	3320^{c}	3249^{c}	155	<0.001
Perennial ryegrass (%)	78.4	79.2	79.4	77.6	78.8	76.1	79.3	76.8	1.0	0.178
White clover (%)	5.7	8.2	7.4	4.6	6.1	7.2	4.7	7.6	1.9	0.790
Weeds (%)	2.4^{ab}	2.9^{a}	1.9^{abc}	2.0^{abc}	0.9^{c}	1.1^{bc}	1.1^{bc}	1.3^{bc}	0.4	0.021
Dead material (%)	16.2^{bcd}	13.7^{d}	14.4^{cd}	16.4^{bc}	17.2^{ab}	19.1^{a}	17.2^{ab}	17.7^{ab}	0.8	0.001
Ryegrass lamina length (cm)	14.2^{a}	13.8^{ab}	11.6^{c}	14.0^{ab}	13.7^{ab}	13.2^{ab}	12.9^{abc}	12.8^{bc}	0.4	0.002
White clover petiole length (cm)	9.1^{c}	9.5^{c}	11.7^{ab}	11.9^{a}	12.6^{a}	12.7^{a}	10.0^{bc}	11.7^{ab}	0.6	0.001
Tiller mass (mg)	55.9^{b}	67.5^{a}	44.3^{d}	55.7^{b}	47.5^{cd}	38.6^{e}	52.4^{bc}	47.0^{cd}	2.0	<0.001
Reproductive stage										
Sward surface height (cm)	23.6^{b}	25.4^{a}	24.6^{ab}	24.6^{ab}	23.3^{b}	20.7^{c}	23.2^{b}	25.4^{a}	0.5	<0.001
Herbage mass (DM kg/ha)	2948^{d}	2990^{d}	3551^{bc}	3912^{ab}	3755^{ab}	3253^{cd}	4039^{a}	3675^{ab}	148	<0.001
Perennial ryegrass (%)	81.9	78.4	78.9	77.2	79.7	76.2	78.4	80.2	1.3	0.015
White clover (%)	4.2	10.7	10.1	4.8	4.1	9.9	3.7	7.1	2.1	0.079
Weeds (%)	1.3^{b}	2.8^{a}	1.1^{b}	2.0^{ab}	1.0^{b}	1.1^{b}	1.5^{b}	0.9^{b}	0.4	0.015
Dead material (%)	14.0^{bc}	12.3^{c}	14.1^{bc}	17.4^{a}	16.8^{ab}	16.8^{ab}	17.1^{a}	15.1^{ab}	0.9	<0.001
Ryegrass lamina length (cm)	12.0^{abc}	13.3^{ab}	11.8^{bc}	13.6^{ab}	12.6^{ab}	10.6^{c}	12.5^{ab}	13.7^{a}	0.6	0.006
White clover petiole length (cm)	10.8^{c}	10.6^{bc}	12.5^{ab}	11.5^{abc}	12.1^{abc}	12.8^{a}	12.5^{ab}	12.9^{a}	0.4	0.040
Tiller mass (mg)	66.4^{a}	74.0^{a}	53.1^{bc}	55.^{7bc}	47.3^{cd}	39.9^{d}	57.6^{b}	55.8^{bc}	2.8	<0.001
Post-heading stage										
Sward surface height (cm)	17.1^{bc}	18.6^{a}	18.7^{a}	18.1^{ab}	17.7^{ab}	16.2^{c}	18.6^{a}	18.7^{a}	0.4	0.001
Herbage mass (DM kg/ha)	1088^{b}	1335^{a}	1540^{a}	1308^{ab}	1495^{a}	1413^{a}	1476^{a}	1445^{a}	78	0.011
Perennial ryegrass (%)	75.0^{a}	74.8^{a}	71.7^{ab}	70.5^{b}	69.3^{b}	73.1^{ab}	70.4^{b}	69.8^{b}	1.2	0.004
White clover (%)	5.2	6.7	6.3	3.3	3.4	5.1	3.5	5.6	1.7	0.701
Weeds (%)	0.8	1.5	1.2	0.8	0.9	0.7	0.7	0.9	0.3	0.621
Dead material (%)	21.6^{c}	20.4^{c}	24.0^{abc}	27.0^{ab}	28.4^{a}	23.6^{bc}	26.9^{ab}	26.5^{ab}	1.4	0.002
Ryegrass lamina length (cm)	14.7^{abc}	16.1^{a}	14.3^{bc}	14.4^{abc}	13.2^{cd}	12.3^{d}	16.0^{a}	15.5^{ab}	0.5	<0.001
White clover petiole length (cm)	8.9^{bc}	8.1^{c}	10.9^{ab}	10.5^{ab}	10.4^{ab}	10.6^{ab}	10.6^{ab}	11.8^{a}	0.7	0.027
Tiller mass (mg)	24.7^{b}	37.9^{a}	26.1^{b}	25.5^{b}	23.1^{bc}	20.1^{c}	26.7^{b}	27.0^{b}	1.4	<0.001

mass and heaver tillers than other cultivars (Table 2). There was no difference in the proportion of white clover in perennial ryegrass cultivars at all three growth stages. There were no interactions between white clover and perennial ryegrass cultivar for sward structure and morphology.

Chemical composition and digestibility

Overall herbage CP concentration was higher and ADF and NDF concentrations were lower when white clover was included (Table 3). Tetraploid cultivars, Base and Bealey, had lower ADF and NDF concentrations than other cultivars at all three stages (Table 4). Generally, AberMagic had the highest WSC concentration, while Alto, Commando and Kamo were low in DOMD.

Preference

Table 5 shows relative preference of each cultivar against all cultivars. Across all three experiments, the tetraploid cultivars, Base and Bealey, and the high-sugar diploid cultivar AberMagic, were more preferred cultivars (preference ranged from 1.02 to 1.45). There were significant interactions (P < 0.05), indicating that the dietary preference for different perennial ryegrass cultivars was affected by the presence of white clover. With few exceptions (such as One50 at pre-heading stage), almost all preferences gathered towards the mean, 1.00, when white clover was present in the pasture.

Correlations

Preference was negatively correlated with herbage mass (r = -0.179, P = 0.013), dead material proportion (r = -0.301, P < 0.001), ADF (r = -0.336, P < 0.001) and NDF (r = -0.287, P < 0.001) concentration and positively correlated with SSH (r = 0.386, P < 0.001), the proportion of perennial ryegrass (r = 0.223, P = 0.002), lamina length (r = 0.233, P = 0.001), tiller mass of ryegrass (r = 0.338, P < 0.001), OM (r = 0.206, P = 0.004) and WSC (r = 0.143, P = 0.049) concentration and DOMD (r = 0.312, P < 0.001). White clover and weed proportion, white clover petiole length and CP concentration were not correlated with preference (P > 0.05).

Discussion

Sward structure, morphology, chemical composition and digestibility

There was a marked effect of perennial ryegrass cultivar on sward structure, morphology, chemical composition and

Table 3 Herbage organic matter (OM, mg/g), crude protein (CP, mg/g), acid detergent fibre (ADF, mg/g), neutral detergent fibre (NDF, mg/g) and water-soluble carbohydrates (WSC, mg/g) and organic matter digestibility in dry matter (DOMD, %) of perennial ryegrass pastures growing with and without white clover. P values for main-effect of white clover are shown.

	With	Without	S.E.M.	P value
Pre-heading stage				
OM	903	907	1	0.079
CP	171	154	2	0.007
ADF	243	248	1	0.033
NDF	470	486	3	0.023
WSC	215	233	1	0.001
DOMD	73.6	73.6	0.2	0.940
Reproductive stage				
OM	903	904	3	0.857
CP	165	145	4	0.082
ADF	267	279	2	0.036
NDF	513	540	4	0.045
WSC	187	195	11	0.702
DOMD	68.6	67.0	0.6	0.200
Post-heading stage				
OM	868	864	2	0.234
CP	249	230	4	0.049
ADF	268	281	3	0.038
NDF	493	521	5	0.023
WSC	63	60	2	0.459
DOMD	67.4	65.5	0.6	0.116

digestibility. In keeping with previous studies (Roegiers et al. 1988; Smith et al. 2001), the tetraploid cultivars, Base and Bealey, had lower SSH and herbage mass and fewer and heavier tillers. Further, consistent with previous studies (Moorby et al. 2006; Wims et al. 2013), the tetraploid cultivars and the high-sugar diploid cultivar, AberMagic, had a greater digestibility and lower fibre content.

Growing white clover in mixed pastures had negligible impact on perennial ryegrass sward structure and morphology, although it did affect some aspects of herbage chemical composition, such as CP, ADF and NDF concentrations. This was most likely due to the greater CP concentration and lower ADF and NDF contents of white clover than perennial ryegrass (Evans et al. 1996). However, the overall size of white clover effect was small compared to that associated with cultivar. For example, ADF concentration decreased from 248 to 243 mg/g when white clover was included, while ADF concentration ranged from 234 to 261 mg/g among perennial ryegrass cultivars at post-heading stage. The possible reason for the limited impact on perennial ryegrass sward structure and morphology could be the low white clover proportion in mixture pastures (< 7% DM), which was, in turn, caused by the high annual nitrogen application rate (325 kg N/ha) suppressing the growth of white clover (Labuschagne et al. 2006).

It was also noteworthy that there were limited effects of perennial ryegrass cultivar on white clover content, with no significant difference in the proportion of white clover

Table 4 Herbage organic matter (OM, mg/g), crude protein (CP, mg/g), acid detergent fibre (ADF, mg/g), neutral detergent fibre (NDF, mg/g) and water-soluble carbohydrates (WSC, mg/g) and organic matter digestibility in dry matter (DOMD, %) of eight perennial ryegrass cultivars. P values for sub-effect of perennial ryegrass are shown. Means within rows followed by different subscripts are significantly different according to Duncan (P < 0.05).

	Base	Bealey	AberMagic	Alto	Commando	Kamo	One50	Prospect	S.E.M.	P value
Pre-heading stage										
OM	904^{bc}	905^{bc}	912^{a}	903^{bc}	908^{ab}	900^{c}	907^{ab}	904^{bc}	2	0.006
CP	166	174	163	160	158	161	154	164	5	0.140
ADF	245^{c}	234^{d}	234^{d}	252^{b}	254^{b}	261^{a}	241^{c}	243^{c}	2	<0.001
NDF	472^{c}	456^{d}	464^{cd}	488^{b}	499^{a}	507^{a}	468^{c}	473^{c}	3	<0.001
WSC	217^{bc}	224^{b}	254^{a}	214^{bc}	224^{b}	196^{c}	241^{ab}	221^{bc}	8	0.001
DOMD	74.0^{cd}	75.2^{ab}	75.9^{a}	73.0^{de}	72.1^{e}	70.3^{f}	74.6^{bc}	73.7^{cd}	0.4	<0.001
Reproductive stage										
OM	910^{a}	905^{ab}	910^{a}	900^{bc}	897^{c}	894^{c}	904^{ab}	906^{ab}	2	<0.001
CP	143^{b}	164^{a}	156^{ab}	152^{ab}	163^{a}	163^{a}	145^{b}	149^{ab}	5	0.001
ADF	270^{bcd}	257^{d}	262^{cd}	276^{abc}	289^{a}	287^{ab}	275^{bc}	272^{c}	4	<0.001
NDF	522^{cd}	500^{d}	509^{cd}	531^{bc}	555^{a}	547^{ab}	530^{bc}	525^{bc}	7	0.001
WSC	220^{a}	208^{ab}	219^{a}	184^{b}	150^{c}	145^{c}	200^{ab}	198^{ab}	8	<0.001
DOMD	69.4^{abc}	70.0^{ab}	70.6^{a}	67.4^{c}	64.4^{d}	64.7^{d}	67.3^{c}	68.0^{bc}	0.7	<0.001
Post-heading stage										
OM	868^{abc}	868^{ab}	870^{a}	863^{bc}	862^{c}	869^{a}	865^{abc}	862^{c}	2	0.010
CP	252^{a}	254^{a}	227^{c}	227^{c}	231^{c}	245^{ab}	234^{bc}	245^{ab}	4	<0.001
ADF	273^{bc}	265^{d}	270^{cd}	282^{a}	281^{a}	272^{c}	278^{ab}	274^{bc}	2	<0.001
NDF	503^{cd}	489^{e}	499de	519^{ab}	522^{a}	505^{cd}	515^{abc}	509^{bcd}	4	<0.001
WSC	59^{bc}	71^{b}	86^{a}	60^{bc}	47^{c}	58b^{c}	61^{bc}	48^{c}	4	<0.001
DOMD	67.4^{a}	68.4^{a}	67.9^{a}	65.1^{c}	64.5^{c}	66.9^{ab}	65.7^{bc}	65.5^{bc}	0.5	<0.001

Table 5 Effect of white clover on the preference of dairy cows for eight perennial ryegrass cultivars. Means within rows followed by different subscripts are significantly different according to Duncan (P < 0.05). Preference has been defined as the decreasing rate in sward surface height relative to the average across all cultivars. Greater preference means more preferred; a preference of 1.00 means intermediate.

White clover	Perennial ryegrass cultivar									P value		
	Base	Bealey	AberMagic	Alto	Commando	Kamo	One50	Prospect	S.E.M.	WC	PRG	PRG × WC
Pre-heading stage												
Without	1.29	1.24	1.36	0.74	0.89	0.72	0.76	1.00				
With	1.05	1.04	1.31	1.00	1.03	1.09	0.63	0.85				
Mean	1.17^{ab}	1.14^{b}	1.34^{a}	0.87^{c}	0.96^{c}	0.91^{c}	0.70^{d}	0.92^{c}	0.09	-	<0.001	0.004
Reproductive stage												
Without	1.09	1.67	1.14	0.89	0.83	0.38	0.71	1.31				
With	1.06	1.23	1.25	0.85	0.95	0.72	0.93	1.01				
Mean	1.07^{bcd}	1.45^{a}	1.19^{ab}	0.87^{d}	0.89^{cd}	0.55^{e}	0.82^{d}	1.16^{bc}	0.13	-	<0.001	0.046
Post-heading stage												
Without	1.14	1.34	1.09	1.05	0.95	0.61	0.64	1.18				
With	0.89	1.26	0.99	0.86	1.12	0.79	1.16	0.94				
Mean	1.02^{b}	1.30^{a}	1.04^{ab}	0.95^{bc}	1.04^{ab}	0.70^{c}	0.90^{bc}	1.06^{ab}	0.12	-	0.003	0.038

among perennial ryegrass cultivars at all three experiments. Frame & Boyd (1986) hypothesised that perennial ryegrass cultivars with an open structure and a lower tiller density, such as tetraploid cultivars, could support more white clover than those diploid cultivars with a dense sward. However, that was not confirmed in this study, perhaps due to low proportions of white clover in the pasture (< 7% DM).

Preference

This study examined the effect of inclusion of white clover in a pasture sward on preference for perennial ryegrass cultivars, as measured by decline in SSH during short-term grazings. A feature of the results was that the differences among dietary preference for perennial ryegrass cultivars were reduced when white clover was present. This effect was most noticeable at the reproductive stage in late spring when the quality of the pasture was the lowest. Given the low overall proportion of white clover in pasture, the results of reduced preference is surprising. The reduced preference probably reflects the partial preference that has been previously shown for white clover (Francis et al. 2006; Rutter et al. 2004), diminishing the effect of perennial ryegrass cultivar *per se*. This is supported by Cosgrove et al. (2002) who showed that dietary preference between ryegrass with a high and low nitrogen concentration was reduced when white clover was offered as another choice.

There was a consistent effect of perennial ryegrass cultivar on preference of dairy cows, such that tetraploid cultivars (Base and Bealey) and high sugar diploid cultivar (AberMagic) were the most preferred in all three experiments. This finding agrees with previous studies (Roegiers et al. 1988; Smit et al. 2006). Previous studies suggested that taller swards are preferred by livestock (Illius et al. 1992). Although, there was a positive correlation between SSH and preference across cultivars, the tetraploid cultivars were not always taller than the diploid counterparts; thus preference for tall herbage is unlikely to explain the strong preference shown for the tetraploid cultivars. In agreement with previous studies (Mayland et al. 2000; Smit et al. 2006), correlation analyses in this study showed positive correlations between preference and digestibility and WSC concentration, and negative concentrations between preference and ADF and NDFconcentrations. Tetraploid cultivars were characterised as having high WSC concentration and digestibility, and low fibre content compared to other cultivars and these factors may have contributed to the high overall preference for these cultivars.

Table 6 Pearson correlation coefficients between preference of dairy cows for perennial ryegrass cultivars and sward structure, morphology characteristics, chemical components and digestibility of perennial ryegrass pastures (n=190).

	Correlation coefficient	P value
Sward surface height	0.386	<0.001
Herbage mass	-0.179	0.013
Perennial ryegrass proportion	0.223	0.002
White clover proportion†	0.038	0.714
Weed proportion	-0.008	0.913
Dead material proportion	-0.301	<0.001
Lamina length	0.233	0.001
Petiole length†	-0.069	0.507
Tiller mass	0.338	<0.001
OM	0.206	0.004
CP	0.070	0.337
ADF	-0.336	<0.001
NDF	-0.287	<0.001
WSC	0.143	0.049
DOMD	0.312	<0.001

†n=95 for white clover measurements

Conclusion

The tetraploid perennial ryegrass cultivars, Base and Bealey, and high-sugar diploid cultivar, AberMagic were preferred by dairy cows. Although white clover had limited effect on sward structure and morphology of perennial ryegrass pastures, its presence reduced the differences of dietary preference for perennial ryegrass cultivars. These findings may have implications for evaluation of perennial ryegrass cultivars for livestock production, although grazing efficiency and milk production studies are required to confirm this.

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