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Understanding factors associated with the grazing efficiency of perennial ryegrass varieties

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ABSTRACT

Herbage utilisation is of primary importance to grassland farmers due to its strong association with profit, yet it is not assessed in routine grass evaluations. On commercial grassland farms, grazing efficiency of varieties is believed to influence their level of herbage utilisation. To understand grazing efficiency the interaction between plant and animal is critical; mechanically simulated grazing protocols are limited in the information they provide. The objective of this paper was to further understand the grazing efficiency of perennial ryegrass varieties by identifying grazing traits which can be used as selection criteria by breeders striving to develop varieties with improved herbage utilisation. Fifty-five perennial ryegrass varieties, both diploid and tetraploid with intermediate and late heading dates, were sown in plots (3 m × 7 m; 21 m^2) following a randomised block design with three replicates per variety. Swards were rotationally grazed by lactating dairy cows during the 2015 and 2016 grazing seasons. Sward structural, morphological, and chemical characteristics were measured and related to grazing efficiency, as measured by post-grazing sward height. These data were analysed using the PROC MIXED procedure to test the fixed effects of traits and the GLM procedure to test their relationships with grazing efficiency. Varieties were shown to differ in their level of grazing efficiency ($p < 0.001$). Tetraploid varieties had significantly ($p < 0.001$) greater grazing efficiency than diploids recording post-grazing sward heights of 3.8 and 4.1 cm, respectively. Increased free leaf lamina ($p < 0.001$), tiller mass ($p < 0.05$) and dry matter digestibility ($p < 0.01$) were shown to significantly improve grazing efficiency of varieties. This study has identified free leaf lamina, tiller mass and dry matter digestibility as key selection criteria for plant breeders to base their developments upon if grazing efficiency is imported into their breeding programmes.

1. Introduction

Within grass-based production systems it is generally accepted that herbage yield is only a partial predictor of the grazing value of grass (Gilliland et al., 2002). The key objective of grazing systems in Ireland is to achieve high levels of herbage utilisation (O'Donovan et al., 2011), as it is a major driver of profit with each additional tonne utilised increasing net profit by an estimated €173 per hectare (Hanrahan et al., 2018). Previous research reported that the average Irish dairy farm utilises 7.8 t of herbage dry matter (**DM**) per hectare (Hanrahan et al., 2018). The efficiency of herbage utilisation in a grazing system can be defined as the proportion of the gross leaf tissue production that is removed by the grazing animals before entering the senescent state (Lemaire and Chapman, 1996).

In maximising grazing efficiency, the interface between plant and animal is of critical importance. Evaluation systems must be responsive to changes in farm management practices (Gilliland et al., 2002; Conaghan et al., 2008; Stewart and Hayes, 2011). It is essential that grass variety evaluators examine traits that are associated with increased levels of herbage utilisation because of its on-farm importance, to date this has not occurred. Current evaluations are mainly focused on herbage yield as determined by mechanically harvesting variety plots. These evaluations put little emphasis on herbage utilisation. Herbage utilisation and the traits which govern its level are poorly understood, making it difficult to include effectively as a breeding objective.

The absence of herbage utilisation from National and Recommended list evaluations, and the difficulty of assessing it on large numbers of accessions has generally deterred breeders from including it

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in their breeding objectives. An easily measured predictor trait for grazing efficiency could overcome this limitation and promote genetic advances in this quality characteristic. Swards are known to adapt their sward structure, morphology and chemical properties in response to lower post-grazing sward height (**PGSH**), which is a survival mechanism to escape severe defoliation and depletion of plant reserves (Briske, 1996). This process creates a sward ideally suited and resilient to animal grazing, however, varieties are not all equally able to adapt. Post-grazing compressed sward height has been reported as an indicator of this grazing efficiency characteristic (O'Donovan and Delaby, 2005; McCarthy et al., 2013). Varieties which form "grazable" swards, i.e., swards that can be consistently grazed to a residual height of 3.5–4 cm have a higher content of green leaf and digestible nutrients, whilst having reduced stem and senescent material (Tuñon et al., 2014). Swards which achieve post-grazing heights of 3.5–4 cm consistently support the highest percentage of herbage utilisation with no effect on sward production (McCarthy et al., 2013; Tuñon et al., 2014). Swards grazed to a PGSH of 3.6 cm can have significantly more net energy (UFL) utilised per ha which supports increased animal production per ha in comparison to swards grazed to 4.0 and 4.5 cm (McCarthy et al., 2013).

Achieving the optimum PGSH (3.5–4 cm) will maximise herbage yield and utilisation (Parsons and Chapman, 2000). Swards with a lower PGSH height are found to be preferentially selected in subsequent rotations (Griffiths et al., 2003). The PGSH achieved, whether positive or negative, will have a carry-over effect on sward performance in successive rotations. In the absence of plant and animal interactions, carry-over effects are not captured in simulated grazing regimes, hence the re-ranking of variety performance under animal grazing (Cashman et al., 2016).

The current study investigated differences in sward structure, morphology and quality properties of perennial ryegrass varieties with different heading dates and ploidy levels, under animal grazing as these properties are believed to influence grazing efficiency. The objective of the study was to further understand the grazing efficiency of perennial ryegrass varieties and identify associated traits which could be used as selection criteria by breeders to develop varieties with improved grazing efficiency.

2. Materials and methods

2.1. Site

A grazing study was conducted at Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co., Cork Ireland (52°09′50″N 08°15′50″W) on a free draining acid brown earth soil of sandy loam texture. The study was undertaken over two grazing seasons (February to October 2015 and 2016). Meteorological data were recorded on site using a synoptic weather station.

2.2. Experimental design

Fifty-five perennial ryegrass (*Lolium perenne* L.) varieties were examined (15 intermediate heading diploids, 10 intermediate heading tetraploids, 18 late heading diploids, 12 late heading tetraploids) which comprised both recommended and candidate varieties for the Republic of Ireland's National/Recommended list sowing 2014. The experiment was a randomised complete block design with three replicates (blocks) of each variety, resulting in a total of 165 plots.

Prior to cultivation, the entire experiment area was treated with glyphosate (Roundup; Monsanto Meath, Ireland) to ensure that all existing botanical species were removed, reducing the regrowth of weed grass species (Lane et al., 2009). Seed bed cultivations commenced 7–10 days after glyphosate application. Excessive surface trash was removed pre-cultivation. A fine and firm seed bed was formed by ploughing, power harrowing and land levelling the experimental area prior to sowing plots.

Each variety replicate was sown in a 3 m × 7 m plot in August 2014 (WINTERSTEIGER Plotseed S; WINTERSTEIGER AG., Dimmelstrasse 9, 4910 Ried im Innkreis, Austria) at a rate of 31 and 40 kg ha^{-1} for diploid and tetraploid varieties, respectively, to account for seed size differences. A seed bed fertiliser of 37 kg N ha^{-1}, 37 kg P ha^{-1} and 74 kg K ha^{-1} was applied. When the three leaf growth stage was reached a post-emergence herbicide (BINDER, DHM AGROCHEMICALS, Dublin) was applied at a rate of 0.75 l ha^{-1} to control broad-leaved weeds. The plots were grazed once in 2014 on 31 October, during an establishment phase.

2.3. Grazing management

Plots were grazed by block (0.20 ha) with lactating dairy cows, when the herbage mass available was visually estimated (O'Donovan et al., 2002) to be 1300 kg DM ha^{-1}. The rotation length between grazings varied between 21 and 45 days depending on herbage accumulation. Cows were allocated an estimated 17 kg DM cow day^{-1}. For the first two grazings each year, autumn-calved cows were used as they had a greater dry matter intake (**DMI**) due to their stage of lactation and this ensured there was sufficient numbers to graze out each block in a 12-h allocation. After the first two grazings, sufficient numbers of spring-calved cows with an estimated DMI of 17 kg DM cow day^{-1} were used to graze plots. A herd of 31 cows, on a predominantly grass-based diet, with minimal concentrate used in early spring and late autumn, were used to graze the plots. During periods of wet weather 'on-off' grazing was implemented to minimise sward damage in spring and autumn (Kennedy et al., 2009). Dung pats were removed from plots after each grazing. The dates and number of grazings along with N applications and pre-grazing compressed sward heights are presented in Table 1. A total of 252 kg N ha^{-1}, 47 kg P ha^{-1} and 197 kg K ha^{-1} was applied in each year, as urea N prior to grazings 1 and 2 and as a compound fertiliser thereafter, with all applications made within three days of the previous grazing.

2.4. Sward measurements

2.4.1. Sward heights

Ten sward height measurements were recorded in each plot pre and post-grazing using a Jenquip rising plate meter (Castle, 1976; Jenquip, 2016). Pre-grazing heights were taken to provide an indication of herbage availability and sward structure, whilst PGSH heights indicated the grazing efficiency of each variety.

Table 1
Calendar dates of grazing and associated pre-grazing compressed sward height (cm) and N[1] application rate (kg N ha^{-1}).

		Animal grazing 2015		Animal grazing 2016	
Grazing No.	N Rate, kg N ha^{-1}	Grazing Date	Pre-height, cm	Grazing Date	Pre-height, cm
.	28	1 February	.	20 January	.
1	28	18 March	5	19 February	8
2	33	15 April	11	05 April	6
3	33	17 May	11	13 May	11
4	33	19 June	12	10 June	12
5	33	14 July	9	06 July	9
6	33	6 August	9	27 July	8
7	33	27 August	9	24 August	8
8	.	29 September	11	21 September	10
9	.	.	.	19 October	7

N[1]: fertiliser was applied within 3 days of each grazing as shown.