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The 22nd International Grassland Congress (Revitalising Grasslands to Sustain Our Communities) took place in Sydney, Australia from September 15 through September 19, 2013.

Proceedings Editors: David L. Michalk, Geoffrey D. Millar, Warwick B. Badgery, and Kim M.

Broadfoot

Publisher: New South Wales Department of Primary Industry, Kite St., Orange New South Wales, Australia

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Effect of defoliation management on expression of the ‘high sugar’ cultivar trait in Tasmania

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Keywords: Crude protein, defoliation interval, dry matter, high sugar cultivar, water-soluble carbohydrates.

Introduction

The proposed benefits of perennial ryegrass (*Lolium perenne* L.) cultivars with a high concentration of water soluble carbohydrates (WSC) for the dairy industry in Australia include enhanced rumen protein metabolism, and potential improvements in milk components (Stewart *et al.* 2009). Perennial ryegrass cultivars have been developed to express higher levels of WSC, and extensive trials have shown consistent trait expression in Europe (reviewed by Edwards *et al.* 2007a). In New Zealand and Australia, there has been less consistent expression of the high sugar trait (Smith *et al.* 1998; Parsons *et al.* 2004; Francis *et al.* 2006), possibly reflecting a genotype by environmental interaction (Parsons *et al.* 2007). The current study was developed to investigate whether the high sugar trait of cultivars AberMagic (developed in Aberystwyth) and SF Joule AR1 (developed in Australia), is consistently expressed in cool temperate Tasmania, Australia, and to quantify the effect of contrasting defoliation management on trait expression. It is also important to confirm that any elevation in WSC concentration does not occur at the expense of dry matter (DM) yield, and to consider the relationship between WSC and crude protein (CP) concentrations - thought to be an important contributor to more efficient nitrogen (N) partitioning (Edwards *et al.* 2007b).

Methods

The experiment was conducted between October 2010 and February 2012 at the Tasmanian Dairy Research Facility in north west Tasmania (41.08 S, 145.77 E, elevation 155.0 m). Twenty-four 2 m x 3 m plots were arranged in a complete block design with two treatment factors (cultivar and defoliation interval), and four blocks. Cultivars were AberMagic, SF Joule AR1 and Arrow (control). Following establishment, three pre-treatment defoliations took place to a height of 45 mm when plants had reached the 3-leaf stage of regrowth. Defoliation interval treatments were then implemented from 4 March 2011 to 1 March 2012, with defoliation management based on the time taken for either 1.5 or 3 leaves per tiller to fully expand (1.5 or 3-leaf stages of regrowth). Herbage DM yield was calculated at each harvest event, and when defoliation intervals coincided (*i.e.* every second 1.5-leaf stage harvest with every 3-leaf stage harvest) leaf samples were collected for analysis of CP and WSC concentrations (the latter within 3 hours of sunrise).

Changes in DM yield, WSC and CP concentrations and WSC:CP ratio over time were analysed by Repeated Measures ANOVA using the statistical procedures of Genstat (Version 9.1, Lawes Agricultural Trust, distributed by VSN).

Results and Discussion

For all cultivars, higher WSC concentrations ($P < 0.05$) were measured at the 3-leaf stage of regrowth than at the 1.5-leaf stage (Table 1), in agreement with previous research that has observed increasing WSC concentrations with maturity, both in leaves as well as in reserve-form in plant stubble (Fulkerson and Donaghy 2001). The mean herbage WSC concentration of AberMagic was consistently higher than that of Arrow throughout the 12-month period, while the herbage WSC concentration of SF Joule AR1 generally fell between that of AberMagic and Arrow (Table 2). Despite decreasing with plant maturity, the CP concentration was maintained at an optimal level at the 3-leaf stage (mean 22.1%), and was not influenced at any stage by cultivar.

Maintenance of an optimal ratio (> 0.7 ; Edwards *et al.* 2007a) of WSC:CP was more strongly influenced by defoliation interval (3-leaf stage $>$ 1.5-leaf stage) than cultivar, although the high WSC cultivars, in particular AberMagic, displayed a higher WSC:CP ratio than Arrow (Table 1). For all cultivars, defoliation at the 1.5-leaf stage of regrowth between March and August 2011, and in February and March 2012, lead to a sub-optimal mean pasture WSC:CP ratio (< 0.7 ; Table 2). This was due to a high pasture CP concentration combined with the lower pasture WSC concentration of less mature leaf tissue. During winter this effect was amplified by a seasonal peak in CP

Table 1. Mean water soluble carbohydrate concentration (WSC) and WSC to crude protein ratio (WSC:CP) for each cultivar under 1.5-leaf and 3-leaf stage defoliation intervals.

Cultivars	Defoliation interval			
	1.5-leaf stage	3-leaf stage	1.5-leaf stage	3-leaf stage
	WSC (%)		WSC:CP	
AberMagic	19.43	24.72	0.74	1.29
Arrow	15.31	17.77	0.58	0.85
SF Joule AR1	16.92	20.53	0.65	1.03
<i>P</i> value	0.002		0.001	
LSD	0.99		0.09	

Table 1. Mean water soluble carbohydrate to crude protein ratio (WSC:CP) at each harvest date for AberMagic, Arrow and SF Joule AR1, under 1.5-leaf and 3-leaf stage defoliation intervals.

Harvest Date	1.5-leaf regrowth stage			3-leaf regrowth stage		
	AberMagic	Arrow	SF Joule AR1	AberMagic	Arrow	SF Joule AR1
4/03/2011	0.63	0.52	0.53	0.74	0.58	0.69
6/05/2011	0.58	0.42	0.46	0.83	0.60	0.75
1/07/2011	0.59	0.37	0.38	1.04	0.58	0.66
26/08/2011	0.32	0.27	0.29	0.54	0.45	0.39
3/10/2011	0.95	0.75	0.76	1.23	0.80	1.07
4/11/2011	0.97	0.83	0.85	2.35	1.41	1.68
5/12/2011	1.24	1.15	1.12	1.82	1.32	1.62
5/01/2012	0.96	0.69	1.07	2.03	1.32	1.53
3/02/2012	0.66	0.44	0.57	1.28	0.77	1.08
1/03/2012	0.51	0.36	0.44	1.02	0.63	0.80

l.s.d. ($P < 0.05$) = 0.30

concentration of less mature leaf tissue. During winter this effect was amplified by a seasonal peak in CP concentration, interacting with a seasonal trough in WSC concentration. Under the 3-leaf stage defoliation interval a mean WSC:CP ratio above 0.7 was maintained with greater consistency (Table 2).

The high sugar cultivars yielded as much DM as Arrow over the 12-month measurement period, with all cultivars producing a mean 20% more ($P < 0.001$) DM when defoliated at the 3-leaf stage compared with the 1.5-leaf stage (mean 18.0 versus 15.0 t DM/ha).

Conclusions

The WSC concentration of AberMagic and SF Joule AR1 was consistently higher than that of Arrow, and was not at the expense of DM yield. Expression of the high sugar trait as WSC:CP > 0.7 was maintained through defoliation at the 3-leaf stage of regrowth, suggesting further research should be carried out to quantify the influence of high sugar cultivars on N partitioning and milk production in Tasmania.

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