

Pasture characteristics of Italian ryegrass and milk production under different management strategies

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Abstract – The objective of this work was to assess the effects of the sward structure of Italian ryegrass (*Lolium multiflorum*), during the first grazing cycle, on its morphological and bromatological characteristics throughout the growing season, and on the performance of dairy cows. The treatments consisted of two structures obtained as a function of canopy-light interception: high-light interception (HLI) and low-light interception (LLI), with different pre-grazing heights in the first grazing cycle. Pasture was managed under rotational grazing with a herbage allowance not below 30 kg dry matter (DM) per cow per day. Three grazing cycles, with a grazing interval of 30 days, were evaluated. Pre-grazing herbage mass was greater (2,240 vs. 1,656 kg ha⁻¹ DM), but the proportion of leaf blades was smaller (0.35 vs. 0.43) for HLI swards. Neutral detergent fiber (NDF) content and organic matter digestibility (OMD) were similar between treatments in the first grazing cycle, but in the second and third ones NDF was greater, and OMD lower, for the HLI swards. Milk yields were greater for cows grazing LLI swards (19.4 vs. 21.1 kg per day). Initial grazing with 90% of light interception promotes greater nutritional value in the subsequent cycles.

Index terms: *Lolium multiflorum*, dairy cow, herbage intake, sward structure.

Características da pastagem de azevém anual e produção de leite sob diferentes estratégias de manejo

Resumo – O objetivo deste trabalho foi avaliar os efeitos da estrutura do pasto de azevém anual (*Lolium multiflorum*), no primeiro ciclo de pastejo, sobre suas características morfológicas e bromatológicas, ao longo da estação de crescimento, e sobre o desempenho de vacas leiteiras. Os tratamentos consistiram de duas estruturas, obtidas em função da intensidade de interceptação luminosa do dossel: alta interceptação luminosa (AIL) e baixa interceptação luminosa (BIL), com diferentes alturas de pasto na entrada para o primeiro ciclo de pastejo. A pastagem foi manejada sob lotação intermitente com oferta não inferior a 30 kg de matéria seca (MS) por vaca por dia. Três ciclos de pastejo, com intervalos de 30 dias entre eles, foram avaliados. A massa de forragem pré-pastejo foi superior (2.240 vs. 1.656 kg ha⁻¹ de MS), mas a proporção de lâminas foliares foi inferior (0,35 vs. 0,43) nos pastos AIL. Os teores de fibra em detergente neutro (FDN) e a digestibilidade da matéria orgânica (DMO) foram semelhantes, no primeiro ciclo de pastejo, mas, no segundo e no terceiro, o FDN foi superior e a DMO inferior nos pastos AIL. A produção de leite foi superior nas vacas dos pastos BIL (19,4 vs. 21,1 kg por dia). O início do pastejo com 90% de interceptação luminosa promove maior valor nutricional nos ciclos subsequentes.

Termos para indexação: *Lolium multiflorum*, vaca leiteira, estrutura do pasto, consumo de forragem.

Introduction

The efficiency of production systems for grazing animals is a function of the ingested herbage quality and quantity, which are strongly correlated to the adopted forage species and management practices (Hopkins & Wilkins, 2006). In terms of quantity, the

ratio between herbage allowance and daily intake is well known (Peyraud et al., 1996). However, the pasture management designed to supply forage, without limiting intake, usually implies on reduced grazing efficiency of accumulated aerial biomass, which may decrease pasture quality throughout its growing season (Purcell et al., 2011).

Some management strategies have been studied, mainly those involving perennial ryegrass pastures in temperate climate regions, in order to achieve an optimal herbage ingestions per cow and per hectare (Delaby & Peyraud, 2009). Among these, are the hastening date of first grazing (O'Donovan et al., 2004; Kennedy et al., 2006, 2007) and the increased defoliating frequencies with reduced intervals between grazing cycles and increasing number of cycles (McEvoy et al., 2009; Curran et al., 2010; Roca-Fernandez et al., 2011). In both cases, milk yield can increase up to 2.0 kg per cow and more than 1,300 kg ha⁻¹. However, little is still known about the effects of aerial biomass availability before the first grazing cycle on milk yield during the growing cycle of the most common winter forage species, such as Italian ryegrass (*Lolium multiflorum* Lam.), in subtropical climate regions. Therefore, it is relevant to know if Italian ryegrass pastures with larger proportion of leaf blades at the beginning of the first grazing cycle would allow for the maintenance of this parameter throughout successive cycles and if it has positive consequences on herbage intake and fat-corrected milk yields.

The objective of this work was to assess the effects of the sward structure of Italian ryegrass (*Lolium multiflorum*) during the first grazing cycle on its morphological and bromatological characteristics throughout the growing season, and on the performance of dairy cows.

Materials and Methods

The experiment was carried out at the Universidade do Estado de Santa Catarina, Lages, SC, Brazil (27°47'4"S and 50°18'26"W, at 920-m altitude), during the 2010 ryegrass growing season (from August to October). The soil was classified as a fine-loamy typical Haplumbrept. Two uniform 1.2 ha paddocks were used for each treatment and were split into three 0.4 ha replicates. It was used the rotational grazing method with electric fence-enclosed areas, inside each replicate slice, for four-day occupancy periods, and a herbage allowance not below 30 kg of dry matter (DM) per cow.

The treatments consisted of two structures obtained as a function of canopy light interception in the first grazing cycle: high-light interception (HLI) and low-light interception (LLI). HLI swards were first grazed when light interception reached 95%, whereas LLI swards were first grazed when light interception had reached 90%. Light interception was measured

with a ceptometer Accupar LP-80, (Decagon Devices, Inc., Pullman, WA, USA). In order to simultaneously graze both treatments, HLI swards were fertilized with 50 kg ha⁻¹ of N, as ammonium nitrate, as soon as tillering had began. Seven days later, LLI swards received the same amount of nitrogen. LLI and HLI swards were first grazed 21 and 28 days after N fertilization, respectively.

Twelve Holstein dairy cows were assigned to two uniform six-cow groups (two cows per replicate per area), according to milk yield (23.1±6.7 kg per day), lactation stage (114±70 days), body weight (569.3±40.3 kg), and amount of lactations (2.5±1.1). Three grazing cycles were monitored during the experiment, with a rest period of 30 days. For each cycle, animals stayed in the experimental area for 12 days, without any supplementation. Measurements were taken during the four last days of each cycle. Each area was fertilized immediately after each cycle, with 50 kg ha⁻¹ of N supplied as ammonium nitrate. In the grazing intervals, all animals stayed, in one single group, in an overseeded ryegrass paddock: ryegrass was overseeded with a mix of temperate climate forage species (*Festuca arundinacea* Schreb., *Trifolium repens* L., and *Trifolium pretense* L.).

Pre-grazing biomass was estimated by the compressed height, measured with a F200 rising plate meter (Farmworks, Feilding, New Zealand), and by the DM amount present at the disk area (0.1 m²). Before and after each grazing cycle, regression equations were obtained for biomass estimation (kg ha⁻¹ DM) as a function of grass height (cm). For this, five points by treatment were cut with scissors at ground level. After manual removal of soil and roots, the samples were oven-dried for 72 hours at 60°C.

Extended tiller and sheath heights were measured before and after grazing in the last four days of each cycle. Representative forage samples were taken at soil level from the same paddocks before grazing. Samples were separated into two subsamples: one was cut at the average post-grazing extended tiller height, with its upper portion oven-dried for 72 hours at 60°C, and was stored for chemical composition assessment; and the other was used for morphological classification and assessment of the mass ratios of leaf blades, stems (stems and pseudostems), dead material, and others.

The protocol for forage sampling in laboratory was performed according to Ribeiro Filho et al. (2003). The

offered biomass underestimated the nutritional value of forage intake. As described, the fraction selected for analysis was always higher than the residual tiller height, which was identified in individual paddocks.

Animals were milked twice a day. Individual milk yield was measured daily for both milking times (at 7h30 a.m. and 4h30 p.m.). Samples were taken in order to assess milk fat and protein contents during the last four days of each evaluated cycle for both milking times. Milk samples were pooled by day and stored at 4°C with the preservative bromopol tablet, (D & F Control Systems, Inc., San Ramon, CA, USA) before being analyzed for fat and protein contents using infrared analysis, method nº 972.160 (Horwitz, 2000). Individual forage intake was assessed from body weight and milk yield and composition, as proposed by Baker (2004). Animals were weighed once a week.

Mineral matter content was assessed by a 4-hour muffle furnace calcination at 550°C. Forage and feces samples were used for crude protein (CP) measurements using the Kjeldahl method. Acid detergent fiber (ADF) was measured according to Robertson & Van Soest (1981), and neutral detergent fiber (NDF) to Van Soest et al. (1991). NDF and ADF contents included ash trace residues. Forage organic matter digestibility was estimated from CP content of feces and forage and

ADF contents of feces, as described by Ribeiro Filho et al. (2003).

Data was subjected to analysis of variance according to a mixed model with repeated measurements in time, using the SAS package (Littell et al., 1998). The paddock was the experimental unit chosen for assessments and calculations. Effects from the experimental treatment, grazing cycle, and treatment x cycle interactions were treated as fixed, whereas the paddock was considered as random data. Measurements taken from animals (herbage intake, milk yield, milk fat, and protein contents) used initial milk yield as a covariate.

Results and Discussion

There was no interaction between sward types and grazing cycles for pre-grazing herbage mass, pre-grazing sward height, and morphological composition (Table 1). Therefore, these results were presented and discussed based on the averages of each factor (type of pasture and cycle).

Sward height was higher for HLI than for LLI swards and increased in the second and third cycles in comparison to the first cycle. Regardless of extended tiller height and sheath, the responses observed were indirectly related to the proportion of blades in the

Table 1. Effects of grazing management (GM) and grazing cycle (GC) on the characteristics of herbage offered to dairy cows grazing Italian ryegrass (*Lolium multiflorum*)⁽¹⁾.

Parameter	Cycle 1		Cycle 2		Cycle 3		SE	Significance		
	HLI	LLI	HLI	LLI	HLI	LLI		GM	GC	GM vs. GC
Pre-grazing sward height (cm)										
Rising plate meter	8.3	6.6	16.2	12.4	17.7	13.1	0.5	***	***	ns
Extended tiller	45.9	35.3	51.8	44.1	56.7	51.6	0.9	***	***	ns
Extended sheath	20.8	15.9	38.7	22.8	44.3	39.1	1.4	**	***	ns
Morphological composition (g kg ⁻¹ DM)										
Live lamina	592	645	286	431	164	221	12.2	***	***	ns
Live sheath and stem	326	337	629	515	703	669	13.3	*	***	ns
Pre-grazing herbage mass (kg ha ⁻¹ DM)										
Total	1,111	710	3,218	2,105	3,124	2,444	48.1	***	***	ns
Live lamina	659	458	911	914	512	543	33.0	ns	***	ns
Chemical composition (g kg ⁻¹ DM)										
Dry matter (g kg ⁻¹)	165	178	222	174	205	210	5.19	ns	**	*
Organic matter	902	900	925	918	938	935	1.97	ns	***	ns
Crude protein	216	258	147	196	148	171	5.4	***	***	ns
Neutral detergent fiber	331a	332a	453a	387b	504a	483b	3.7	***	***	***
Acid detergent fiber	174	164	246	215	280	258	3.9	**	***	ns
Organic matter digestibility ⁽²⁾	0.76a	0.75a	0.70b	0.75a	0.68b	0.70a	0.004	**	***	**

⁽¹⁾Means inside each cycle followed by equal letters do not differ by the t test at 5% probability. ⁽²⁾Calculated from the fecal crude protein content, the fecal acid-detergent content, and the crude protein content of the offered herbage according to Ribeiro Filho et al. (2003). HLI, high-light interception (95%); LLI, low-light interception (90%); SE, standard error; DM, dry matter.

canopy. The proportion of live laminae was higher and the proportion of live sheathes and stems was lower for LLI than for HLI swards. Similarly, the proportion of live laminae decreased and the proportion of live sheathes and stems increased from the first to the third cycle. Total herbage mass was higher for HLI than for LLI swards, but the live laminae of herbage mass was similar between them. The CP ratio was 38 g kg⁻¹ higher, and the ADF ratio was 21 g kg⁻¹ lower for LLI swards, when compared to HLI swards. In the third cycle, CP decreased 77 g kg⁻¹ DM, whereas ADF increased 100 g kg⁻¹ DM in comparison to the first cycle. However, the proportion of NDF and organic matter (OM) digestibility were similar between swards for the first cycle, but for the second and third ones NDF was lower and OM digestibility was higher for the LLI swards.

The differences observed in chemical composition between treatments can be attributed to the larger amount of aerial biomass per hectare, as well as to the smaller proportion of laminae and the higher post-grazing height for HLI swards, in comparison to the LLI swards. Larger biomass values at pre grazing implies on a reduced quality of forage (Purcell et al., 2011), which could be associated to a lower proportion of leaf blades and larger proportion of stems and dead material in the canopy (McEvoy et al., 2009; Roca-Fernandes et al., 2011). Furthermore, these results confirm that younger and leafy plants have larger N content and better digestible OM content, and that more mature plants present higher NDF and ADF values (Hopkins & Wilkins, 2006). For perennial ryegrass pastures, increases in CP content and decreases in NDF and ADF have already been observed (O'Donovan et al., 2004; Kennedy et al., 2006) as consequences for hastening date of the first grazing cycle.

Total herbage allowance did not change between swards, but increased drastically in the third cycle in comparison to the first and second ones (Table 2). Live laminae herbage allowance was similar between HLI and LLI swards in the first and third cycles, but it was higher for LLI swards in the second cycle. Post-grazing sward height was lower for LLI than for HLI swards in the first cycle and similar between swards in the second and third ones. The extended tillers and sheaths heights were lower for LLI than for HLI swards in the first and second cycles, but did not differ in the third one. Pastures with larger proportion of leaf blades in the first grazing cycle tend to maintain this characteristic and

to have better digestibility in the second grazing cycle (Kennedy et al., 2007; Curran et al., 2010), whereas the quality of forage shows a greater decrease in the next grazing cycle for pastures with larger proportion of stems and dead material close to soil surface (O'Donovan et al., 2004). In terms of post-grazing height, Curran et al. (2010) found that forage quality is enhanced at subsequent grazing cycles due to lower post-grazing heights and less dead material from residual pasture left from the previous cycle.

HLI and LLI herbage intake showed no variation with sward type, but herbage digestible OM intake and metabolisable energy intake decreased as grazing cycles progressed. Milk yield was higher for LLI than for HLI swards (1.7 kg per day) and decreased throughout the cycles. Fat content of milk did not vary with treatments or grazing cycles. Live weight also did not change with treatments or grazing cycles, but protein yield was higher for LLI than for HLI in the second cycle, and it did not vary with sward type in the first and third cycles.

The similarity in herbage intake can be attributed to the fact that, for both treatments, severity of defoliation was always lower than 50% of pre-grazing height at the beginning of grazing. At this condition, animals always ingest only the higher strata of the canopy, avoiding stems, which act as a barrier to defoliation and reduce both instantaneous and daily herbage intake (Drescher et al., 2006). However, DM herbage allowance as live lamina (Table 2), during the second and third grazing cycles for HLI swards, was lower than the estimated DM intake (Table 3). This result indicates larger proportion of stems in the diets of cows in the HLI pastures.

Therefore, the larger milk yield under the LLI treatment is clearly associated to the quality of herbage intake, when compared to the HLI treatment. These results confirm the findings of O'Donovan et al. (2004), who attributed larger milk yield by cows grazing forage with larger proportion of leaf blades to a better feeding, even when the animals ingested about 1.0 kg DM less per cow with high requirement. Curran et al. (2010) also found increasing milk yield per kg of ingested herbage for decreasing pre-grazing herbage mass. Moreover, the larger protein yield by cows in LLI pastures in the second grazing cycle is closely related to animal energy balances. The effects of energy supply on protein synthesis for milk is widely known, since protein synthesis in the mammary glands is an energy-expensive process (Coulon & Rémond, 1991).

Table 2. Herbage allowance and effects of grazing management (GM) and grazing cycle (GC) on post-grazing sward height of Italian ryegrass (*Lolium multiflorum*)⁽¹⁾.

Parameter	Cycle 1		Cycle 2		Cycle 3		SE	Significance		
	HLI	LLI	HLI	LLI	HLI	LLI		GM	GC	GM vs. GC
Herbage allowance (kg of DM per day)										
Total	31.1	29.8	36.6	35.9	71.0	68.4	0.8	ns	***	ns
Live lamina	18.4a	19.2a	10.3b	15.6a	11.6a	15.2a	0.7	**	**	*
Post-grazing sward height (cm)										
Rising plate meter	3.2	2.4	4.8	5.2	5.0	4.7	0.2	*	***	*
Extended tiller	20.6a	15.3b	30.1a	25.2a	30.5a	32.7a	0.7	*	***	*
Extended sheath	12.4a	8.3b	27.5a	19.9b	25.8a	26.7a	5.4	**	***	***

⁽¹⁾Means inside each cycle followed by equal letters do not differ by the t test at 5% probability. HLI, high-light interception (95%); LLI, low-light interception (90%); SE, standard error.

Table 3. Effects of grazing management (GM) and grazing cycle (GC) on herbage intake and animal performance of dairy cows grazing Italian ryegrass (*Lolium multiflorum*).

Parameter	Cycle 1		Cycle 2		Cycle 3		SE	Significance		
	HLI	LLI	HLI	LLI	HLI	LLI		GM	GC	GM vs. GC
Herbage DM intake (kg per day)	15.9	15.3	15.3	14.8	12.9	14.6	0.45	ns	ns	ns
Herbage OM intake (kg per day)	14.4	13.7	14.2	13.5	12.1	13.7	0.40	ns	ns	ns
Herbage DOM intake (kg per day)	11.0	10.4	10.0	10.2	8.2	9.6	0.31	ns	*	ns
ME intake (Mcal per day)	45.9	43.6	40.5	41.6	32.9	38.6	1.32	ns	**	ns
Milk yield (kg per day)	23.5	24.3	18.6	21.7	16.6	17.2	0.3	*	***	ns
FCM yield ⁽²⁾ (kg per day)	21.4	21.5	17.3	19.5	14.3	15.5	0.3	*	***	ns
Milk fat content (g kg ⁻¹)	33.9	32.3	35.9	33.5	32.5	33.5	1.1	ns	ns	ns
Milk protein content (g kg ⁻¹)	32.5	30.4	33.3	32.0	36.0	33.0	0.4	*	**	ns
Milk fat yield (kg per day)	794	787	667	728	542	575	17	ns	***	ns
Milk protein yield (kg per day)	751a	742a	606b	691a	552a	567a	8.2	*	***	*
Live weight (kg)	576	563	594	573	557	552	9.3	ns	ns	ns
Energy balance (Mcal per day)	-0.9a	-4.9a	-5.8b	0.4a	-7.3a	-6.9a	1.14	ns	ns	*

⁽¹⁾Means inside each cycle followed by equal letters do not differ by the t test at 5% probability. ⁽²⁾FCM, 4% fat-corrected milk. HLI, high-light interception (95%); LLI, low-light interception (90%); SE, standard error; DM, dry matter; OM, organic matter; DOM, digestible organic matter; ME, metabolisable energy.

Conclusions

1. The onset of grazing when light interception of Italian ryegrass reaches 90% results in larger proportions of live lamina in the canopy and greater nutritional value in the subsequent cycles.

2. Better quality of herbage throughout the pasture growth cycle allows for increasing fat-corrected milk yields by dairy cows, regardless of herbage intake variations.

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