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Short Communication

High pasture allowance does not improve animal performance in supplemented dairy cows grazing alfalfa during autumn–winter

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ABSTRACT

The aim of this study was to assess the effect of three alfalfa pasture herbage allowances on milk yield and composition during autumn–winter grazing season on early autumn calving dairy cows. Eighteen multiparous Holstein dairy cows were assigned to one of three treatments in a 3 × 3 Latin square design: low herbage allowance (14 kg DM/cow; LHA), medium herbage allowance (27 kg DM/cow; MHA) and high herbage allowance (41 kg DM/cow; HHA). Dry matter disappearance was lower at LHA although remained similar between MHA and HHA ($P<0.05$). However, as herbage allowance (HA) increased, lower grazing efficiencies (as the proportion of material removed) were registered ($P<0.05$). Total dry matter intake (DMI; kg/d) was also lowest for LHA and similar between the other two treatments ($P<0.05$). Milk yield, 4%FCM, milk fat (g/kg) and casein (g/kg) tended to increase from LHA to HHA ($P<0.10$). Cows at LHA tended to loss weight whilst cows at MHA and HHA had a tendency to increase BW according the season progressed ($P<0.10$). In summary, managing cows at HHA will allow cows to a slightly increase in individual milk production and BW gain but in detriment of herbage utilization and potentially, milk production per hectare.

1. Introduction

Pasture dry matter intake (DMI) is usually low in comparison to DMI achieved in total mixed ration (TMR) systems and is indicated as one of the most limiting factors for increasing individual milk yield (Bargo et al., 2002). Several factors affect DMI in grazing situations as grazing time, fibre content of the pasture, herbage mass and supplementation (McEvoy et al., 2009). Herbage allowance (HA) is in turn, one of the major factors affecting DMI and milk production in grazing dairy cows (McEvoy et al., 2008; Alvarez et al., 2006). An increase in HA has been reported to lead to an increase in DMI and individual milk yield (McEvoy et al., 2008). However, milk production per hectare and grazing efficiency (as a proportion of herbage mass removed over the total herbage mass offered) declines with increasing HA (Baudracco et al., 2014, Alvarez et al., 2006). It is important to note that many of these studies were carried out during the main grass growing season, i.e. spring, since grazing systems are usually based on a spring calving season in order to match the high grass supply with the high cow energy demand. Nevertheless, in some countries as Argentina, year-round calving is common and consequently, it is relevant to evaluate the effect of HA on early lactation dairy cows during the autumn–winter season. Additionally, there is evidence showing that dairy cows consume less DM from pasture in autumn compared to spring (Dillon, 2006). To our best knowledge, there is a lack of studies available about the effect of HA on milk performance under alfalfa grazing during autumn–winter time. Alfalfa pasture is one of the most important feeds for dairy cows in Argentina (Baudracco et al., 2014). The aim of this particular study was to assess the effect of combining three herbage allowances with only one level of concentrate supplementation (flat rate) on milk yield and composition during autumn–winter grazing season on early autumn calving dairy cows.

2. Materials and methods

The study was carried out from March to July at the Rafaela Agricultural Experiment Station, (INTA, 31° 15' S, 61° 21' W), Argentina, on a permanent alfalfa pasture sown in an Argiudol typical soil, well-drained of silt loam.

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2.1. Weather data

Total monthly precipitations were 58, 89, 15, 54 and 39 mm between March and July 31st, coincident with data from previous 50 years. Average monthly maximum temperatures were 27, 24, 21, 19 and 18 °C, and average low temperatures were 16, 12, 11, 8 and 7 °C for the same period, normal for the region and similar to the previous recorded 50-yr average.

2.2. Experimental design, animals and treatments

Eighteen multiparous Holstein dairy cows (613 ± 58.4 kg body weight (BW); 87 ± 22 days in milk (DIM); previous lactation yield ≈ 5600 kg of 4% fat-corrected milk (FCM)) were assigned to one of three treatments during 3 periods (5 weeks per period, 2 weeks adaptation period and 3 weeks for data collection) in a 3 × 3 Latin square design. Cows were divided into 6 squares (block) of 3 animals each according to previous lactation yield, BW, parity and calving date. Within square, each animal was randomly assigned to each experimental treatment: low herbage allowance (14 kg DM/cow; LHA), medium herbage allowance (27 kg DM/cow; MHA) and high herbage allowance (41 kg DM/cow; HHA). Levels of herbage allowance were selected in order to provide one, two or three times the expected herbage daily intake. Dairy cows were allocated in a 12 ha single paddock of a 2nd year alfalfa pasture (*Medicago sativa L.*) which was strip-grazed daily. Cows were milked at 05:30h and 16:30h and received in the milking parlour 5 kg/day (fresh weight, divided in two meals) of a cereal grain-based pelleted concentrate (Table 1).

2.3. Pasture measurements and dry matter intake from pasture

Table 1 shows the characteristics and chemical composition of the alfalfa pasture and the concentrate during the three experimental periods. Herbage mass (HM) was measured once a week at 5 cm above ground by cutting at least in 10 randomly sites. Sampling was done after noon, before and after grazing. Each sample was manually classified into alfalfa and weeds, weighing each fraction fresh and oven dried 48 h at 65 °C to determine DM content. The targeted daily HA was achieved by weekly adjusting the size of the strip-grazed area as a function of HM (kg DM/Ha).

Alfalfa DMI and grazing efficiency were estimated at each sampling date by the difference between initial and final herbage DM available biomass (Meijs, 1981).

Table 1
Characteristics and chemical composition of alfalfa pasture and concentrate; Mean ± SD.

Item	Experimental periods			Concentrate
	P I	P II	P III	
Date	6 Apr. – 3 May.	4-31 May.	1 Jun. – 5 Jul.	
Alfalfa HM[a] (t DM/ha)	2.0 ± 0.04	1.7 ± 0.02	1.1 ± 0.06	
Alfalfa[b] DM (proportion of HM)	0.72	0.55	0.58	
Canopy height (cm)	45 ± 5.0	45 ± 4.0	25 ± 3.5	
Crude protein (g/kg DM)	217 ± 1.36	217.8 ± 2.53	223.6 ± 2.49	163.7
NDF (g/kg DM)	415.3 ± 18	412.3 ± 31	434.7 ± 26	ND[c]
ADF (g/kg DM)	322.9 ± 11	327.9 ± 0.9	334.1 ± 12	95
ADL (g/kg DM)	82.8 ± 0.5	82.9 ± 0.8	87 ± 0.8	ND
IVDMD[d] (g/kg)	718 ± 17.9	717 ± 18.8	707 ± 17	826

[a] Herbage mass, ton of DM/ha.
[b] Alfalfa DM contribution to total HM as proportion.
[c] Not determined.
[d] In vitro dry matter digestibility.

2.4. Animal performance

Individual milk yields were recorded daily using Alfa-Laval™ milk jar recorders. An aliquot milk sample was taken twice a week from each animal in a pm:am basis and stored for compositional analysis. Cows were weighed every two weeks for three consecutive days at the same time after morning milking.

2.5. Chemical analysis

Concentrate was sampled every 15 days during the collection periods. Samples of alfalfa pasture and concentrate were dried at 65 °C ground through 1 mm screen in a Wiley-type mill, composite and stored for chemical analysis. From each sample, nitrogen content was determined by Kjeldhal method (AOAC, 1975). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) in alfalfa were determined according to Goering and van Soest (1970); and by the modified procedure of Robertson and van Soest (1981) in the concentrate. Alfalfa and concentrate *in vitro* DM digestibility was done according to Tilley and Terry (1963).

Milk samples were analyzed for total solids (TS); ash; fat; total nitrogen; protein N; Non protein N (NPN); Casein, and lactose. Milk fat, protein and non protein nitrogen contents were determined by standard methodologies according to the International Dairy Federation (FIL-IDF 1964, 1987, 1996). Protein was analyzed as (Nx6.38 – NPN). Lactose was estimated as the difference between non fat milk solids (NFS) minus (N + Ashes); 4% fat-corrected-milk (4%FCM) was estimated according to Gaines and Davidson (1923). The energy concentration of the milk was predicted from its fat and protein concentration using the formula of Tyrrell and Reid (1965).

2.6. Statistical analyses

Results (animal performance and herbage utilization) were analyzed by a repeated measurements procedure on the basis of a 3 × 3 Latin Square. Model includes terms for period within square, treatment and square (animal within square was used as random effect). Results were adjusted by covariance using the corresponding individual performances obtained during the pre-experimental period. The degrees of freedom for the F test were adjusted with the Kenward–Rogers option (SAS Proc Mixed, 1999). When significant ($P < 0.05$), mean separation was conducted by the Tukey's method.

3. Results

3.1. Dry matter intake

As shown in Table 1, chemical composition of the alfalfa pasture was similar along the experiment. However, HM and canopy height declined as the season progressed from autumn to winter (no statistical analysis was performed in this data). Since HA was reached as the combination of HM and surface available per cow, treatments differences were maintained according to the objective of this experiment (Table 2).

The DM disappearance (Table 2), which represents the pasture DMI, was lower at LHA although remained similar between MHA and HHA ($P < 0.05$). However, as HA increased, lower grazing efficiencies were registered ($P < 0.05$). With regards to total DMI, a similar pattern to pasture intake was observed (concentrate DMI

Table 2
Effect of herbage allowance on pasture use and dry matter intake of dairy cows grazing autumn–winter alfalfa.

Item	Herbage allowance			SED	Significance[a]
	Low	Medium	High		
DM allowance (kg/cow day)	13.7	27.2[b]	40.5[a]	0.22	**
DM disappearance (kg/cow day)	12.1[b]	14.4[a]	14.7[a]	0.11	*
Efficiency of alfalfa grazing[b]	0.89[a]	0.53[b]	0.36	0.001	*
Concentrate DMI (kg/day)	4.4	4.4	4.4	–	ND
Total DMI (kg/day)	16.5[b]	18.8[a]	19.1[a]	0.18	*

*, **: significant at $p<0.10$, $p<0.05$ and $p<0.01$, respectively.
[a] Significance; ND = not determined ($p>0.10$).
[b] DM disappeared/DM allowed

Table 3
Effect of herbage allowance on milk production and composition of dairy cows grazing autumn–winter alfalfa.

Item	Herbage allowance			SED	Significance[a]
	Low	Medium	High		
Milk yield (kg/day)	24.3	26.2	27.7	0.56	†
4% FCM[b] yield (kg/day)	21.3	22.7	25.00	0.36	†
Milk composition and yield					
Fat (g/kg)	31.8	31.2	33.4	0.31	†
Fat (kg/day)	0.77[b]	0.81[b]	0.93[a]	0.280	*
Total protein (g/kg)	25.3	25.4	25.5	1.02	NS
Total protein (kg/day)	0.62[b]	0.66[a,b]	0.71[a]	0.398	*
True protein (g/kg)	23.8	23.8	23.8	1.18	NS
Casein (g/kg)	19.1	19.8	20.8	0.89	†
Ash (g/kg)	6.5	6.4	6.4	0.56	NS
Total solids (g/kg)	113.6	113.4	115.4	0.92	NS
Total solids (kg/day)	2.76[b]	2,97[a,b]	3,19[a]	0,191	*
Non fat solids (g/kg)	81.7	82.3	81.9	1.01	NS
Non fat solids (kg/day)	1.99[b]	2.15[a,b]	2.27[a]	0.282	*
Body-weight change (g/day)	−349	84	233	1.1	†

NS = not significant (p > 0.10).
†, *, **: significant at p < 0.10, p < 0.05 and p < 0.01, respectively.
[a] Significance.
[b] 4% Fat Corrected Milk (Gaines and Davidson, 1923)

did not change across treatments), being the lowest for LHA and similar between the other two treatments ($P<0.05$).

3.2. Milk yield and composition

Milk yield and composition is shown in Table 3. Milk yield and 4%FCM tended to increase from LHA to HHA ($P<0.10$). Also milk fat (g/kg) and casein (g/kg) presented a tendency to increase as the HA did (Table 3). In turn, milk fat yield (kg/d) were highest at HHA, intermediate at MHA and the lowest at LHA ($P<0.05$). Even though milk protein (g/kg) remained similar between treatments, milk protein yield was higher at HHA compared to LHA ($P<0.05$). Same pattern was recorded for total solids and total non fat solids. Regarding BW change, cows at LHA tended to loss weight whilst cows at MHA and HHA had a tendency to increase BW according the season progressed ($P<0.10$).

4. Discussion

Herbage allowance is recognized as one of the main factors affecting DMI in pasture (McEvoy et al., 2008; Alvarez et al., 2006; Dillon, 2006). Usually, a curvilinear relationship between HA and DMI can be found (Greenhalgh et al. 1966; Peyraud 1996; Maher et al. 2003). Similar to previous studies carried out on grass based pastures, increasing HA from low to high did not increase pasture intake in a linear relationship, showing that MHA (27 kg/cow) was enough to reach the maximum pasture intake in the present experiment (Table 2). This is in agreement with Peyraud and González-Rodríguez 2000 who showed that increasing HA above 20 kg of organic matter offered per cow did not increase herbage intake greatly. Contrary to our results, in an alfalfa based pasture experiment, Alvarez et al. (2006) found a linear increase in herbage intake as HA increased. Differences between trials may be due to seasonal effects. The experiment of Alvarez et al. (2006) was carried out in late spring-early summer, which is coincident with a pasture growing at a higher rate and lower alfalfa quality. In that context, animals in the high HA are able to select the high herbage quality whilst animals in lower HA treatments can not do it. Our experiment was carried out during autumn–winter and, as shown in Table 1, the pasture quality did not change along the time. Therefore, pasture quality may not be a negative factor affecting herbage intake and consequently differences maybe attributable to non-nutritional factors.

Stocking rate (SR), defined as the number of animals allocated to an area of land (i.e., cows/ha), has been recognized as the primary driver of milk production per hectare and profitability in grazing systems for over half a century (Castle et al., 1972; Fales et al., 1995). In this study, as HM was comparable between treatments, increasing HA leads to a decrease in the SR, since more grazing area is needed. Our results show clthat increasing HA is potentially detrimental for herbage utilization and consequently for SR and milk production per ha (Table 2). These results are consistent with those of Wales et al. (1999), Bargo et al. (2003) and Baudracco et al. (2014).

Previous reports shows that milk yield increased with increasing HA (Baudracco et al., 2014; McEvoy et al., 2008, Bargo et al., 2003). In the present study, milk yield and 4%FCM tended to increase as HA did (Table 3). However, total DMI was similar between MHA and HHA. The reason why milk production increased at HHA whilst DMI remained similar to MHA may be related to the greater possibility for animals at HHA to select herbage. In fact, animals in the HHA tended to gain weight in contrast to animals at LHA (Table 3) showing that these animals are capable of selecting better quality of herbage and consequently, to reach a higher energy intake. In agreement, McEvoy et al. (2008) found a higher BW loss at low HA (13 kg DM/cow) in comparison to high HA (17 kg DM/cow). Finally, in agreement with previous studies (Baudracco et al., 2014; McEvoy et al., 2008; Alvarez et al., 2006), changes in HA did not affect milk composition but component yields were affected in the same manner that milk yield did it.

5. Conclusion

Increasing HA in dairy cows grazing alfalfa in autumn–winter season slightly increase milk yield and milk components (kg/d) per cow although this improvement may be in detriment of milk production per hectare as herbage utilization diminishes. Total and pasture DMI were similar between MHA and HHA, showing that the maximum herbage intake was reached at 27 kg DM/cow (MHA), whilst cows at HHA are allowed to select better quality herbage. This last effect is reflected in the highest milk yield and positive BW change in cows at HHA. Summarizing, managing cows at HHA will allow cows to a slightly greater individual milk production and BW gain but in detriment of herbage utilization and potentially, milk production per hectare.

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