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Grazing regimes and fertilisation rates: effects on dry matter yields, crude protein content and digestibility of meadows in the Northeast of Portugal

Fernández-Núñez E.[1], Pires J.M.[1], Fernandes A.[2], Pires J.[1] Aguiar C.[1], Galvão L.[1] and Moreira N.[3]
[1]*Mountain Research Centre* (*CIMO*), *IPB*, *5300 Bragança*, *Portugal*
[2]*DRAPN*, *Largo do Toural*, *5300 Bragança*, *Portugal*
[3]*School of Agriculture & Veterinary Sciences*, *UTAD*, *5001-801 Vila Real*, *Portugal*
Corresponding author: esther.fernandez@ipb.pt

Abstract

The aim of this study was to evaluate the effect of two grazing regimes: the usual for the area and late spring grazing, and three rates of N fertilisation, on dry-matter (DM) yields and nutritive value in three mountain meadows (*Anthemido-Cynosuretum cristati*, *Gaudinio-Agrostietum cristati* and *Bromo-Cynosuretum cristati*). The results showed that the lowest DM yield was obtained on *Bromo-Cynosuretum cristati* meadow. Dry matter yields increased significantly with N fertilisation in all meadows, independent of grazing regimes. The highest nutritive values occurred at the beginning of spring, and decreased during the year as a result of maturation. This effect was favoured by N fertilisation and it was independent of grazing regimes. Nutritive values were sufficient to meet the daily requirements of beef cattle during the study.

Keywords: grazing management, fertilisation, nutritive value

Introduction

The growing season in Mediterranean mountains limits the production of meadows to spring and autumn (Pires and Moreira, 2000). Nevertheless, meadows are grazed during the year, beyond the usual cut for hay in spring. In the Northeast of Portugal, the hay cut represents more than 50% of yearly DM yields (Pires *et al*., 2000), even in summer irrigated meadows, but with relative low nutritive value. Since the hay cut cannot be taken much earlier than the usual date, because of rainfall occurrence, the only way to improve its nutritive value is to reduce the period of growth and to close up meadows later. In this situation, dry matter (DM) yields and nutritive value of meadows must be studied because when the hay yield is increased, its nutritional value decreases due to advancing maturity in plants (Vázquez Aldana *et al*., 2000). On the other hand, the effect of N fertilisation on DM yield and nutritive value, both as a direct or indirect effect through the changes it induces in the relative proportion of legumes and grasses (Sun *et al*., 2008) must be studied too. The objective of the present study was to evaluate the effects of two grazing regimes, and three rates of N fertilisation, on dry matter (DM) yields and nutritive value in three mountain meadows.

Materials and methods

In 1998 and 1999, three meadows were studied in the North-east of Portugal: *Anthemido-Cynosuretum cristati* (M1), *Gaudinio-Agrostietum cristati* (M2) and *Bromo-Cynosuretum cristati* (M3). The treatments consisted of two grazing regimes: usual for the area (G) and a late spring grazing (LG) period with meadows closed up for hay three weeks later; and three rates of N fertilisation (N0-0; N1-75 and N2-150 kg ha^{-1} $year^{-1}$). The experimental design was a hierarchical completely randomised split-split plot, where meadows (M) were the main plots, and grazing regimes (G and LG) the subplots and N fertilisation (N) the sub-subplots. Three samples were harvested inside exclosure cages of 0.25 m × 0.25 m

within sub-plots, at the beginning of spring (March/April), at the hay cut (June), and at the end of autumn (November). Samples were dried to constant weight at 60ºC (48 h). Dry-matter yields and nutritive value (crude protein content (CP), and digestibility (IVOMD)) were determined. CP content was analysed after macrokjeldahl digestion and the IVOMD was determined according to Marten and Barnes (1980). General linear models procedure (SYSTAT 12) was used for ANOVA, and the difference among means was detected by Tukey's HSD test at the 0.05 probability level. Multiple regressions for CP yields and metabolizable energy (ME) were carried out. These models were adjusted by stepwise regression for each meadow taking the grazing treatment (G-LG), and the nitrogen fertilization (N) as independent variables. Only the independent variables with $P < 0.05$ were retained in the model.

Results and discussion

Anthemido-Cynosuretum cristati (M1) had the highest DM yields in spring and autumn, whilst *Agrostietum cristati* (M2) had the highest DM yields in the hay cut (Figure 1). The high N rate (N2) combined with late spring grazing (LG) significantly increased DM yields in M1 in spring (Figure 1). In this harvest, DM yields increased significantly in all meadows ($P < 0.001$) and in the usual grazing (G) with fertilisation (N1 and N2). Additionally, DM yields significantly increased by the late spring grazing (LG) but only in M1 in hay cut and in M3 in autumn.
In the no-fertiliser treatment (N0), the proportions of the annual DM yields harvested in the hay cut accounted for 66–78–50% in G, and 64–70–55% in LG for meadows M1-3, respectively. In the case of the high N-rate treatments (N2) the proportions were 64–70–55% (G) and 63–79–58% (LG) in M1-3, respectively.

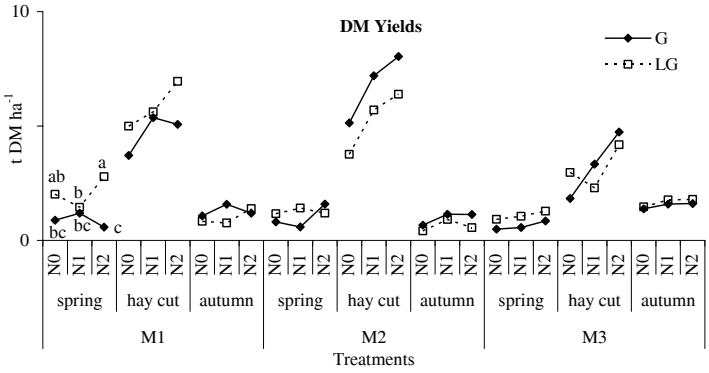

Figure 1. DM yields, in the three harvests. Different letters indicate significant differences ($P < 0.05$) between N fertlilser treatments (N0-0; N1:-75 and N2-150 kg N ha^{-1}), and grazing regimem (G: usual grazing, LG: late spring grazing) in the same meadow (M1-3), and in the same harvest

It is well documented that maturation causes changes in chemical composition resulting in a decline in CP content and IVOMD (Vázquez Aldana *et al*., 2000). Our results showed that the lowest nutritive values (CP content and IVOMD) were obtained in the hay cut and in autumn in all meadows, independent of N rate and grazing regimes, but values were sufficient to meet the daily requirements of beef cattle (NRC, 1996). Additionally, there was a significant interaction of fertilisation × grazing for nutritive value in spring ($P < 0.001$ and $P < 0.01$ for CP content and IVOMD, respectively) whereby late spring grazing (LG) combined with high N rate (N2) significantly increased CP content (Figure 2). While IVOMD content tended to be lower in LG regimen, a significant difference was detected only in the N1 treatment (Figure 2). On the other hand, the highest nutritive value was achieved with the highest N rates (N2) in all meadows. It is know that N fertiliser greatly increases the CP content and herbage digestibility (Duru, 2003). A different effect of grazing regimes (G) was obtained on ME and CP yields (Table 1) in meadows M1 and M2.

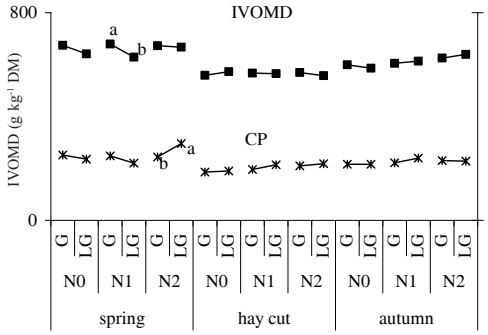

Figure 2. CP content and IVOMD in the three harvests. Different letters indicate significant differences ($P < 0.05$) between grazing regimem (G: usual grazing, LG: late spring grazing) in the same N fertililsation treatments (N0-0; N1-75 and N2-150 kg N ha^{-1}) and harvest

While ME and CP yields increased with LG regimen and N fertilisation in M1, the opposite response was obtained in M2. This different response could be explained by the fact that the proportion of grasses in M1 was favoured by G regimen (and reduced the presence of legumes and other species) whilst on M2 the late spring grazing increased the presence of grasses (data not shown). Additionally, N fertilisation favours the presence of annual grasses (Sun *et al*., 2008), e.g. *Gaudinia fragilis* (L.) Beauv on M2, which contributed to a reduction in ME yields. Yields of ME and CP increased significantly with N fertilisation of M3 and this effect was independent of grazing.

Table 1. Adjusted models for CP yields and ME in hay cut in meadows M1-3 taking the independent variables: grazing: 0 (G), 21 (LG) and N: 0–150 kg N ha^{-1}. (n = 36)

	CP (t ha^{-1})	R^2	S	ME (MJ ha^{-1})	R^2	S
M1	$0.494+9.1 \times 10^{-5} \times N \times G$	0.36	0.15	$33143+497 \times G+99 \times N$	0.42	9808
M2	$0.548–7 \times 10^{-3} \times G+4.2 \times 10^{-3} \times N–1.5 \times 10^{-5} \times N^2$	0.63	0.12	$47454–590 \times G+159 \times N$	0.54	11011
M3	$0.179+1.2 \times 10^{-5} \times N^2$	0.45	0.14	$18072+0.7364 \times N^2$	0.32	10475

Conclusions

When changes are introduced in meadow management it is important to note the initial community botanical composition. In our case, the change in spring management was more suitable for *Anthemido-Cynosuretum cristati* meadow, and less suitable for *Gaudinio-Agrostietum cristati*. N fertiliser increased DM yields and nutritive value in all meadows.

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