OPTIONS méditerranéennes

SERIE A : Séminaires Méditerranéens
Numéro 67

Sustainable Grazing, Nutritional Utilization and Quality of Sheep and Goat Products

Pâturage Durable, Utilisation Nutritionnelle et Qualité des Produits des Ovins et des Caprins

FAO CIHEAM CSIC

Meadow management, hay yields and nutritive value in the Mediterranean mountain regions of the Northeast of Portugal

J.M. Pires*, A. Fernandes, A. Bernardo**, J. Pires* and N. Moreira*****
*Mountain Research Center, Escola Superior Agrária de Bragança,
5300 Bragança, Portugal
**Direcção Regional de Agricultura de Trás-os-Montes, Largo do Toural,
5300 Bragança, Portugal
***Crop Science Department, Universidade de Trás-os-Montes e Alto Douro,
5001-911 Vila Real, Portugal

SUMMARY – To evaluate the possibility of improving hay nutritive value, six hay meadows were studied in the Northeast of Portugal from 1998 to 2000. The treatments were fertilization rates of 0, 75 and 150 kg N/ha/y in combination with two cutting/grazing regimes: the usual for the area (NG) and a larger spring grazing period with meadows closed off for hay three weeks later (LG). Their effects on crude protein content, in vitro organic matter digestibility, and dry-matter, crude protein and metabolizable energy yields were evaluated. The treatments studied significantly influenced the parameters evaluated. Late spring grazing induced the greatest changes in the highest yielding meadows (M3 and M5) increasing nutritive values but decreasing the DM yield (-2t DM/ha, +1% CP and +3% IVOMD). However, the positive influences on CP content and IVOMD are not high enough to overcome the low values (less than 10% CP and 50% IVOMD) observed in meadows with hay growth periods longer than 60-70 days.

Keywords: Crude protein, digestibility, dry-matter yield, hay, nitrogen fertilization.

RESUME *– "Gestion de la production des foins de prairie et de la valeur nutritive dans les montagnes du Nord-Est de Portugal". Dans le but d'améliorer la valeur nutritive du foin de prairies des montagnes méditerranéennes, six prairies situées au Nord-Est du Portugal ont été évaluées pendant la période comprise entre 1988 et 2000. Les traitements étaient la fertilisation azotée (0, 75 et 150 kg·N /ha/an) et la durée de pacage au printemps : une durée normale (NG) et une autre durée plus longue c'est-à-dire trois semaines au-delà de la période normale (LG). Ces traitements ont influencé significativement la teneur en matières azotées totales (MAT) et la digestibilité in vitro de la matière organique, les rendements en matière sèche, en matières azotées totales et en énergie métabolisable de la biomasse. La durée de pacage LG a provoqué les plus grandes altérations dans les prés plus productifs (-2 tonnes MS/ha; + 1% MAT et + 3% digestibilité). Cependant, l'effet positif sur la teneur en MAT et sur la digestibilité n'a pas permis de dépasser, respectivement, 10% et 50% pour le foin des prés récolté après une période de croissance dépassant 60-70 jours.*

Mots-clés : *Aménagement, prairie, fertilisation azotée, foin, valeur alimentaire.*

Introduction

The hay of the semi-natural species-rich pastures continues to be the most important forage for beef cattle nutrition, mainly in the winter at the mountain regions of the Northeast of Portugal. However, Ferreira *et al.* (1981) observed mean values for the meadows of Northeast of Portugal of 55% DMD and 9% CP content at hay cut. Later, Pires *et al.* (1990) referred to the positive significant effect of nitrogen fertilization on CP content in April and May, but not to the hay cut.

One of the reasons for the low nutritive value of the hay is perhaps the late date of cut when most of the seeds are ripe. But often the atmospheric conditions don't allow an early cut. In order to counteract this situation the introduction of a longer period of spring grazing was studied, together with nitrogen fertilization. Dry matter (DM) yield, crude protein (CP) content and *in vitro* organic matter digestibility (IVOMD) were determined. The results obtained in this study are the object of analysis in this paper.

Material and methods

Six meadows were studied from the spring of 1998 to the spring of 2000, three located in a more humid and cold region (M1, M2, M3) and three located in a more Mediterranean region (M4, M5, M6). Meadow M1 is an *Agrosto-Arrhenatheretum bulbosi*, M2 and M3 are *Anthemido-Cynosuretum*, M4 is a *Gaudinio-Agrostietum castellane*, M5 a *Bromo-Cynosuretum cristati* and M6 a *Gaudinio-Agrostietum cristati*. Two periods of grazing were studied, the usual for the area (NG) and a late grazing (LG) with meadows closed up three weeks later, in combination with three levels of nitrogen fertilization: 0 (N0), 75 (N1) and 150 kg/ha (N2). The nitrogen was applied when meadows were closed up. The N2 nitrogen application was split, with half applied 20 or 30 days later.

Meadows M1, M2 and M3 are located around Montalegre (41°49' N, 7°47' W) at altitudes of 842, 589 and 1038 m asl, with long term average annual rainfall of 1531 mm and annual temperature of 9.6 °C. Meadows M4, M5 and M6 are next to Bragança (41°49' N, 6°46' W) at altitudes of 680, 820 and 750 m asl, with long term average annual rainfall of 741 mm and annual temperature of 12°C.

Samples (0.25 m^2) were cut in three replications at each sampling period: meadow closing up, during hay growth (an intermediate date) and at hay cut. The DM yields, CP content (CP = Kjeldhal N x 6.25) and IVOMD were evaluated, and CP and metabolizable energy (ME) yields were calculated. The IVOMD and later the "D" values were estimated by the Tilley and Terry (1963) method, modified by Marten and Barnes (1980). The ME content was estimated as follows: MJ/kg of DM = 0.157 x "D" (AFRC, 1993).

Data was analysed through analysis of variance considering meadows as main plots, grazing treatment (G) as subplots and nitrogen as sub-subplots for the evaluated parameters, followed by multiple regressions for the five parameters (evaluated and calculated): CP content and IVOMD, DM, CP and ME yields. These models were adjusted by stepwise regression for each meadow taking the grazing treatment (G), the nitrogen fertilization (N) and the hay growth period (D) as independent variables. Only the independent variables with $P<0.05$ were kept in the model.

Results and discussion

Results

Analyses of variance

There were significant differences among meadows for all parameters in the three sampling periods, except in the intermediate cut for CP content. This fact was decisive in the significance of the interactions, as was the case of meadow (M) x grazing (G), which was the most frequent interaction (Table 1). The significance of nitrogen fertilization and its interaction with meadow occurred only in the hay cut for the CP content and IVOMD (Table 1).

Meadow effect

Regarding also the multiple regressions adjusted for all parameters (Table 2), M4 had the highest values of CP content (18.7%) and IVOMD (73.9%) at meadow closing up, while the lowest ones belong to the M2 (10.8% CP), and M1 and M3 (59.1% IVOMD). At hay cut M4 kept the highest values (11.7% CP and 58.1% IVOMD) together with M5 (58.1% IVOMD). The lowest values reached 7.3% in CP content (M2) and 46.7% in IVOMD (M3). The DM yields, at meadow closing up, were the highest in meadow M5 (3.4 t/ha (NG) 4.3 t/ha (LG)) and the lowest in M6 (0.93 t/ha (NG) and 1.7 t/ha (LG). At hay cut the highest DM yields were obtained in M5 (7.7 t/ha), while M6 (3.9 t/ha) gave the lowest ones.

Table 1. Yields in t DM/ha (DM), CP content in % of DM (CP) and IVOMD (% of OM) for each cut and treatment, meadows (M), grazing (G) and nitrogen fertilization (N). Standard errors (s.e.) from ANOVA(s) and significance of each treatment (NS: P≥0.05; *: P<0.05; and **: P<0.01)

Treatments			Closing up cut			Intermediate cut			Hay cut		
M	G	N	DM	CP	IVOMD	DM	CP	IVOMD	DM	CP	IVOMD
M1	NG	N0	1.2	14.0	62.8	2.8	11.0	56.8	3.5	6.4	47.4
		N1	1.2	11.1	57.4	3.6	14.6	57.7	5.1	7.5	45.7
		N2	1.0	11.9	56.5	5.1	17.3	60.6	6.4	8.2	47.1
M1	LG	N0	1.2	12.4	63.0	3.1	12.6	57.3	3.5	7.8	51.6
		N1	1.2	10.9	63.4	3.2	12.2	54.1	3.9	7.6	45.3
		N2	1.0	11.4	64.3	4.4	14.5	58.2	5.0	8.5	47.9
M2	NG	N0	1.3	10.1	65.8	3.2	6.9	50.1	5.6	6.0	45.3
		N1	1.3	10.1	64.9	4.6	13.3	60.5	7.1	7.9	48.8
		N2	1.5	10.6	65.2	4.0	11.9	57.8	8.6	6.8	46.6
M2	LG	N0	3.1	10.6	63.3	3.8	8.2	57.8	4.6	5.5	43.8
		N1	3.1	10.4	61.2	3.7	8.8	55.3	6.3	6.9	45.1
		N2	2.6	9.7	66.4	4.2	11.5	57.6	9.0	8.6	47.8
M3	NG	N0	1.7	15.0	61.4	2.8	11.9	52.6	4.1	6.1	46.3
		N1	1.7	12.5	58.0	4.7	14.2	54.3	5.7	6.4	43.9
		N2	1.9	15.2	59.0	5.8	14.7	54.0	10.1	9.5	46.5
M3	LG	N0	1.7	13.5	61.2	3.4	11.1	51.1	4.5	7.6	45.0
		N1	1.9	12.0	57.7	4.2	12.2	52.1	5.8	6.7	46.4
		N2	2.2	12.0	56.3	6.5	14.3	55.3	7.0	8.3	44.3
M4	NG	N0	1.4	17.1	73.1	2.7	12.2	60.5	4.3	11.5	60.4
		N1	1.4	18.8	75.2	2.9	11.2	60.6	6.7	10.9	58.3
		N2	1.0	17.6	71.5	3.5	14.3	60.2	8.0	11.5	57.0
M4	LG	N0	2.8	14.5	71.5	2.5	11.5	62.4	4.4	11.7	61.6
		N1	3.1	14.7	70.9	2.7	13.1	63.1	5.0	12.5	61.0
		N2	3.1	15.6	70.4	2.7	16.3	66.5	6.2	12.0	57.7
M5	NG	N0	2.7	13.5	68.5	4.5	9.4	59.7	6.7	7.2	55.3
		N1	3.0	14.2	70.4	5.6	11.1	61.8	9.6	8.7	56.9
		N2	2.9	13.0	66.3	8.4	12.4	59.6	9.6	9.9	55.3
M5	LG	N0	4.7	10.5	64.2	2.6	11.5	64.5	4.0	8.4	56.3
		N1	4.2	9.5	64.9	3.4	16.2	67.1	5.0	10.7	60.0
		N2	5.3	14.4	67.6	4.5	16.3	68.3	5.8	11.5	55.9
M6	NG	N0	0.7	11.6	59.5	1.7	8.6	52.0	2.6	8.3	47.6
		N1	1.0	9.9	63.3	3.2	10.3	56.5	3.7	7.3	45.8
		N2	0.8	12.1	62.6	4.8	10.9	54.0	5.6	8.0	45.5
M6	LG	N0	1.4	9.9	53.2	2.2	9.3	52.3	2.3	7.8	47.4
		N1	1.3	11.3	58.0	3.6	10.1	51.0	4.2	8.2	44.9
		N2	1.7	12.3	60.0	4.0	12.2	53.4	4.4	9.3	47.5
M		P	**	**	**	**	NS	**	**	**	**
		s.e.	1.5	2.4	7.8	1.8	4.8	11.9	2.2	2.8	11.5
G		P	*	NS	NS	NS	NS	NS	NS	**	NS
M x G			*	NS	NS	**	*	**	**	NS	NS
		s.e.	1.0	2.3	7.7	1.2	2.7	4.5	1.7	2.1	4.8
N		P	NS	NS	NS	NS	NS	NS	*	**	NS
M x N			NS	NS	NS	NS	NS	NS	NS	**	**
G x N			NS	NS	NS	NS	NS	NS	NS	NS	NS
M x G x N			NS	*	NS	NS	NS	NS	NS	NS	*
		s.e.	0.6	1.9	4.7	1.5	2.1	3.9	1.4	1.9	3.2

Table 2. Adjusted models for the five parameters in each meadow taking the independent variables: grazing (G) with values 1 (NG) or 2 (LG); nitrogen fertilization (N) with values from 0 to 150 kg N/ha; and hay growth period (D) with values from 0 days at meadow NG closing up to 120 at hay cut.

Meadows	Regressions		n	R^2	P	S
M1 - *A-A bulbosi*	CP (%DM)	$= 12.67 + 0.0367xD - 0.0009xD^2 - 0.0067xNxG + 0.0003xNxD$	144	0.373	0.000	2.82
	IVOMD (%OM)	$= 59.75 + 2.0617xG - 0.0661xN + 0.0004xN^2 - 0.0014xD^2$	144	0.559	0.000	5.65
	DM (t/ha)	$= 1.389 + 0.0415xD - 0.0002xD^2 - 0.0038xNxG + 0.0002xNxD$	126	0.616	0.000	1.299
	CP (t/ha)	$= 0.122 + 0.00866xD + 0.00001xN^2 - 0.00008xD^2 - 0.00094xNxG + 0.00002xNxD$	126	0.499	0.000	0.179
	E (MJ/ha)	$= 10345 + 404.58xD + 0.449xN^2 - 2.486xD^2 - 52.08xNxG + 1.360xNxD$	126	0.574	0.000	10450
M2 - *A-Cynosuretum*	CP (%DM)	$= 10.13 + 0.0089xN - 0.0410xD$	126	0.320	0.000	2.50
	IVOMD (%OM)	$= 64.11 - 0.2053xD + 0.0119xNxG$	126	0.588	0.000	6.80
	DM (t/ha)	$= 2.173 - 0.5741xG + 0.0823xD - 0.0004xD^2 + 0.0003xNxD$	114	0.698	0.000	1.582
	CP (t/ha)	$= 0.172 + 0.00604xD - 0.00005xD^2 + 0.00003xNxD$	114	0.453	0.000	0.177
	ME (MJ/ha)	$= 18307 - 3858.6xG + 630.02xD - 4.026xD^2 + 2.037xNxD$	114	0.654	0.000	11975
M3 - *A-Cynosuretum*	CP (%DM)	$= 13.60 + 0.0655xD + 0.0001xN^2 - 0.0016xD^2 - 0.0148xNxG + 0.0003xNxD$	132	0.541	0.000	2.49
	IVOMD (%OM)	$= 59.07 - 0.0016xD^2$	132	0.428	0.000	6.20
	DM (t/ha)	$= 1.589 + 0.0001xN^2 + 0.0004xD^2 - 0.0053xNxG + 0.0003xNxD$	108	0.818	0.000	1.124
	CP (t/ha)	$= 0.309 + 0.00001xN^2 - 0.00119xNxG + 0.00005xNxD$	96	0.570	0.000	0.212
	ME (MJ/ha)	$= 21485 - 256.05xD + 4.043xD^2 - 30.68xNxG + 3.001xNxD$	96	0.781	0.000	8548
M4 - *G-A castellane*	CP (% DM)	$= 17.36 - 0.0948xD + 0.0039xNxG$	126	0.585	0.000	2.24
	IVOMD (%OM)	$= 70.59 + 3.3228xG - 0.2505xD$	126	0.702	0.000	4.29
	DM (t/ha)	$= 2.270 - 1.119xG + 0.1392xD - 0.0014xD^2 + 0.0002xNxD$	126	0.551	0.000	1.631
	CP (t/ha)	$= 0.316 - 0.10463xG + 0.01847xD - 0.00022xD^2 + 0.00003xNxD$	126	0.461	0.000	0.212
	ME (MJ/ha)	$= 19626 - 8918.2xG + 1251.6xD - 13.25xD^2 + 1.977xNxD$	126	0.513	0.000	14025
M5 - *B-C cristati*	CP (%DM)	$= 12.05 - 0.0008xD^2 + 0.0132xNxG$	162	0.385	0.000	2.80
	IVOMD (%OM)	$= 69.89 - 0.405xD - 0.0004xN^2 + 0.0034xD^2 + 0.0404xNxG$	162	0.247	0.000	7.47
	DM (t/ha)	$= 5.412 - 2.012xG + 0.0419xD + 0.0003xNxD$	162	0.518	0.000	2.005
	CP (t/ha)	$= 0.588 - 0.13116xG + 0.00005xNxD$	162	0.478	0.000	0.197
	ME (MJ/ha)	$= 45544 - 15033.5xG + 280.54xD + 2.592xNxD$	162	0.487	0.000	16187
M6 - *G-A cristati*	CP (%DM)	$= 10.97 - 0.0007xD^2 + 0.007xNxG$	162	0.410	0.000	2.04
	IVOMD (%OM)	$= 62.75 - 2.6019xG - 0.1449xD + 0.0251xNxG - 0.0006xNxD$	162	0.525	0.000	5.22
	DM (t/ha)	$= 0.928 + 0.0458xD - 0.0004xD^2 - 0.0042xNxG + 0.0004xNxD$	162	0.667	0.000	1.064
	CP (t/ha)	$= 0.093 - 0.02973xG + 0.00803xD - 0.00009xD^2 + 0.00003xNxD$	162	0.561	0.000	0.117
	ME (MJ/ha)	$= 7252 + 407.13xD - 3.770xD^2 - 31.95xNxG + 2.956xNxD$	162	0.641	0.000	8822

Late grazing effect

From the adjusted models (Table 2), late grazing increased the CP content up to 1% and IVOMD 3.0% in M5. In meadows M1 and M3 the CP content decreased up to 1% CP. The grazing effect was always in interaction with N fertilization for CP content and for IVOMD in meadows M2, M5 and M6.

The highest increase occurred in the M5, 2% CP and 6.1% IVOMD for LGx150 kg N/ha. The LG grazing induced lower yields in all meadows even with N fertilization in M1, M3, M6, relative to DM yields. In meadow M5 LG grazing induced -2t DM/ha and in meadow M4 -1.1 t DM/ha. In the remaining meadows the DM yield reduction was less than 0.7t/ha. Similar effects were obtained for CP and ME yields.

Nitrogen fertilization x period of hay growth interaction

Nitrogen effect was positive for hay cut on CP content with the greatest increase in meadow M3 (4.0%) while the lowest occurred in meadow M4 (0.6%), from 0 to 150 kg N/ha. For IVOMD the nitrogen fertilization caused a decrease of 2.5% (M6) and 0.9% (M1) and an increase of 1.7% in the M2. The remaining meadows did not show significant changes in IVOMD relative to N fertilization.

Nitrogen fertilization, associated with hay growth period (D), had always a positive effect on CP content (M1 and M3) and on DM, CP and ME yields in all meadows (Table 2). The significant effect of this interaction (NxD) on IVOMD occurred only in M6, but it was a negative one. In no model was it possible to reach the maximum yields for N fertilization, while the maximum number of days of hay growth since meadow NG closing up was obtained in all meadows except in M3 and M5 (Table 3 and Fig. 1). From the linear substitution models (Table 3), obtained by differential calculus of initial models, we see that the number of days of hay growth increased with N fertilization. The periods found for hay growth are longer than the usual for hay cut in meadows M1 and M2 and in M6 for N fertilization>23kg/ha, relative to DM yields. For ME yields the hay growth periods are shorter than those for DM yields being CP yields still shorter. Meadow M4 was the only one with maximum DM, CP and ME yields obtained with periods of growth were shorter than the usual (Table 3 and Fig. 1).

Table 3. Linear substitution models obtained from adjusted regressions, relative to the maximum hay growth period in presence of the significant interaction NxD. Number of days (D) estimated for maximum yields for each level of nitrogen fertilization (N) and usual hay growth period (H) after meadow NG closing up (mean date for three years)

Meadows/parameters		Linear substitution models	Date of NG closing up	Number of days (D)			
				N=0	N=75	N=150	*H*
M1 - *A-A bulbosi*	DM (t/ha)	D = 103.8 + 0.5xN	April 3	104	141	179	94
	PB (t/ha)	D = 54.1 + 0.125xN	April 3	54	64	73	94
	ME (MJ/ha)	D = 81.4 + 0.274xN	April 3	81	102	123	94
M2 - *A-Cynosuretum*	DM (t/ha)		April 12	103	131	159	85
	PB (t/ha)		April 12	60	83	105	85
	ME (MJ/ha)		April 12	78	97	116	85
M3 - *A-Cynosuretum*			April 18				88
M4 - *G-A castellane*	DM (t/ha)	D = 49.7 + 0.071xN	April 8	50	55	60	63
	PB (t/ha)	D = 42.0 + 0.068xN	April 8	42	47	52	63
	ME (MJ/ha)	D = 47.2 + 0.075xN	April 8	47	53	58	63
M5 - *B-C cristati*			April 19				67
M6 - *G-A cristati*	DM (t/ha)	D = 57.3 + 0.5xN	April 11	57	95	132	69
	PB (t/ha)	D = 44.6 + 0.167xN	April 11	45	57	70	69
	ME (MJ/ha)	D = 54.0 + 0.392xN	April 11	54	83	113	69

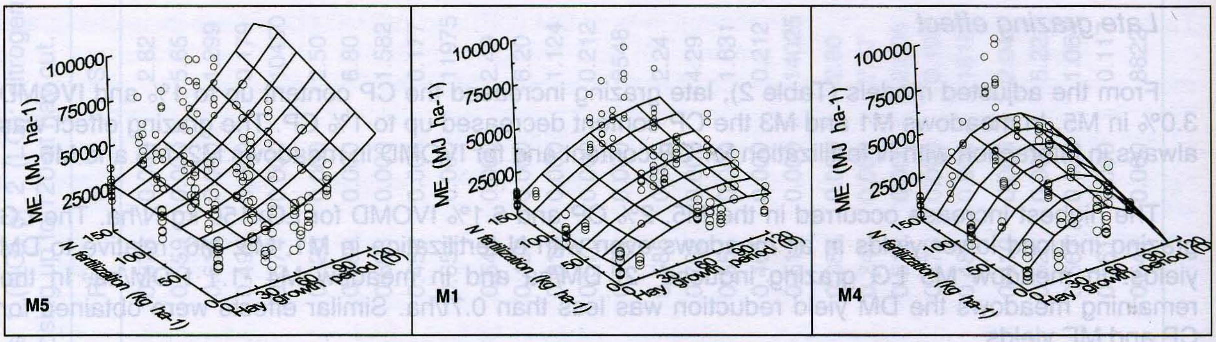

Fig. 1. Three growth shapes for the ME yields obtained from the regression models of Table 2.

Discussion

The values of CP content and IVOMD found in these meadows are similar to those referred by other authors, like Ferreira *et al.* (1981), Pires *et al.* (1990) and Debosz and Nielsen (1993). Todorova and Kirilov (2002) obtained values of 28% of CP content and 70% of OMD at the beginning of booting in *Agrostis capillaris-Festuca fallax* and 15% and 49.4% at seed formation, with a period of 48 days of growth. It is clear that most of the species in our study, mainly in M1, M2 and M3 already have the seeds ripe at the hay cut.

The DM yields from meadow closing up to hay cut agree with those obtained by other authors. Verbic *et al.* (2002) obtained DM yields with *Phleum pratense* of 3t/ha in May and 8t/ha in June. The effect of fertilization (N:P:K = 200:20:105) on CP content and IVOMD and on DM yields is referred by Debosz and Nielsen (1993) with increases of 4%, 3% and 2.3 t/ha. However, the positive effect on IVOMD is not so regular as on CP content.

The late grazing period is not more than a "déprimage", which can increase by 1 t/ha the DM biomass for grazing and reduce the yield in the hay cut by 10-20%, but with increases in CP and energy content (Balais *et al*, 1982), as was the case in our experimental meadows.

The meadows of this study differed in relation to growth curves and they can be subdivided into three groups. One included M3 and M5, another included M1, M2 and M6 and the other included the M4 meadow. The first group had the greatest responses to nitrogen fertilization, and the last one had the lowest. This is due to less water stress in the M3 and M5 meadows, both located at the bottom of a hill in soils with medium to high productive capacity. The M4 has also the same localization but in a warmer region where the water shortage in spring is more important, which implies a shorter period of hay growth and the type of response to N that can be seen in Fig. 1.

In relation to the usual periods of hay growth, the meadows can be split into two groups, one with M1, M2 and M3 meadows, more humid and cold, and the other one with the remainder, more Mediterranean. In this latter group the hay growth period has less than 70 days, while in the first group the hay growth period has more than 85 days and less than 50% of IVOMD. As the main limitation of meadow hay is the nutritive value, particularly the low IVOMD, it is possible to have in all meadows more than 50% of IVOMD and more than 10% of CP if the hay growth period is not longer than 60-70 days.

Other groups can be seen relative to the productive capacity and to the nutritive value. The M3 and M5 form the highest yielding group and M4, followed closely by M5, form the highest nutritive value group.

The botanical composition of M4 meadow, with 32% of legumes and 42% of grasses (Pires *et al.*, 2002) explains also the highest nutritive value and the lowest response to nitrogen fertilization. Oprea and Cardasol (2002) show that, when legumes were associated with *Phleum pratense*, CP content at flowering is 4% higher than in grass alone, even with nitrogen fertilization.

Conclusions

The highest yielding meadow at hay cut reached 7.7 t DM/ha, 0.708 t CP and 62,331 MJ with a rate of 75 kg N/ha, while the lowest yielding meadow gave only 3.9 t DM, 0.344 t CP and 30,295 MJ (ME). The highest nutritive values at hay cut reached 11.7% CP content and 58.1% IVOMD for 75 kg N/ha, while the lowest nutritive values were 7.3% CP and 46.7% IVOMD.

There were three types of growth shapes for yields associated with the kind of communities, by turn associated with soil and climate conditions. Meadows located in a more humid and cold region have longer periods of hay growth, greater than 85-90 days to which correspond the lowest CP and IVOMD. Values greater than 10% CP and 50% IVOMD are obtained in all meadows with 60-70 days of hay growth.

The later spring grazing management regime, in combination with nitrogen fertilization, were not able to improve the hay nutritive value in order to counteract the lower dry-matter yields got with LG treatment that may reach 2 t DM/ha.

Nitrogen fertilization had a marked positive effect on the rise of yields by 5.4t DM ha^{-1} and on the increase CP content by 4.0%. The effect on IVOMD was not clear in the meadows studied. The significance of the interaction NxD shows that the length of the hay growth period, in order to reach the maximum yields, increase with N fertilization rates.

References

AFRC (1993). *Energy and Protein Requirements of Ruminants*. CAB International, Wallingford.

Debosz, K.K. and Nielsen, A.L. (1993). Grass production from meadowlands managed in a extensive and environment friendly way. In: *Grassland Management and Nature Conservation, Occasional Symposium n° 28*, Leeds University, 1993, Haggar, R.J. and Peel, S. (eds). BGS, pp. 258-260.

Ferreira, A.M., Dias da Silva, A., Cruz, M.A., Vieira, R.F., Azevedo, J. and Sousa, A. (1981). Os fenos no Nordeste de Portugal. *Pastagens e Forragens*, 2: 67-77.

Marten, G.C. and Barnes, R.F. (1980). Prediction of energy digestibility of forage with *in vitro* rumen fermentation and fungal enzyme systems. In: *Standardization of Analytical Methodology for Feeds*, Pidgen, W.C., Balch, C.C. and Graham, M. (eds). IDRC, Ottawa, pp. 61-71.

Oprea, G. and Cardasol, V. (2002). Productivity and quality of some simple grass/legume mixtures during different growth periods. In: *Multi-Function Grasslands: Quality Forages, Animal products and Landscapes,* 19th general meeting of the European Grassland Federation, La Rochelle, France, 27-30 May 2002, Durand, J.-L., Emile, J.-C., Huyghe, C. and Lemaire, G. (eds). AFPF, BGS, Versailles, pp. 148-149.

Pires, J.M., Aguiar, C., Moreira, N., Fernandes, A. and Pires, J. (2002). Hay meadow management and botanical composition in the Northeast of Portugal. In: *Multi-Function Grasslands: Quality Forages, Animal products and Landscapes,* 19th general meeting of the European Grassland Federation, La Rochelle,France, 27-30 May 2002, Durand, J.-L., Emile, J.-C., Huyghe, C. and Lemaire, G. (eds). AFPF, BGS, Versailles, pp. 834-835.

Pires, J.M., Centeno, M.S.L., Rego, F.C., Raposo, J.A. and Carvalho, M.J.R. (1990). Influência da fertilização na composição florística de Lameiros. *Pastagens e Forragens*, 11 (2): 69-86.

Tilley, J. M. A. and Terry, R. A. (1963). A two-stage technique for the *in vitro* digestion of forage crops. *Journal of the British Grassland Society*, 18: 104-111.

Todorova, P.A. and Kirilov, A.P. (2002). Changes in the permanent grassland composition and feeding value during the growing season. In: *Multi-Function Grasslands: Quality Forages, Animal products and Landscapes,* 19th general meeting of the European Grassland Federation, La Rochelle,France, 27-30 May 2002, Durand, J.-L., Emile, J.-C., Huyghe, C. and Lemaire, G. (eds). AFPF, BGS, Versailles, pp. 170-171.

Verbic, J. and Babnik, D. (2002). The nutritive value and agronomically important traits in autochthonous populations of timothy in Slovenia. In: *Multi-Function Grasslands: Quality Forages, Animal products and Landscapes,* 19th general meeting of the European Grassland Federation, La Rochelle,France, 27-30 May 2002, Durand, J.-L., Emile, J.-C., Huyghe, C. and Lemaire, G. (eds). AFPF, BGS, Versailles, pp. 172-173.