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Rangeland and pasture rehabilitation in Mediterranean areas

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Pasture improvement in the Mediterranean mountains of Northeastern Portugal: Yield and botanical composition

J.M. Pires*, A. Fernandes, J. Pires* and N. Moreira*****
*Escola Superior Agrária de Bragança, 5300 Bragança, Portugal
**Direcção Regional Agricultura Trás-os-Montes, 5300 Bragança, Portugal
***Universidade de Trás-os-Montes e Alto Douro, 5000 Vila Real, Portugal

RESUME – *"Amélioration pastorale dans les montagnes méditerranéennes du Nord-est du Portugal : Production et composition botanique". Pour étudier l'amélioration de prairies dans les montagnes méditerranéennes sans irrigation du Nord-est du Portugal trois techniques ont été comparées : végétation spontanée, végétation spontanée plus fertilisation et prairie semée plus fertilisation. Cette expérience a été déclinée dans six localités différentes et sous plusieurs conditions environnementales. Les productions saisonnières et annuelles, et la composition botanique (graminées, légumineuses, autres familles et sol nu) sont présentées pour la période 1998-2000. Les prés les plus fertilisés ont donné les productions les plus élevées. Les différences entre les trois techniques d'amélioration pastorale s'atténuent au cours des années, la végétation spontanée fertilisée conservant une position intermédiaire. La proportion de légumineuses, est la plus élevée dans les prés semés et fertilisés et elle augmente au cours des années. Ces prairies donnent aussi les productions les plus élevées et les plus régulières pendant l'année.*

Mots-clés: *Amélioration pastorale, fertilisation, graminées, légumineuses, rendement, couvert.*

Introduction

Mixed farming systems with livestock, mainly cattle, and grain crops, mainly rye and wheat, were predominant for decades in the mountain regions of Northeastern Portugal. However in the last few decades important changes occurred, with a substantial decrease of the cereal area and consequently with increasing areas without cultivation and greater importance of the animal production. The aim of this work was to evaluate alternative techniques for pasture improvement in these rain-fed Mediterranean hill areas.

Materials and methods

Fertilisation of native vegetation (F) and fertilisation plus sown pasture (SF) were compared to the native vegetation without fertilization (WF). These three treatments were applied in six different farms, located at foot hill (Pl and A), upland (F1 and F2), hill summit (Sr) and hillside (Sn), which corresponded to six locations in different environmental conditions, between 650 and 900 m a. s. l., 647 and 972 mm long term annual rainfall, 11 and 12°C mean annual temperature, 5.0 and 5.9 soil pH, 20 and 53 mg kg^{-1} P_2O_5, 60 and 144 mg kg^{-1} K_2O.

The "SF" treatment was sown with the same broad mixture for the six locations (kg ha^{-1}): *Trifolium resupinatum* Kyambro (2.0); *T. michelianum* Balansa (2.0); *T. repens* Ladino (0.5); *Lotus uliginosus* Maku (0.25); *L. corniculatus* Leo (0.75); *T. subterraneum* Denmark, Goulburn, Gosse (6.0); *Lolium perenne* Nui (2.5); *L. perenne* Victorian (3.0); *Dactylis glomerata* Currie and Porto (3.0); *Phalaris aquatica* Holdfast (2.0) and *Festuca arundinacea* Fuego (3.0). Pastures were sown during mid October 1997 (Y0) to July 2000, and fertilisation was applied only at sowing time (3 t·ha^{-1} of lime, 130 kg·ha^{-1} of P_2O_5 and 60 kg·ha^{-1} of K_2O). Pastures were submitted to the usual extensive cattle grazing in each farm over the year.

Proportions of grasses (G), legumes (L), other families (O) and bare ground (Bg) were assessed by point quadrats with 10 pins·m^{-1}, and samplings of DM yield were obtained in spring and autumn each year inside three exclusion cages of 1 m^2 by treatment. The residual biomass ungrazed (RDM) was assessed by cutting the biomass remaining 3 cm above ground level in a 0.5 x 0.5 m square, at the same date and in the same way used inside exclusion cages. These were removed to other places after each sampling (ECDM).

The results were analysed through principal components for "ECDM", "RDM" and sward functional groups, followed by analyses of variance of the treatment effects on the scores of the two first principal components (having until 65% of cumulative variance), which explained all the significant interactions among treatments in May (M) and December (D). In June/July the "ECDM" and "RDM" were analysed only through analyses of variance. For this kind of analyses, pastures/locations (P) were considered as main plots, improvement techniques (I) as subplots and years (Y) as sub-subplots.

Results and discussion

Beyond the statistical analyses shown in Table 1, the ANOVAs done for the "ECDM" and "RDM" in the cut of July and annual yields showed significant interactions between pastures and years as well as pastures, years and treatments.

Table 1. Loadings and scores of principal components in May and December cuts for the main treatments whose significant effects (P<0.05) were evaluated through analysis of variance

		Variables						Standard Error (s.e.)		
PC		ECDM	RDM	G	L	O	Bg	P	I	Y
pc1(M)	Loadings	0.743	0.597	0.416	0.780	*-0.697*	*-0.724*	0.472	0.477	0.410
pc2(M)	Loadings	0.405	0.430	0.578	*-0.622*	0.375	0.071	0.694	0.849	0.712
pc1(D)	Loadings	*-0.687*	0.035	*-0.787*	*-0.528*	0.696	0.637	0.597	0.445	0.539
pc2(D)	Loadings	0.499	0.763	0.209	*-0.580*	0.314	-0.069	0.626	0.509	0.609

		Treatments											
PC		Sn	Pl	A	Sr	F1	F2	WF	F	SF	Y1	Y2	Y3
pc1(M)[*,1,2]	Scores	*-0.93*	0.80	0.73	-0.02	-0.11	*-0.48*	-0.31	-0.16	0.48	*-0.62*	0.21	0.40
pc2(M)[1]	Scores	-0.28	1.02	0.19	*-0.82*	-0.07	-0.04	0.10	0.26	-0.37	0.11	-0.23	0.12
pc1(D)[*]	Scores	0.90	*-0.56*	-0.17	0.07	*-0.43*	0.19	0.42	0.43	*-0.85*	0.21	-0.21	–
pc2(D)[*]	Scores	*-0.44*	1.32	0.24	*-0.79*	0.02	-0.36	0.08	0.12	-0.20	0.28	-0.28	–

Significant effects of the interactions (P<0.05): * Pasture (P) x Improvement (I); [1] Pasture xYear (Y); [2] Pasture x Improvement x Year.

From the statistical analyses the following results can be drawn:

– The pastures can be split into three groups; a more productive one with mean annual yields (t $DM \cdot ha^{-1}$) of 9.1 (Pl) to 5.7 (A), other with 3.7 (Sr) or 4.0 (F1) and the lowest yielding one with 3.3 (F2) or 3.2 (Sn) (pc1(M)-Table 1 and Fig. 1), yields that are in line with similar works (Carter, 1977; Moreira and Trindade, 1992).

– The highest differences between "WF" and "SF" relative to annual yields occurred in the highest yielding pastures (2.2 t $DM \cdot ha^{-1} \cdot a^{-1}$ (Pl)), keeping the "F" treatment at an intermediate position (pc1-Table 1 and Fig. 1).

– The proportion of spring DM in annual yields lied between 85% and 93%, however it was 4 to 8 % higher in "WF" than in "SF" treatment (pc1(D)-Table 1 and Fig.1).

– The ungrazed pasture (RDM) was highest in "WF" and "F" treatments (2.3 t $DM \cdot ha^{-1} \cdot a^{-1}$ (Pl and A)), with differences to "SF" treatment lying between 0.6 t (Pl, F2) and 0.06 t (F1), mainly after the first year.

– DM yields and grass plus legume proportion increased along the years, mainly in the "WF" treatment in the highest yielding pastures, through the substitution of other families and bare ground proportions (pc1 (M)-Table 1 and Figs. 1 and 2), as Pires *et al.* (2002) verified for permanent meadows too.

– The difference between legume proportion in "SF" treatment and in other treatments was higher in the lowest yielding pastures (51% (F2), 37% (Sn)) than in the highest yielding ones (5% (A), 21% (Pl)) in May cut (Fig. 2);

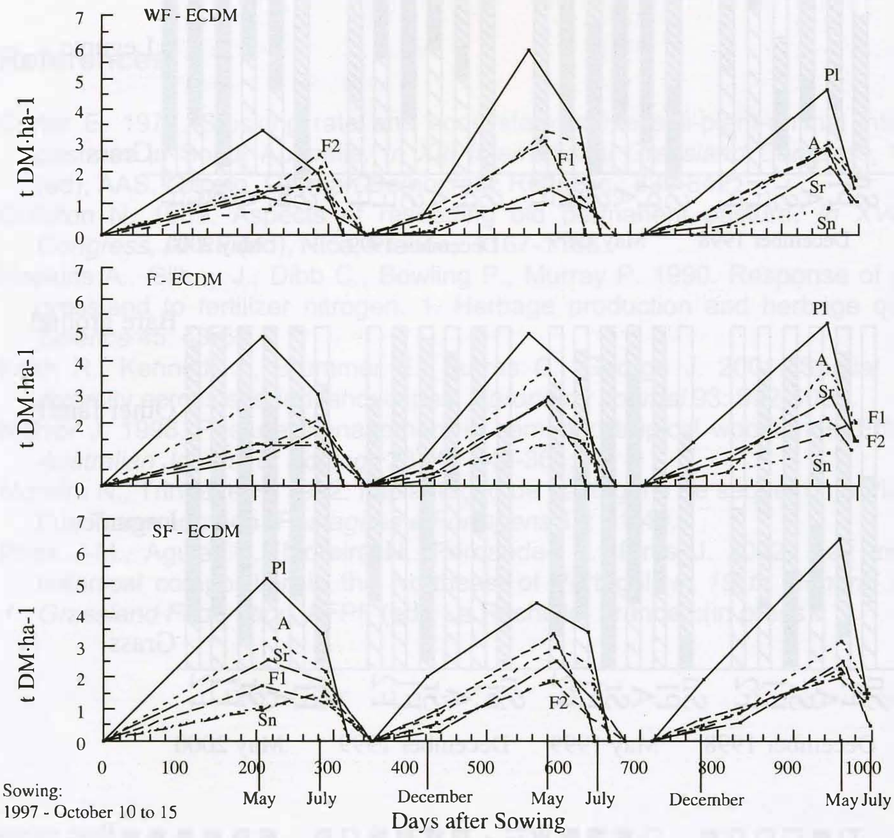

Fig. 1. DM yields (ECDM) in the three treatments, native vegetation (WF), native vegetation plus fertilisation (F) and sown pasture plus fertilisation (SF) for the six pastures (Sn, Pl, A, Sr, F1, F2) along years (days after sowing).

Grazing of native vegetation had a positive effect on DM yields and grass plus legume proportion along the years, mainly in the higher yielding pastures (Pl, A, F1), which decreased the differences among treatments in the last year as observed by Culleton (1989) in Ireland. Hopkins *et al.* (1990) in Great Britain concluded that the reseeded swards gave similar yields along the years, mainly with low fertilizer-N, despite its higher yields in the first year. McIvor (1998) reported also an increase in the native species density with high stocking rates.

The "SF" treatment, despite its highest yields and grass plus legume proportion in the first year, gave also the highest yields in autumn, leading to less seasonality, and simultaneously was the treatment with the less ungrazed DM. This means a greater preference for sown species than for native vegetation, but it depend on the kind of native vegetation as the differences among pastures showed. Moreira and Trindade (1992) in a similar area of NE Portugal obtained also higher yields in autumn in sown pastures than in native vegetation and consequently a more regular production over the year.

The differences among pastures/locations relative to DM yields and grass plus legume proportion may be explained by the environmental conditions. The pastures located in foot hill, more productive ones (Pl, A), and particularly with higher rainfall (Pl), gave the highest yields, while those located on hillside (Sn) gave the lowest ones as Keith *et al.* (2001) also reported.

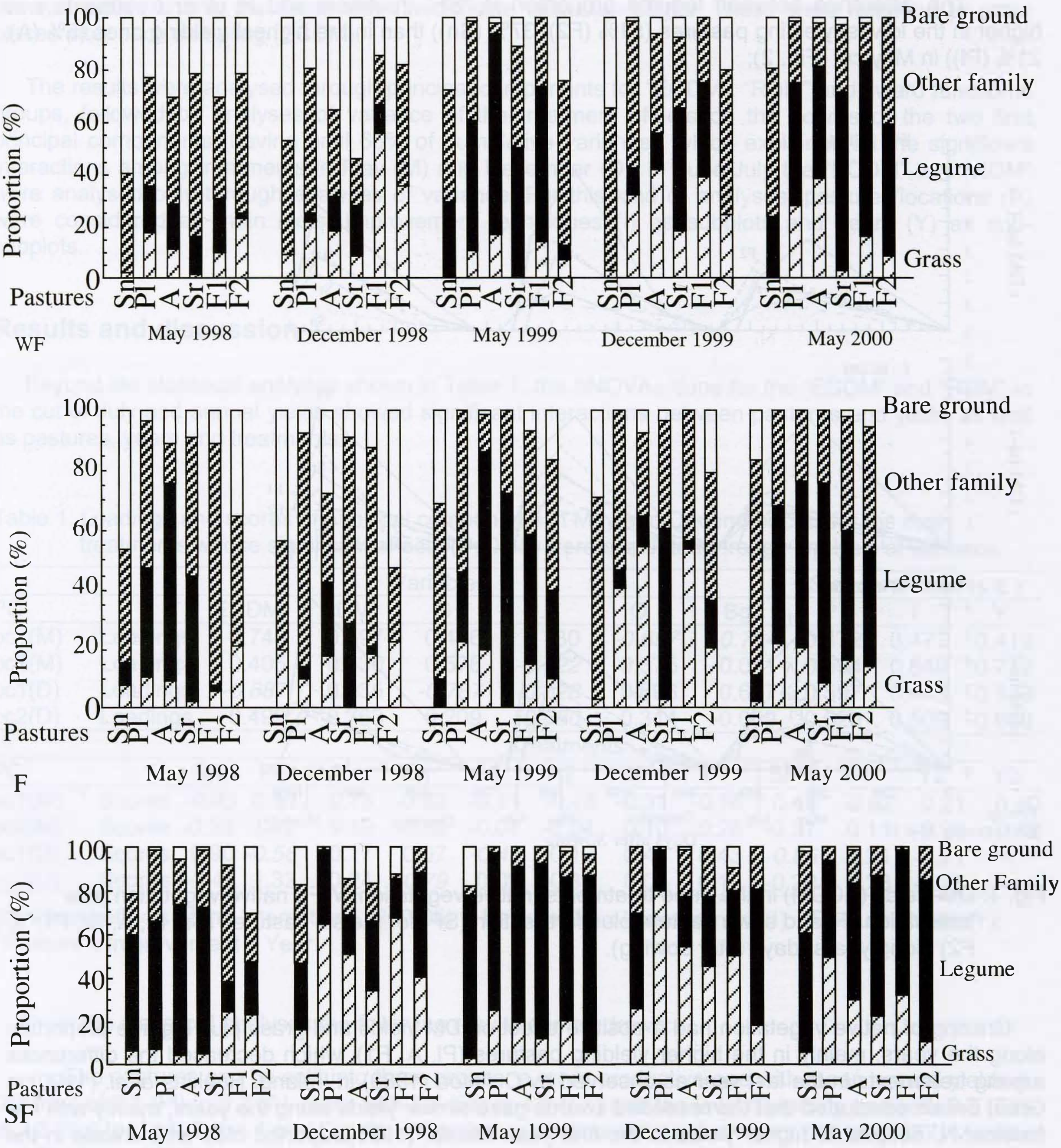

Fig. 2. Grass, legume, other families and bare ground proportion (%) in spring (May) and autumn (December) along years, in the three treatments, native vegetation (WF), native vegetation plus fertilization (F) and sown pasture plus fertilization (SF), for the six pastures (Sn, Pl, A, Sr, F1, F2).

Conclusions

The differences among treatments relative to DM yields and grass plus legume proportion were reduced along years mainly in the more productive pastures. The "SF" treatment gave the highest yields in autumn, mainly in the more productive pasture, leading to a more regular production over the year. This treatment also showed a tendency to be preferred by livestock leading to a sward best consumed in opposition to the other treatments.

The highest annual yielding pastures were those in foot hill, more productive ones, with 5.7 to 9.1 t DM·ha^{-1} a^{-1} while the lowest yielding one is located in hillside, with 3.2 t DM·ha^{-1} a^{-1}. The spring yields represented 85% (SF) or 93% (WF) of the total annual yields. The grass plus legume proportion reached almost 100% in the spring of the last year on the more productive pastures and "SF" treatment (sown pasture plus fertilization) reached around 82% in the native vegetation without fertilization (WF).

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