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SUMMARY – The aim of this work is to improve pasture production in the semiarid mountain areas in the North-eastern Iberian Peninsula in order to optimize the management of livestock farms. Three experiments were carried out: (i) pasture improvement of abandoned fields invaded by *Genista scorpius* (L.) DC by clearing and mineral fertilization; (ii) establishment of sown meadows; and (iii) improvement of drought grasslands by mineral fertilization. The annual average yields obtained in these experiments were 1439, 4291 and 3948 kg DM/ha, respectively. Eighty percent of the forage yield was obtained in the May-July period and the remaining in September. Therefore, animals were short of pastures at least six months a year. Present stocking rate is 0.21 LU/ha, and it could be increased to 0.32 LU/ha, if pasture production is improved.

Keywords: Mountain pasture, semiarid areas, forage yield, clearing.

RESUME – *"Augmentation de la charge animale au moyen de l'amélioration des pâtures dans le Maestrazgo Turolense, NE d'Espagne". On essaie d'améliorer la gestion des pâtures de montagne dans les zones semi-arides du Nord-est de l'Espagne par l'augmentation de la production de fourrage. Pour atteindre cet objectif on a effectué trois expériences : (i) débroussaillement mécanique de l'arbuste envahissant* Genista scorpius *(L.) DC en champs abandonnés et fertilisation minérale ; (ii) semis des prairies ; et (iii) fertilisation minérale d'une prairie naturelle. La production moyenne annuelle de fourrage dans ces expériences a été de 1175, 4291 et 3948 kg MS/ha, respectivement. Les 80% ont été obtenus pendant la période mai-juillet, et le reste jusqu'en septembre, donc les animaux ne disposent pas de pâtures au moins six mois dans l'année. La charge animale actuelle de 0,21 UGB/ha, pourrait arriver à 0,32 UGB/ha sans avoir besoin de ressources fourragères ou de concentrés de l'extérieur, si les terres de culture actuelles étaient destinées à des prairies et cultures fourragères.*

Mots-clés : *Pâturage montagneux, terres semi-arides, ressources fourragères, débroussaillement.*

Introduction

The Maestrazgo Turolense is located in the North-eastern Iberian Peninsula between latitudes 40º20' and 40º50' N and longitudes 0º20' and 1º20' W. It is a mountainous area with 96% of the land at 800-1800 m altitude. Its surface is 354,550 ha and the population 12,469 inhabitants in 2005 (IAEST, 2005). Its average annual rainfall is 400-700 mm and the temperature 8-10ºC. However, the extreme lowest temperatures may reach -20ºC. Soil is mainly limy with more or less horizontal and fractured stratification, what has given place to an intense karstification with slight retention of rainwater.

Extensive livestock is clearly an option in this region because its location, far from highly populated areas, mountainous orography, high altitude and semi-arid climate do not favour intensive agriculture. Soils occupation is as follows: agricultural lands, 30,999 ha; dry grasslands, 137,782 ha; forested mountains, 127,288 ha; other surfaces, 54,810 ha. From agricultural lands, herbaceous crops cover 12,599 ha, 89.7%devoted to cereals. Fallows and abandoned lands susceptible of grazing sum up 16,317 ha. Sheep farming is dominant with 120,072 heads, followed by cattle with 10,252 heads, while goats are not relevant (3,380 heads) (Departamento de Agricultura y Alimentación, Gobierno de Aragón, unpublished data). On the other side, extensive livestock shapes the mountainous landscape in a mosaic pattern, with grasslands and cultured fields interspersed with pine forests and shrubland in the steepest areas that besides attracting tourism, makes the diversity and preservation of the flora and fauna feasible, and the expansion of fires more difficult.

However, the agricultural activity has decreased in the last years due to the population decrease or abandonment of farming, changing to other activities such as intensive pigs farms or tourism. This fact has led to a drastic decrease of the livestock that profits from these areas vegetal resources with the corresponding landscape transformation (Flores *et al.,* 2002; 2003). One of the problems due to the land abandonment and the reduction of the stocking rate, overall sheep and goats, has been the decrease of grazing area caused by the increment of thick bushes in plots previously used for grazing purposes.

One way of promoting extensive livestock would be improving the yield and use of pastures. The aim of this work is to know the grazing potential of grasslands in the Maestrazgo Turolense in order to favour the design and management of livestock farms.

Material and methods

Three experiments were carried out.

Experiment 1. Pasture improvement of abandoned fields invaded by *Genista scorpius* (L.) DC

The experiment was carried out at Gúdar (latitude 40º28' N; longitude 0º39' W; altitude 1481 m) and Cantavieja (latitude 40º32' N; longitude 0º26' W; altitude 1200 m), in formerly cultured plots now abandoned and covered 80% and 67.5% respectively by shrubs with dominating *Genista scorpius* (L.) DC, in the 1998-2001 period.

The extreme values of monthly average maximum and minimum temperatures were 28.7ºC and -1.9ºC, with an absolute minimum of -9ºC at Cantavieja; 27.6ºC and -5.8ºC, with an absolute minimum of -12.5ºC at Gúdar. Annual rainfall ranged 390.9-672.7 mm at Cantavieja and 464.9-859.4 mm at Gúdar.

The improvement consisted in clearing and an annual application of 250 kg of the complex 8-24-8/ha, at the end of the winter.

A comparative trial was established to evaluate pasture yield. The statistical design was random blocks with three repetitions in 60 m^2 and 100 m^2 plots at Gúdar and Cantavieja respectively.

The species, stocking rate and grazing programme were the same as before clearing. At Cantavieja, grazing was practiced with meat cattle from July to October. Stocking rate was 0.27 heads/ha/year. At Gúdar, the same type of cattle grazed from May to July and from October to December with a stocking rate of 0.16 heads/ha/year.

Herbaceous biomass was measured within the comparative plots, at the cattle entrance and issue, by harvesting four 0.25 m^2 squares at random/plot at 1 cm from the soil. Also, a 0.5 m^2 exclusion cage/plot for the estimation of the total pasture production was placed. In the laboratory, the percentages of humidity by desiccation in a forced air chamber at 60ºC were determined.

Experiment 2. Meadows establishment

The experiment was carried out at Fortanete (latitude 40º30' N; longitude 0º31' W; altitude 1352 m), in a rainfed, cultured plot in the 2002-2004 period.

The extreme values of the monthly average maximum and minimum temperatures in that period were 29.7ºC and -4.8ºC and the absolute minimum -14.3ºC. Annual rainfall ranged between 528 and 684.4 mm. The analysis of soil texture and fertility at 0-30 cm depth provided the following results: loamy soil with basic pH, high organic matter contents and acceptable phosphorus and potassium levels.

The following species and varieties were studied: (i) 'Aragón' lucerne, at a rate of 20 kg/ha; (ii) sainfoin of Turkish origin, 150 kg/ha; (iii) 'Ludac' cocksfoot, 20 kg/ha; (iv) 'Fuego' tall fescue, 20 kg/ha; (v) 'Ansyl' Italian ryegrass, 20 kg/ha; (vi) 'Aragón' lucerne + 'Ludac' cocksfoot, 10+10 kg/ha; and (vii) 'Aragón' lucerne + 'Fuego' tall fescue, 10+10 kg/ha.

The trial was sown 23 May 2002, the plot measured 10 m^2 (2x5 m) and the statistical design was random blocks with four repetitions. As fertilization before seeding, 250 kg/ha of the complex 8-24-8 were applied.

Three cuts were practiced in the sowing year and three cuts the following years in May, July and September, when most species started blooming or ear emergence. One forage sample of 0.5 m^2 was desiccated in a forced air chamber at 60ºC.

Experiment 3. Drought grassland improvement by mineral fertilization

The experiment was carried out at Fortanete (latitude 40º27' N; longitude 0º32' W; altitude 1400 m) in a drought grassland, in the 2002-2004 period.

The climatological conditions were similar to Experiment 2. The analysis of soil texture and fertility at 0-20 cm depth corresponds to a loamy-clayey-sandy soil, basic pH, with a high organic matter contents, poor in phosphorus and acceptable in potassium.

The following fertilizers were applied annually: (i) only N fertilization, at a rate of 50 UF/ha; (ii) only phosphorus fertilization, 100 UF/ha; (iii) only potassium fertilization, 100 UF/ha; (iv) complex 8-24-8, 250 kg/ha; and (v) control, not fertilized.

Elemental plots measured 25 m^2 (5x5m), statistically distributed in three blocks at random. A 0.5 m^2 exclusion cage was placed at each plot in order to record the biomass production. The experiment started 27 May 2002. Three cuts per year were practiced in June, July and October. The forage was dried in a forced air chamber at 60ºC.

Results and discussion

The forage yield obtained in Experiment 1, in abandoned agricultural plots submitted to clearing was 1439 kg and 1211 kg DM/ha at Cantavieja and Gúdar respectively, when fertilized, and 911 kg and 738 kg DM/ha in non fertilized ones (Table 1). 77.4% of the forage yield was obtained till July and the remaining yield in the summer. Mineral fertilization improved yield significantly from the third year onwards.

The average forage yield, obtained in Experiment 2 by sowing species and forage mixtures was 4291 kg DM/ha distributed in three cuts: 50.2%, first cut made at the end of May; 30.6%, second cut in the middle of July; and 19.2%, third cut at the end of September (Table 2). Lucerne and its associations with cocksfoot and tall fescue stood out significantly because of their yield and persistence.

The average forage yield, obtained in Experiment 3 in a grass plot with different types of fertilization was 3948 DM kg/ha distributed in three cuts: 72.9%, first cut made at the beginning of June; 17.3%, second cut at the end of July; and 9.8%, third cut at the beginning of October (Table 3). Only mineral N fertilized plots stood out significantly with respect to non-fertilized ones, with 4563 kg *vs* 3709 kg DM/ha, as four-year average.

The obtained forage yields are similar or lower than those reached in cultured plots at other locations of Aragón with similar or lower rainfall than at the Maestrazgo Turolense (Delgado, 1984, 1995; Hycka and Armero 1990). Mineral fertilization scarcely contributed to improve forage production, what is attributed to the low capacity of carstic soils to keep moisture (Ferrer *et al.,* 1993).

Table 1. Herbaceous yield (kg DM/ha) in abandoned agricultural plots submitted to clearing at the beginning of the experiment and at the end of each year at Cantavieja and Gúdar (Teruel)

Location	Treatment	Date				
Cantavieja		2.3.98	10.11.98	6.10.99	18.10.00	24.10.01
Kg DM/ha	Fertilized	-	1428.2	1534.7	2488.9	304.1
	Non fertilized	-	1260.1	741.2	1351.4	292
Signification		-	NS	NS	*	NS
Annual rainfall (mm)		-	390.9	599.5	672.7	489.9
Gúdar		12.2.98	15.10.98	19.10.99	5.10.00	28.11.01
Kg DM/ha	Fertilized	-	448	1237.5	1678	1479.6
	Non fertilized	-	286	870	1139	655.9
Signification		-	NS	NS	*	*
Annual rainfall (mm)		-	479.1	718.4	859.4	464.9

NS = P>0.05; *= P<0.05.

Table 2. Forage annual yield (kg DM/ha) from different forage species and mixtures at Fortanete (Teruel)

Treatment	Total 2002		Total 2003		Total 2004	
	Total	% grass†	total	% grass†	total	% grass†
Lucerne	4915 [a]	-	6449 [abc]		5250 [b]	
Sainfoin	4432 [ab]	-	5310 [cd]		3743 [c]	
Cocksfoot	557 [d]	-	4090 [d]		1817 [d]	
Tall fescue	165 [d]	-	4161 [d]		2245 [d]	
Italian ryegrass	2073 [c]	-	5923 [bc]		3428 [c]	
Lucerne + cocksfoot	4311 [b]	0.4	7299 [a]	38.8	6386 [a]	47.5
Lucerne + tall fescue	4107 [b]	1.2	6853 [ab]	20.7	6589 [a]	33.8
Signification	***	-	***		***	
Rainfall (mm)	528		684.4		530.6	

***= P<0.001. Differences between numbers with the same letter are not significant (P>0.05).
†% grass = Participation of cocksfoot or tall fescue in the mixture.

Table 3. Annual forage yield (kg DM/ha) of a grass plot with different fertilizations at Fortanete (Teruel)

Treatment	2002	2003	2004	2005
Control	2144.4	5240.8	5266 b	2186
Only N	2536.7	5556.2	7216 a	2943.7
Only K	2297.5	4666.7	5322 b	2319
Only P	2541.9	5268.6	5445 ab	2120.3
Complex	2388.4	5163.9	5608 ab	2726
Signification	NS	NS	*	NS
Rainfall (mm)	528	684.4	530.6	

NS = P>0.05; *= P<0.05.

A percentage higher than 80% of the forage yield is obtained in the May-July period and the

remaining one till September. Therefore animals are short of pastures at least six months a year, thus needing off-farm feeding and a grazing of fallows and shrubland as stated in the survey made to farmers by Flores *et al*. (2002 and 2003). Approximately, farmers buy off-farm 50% of feeding.

Present stocking rate at the Maestrazgo Turolense is 0.21 LU/ha, estimated from the present surface of grasslands. If we consider the forage yields obtained in previous experiments and that all cultivated lands are devoted to sown meadows and forage crops, the potential stocking rate of the Maestrazgo Turolense is 0.32 LU/ha, assuming a forage availability of 13.4 kg DM/LU/day in sown meadow and forage crops and 20 kg/LU/day in drought grasslands. This means that the stocking census could increase 83% LU and that only 45% of their forage possibilities are being used. Similar conclusions were presented by Ferrer *et al*. (1993) for the Maestrazgo Castellonense. These authors showed that the stocking rate was 47% of the forage possibilities in this area

Conclusions

The annual average yield obtained in these experiments was 1439, 4291 and 3948 kg DM/ha respectively. Mineral fertilization improved yield significantly. Eighty percent of the forage yield was obtained in the May-July period and the remaining one till September. Therefore animals are short of pastures at least six months a year.

The present stocking rate is 0.21 LU/ha, but could be increased to 0.32 LU/ha, if we consider the forage yields obtained in previous experiments and if improving pasture production is carried out.

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