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SOMMARIO

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Plant response to fertilization and sheep grazing on rangeland in Sardinia

Simonetta Bullitta, Paolo Motroni and Leonardo Sulas ([1])

Summary

A four-year study (1981-1985) was conducted to determine the response to fertilizer applications and the effects of sheep grazing on productivity and botanical composition of a natural rangeland in Sardinia. A site of three hectares was enclosed and divided in two plots which were alternately grazed and rested by moving 12 ewes from one plot to the other. Nitrogenous and phosphatic fertilizers were applied. Botanical composition after grazing was monitored by means of exclosures moved to adjacent positions at the end of every trial year. Samplings of forage production were made at different times of the year and the effects of early winter and late utilization on spring regrowth were studied. Dry matter production showed to be markedly affected by climatic trends but was not influenced by fertilization. A stocking rate of 0.25 ha per animal unit had no detrimental effect on sward composition and production although the normal stocking rate for the area was less than half of that utilized for the present experience.

Key words: rangeland, fertilization, botanical composition, sheep grazing.

Riassunto

RISPOSTA ALLA CONCIMAZIONE ED AL PASCOLAMENTO CON OVINI IN UN PASCOLO NATURALE DELLA SARDEGNA

Uno studio quadriennale (1981-1985) è stato condotto per determinare la reattività alla concimazione e gli effetti del pascolamento con ovini sulla produttività e composizione floristica di un pascolo naturale in Sardegna. Un settore di pascolo di 3 ha è stato recintato e diviso in due parcelle che sono state utilizzate alternativamente da 12 pecore. È stata effettuata la concimazione azotata e fosfatica. La composizione floristica dopo il pascolamento è stata determinata con l'ausilio di gabbie di esclusione che venivano spostate alla fine di ogni anno di prova. Campionamenti di produzione di foraggio sono stati fatti in differenti periodi per studiare gli effetti dell'utilizzazione invernale anticipata e ritardata sulla ricrescita dell'erba. La produzione di sostanza secca è risultata essere fortemente influenzata dagli andamenti climatici ma non dalla concimazione. Un carico di 4 pecore per ha non ha avuto effetti negativi sulla composizione e produzione della cotica, sebbene il normale carico di bestiame nella zona fosse meno della metà di quello utilizzato nella prova.

Parole chiave: pascolo naturale, concimazione, composizione floristica, pascolamento.

Introduction

The low productivity of Sardinian pasturelands is basically due to pedological and climatic factors, often defeating the somewhat limited improvement programs so far attempted (Bullitta, 1980). These conditions impose short growth periods on the prevalently annual plant communities. Dry spring weather rapidly promotes plant reproductive stage and any possible late spring rains are not useful for the herbage accumulation. Fall production fails in upland regions if fall rains arrive late when low temperatures limit herbage growth. At times, especially in the upland, conditions are so adverse that plant growth only lasts for few months, and long periods of forage scarcity (dry matter production of 1 kg ha^{-1} day) become interposed with brief periods of excessive availability (dry matter production of 200 kg ha^{-1} day). In these circumstances the choice of a correct stocking rate becomes a problem. A low rate is essential in lean periods to avoid livestock underfee-

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ding, but with high forage allowance the animals select only the best plants, eliminating their reseeding capacity; a too high rate leaves only the less palatable species to proliferate. In time, the sward composition can thus deteriorate. According to Piano (1987), high levels of flexibility is required to the grazing systems in the Mediterranean environment where pastures rich in annual self-reseeding legumes are often formed of many species which, in terms of survival, respond differently to different grazing regimes, and botanical composition may vary from year to year. The problem to solve is to determine for pastures based on different dominant species the grazing regimes which mediate between the need of maximizing dry matter yield and preserving long term survival of these species. According to Bentley and Talbot (1951), some adjustment in stocking rate is needed nearly every year to meet fluctuations in forage supply and obtain efficient utilization of annual plants. Although data exist on optimum maintainable stocking rates for many sheep rearing countries (De Fernandez, 1978; Pitt and Heady, 1979; Sharrow *et al.*, 1981), further data are needed for Sardinian rangelands. A stocking rate of two ewes ha^{-1} is the maximum allowed for many Sardinian pasturelands because of lack of proper management causing severe deterioration of sward and the limits imposed by climatic and pedological factors.

The 4-year preliminary study reported here was aimed at evaluating the effects of doubling the maximum stocking rate and the response to fertilization on range production and plant community composition in Sardinia.

Materials and methods

The study area forms part of the Bonassai permanent pasture of the «Istituto Zootecnico e Caseario per la Sardegna», located in a lowland at 60 meters above sea level in the North-western region of the island known as La Nurra. The soil has a depth of 70 cm, stone cover is 10% and rocks are absent, according to the Soil Taxonomy (1975), the study site can be considered a Typic Xerochrepts (Baldaccini *et al.*, 1982). The soil presents 12.50% of particles over 2 mm diameter, mechanical analysis showed 72.20% sand, 10.92% silt and 16.88% clay.

Chemical analysis showed 2.06‰ organic matter, 0.942‰ total nitrogen, 16.5 p.p.m. available P_2O_5, 230.4 p.p.m. available K_2O and pH 7.6 (methods used were: bichromate for organic matter, Kjieldhal for nitrogen, Jackson for P_2O_5 and extraction in 2N ammonium acetate for K_2O, see Jackson (1965) and S.I.S.S. (1985) for references.

For the 4-year study (October 1981 through September 1985) a site of three hectares was enclosed and divided into two plots, which were alternately grazed and rested for 15 days periods by moving 12 ewes from one plot to the other. To evaluate the effects of fertilization as well as those of the stocking rate (0.25 ha AU^{-1}) on rangeland production, two areas (500 m^2 each one) were allotted in each plot, one for phosphate (100 kg ha^{-1} $year^{-1}$ P_2O_5) and the other for nitrogenous fertilizer (100 kg ha^{-1} $year^{-1}$ N). Treatment with the latter was effected in two half doses each year, the first at the onset of the first fall rains and the second in mid-February. Phosphate was applied (full dose) in the fall only. Following normal rangeland practice, the fertilizers were applied over the land surface without being plowed in.

To monitor sward evolvment after grazing, two exclosures (2 x 2 m) were installed on each of the 500 m^2 sub areas and on each of the unfertilized sub-areas, in effect being equivalent to 4 replicates for each type of sub-area. All exclosures were moved to an adjacent position before the end of every trial-year. Each exclosure was sub-divided into four 1 m^2 sub-areas sections (A, B, C and D); D was reserved for examination of the plant community and A, B and C for production evaluation sampling (PES) at different periods, as follows:

A1) in December (except first year), first PES (when sward height reached 8-10 cm), and

A2) in spring, second PES (of regrowth);

B1) after winter dormancy, 1st PES (previously unsampled sward) and

B2) in spring, 2nd PES (of regrowth);

C) when herbage was ready for haying (only one PES, the section being previously unsampled).

At the beginning of the trial, the grass plants present, 90% of the sward, were mainly *Hordeum murinum* L., *Bromus mollis* L., *Bromus sterilis* L., *Vulpia* spp., *Avena barbata* Pott., and *Triticum villosum* Beav., *Compositae*, *Convolulaceae*, *Umbelliferae* and an extremely slight presence of legumes constituted the reimaing 10%. There was also a thick layer of coarse grass litter. This accumulation was due to abundant growth during the previous spring and to the rapid qualitative deterioration of the grasses turning to seed, with consequently reduced utilization by the flocks. During the trial period, the whole site was cleared each summer after natural reseeding had taken place, plant residues being cut down and in part fed to the sheep or removed.

Weather conditions varied considerably from year to year affecting both annual and seasonal production.

Annual rainfall, recorded from September through August, (Fig. 1) was 360, 540, 619 and 586 mm. In the first trial-year, the spring rainfall (1982) was low, with correspondingly reduced vegetative activity. The second trial year began with abundant rainfall (fall, 1982) enabling the A1 production evaluation to be effected in

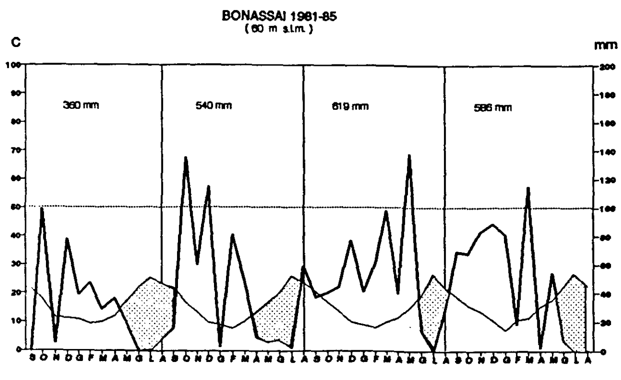

Fig. 1 - Temperatures and rainfall trend from September 1981 through August 1985.

Fig. 1 - Andamento termo-pluviometrico nel periodo settembre 1981 - agosto 1985.

December 1982. Growth was then slowed by low temperatures, so that the B1 evaluation was made in March 1983. Again scanty spring rainfall hastened the process of turning to seed. Rainfall in the third trial-year was more favorably distributed, but low temperatures were a limiting factor. In the fourth trial-year (October 1984 through September 1985), fall rainfall was satisfactory, but the spring rains did not arrive until late May, too late to have any effect on herbage production.

Analysis of variance was performed on dry matter yield data following a split plot in space and time model (Steel and Torrie, 1980).

Results

Anova results relative to dry matter yields are reported in Table 1. The sources of variation in which mean squares appear to be significantly higher than error are BC (management per years interaction, F = 5.31 **) and C (years, F = 13.96 *). Management is referred to PES (production evaluation sampling), considering the production of these cuttings as the forage available for early winter and spring regrowth utilization (management A1 + A2), late winter and spring regrowth utilization (management B1 + B2) and late utilization (management C).

The significance of the source of variation years confirms the relation between annual range production and yearly weather conditions. Similar conclusions about the effect of climate on annual range production are reported by several authors. Rosiere (1987) believes that herbage production is impacted more by annual growing conditions than by grazing regimes. Pitt and Heady (l.c.) found that variations in cover and productivity on annual vegetation were greater between years than between stocking rates. Rosiere and Torrel (1985) found that nutrients properties were not affected by grazing intensity, except possibly for crude protein, seasons on the contrary had a large influence on nutritional parameters. The source of variation fertilization did not show significance and further trials are in progress to define more precisely this aspect as the effect of N and P_2O_5 fertilization on improvement of pasturelands was always evident in previous trials carried out in Sardinia (Bullitta and Caredda, 1980, 1981; Bullitta *et al.* 1980, 1981; Bullitta and Caredda, 1982; Bullitta *et al.*, 1987).

Table 2 gives the production evaluations (t ha^{-1} of dry matter) of all samplings made during the four trial-years. All first-year A1 samplings (not possible until February 1982) showed low yields. Growth rates then increased rapidly, so that B1 samplings (March) showed double the A1 yields. Both A2 and B2 regrowth evaluations were made, but total yields were higher where early sampling had been effected (A1 + A2) > (B1 + B2). Yields of the C samplings (left for haying and made toward the end of April) varied from 1.4 t ha^{-1} (unfertilized area) to 4.2 t ha^{-1} (fertilized with N).

The first A1 sampling for the second year was possible in December 1982 and the first B1 sampling in early March 1983. This year B1 + B2 samplings showed the highest yields. In the third trial-year, A1 sampling

TABLE 1 - *Anova results relative to dry matter yield (t ha^{-1}) in the period 1981-1985.*

TABELLA 1 - Analisi della varianza relativa alla produzione di sostanza secca (t ha^{-1}) nel periodo 1981-1985.

Source of variation	df	Mean square	F
Blocks, R	1	72.16	< 1
Fertilization, A	2	2411.01	10.75 n.s.
Error (a), RA	2	224.23	
Subtotal I	5		
Management, B	2	70.22	4.37 n.s.
AB	4	20.60	1.28 n.s.
Error (b), RB + RAB	6	16.03	
Subtotal I + II	17		
Years, C	3	577.40	13.96 *
Error (c), RC	3	41.34	
Subtotal III	7		
AC	6	137.58	1.35 n.s.
Error (d), RAC	6	101.42	
Subtotal I + II + III	23		
BC	6	140.86	5.31 **
ABC	12	55.39	2.09 n.s.
Error (e), RBC + RABC	18	26.50	
Grand total	71		

n.s. = not significant.
* = significant at 0.05 probability level.
** = significant at 0.01 probability level.

TABLE 2 - *Dry matter production (t ha⁻¹) at each sampling date with totals for year.*

TABELLA 2 - Produzione di sostanza secca (t ha^{-1}) per data di campionamento con totali per anno.

	1981-82			1982-83			1983-84			1984-85		
	A1	A2	Totals	A1	A2	Totals	A1	A2	Totals	A1	A2	Totals
Sampling date	2 Feb 82	5 May 82		22 Dec 82	22 Apr 83		29 Dec 83	16 Apr 84		21 Dec 84	24 Apr 85	
TEST	0.44	1.66	2.10	0.41	1.24	1.65	0.52	0.48	1.00	0.50	0.95	1.45
N	0.69	2.60	3.29	1.45	3.66	5.11	1.18	0.95	2.13	0.82	1.34	2.16
P_2O_5	0.39	3.06	3.45	0.66	1.77	2.43	0.62	0.58	1.20	0.50	1.22	1.72
	B1	B2	Totals	B1	B2	Totals	B1	B2	Totals	B1	B2	Totals
Sampling date	5 Mar 82	7 May 82		7 Mar 83	17 May 83		6 Feb 84	10 May 84		14 Feb 85	4 May 85	
TEST	0.75	1.22	1.97	0.89	1.68	2.57	0.67	1.14	1.81	0.58	1.14	1.72
N	1.40	1.55	2.95	2.77	3.54	6.31	1.84	1.82	3.66	0.81	1.49	2.30
P_2O_5	0.94	1.57	2.51	1.10	2.47	3.57	0.92	1.43	2.35	0.49	1.70	2.19
	C		Totals	C		Totals	C		Totals	C		Totals
Sampling date	21 Apr 82			30 Apr 83			29 Apr 84			6 May 85		
TEST	1.44		1.44	2.20		2.20	1.54		1.54	1.67		1.67
N	4.25		4.25	4.23		4.23	3.74		3.74	3.50		3.50
P_2O_5	1.77		1.77	2.45		2.45	3.06		3.06	2.57		2.57

A1 = first production evaluation sampling (PES).
A2 = second PES: regrowth in spring.
B1 = first PES: after winter dormancy.
B2 = second PES: regrowth in spring.
C = PES (one only): at haying.

was possible at the end of December 1983. B1 sampling (in early February 1984) produced only slightly greater yields values, due to low temperatures. This year's favorable spring resulted in C sampling showing the best results in the fertilized areas, despite the previous winter's negative influence on total production. In the fourth year little difference was observed again between A1 and B1 sampling evaluations due to adverse winter weather.

This slow initiation of vegetative activity reflected upon the total production, further affected by lack of rain in April causing premature turning to seed. C sampling again gave best results, the highest production being obtained from N fertilized areas (3.5 t ha^{-1}).

Table 3 gives the results of qualitative chemical analyses in milk forage unit (MFU) for all sampling (MFU = the French UFL, unitè fourragère lait - Vermorel, 1978).

In the first trial year, the best results, 2766 MFU ha^{-1}, were obtained from C sampling in N fertilized areas. Second year values showed the best results from B1 + B2 samplings, in correspondance with the quantitative findings. In the third year, the higher values came from B1 + B2 samplings. In the fourth year, the best results were obtained from C sampling. Yearly variations are to be considered in relation to climatic factors.

Examination of the botanical composition (D sampling) took place at haying time each year. Table 4 gives the averaged percentage composition of the sward as observed at the time in each type of sub-area. Some variations were discernible from year to year in all the sub-areas, of special interest being a noticeable increase in legumes (particularly constant in P_2O_5 fertilized areas) which were practically absent at the beginning of the trial. By the end of the fourth year, a general improvement had taken place. Among the grasses, *Hordeum murinum* L. and *Vulpia* spp. had decreased, the bromegrass and *Avena barbata* Pott had increased and *Lolium rigidum* Gaud. (absent at first) had appeared. Legumes had increased, reaching 8% in P_2O_5 fertilized areas. In the latter, *Trifolium campestre* Schreb., and *T. spumosum* L. were already present at the first year, and the appearance of *Medicago arabica* (L.) Huds and *M. polymorpha* L. in the second year further increased the legume presence.

Discussion and conclusions

Both seasonal and total productivity proved to be conditioned by climatic factors and the annual character of the plant community making up the sward. Rapidly going to seed at the first signs of adverse spring weather, these plants quickly terminate their cycle; any rainfall occurring in late spring can have no further influence on herbage production. In the winter period, abnormally low temperatures or low rainfall restricted growth, consequently reducing total production. The

TABLE 3 - *Milk forage units ha^{-1} at each sampling date with totals for year.*

TABELLA 3 - Unità foraggere latte ha^{-1} per data di campionamento con totali annui.

	1981-82			1982-83			1983-84			1984-85		
	A1	A2	Totals	A1	A2	Totals	A1	A2	Totals	A1	A2	Totals
Sampling date	2 Feb 82	5 May 82		22 Dec 82	22 Apr 83		29 Dec 83	16 Apr 84		21 Dec 84	24 Apr 85	
TEST	317	1160	1477	319	810	1129	322	447	769	365	859	1224
N	502	1760	2262	1030	2274	3304	743	1361	2104	621	1151	1772
P_2O_5	253	2062	2315	551	1137	1688	397	1124	1521	377	1090	1467
	B1	B2	Totals	B1	B2	Totals	B1	B2	Totals	B1	B2	Totals
Sampling date	5 Mar 82	7 May 82		7 Mar 83	17 May 83		6 Feb 84	10 May 84		14 Feb 85	4 May 85	
TEST	453	858	1311	741	966	1707	388	690	1078	416	855	1271
N	1045	1120	2165	2109	2133	4242	1158	1172	2330	578	1093	1671
P_2O_5	547	1104	1651	886	1319	2205	542	930	1472	359	1210	1569
	C		Totals	C		Totals	C		Totals	C		Totals
Sampling date	21 Apr 82			30 Apr 83			29 Apr 84			6 May 85		
TEST	944		944	1439		1439	668		668	1330		1330
N	2766		2766	2994		2994	1729		1729	2856		2856
P_2O_5	1223		1223	1580		1580	1510		1510	2167		2167

A1 = first production evaluation sampling (PES).
A2 = second PES: regrowth in spring.
B1 = first PES: after winter dormancy.
B2 = second PES: regrowth in spring.
C = PES (one only): at haying.

TABLE 4 - *Botanic composition at the haying time: percentages calculated from dry matter.*

TABELLA 4 - Composizione floristica in corrispondenza della fienagione: percentuali calcolate dalla sostanza secca.

	1981-82			1982-83			1983-84			1984-85		
	Grasses	Legumes	Others	Grasses	Legumes	Others	Grasses	Legumes	Others	Grasses	Legumes	Others
TEST	93.8	1.5	4.7	96.3	0.4	3.3	94.3	1.7	4.0	89.2	4.1	6.7
N	97.2	—	2.8	95.0	—	5.0	94.7	1.1	4.2	90.1	3.3	6.6
P_2O_5	93.0	5.0	5.0	90.0	4.2	5.7	90.1	5.1	4.7	86.1	8.1	5.8

stocking rate of 0.25 ha AU^{-1} had no detrimental effect on the sward composition. On the contrary, some improvement in quality was observed; a legume presence became evident, while oatgrass and ryegrass increased at the expense of *Hordeum murinum* L. and silver grass (*Vulpia* spp.). The additional organic matter supplied by the animals may well have been involved in producing this improvement. A further explanation may be that high growth rate of herbage in spring could easily withstand the stocking rate and the reseeding was facilitated being the stocking rate lower than the forage availability. Obviously the underdimensioned stocking rate is referred to the peak growth period in spring. In conclusions, the 3-hectares study site allowed the grazing of 12 ewes for a whole year with rest rotation grazing and rested period of 15 days. From the results obtained so far, it would seem possible to increase the stocking rate or reduce the grazing area during the spring. The pasture temporarily freed could be put to haymaking, or utilized as reserve grazing land in the summer and fall.

The management of annual grassland must be always related to climatic trend as shown by the different PES samplings, herbage availability suggested a more suitable early winter or late winter utilization depending from yearly weather variations.

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