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Behaviour of phytocenoses and herbage production regarding variation of top soil fertility in pasturelands of National Parks in Mediterranean environments

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SUMMARY – In the last decade, because of the large needs of biomass for animal feeding, the sward of pasturelands were subject to stress. The application of chemical compounds was the agronomic approach used for restoring the ancient agropastoral and ecological activity of pasturelands. The aims of the study were to assess the effect of nitrogen-phosphorous fertilizer on biomass, herbage quality, flora composition and soil fertility in four Italian protected pastures of National Parks in Mediterranean environments. The results of the study show the efficiency of fertilisation to increase qualitative and quantitative herbage production, topsoil fertility and to minimize the variation of natural flora in the sward.

Keywords: National Park, fertilizer application, herbage nutritive value, flora composition.

RESUME – *"Comportement des phytocénoses et production herbacée par rapport à la variation de fertilité de la couche superficielle du sol dans les pâturages des milieux du Parc National de la Méditerranée". Dans les dernières années, la forte demande pour l'alimentation animale a influencé négativement la densité du peuplement végétal dans les pâturages. L'augmentation de la fertilité du sol est un facteur permettant d'améliorer la production fourragère sans modifier la composition floristique du pâturage. La fertilisation avec des éléments appropriés est une méthode efficace pour augmenter la production et la qualité fourragères, pour réduire la diversité des communautés végétales et améliorer la fertilité du sol. Le traitement avec azote et phosphore en combinaison, a été évalué dans quatre systèmes naturels pâturés en milieu protégé du Parc National de la Méditerranée en considérant l'effet sur la production et la qualité de l'herbe, sur la composition floristique et sur les composants de la fertilité du sol. Les résultats ont mis en évidence l'efficacité de la combinaison azote-phosphore pour augmenter quantité et qualité de la production, réduire la variabilité floristique et améliorer la fertilité du sol.*

Mots-clés : *Parc national, fertilisation, quantité et qualité de l'herbe, composition floristique.*

Introduction

The extension of natural pasturelands of National Parks (NP), Sites with Community Importance (SIS) and Zones of Special Protection (ZPS) in the Mediterranean districts of southern Italy cover 33.8%, 49.6% and 38.1% respectively of the total Italian land (Boitani *et al.*, 2002). The number of NP, SIC and ZPS scattered over the territories amount to 2417 and 343, respectively and cover a surface of 1,097,748 ha for NP, 4,172,447 ha for SIC and 1,845,619 ha for ZPS (Table 1). The biodiversity existing in all these areas is protected by law (SIC and ZPS by European Directive 92/43 of the 1992 and NP by Italian Legislative Decree 394 of 1991).

In the last decade, as consequences of agro-pastoral farmers activity for satisfying visitors demand's of the livestock's gross products, the sward of pasturelands was stressed. Thus, the intensive grazing, for animal feeding requirements, caused sward overgrazing of natural pastures. However, because the biodiversity of these natural pastures is protected by law, the retrieve of their ancient agro-pastoral and ecological function is linked to adequate agro-pastoral techniques of management. Many agronomic approaches have been proposed for improving productivity and ecological function of the protected pasturelands. Among them, chemical fertilizer application was the most popular and realistic approach used for restoring, in many countries of the world (Australia, Canada and USA), the sward productivity, the nutritive herbage characteristics and the ecological and social function of the native pastures.

Table 1. Extension of natural pasturelands National Parks (NP), Special Protected Zones (ZPS) and Sites of the Community Importance (SIC), and number of areas for each category in the regions of the southern Italy (Boitani *et al*., 2002)

Region	Natural pastures (ha)	NP (ha)	ZPS (ha)	SIC (ha)	NP (no.)	ZPS (no.)	SIC (no.)
Latium	161,000	35,712	235,619	126,033	2	48	177
Abruzzo	91,180	96,950	318,749	256,022	2	4	130
Molise	36,000	4,400	817	69,457	1	3	46
Campania	214,190	178,172	171726	342,446	3	13	154
Apulia	209,550	30,000	213,592	406,036	1	16	75
Basilicata	186,700	102,973	34,237	60,998	1	17	69
Calabria	171,450	109,394	27,339	66,983	4	4	171
Sicily	289,924	----	124,143	368,993	---	47	214
Sardinia	1,199,288	169,190	16,118	405,623	3	9	114
Total area	2,559,282	726,791	1,142,340	2,102,861	17	161	1150
National area	3,758,200	1,097,748	1,845,619	4,172,447	24	343	2417

The effect of treatment increased soil fertility favouring germination of the indigenous seedbank present in the sward, development of native flora, productivity and nutritive characteristics of herbage pasturelands. Other practices, like as reseeding with exogenous ecotypes, because the application promotes genetic contamination of pastures phytocoenoses, is forbidden by law.

The aims of the experiments were to determine the effect of chemical applications on flora composition, biomass production, nutritive value of herbage and chemical composition in Ap horizon of soil in four National Parks of southern Italy.

Materials and methods

Pasturelands of four locations, layout in the protected area of the National Park of Gargano (Carpino and Rignano Garganico), Cilento (Gioi) and Circeo (Monterotondo), were studied for two years (2004-2005). The geographical characteristics of locations were comprised among 12° 57 to 15° 35' E, and 40° 17' and 42° 03' N. The herbages of pasturelands were grazed by sheep and goat at Carpino, cow at Rignano and buffalo at Gioi and Monterotondo.

About 20 ha of pasturelands of each location, at the middle of the November, were fertilised by combined nitrogen-phosphorous at rate of 32 and 96 kg ha^{-1}, respectively. In each pasture site, the experimental scheme was a random block design with two entries (control without fertilizer and fertilized treatments) with three replications. The area of replication, for preventing animal damage of herbage development, was protected by iron net fence (2.25 m^2, 1.5x1.5 ml). The soil characteristics, at beginning and at end of experiments, were assessed in the 0-30 cm Ap horizon.

The samples were air-dried and, after root separation, were sieved thought a mesh screen of 2 mm of Ø, and later used for assessed pH (1:2.5 soil:water ratio), total nitrogen (micro-Kjeldahl), organic carbon, available phosphorous, and exchangeable potassium.

The effect of fertilizer treatments was determined each year on: dry matter yield (DM), floristic composition and nutritive value of the herbage. The harvest was made in the last week of May when the grass was at flowering stage. From each replication, two samples of biomass of 1 m^2 were manually cut. One sample of herbage was used for assessing DM yield and to provide flour for laboratory analyses. At harvest, the biomass was weight and a random sample of about 500 g, was oven dried (60 ℃ for 72 h) for determination t he content of herbage humidity and afterwards ground (Cyclotec mill with a mesh screen of 1 mm). The nutritive values: crude protein (CP), crude fibre (CF) neutral-detergent fibre (NDF), acid-detergent fibre (NDF) and acid-detergent lignin (ADL) were chemically determined. The nutritive values of the herbage (MFU), was assessed according to the method of Andrieu and Weiss (1981).

The second sample of biomass, was used to determine flora association in the pasture according to Fiori (1969) botanical guide. The flora species, whose proportion in the DM was less than 3%, was grouped into Graminaceae, Leguminousae and Compositae botanical families and a miscellaneous group which included species of the Boraginaceae, Ranunculaceae, Scrophulariaceae and Umbelliferae families. The separated samples were weighed, dried and their contribution to herbage DM determined.

Statistical analyses of the traits were conducted according to a model split plots of years, sites and fertilizer treatment, where pastures and fertilizer treatment were nested within the year. The model considers sites, replications and fertilizer treatments as fixed effects and years as a random effect. The arcsine transformation was made on percentage traits before analysis. The effect of years, sites and fertilizer treatment were tested with appropriate error terms (Steel and Torrie, 1980). Means comparisons were performed according to the LSD statistical test at the P=0.05 level of probability.

Results and discussion

The effect of fertilizer in all pastures increased, at the end of experiments, the content (mean over sites) of chemical parameters of the control by 15.5% total nitrogen, 32.8% of P_2O_5 and reduced by 0.7% the content of organic carbon (Table 2). Thus, amount of traits content in topsoil was 0.5 mg kg^{-1} and 8.7 ppm higher than those of control, respectively for total nitrogen and P_2O_5. The variation of organic carbon between fertilized and control treatment was inconsistent.

Table 2. Top soil traits pastures of National Parks at the starting and end of the experiments

Parameters	Gargano NP				Cilento NP		Circeo NP	
	Carpino		Rignano G.		Gioi		Monterotondo	
	Control	Treated	Control	Treated	Control	Treated	Control	Treated
pH	7.5	7.6	7.8	7.2	8.2	7.5	7.4	7.3
Organic carbon (%)	10.5	10.0	10.4	10.2	14.6	14.3	16.8	16.9
Total Nitrogen (‰)	3.1	3.2	3.6	4.1	2.2	2.6	2.7	3.8
P_2O_5 (ppm)	27.1	28.0	16.2	27	14	25	14	26
K_2O (ppm)	533	479	377	462	404	222	1785	2365

The DM of the control treatment of Monterotondo was 73%, 76% and 66% higher than those of the pasture of Carpino, Rignano, and Gioi, respectively. The effect of fertilizer treatment increased the DM of the unfertilized control by 40%, 60%, 34% and 40% in the pasture of Carpino, Rignano, Gioi and Monterotondo, respectively, and 1 point of percentage the humidity at harvest (Table 3). As consequences of fertilizer treatment on DM, the average of MFU ha^{-1} was 49% higher than those of the unfertilized control.

Table 3. Effect of fertilized treatment on dry matter yield (g m^{-2}) and nutritive value ha^{-1}

Location of Natural Park	DM (g m^{-2})			Moisture at harvest (%)			Milk Feed Unit ha^{-1}		
	Control	Treated	LSD	Control	Treated	LSD	Control	Treated	LSD
Carpino	259	647	21	73	71	1	1424	3227	40
Rignano G.	227	673	29	65	63	1	1201	3769	29
Gioi	319	480	47	74	77	1	1674	2687	29
Monterotondo	944	1588	18	74	77	1	3491	6824	62
LSD 0.05	27	40		2	3		75	119	

The natural pastures of the National Parks present about similar flora composition except in Monterotondo where prevaled Compositae species (mainly *Cirsium* spp.) and as consequences the nutritive values were lower (0.37 MFU) than other pastures (Tables 4 and 5). The effect of fertilizer application increased the flora percentage of the control treatment by 27/% in Graminaceae and 29.5% in Leguminosae and reduced those of Compositae and miscellaneous group (data not presented) by 61% and 42%, respectively (Table 4). The content of CP in the herbage of the control and fertilized sward showed statistical significance only in Rignano pasture while higher difference among herbage was found for CF. The effect of fertilizer increased the content of CF by 3.3% in comparison to those of control. As consequences of the effect of fertilizer application on the flora of the species with high nutritive values, (increase flora of Leguminosae and reduced those of Compositae and miscellaneous group) the content of MFU was 5.7% higher than those of the control (Table 4).

Table 4. Effect of fertilized treatment on flora composition

Location of National Park	Graminaceae (%)			Leguminosae (%)			Compositae (%)		
	Control	Treated	LSD	Control	Treated	LSD	Control	Treated	LSD
Carpino	49	51	1	9	19	6	12	10	1
Rignano G.	34	51	5	15	30	4	22	5	5
Gioi	34	52	5	23	18	1	17	8	3
Monterotondo	31	51	5	15	21	2	27	7	5
LSD 0.05	3	1		5	4		5	2	

Table 5. Effect of fertilized treatment on qualitative parameters of the herbage

Location of Natural Park	CP (%)			CF (%)			Milk Feed Unit (DM kg^{-1})		
	Control	Treated	LSD	Control	Treated	LSD	Control	Treated	LSD
Carpino	14	14	NS	37	34	2	0.55	0.53	0.01
Rignano G.	11	13	1	36	35	NS	0.53	0.56	0.01
Gioi	14	13	NS	22	25	1	0.52	0.56	0.02
Monterotondo	11	10	NS	23	28	1	0.37	0.43	0.04
LSD 0.05	1	1		4	3		0.02	0.01	

Conclusions

Combined nitrogen-phosphorous fertilizer favoured the development of herbage with high nutritive value, reduced flora biodiversity slightly and increased the content of P_2O_5 in soil of pastures. The low variation organic carbon between control and nitrogen-phosphorous fertilized soils evidenced that the treatment favoured activity and development of physiological process in soil (seedbank or rhyzobium). Thus, the fertilised application proposed in the study may be useful to exploit the development of the herbages in the swards of the protected areas (NP, SIC and ZPS), favouring the increases in forage production and nutritive value of the herbage with a low variation of phytocoenoses of the sward and forbidding the possibility of genetic contamination and consequently saving the variability of the flora species present in the swards of the European Union rangelands.

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