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Estimation of usage and fertilization impact on quality of *Festuca rubra* pasture and sustainability of some technological variants

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Abstract. The purpose of this research was to study the effect of some treatments (fertilization, over-sowing, cutting, grazing) on a *Festuca rubra* mountain pasture from Cindrel Mountains (Meridional Carpathians, Romania), in order to improve the quality of this pasture. Yearly fertilization with organic fertilizers or moderate chemical fertilization ($N_{100}P_{22}K_{83}$ kg·ha^{-1}·y^{-1}) positively influence some soil chemical features, the nutritional status with N of plants and the level of forage yields of this pasture. The amplification of N biogeochemical cycle in the variants fertilized with moderate dozes of N determines significant increases of quantity and quality of forage production.
Key Words: *Festuca rubra*, cutting, grazing, yield, consumption efficiency.

Rezumat. Scopul prezentei cercetări a fost acela de a studia efectul unor tratamente (fertilizare, supraînsămânţare, cosit, păşunat) pe o pajişte montană de *Festuca rubra* (Munţii Cindrel din Carpaţii Meridionali–România) cu scopul de a îmbunătăţii calitatea acestei pajişti. Fertilizarea anuală cu îngrăşăminte organice sau fertilizarea chimică moderată ($N_{100}P_{22}K_{83}$ kg·ha^{-1}·an^{-1}) influenţează pozitiv unele proprietăţi chimice ale solului, starea de nutriţie cu N a plantelor şi nivelul producţiei de furaje în acest tip de pajişte. Amplificarea ciclului biogeochimic al azotului în variantele fertilizate cu doze moderate de azot determină creşteri semnificative ale cantităţii şi calităţii producţiei de furaje.
Key Words: *Festuca rubra*, cosit, păşunat, producţie, eficienţa consumului.

Introduction. Sustainable production of forage in the mountain area is a compulsory condition for a sustainable agriculture development (Sima et al 2002). Soil is an important factor which determines the quantity and the quality of forage production in mountain pastures (Anghel et al 1965; Bălăceanu & Marian 1985; Bărbulescu & Motcă 1983). Permanent pastures from Romania were used too less for forage production after 1989 year, moreover one of them being abandoned. In Romania, *Festuca rubra* natural pastures occupy an area about 1 million ha (Maruşca 2001ab). The importance of *Festuca rubra* mountain pastures from the Cindrel Mountains is given by their large area (5,900 ha) which provides them an important role in the pastoral economy of the region (Cardaşol & Daniliuc 1979; Buza & Fesci 1983; Rotar et al 1997; Rotar et al 2000). In this situation, in 1998 year, a long duration experiment (1998 – present) was settled down on a *Festuca rubra* pasture with a view to establish technological variants for sustainable production of forage.

Material and Method. The research was developed on a *Festuca rubra* mountain pasture from Cindrel Mountains, at 1348 m altitude. The climate of this region is typical for boreal level (Neacşu et al 1978) and characterized by annual mean temperature of 4.5°C and annual rainfall over 900 mm. The area of experiment included a Dystric cambisol type of soil. The experiment included four blocks with cutting usage and one block with grazing usage. The variants of all blocks had the following treatments: 1) *Festuca rubra – Agrostis capillaris* pasture as control; 2) $N_{100}P_{22}K_{83}$ kg·ha^{-1}·y^{-1}; 3) sheep folding during 3 nights (one sheep m^{-2}); 4) $P_{22}K_{83}$ kg·ha^{-1}·y^{-1} + over sowing with *Trifolium repens*; 5) $P_{22}K_{83}$ kg·ha^{-1}·y^{-1}. The production and the consumption efficiency of forage were determined by cutting and weighing of harvest obtained during vegetative period. The nutritional index (IN) of plants for nitrogen (INN) was determined by next relation: (INN) = $100 \cdot N/4.8 \cdot DM^{-0.32}$ elaborated by Lemaire (1997) and Balent et al (1997), which for N represents the content of plant in this element (as % from dry matter) and DM (dry matter) represents the yield in $t \cdot ha^{-1}$. Grazing was done with ovine youth of Turcana breed. The statistical interpretation of results was done using ANOVA model.

Results and Discussion. Considering the low level of pasture's soil supply in nutritive elements available to plants (Puia et al 1976; Anghel et al 1985; Motcă & Geamănu 1998), all applied inputs determined increases of dry matter harvest, as it can be observed from Tables 1 and 2. In block with cutting usage the highest yield efficiency (141.6%) was obtained in variant mineral fertilized with $N_{100}P_{22}K_{83}$ (4.30t/ha DM). Yield efficiencies obtained in the other variants in comparison with control were lower but all of them were statistically assured.

In block with grazing usage, for variant which the same fertilization was used ($N_{100}P_{22}K_{83}$), yield was only with 82% higher than yield of natural pasture (control). Dry matter yield efficiencies obtained for the rest of the variants did not surpass 1 $t \cdot ha^{-1}$. Analyzing the obtained yields it can be noticed that the usage of pasture (cutting, grazing) influenced their levels (Rotar et al 2000).

Table 1

The influence of fertilization on DM yield – second experimental year (cutting usage)

Variants	*DM yield $t \cdot ha^{-1} \cdot y^{-1}$*	*Relative yield (%)*	*Difference (+/-)*	*Signification*
V1	1.78	100.0	0.00	-
V2	4.30	241.6	2.52	***
V3	2.08	116.9	0.30	***
V4	2.72	152.8	0.94	***
V5	2.83	159.0	1.05	***
LSD (p 5%)=+0.03		LSD (p 1%)=+0.04	LSD (p 0.1%)=+0.06	

Even if in case of using of pastures as grazing the levels of yields are lower than in case of using as cutting, it is important to notice the fact that a part of substances extracted by plants from soil return through animal dejections and unconsumed rest of plants (Rotar & Carlier 2005). As it can be observed in Table 2, the efficiency of forage consumption varied between 71.20% and 79.50%, which indicates that on an average approximately 25% of first cycle harvest returned into the soil.

Table 2

The yield and consumption of DM – first cycle (grazing usage)

Variants	*DM yield $t \cdot ha^{-1} \cdot y^{-1}$*	*Relative yield (%)*	*Difference (+/-)*	*Consumed DM quantity*	*Consumption efficiency (Ec) (%)*
V_1	1.60	100.00	0.00	1.15	71.90
V_2	2.91	182.00	1.31	2.14	73.50
V_3	2.02	126.00	0.42	1.44	71.30
V_4	2.40	150.00	0.80	1.91	79.60
V_5	2.00	125.00	0.40	1.55	77.50

The qualitative influence of treatments applied on pasture for both usages can also be assessed on the basis of data regarding the efficiency of consumption and the digestible DM yield (Tables 2 and 3).

Among all mineral fertilized variants, that with complex fertilization (N, P, K) recorded the lowest consumption efficiency, about 73.50%. In spite of this fact, on the basis of calculation of digestible DM yield, the highest digestible DM yield was obtained for $N_{100}P_{22}K_{83}$ fertilized variant.

It is interesting to notice the fact that if the relative DM yield obtained for variants 2 of the two blocks (cutting and grazing) are compared, the difference between them is about 1.39 $t \cdot ha^{-1} \cdot y^{-1}$ while, if the same comparison is done considering the digestible DM yield, the difference is only 0.62 $t \cdot ha^{-1}$.

Table 3

Digestible DM yield obtained at first cycle of harvesting

Digestible DM yield $t \cdot ha^{-1}$		Variant		Digestible DM yield $t \cdot ha^{-1}$
1.27	*cutting*	Natural pasture	*grazing*	1.05
2.61		$N_{100}P_{22}K_{83}$ $kg \cdot ha^{-1} \cdot y^{-1}$		1.99
1.52		Sheep folding (one sheep$\cdot m^{-2}$ – 3 nights)		1.36
2.14		$P_{22}K_{83}$ $kg \cdot ha^{-1} \cdot y^{-1}$ + over sowing with *Trifolium repens*		1.75
2.04		$P_{22}K_{83}$ $kg \cdot ha^{-1} \cdot y^{-1}$		1.42

In order to obtain a good quantitative and qualitative harvest on these pastures, it is necessary as plants to benefit by all nutritive substances they need from soil and, among these, an important role has nitrogen (Rotar et al 1997; Rusu 1997). For the soil which formed under secondary natural pastures of *Festuca rubra* from boreal level (Anghel et al 1982; Ţucra et al 1987), quite high organic matter content, but with a pronounced acid character, was determined. For this reason plant nutrition was poor in macro elements as N, P, K, and the level of yields were those presented in Tables 1-3.

On the basis of analysis of chemical composition of forage the nutritional index of plant for nitrogen was determined, index which reflects the nutritional status of plants with this element (Table 4). Thus, the values over 80 obtained for $N_{100}P_{22}K_{83}$ $kg \cdot ha^{-1} \cdot y^{-1}$ fertilized variant, both on cutting and on grazing usage, indicate a normal nutritional status of plant with N. Knowing this index the impact and the efficiency of applied treatments can be estimated (Motcă & Geamănu 1998; Sima et al 2001). It is important to remark the fact that in natural pasture with cutting usage the most severe deficiency in nutrition of plant with N was recorded.

Table 4

Nutritional status of plants with N and N output with DM yield

CUTTING		Variants	GRAZING	
Nutritional index of plant for nitrogen (INN)	Nitrogen output with yield ($kg \cdot ha^{-1}$)		Nitrogen output with yield ($kg \cdot ha^{-1}$)	Nutritional index of plant for nitrogen (INN)
46.98	40.58	Natural pasture	26.10	54.96
89.26	114.40	$N_{100}P_{22}K_{83}$ $kg \cdot ha^{-1} \cdot y^{-1}$	68.40	93.84
55.15	43.50	Sheep folding (one sheep$\cdot m^{-2}$ – 3 nights)	32.80	59.53
58.00	55.20	$P_{22}K_{83}$ $kg \cdot ha^{-1} \cdot y^{-1}$ + over sowing with *Trifolium repens*	38.20	55.24
59.71	58.30	$P_{22}K_{83}$ $kg \cdot ha^{-1} \cdot y^{-1}$	39.10	65.45

Sustainability of applied measures can and must be also assessed on the basis of analysis of balance between the inputs of elements introduced by man in pasture's ecosystem and the output of elements which happen with forage harvesting (Carlier et al 1998).

As it can be also observed from Table 4 data, the highest N output was realized in variants fertilized with N (cutting and grazing) and which for the highest yields were obtained. The ratio between the yields of the two variants is 1.48, while the ratio between N outputs is 1.67.

In case of cut and fertilized with 100 kg $N \cdot ha^{-1}$ variant (first cycle of harvest) a quantity about 114.40 kg N ha^{-1} was exported with forage harvest while, in the same cycle, in case of similar fertilized but grazed variant the output of N was about 68.40 kg $N \cdot ha^{-1}$.

The quantity of exported nitrogen for each kg of DM yield was about 0.02 kg in all variants of the block with cutting usage while in the block with grazing usage only for variant fertilized with N the same quantity of exported N was recorded (0.02 kg) but for the rest of the variants the output was about 0.01 kg for each kg of DM yield.

Conclusions. The usage of pasture (cutting, grazing) influenced the reaction of vegetation and the forage production. Thus, in the block with cutting usage, more depleted in nutritive elements as nitrogen, the reaction of vegetation was stronger and provided higher yields than in the block with grazing usage.

Complex fertilization with $N_{100}P_{22}K_{83}$ $kg \cdot ha^{-1} \cdot y^{-1}$ provided the highest yields, with high quality and lower forage consumption.

Fertilization with N is compulsory on these pastures because only through providing of a normal nutritional status of plants with this element the mentioned performances can be obtained.

To assess the sustainability of pasture's fertilization with 100 kg $N \cdot ha^{-1}$, a more complex agrochemical research is necessary.

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