EFFECT OF DIFFERENTIATED FERTILIZATION ON SOIL AND FODDER PRODUCTION OBTAINED ON GRASSLANDS IN THE MOUNTAIN AREA

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ABSTRACT

The paper highlights the evolution of soil fertility and fodder production in the mountain area with poor quality land for agricultural and horticultural practice, being necessary to take ameliorative measures regarding the delimitation of optimal and risk areas and implementation of differentiated soil fertilization systems to achieve superior qualitative and quantitative productions.

The soils in the mountain area are usually covered with natural forests and grasslands and the physical and chemical properties of each type of soil in the mountain area are in accordance with the solification factors. Cultivating these lands consolidates or modifies certain characteristics of fertility for these soils both as a result of anthropogenic interventions and as an impact effect of particular climatic or vegetation properties. The objective of the research presented in this paper is the effect of differentiated organic and organo-mineral fertilization on the quantitative and qualitative achievement of fodder production and the change of the main agrochemical indices of the soil in mountain area, without disturbing the environment.

Maintaining and improving the biodiversity of grasslands is a strategic goal for the mountain area, as agri-environment and climate measures reflect this within the European Union. In this sense, the experiments were located in the mountain area on an Agrostis capillaris type grassland with Festuca rubra, on a eumezobasic and eutricambosoil soil type, with a high clay and skeleton content as well as a small edaphic volume with low fertility.

The importance, originality and novelty of these experiments in the agronomic field, are due to problems still unresolved today, in terms of fertilization combinations, by implementing a soil fertilization system and ecological protection to maintain and increase the content of organic matter in the soil, in accordance to climatic specifics of the mountain area and to the requirements of nutrient consumption of fodder species, in order to achieve quantitative and qualitative fodder production.

INTRODUCTION

In our country, the permanent grasslands mostly occupy land areas located on soils exhibiting a low degree of fertility that determine a quantitative and qualitative limitation of the obtained productions. Along with a series of soil improvement measures aimed at combating acidity, salting, compaction, excess moisture, etc., fertilization contributes in the most important way to improving the soil-plant-fertilizer relationship.

In this context, this research aims to analyze an area characterized by a landscape with a great diversity of geomorphological forms due to a wide range of rocks that form them, such as metamorphic rocks, crystalline schists,

conglomerates with clay intercalations and ferruginous sandstones, determining soils with low fertility and poorly productive. Thus, the representative soils of the mountain area, starting from altitudes over 800-1000 m, are of the cambisoils class, the most widespread being districambosoils (former acidic brown soils) and eutricambosoils (former brown forest soils, eutrophic brown soils or textural undifferentiated forest soils). From the fertility point of view, these soils are considered of low fertility and with an accentuated need for fertilizers, because they are poor in elements, indispensable for the growth and development of plants. Their physico-chemical properties are unfavorable to high harvests, so they must be corrected by fertilizers and amendments after a rigorous agrochemical study performed and harmonized with sustainable fertilization. On such soils organic fertilizers are indispensable, as they are the main means of increasing the content of organic matter and restoring and maintaining their fertility.

This research is based on rigorous experiments on an eutricambosoil from the mountain area in Brașov County, exhibiting differentiated organic and organo-mineral fertilization systems, on an Agrostis capillaris with Festuca rubra type,grassland

MATERIAL AND METHOD

The multifactorial experiments were located on the territory of ICDP Brasov, on an Agrostis capillaris type of grassland with Festuca rubra, on an eutricambosoil, a brown forest soil of eu-mesobasic type from the cambisoils class, with a pH lower than 6.5, medium supplied with phosphorus (24 ppm P) and potassium (107 ppm K). In order to achieve the goals of this research, two experiments were designed, aiming, on the one hand, "the impact of fertilization with organic fertilizers" and on the other hand "the impact of fertilization with organo-mineral fertilizers" on the soil and fodder production in the mountain area of Braşov county.

In the organic fertilization experiment the factors are:

1. Doses of organic fertilizers

a1 - 20 t/ha (or the equivalent of 60 kg/ha N) at 2 years;

a2 - 40 t/ha (or the equivalent of 120 kg/ha N) at 4 years;

a3 - 60 t/ha (or the equivalent of 180 kg/ha N) at 4 years;

2. Period of application

b1 - autumn - winter (November - December);

b2 - spring (late winter, early spring);

3. Type of exploitation

c1 - (mowed) hay;

c2 - grazing simulation.

Manure was applied in February for winter applications and in April for spring applications. The size of a plot is 30 sqm (3x10), with 3 repetitions. At application, samples were extracted by probing the manure platform and analyzed in the laboratory. The average content of nutrients in the sample is: 4.13 kg/t N; 2.0 kg/t P; 5.3 kg/t K and 2.5 kg/t Ca. Following the application of manure doses resuled the following amounts of N, P, K and Ca kg active substance (a.s.)/ha applied(Table.1).

Table 1.

Manure dose	Element quantity - kg a.s./ha			
	N	P	K	Ca
20 tons/ha	82,6	40	106	50
40 tons/ha	165,2	80	212	100
60 tons/ha	247,8	120	318	150

In the organo-mineral fertilization experiment the factors are:

Differentiated levels of organo-mineral fertilization;

a1 – manure 20 t/ha + 50 P2O5 (kg a.s./ha);

a2 – manure 20 t/ha +50 P2O5 + 50 K2O (kg a.s./ha);

a3 – manure 20 t/ha +50 N +50 P2O5 + 50 K2O (kg a.s./ha);
a4 – manure 20 t/ha +100 N +50 P2O5 + 50 K2O (kg a.s./ha);
a5 – manure 20 t/ha +150 N + 50 P2O5 + 50 K2O (kg a.s./ha);
a6 – manure 40 t/ha + 50 P2O5 (kg a.s./ha);
a7 – manure 40 t/ha +50 P2O5 + 50 K2O (kg a.s./ha);
a8 – manure 40 t/ha + 50 N +50 P2O5 + 50 K2O (kg a.s./ha);
a9 – manure 40 t/ha +100 N + 50 P2O5 + 50 K2O (kg a.s./ha);
a10 – manure 40 t/ha +150 N + 50 P2O5 + 50 K2O (kg a.s./ha);
a11 – unfertilized.

Manure had the same chemical composition as in the previous experiment. Following the application of manure and mineral fertilizers, the following fertilization scheme resulted. (Table.2).

Table 2.

Alternative	Fertilizer dose kg s.a./ha			
	N	P	K	Ca
Manure 20 t/ha 50 P_2O_5	82,6	62	106	50
Manure 20 t/ha 50 P_2O_5 ; 50 K_2O	82,6	62	147,5	50
Manure 20 t/ha 50 N ;50 P_2O_5 ; 50 K_2O	132,6	62	147,5	50
Manure 20 t/ha 100 N ;50 P_2O_5 ; 50 K_2O	182,6	62	147,5	50
Manure 20 t/ha 150 N ; 50 P_2O_5 ; 50 K_2O	232,6	62	147,5	50
Manure 40 t/ha 50 P_2O_5	165,2	102	212	100
Manure 40 t/ha 50 P_2O_5 ; 50 K_2O	165,2	102	262	100
Manure 40 t/ha 50 N ;50 P_2O_5 ; 50 K_2O	215,2	102	262	100
Manure 40 t/ha 100 N ;50 P_2O_5 ; 50 K_2O	265,2	102	262	100
Manure 40 t/ha 150 N ;50 P_2O_5 ; 50 K_2O	315,2	102	262	100
Unfertilized.	-	-	-	-

RESULTS AND DISCUSSIONS

a) The influence of the dose and the period of application of the organic fertilizers on the production and the quality of the grassland

Organic fertilization with increasing doses of manure equivalent to 60, 120, respectively 180 kg a.s./ha N, led to the obtaining of 4, respectively 3 harvests, depending on the harvesting method, frequent mowing (simulated grazing) or in grassland.

The production of dry substance (d.s.) at the first harvest cycle had values between 1.93 t d.s./ha and 5.10 t d.s./ha the productive yield being correlated with the harvest time and the level of the dose of organic fertilizer applied.

In the second harvest cycle, the production was strongly influenced by the climatic conditions, the lack of precipitation leading to a uniformization of the productive yield of the experiment alternatives. The productive level was between 0.37 t d.s./ha and 1.18 t d.s/ha close to the productive level of the unfertilized grassland - 0.44 t/ha. At this harvest cycle a higher yield efficiency of the grassland is obtained, explained by capitalizing the fallen precipitations immediately after the first harvest cycle.

The third cycle is also maintained as a productive yield close to that of the unfertilized grassland. From a quantitative point of view the dry substance (d.s.) productions were below 1 t/ha being between 0.33 t/ha and 0.83 t/ha.

The fourth harvest cycle was also obtained by frequent mowing (grazing simulation), which benefited more from the precipitations that fell at the end of summer and the beginning of September, which led to the production of dry substance quantities between 0.42 t/ha and 0.70 t/ha.

The total annual production of dry substance exceeded 3.71 t/ha in all alternatives reaching the level of 6.26 t/ha by applying 60 t/ha manure, in the spring at grazing hay harvesting type. (Table 3). Compared to the unfertilized grassland,

the production increase achieved by the organically fertilized alternatives was between 5% and 76%.

Table 3.

Influence of organic fertilization and usage on the dry substance production

Manure dose	Period of application	Usage	Dry substance production t/ha				Sum of harvests t/ha	Rel. Prod. %
			H I	H II	H III	H IV		
20 t/ha	autumn	pasture	1,93	1,00	0,63	0,42	3,98	112
		grassland	3,64	0,37	0,33	-	4,33	122
	spring	pasture	1,96	0,70	0,48	0,57	3,71	105
		grassland	3,64	0,39	0,34	-	4,37	124
40 t/ha	autumn	pasture	2,06	0,90	0,61	0,64	4,21	118
		grassland	3,93	0,45	0,47	-	4,85	137
	spring	pasture	2,39	1,18	0,83	0,60	5,00	141
		grassland	3,98	0,48	0,48	-	4,94	139
60 t/ha	autumn	pasture	2,76	1,25	0,76	0,70	5,47	**154**
		grassland	4,55	0,56	0,31	-	5,42	**153**
	spring	pasture	2,06	1,17	0,76	0,53	4,52	127
		grassland	5,10	0,50	0,66	-	6,26	**176**
Unfertilized control			2,58	0,44	0,53	-	3,55	100

Analyzing the data presented in Table 4, there is an increase in the productive yield of the vegetal carpet simultaneously with the increase of the dose of organic fertilizer. The production increase expressed in kg d.s./t of organic fertilizer is very close to 27.5; 30.0; respectively 31.0 kg dry substance for doses of 20, 40, respectively 60 t/ha manure.

Table 4.

Influence of organic fertilizer dose on dry substance production

Organic fertilizer dose	Obtained dry matter production t/ha	Relative production %	Difference t/ha	Increase kg d.s./t
20 t/ha	4,10	115	0,55	27,5
40 t/ha	4,75	134	1,20	30,0
60 t/ha	5,41	**152**	1,86	31,0
Unfertilized	3,55	100	Mt.	-

The application period of organic fertilizer in autumn or spring does not categorically influence the productive yield of the grassland, the production increase between the two periods being 4%, 131% for autumn application and 135% for spring application (Table 5). This aspect highlights the importance of applying organic fertilizer and less of the application period, it is important to be in the optimal period of application during theyear.

Table 5.

Influence of organic fertilizer application period on dry substance production

Application period	Dry substance production t/ha	Relative production %	Difference t/ha
Autumn	4,65	131	1,10
Spring	4,80	**135**	1,30
Unfertilized	3,55	100	Mt.

It is also confirmed that by harvesting through mowing as grassland the production of dry substance obtained is 56% higher (Table 6). This difference comes this year from the first harvest cycle, the following being greatly influenced by climatic conditions.

Table 6.

Influence of fertilization and usage of pasture on dry matter production

Usage	Absolute dry substance production t/ha	Relative production %	Difference t/ha
Frequent mowing (pasture)	4,46	125	0,91
Grassland	5,53	**156**	1,98
Unfertilized	3,55	100	Mt.

b) The influence of organic fertilizers dose and the application period on soil fertility;

The results of the evolution of some chemical properties of the soil are presented in Table 7.

Table 7.

The evolution of some basic agrochemical properties of the soil for the alternatives fertilized with increasing doses of organic fertilizer and usage

Manure dose t/ha	Application period	Harvasting method	pH (H_2O)	Ah	SB	V%	Hum. %	IN	P_{AL} ppm	K_{AL} ppm	Nt %
				Me/100 g							
20	autumn	pasture	5,6	7,4	18,3	75	5,2	3,4	61	94	0,269
		grassland	5,5	7,9	18,7	68	5,3	3,5	57	104	0,248
	spring	pasture	5,6	8,2	18,4	68	5,3	3,7	65	88	0,274
		grassland	5,6	8,6	17,9	67	5,2	3,5	58	76	0,287
40	autumn	pasture	5,7	7,5	19,3	72	5,3	3,6	82	120	0,278
		grassland	5,7	7,5	19,3	72	5,3	3,6	82	120	0,278
	spring	pasture	5,6	7,2	20,8	74	5,2	3,7	94	164	0,270
		grassland	5,6	7,0	19,7	74	5,2	3,7	67	152	0,268
60	autumn	pasture	5,6	6,8	20,3	74	5,3	4,1	98	116	0,262
		grassland	5,7	6,6	21,8	78	5,7	4,4	110	122	0,289
	spring	pasture	5,8	6,4	23,4	80	5,4	4,7	92	118	0,280
		grassland	5,9	6,0	22,3	83	5,6	5,5	95	116	0,288
Unfertilized			5,8	5,1	32,3	98	5,07	4,8	67,0	78	0,290

Organic fertilization applied in moderate dose determines first of all an action of protection and even of amelioration of the soil reaction both by effective contribution of cations and by the action of complexation and immobilization of acidity factors (Al^{3+} ions, H^+). During the experiment period, the ameliorating effect on the reaction of the organic fertilizer is much more significant.

The application of organic fertilizers also positively influences the supply regime with humus and total forms of nitrogen, changes that in a limited period are attributed to the raw forms of humus and the promotion of humification through a global improvement intervention from this range of fertilizers.

Also, organic fertilization positively modifies the intake and content of phosphorus and potassium in mobile forms which over time show constant and beneficial changes for agricultural crops compared to unfertilized soils.

The positive effect of organic fertilization is felt substantially in the basification of the adsorbent complex, in its tendencies of evolution towards saturation with the favorable modification of the soil buffering capacity.

c) Influence of organo-mineral fertilization of the production of the grassland;

The combined effect of the application of organic fertilizers on grasslands in different combinations with mineral fertilizers determines at certain combinations the obtaining of some productions close to those obtained on temporary grasslands.

In this sense, three harvest cycles were obtained, predominant being the production obtained at the first harvest of 70-80%, the other two crops covering obtaining 30-20% of the total dry substance. The total dry substance production had quite wide variation limits, between 4.22 t/ha for the alternative fertilized with 20 t/ha manure in combination with 50 P_2O_5; 50 K_2O (kg a.s./ha) and 7.58 t/ha for the alternative fertilized with 40 t/ha manure in combination with 100 N; 50 P_2O_5; 50 K_2O (kg a.s./ha). Compared to the unfertilized alternative, nine out of ten alternatives obtain yields that exceed the control (Table.8).

Table 8.

Influence of organo-mineral fertilization on dry substance production obtained during the experimental year

Alternative	Production obtained t/ha				Relative production	Difference
	H I	H II	H III	Harvast sum		
Manure 20 t/ha 50 P_2O_5	4,41	0,93	0,10	5,44	104	0,23
Manure 20 t/ha 50 P_2O_5 ; 50 K_2O	3,27	0,84	0,11	4,22	81	-0,99
Manure 20 t/ha 50 N; 50 P_2O_5; 50 K_2O	5,82	0,85	0,14	6,81	131	1,60
Manure 20 t/ha 100 N;50 P_2O_5;50 K_2O	6,04	1,24	0,19	7,47	143	2,26
Manure 20 t/ha 150 N;50 P_2O_5; 50 K_2O	5,74	1,44	0,19	7,37	141	2,16
Manure 40 t/ha 50 P_2O_5	4,07	1,20	0,16	5,43	104	0,22
Manure 40 t/ha 50 P_2O_5 ; 50 K_2O	5,03	0,90	0,17	6,10	117	0,89
Manure 40 t/ha 50 N ;50 P_2O_5 ; 50 K_2O	5,04	1,17	0,11	6,32	121	1,11
Manure 40 t/ha 100 N;50 P_2O_5; 50 K_2O	5,95	1,45	0,18	7,58	**145**	2,37
Manure 40 t/ha 150 N;50 P_2O_5;50 K_2O	5,66	0,92	0,23	6,81	131	1,60
Unfertilized	3,67	1,36	0,18	5,21	100	-

Analyzing the separate influence of the analyzed factors on the productivity of the vegetal carpet, it is found that the applied organic fertilizer brings during the experimental year an increase of production of 20-24% (Table 9) compared to the unfertilized control.

Table 9.

Influence of organic fertilizer dose on the dry matter substance obtained (average of agrofunds)

Fertilizer dose t/ha	Absolute production t/ha	Relative production %	Difference t/ha	Difference (b – a)
(a) 20	6,26	120	1,05	-
(b) 40	6,44	**124**	1,23	0,18
Unfertilized	5,21	100	Mt.	-

Analyzed comparatively the two doses of organic fertilizer applied, an increase of 0.18 t/ha dry substance is observed by doubling the dose, an increase that attests to the residual effect of the organic fertilizer and the gradual release of plant nutrients.

Regarding the effect of the mineral fertilizer type applied on a base of organic fertilizer, it is found that fertilization with

increasing doses of nitrogen (Table 10) dry substance production increases between 26 and 44% compared to the unfertilized control. The application of 100 kg N kg a.s./ha induces the achievement of the production maximum of 7.52 t/ha dry substance more by 0.53 t/ha and 0.43 t/ha dry substance compared to 50 kg/ha N, respectively 150 kg/ha N. The production increase achieved for 1 kg of applied nitrogen is between 12.5 kg dry substance for the dose of 150 kg/ha N and 27.0 kg dry substance for the dose of 50kg/haN.

Table 10.

Influence of different levels of nitrogen fertilization on dry substance production (average of agrofunds)

Fertilization level	Absolute production t/ha	Relative production %	Difference (t/ha)				Dry substance increase for 1 kg. N
			Control	c - a	c - b	b - a	
a. N 50 kg/ha	6,56	126	1,35	0,53	-	0,96	27,0
b. N 100 kg/ha	7,52	144	2,31	-	-0,43	-	23,1
c. N 150 kg/ha	7,09	136	1,88	-	-	-	12,5
Nefertilizat	5,21	100	-	-	-	-	-

Phosphorus and potassium fertilizers contribute to the production in a lower proportion compared to nitrogen fertilizer. From the data presented in Table 11 results that phosphorus and potassium fertilizer applied contributes by 4% to the increase of the productive level while by the application in combination PK of the potassium a decrease of the production of dry substance takes place.

Table 11.

The influence of fertilization with phosphorus, potassium and their combinations on the dry substance production obtained (average of the agrofund)

Alternative	Absolute production t/ha	Relative production %	Difference (t/ha)			
			Control	c - a	c - b	b - a
a. P fertilization	5,44	104	0,23	1,62	-	-
b. PK fertilization	5,16	99	-0,05	-	1,90	-0,28
c. NPK fertilization	7,06	135	1,85	-	-	-
Unfertilized	5,21	100	-	-	-	-

The complex mineral fertilization with NPK proved to be the most beneficial, the plants reacting favorably to ensure the necessary nutrients during the vegetation period.

d) The influence of the dose and application period of the organo-mineral fertilizers on the agrochemical properties of the soil

Under the action of organo-mineral fertilization there are some changes of some basic agrochemical properties of the soil. From the data presented in Table 12 there is a slight improvement of the pH values by 0.2 to 0.6 units and an increase of the degree of saturation in the bases (V%).

The soil content in humus is kept close to the initial values, which is

explained by the relatively short time from the application of fertilizers, instead the value of the nitrogen index (IN) indicates a slight increase in all alternatives in the experiment compared to the unfertilized control.

Phosphorus fertilization has the effect of improving the supply of this nutrient, maintaining a very good level for plant nutrition in all alternatives.

The soil content in potassium exhibits important variations, starting from a good state of soil supply in this element to the unfertilized alternative (176 ppm) and a decrease in the concentration of soil solution in this element due to export with harvest and fixation without change in the layers of clay minerals specific to these soils in the mountain area.

Table 12.

Evolution of some basic agrochemical soil characteristics for the organo-mineral fertilized alternatives

Fertilization				pH H_2O	Ah	SB	V%	Hum %	IN	P_{AL} ppm	K_{AL} ppm	Nt %
Organic t/ha	Mineral (kg)				me/100 gr. soil							
	N	P_2O_5	K_2O									
Manure 20 t/ha ;50 P_2O_5	-	50	-	6,5	2,3	22,8	90,8	5,78	5,24	117	101	0,295
Manure 20 t/ha 50 P_2O_5 ; 50 K_2O	-	50	50	6,6	1,4	26,9	95,0	6,11	5,80	111	109	0,329
Manure 20 t/ha 50 N ; 50 P_2O_5 ; 50 K_2O	50	50	50	6,4	2,1	21,6	91,1	5,85	5,32	128	85	0,315
Manure 20 t/ha 100 N ; P_2O_5 ; 50 K_2O	100	50	50	5,9	4,2	20,1	82,7	6,17	5,10	106	73	0,328
Manure 20 t/ha 150 N ; P_2O_5 ; 50 K_2O	150	50	50	6,1	2,3	22,0	90,5	5,85	5,29	133	110	0,321
Manure 40 t/ha 50 P_2O_5	-	50	-	6,1	3,2	20,9	86,7	6,17	5,34	93	97	0,329
Manure 40 t/ha 50 P_2O_5 ; 50 K_2O	-	50	50	6,6	1,6	24,3	93,8	5,98	5,60	101	193	0,322
Manure 40 t/ha 50 N ; 50 P_2O_5 ; 50 K_2O	50	50	50	6,0	4,4	20,1	82,0	6,17	5,05	133	156	0,325
Manure 40 t/ha 100 N ;50 P_2O_5 ; 50 K_2O	100	50	50	6,4	2,5	20,5	89,1	5,98	5,32	111	105	0,322
Manure 40 t/ha 150 N ; 50 P_2O_5 ; 50 K_2O	150	50	50	6,6	1,4	25,4	94,7	5,98	5,66	97	86	0,322
Unfertilized	-	-	-	5,8	5,1	19,3	79	5,98	4,72	89,0	176	0,336

CONCLUSIONS

Organic fertilization applied systematically to the species on permanent landgrass of *Festuca rubra* type with *Agrostis capillaris* in the mountain area, modifies positively in the long term, the acid reaction (specific to mountain soils) by neutralizing it and also modifies crude humus content, nutrient regime, basification of the adsorbent complex, the physico-chemical properties of the soil, as well as the production of fodder (dry substance) per hectare.

Organo-mineral fertilization positively influences the productive yield of the vegetal carpet, the association of the doses of organic fertilizers of 20 t/ha, or 40 t/ha in combination with N-100; P_2O_5 -50; K_2O -50 (kg a.s./ha) ensures the highest fodder production.

The combined organo-mineral fertilization detaches as a positive effect, the nutritional and fertilizing value of the organo-mineral combinations, with organic substrate (20 - 40 t/ha manure) supplemented with a mineral support of nitrogen, phosphorus and potassium, systems that reveal the summing and even synergistic effect of these combinations for fodder production. This

positive combinatorial effect is due both to the initial level of the precarious soil fertility, representative for the area, but also to the capacity of the species of permanent grasslands of *Festuca rubra* type with *Agrostis capillaris* that can positively capitalize the organo-mineral interactions.

Organo-mineral fertilization, most compatible with the biological and nutritional requirements of permanent grasslands, increases the bioavailability of soil nutrients on the background of organic matter, improves the acid reaction of the soil, maintains and increases soil fertility in the mountain area.

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