

THE LONG-TERM INFLUENCE OF THE IMPROVEMENT FACTORS OF NARDUS STRICTA GRASSLANDS IN THE BUCEGI MOUNTAINS, THE ORGANICLY FERTILIZED VARIANT

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Abstract

In an experience regarding the improvement of subalpine grasslands degraded by *Nardus stricta* located in the Bucegilor Plateau at 1800 m altitude, established in 1995, the long-term effect of the intervention on the natural grass carpet, overseeded and reseeded on unamended and calcium amended soil with a organic fertilization by grazing with sheep and cattle was studied. The study in the final phase, 2019-2023 after 24-28 years on average from the improvement options, highlighted the prolonged effect of calcium amendment to 2/3 of the hydrolytic acidity (Ah), by which the pastoral value increases by 5% and mass production green by 12% compared to the unamended variants. As for the grass carpet, the overseeded grassland is superior to the other two variants natural and reseeded. The effect of the improvement factors of these degraded grasslands is even better highlighted by the milk production, which reaches 4120 liters/ha in the oversown variants and 4150 liters/ha in the calcium-amended ones, respectively 2-5% higher than of the average of the control variants. Uniform organic fertilization by livestock paddocking strongly stimulated the participation of valuable species, such as *Poa pratensis*, *Agrostis capillaris*, *Festuca nigrescens* and *Trifolium repens* alongside *Phleum pratense* introduced by overseeding almost 30 years ago.

Keywords: degraded mountain grasslands, improvement, pastoral value, green mass production, milk production.

INTRODUCTION

On grasslands used for grazing animals, in many cases the worthless species *Nardus stricta* settles and dominates, in the Alps and other mountains in Europe, due to irrational use (Coulon 1923).

Grasslands dominated by the species *Nardus stricta* in the mountain area, have the most degraded vegetation, requiring to be improved by different methods of fertilization, amendment, overseeding and reseeded.

Up to now in our country, starting from 1941, numerous experiments have been carried out to improve mountain *Nardus stricta* grasslands over variable periods of 3-5 years in most cases (Obrazencu, 1941; Pușcaru et al. 1956; Safta et al. 1960; Resmeriță 1969; Niedermaier 1970; Bărbulescu 1975, 1977 and others).

The main means of improvement were fertilizing with mineral and organic fertilizers by livestock paddocking, calcium amendment, overseeding after total weeding, reseeded after loosening with the tiller or plow, and others.

In the case of improving the grass carpet only by fertilization and amendment after 3 - 5 years *Nardus stricta* was replaced by successively by *Festuca rubra* and *Agrostis capillaris*. (Safta, Pavel, 1960)

Through weeding and overseeding or loosening by milling or plowing with reseeded on a suitable agrofund, high productivity sown grasslands were established.

Less well known is the evolution over time of the grassy carpet after 3-5 years under the influence of improvement factors, especially calcium amendment, mineral, organo-mineral and organic fertilization, as well as the durability of the components of the mixtures of perennial grasses and legumes.

In some more recent works, the long-term effect of some improvement factors, especially amendment and overseeding and reseeding, have been studied (Marușca 2021).

In the present work, research is continued on the durability of calcium amendment, the evolution of the floristic composition in the natural grass carpet and the persistence of some species in the sown grass mixtures.

MATERIALS AND RESEARCH METHOD

The experiments were started in 1995 at the "Teodor Marușca" Mountain Grasslands Research Base Blana-Bucegi on a subalpine grassland degraded by *Nardus stricta* located at 1800 m altitude.

The primary vegetation of the subalpine level of the Bucegi Plateau, where this bifactorial experience was located, was in the past dominated by juniper (*Pinus mugo*), which for centuries has been cleared to establish the grassy vegetation of the grasslands necessary for transhumance animals.

The variants of the experimentation were the following:

Factor A: The type of grass carpet of the grassland

1. Semi-natural grassland of *Nardus stricta* after juniper (*Pinus mugo*) deforestation, a century ago;
2. Overseeded grassland after total weeding with "glyphosate" 5 liters per hectare in 1995, harrowed at 2-3 cm and sown with a mixture of perennial grasses for grasslands;
3. Reseeded grassland after total herbicide treatment with "glyphosate", processed with a tiller at a depth of 10-12 cm and sowing grasses.

Factor B: Calcium amendment

1. Unamended (Witness);
2. Amended to 2/3 Ah (7.5 t/ha CaO lime powder);

The floristic composition of the grassland in 1995, before the establishment of the experiment, was as follows: *Nardus stricta* 68%, *Festuca nigrescens* 7%, *Phleum alpinum* 3%, *Agrostis rupestris* 2%, *Festuca ovina ovina* 2%, *Deschampsia caespitosa* 2%, *Anthoxanthum odoratum* 1 %, *Deschampsia flexuosa* 1%, *Trifolium repens* 4%, *Potentilla ternata* 5%, *Ligusticum mutellina* 2% *Polygonum bistorta* 2%, *Campanula abietina* 1%, *Geum montanum* +, *Hieracium amantiacum* +, *Rumex acetosella* +, *Viola declinata* + and others.

The composition of the mixture of herbs for oversowing and resowing: *Festuca pratensis* Transylvania variety 40%; *Phleum pratense* Favorite 25%; *Lolium perenne* Mara 5%, *Lotus corniculatus* Orchard 15%; *Trifolium hybridum* Brașov 5%, species that are not found in the spontaneous flora.

Organic fertilization was carried out only by sheep and cows paddocking on the pasture as follows:

- the year 1995 after weeding and the application of the amendments before sowing, 5-night grazing, one sheep per square meter;
- year 2000, 5 nights of sheep grazing per square meter;
- year 2005 idem 2000;
- year 2011 grazing 5 nights a cow/6 sqm;
- year 2018 idem 2011.

The size of a plot was 18 sq m (6 x 3). The number of repetitions was 4.

Each year, floristic surveys were carried out with 2 repetitions of each experimental variant, before harvesting.

Green mass harvesting was carried out on 1 square meter of each plot to determine green mass production and take samples for dry matter and chemical analyses.

After harvesting, the cows were introduced to graze on the remaining 17 square meters on each of the 24 plots, so that the influence of the animals on the grassy carpet through grazing, trampling and droppings is as close as possible to normality in relation to the experiences fully harvested by mowing.

Surveys from the last 5 years 2019 - 2023, respectively after 24 - 28 years after the application of the amendments, the first livestock paddocking and sowing, were studied.

The productivity of the grasslands, respectively the pastoral value and the production of green mass was evaluated based on the floristic survey (Maruşca 2019).

The production of green mass served to establish the optimal load with animals according to a method also presented in this journal (Maruşca 2022).

The pastoral value multiplied by the transformation coefficient of 51.24 effectively established after 25 years to the bordering cows experience, allowed us to evaluate milk production per hectare (Maruşca et al. 2018).

RESULTS AND DISCUSSION

To organic fertilizing by livestock paddocking the component species of the grass carpet (natural, overseeded, reseeded) types reacted differently even after an average of 24 - 28 years after the main improvement (Table 1).

Thus, the basic species *Agrostis capillaris* has an average participation of 25% in the overseeded variant (factor A 20) and 32.5% participation in the reseeded variant (factor A 30) compared to 6.5% in the natural reference variant (factor A 10).

The species *Poa pratensis* participates in a proportion of almost 38% in the variant with natural carpet (factor A 10), 2.5 times higher compared to the over-seeded version (20) and more than 4 times compared to the version processed with the tiller (factor A 30).

The sown species *Phleum pratense* is maintained in variants 20 and 30 at a rate of 14.5% after 24-28 years, although it has not reached maturity to self-seed.

The *Trifolium repens* species from the spontaneous flora is maintained in proportion of 22% in variants 10 and 20, respectively 18% in variant 30, being less influenced by the action on the soil.

Species from other families are better represented in the natural variant 10 in proportion of 15.6% overseeded and decreases in variant 20 to 10% and on variant 30 with 8%.

More important changes in the grass carpet were produced by the amendment factor (factor B 02). Through calcium amendment, the valuable *Poa pratensis* species with an average participation of 15.7% in the unamended variants (factor B 01) reaches 24.3% in the amended ones (factor B 02) with a maximum of almost 47% in variant 12, natural grass carpet. The *Agrostis capillaris* species after amendment decreases in the grass carpet from 27.6% to 15%, having the highest participation at 38% in variant 13, without amendment, processing with the tiller.

Table 1. The floristic composition, pastoral value and green mass production of the organically fertilized experimental variants (Blana - Bucegi (2018-2023) - part 1)

No.	Species	Indices		B 01 Unamended (%)			
		F	M	11	21	31	Media
1	Grasses	x	x	69.8	73.8	78.4	74.0
2	<i>Agrostis capillaris</i>	7	5	13.0	31.6	38.2	27.6
3	<i>Agrostis rupestris</i>	5	1	0.8	5.4	5.0	3.7
4	<i>Deschampsia caespitosa</i>	3	0	0.6	0	0.6	0.4
5	<i>Deschampsia flexuosa</i>	4	3	1.8	0.4	0	0.6
6	<i>Festuca nigrescens</i>	7	5	13.4	10.4	12.8	12.2
7	<i>Poa media</i>	5	2	8.2	0.2	2.8	3.7
8	<i>Poa pratensis</i>	8	6	28.6	12.6	6.0	15.7
9	<i>Phleum alpinum</i>	7	2	1.8	0	1.2	1.0
10	<i>Phleum pratensis</i> *)	9	8	1.6	13.2	11.8	8.9
11	Vegetables	x	x	16.2	15.6	13.4	15.1
12	<i>Trifolium repens</i>	8	5	16.2	15.6	13.4	15.1
13	Other families	x	x	14.0	10.6	8.2	10.9
14	<i>Campanula abietina</i>	3	0	0.2	0.8	1.2	0.7
15	<i>Campanula serrata</i>	3	0	2.4	0.6	1.6	0.8
16	<i>Hieracium aurantiacum</i>	4	2	0	0.6	1.2	0.6
17	<i>Linguisticum mutellina</i>	7	1	4.4	1.2	0	1.8
18	<i>Polygonum bistorta</i>	5	4	0	0	0.8	0.3
19	<i>Potentilla ternata</i>	4	1	2.2	1.2	0.6	1.3
20	<i>Rumex acetosella</i>	3	0	0.2	0.2	0	0.1
21	<i>Taraxacum officinalis</i>	7	3	3.8	3.6	2.0	3.1
22	<i>Viola declinata</i>	3	0	0	0	0	0
23	Other species	3	0	2.8	2.4	1.4	2.2
24	Pastoral value (ind.)			76.5	78.8	76.8	77.3
25	Green mass production (t/ha)			11.49	13.26	12.47	12.41

*) *Phleum pratense* from overseeding or reseeding

F = forage value indices (1-9)

M = green mass indices (1-9)

Also, the sown species *Phleum pratense* has a higher participation of 16-17% on the 02 variants compared to 12-13% on the 01 variants, although it was fertilized exclusively by grazing with animals.

The amendment boosted the participation of *Trifolium repens* species from 15% in the unamended variant to 26.5% in the 02 variant, with a maximum of 29% in the overseeded variant (22).

Table 1. The floristic composition, pastoral value and green mass production of the organically fertilized experimental variants (Blana - Bucegi (2018-2023) - part 2)

No.	B 02 Amended (%)				Difference B 02 – B 01 (%)	Average factor A (%)			Difference factor A (%)		
	12	22	32	Av.		10	20	30	20-10	30-10	30-20
1	55.4	61.6	68.8	61.9	81	62.6	67.7	73.6	108	118	109
2	0	18.2	26.8	15.0	54	6.5	24.9	32.5	383	500	131
3	0	2.0	5.4	2.5	68	0.4	3.7	5.2	925	1300	141
4	0	1.0	0	0.3	75	0.3	0.5	0.3	167	100	60
5	0.6	0	0	0.2	33	1.2	0.2	0	17	0	0
6	6.8	8.0	5.4	6.7	55	10.1	9.2	9.1	91	90	99
7	0.2	2.6	1.2	1.3	35	4.2	1.4	2.0	33	48	143
8	46.8	13.8	12.4	24.3	155	37.7	13.2	9.05	35	24	69
9	0.6	0	0.4	0.3	30	1.2	0	0.8	0	67	0
10	0.4	16.0	17.2	11.2	126	1.0	14.6	14.5	1460	1450	99
11	27.4	29.0	23.0	16.5	175	21.8	22.3	18.2	102	83	82
12	27.4	29.0	23.0	26.5	175	21.8	22.3	18.2	102	83	82
13	17.2	9.4	8.2	11.6	106	15.6	10.0	8.2	64	53	82
14	0.2	0	0.4	0.2	29	0.2	0.4	0.8	200	400	200
15	0	0.4	0.6	0.4	50	1.2	0.5	1.1	42	92	220
16	0.2	0.4	0.4	0.4	67	0.1	0.5	0.8	500	800	160
17	5.8	0.4	0	2.1	117	5.1	0.8	0	16	0	0
18	0	0.4	0.8	0.4	133	0	0.2	0.8	0	0	400
19	0.4	0.6	0	0.4	31	1.3	0.9	0.3	69	23	33
20	0	0	0	0	0	0.1	0.1	0	100	0	0
21	4.4	5.2	4.6	4.7	152	4.1	4.4	3.3	107	80	75
22	1.6	0	0.2	0.6	0	0.8	0	0.1	0	13	0
23	4.6	2.0	1.8	2.6	118	3.7	2.2	1.3	59	35	59
24	80.7	82.0	80.2	81.0	105	78.6	80.4	78.5	102	100	98
25	12.90	14.36	14.39	13.89	112	12.2	13.31	13.34	113	110	97

In general, the amendment stimulated species from other families, of which the fodder species *Taraxacum officinale*, *Ligusticum mutellina* and *Polygonum bistorta* stand out.

Profound changes in the composition of the grass carpet as a result of the factors of amendment 02 and sowing (20,30) have had a decisive influence on the productivity of grasslands.

The highest pastoral values were recorded for the overseeded variants (20) of 80.4 and amended (22) of 82.0 index.

The same conclusion was reached after 21 years of this experience (Maruşca 2017).

The highest green mass production was evaluated for variants 20 and 30 with 13.3 t/ha and amended variants 22 and 32 with 14.4 t/ha. By amendment, even after 24 - 28 years of administration, the production is 12% higher compared to the unamended variants.

Also, by overseeding and reseeding (20; 30) over the same time interval of almost 30 years, the production increases by 10-13% compared to the natural grassland with species from the spontaneous flora (100).

Next, the influence of improvement factors on cow milk production is presented, as a final result of our research (Table 2).

Table 2. Influence of improvement factors on cow milk production to the organically fertilized variants

Improvement factors	Variants	Green mass production		Pastoral value (ind.)	Cow milk production	
		t/ha	%		L/ha	%
A. Grass carpet type	1. Natural	12.20	100	78.6	4030	100
	2. Overseeding	13.31	109	80.4	4120	102
	3. Reseeding	13.34	109	78.5	4020	100
B. Lime amendment	1. Unamended	12.41	100	77.3	3960	100
	2. Amended	13.89	111	81.0	4150	105

Grasslands improved by overseeding (20) and reseeding (30) are rated with 9% higher green mass production compared to semi-natural grasslands (10) even after an average of 24-28 years after sowing.

Amended variants (02) have an even greater influence on production, having 11% more green mass than unfined variants (01).

Milk production was evaluated over 4000 litres, in an average season of 85 days of transhumance grazing on the livestock paddocking improved pastures, with a small difference of 2% more in the overseeded variant (20) than the other two variants 10 and 30.

Organic fertilization by simple grazing alone can cover 3% after 5 years, 7% after 10 years, 11% after 15 years and 15% after 20 years, if animals use constantly the same area of *Nardus stricta* degraded grassland in proportion of more than 60 - 80%, requiring radical measures to improve the grass carpet (Maruşca 2016).

Finally, the amended variants achieve the highest production of 4150 liters of milk per hectare, 5% higher than the unamended variants.

CONCLUSION

The factors to improve grasslands degraded by subalpine *Nardus stricta*, through calcium amendment, overseeding and reseeding have an influence almost 30 years after their application.

Through calcium amendment the production of green mass increases by 11% to 13.89 t/ha, from 12.41 t/ha for unamended.

By overseeding and reseeding, the average production of green mass after 24-28 years is 9% higher than the control grassland, a natural grass carpet with spontaneous species.

The evaluated production of cow's milk is around 4000 liters per hectare, 2% higher in the overseeded variants and 5% in the calcium-amended ones.

In the 5 series of grazing with sheep the first 3, and cows the last 2, in 28 years the species *Poa pratensis*, *Agrostis capillaris*, *Festuca nigrescens*, *Trifolium repens* and other valuable fodder species were strongly stimulated, which completely removed the dominant harmful species *Nardus stricta* at the beginning of the experiments.

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