Effect of some Improvement Works on the Floristic Composition of the Vegetal Cover in Nardus stricta Grasslands

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Abstract
The study of the floristic composition of Nardus stricta grasslands improved through fertilisation, amendment and re-sowing for 18 years points out a structural change of the vegetal cover compared to the initial state of the floristic composition. During this time interval, the share of Nardus stricta dropped from 40 to 14% in the variants grazed rationally (without treatments), from 40 to 4% in the variant fertilised with NPK and grazed, and from 40% to the total disappearance of the species in the variants fertilised with NPK, amended, and re-sowed. The species Nardus stricta was replaced by high-fodder value species such as Agrostis capillaris, Poa pratensis, and Trifolium repens.

Keywords: Nardus stricta; floristic composition; fertilisation; amendment; re-sowing.

1. Introduction

The Nardus stricta grasslands in the sub-Alpine area of Romania are degraded from a floristic point of view, because the dominating species has a high ecological plasticity and adapts to different levels of moisture and temperature, from 300 m to 2,200 m altitude, on acid, non-aerated, oligobasic, and oligotrophic soils. Research on these grasslands aimed at altering their floristic structure through improvement works such as replacing vegetation with more valuable species of grassland gramineae and legumes [1-7].
This paper point out the remnant effect of such works as fertilisation, amendment, and super-seeding on the evolution of the floristic composition of Nardus stricta grasslands.

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2. Materials and methods

Research results presented in this paper were produced by the Grassland Research-Development Institute (G.R.D.I.) of Braşov, Braşov County, Romania, in an experiment organised on Nardus stricta grasslands in the Bucegi Mountains, at an altitude of 1,800 m. The experiment encompassed complex technological variants during 1995-2010, with the following graduations of the experimental factors:
- A – natural grassland, not improved, and constantly grazed by cattle;
- B – natural grassland, improved with the following technology: $N_{150}P_{75}K_{75}$ (during 1996-1998) and cow folding (5 nights, 1 cow/6 m^2) in 2004 and 2010;
- C – natural grassland, improved with the following intense technology: amendments with CaO (7 t/ha) in 1995, fertilisation with $N_{150}P_{75}K_{75}$ (during the period 1996-1998) and

cow folding (5 nights, 1 cow/6 m^2) in 2003 and 2009;
- D – natural super-sowed grassland improved with the following technology: super-seeding with a mixture of gramineae and perennial legumes (1995), fertilisation with $N_{150}P_{75}K_{75}$ (during the period 1996-1998) and cow folding (5 nights, 1 cow/6 m^2) in 2002 and 2008. The area of each experimental plot was 0.75 ha; the plot was surrounded by a fixed fence. The study of the vegetation was carried out with the square method which allows to determine the pastoral value (PV) of each experimental variant. The paper presents the evolution of the floristic composition of Nardus stricta grasslands as a remnant effect of the treatments applied.

3. Results and discussions

The floristic structure of the sub-Alpine Nardus stricta grasslands in the Bucegi Mountains, Romania, in 1995, when the experimental field of Blana (1,800 m altitude) was established, had the following share of botanical families: 80% species of gramineae (Poaceae), 8% species of legumes (Fabaceae), and 12% species of other botanical families. Of the 15 botanical species identified, Nardus stricta shared 40%, followed by Poa media (17%), Agrostis rupestris (12%), Festuca ovina (8%), Trifolium repens (8%), Ligusticum mutellina (8%), Potentilla aurea (4%), Deschampsia flexuosa (3%), and other species.
From the point of view of fodder value, Nardus stricta grasslands in the studied area are made up of species with no fodder value at all (50%), followed by species with low fodder value (30%), and by species with medium fodder value (20%). Among higher fodder value species we identified in the vegetal cover of these grasslands, we noted Trifolium repens (8%) and Ligusticum mutellina (8%), as well as species with lower fodder value (Festuca ovina, Agrostis rupestris, Poa media, and Potentilla aurea). The pastoral value of the Nardus stricta grasslands in the Bucegi Plateau is 18, which points to a very poor fodder value of the vegetal cover. The evolution of the floristic composition of the Nardus stricta grasslands improved through fertilisation, amendment, and re-seeding for 18 years points out a structural change of the vegetal cover compared to the initial state of the floristic composition. Thus, floristic measurements in 2010 showed a strong decrease of the Nardus stricta share of the vegetal cover depending on the degree of technology applied: from the initial share of 40% in 1995, to 14% in the grassland rationally grazed by animal (with no treatment whatsoever), to 4% in the variant B fertilised with NPK, and to 0% in the variants C with fertilisation and amendment and D with re-seeding, fertilisation, and amendment (Table 1).
The number of species increased in the variants improved with about 30% compared to the natural Nardus stricta grasslands (not improved) and with 50% in the case of the high fodder value species. The species with the largest share that was present in all experimental variants and pointing to a good fodder value (index 3) was Agrostis capillaris: 12% in the variant A, 30% in the variant B, 14% in the variant C, and 39% in the variant D. To also note the appearance of a high fodder value species of gramineae (index 4), Poa pratensis: 7% in the variant A, 19% in the variant C (the influence of the amendment is obvious here) and 10% in the variant D. In the variant D (fertilised – amended – re-seeded), the share of the initial species of gramineae 15 years after treatment is rather good: Phleum pratense 10%, Festuca pratensis 5%, and Dactylis glomerata 4%. The pastoral value of the Nardus stricta grassland in 2010 in the variants improved ranged between 44 and 64 per variants from the point of view of the fodder value of the species existing in the vegetal cover: 44 in the variant A (rationally grazed), 50 in the variant B (fertilisation), 54 (fertilisation – amendment) and 64 (fertilisation – amendment – re-seeding). These values point to a high level of fodder quality in these improved grasslands. Floristic surveys in 2011 showed an improvement of the quality of the floristic structure in the experimental variants, i.e. an increase of the share of high fodder value plant species (Table 2). From this point of view, we noted a strong increase of the share of the species Poa pratensis (quality index 4): 45% in the variant A, 27% in the variant B, 45% in the variant C, and 50% in the variant D. The share of the species Festuca nigrescens also kept at the level of 2010 and, together with the species Poa pratensis, it has practically replaced the species Nardus stricta, which disappeared from the vegetal cover in all the variants except for the variant A (grazed rationally but not improved) where Nardus stricta still shares 15%. Legume species kept the level of 2010 in the variants B and C, but there was a

decrease of 50% in the variants A and D. in this category, Trifolium repens is the only species present in the vegetal cover. In the case of other botanical families, they increased slightly in all the variants improved. The pastoral values we calculated are higher than in 2010 (47 in the variant A, 53 in the variant B, 58 in the variant C, 62 in the variant D), which points to a considerable improvement of the floristic composition of these grasslands through the increase of high fodder values species in the floral composition.

Table 1. Floristic composition of improved grasslands valorised through dairy cows grazing at Blana – Bucegi, 2010

Species	Witness 1995	Variant (% participation)				Fooder value index
		A	B	C	D	
TOTAL GRAMINEAE	80	77	79	66	81	X
Nardus stricta	40	14	4	+	-	0
Festica nigrescens	+	18	27	17	5	3
Festuca ovina	8	2	-	+	-	1
Agrostis rupestris	12	9	5	4	4	1
Agrostis capillaris	-	12	30	14	39	3
Poa media	17	8	2	6	1	1
Poa pratensis	-	7	-	19	10	4
Poa annua	-	-	-	+	-	2
Deschampsia caespitosa	-	-	1	2	-	0
Deschampsia flexuosa	3	1	4	+	-	0
Anthoxanthum odoratum	+	-	-	+	-	1
Phelum alpinum	-	5	6	4	2	2
Dactylis glomerata (sem)	-	-	-	-	4	5
Festuca pratensis (sem)	-	-	-	-	5	5
Phleum pratense (sem)	-	1	-	-	10	5
TOTAL LEGUMES	8	11	10	13	9	X
Trifolium repens	8	11	10	13	8	4
Trifolium hybridum	-	-	-	-	1	4
Lotus corniculatus	-	-	-	-	-	4
TOTAL OTHER FAMILIES	12	12	11	21	10	X
Potentilla aurea chrys.	4	4	1	2	1	1
Ligusticum mutellina	8	5	1	2	-	3
Viola declinata	+	-	+	-	-	0
Campanula napuligera	+	-	1	-	-	0
Geum montanum		1	1	1	1	0
Ranunculus montanus	+	1	1	3	3	0
Hieracium aurantiacum	-	-	1	-	-	1
Alchemilla vulgaris	-	+	+	2	4	2
Polygonum bistorta	-	+	5	11	1	0
Alchillea sp.	+	-	+	1	-	2
Taraxacum sp.	-	1	-	1	1	2
Cerastium sp.	-	-	-	-	+	0
Veronica sp.	-	-	+	-	-	0
PASTORAL VALUE	18	44	50	54	64	X

In 2012, the floristic structure of the vegetal cover was characterised by interesting floral alterations compared to the previous years (Table 3). That year, the characteristics of the floristic composition were as follows:

- A drop to 10% of the share of Nardus stricta in the variant A (rational grazing alone);
- A decrease of the share of gramineae in all experimental variants: 67% in the variant A, 55%

in the variant B, 54% in the variant C, and 70% in the variant D;
- The occurrence, at higher levels, of Agrostis rupestris (3-8%), whose fodder value is low (index 1);
- The balanced maintenance of Agrostis capillaris (2-31%) and Poa pratensis (10-20%), species that increase the most the pastoral value of these grasslands;
- A slight increase of the share of legumes, i.e. of the specie Trifolium repens (7-18%);
- An increase of the share of species from other botanical families (20-33%) through the occurrence of other species in the vegetal cover whose fodder value is low (Ranunculus montanum, Campanula napuligera, and Polygonum bistorta). The pastoral value of the improved variants in 2011 varied within a range of 41 and 50, with higher values in the variant D that was fertilised – amended – re-seeded.

Table 2. Floristic composition of improved grasslands valorised through dairy cows grazing at Blana – Bucegi, 2011

Species	Witness	Variant (% participation)				Fooder value
	1995	A	B	C	D	index
TOTAL GRAMINEAE	80	93	70	64	80	X
Nardus stricta	40	15	+	-	-	0
Festica nigrescens	+	25	22	11	7	3
Festuca ovina	8	+	+	-	-	1
Agrostis rupestris	12	5	+	+	-	1
Agrostis capillaris	-	+	2	+	2	3
Phleum aplinum	-	+	2	3	+	2
Poa pratensis	-	45	27	45	50	4
Poa annua	-	1	8	+	+	2
Deschampsia flexuosa	3	2	+	-	1	0
Deschampsia caespitosa	-	+	5	5	10	0
Phleum pratense (sem)	-	-	-	-	5	5
Festuca pratensis (sem)	-	-	-	-	1	5
Dactylis glomerata (sem)	-	-	-	-	2	5
Poa media	17	+	4	+	2	1
TOTAL LEGUMES		5	14	13	4	X
Trifolium repens	8	5	14	13	4	4
TOTAL OTHER FAMILIES	12	2	16	23	16	X
Ranunculus montanus	+	1	3	6	7	0
Polygonum bistorta	-	+	10	11	2	0
Taraxacum officinalis	-	+	1	4	2	2
Potentilla ternata	4	+	+	+	+	1
Ligusticum mutellina	8	+	1	+	+	3
Hieracium aurantiacum	-	1	+	+	+	1
Viola declinata	+	+	+	+	+	0
Campanula napuligera	+	+	+	+	+	0
Campanula abietina		+	+	+	+	0
Achillea sp.	+	+	+	+	5	2
Alchemilla sp.	-	+	1	2	+	2
PASTORAL VALUE	18	47	53	58	62	X

Table 3. Floristic composition of improved grasslands valorised through dairy cows grazing at Blana – Bucegi, 2012

Species	Witness	Variant (% participation)				Fooder value
	1995	A	B	C	D	index
TOTAL GRAMINEAE	80	67	55	54	70	X
Spontaneous	80	66	55	54	60	X
Nardus stricta	40	10	+	-	-	0
Festica nigrescens	+	13	6	5	8	3
Festuca ovina	8	+	+	1	+	1
Agrostis rupestris	12	8	5	3	5	1
Agrostis capillaris	-	2	12	18	31	3
Phelum alpinum	-	2	3	2	2	2
Poa media	17	4	5	1	+	1
Poa pratensis	-	20	13	19	10	4
Poa annua	-	+	7	+	-	2
Anthoxanthum odoratum	+	2	+	+	-	1
Deschampsia flexuosa	3	4	+	+	-	0
Deschampsia caespitosa	-	1	4	5	4	0
Seeded	-	1	-	-	10	X
Phleum pratense	-	1	-	-	7	4
Festuca pratensis	-	-	-	-	3	4
TOTAL LEGUMES	8	13	18	13	7	X
Trifolium repens	8	13	18	13	7	4
TOTAL OTHER FAMILIES	12	20	27	33	23	X
Potentilla aurea	4	5	3	3	+	1
Ligusticum mutellina	8	7	5	5	2	3
Ranunculus montanus	+	2	2	3	3	0
Polygonum bistorta	-	+	12	16	7	0
Hieracium aurantiacum	-	1	+	+	-	1
Campanula napuligera	+	1	1	1	+	0
Taraxacum officinale	-	4	1	5	+	2
Achillea millefolium	-	+	1	+	1	2
Alchemilla vulgaris	-	+	2	+	10	2
Others species	-	+	+	+	+	0
PASTORAL VALUE	18	38	42	41	50	X

From a floristic point of view, the share of the species in the vegetal cover in 2013 maintained at the level of 2011, with a few exceptions (Table 4):

- The complete disappearance of the species Nardus stricta in the variants C and D with maintenance of the share in the variant A (15%) and the re-appearance, 15 years later, of the species in the variant B (4%), where the remnant effect of the mineral fertilisation and of the cow folding disappeared;
- The maintenance of a large share of some species of valuable gramineae such as Agrostis capillaris (13-32%), Poa pratensis (13-26%), and Festuca nigrescens (2-20%);
- The maintenance of the share of legumes (6-18%), with an increase in the variant D (18%);
- A slight decrease of the share of different species (8-23%), stronger in the variant D (23%).

In 2013, the pastoral value ranged between 40 and 61%, with a peak in the variant D (61).

Table 4. Floristic composition of improved grasslands valorised through dairy cows grazing at Blana – Bucegi, 2013

Species	Witness	Variant (% participation)				Fooder value
	1995	A	B	C	D	index
TOTAL GRAMINEAE	80	74	69	65	74	X
Spontaneous	80	74	69	65	64	X
Nardus stricta	40	15	4	-	-	0
Festica nigrescens	+	20	12	17	2	3
Festuca ovina	8	5	+	+	+	1
Agrostis rupestris	12	10	7	1	3	1
Agrostis capillaris	-	+	18	13	32	3
Phelum alpinum	-	2	5	4	+	2
Poa media	17	5	2	2	+	1
Poa pratensis	-	13	14	26	23	4
Poa annua	-	+	+	+	-	2
Anthoxanthum odoratum	+	+	+	+	-	1
Deschampsia flexuosa	3	2	2	+	-	0
Deschampsia caespitosa	-	+	5	3	4	0
Seeded	-	2	-	-	10	X
Phleum pratense	-	2	-	-	7	4
Festuca pratensis	-	-	-	-	3	4
TOTAL LEGUMES	8	6	8	15	18	X
Trifolium repens	8	6	8	15	18	4
TOTAL OTHER FAMILIES	12	20	23	20	8	X
Potentilla aurea	4	7	3	1	+	1
Ligusticum mutellina	8	10	2	1	+	3
Ranunculus montanus	+	1	+	2	2	0
Polygonum bistorta	-	1	15	12	1	0
Hieracium aurantiacum	-	+	+	+	+	1
Campanula napuligera	+	1	1	1	2	0
Taraxacum officinale	-	+	2	2	+	2
Achillea millefolium	-	+	+	+	+	2
Alchemilla vulgaris	-	+	+	1	3	2
Others species	-	+	+	+	+	0
PASTORAL VALUE	18	40	42	52	61	X

4. Conclusions

The evolution of the floristic composition of the *Nardus stricta* grasslands improved through fertilisation, amendment, and re-seeding treatments for a period of 18 years points out a structural change of the vegetal cover compared to the initial state of the floristic composition. Thus, floristic measurements made in 2010 show a strong decrease of the share of *Nardus stricta* of the vegetal cover depending on the intensity of the technology applied: from the initial share of 40% in 1995 to 14% in the grassland grazed rationally but with no treatment whatsoever, to 4% in the variant B fertilised with NPK, and to 0% in the variants C with fertilisation and amendment and D with re-seeding, fertilisation, and amendment.

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