The Influence of Mineral Fertilizer on the North-Eastern Romania Permanent Grassland as Investigated by Epithermal Neutron Activation Analysis

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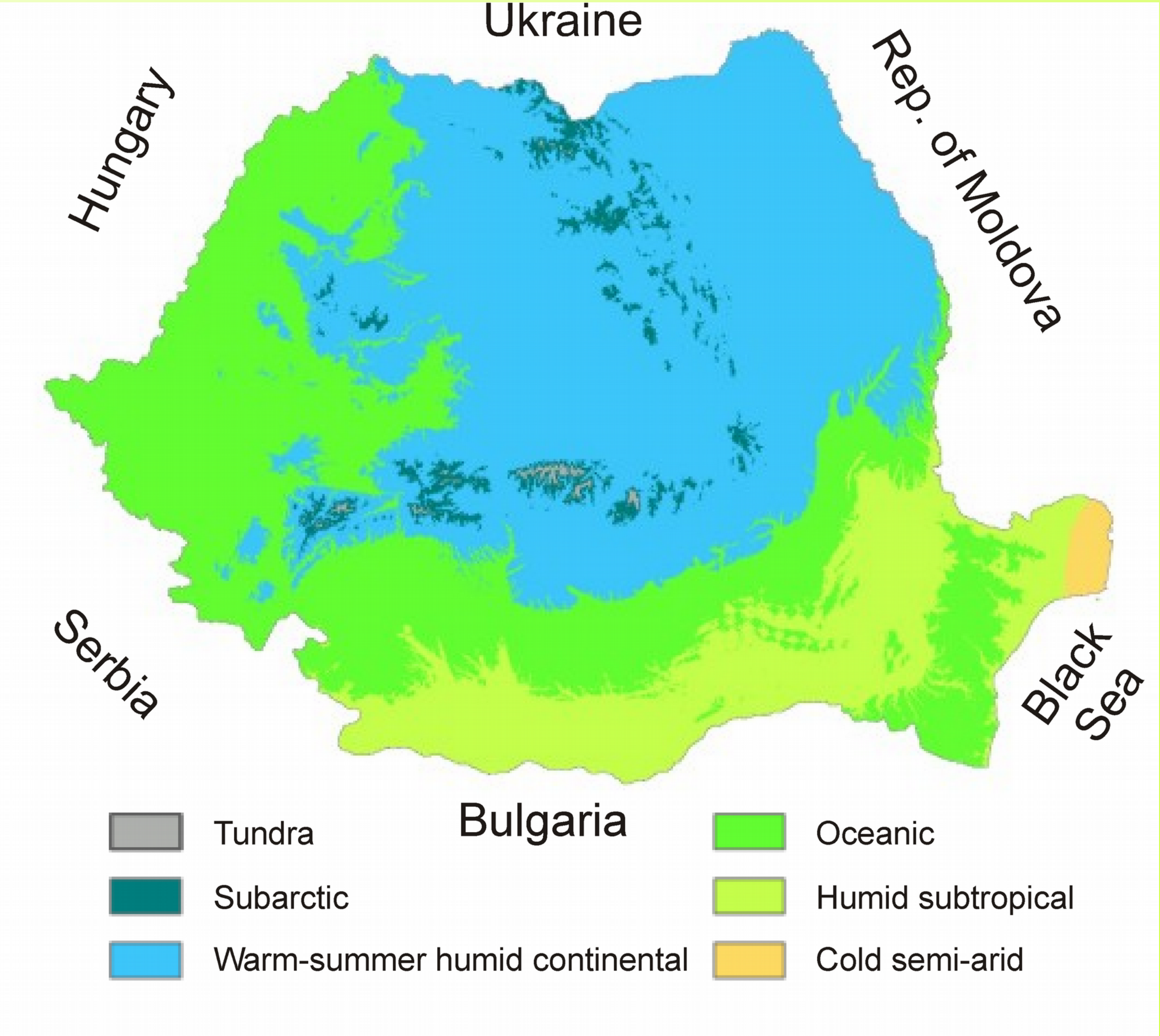
The Project

Romania is located in Southeastern Europe, bordering on the Black Sea, the country is halfway between the equator and the North Pole and equidistant from the westernmost part of Europe—the Atlantic Coast—and the most easterly—the Ural Mountains

The Project

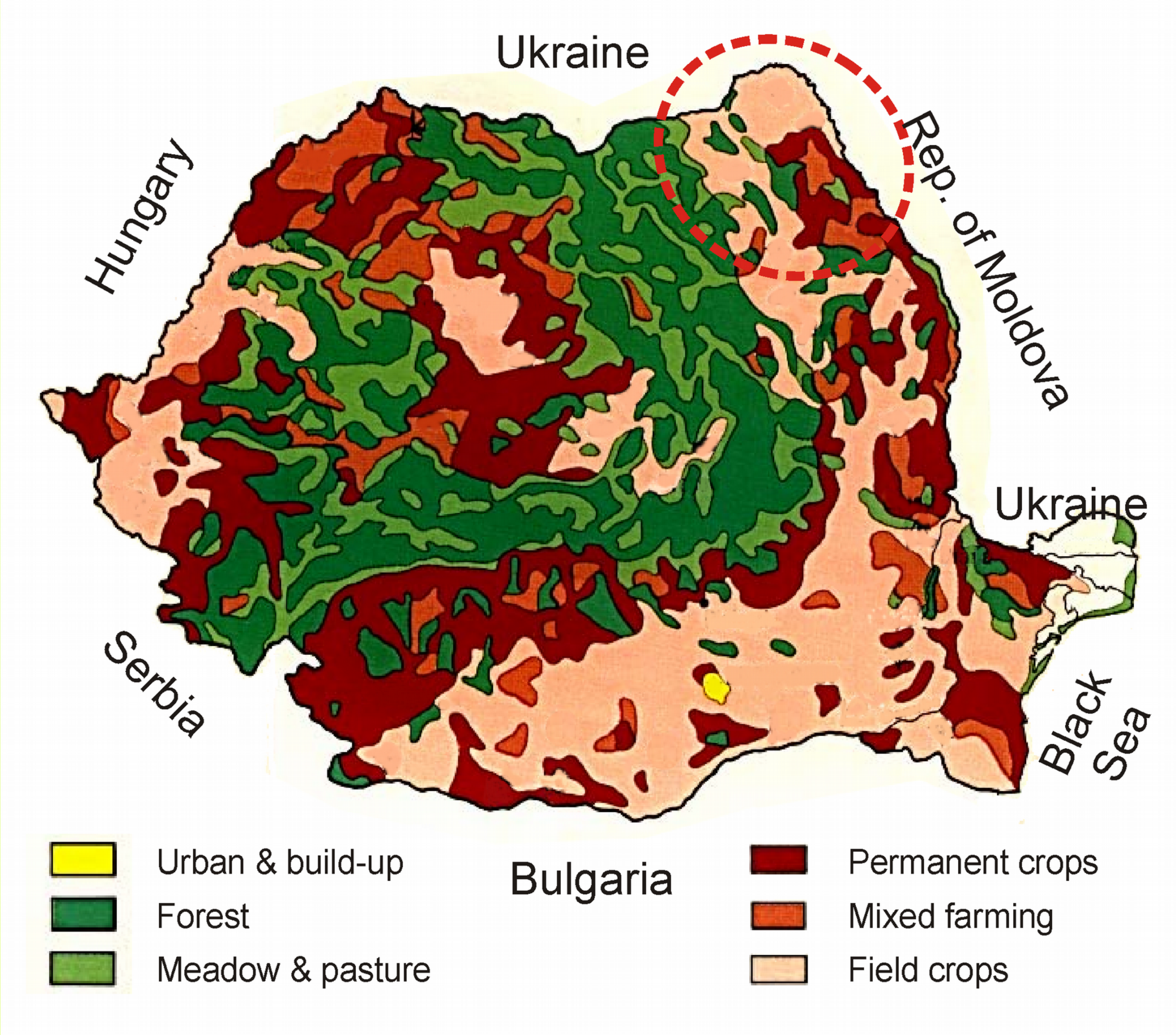
Various climatic zone from Humid subtropical to Subarctic and Tundra with an average temperature varying between + 11 °C South and + 8 °C North

Average precipitations are of 589 mm while average relative humidity is of 70 %



The Project

As climate and altitude play a paramount role in land using, Romania, from a total of 14.8 Mha agriculture classes, the exploitable grassland (pasture & hayfield) covers about 4.9 Mha



The Project

Altitude (m)	Pasture (kha)	Meadow (kha)	Total (kha)	%
> 2000	44	2	46	2
1501 - 2000	154	21	175	8
1001 – 1500	227	131	358	17
751 – 1000	311	291	602	30
501 – 750	488	375	863	43
Total	**1244**	**820**	**2044**	**100**

* Mountain areas (land over 500 m) occupy about 1/3 of the country

Pastures, which cover about 60 %of the mountain area (18 % of entire country) are in many places overgrazed.

As the number of cattle, sheep and goat is continuously growing, fertilizers appear as the best solution

The Project

Organic Fertilizers **healthy growing environment**	**Chemical Fertilizer** **rapid nutrition**
• Add natural nutrients to soil • Increase soil organic matter • Improve soil structure • Improve water holding capacity • Reduce soil crusting and erosion from wind and water • Consistent, but slow release of nutrients. • Non uniform distribution of nutrients • Cheaper per pound but less richer in essential nutrients	• Rich in essential nutrients needed for plants • Always ready for immediate supply of nutrients to plants if situation demands. • Some have acid content • Long term administration changes soil fertility • Apparently cheaper as pack more nutrients per pound of weight • May contain high level of harmful components

Before making a choice between organic and mineral fertilizers, a short differential analysis could be of interest

The Project

Major elements in forages for ruminant nutrition

Sodium and chlorine - to maintain proper acidity levels in body fluid and pressure in body cells

Magnesium is necessary for the utilization of energy in the body and for bone growth

Phosphorus is the essential component of ATP, the universals energy vehicle in mammals, and not only

Calcium - blood clothing, of muscles contraction, proper functions of numerous biochemical reactions in the body

Potassium - maintains proper acidity levels in body fluids, optimal pressure in body cells as well as participate to the enzymatic reactions in carbohydrate metabolism and protein synthesis

The Project

Trace elements in forages for ruminant nutrition

Iron is an essential part of hemoglobin

Cobalt is necessary for the microorganisms in the rumen to synthesize vitamin B12

Copper deficiency can result in anemia, depigmentation in hair, infertility, scouring, and cardiac failure

Zinc affects growth rate, reproduction, skeletal development, the utilization of protein, carbohydrates and fats

Manganese is essential for the utilization of carbohydrates

Molybdenum forms an essential part of some enzymes and also have a stimulating effect on fibre-digesting microorganisms in the rumen

Selenium deficiency may result in nutritional muscular dystrophy

The Aims

Main Goal:

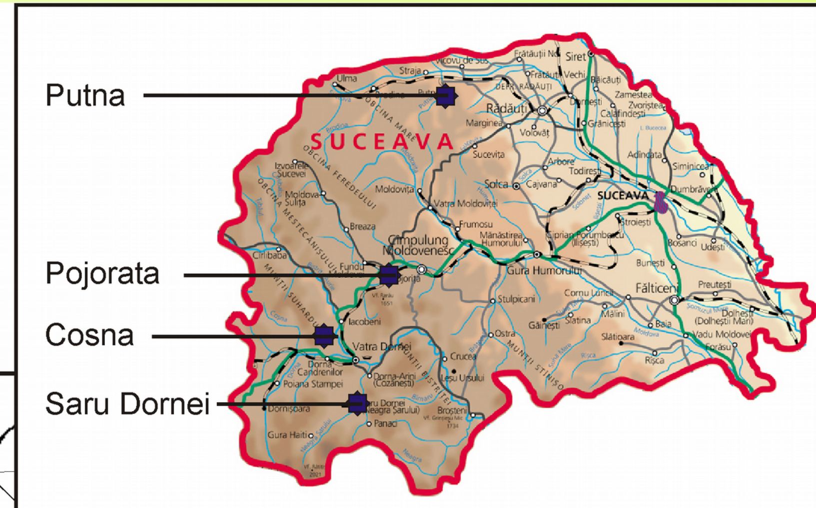
To characterize the quality of permanent grasslands in a potential area of ecological agricultural production in North-Eastern Romania by evaluating the content of essential and potential pollutant elements in order to optimize ruminants nutrition

Specific question:

- Do the organic and mineral fertilization influence the intake of essential minerals into forages ?
- Do the investigated forages fulfill the dietary requirements ?

Materials and Methods

Four different grasslands in Suceava county, North-eastern Romania



Coşna (840 m alt.)
Pojorîta (717 m alt.)
Putna (611 m alt.)
Saru-Dornei (940 m alt.)

Materials and Methods

Agrotis capillaris

Festuca rubra

Nardus stricta

Three different species of grasses, well appreciated by ruminants (cattle, goat, sheep) and commonly found on mountai grasslands

Materials and Methods

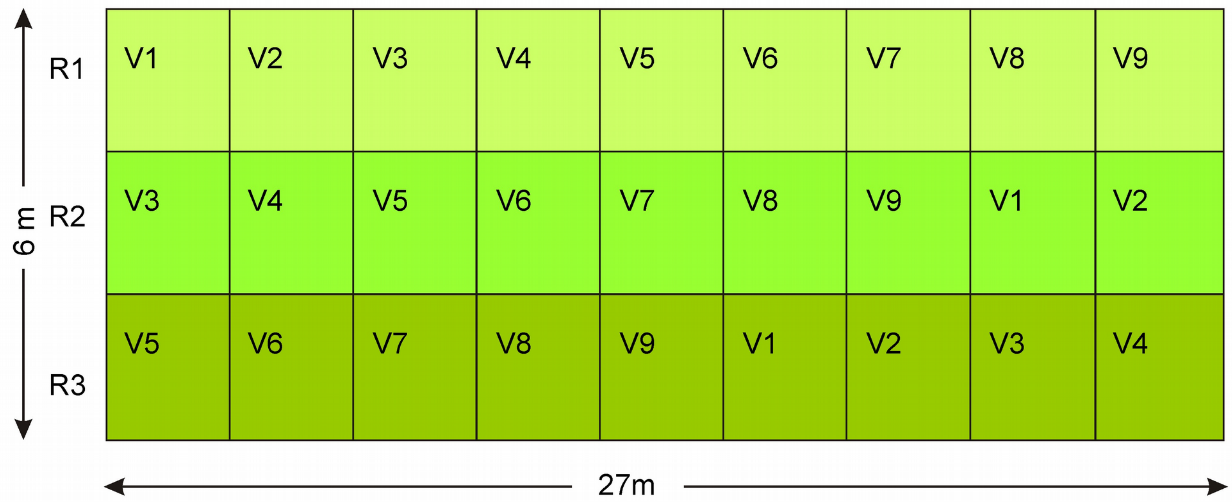
Locality ***Grass species***	**Natural fertilizer** **(tons/ha)**	**Chemical Fertilizer** **(kg/ha)**
Cosna *Nardus stricta* L	20 to 50 t of manure applied annually or bi-annually (1 – 4 y)	$N_{100}P_{100}$; $N_{140}P_{140}$; $N_{200}P_{200}$ $N_{100}P_{100} + N_{40}P_{40}$ $N_{100}P_{100} + N_{100}P_{100}$ $N_{80}P_{80} + N_{60}P_{60}$
Pojorata *Agrostis capillaris* L *Festuca rubra* L. *Nardus stricta* L.	10 to 50 t of manure applied annually, bi-annually (1 – 4 y)	30 kg -50 kg mineral nitrogen + 10 to 30 t of manure applied annually, bi-annually or every three years
Putna *Agrotis capillata* L, *Festuca rubra* L	20 to 50 t of partially or totally fermented manure	-----
Sarul Dornei *Festuca rubra* L, *Nardus stricta* L	20 t to 30 t of manure applied annually and bi-annually 50+0+40+0 t during four years	-----

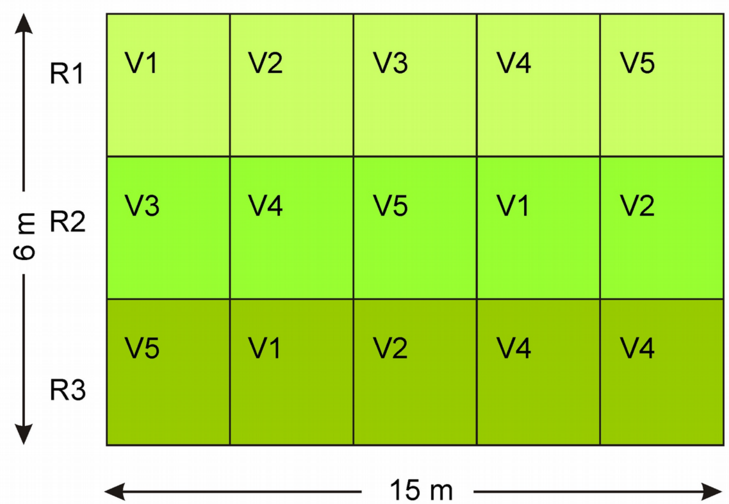
The experiments were set up in 2006 as a random block system of 5 to9 plots of land in 3 replications. Plants were collected and analyzed in 2010 and 2011

Materials and Methods

The experiments were set up in 2006 as a random block system of 5, 7 or 9 plots of land in 3 replications

Plants were collected and analyzed in 2010 and 2011





Cosna: 27
Pojorata: 21
Putna and Sarul Dornei: 15 blocks each

Materials and Methods

Contents of major and trace elements

Na, Mg, Al, Cl, K, Ca, Sc, V, Cr, Mn, Ni, Fe, Co, Zn, Se, As, Br, Sr, Rb, Mo, Sb, Ba, Cs, La, Sm, Hf, Ta, Th, and U were determined by Epithermal Neutron Activation performed at IBR-2 reactor of JINR

P content was determined by ICP-OAS (λ = 420 nm)

Forage quality chemical parameters

Ash (A), % – gravimetrically by muffle furnace at 550 °C ignition

Crude protein (CB), % – Kjeldahl method

Ether extract (EE), % - Soxhlet method

Acid Detergent Fiber (ADF),% - Van Soest method

Neutral Detergent Fiber (NDF), % – Van Soest method

Sulfuric lignin content (ADL), % – Van Soest method

Results and Discussion

Major and trace elements – unfertilized parcel

Chronic deficit of Na, partially of Cl and Mo (only Cosna). No elements above the maximum tolerable range

Element	BR	RR	AR	ATL	BR	RR	AR	ATL
	Cosna				Pojorîta			
Major elements								
Na	100	-	-	-	100	-	-	-
Mg	-	38	62	**12**	-	-	100	7
Cl	10	56	34	-	47	53	-	-
K	3	28	69	-	-	-	100	-
Ca	9	47	44	-	-	20	80	-
Trace elements								
Mn	-	-	100	9	-	-	100	-
Fe	-	-	100	9	-	-	100	**3**
Co	-	28	72	-	7	50	43	-
Zn	-	56	44	-	3	97	-	-
Se	-	97	3	-	-	73	27	-
Mo	41	-	59	-	-	-	100	-

BR below requirements; RR in requirements range; AR above requirements range; ATL above maximum tolerable range

Results and Discussion

Major and trace elements – fertilized parcel

Chronic deficit of Na, and Mo. No elements above the maximum tolerable range

Element	BR	RR	AR	ATL	BR	RR	AR	ATL
	Sarul Dornei				Putna			
Major elements								
Na	100	-	-	-	100	-	-	-
Mg	-	30	70	-	-	80	20	-
Cl	-	30	70	-	-	40	60	-
K	-	-	100	-	-	-	100	-
Ca	9	-	100	-	10	90	30	-
Trace elements								
Mn	-	-	100	-	-	-	100	-
Fe	-	-	100	-	-	-	100	-
Co	20	40	40	-	-	30	70	-
Zn	-	-	100	-	-	90	10	-
Se	-	50	50	-	-	90	10	-
Mo	40	-	60	-	50	-	50	-

BR below requirements; RR in requirements range; AR above requirements range; ATL above maximum tolerable range

Results and Discussion

Dietary Cation-Anion Difference (DCAD): Na + K – Cl represents the main descriptor of the influence of the grass major elements on cattle lactation and meat productivity

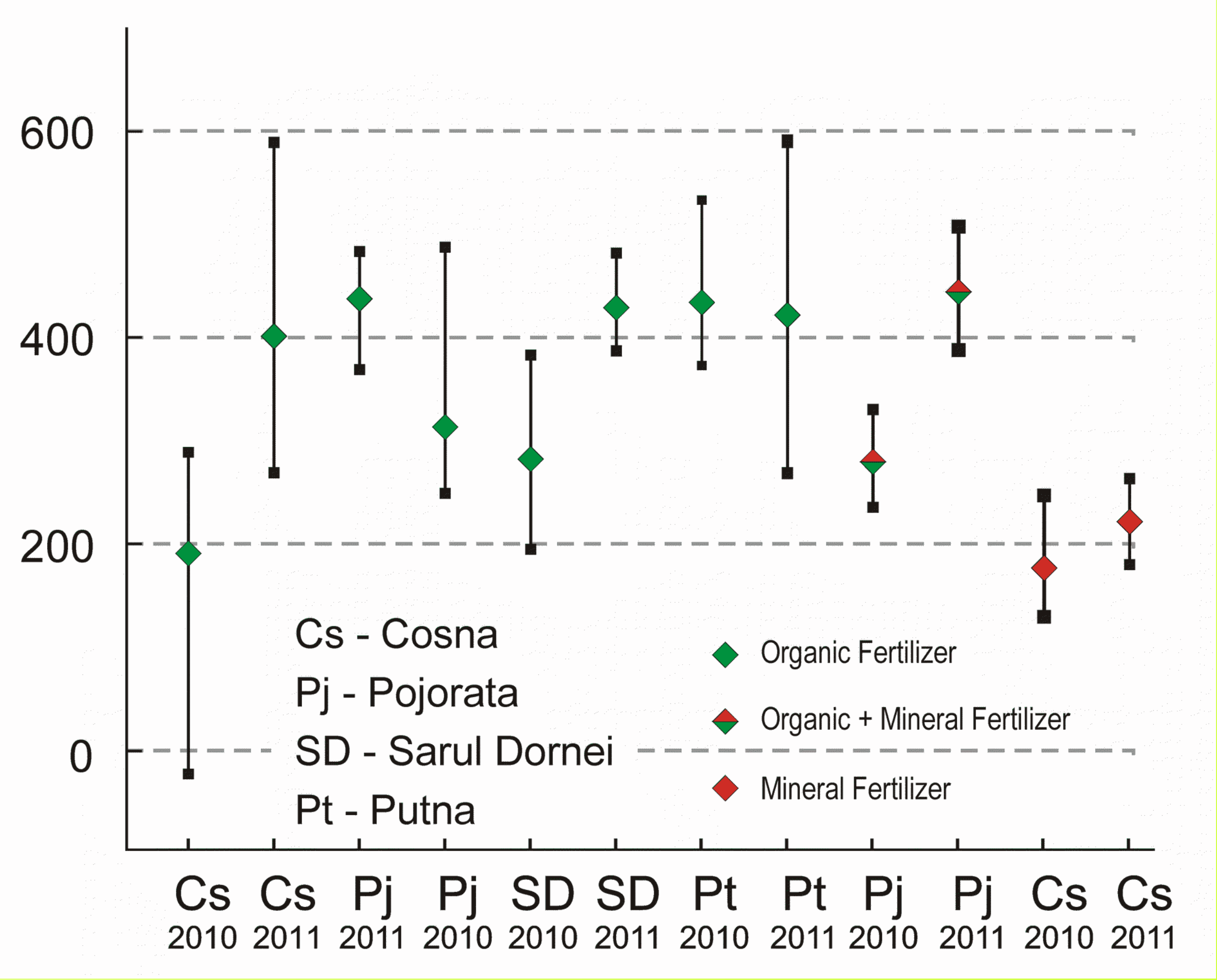
Location	Year	Mean ± St.Dev	Min	Max
Cosna	2010	194 ± 103	-21	293
Organic Fertilizers	2011	271 ± 88	401	593
Cosna	2010	181 ± 40	129	247
Mineral Fertilizers	2011	255 ± 30	225	265
Pojorata	2010	441 ± 44	366	493
Organic Fertilizers	2011	315 ± 75	244	488
Pojorata	2010	284 ± 16	269	306
Organic + Mineral Fertilizers	2011	449 ± 38	380	509
Sarul Dornei	2010	287 ± 71	196	359
Organic Fertilizers	2011	432 ± 42	386	483
Putna	2010	436 ± 67	369	535
Organic Fertilizers	2011	423 ± 21	401	451

In dry cows, a negative DCAD can help prevent metabolic problems; in lactating cows, a positive DCAD help increase milk production and milk components

Results and Discussion

Final results concerning the influence of fertilizer type on the DCAD evolution during experiment

Excepting one single case (Cosna, 2010), all other experiments with exclusive or blend organic and mineral fertilization indicate a higher DCAD than mineral fertilization



Results and Discussion

Final results concerning the influence of fertilizer on the content of major and some essential trace elements

Locality	Fertilizer	Na	Mg	Cl	K	Ca	Mn	Fe	Co	Zn	Se	Mo
Cs	O/2010										nsd	
Cs	O/2011		nsd	nsd				nsd			-	
Pj	O/2010			nsd			nsd	nsd	nsd		nsd	nsd
Pj	O/2011			nsd	nsd			nsd	-		-	nsd
SD	O/2010	nsd	nsd	nsd	nsd				nsd	nsd	-	nsd
SD	O/2011		nsd		nsd	nsd	nsd			nsd	-	nsd
Pt	O/2010		nsd	nsd				nsd	nsd		-	nsd
Pt	O/2011	nsd	nsd				nsd				-	nsd
Pj	(O+M)/2010		nsd	nsd	nsd	nsd		-	nsd	nsd	-	nsd
Pj	(O+M)/2011	nsd	nsd	nsd	nsd	nsd				nsd	-	nsd
Cs	(O+M)/2010			nsd	nsd	nsd			nsd	nsd	nsd	
Cs	(O+M)/2011							nsd	nsd		-	

Cs – Cosna, PJ – Pojorata, SD – Sarul Dornei, Pt – Putna; nsd – no significant difference, horizontal line - below detection limit; O – organic fertilizer, M – mineral fertilizer; all results were significant at $p < 0.01$ according to Student's t test

Cl, K and Ca have quite similar behavior

The most significant differences are in Cosna region, most probable due to differences in geographic position and soil properties

Results and Discussion

Final results concerning the content of some essential trace elements in all investigated grass species

Element	Cosna		Pojorita		Saru-Dornei		Putna		MTL
	min	max	min	max	min	max	min	max	
Al	90	1750	84	1370	157	1030	143	324	1000
V	0.4	2.2	<0.2	1.7	<0.4	1.7	0.5	1.0	50
Cr	<1.7	11	1.6	7.3	<2.3	6.1	2.9	4.9	100
Ni	<1.2	4.8	1.4	5.2	<1.8	6.0	3.4	7.6	100
As	0.6	3.4	0.4	2.8	0.8	2.6	0.9	2.0	30
Sr	13	48	9	209	28	51	21	41	2000

MTL Maximum Tolerable Level

Only the Aluminum content has overpasses the Maximum Tolerable Level

Results and Discussion

Final results concerning the influence of organic fertilization on chemical composition of forages obtained from *Nardus stricta* L. grasslands

Fertilization variant	CP	A	EE	NDF	ADF	ADL
V1 Unfertilized control	6.4	5.4	1.6	75	47	11
V2 20 t ha-1 every year	9.3	9.8	2.0	60	38	10
V3 30 t ha-1 every year	12	9.0	1.6	55	37	10
V4 40 t ha-1 every year	9.7	11	1.9	50	38	10
V5 50 t ha-1 every year	11	10	2.2	54	41	10
V6 20 t ha-1 every 2 years	12	8.8	1. 7	57	38	10
V7 30 t ha-1 every 2 years	12	9.0	1.3	58	39	9.5
V8 40 t ha-1 every 2 years	13	9.4	1.3	56	39	9.6
V9 50 t ha-1 every 2 years	13	10	1.5	55	43	9.2
LSD at $p < 0.05$	0.9	1.9	0.2	1	1	0.4

CP - crude protein; A – ash; EE - ether extract; NDF- neutral detergent fibre; ADF - acid detergent fibre; ADL -sulphuric lignin content; LSD – Lowest Significant Difference

Results and Discussion

Final results concerning the influence of mineral fertilization on chemical composition of forages obtained from *Nardus stricta* L. grasslands

Fertilization variant	CP	A	EE	NDF	ADF	ADL
V1 Unfertilized control	6.5	7.6	2.7	72	46	10
V2 $N_{100}P_{100}$	6.6	6.3	3.0	59	34	9.6
V3 $N_{140}P_{140}$	8.1	6.2	3.1	59	33	9.8
V4 $N_{200}P_{200}$	10	7.1	3.2	52	33	9.5
V5 $N_{100}P_{100} + N_{40}P_{40}$	11	6.0	3.0	55	34	9.7
V6 $N_{100}P_{100} + N_{100}P_{100}$	14	7.3	3.3	54	32	10.5
V7 $N_{80}P_{80} + N_{60}P_{60}$	11	6.2	2.6	59	40	9.6
LSD at $p < 0.05$	0.2	0.3	0.2	1.2	0.7	0.4

CP - crude protein; A – ash; EE - ether extract; NDF- neutral detergent fibre; ADF - acid detergent fibre; ADL -sulphuric lignin content; LSD – Lowest Significant Difference

Results and Discussion

Summary statistics regarding the content of major and trace elements at the end of 2010 – 2011 experiment (83 samples, ENAA results)

Element	Cosna non-fertilized	Cosna fertilized min	Cosna fertilized max	Pojorita non-fertilized	Pojorita fertilized min	Pojorita fertilized max	Saru-Dornei non-fertilized	Saru-Dornei fertilized min	Saru-Dornei fertilized max	Putna non-fertilized	Putna fertilized min	Putna fertilized max	RDMR	MTL
DACD elements (mg/kg)														
Na	84 ± 52	51	248	95 ± 25	70	176	70 ± 17	37	82	75 ± 19	61	107	1000-2200	40000
Cl	1960 ± 1300	634	6290	1350 ± 490	732	2760	2450 ± 2100	1950	8020	1750 ± 1700	1660	5670	1300-2900	40000
K	9500 ± 4500	1520	26600	16500 ± 3600	10300	22200	16200 ± 3500	13200	23200	16800 ± 3700	16100	26500	4700-10000	30000
Metabolic and structural elements (mg/kg)														
Mg	2800 ± 2400	1100	1140	5700 ± 1300	2520	7160	2500 ± 800	1700	4100	1900 ± 550	1140	2990	1100-2100	6000
P		700	4300		880	1740		1600	2800		1200	3300	2200-3800	7000
Ca	5150 ± 2600	2700	13200	1420 ± 4700	3920	19200	8650 ± 830	7950	11100	4100 ± 1550	3250	7630	3700-6200	18000
Enzymatic elements (mg/kg)														
Mn	550 ± 350	160	1410	87 ± 18	43.4	122	285 ± 40	197	323	540 ± 90	357	618	13-24	1000
Fe	300 ± 180	60	811	310 ± 150	<60	567	250 ± 130	<83	408	165 ±85	<86	330	12-40	500
Co	0.23 ± 0.10	0.12	0.45	0.21 ± 0.11	<0.06	0.30	0.1 ± 0.05	0.09	0.21	0.20 ± 0.10	0.15	0.24	0.10-0.15	25
Zn	70 ± 15	40	99	45 ± 3	<2.2	52	70 ± 10	57	82	48 ± 6	37	64	21-55	500
Se	0.10 ± 0.05	<0.14	0.34	0.20 ± 0.10	0.13	0.44	bdl	<0.24	0.38	bdl	<0.25	0.34	0.1-0.3	2
Mo	0.48 ± 0.41	<0.01	1.88	0.70 ± 0.10	0.24	0.89	0.10 ± 0.05	0.10	0.40	0.10 ± 0.10	<0.16	0.50	0.2	5
Potential toxic elements (mg/kg)														
Al	510 ± 440	90	1750	520 ± 390	84	1370	600 ± 330	157	1030	200 ± 50	143	324	--	1000
As	2.0 ± 1.0	0.6	3.4	1.0 ± 0.05	0.4	2.8	2.0 ± 1.0	0.8	2.6	1.5 ± 0.5	0.9	2.0	--	30
Sr	20 ± 9	13	48	bdl	9	209	bdl	28	51	bdl	21	41	--	2000

RDMR
Recommended Dietary Mineral Requirements

MTL
Maximum Tolerable Level

Concluding remarks

- The content of major elemets, except for Na, Cl and Mo (some localities) are in the requirement range or above.
- Only few grass samples contain essential minerals Mg, Mn and Fe in concentrations slightly higher than maximum tolerable limits
- The content of non-essential elements (except Al in very few cases) were well below the maximum tolerable limits
- The use of organic or blended organic and mineral fertilizers showed, excepting Cosna location, higher DCAD than mineral fertilizer ones
- The fertilization of *Nardus stricta* L. grasslands with organic and mineral fertilizers significantly improves its quality
- No significant differences between the use of organic and mineral fertilization were observed for the essential grass chemical parameters

Thank you for attention

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