INDICATOR SPECIES FOR SOIL ECOLOGICAL FACTORS FOUND IN THE NATURAL HABITAT 62C0* PONTO-SARMATIC STEPPES FROM ROSCI 0201, NORTH DOBROGEAN PLATEAU

Teodor Maruşca[*,**], D. Memedemin[*], Atena Groza[*], O.G. Pop[*], Ioana Simion[*], M.N. Tîbîrnac[*], D.I. Maftei[*], M. Mărunțiu[*], Elena Taulescu[**], Nicoleta Marin[***]**

[*]*Association for Sustainable Development DAKIA*
[**]*Research and Development Institute for Grassland - ICDP, Braşov*
[***]*National Research and Development Institute for Soil Science, Agrochemistry and Environment - ICPA, Bucharest*
[****]*Corresponding author e-mail*: maruscat@yahoo.com

Abstract

This paper makes a first assessment on the indicator species for physical and agrochemical conditions of soil specific to the Natural Habitat 62C0 Ponto-Sarmatic steppes from the protected area ROSCI 0201, North Dobrogean Plateau. The species Galium humifusum indicates soil without skeleton content while the species Astragalus glaucus indicates soil with a high skeleton content; Festuca callieri prefers soils with mild acid reaction and Marrubium peregrinum indicates soils with mild alkaline reaction; Dianthus nardiformis indicates a low carbonates content while Medicago falcata highlights a high carbonates content; Medicago lupulina prefers soils with a low humus supply and Achillea pannonica a high humus supply; Agropyron cristatum and Bromus hordeacens are indicator species strictly for a low phosphorus content and finally the species Thymus zygioides and Cynodon dactylon reveal high and very high potassium content. These data are valuable for assessing proper management strategies for this protected area and for its biodiversity and pastoral landscape conservation.*

Keywords: steppe grasslands**,** indicator species, soil agrochemical analysis.

INTRODUCTION

It is well known that spontaneous plant species characteristic to the vegetation of permanent grasslands are found in certain natural stationary conditions and under specific anthropogenic influences. Numerous scientific works pointing out the biological, ecological and economic indicators of the grassland flora have been published over time in our specialized literature (Csűrős *et al.*, 1967; Kovacs, 1979; Păcurar and Rotar, 2014; Maruşca, 2016). The ecological optimum for light, temperature, humidity, soil reaction and trophic conditions as well as agronomic characteristics as forage value index and usable production value, tolerance to mowing, crushing, grazing and other were rated for these species with grades from 1 to 5 or from 1 to 9. Thus, each species from a permanent grassland prefers to grow and develop in certain seasonal

conditions and under different management practices. We could say that there is a close link between definitions of "optimum" and "indicator" species. Thus, if it can be shown that a plant prefers certain natural and management conditions, it can be considered an indicator for the factors that make up these conditions.

Recently, indicators for permanent grasslands management have been developed, expressing the degree of production intensification and the forage quality represented by the floristic composition of the vegetal layer (Rotar *et al*., 2017; 2020).

So far, for the stationary soil conditions were evaluated only the soil reaction (pH) and trophicity (N) with little reference to the physical and agro climatic factors (Hund, 1966; Lauer, 1974; Maruşca, 1982). This paper presents the indicator species characteristic for the main physical and agrochemical conditions of soils, specific to the Natural Habitat 62C0* Ponto-sarmatic steppes within the protected area ROSCI0201, Nord Dobrogean Plateau.

MATERIAL AND METHOD

The research was made within the project ”***Integrative management for the North Dobrogean Plateau (MiPoNoDo), 116964 MySMIS code*** ” which covered non-forestry habitats, precisely ”*Natural habitats of community interest 62C0*, Ponto-Sarmatic steppes in ROSCI0201*” (figure 1).

In 2019 we performed 67 floristic surveys (during two field trips made in June and July).

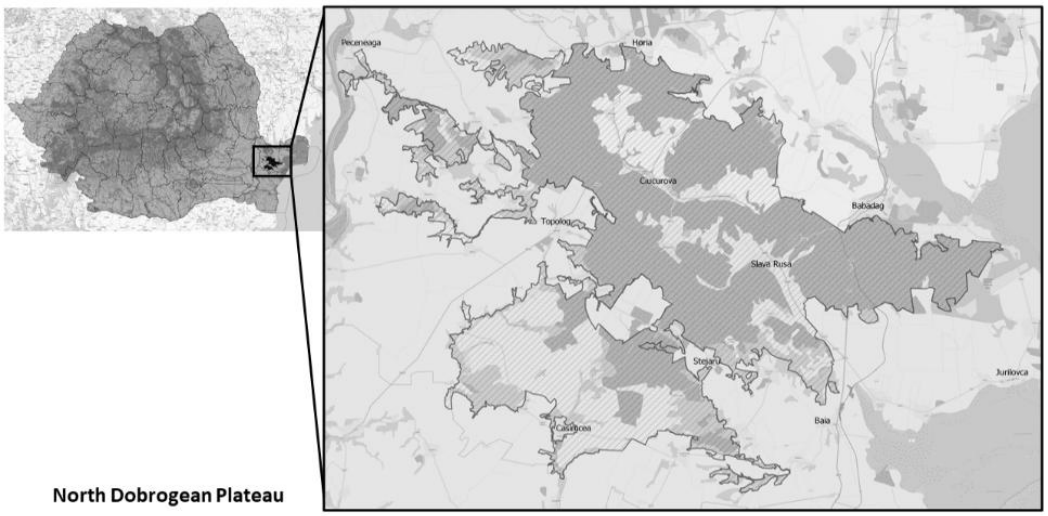

Figure 1. Location of the research area
Source: Original

The sampling surface was 100 m^2 (10x10m). Soil samples were taken on the diagonals of the sampling area, from a depth of 10 cm with a soil corer having a diameter of 25 mm. The participation of plant species in grassland vegetal layer was appreciated directly in percentages according to the Klapp - Ellenberg method.

Regarding the floristic composition, the Habitat 62C0* Ponto – Sarmatic steppe is dominated by the species *Festuca valesiaca* (27%) and *Botriochloa ischaemum* (13%), followed by *Cynodon dactylon, Stipa capillata, Thymus pannonicus, Artemisia austriaca, Euphorbia sequeriana, Crataegus monogyna, Teucrium chamaedrys, Poa bulbosa, Eryngium campestre, Achillea pannonica, Thymus zygioides, Potentilla argentea, Teucrium polium* and *Agropyron cristatum* with a percent of participation of 1 - 5%, the rest of the species accounting approximately 90% of the total identified species, shared a participation under 1% in the vegetal layer of these grasslands.

These grasslands are in a very advanced state of degradation due to inappropriate maintenance and irrational exploitation with very high number of animals, especially sheep, all year round.

The pastoral value is low (only 26) and the usable grass production is 2.54 t / ha green mass that supports a very low stocking rate of 0.21 LU / ha. The assessment of the soil physical components, respectively skeleton content (2-25 mm) and their classification was made at the Geological Institute of Bucharest. The geological substrate represented by the skeleton content of the soil sampled from the 67 stations, is mainly made up of "green shales" (green siltite, fine sandstone, hydrothermal quartz, para gneise, quartzo-feldspathic sandstone, rhyolite, etc.), with acid reaction, widespread in the Casimcea Plateau.

In the Babadag Plateau, the skeleton content of the soil collected from the surface belongs to a cover dating from the Upper Cretaceous period (fine sandstone limestones, fine calcarenites, microsparitic limestones, silicified limestones, etc.) that gave rise to soils with basic reaction, richer in carbonates.

The agrochemical analysis of the soil were performed by ICPA – Bucharest according to the following methods:

- **pH** in water suspension 1:2,5; SR 7184-13:2001, PTL 04
- **Carbonates:** gas-volumetric method; STAS 7184/16-80; PTL 43
- **Humus:** wet oxidation; STAS 7184/21-82; PTL 12
- **P_{AL}:** phosphorus extractable in ammonium acetate-lactate; STAS 7184/19-82; PTL 19
- **K_{AL}:** potassium extractable in ammonium acetate-lactate; STAS 7184/18-80; PTL 22

The assessment of the physical components, respectively the skeleton content (2-25 mm), was made after an own evaluation, the rest of the agrochemical components being determined

according to the standardized classical methodology (Florea *et al*., 1987). The soil reaction classes (pH), those expressed in percentage (carbonates, humus, total nitrogen) and mg / kg (phosphorus and mobile potassium) with their assessment are presented in the tables and diagrams in the next paragraph.

Thus having for each floristic survey the main physical and agrochemical characteristics of the soil from the same surface, we were able to draw up ecological diagrams according to the Hund method (1966). Originally, the method highlighted the relative presence of a plant species in grassland vegetal layer in dependence with the agrochemical characteristics of the soil. Later the Hund method was improved by Lauer (1974) and Maruşca (1982), who introduced the relative participation in relation to the same soil agro-chemical characteristics. Specifically, in order to evaluate the relationship between them, each agro-chemical factor is related with the presence and participation of a certain plant species. This results in a series of data regarding the presence and participation of the selected plant species in relation to the analyzed soil characteristic. Furthermore, the highest score for the presence of evaluated species is equalized with 100, number to which relate the rest of the presences of plant species for the other lower scores for the same agro-chemical factor. The same approach is used to evaluate the participation of plant species in the vegetal layer In relation with the agro-chemical factors.

The result is an expressive chart (eco-diagram) presenting the relative dependence of the presence and participation of a species in the vegetal layer in relation with some physical or agro-chemical components of the soil. The species chosen to represent the ecological optimum and indicator species for the agrochemical factors in the soil, met the following conditions: - they are perennial species;

- share the same management conditions (overgrazing with sheep);
- presence over 10% from the total floristic surveys (minimum 7 or more plots);
- participation from"+" up to more than 3% in the grassy carpet;
- curve overlapping of maximum presence over maximum participation at the same value range in the distribution chart for ecological optimum;
- presence and participation within the same agrochemical value range for strict indicator species.

Following these basic criteria for each agrochemical factor and value range, the 3 most representative species were selected in order of their importance. Since we did not find indicator species for all agrochemical values, several species that vegetate within the broader limits of factors not mentioned in the main table of results have been accepted.

RESULTS AND DISCUSSION

First of all we present data concerning the minimum, maximum and average limits of the physical and agrochemical values of the soil for Habitat 62C0* and for the species *Festuca valesiaca*, found in all 67 surveys compared to the 19 most important indicator species (Table 1).

Table 1

The physical and chemical analyzes of soils characteristic to the surveys found in the Habitat 62C0* *Ponto - sarmatic steppes*

No. crt.	Item (no. stations)	Value	P (%)	Skeleton (2-25 mm) %	pH	Carbonates (%)	Humus (%)	N total (%)	P_{AL} (mg/kg)	K_{AL} (mg/kg)
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	Habitat 62 C0* (67 st.)	Min.	50	0.0	5.33	0.0	1.66	0.141	4	99
		Max.	100	49.9	8.32	34.1	15.87	0.708	137	696
		Mean	**83.0**	**6.9**	**7.06**	**5.4**	**6.40**	**0.338**	**15**	**238**
1	*Festuca valesiaca* (67st.)	Min.	1	0.0	5.33	0.0	1.66	0.141	4	99
		Max.	55	49.9	8.32	34.1	15.87	0.708	137	696
		Mean	**22.5**	**6.9**	**7.06**	**5.4**	**6.40**	**0.338**	**15**	**238**
		%	27,1	100	100	100	100	100	100	100
2	*Achillea pannonica* (20 st.)	Min.	1	0	5.42	0	2.37	0.141	5	110
		Max.	20	6.7	8.3	34.1	9.06	0.557	80	696
		Mean	**1.22**	**2.4**	**6.98**	**5.2**	**6.6**	**0.355**	**18**	**338**
		%	1.5	35	99	97	103	105	120	142
3	*Agropyron cristatum* (7 st.)	Min.	+	0.0	6.01	0.0	2.15	0.162	9	119
		Max.	32	7.8	8.32	33.1	8.77	0.409	13	268
		Mean	**8.1**	**4.3**	**7.63**	**13.8**	**5.43**	**0.290**	**11**	**186**
		%	9.8	62	108	256	85	86	73	78
4	*Bromus hordeaceus* (6 st.)	Min.	1	0.0	6.20	0.0	2.15	0.162	9	127
		Max.	5	4.3	8.32	34.1	9.06	0.557	17	453
		Mean	**2.7**	**2.7**	**7.13**	**7.0**	**6.70**	**0.350**	**13**	**287**
		%	3.3	39	101	130	105	104	87	121
5	*Convolvulus cantabricus* (8 st.)	Min.	1	2.2	6.54	0	4.74	0.268	5	135
		Max.	15	25.3	8.05	34.1	13.27	0.557	16	376
		Mean	**5.88**	**8.83**	**7.64**	**12.26**	**8.39**	**0.411**	**11**	**241**
		%	7.1	128	108	227	131	122	76	101
6	*Crataegus monogyna* (17 st.)	Min.	1	0	5.74	0	3.08	0.18	5	99
		Max.	20	6.7	8.02	28.7	15.87	0.708	17	519
		Mean	**1.75**	**2.9**	**6.82**	**3**	**7.98**	**0.41**	**10**	**255**
		%	2.1	42	97	56	125	121	67	107

Table 1 (continuation)

0	1	2	3	4	5	6	7	8	9	10
7	*Cynodon dactylon* (25 st.)	Min.	+	0.0	5.42	0.0	2.15	0.141	5	125
		Max.	55	32.8	8.32	20.8	9.06	0.440	137	696
		Mean	**12.6**	**3.1**	**7.03**	**3.3**	**6.30**	**0.313**	**23**	**309**
		%	15.2	45	100	61	98	93	153	130
8	*Dianthus nardiformis* (10 st.)	Min.	+	4.2	5.73	0.0	5.01	0.240	5	126
		Max.	8	49.9	7.80	1.1	7.87	0.443	27	284
		Mean	**4.8**	**21.0**	**6.59**	**0.2**	**6.10**	**0.327**	**12**	**182**
		%	5.8	304	94	4	95	97	81	76
9	*Eryngium campestre* (52 st.)	Min.	+	0	5.33	0	2.15	0.141	5	99
		Max.	5	49.9	8.28	34.1	13.27	0.592	137	656
		Mean	**1.58**	**7.66**	**6.89**	**3.99**	**6.19**	**0.333**	**15**	**231**
		%	1.9	112	98	74	97	99	100	97
10	*Euphorbia sequeriana* (16 st.)	Min.	1	0	6.04	0	2.62	0.141	5	120
		Max.	30	49.9	8.3	33.1	7.87	0.405	137	411
		Mean	**7.94**	**7.44**	**7.49**	**7.1**	**5.14**	**0.277**	19	**215**
		%	9.6	108	106	131	80	82	127	90
11	*Fragaria viridis* (11 st.)	Min.	+	0	6.36	0	3.08	0.18	5	156
		Max.	5	8.9	8.00	9.4	11.37	0.592	42	696
		Mean	**2.18**	**3.04**	**6.84**	**1.1**	**7.08**	**0.368**	**13**	**308**
		%	2.6	44	97	20	111	109	87	129
12	*Galium humifusum* (16 st.)	Min.	+	0	5.42	0	2.62	0.141	5	127
		Max.	3	6.7	8.3	12.1	9.06	0.424	42	696
		Mean	**1.44**	**2.06**	**7.2**	**4.1**	**5.91**	**0.299**	**15**	**295**
		%	1.7	30	102	76	92	88	100	124
13	*Herniaria glabra* (15 st.)	Min.	+	0.6	5.42	0	2.37	0.191	5	119
		Max.	3	32.8	8.28	16.9	8.82	0.418	30	329
		Mean	**1.47**	**8.28**	**6.25**	**1.2**	**5.59**	**0.317**	**12**	**174**
		%	1.8	120	89	22	87	94	80	73
14	*Inula ochulus-christi* (7 st.)	Min.	1	1.6	6.15	0	7.58	0.388	6	110
		Max.	4	6.8	8.02	34.10	15.87	0.708	17	519
		Mean	**2.57**	**3.30**	**7.49**	**14.21**	**9.90**	**0.509**	**12**	**308**
		%	3.1	48	106	263	155	151	80	130
15	*Marrubium peregrinum* (14 st.)	Min.	1	0	6.54	0	2.37	0.191	5	168
		Max.	8	8.9	8.28	34.1	15.87	0.708	42	696
		Mean	**3.57**	**3.3**	**7.81**	**14.5**	**7.26**	**0.386**	**15**	**338**
		%	4.3	48	111	269	113	114	100	142
16	*Medicago falcata* (7st.)	Min.	1	2.1	6.01	0.0	4.77	0.179	7	99
		Max.	5	7.3	8.19	33.1	9.06	0.468	17	268
		Mean	**0.27**	**4.5**	**7.46**	**14.0**	**7.03**	**0.330**	**11**	**183**
		%	0.3	65	106	259	110	98	73	77
17	*Medicago lupulina* (7st.)	Min.	+	0.0	5.94	0.0	1.66	0.144	4	146
		Max.	4	6.7	8.25	12.1	8.11	0.440	80	541
		Mean	**0.15**	**1.9**	**7.44**	**4.5**	**4.76**	**0.271**	**22**	**300**
		%	0.2	28	105	83	74	80	147	126

Table 1 (continuation)

0	1	2	3	4	5	6	7	8	9	10
18	*Plantago lanceolata* (23 st.)	Min.	1	0	5.42	0	2.15	0.162	6	121
		Max.	5	14.5	8.32	20.8	9.06	0.592	137	696
		Mean	**0.61**	**3.2**	**6.9**	**3.7**	**5.93**	**0.328**	**19**	**290**
		%	0.7	46	99	69	93	97	127	122
19	*Poa bulbosa* (16 st.)	Min.	2	0.6	5.42	0.0	2.37	0.191	5	99
		Max.	35	14.5	8.28	16.9	15.87	0.708	42	696
		Mean	**6.6**	**4.4**	**6.79**	**1.4**	**6.85**	**0.350**	**13**	**234**
		%	8.0	64	96	26	107	104	87	98
20	*Thymus zygioides* (13 st.)	Min.	1	2.7	5.73	0.0	4.29	0.185	7	120
		Max.	15	39.8	8.06	33.1	13.27	0.443	18	256
		Mean	**5.8**	**12.5**	**6.99**	**6.24**	**7.04**	**0.343**	**10**	**188**
		%	7.0	181	99	116	110	101	70	79

The coverage or the participation of species from Habitat 62C0* in the vegetal layer is 83%, the rest of 17% being gaps in vegetation (area without vegetation), from which 6.6% fixed or mobile stones and 10.4% bare soil caused by overgrazing with animals. The participation of species in the vegetal layer varies starting from 0.2% for *Medicago lupulina* to 27.1% for *Festuca valesiaca* compared to 83% average vegetation cover for the evaluated habitat type.

These data can be related with a rather large variation of the physical and agro-chemical values of the soil.

Thus, the skeleton content (2-25 mm) varies from absence up to almost 50% of the weight of some soil samples. The soil reaction (pH) varies from moderate acid (5.33) to slightly alkaline (8.32) respectively on a gap of 3 units.

The carbonate content (%) ranges from the absence of carbonates up to 34.1% respectively very high value; the humus (%) ranges from low (1.66%) to very high (15.87%); total N ranges from middle content (0.141%) to very high content (0.708%); P_{AL} (mg / kg) ranges from 4 (very low) to 137 (very high) and K_{AL} fluctuates from 110 (low) to 696 (very high). We did not present which is the ecological optimum for the vegetal layer of the studied habitat, thus an eco-diagram is presented (figure 2).

Our diagram shows that both Habitat 62C0* and *Festuca valesiaca* species, found in all the 67 surveys, prefer soils with a very low skeletal content (0.1-3%), slightly alkaline (pH 7.9- 8.4), low carbonate content (less than 1%), medium in humus (3.6-8.0%), high in total N content (0.271-0.600%), low in P_{AL} (9-18 mg / kg) and high K_{AL} content (201-300 mg / kg). In order to choose the indicator species, in addition to their presence according to soil characteristics, the participation of species was also introduced. As example, the eco diagram of the *Agropyron cristatum* species is presented, which prefers soils with a lower skeletal content, weakly alkaline, medium nitrogen content and clearly indicates a low

mobile phosphorus content (figure 3). This species is unresponsive to carbonates, humus and mobile potassium content. After the elaboration of the eco diagrams for the main species found in the vegetal layer of 62C0* Habitat and after analyzing their selection conditions, the list of indicator species for the ecological optimum for the 7 physical and agro-chemical factors of the soil is presented (table 2).

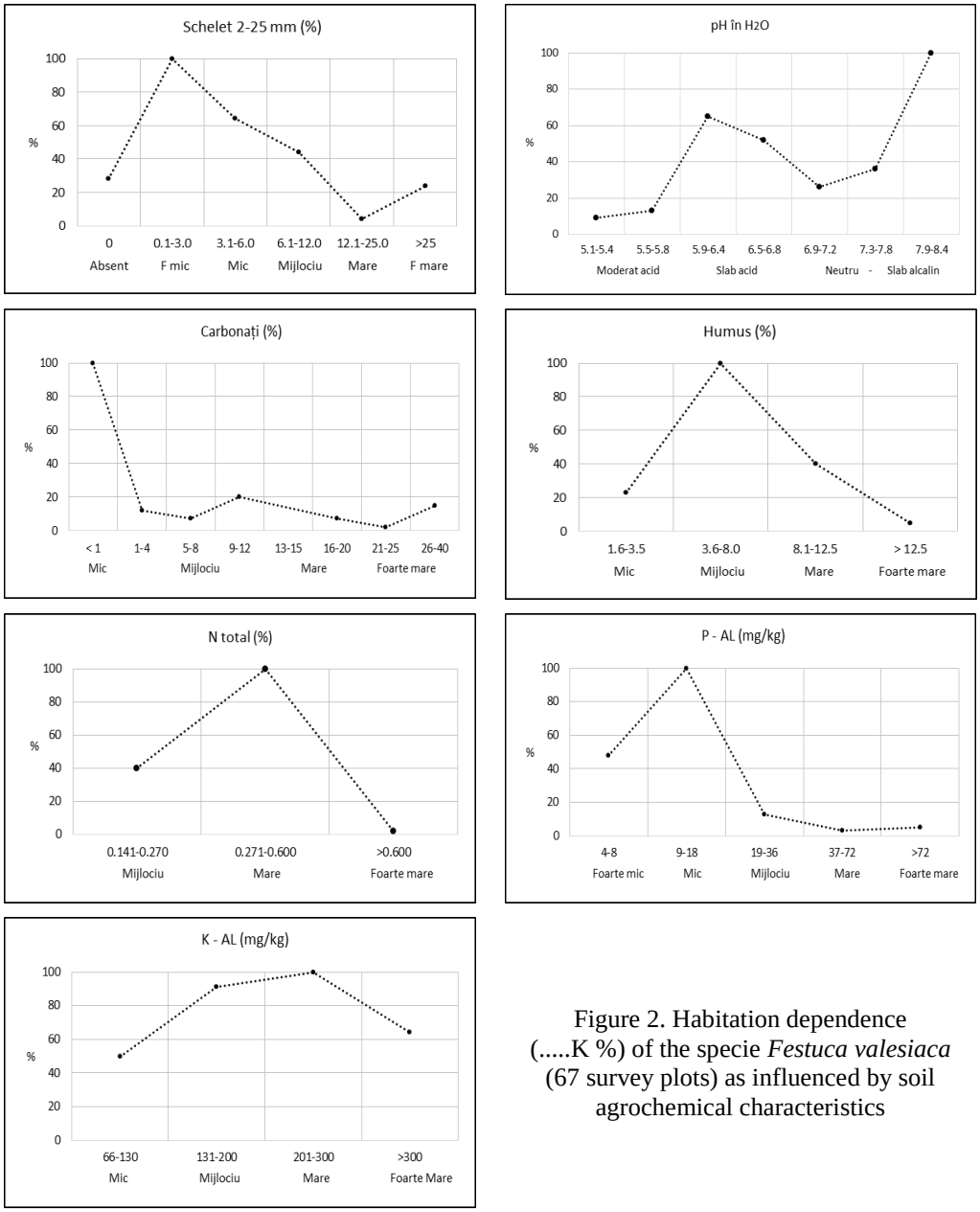

Figure 2. Habitation dependence (.....K %) of the specie *Festuca valesiaca* (67 survey plots) as influenced by soil agrochemical characteristics

Table 2

Indicator and ecological optimum species related to soil factors

Values	Species
1. Conţent in skeleton (2-25 mm)	
- Absent (0 %)	*Galium humifusum;*
- Very low (0,1-3 %)	*Medicago lupulina, Achillea pannonica, Marrubium peregrinum;*
- Low (3,1-6 %)	*Bromus hordeaceus, Agropyron cristatum;*
2. Soil reaction (pH)	
- Low alkaline (7,3-8,4)	*Marrubium peregrinum, Agropyron cristatum, Euphorbia sequieriana;*
3. Carbonates (%)	
- Low (< 1%)	*Dianthus nardiformis, Herniaria glabra, Poa bulbosa ;*
- High (13-25%)	*Medicago falcata;*
4. Humus content (%)	
- Low (1,6-3,5%)	*Medicago lupulina;*
- Average (3,6-8%)	*Herniaria glabra, Plantago lanceolata, Eryngium campestre;*
- High (over 8,1%)	*Achillea pannonica*
5. Total N (N; %)	
- Average (0,141-0,270%)	*Medicago lupulina, Agropyron cristatum ;;*
- High (0,271-0,600%)	*Convulvulus cantabricus*, Poa bulbosa, Fragaria viridis;*
- Very high (> 0,600%)	*Inula oculus-christi;*
6. Mobile phosphorus (P_{AL}; mg/kg)	
- Very low (4-8 mg/kg)	*Medicago lupulina;*
- Low (9-18 mg/kg)	*Agropyron cristatum*, Bromus hordeaceus*, Crataegus monogyina*
7. Mobile potassium (K_{AL}; mg/kg)	
- High (201-300 mg/kg)	*Thymus zygioides ,Eryngium campestre, Fragaria viridis;*
- Very high (> 300mg/kg)	*Cynodon dactylon, Galium humifusum, Plantago lanceolata;*

For each value attributed to the soil constituents, there are one to three indicator plant species for the ecological optimum.

Some species are strictly indicators for a range of soil values such as *Convolvulus cantabricus* for high total nitrogen content (0.271-0.600%), *Agropyron cristatum* and *Bromus hordeaceus* for low mobile phosphorus content (9-18 mg / kg). For the rest of the species mentioned in the previous tables the results are quite suggestive.

However, our results showed that for some ranges of values correspondent to some soil factors, we do not have indicator species chosen according to the established criteria.

Thus in addition, the following species are characterized according to their preference for the missing ranges of soil factors found in Table 2:

- *Astragalus glaucus* and *Astragalus onobrychis* prefer a medium skeleton content (6.1-12%) and a very high carbonates content (> 25%);
- *Asperula cynanchica* prefers a medium skeleton content as well as the previous species and a medium mobile potassium content (131-200 mg / kg);

- *Festuca callieri* is found especially on weakly acid soils (pH 5.9-6.8) without carbonates;
- *Onobrychis viciifolia* also prefers weakly acid soils with a medium mobile potassium content. These data concerning the indicator value of some species found in the Natural Habitat 62C0* Ponto-Sarmatic steppes, come in addition to the results regarding these species' autecology in relation to the physical and agro-chemical factors of the soil, aspects less studied so far.

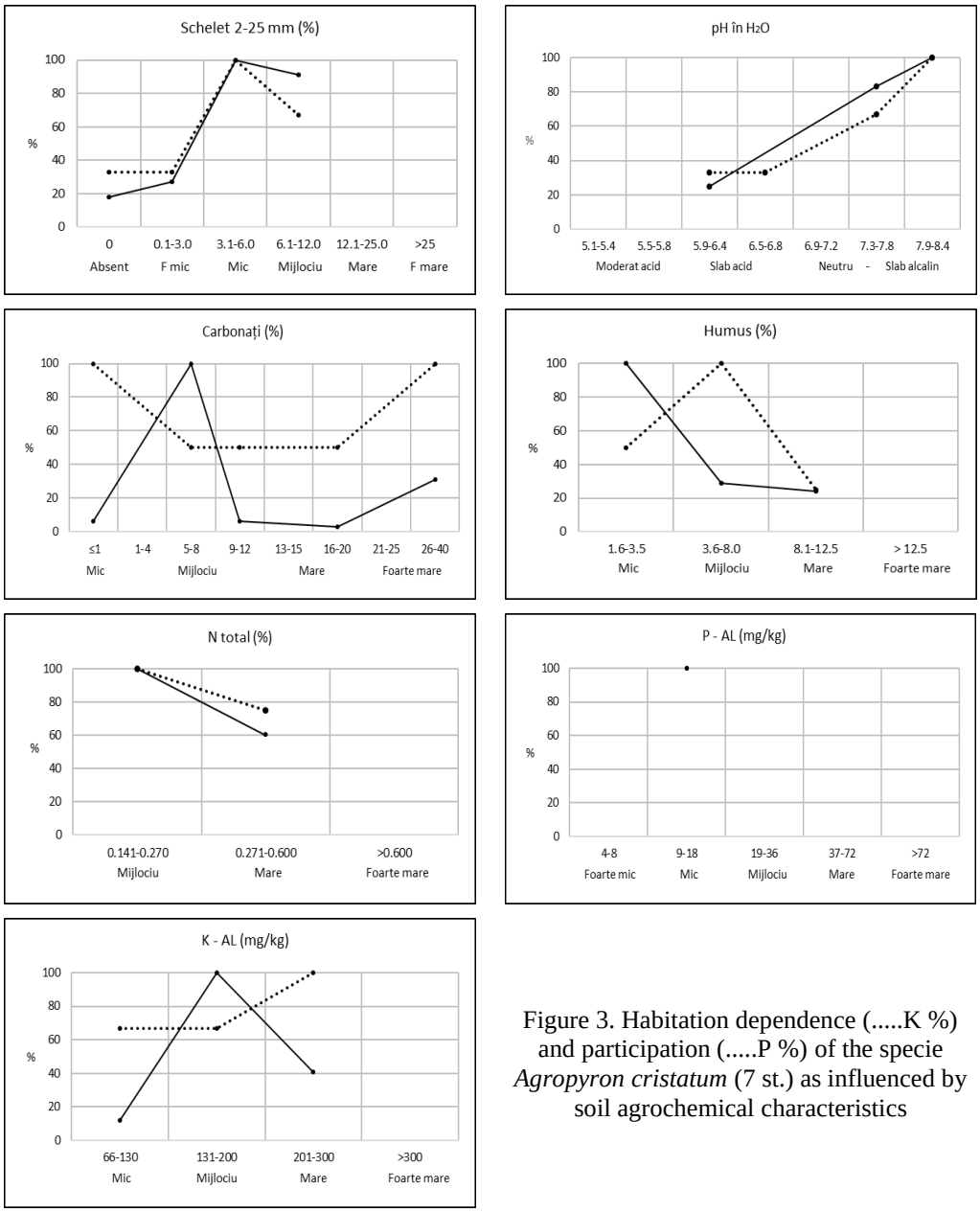

Figure 3. Habitation dependence (.....K %) and participation (.....P %) of the specie *Agropyron cristatum* (7 st.) as influenced by soil agrochemical characteristics

CONCLUSIONS

The studies concerning plant-soil relationship from steppe grasslands have highlighted numerous indicator species for the physical and agrochemical values of the soil.

The physical and agrochemical properties of the soil characteristic to the Habitat 62C0* Ponto-Sarmatic steppes are extremely different, having a higher skeletal content, neutral-weakly alkaline soil reaction, high humus and total nitrogen content, being very low and low in mobile phosphorus and medium and high in mobile potassium.

The indicator species for soil conditions are useful tools to correct some limiting properties for the productivity and biodiversity of steppe grasslands and to establish their integrated management measures.

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