Zbigniew KACZMAREK[1], Piotr GAJEWSKI[1], Andrzej MOCEK[1], Mieczysław GRZELAK[2], Agnieszka KNIOŁA[2], Bartłomiej GLINA[1]
Poznań University of Life Sciences
[1] Department of Soil Science and Land Protection, ul. Szydłowska 50, 60-656 Poznań, Poland
[2] Department of Grasslands and Natural Landscape Sciences, ul. Dojazd 11, 60-632 Poznań, Poland
e-mail: kazbig42@up. poznan.pl

GEOBOTANICAL CONDITIONS OF ECOLOGICAL GRASSLANDS ON LIGHT RIVER ALLUVIAL SOILS

Summary

The paper contains a geobotanical characteristics of grassland habitats where ecological management is conducted. It covers the assessment of floral diversity and a detailed description and interpretation of soil conditions. The research was conducted in the vegetation season of 2014 in an individual farm in Średnica (wielkopolskie Voivodeship, czarnkowsko-trzcianecki district). In the research area a number of phytosociological relevés was taken. Local habitats were described and characterised. Four soil opencasts were done within the area. Such properties as reaction, the content of total carbon, texture, soil density and its solid phase density, porosity, maximal hygroscopic capacity, water bond potentials of soil, readily and total available water and saturated hydraulic conductivity were marked. The investigated soils were river alluvial soils formed from alluvial sands of Notec's proglacial stream valley, they were characterised by high water permeability and low retention, both of which are typical to light soils. There was little amount of productive and available for plants water. Soil's porosity and density, as well as reaction, were on a beneficial level. Top horizons had high – as for sands – content of carbon which was a result of the specificity of alluvial origin of these soils. The investigated phytocenoses were covered with termophilic xerothermic plants which classifies to xerothermic grasses Festuco-Brometea. These were mainly phytocenoses with the domination of Festuca ovina, Festuca rubra and Agrostis capillaris. Furthermore, a group of Spergulo-vernalis Corynephoretum was found, with a large share of species from Agropyro-Rumicion crispi, what may indicate a flooding character of these grasslands.
Key words*: habitat, soil conditions, xerotermic grasslands*

WARUNKI GEOBOTANICZNE EKOLOGICZNYCH UŻYTKÓW ZIELONYCH WYSTĘPUJĄCYCH NA LEKKICH MADACH RZECZNYCH

Streszczenie

W pracy przedstawiono geobotaniczną charakterystykę siedlisk łąkowych, na których prowadzona jest rolnicza gospodarka ekologiczna. Obejmowała ona ocenę zróżnicowania florystycznego pokrywy roślinnej oraz szczegółowy opis i interpretację warunków glebowych. Badania wykonano we wrześniu 2014, na terenie indywidualnego gospodarstwa rolnego w miejscowości Średnica (województwo wielkopolskie; powiat czarnkowsko-trzcianecki). Na badanym terenie wykonano szereg zdjęć fitosocjologicznych. Opisano i scharakteryzowano występujące tam zbiorowiska. W obrębie wydzielenia wykonano 4 odkrywki glebowe. Oznaczono takie właściwości gleby, jak: pH, zawartość węgla ogólnego, uziarnienie, gęstość gleby oraz jej fazy stałej, porowatość, maksymalną pojemność higroskopową, potencjał wiązania wody przez glebę oraz jej potencjalną i efektywną retencję użyteczną, współczynnik filtracji. Badane gleby reprezentowały typ mad rzecznych, wytworzonych z piasków aluwialnych pradoliny Noteci; charakteryzowały się, typową dla gleb lekkich wysoką wodoprzepuszczalnością i niską retencją. Woda produkcyjna oraz dostępna dla roślin występowała w nich w niewielkich ilościach. Porowatość i gęstość gleby, jak również pH, kształtowały się w nich na korzystnym poziomie. Poziomy wierzchnie cechowały się wysoką – jak na piaski – zawartością węgla, co wynikało ze specyfiki aluwialnej genezy tych gleb. Badane zbiorowiska porośnięte były ciepłolubną roślinnością kserotermiczną, kwalifikującą się do klasy muraw kserotermicznych Festuco-Brometea. Były to głównie zbiorowiska z dominacją kostrzewy owczej (Festuca ovina), kostrzewy czerwonej (Festuca rubra) oraz mietlicy pospolitej (Agrostis capillaris). Ponadto wyróżniono zespół Spergulo-vernalis Corynephoretum, ze znacznym udziałem gatunków ze związku Agropyro-Rumicion crispi, co może oznaczać zalewowy charakter badanych łąk.
Słowa kluczowe*: siedlisko, warunki glebowe, murawy kserotermiczne*

1. Introduction

Water, soil and climate conditions as well as the intensity and system of tillage were the most important flora forming factors in the grassland [2, 3, 4, 5, 11, 12]. Negative changes are also often caused by inappropriately conducted amelioration [18]. These factors influence the biocenosis complexly, therefore, classic phytosocioogical research should be accompanied by the characteristics of a soil cover. Moreover, the research ought not to be finished on the analysis of top horizons, but cover the whole range of profiles. The paper contains a geobotanical characteristics of habitat grasslands where agricultural ecological management is conducted. It covered the assessment of floral cover and a detailed description and interpretation of soil conditions in the area formed by the alluvial river action. River valleys are areas of significant natural, utilization and cultural qualities. Plant habitats in the valleys differ in terms of nature as they are in various phases of evolutionary development of formation [6].

Maintained in natural state, they are considered as ecosystems of the most complicated structure and exceptionally high biological diversity. The development of grassland habitats, their richness and floral diversity stem mainly from the mosaicism of habitats, their trophism and intensity of tillage [2, 3].

2. Object and methodology

The research was conduced in the vegetation season of 2014 in the area of the Middle Notec valley in Środnica (Wielkopolskie Voivodeship, czarnkowsko-trzcianecki district). The object of the research was a grassland of 20 ha. It was tilled in an ecological manner which allowed observation of plant succession close to natural, at limited anthropic pressure. Floral research was conducted with Braun – Blanquet's method [1] in areas of 25 m^2. 26 phytosociological relevés were taken, the research included the most representative of them, though. In each of them, a percentage of undergrowth cover was determined, with the list of species including their numerical and sociability level. The species adherence to syntaxonomical units and flora classification was done in accordance to Matuszkiewicz [8], whereas the nomenclature of traheotypes – in accordance with Mirek et al. [9]. Soil cover of the object was composed of river alluvial soils. Such soils cover main river channels and their presence is a prove of a long-term and gradual development of valleys and proglacial stream valleys. They are mainly composed of alluvial sediments both mineral and organic, lay down by the floating waters and from the sediments deposited during rising water and also sedimenting during periodical flooding. Mineral material of alluvial soils is usually flat and its individual facies are characterised with strong arrangement, of the same graining and high stage of mineral grains coating, which differs it from heap sediments. Satification of these soils clearly visible in transverse soil profiles is one of their most characteristic traits. It is connected with periodical sedimentation of the mentioned sediments – of various granulometric, mineralogical and chemical composition. Thickness of such horizons in the examined soils was between several to several dozens centimetres. They were so called very light alluvial soils which were composed of loose and lightly clay sands within whole profiles. Up to the depth of 1.5 m, none soil-ground waters were found in these soils. Four soil opencasts were done in the area, in points representative for each phytocenosis. All the investigated soils were classified as weakly formed soils, type – proper alluvial soils [17]. Profiles 1 and 4 were classified to the 5^{th} bonitation class and profiles 2 and 3- accordingly to the 4^{th} and 6^{th} class. Agricultural suitability of the whole object was aligned at the level of 3z complex. Samples of affected and intact structure were collected from the genetic horizons and such properties were marked as texture (aerometric-sieve method) [15], solid phase density (pycnometric method) [19], soil density (with Nitzsh's vessels of 100 cm^3 capacity), total porosity (on the basis of density) [10], maximal hygroscopic capacity (in a chamber at vacuum of 8 atm and saturated solution of K_2SO_4), water bond potential (Richard's vacuum chambers method) [7], potential and effective useful retention (on the basis of pF), content of total carbon (with Vario Max CNS analizator), pH (potentialometrically in 1MKCl). All the results are average from five replications.

3. Results and discussion

The investigated grassland area differs due to the mosaicism of habitat conditions. It is covered with thermofilic xerothermic flora whose appearance is mainly conditioned by soils and climate. Partly, these are non-hierarchical phytocenoses which may be classified as xerothermic grasses of *Festuco-Bromete*, mainly the phytocenoses of *Festuca ovina*, *Festuca rubra* and *Bromus sterillis*. They share a lot of traits with grasslands and therefore may be treated as intermediary state between thermofilic fresh grasslands and xerothermic grasses. Selected phytocenoses are colorful grasses of rich and diverse flora, often with rare species. Some areas may be counted as impoverished forms of *Arrhenatheretum elatioris*. Others should be counted as *Arrhenatherion* with the undergrowth composed of common bent *Agrostis capillaris* with false oat-grass *Arrhenatherum elatius*. Attention is drawn by species from *Agropyro-Rumicion* crispi which indicates a flooding character of these grasslands (tab. 1).

In the soils of alluvial character, a set of most of their properties depends on the origin and graining of the composing sediments. Therefore, the key parameters are texture and content of carbon. Top horizons (Ai) showed sandy (S) or loamy sandy (LS) texture; deeper horizons were formed of sands (S) or occasionally of loamy sand (LS) (profile 3; depth of 15-42 cm) or organic alluvion (profile 2; depth of 32-38 cm). In these deposits, the content of clay fractions was low (0-4%) and the content of silt did not exceed 13% (tab. 2) [16]. PH was also connected with sandy texture and, what probably follows, high content of quartz, as well as lack of calcium carbonate. In top horizons it oscillated in the range of slightly acid reaction from 6.17 (prof. 4) to 6.79 (prof. 3). This slightly acid and acid reaction of similar soils was also noticed by other authors [13, 14]. Along with the depth, pH decreased and reached the values from 5.4 (prof. 3; depth of. 43-130 cm) to 6.12 (prof. 4; depth of 25-47 cm). PH of organic alluvion (prof. 2; depth of 32-38 cm) was the highest – 7.06 (tab. 3). It also contained the most of total carbon (32,5 $g \cdot kg^{-3}$). Among other profiles, the highest content of carbon was observed in epipedones ranging from 8.4 $g \cdot kg^{-1}$ (prof. 4; depth of 0-25cm) to 13.6 $g \cdot kg^{-1}$ (prof. 2; depth of 0-32 cm). Along with the depth, the content of total carbon decreased and reached the values from 0.7 $g \cdot kg^{-1}$ (prof. 2; depth of 72-130 cm) to 6.6 $g \cdot kg^{-1}$ (prof. 3; depth of 15-43cm) (tab. 3). Sandy texture was the reason for very aligned values of solid phase density. All of them oscillated around the density of 2.65 $Mg \cdot m^{-3}$. Smaller figures of solid phase density were observed only in epipedones where the values were lowered by organic matter (from 2.63 to 2,64 $Mg \cdot m^{-3}$), which accumulated there in bigger amount, and in the alluvion layer – 2.61 $Mg \cdot m^{-3}$ (prof. 2; depth of 32-38cm) (tab. 3). Soil density and – what follows – total porosity were similar in all the profiles and depths. The lowest density (1.26 $Mg \cdot m^{-3}$) at the highest porosity (51.72%) was found in alluvion. Epipedones underwent systematic thickening along with the growth of depth and reached 1.75 $Mg \cdot m^{-3}$, at porosity of 33.96% (prof. 1; 66-120cm). Epipedones of slightly heavier texture and higher carbon content had smaller densities (1.31-1.55 $Mg \cdot m^{-3}$), at highest porosities

(50.38-41.29%) (tab. 3). Saturated hydraulic conductivity was high and characteristic to sands [20]. Its lowest value was observed in the alluvion layer (9.81 µm·s^{-1}). In epipedones the speed of filtration was lower – from 16.25 µm·s^{-1} (prof. 1) to 80.40 µm·s^{-1} (prof. 4) - than in deeper horizons where it reached figures from 24.47 µm·s^{-1} (prof. 3; depth of 15-43 cm) to 133.18 µm·s^{-1} (prof. 4; depth of 47-125 cm) (tab. 3). Maximal hygroscopic capacity also depended on texture and carbon content. In epipedones it oscillated from 1.09% (prof. 3) to 2.31%v/v (prof. 2); in sandy epipedones the figures were smaller, from 0.64% (prof. 3; depth of 43-130 cm) to 1.29% v/v (prof. 4; depth of 25-47 cm). Due to high content of organic matter, MH of organic alluvion was the highest – 4.82% v/v (prof. 2; depth of 32-38 cm) (tab. 3). Water bond potential depends mostly on graining, porosity and content of organic matter [10]. In the examined soils, maximal water capacity in each genetic horizon was of about 2-3% lower than total porosity. It is caused by methodological limitation which prevents soils from total venting during analysis. Field water capacity (pF 2.0) was low and oscillated between 11.38% (prof. 2) to 19.53% v/v (prof. 3) for epipednes and from 8.72% (prof. 2; depth of 38-72 cm) to 15.46% v/v (prof. 1; depth of 37-66 cm) for endopedones. At the point of productive water (pF 3.7), moisture was much higher in epipedones – from 5.58% (prof.4) to 8.29% v/v (prof. 1) than in sandy endopedones - from 2.13% (prof. 3; depth of 43-130 cm) to 5.64% v/v (prof. 1; depth of 37-66 cm). At the permanent wilting point (pF 4.2), according moisturizations were lower of 2-4% and oscillated between 1.36% (prof. 3; depth of 43-130 cm) to 4.45% (prof. 1; depth of 0-37 cm). Readily and total available water, calculated on the basis of pF markings, were at the level characteristic to light soils [10, 18]. Readily available water for the investigated sandy deposits was between 5-12% and total available water was higher of 1.5-4% in each case.

Table 1. Floristic characteristic of the distinguished plant communities
Tab. 1. Charakterystyka florystyczna wyróżnionych zbiorowisk

Number of record / Cover in %	95	75	80	50
Plant community with	*Festuca rubra*	*Festuca ovina*	*Agrostis capillaris*	*Spergulo-vernalis Corynephoretum*
Ch.Ass. ***Arrhenatheretum elatioris***				
Arrhenatherum elatius	2.3	1.1	+	-
Campanula patula	-	-	+	-
Ch. ***Agrostis capillaris***				
Agrostis capillaris	.-	+	3.4	1.2
Ch.O. ***Molinietalia***				
Equisetum palustre	1.2	-	-	-
Lotus uliginosus	+	-	-	-
Ch.O. ***Arrhenatheretalia***				
Galium mollugo	1.1	-	-	-
Leontodon autumnalis	.-	+	.	+
Achillea millefolium	+	+	+	-
Daucus carota	-	+		-
Ch.O/All. ***Agropyro-Rumicion crispi***				
Carex hirta	1.2	-	-	-
Elymus repens	-	+	+	+
Potentilla anserina	1.2	-	+	-
Rumex crispus	+	-	+	-
Ch.Cl. ***Molinio-Arrhenatheretea***				
Centaurea jacea	+	-	-	-
Festuca rubra	3.3	-	.+.1	-
Lathyrus pratensis	1.1	-	-	-
Plantago lanceolata	1.2	-	1.1	-
ChCl. ***Koelerio glauce- Corynephoretea canescentis***				
Festuca ovina	-	3,3	-	r
Corynephorus canescens	-	1.1	-	3.3
Helichrysum arenarium	-	.	-	+
Rumex acetosella	-	1.1	-	2.2
ChCl. ***Trifolio-Geranietea*** *sanguinei*				
Galium verum	+	-	-	-
ChCl. ***Artemisietea vulgaris***				
Artemisia vulgaris	-	+	-	-
Cirsium arvense	1.2	-	-	-
ChCl. ***Agropyretea*** *intermedio-repentis*				
Cerastium arvense	-	+	-	1.1
Poa angustifolia	-	+	-	1.2
ChCl. ***Stellarietea mediae***				
Bromus sterilis	-	+	-	-
Other				
Festuca ovina	-	3.3	-	-
Erigeron canadensis	-	-	-	-
Festuca trachyphylla	-	-	-	2.2

Source: own work / Źródło: opracowanie własne

Table 2. Texture of investigated soils
Tab. 2. Uziarnienie badanych gleb

Profile number	Genetic horizon	Depth [cm]	Percentage content of fraction on diameter [mm]						Texture acc.	
			2,0 - 0,10	0,10 - 0,05	0,05 - 0,02	0,02 - 0,005	0,005 - 0,002	< 0,002	PTG 2008	FAO/ USDA
1	Au	0-37	73	8	7	2	2	2	ps	S
	C1	37-66	80	13	5	0	1	1	pl	S
	C2	66-120	87	7	3	1	2	0	pl	S
2	Au	0-32	68	18	8	2	3	1	ps	S
	2A	32-38	-	-	-	-	-	-	namuł	mud
	C1	38-72	77	15	5	1	0	2	pl	S
	C2	72-130	80	10	7	2	1	0	pl	S
3	Au	0-15	73	14	6	1	2	4	ps	LS
	C1	15-43	68	12	9	5	4	2	pg	LS
	C2	43-130	85	7	5	1	1	1	pl	S
4	Au	0-25	75	12	6	2	2	3	ps	LS
	C1	25-47	88	4	5	2	0	1	pl	S
	C2	47-125	86	5	7	1	1	0	pl	S

Source: own work / Źródło: opracowanie własne

Table 3. Basic chemical also physical and water properties of investigated soils
Tab. 3. Podstawowe właściwości chemiczne oraz fizyczne i wodne badanych gleb

Profile number	Genetic horizon	Depth	pH in 1M KCl	Total carbon	Specific density	Bulk density	Porosity	Saturated hydraulic conductivity	Maximal hygroscopic capacity
		[cm]		[g·kg^{-3}]	[Mg·m^{-3}]	[Mg·m^{-3}]	[%v/v]	[µm·s^{-1}]	[%v/v]
1	Au	0-37	6.55	11.3	2.64	1.31	50.38	16.25	1.77
	C1	37-66	6.04	1.7	2.65	1.60	39.62	62.38	0.45
	C2	66-120	5.42	1.2	2.65	1.75	33.96	89.44	0.91
2	Au	0-32	6.24	13.6	2.63	1.39	47.15	28.63	2.31
	2A	32-38	7.06	32.5	2.61	1.26	51.72	9.81	4.82
	C1	38-72	5.78	4.5	2.65	1.63	38.49	47.23	1.15
	C2	72-130	5.65	0.7	2.65	1.65	37.74	92.84	0.78
3	Au	0-15	6.79	10.4	2.63	1.38	47.53	54.36	1.09
	C1	15-43	6.21	6.6	2.65	1.58	40.38	24.47	1.22
	C2	43-130	5.24	2.9	2.65	1.67	36.98	104.12	0.64
4	Au	0-25	6.17	8.4	2.64	1.55	41.29	80.40	1.75
	C1	25-47	6.32	2.7	2.65	1.67	36.98	101.49	1.29
	C2	47-125	5.33	0.82	2.65	1.73	34.72	133.18	0.66

Source: own work / Źródło: opracowanie własne

Table 4. Soil water potentials and the total (TAV) and readily (RAV) available water
Tab. 4. Potencjał wiązania wody oraz potencjalna (PRU) i efektywna (ERU) retencja użyteczna

Profile number	Horizon	Depth	Water capacity at pF [%v/v]						Readily available water [%v/v]	Total available water [%v/v]
			0.0	2.0	2.5	3.7	4.2	4.5	2.0 – 3.7	2.0 – 4.2
1	Au	0-37	49.76	16.79	11.46	8.29	4.45	1.77	8.50	12.34
	C1	37-66	37.15	15.46	13.57	5.64	1.22	0.45	8.82	11.24
	C2	66-120	30.33	10.84	12.53	3.56	1.63	0.91	7.28	9.21
2	Au	0-32	45.28	11.38	9.76	6.24	3.73	2.31	5.14	7.65
	2A	32-38	48.39	32.94	24.84	13.64	7.68	4.82	19.30	25.26
	C1	38-72	36.20	8.72	5.36	3.66	2.55	1.15	5.06	6.17
	C2	72-130	35.44	11.15	7.67	3.43	1.43	0.78	7.72	9.72
3	Au	0-15	44.55	19.53	15.44	7.25	3.27	1.09	12.28	16.26
	C1	15-43	37.83	21.67	17.24	9.64	2.96	1.22	12.03	18.71
	C2	43-130	33.89	9.76	6.75	2.13	1.36	0.64	7.63	8.40
4	Au	0-25	38.95	14.24	8.49	5.58	3.17	1.75	8.66	11.07
	C1	25-47	34.01	10.68	7.32	3.44	2.02	1.29	7.24	8.66
	C2	47-125	32.35	12.52	11.36	3.21	2.21	0.66	9.31	10.31

*aluvial organic mud

Source: own work / Źródło: opracowanie własne

4. Summary

Grassland phytocenoses in the examined area are thermophiles, close in their character to xerothermic grasses whose appearance depends on climate, edafic and antropological conditions. Selected phytocenoses are colorful grasses of tuft structure and diverse flora, often with rare species. Their appearance is formed by the presence of species of clearly xeromorphic structure with a visible domination of grasses and a large share of annual plants. Their soil habitat was characterized with high water permeability and low retention, which is typical for light soils. Productive water and available for plants appeared in small amounts. Porosity and soil density, as well as pH, were on a beneficial level, from an agricultural point of view. As for sands, top horizons have high carbon content which stemmed from alluvial specification of the origin of these soils. In spite of the fact that they do not provide the undergrowth with optimal hydration conditions, their management as solid, ecological grasslands protects them from anthropogenic, tillage degradation.

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