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SOIL MICROFLORA OF MEADOW ASSOCIATIONS
IN THE SUPRAŚL VALLEY*

Quantitative investigations were made of the basic systematic and physiological groups of micro-organisms in the turf level of soils in meadow associations. It was found that the soils of plant associations are characterised by a specific distribution of micro-flora.

The connection between soil micro-organisms and the vegetation mantle, and in particular associations, is of very importance to phytosociology, since they form, together with the higher vegetation, an intricate and closely inter-connected and dependent whole (Sławiński 1958). The higher plants, by the secretion of the products of metabolism to the soil through their roots, influence the growth and development of soil micro-organisms, while these in turn stimulate or restrict the development of higher plants (Krasilnikov 1958).

MATERIAL AND METHODS

Investigations were made in the Supraśl valley in the section from the town of Supraśl to Zasady. Samples for analysis were taken in two vegetation seasons, in June 1958 and 1959. Soil was taken from the turf layer at a depth of 5 to 10 cm. Micro-biological analyses were made immediately after the samples arrived in the laboratory of the Division of Ecology, Warsaw Agricultural University. Investigations included 10 meadow associations, the systematic stands of which, according to Oberdorfer (1957) are as follows:

* From the Warsaw Agricultural University, Division of Plant Ecology, Warszawa.

- Class: *Phragmitetea* Tx. et Preisg. 1942
 Order: *Phragmitetalia* W. Koch 1926
 Alliance: *Magnocaricion* W. Koch 1926
 Association: 1. *Caricetum gracilis* Tx. 1937
 Association: 2. *Caricetum appropinquatae* Tx. 1947
 Class: *Scheuchzerio-Caricetea fuscae* Nordh. 1936
 Order: *Scheuchzeritalia palustris* Nordh. 1936
 Alliance: *Eriophorion gracilis* Preisg. mscr.
 Association: 3. *Caricetum lasiocarpae* W. Koch 1926
 Association: 4. *Caricetum diandrae* (Jon. 1932) Oberd. 1957
 Order: *Caricetalia fuscae* W. Koch 1926
 Alliance: *Caricion canescenti-fuscae* Nordh. 1937
 Association: 5. *Carici (canescentis) - Agrostidetum* Tx. 1937
 Class: *Molinio-Arrhenatheretea* Tx. 1937
 Order: *Molinietalia* W. Koch 1926
 Alliance: *Calthion* Tx. 1936
 Association: 6. *Juncetum subnodulosi* W. Koch 1926
 Association: 7. *Cirsio-Polygonetum* Tx. 1951
 Alliance: *Filipendulo-Petasition* Br.-Bl. 1947
 Association: 8. *Filipendulo-Geranietum* W. Koch 1926
 Order: *Arrhenatheretalia* Pawł. 1928
 Alliance: *Arrhenatherion* Br.-Bl. 1925
 Association: 9. *Arrhenatheretum medioeuropaeum* (Br.-Bl. 1919) Oberd. 1952
 Class: *Nardo-Callunetea* Preisg. 1949
 Order: *Nardetalia* (Oberd. 1949) Preisg. 1949
 Alliance: *Nardo-Galium (saxatilis)* Preisg. 1949
 Association: 10. *Nardo-Juncetum* (Nordh. 1920) Bük. 1942

A total of 32 samples of soil were taken from 10 plant associations. The following were determined in the soils:

1. Total amount of bacteria (including the percentage in the form of spores) of *Actionomycetales* and fungi – by the plate method on agar mediums with a soil extract.
2. Total amount of micro-organisms reducing nitrates-by the dilution method on a liquid medium with saccharose and KNO_3 .
3. Total amount of anaerobic assimilators of free nitrogen – by the dilution method in columns of agar with saccharose and soil extract.
4. Presence of azotobacter – by the dilution method in Beijerinck liquid medium.
5. Presence of nitrosobacteria – on siliceous plates, using the Winogradsky method.
6. Cellulose decomposition in soil samples placed in Petrie vessels.
7. Certain physico-chemical properties of the soils: a) moisture – by drying to constant weight at a temperature of 105° , b) organic substances contents –

loss by burning in a muffle furnace at a temperature of 400°, c) pH – potentiometrically in a soil water solution.

RESULTS OF INVESTIGATIONS

The investigations revealed differences in the microflora of meadow soils depending on plant associations.

A. Association of the class *Phragmitetea* Tx. et Preisg. 1942

The soils of two associations were investigated from this class: *Caricetum gracilis* and *Caricetum appropinquatae*. These are soils of the hydromorphic type with a high organic mass content. Their pH is slightly acid (Tab. I). Soils of the *Caricetum gracilis* association are characterised by a large amount of bacteria, a small percentage of which occurred in the form of spores. Slightly fewer *Actinomycetales* than bacteria were found and an extremely small amount of fungi (Tab. I). Of the physiological groups, the most numerous were the micro-organisms reducing nitrates and anaerobic assimilators of free nitrogen. Very little nitrosobacteria and azotobacter were found. Cellulose decomposition was average in the samples taken in 1958, and advanced in 1959 (Tab. II). Microbiological relations in the soils of the *Caricetum appropinquatae* association were similar to those in *Caricetum gracilis* (Tables I, II).

B. Associations of the class *Scheuchzerio-Caricetea fuscae* Nordh. 1936

Within this class investigation was made of the soils of 3 meadow associations in the Supraśl valley: *Caricetum lasiocarpae*, *Caricetum diandrae* and *Carici-Agrostidetum*. The associations of low-growing *Carex* within the study area chiefly occupy the very wet peaty soils. The pH of these soils in the surface layer varied within limits of from pH 5.4 to pH 7.1. A relatively large amount of micro-organisms were found in the soils, rich in organic substances and saturated with water, of these associations. Bacteria occurred most abundantly in the soils of the *Caricetum diandrae* and *Carici-Agrostidetum* associations, less numerously in *Caricetum lasiocarpae*, where over 50% occurred in the form of spores. Decidedly fewer *Actinomycetales* were found than bacteria, which indicates the slight degree to which these soils have changed to humus. Similar relations were found in meadow soils in the Narewka valley (Zimna J., Zimny H. 1962). Fungi were found in the smallest numbers, but even so their numbers were greater than in the soils of the *Caricetum gracilis* and *Caricetum appropinquatae* associations (Tab. I). Of the physiological groups the micro-organisms reducing nitrates were fairly numerous and the anaerobis assimilators

Results of analyses of soil samples and number of microorganisms in the surface

Association	No of experimental area	pH	Percentage of moisture content in soil sample		Percentage of organic substance in dry matter	
			1958	1959	1958	1959
<i>Caricetum gracilis</i>	1	6.8	—	80.9	—	62.3
	2	5.4	61.7	53.2	30.3	23.3
	3	6.1	80.3	75.9	79.2	66.4
<i>Caricetum appropinquatae</i>	4	5.5	88.8	87.5	89.5	87.2
	5	5.5	—	74.5	—	57.5
<i>Caricetum lasiocarpae</i>	6	5.4	83.3	82.4	84.0	83.6
<i>Caricetum diandrae</i>	7	5.8	81.3	80.8	73.4	74.6
	8	7.1	89.7	84.0	83.0	84.7
<i>Carici-Agrostidetum</i>	9	6.0	80.0	84.1	69.7	84.0
	10	6.2	81.8	71.9	74.1	30.8
<i>Juncetum subnodulosi</i>	11	7.2	86.0	90.7	83.0	82.5
<i>Cirsio-Polygonetum</i>	12	5.5	76.5	—	67.2	—
	13	6.4	73.2	64.4	49.0	49.4
	14	5.9	46.5	54.4	20.6	23.9
<i>Filipendulo-Geranietum</i>	15	6.4	82.5	—	46.5	—
<i>Arrhenatheretum medioeuropaeum</i>	16	5.1	68.6	—	49.5	—
	17	5.5	8.4	23.2	7.4	12.6
<i>Nardo-Juncetum</i>	18	5.1	14.4	9.3	12.5	16.2
	19	5.2	30.4	—	9.4	—

layer of meadow soils in the Supraśl valley in thousands per 1.0 gr. of dry soil

Tab. I

Bacteria				<i>Actinomycetes</i>		Fungi	
whole mass		percentage of spores					
1958	1959	1958	1959	1958	1959	1958	1959
—	7500	—	16.0	—	2000	—	5
6266	1521	25.0	38.5	5744	1086	7	6
10659	4000	14.0	27.0	2538	800	5	24
28571	5380	6.2	0.4	1785	769	44	0.8
—	5600	—	30.0	—	3600	—	20
4191	2222	65.3	62.5	4790	1666	119	66
8556	5500	27.7	22.7	4278	1000	16	3
20388	8125	9.0	24.6	6796	625	97	50
10000	17800	21.0	37.6	2000	2857	5	2
10989	6428	31.0	18.8	4395	3571	38	7
18571	4000	27.6	47.5	7857	1900	100	390
14042	—	10.0	—	8510	—	110	—
17537	5555	6.5	0.9	7462	6389	11	0.3
3925	1300	11.9	63.0	2429	2173	9	6
6857	—	8.3	—	1142	—	11	—
4777	—	18.6	—	4140	—	12	—
3165	2207	21.0	28.8	6550	2851	101	106
3146	1555	26.0	60.0	5827	4333	116	103
1431	—	42.8	—	143	—	79	—

Presence of microorganisms active at conversion of nitrogen compounds and of those

Association	No of experimental area	Microorganisms reducing nitrates	
		1958	1959
<i>Caricetum gracilis</i>	1	—	100
	2	100	100
	3	100	100
<i>Caricetum appropinquatae</i>	4	10	100
	5	—	100
<i>Caricetum lasiocarpae</i>	6	100	10
<i>Caricetum diandrae</i>	7	100	1000
	8	100	1000
<i>Carici-Agrostidetum</i>	9	10	100
	10	100	100
<i>Juncetum subnodulosi</i>	11	10	10
<i>Cirsio-Polygonetum</i>	12	100	—
	13	100	1000
	14	10	1000
<i>Filipendulo-Geranietum</i>	15	100	—
<i>Arrhenatheretum medioeuropaeum</i>	16	10	—
	17	10	100
<i>Nardo-Juncetum</i>	18	10	10
	19	10	—

+ — poor decay, ++ — average decay, +++ — advanced decay

assimilating free nitrogen in thousands per 1.0 gr. of fresh soil and cellulose decomposition

Tab. II

Nitroso microorganisms	<i>Azotobacter</i>	<i>Clostridium</i>		Cellulose decomposition	
		1958	1959	1958	1959
1959	1959				
0.01	0.10	-	100	-	+
0.10	0.01	100	10	++	+++
0.10	0.10	100	100	++	+++
0.10	0.01	10	10	+++	+++
0.01	0.10	-	100	+++	+++
traces	000	10	10	+	+++
000	000	10	10	+++	+
0,01	0.01	100	10	+++	++
0.01	0.10	10	10	+++	+++
traces	0.10	1000	100	+++	+++
0.10	0.10	100	10	+++	+++
-	-	100	-	+++	-
0.10	000	100	10	+++	+++
0.10	000	10	100	+++	+++
-	-	10	-	+++	-
-	-	10	-	++	-
0.01	0.10	10	100	++	++
traces	000	10	10	+	+++
-	-	10	-	+++	-

of free nitrogen less numerous. There were relatively few azotobacter and scarcely a trace of nitrosobacteria. Cellulose decomposition was fairly advanced (Tab. II).

C. Association of the class *Molinio-Arrhenatheretea* Tx. 1937

The class *Molinio-Arrhenatheretea* is represented by 4 meadow associations. Three of them — *Juncetum subnodulosi*, *Cirsio-Polygonetum* and *Filipendulo-Geraniatum* belong to the order *Molinietales*. These are associations occupying fertile and well moistened soils, rich in organic mass. The pH of these soils varies from slightly acid to neutral (Tab. I). On account of the rich and varied vegetation growing on the soils of these habitats it must be assumed that the microbiological life prevailing in these soils is abundant. Bacteria formed the chief component here, particularly in the samples taken in 1958. In soil examined in 1959 the amount of bacteria was considerably smaller, and *Actinomycetales* predominated (Tab. I). In comparison with other associations in the soils of the *Juncetum subnodulosi* and *Cirsio-Polygonetum* associations, the amount *Actinomycetales* found was the greatest here (Tab. I). Fungi, as they were in other associations, were third in order of abundance. They occurred relatively abundantly in the soils of the *Juncetum subnodulosi* (Tab. I). Of the physiological groups, a large amount of micro-organism reducing nitrates were found. Nitrosobacteria were found in each soil. Azotobacter occurred in *Juncetum subnodulosi*. Cellulose decomposition was fairly advanced (Tab. II).

The order *Arrhenatheretales* in the study area was represented by the *Arrhenatheretum medioeuropaeum* association, which occupies sandy soils with different organic mass contents. The pH of the soils of this association is slightly acid (Tab. I). The soil microflora is far poorer than in the associations of the order *Molinietales*. The amount of bacteria varied from over 2 million to over 4 million, calculated for 1.0 gr. of dry mass of soil. Slightly more *Actinomycetales* than bacteria were found (Tab. I). *Actinomycetales* formed the chief component in the soils of this association. Far fewer fungi were found than bacteria and *Actinomycetales*. According to research made by Gołębiowska, Kobus, Maliszewska, Sobieszkański and Strzemska (1961) fungi are not suitable micro-organisms for defining, on the basis of their abundance, differences in the microbiological state of the kinds of soil compared. These micro-organisms are very sensitive to changes in the micro-climate of the soils, in particular to moisture. In addition, when making plate analyses, it is difficult to establish whether the colonies developed from mycelium or from spores. Of the physiological groups, a medium amount of micro-organisms reducing nitrates and anaerobic assimilators of free nitrogen were found. These micro-organisms occurred in amounts from 10 thousand to 100 thousand, calculated for 1.0 gr. of fresh soil (Tab. II). There was little nitrosobacteria, or azotobacter. Cellulose decomposition was fairly advanced.

D. Association of the class *Nardo-Callunetea* Preisg. 1949

Investigation was made of the soils of the association *Nardo-Juncetum* from the class *Nardo-Callunetea*. This association occupies sandy soils with little humus and moisture. The pH of these soils is acid (Tab. I). The sandy soils, with small organic mass content, of the *Nardo-Juncetum* association are characterised by the relatively small amount of bacteria found in them, of which a considerable percentage occurred in the form of spores. *Actinomycetales* occurred in varying amounts. In samples taken from experimental area 18 in soil richer in organic compounds, they were relatively abundant in comparison with area 19, which was poor in organic mass. Fungi formed the third component in order of abundance, of the microflora of the soils of this association (Tab. I). Of the physiological groups, relatively few micro-organisms reducing nitrates were found. *Clostridium* was similarly scanty. There was scarcely a trace of nitrosobacteria and azotobacter was absent (Tab. II). Similar distributions were found in the soils of an analogical association in the Narewka valley (Zimna J., Zimny H. 1962). The investigations made by Zimna (1962) of the occurrence of *Clostridium* and azotobacter in the rhizosphere of certain meadow plants in meadow associations in the Narewka valley revealed the presence of azotobacter in the rhizosphere of *Nardus stricta*, *Juncus effusus*, *Luzula campestris* and *Potentilla erecta* even in *Nardetum*, despite their not having been found outside the reach of roots in earlier investigations. Cellulose decomposition in the soils of the *Nardo-Juncetum* association in the Supraśl valley was relatively advanced, as it was in the soils of other associations from this area.

CONCLUSIONS

1. The soils examined of meadow associations were characterised by a fairly great abundance of bacteria which usually predominated over the remaining systematic groups of micro-organisms.

2. *Actinomycetales* predominated over bacteria in sandy soils with little moisture — associations *Arrhenatheretum medioeuropaeum* and *Nardo-Juncetum* (experimental area 18).

3. The amount of fungi varied considerably, even within the same association, and did not exhibit correlation with plant associations.

4. Of the physiological groups the micro-organisms reducing nitrates and anaerobic assimilators of free nitrogen were the most abundant. There was little nitrosobacteria or azotobacter. Cellulose decomposition is relatively advanced in all soils.

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MIKROFLORA GLEB ZESPOŁÓW ŁĄKOWYCH DOLINY SUPRAŚLI

Streszczenie

W czerwcu 1958 i 1959 przeprowadzono badania nad mikroflorą gleb zespołów łąkowych w dolinie Supraśli na odcinku od Supraśla do Zasad. Próbki gleb z poziomu damiowego pobrano z 19 powierzchni doświadczalnych. Gleby te porastała roślinność łąkowa zakwalifikowana do 10 zespołów. Ogółem pobrano i zbadano 32 próbki glebowe.

W glebach tych oznaczono:

1. ogólną ilość bakterii (w tym procent ich w postaci spor), promieniowców i grzybów — metodą płytkową na pożywkach agarowych z wyciągiem glebowym,
2. ogólną ilość drobnoustrojów redukujących azotany — metodą rozcieńczeń w pożywece płynnej z sacharozą i KNO_3 ,
3. ogólną ilość beztlenowych asymilatorów wolnego azotu — metodą rozcieńczeń w słupach agarowych z sacharozą i wyciągiem glebowym,
4. obecność azotobaktera — na płytkach krzemionkowych, metodą Winogradskiego,
5. rozkład błonnika w próbkach gleb umieszczonych w szalkach Petrieo,
6. niektóre właściwości fizyko-chemiczne gleb: a) wilgotność — przez suszenie do stałej wagi w temp. 105° , b) zawartość substancji organicznej — przez ubytek żarzenia w piecu muflowym w temp. 400° , c) pH — potencjometrycznie w zawieszynie wodnej gleby.

Przeprowadzone badania wykazały zróżnicowanie ilościowe mikroflory gleb łąkowych w zależności od zbiorowisk roślinnych. W badaniach tych stwierdzono, że:

1. Zbadane gleby zespołów charakteryzowały się dość dużą ilością bakterii, które w większości dominowały nad pozostałymi grupami systematycznymi drobnoustrojów.
2. W glebach piaszczystych i słabo wilgotnych promieniowce dominowały nad bakteriami — zespół *Arrhenatheretum medioeuropaeum* i *Nardo-Juncetum* powierzchnia 18.
3. Liczba grzybów wahała się znacznie nawet w obrębie tego samego zespołu i nie wykazywała korelacji ze zbiorowiskami roślinnymi.
4. Z grup fizjologicznych najliczniej występowały drobnoustroje redukujące azotany i beztlenowe asymilatory wolnego azotu. Nitrozobakterii mało, azotobakter również znaleziony był w niewielkich ilościach. Rozkład błonnika stosunkowo dobry we wszystkich zbadanych glebach.

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