

Content of Organic Carbon and Nitrogen as Well as Root Mass in Meadow Soils Under a Combined Slope and Flood Irrigation System

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Abstract The aim of the present research was to determine the effect of long-term irrigation of grasslands on the content of organic carbon and nitrogen as well as on root mass in meadow soils. The research involved the Podlesie Czersk meadow complex unique in the Central Europe, under a combined slope and flood irrigation system. The system has been operating since 1850. In the complex investigated, three areas were selected: Kamienna, Podlesie and Cegielnia. From each area, *Brunic Arenosols* were sampled from the following horizons: Ad, AEes and ABv. From those horizons, there were also sampled soil monoliths together with root systems. The soil samples were assayed for the total organic carbon (TOC), total nitrogen (Nt) and root mass. It was demonstrated that horizon AEes showed the highest content of organic carbon and nitrogen, as compared with the other horizons, with a relatively low value of ratio TOC/Nt. The meadow sward root mass was, on the other hand, highest in horizon Ad, which does not positively correlate with the total organic carbon (TOC) and total nitrogen (Nt) in that layer. Drawing on the results, one can observe that such relationships are a result of permanently irrigated meadows applying a combined slope and flood irrigation system for the period of 150 years.

Keywords *Brunic Arenosol* • Root mass • Total nitrogen • Organic carbon

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Introduction

The soils of permanent grasslands are an essential reservoir of organic carbon, and its resources are similar or higher than the resources of carbon in forest soils (Gonet 2007). It is assumed that organic matter is the key factor conditioning the natural soil fertility and shows a significant effect on their chemical, physical and biological properties. Under the optimal moisture and aeration, it enhances the plant root development and has a significant effect on the yield size (Gonet 2007). For that reason, the meadow ecosystems are one of the key important methods of the agricultural land use, preventing organic carbon losses in soils. They also help the exchange of organic carbon in soil and CO₂ from the atmosphere and play an important role in its sustainable management (Sapek 2009).

Materials and Methods

The research involved meadow soil sampling from the area of Podlesie Czersk meadow complex, unique in Central Europe, under a combined slope and flood irrigation system. The complex, of the total area of about 360 ha, was set up in 1850 in the former pine forest areas, in *Brunic Arenosols* of a natural groundwater level deposited below 2 m. From the complex investigated, there were selected three areas referred to under the historic names of Kamienna, Podlesie and Cegielnia. In each area, soil was sampled from horizons Ad, AEes and ABv from three sampling points (I, II, III) at a varied distance from the irrigation ditch. At the same time at the same sites, soil monoliths were sampled together with root systems to determine the root mass (Smit et al. 2000). In the soil samples, the following were determined: total organic carbon (TOC) and total nitrogen (Nt) applying the dry combustion method with the Vario Max CN analyser manufactured by Elementar (Germany) and the pH value with the potentiometric method (Mocek et al. 1997).

Results and Discussion

The plant communities which occur in the area of the Podlesie Czersk meadow complex making up the meadow sward represent class *Arrhenatheretea* and *Molinio-Arrhenatheretea*. With the root mass results obtained (Table 1), it was found that the main plant root mass was deposited in horizon Ad and ranged from 0.780 to 1.373 kg m⁻².

Table 1 Total organic carbon (TOC), total nitrogen (Nt) contents and pH values

Measurement point	Horizon (Depth) [cm]	pH in H ₂ O	TOC [g kg ⁻¹]	Nt [g kg ⁻¹]	TOC/Nt	Root mass [kg m ⁻²]
<i>Area of Kamienna</i>						
I	Ad (0–11)	5.98	7.83	0.40	19.65	1.373
	AEes (11–25)	6.39	43.5	3.77	11.53	0.164
	ABv (25–33)	7.12	16.3	1.35	12.10	0.013
II	Ad (0–7)	6.13	7.88	0.46	17.06	1.135
	AEes (7–19)	6.24	44.5	3.85	11.55	0.193
III	Ad (0–7)	6.63	26.8	2.11	12.66	1.022
	AEes (7–19)	7.14	55.1	4.93	11.16	0.158
<i>Area of Podlesie</i>						
I	Ad (0–6)	6.17	26.4	2.34	11.28	1.035
	AEes (6–15)	6.55	46.4	4.04	11.47	0.215
II	Ad (0–7)	6.66	18.7	1.57	11.94	1.107
	AEes (7–11)	7.13	59.7	5.24	11.39	0.136
III	ABv (11–17)	7.38	25.0	2.10	11.92	0.129
	Ad (0–8)	6.81	8.48	0.60	14.09	0.837
	AEes (8–17)	7.20	64.5	5.50	11.72	0.134
	ABv (17–22)	7.32	39.5	3.16	12.51	0.097
<i>Area of Cegielnia</i>						
I	Ad (0–6)	7.38	18.5	1.04	17.68	0.780
	AEes (6–11)	7.54	52.9	3.59	14.76	0.112
	ABv (11–22)	7.54	46.3	2.44	18.97	0.155
II	Ad (0–7)	6.56	9.68	0.59	16.53	1.048
	AEes (7–17)	6.93	36.7	3.48	10.54	0.338
	ABv (17–31)	7.41	35.6	3.32	10.72	0.145
III	Ad (0–5)	7.53	8.45	0.68	12.51	0.852
	AEes (5–9)	7.59	44.5	4.34	10.27	0.110
	ABv (9–33)	7.58	43.2	4.41	9.80	0.274

The content of organic carbon in horizon Ad ranged from 7.83 to 26.8 g kg⁻¹, and total nitrogen (Nt) – from 0.4 to 2.34 g kg⁻¹. Interestingly, the highest contents of organic carbon and nitrogen were recorded in horizon AEes, which contained, on average, 49.8 g kg⁻¹ TOC and 4.30 g kg⁻¹ Nt (Table 1). A specific feature of that layer is a relatively low value of ratio TOC/Nt – on average 11.6, as compared with horizon Ad. With the present results recorded, one can state that meadows permanently maintained for 150 years, under a combined slope and flood irrigation system, resulted in an accumulation of organic carbon and nitrogen in soil layers to the depth of about 25–33 cm (Table 1).

The management method, namely, permanent grasslands in *Brunic Arenosols*, showed a considerable effect on the pH values, which, in horizon Ad, remained on average at the level of 6.6 and were increasing deep down the soil profile. Just to compare, in typical *Brunic Arenosols*, the pH values range from 4.0 to 4.5 (Czepinska-Kaminska et al. 2003).

Conclusions

As a result of a combined slope and flood irrigation system applied to meadows in poor *Brunic Arenosols*, the greater the depth, the lower their acidity and the narrower the value of ratio TOC/Nt. The highest contents of organic carbon and nitrogen were found for horizon AEEs, and the main root mass involved horizon Ad.

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