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INFLUENCE OF DIFFERENTIATED IRRIGATION ON CHANGES IN THE FRACTION COMPOSITION OF MOORSHY HUMUS

T. Wojcieszczuk

Institute of Soil Science, University of Agriculture, Słowackiego 17, 71-434 Szczecin

A b s t r a c t. In order to determine the direction of moorshy soil organic substance transformation, especially its fraction composition, under different humidity conditions laboratory experiment was carried out using a Column Device for investigation the soil with irrigation (PO no. 54427). Soil material was taken from accumulation horizon of mineral-moorshy soil from the 0-10 cm layer, placed in columns and irrigated after appropriate preparation using following water doses: 0 - without irrigation, I - to fill the capillary water capacity, II - 615 ml, III - 1042 ml, IV - 1657 ml. The fractions of humus, reaction, sorption properties and total content of carbon and nitrogen were determined in the soil material with methods commonly used in soil science.

The results indicate that along with the increase of water dose increase the amount of eluted total carbon from the soil material. Quantity changes of total carbon are accompanied by qualitative and quantitative changes of particular determined humus.

K e y w o r d s: moorshy humus, humus fractions, irrigation

INTRODUCTION

Water relations occurring in soil have an essential influence on the direction of changes in the organic substance of soil and on the final products of the humification process. Usually, when soil humidity decreases, so does the amount of carbon and organic substance, whereas when soil humidity increases, so does the amount of carbon and organic substance.

Water delivered to soil, despite the atmospheric rainfall, affects the transformations in chemical properties, including humus. The dynamics of the chemical and bio-chemical change of the organic substance of soil depends on the amount and quality of water that filters trough the soil profile [2]. It was stated, among other observations, that using frequent and overdosed irrigation doses caused a decrease in the content of humus [11].

In order to determine the direction of soil organic substance transformations, especially its fraction composition, under the influence of different humidity conditions, laboratory research were carried out.

METHODS

Quality and quantity changes in properties of humus, occurring under the influence of differentiated irrigation were analyzed on the bases of a laboratory experiment with the use of a Column Device for investigating the soil with irrigation (PO no. 54427). Soil material taken for research from the accumulation horizon of mineral-moorshy soil, from the 0-10 cm layer, was placed in columns of the mentioned device after appropriate preparation. Particular columns were filled with soil material taken from the object in Konarzewo, mostly used as meadows, situated 5 km northwest of Nowogard. The material was taken from the place where no fertilization nor irrigation were used. The investigated soil belongs to the section of hydrogenic soils, order of post-boggy soils, type of moorshy soils, sub-type of mineral-moorshy soils.

Usually in muck soil the level of ground water appears on a shallow level and during summer months it drops to the level of 100-150 cm. The humus horizon of the investigated soils consists of two masses: mineral and organic - which are not related to each other or very weakly related. Those soils are usually gleyed and the effect of the gleying process is usually very weak. According to the taxonomy elaborated by Rząsa [9], the soils of the Konarzewo object belong to weakly moorshy sands, in terms of content of total carbon, because they contain less than 2.5% carbon, in average, in the accumulation horizon (Table 1). On the turn of May, the level of ground water was on the depth of 71-85 cm in the investigated soils. In terms of mechanical composition, they are usually loose or loamy fine sands of glacial origin.

The received results of research set up using the method of complete randomization for the two-factor experiment (1st factor - volume of irrigation dose: 0 - no irrigation, I - capillary water (W_c), II - 615 ml, III - 1042 ml, IV - 1657 ml; 2nd factor - thickness of soil layer in column: a - 0-18 cm, b - 18.5-37.0 cm, c - 37.0-55.5 cm) were elaborated statistically with separation of uniform groups.

The following were determined in the soil material prior to spray irrigation (collective samples) and after spray irrigation (samples separated from particular layers in columns): fractions of humus with the Konowowa method, reaction, sorption properties, and general content of carbon and nitrogen with methods commonly used in soil science.

T a b l e 1. Table 1. Properties of non-irrigated meadow mineral moorshy soil determined for the accumulation horizon (3 year and 3 repetition average values)

Bulk density, g cm^{-3}	1.43
Capillary water, % grav.	27.10
% vol.	38.60
pH KCl	3.9-4.4
pH H_2O	4.9-5.5
Total exchange base me 100 g^{-1} soil	4.79
Hydrolytic acidity	5.18
Exchange capacity	9.97
Degree of base saturation %	45.20
Soluble in M 0.1 HCl mg 100 g^{-1} soil	
CaO	68.97
K_2O	5.41
Na_2O	2.11
Soluble H_2O mg 100 g^{-1} soil	
CaO	2.17
K_2O	2.24
Na_2O	1.09
C total %	1.78
N total %	0.34
C:N	6.71
C - bitumin in % total C	8.13
C - after decalcitation	2.80
Fraction I C_h	30.70
C_f	23.60
Fraction II C_h	1.85
C_f	2.40
C - nonhydrolisable	27.98
C_h:C_f I Fraction I	1.25
Fraction II	0.68
Total	1.19

RESULTS

Among the factors, which influenced the organic mass transformations, water relations were very important [5].

Humus compounds constitute a reasonably durable system, which is not that susceptible to changes under the influence of environmental conditions. Research carried out by Kowaliński *et al.* [1] proved that the total content of C, as well as the fraction composition of humus compounds under cereal plant cultivation in monoculture and in crop rotation, had not really changed in 10 years and had not significantly depended on the level of the used mineral fertilization. The speed of humus compound degradation, commonly considered a symptom of soil culture quality decrease, depends on many factors.

Changes of the soil organic substance in terms of quantity, depending on the changing humidity conditions and soil properties, are indicated in the first place by the changing amount of total carbon and nitrogen. As the result of irrigation of mineral moorshy soil, the amount and intensity of the eluded total carbon grows with the increasing dose of water. This relation is supported by especially thorough statistical calculations (Table 2). In the field experiment after 10 years of irrigation it was stated that at spray irrigation at the dose of 388.6 mm, the soil had lost 0.33% of C, whereas at drowning with a 846.6 mm water dose the loss equaled 0.70% of total C, comparing to the content in non-irrigated soil. In the laboratory experiment, the soil material from the horizon A_1M, in case of using the

Table 2. Influence of the irrigation dose size on chemical properties of mineral-moorshy soil (A(M))

	O*	I	II	III	IV
N total %	0.300**	0.277a	0.285a	0.234b	0.236b
C total %	4.080b	4.020ba	4.030b	3.710a	3.710a
C after decalcitation g 100 g-1	0.166c	0.097a	0.106a	0.116b	0.117b
Fraction I					
Ch 100 g soil					
Cf 100 g soil	1.190b	0.926a	0.949a	1.000a	0.997a
Fraction II	0.911b	0.742a	0.795a	0.868ab	0.891b
Ch 100 g soil					
Cf 100 g soil	0.045ac	0.056a	0.045ac	0.031b	0.034bc
C nonhydrolisable	0.037b	0.075a	0.071a	0.031b	0.034b
	1.21	1.660a	1.570a	1.200b	1.060b

*O - no irrigation; I - capillary water; II - 615 ml; III - 1042 ml; IV - 1657 ml; ** average values designated with the same letter (a,b,c) do not differ significantly.

ond (II) dose of water (615 ml; 388.6 mm) lost 0.13% of C, the third (III) dose (1041 ml; 658.0 mm), the loss was 0.20%, and using the fourth (IV) dose (1656 ml; 1046.6 mm) it was 0.30% of total C, on the average, comparing to its content in soil at the beginning of the experiment. The amount of total carbon that stayed in the soil material after finishing the spray irrigation in laboratory conditions, is different for particular variants of irrigation and at the use of irrigation according to doses VI and III, the losses of total carbon are extremely important (Table 2). At dose II, the losses of total C are not important, although an average loss was 0.13%. Determination of the amount of losses of total carbon in irrigated soils were, in each case, compared with the amounts of that element in the initial sample prior to irrigation. Moreover, in collective air dry samples (0), kept in a laboratory, it was stated an increase in the content of total carbon after six months. This increase was expressed by the ratio of 1:1.27 (Table 2).

If we do the same calculation for the content of total C in the air dry soil to the content measured at the beginning of the experiment, and for the soil moisturized according to its capillary capacity, this ratio will be 1:1.24. This ratio means that the content of total carbon grew also in the soil stored in the humid state (according to W_c). However, if we compare the content of total carbon measured in the soil material stored in a dry state (0) and in a humid state (I) after completing the experiment, it turns out that the numerical value of this comparison is 1:1.02, which means a close amount of total carbon in both combinations.

Especially worth attention is the stated dependency between the volume of the water dose and the increase of the amount of total carbon. The research carried out indicates that the use of higher water doses causes greater total carbon losses and

Table 3. Changes in the content of total carbon in soil material in particular stages of the experiment, given in forms of quotients. Average values from 3 repetitions

Water dose (ml) Quotient*	Capillary water W_c	615	1042	1657
y:x	1.27	1.27	1.27	1.27
z:x	1.25	1.25	1.16	1.14
y:z	1.02	1.02	1.10	1.11
(w+z):y	-	2.44	2.90	4.08
(w+z):x	-	3.10	3.78	5.20
x:z	0.80	0.80	0.86	0.87

* Denotations in soil material: x - non-irrigated at the beginning of the experiment; y - non-irrigated after completing the experiment; z - irrigated after completing the experiment; w - sum of components eluded during spray irrigation.

influenced, at the same time, the increase of greater quantities of that component, which means completing those losses of carbon in the investigated soils. At the use of dose II, the content of total carbon increased two times as compared to the initial content (0), at dose III it grew four times, and at dose IV it grew about five times (Table 3).

It should be mentioned that in the performed laboratory experiment, there was no additional organic mass brought into the irrigated soil material.

Literature data indicates that the growth in the content of total carbon in both the irrigated and the non-irrigated soil is a result of the influence of various groups of autotrophic microorganisms, i.e., nitrifying, sulphur, iron reducing and oxidizing or hydrogen bacteria. Those bacteria are capable of synthesizing organic bindings from mineral components in processes of photosynthesis or chemosynthesis by taking carbon from CO_2 and nitrogen from simple mineral bindings [4].

As the result of irrigation, according to the results of the field and laboratory research, along with the growth of the water dose increases the production of organic compounds synthesized by micro-organisms, as well as their amounts and the speed of elusion from soils, which is also supported by statistical calculations (Table 2).

Quantitative changes in the content of general carbon in the investigated soil material are accompanied by quality and quantity changes in particular humus fractions.

It is commonly believed that the easily soluble humus compounds are mainly those, which belong to the fraction I, which are: fulvic acids and humic acids - eluded from soil in the first order. It was stated that humus compounds mineralize more intensively in anaerobic conditions under incubation than dead plants and microorganisms, regardless of the soil kind.

In another laboratory experiment, lasting for 10 months, it was stated that the decomposition of humic substances occurs much more intensively (losses of

Ch=10%, Cf=14%, and losses of humic substances in general = 16%) than in natural conditions, where - as indicated by literature - only 1-2% a year of humic substances is decomposed [10].

In his research, Myśków [8] proved that the precursors of humic substances, created during transformations of fiber in sand with a mineral nutrient, were mostly metabolites of microorganisms. In those conditions, humins were fiber transformed under the influence of microorganisms and containing their metabolites. Chemical properties and biological activity of the created humic substances depends on the species composition of microorganisms developing in the soil substrate. Humic substances derived from fiber were different from the analogic substances derived from plant roots in terms of their properties.

In the laboratory research, where the content of total carbon was differentia-ted by using different doses of water, fractions of humus, which were weakly soluble in water, went through the greatest transformations. Among them were fulvic acids and humic acids of the second fraction, bitumins, and a fractions of non-hydrolyzing carbon.

Analyzing the results of field and laboratory research, supported by statistical calculations, a conjecture arises that those transformations lead to an increase in the amounts of easily soluble organic compounds, which are fulvic acids of fraction I and humic acids having a less complicated structure in moorshy soils. Quality and quantity changes in particular humus fractions were analyzed on the background of their content in the non-irrigated (0) and irrigated (I, II, III, IV) soil material and determined after completing the laboratory experiment. In the irrigated soil material, the differences (depending on the water dose) in the content of humic acids of fraction I were statistically insignificant. Only the soil stored in the air dry state (0) contained significantly more of that fraction of humus. Fulvic acids of fraction I, being the most mobile, behaved differently. Soils irrigated with the greatest doses of water (III, IV) contained the most of that fraction despite of the fact that, at the same time, they were loosing the most of total carbon. However, soils that were less irrigated (II) and moisturized (I) contained the smallest amounts of that fraction (Tables 2 and 4).

Quantity changes of fulvic acids are specifically related to the transformation of fractions of non-hydrolyzing carbon. Specific character of that relation is shown, among others, by changes in the amount of this carbon, regardless of the size of the used water dose, meaning the degree of soil humidity. Irrigating soils with smaller doses of water (I, II) it was stated, as compared to the non-irrigated soil (0), that there had been some increase in the number of non-hydrolyzing carbon fractions, whereas at higher doses of water (II, IV) there had been a decrease in the number

Table 4. Changes in contents of humus fractions in soil material prior to (y) and after irrigation (z) given in form of a quotient (y:z). Average values from 3 repetitions

Water dose (ml) / Humus fraction	Capillary water W_c	615	1042	1657
C-bitumin	1.16	1.28	2.00	0.97
C-after decalcitation	1.70	1.57	1.43	1.42
C_h - Fraction I	1.29	1.26	1.18	1.20
C_f - Fraction I	1.23	1.15	1.05	1.03
C_h - Fraction II	0.81	1.01	1.46	1.34
C_f - Fraction II	0.49	0.53	0.86	0.97
C nonhydrolisable	0.73	0.81	1.05	1.15

of those fractions (Table 4). An increase of the non-hydrolyzing carbon may be explained by the creation of new bindings of humins and ulmins, which are compounds typical for that fraction. Meanwhile, at higher doses of water, the decrease of the non-hydrolyzing carbon is probably caused by the growth in the amount of fulvic acids, which proves the on-going transformations of the hardly soluble fraction. This statement confirmed in a great part, by the composition of the fraction of non-hydrolyzing carbon of the investigated mineral-moorshy soils, in which dominant are weakly decomposed plant remains, which are not soluble in acids and bases. Moreover, some support of the righteousness of this interpretation are investigations carried out by Myśków [6,7], who stated that in result of the decomposition of fiber in sand by microorganisms, mainly fungi, 50-85% of the whole mass had been decomposed in four months, creating mainly fulvic acids.

It should be said that, in conditions of anaerobiosis, in the surface layer of soil, as proved by the investigations of podzolic soils carried out by Kuźnicki *et al.* [3], easily created in the anion form are mobile bindings of fulvic acids with Fe^{+2}, which easily move deeper into the soils profile causing similar losses of soil humus.

CONCLUSIONS

1. In result of irrigation, as indicated by the laboratory research, along with the growth of the water dose, increase the amount of totall carbon eluded from the soil material. It is supported by statistical calculations. Quantity changes of total carbon are accompanied by quantity and quality changes of particular, determined humus fractions.

2. Intensive transformations in conditions of the performed experiment occurred in humus fractions recognized as weakly soluble in water: fulvic acids and humic acids of fraction II; bitumins; a fraction of non-hydrolyzing carbon.

3. In the irrigated soil material, the differences in the content of humic acids of fraction I, regardless of the volume of the used irrigation dose, were statistically insignificant. Significantly more of that fraction was in the non-irrigated soil.

4. In soils irrigated with the greatest doses of water (II, IV), the most fulvic acids of fraction I were stated, despite the fact that at the same time they were losing the most total carbon. Comparing to the non-irrigated soil (0), in soils irrigated with smaller doses of water (I, II) a particular increase in fractions of the non-hydrolyzing carbon was stated, whereas a decrease of carbon was observed when using greater doses of water.

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