FRACTIONATION OF THE HUMUS OF SOME CHERNOZEMIC SOILS OF SOUTHERN ALBERTA¹

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ABSTRACT

Two orthic profiles, widely separated geographically, of each of four parent materials—lacustrine, alluvial-lacustrine, glacial till, and aeolian—were selected at undisturbed sites within each of the Brown, Dark Brown, and Thin Black soil zones. Material from the Ah and Bm horizons was subjected to solvent extraction, and for each sample the total organic carbon of seven different fractions was determined.

The efficiency of the procedure in extracting humus carbon decreased as the total carbon content of the soil increased. Total organic matter, the first humic acid fraction, and the combined total of the three humic acid fractions showed significant differences between soil zones. The only significant separation between all four parent materials was made by the alcohol-benzene fraction. Other parent material separations were possible only following the summation of data of several fractions, such as the three humic acid fractions or the two fulvic acid fractions. A simplification of the procedure in case of soils of one Order and a modification to overcome the impeding effect of increased carbon content are requisite.

INTRODUCTION

Chernozemic soils are found on various parent materials (14), yet morphologically similar soils may still differ in the nature of their humus complex. The effect of the composition of parent materials on soil formation has been shown (1, 6, 13): for example, solonetzic and chernozemic soils occur side by side within the same soil zone. Further, parent material has been found to correlate with certain grass species (4, 5, 7), which in turn could lead to qualitative differences of the soil organic matter.

Differential-extraction methods that are supposed to give an indication of the state of combination of humic substances in the soil have been devised by Russian soil scientists (10). It should be realized, however, that the fractionation of the organic matter is to some extent arbitrary since the fractions are closely interconnected by transitional forms. The purpose of this study was to determine if a procedure currently in use in the U.S.S.R. for fractionating soil humus could separate chernozemic soils of southern Alberta by soil zone and parent material on the basis of the soil humus.

MATERIALS AND METHODS

Two profiles, widely separated geographically, of each of four parent materials—lacustrine, alluvial-lacustrine, glacial till, and aeolian—were selected at undisturbed sites within each of the Brown, Dark Brown, and Thin Black soil zones. The soil series sampled were all members of the orthic subgroups of the Brown, Dark Brown, and Black Great Groups of the Chernozemic Order (Table 1). Samples were taken from the central part of each of the Ah and Bm horizons. Each sample was air-dried and ground to pass a 60-mesh sieve.

The humus was fractionated by a procedure originally devised by Tyurin (16) and subsequently modified by Kononova and co-workers (8, 9, 10, 11). For convenience, the method of fractionation is shown in flow-sheet form.

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FLOW SHEET FOR FRACTIONATION OF SOIL HUMUS BY TYURIN-KONONOVA METHOD

TABLE 1. DESCRIPTION OF SOILS FROM SOUTHERN ALBERTA

Zone	Parent material	Series	Texture
Brown	Lacustrine	Seven Persons	Silt loam
	Alluvial-lacustrine	Chin	Silt loam
	Sorted till	Foremost	Loam
	Aeolian	Cavendish	Loamy fine sand
Dark Brown	Lacustrine	Coaldale	Silty clay loam
	Alluvial-lacustrine	Lethbridge	Loam
	Sorted till	Readymade	Loam
	Aeolian	Carmangay	Very fine sandy loam
Thin Black	Lacustrine	Pincher	Clay
	Alluvial-lacustrine	Stand Off	Silty clay loam
	Till	Leavitt	Loam
	Aeolian	Irma	Medium sand

Total organic carbon of the soils was determined by difference between total carbon (3) and inorganic carbon (2). The carbon content of the various fractions was determined by the procedure of Allison (2). Mechanical analyses were carried out according to a modified procedure for pipette analyses (15).

RESULTS AND DISCUSSION

Total organic carbon values increased significantly (at 5% level) in both the Ah and Bm horizons from the Brown to the Thin Black soil zone for each parent material except the aeolian sample (Table 2). No adequate explanation can be given as yet for the low carbon content of the Irma medium sand. Within each zone the aeolian parent material contained significantly less total organic carbon than the other three parent materials. Only in the Thin Black soil zone did the till soil contain significantly more organic carbon than the soils formed from lacustrine and alluvial-lacustrine parent materials.

The H_1 fraction and the combined total of the three humic acid fractions ($H_1 + H_2 + H_3$) also showed significant differences between zones (Table 3). Although the carbon content of all the other fractions increased going from the Brown to the Thin Black soil zone, these differences were not significant.

The recovery of organic carbon proved to be complete for both horizons of all soils. However, the amount of organic carbon in the soil residue increased as the total carbon content of the soil increased. This indicates that this extraction procedure is not satisfactory. Modifications seem necessary to overcome this effect of increased carbon content.

TABLE 2. PER CENT TOTAL ORGANIC CARBON OF CHERNOZEMIC SOILS OF SOUTHERN ALBERTA (AVERAGE OF TWO PROFILES EACH ANALYSED IN DUPLICATE)

Zone:	Brown		Dark Brown		Thin Black	
Horizon:	Ah	Bm	Ah	Bm	Ah	Bm
Lacustrine	2.27	1.24	3.98	2.01	5.73	2.55
Alluvial-lacustrine	2.75	1.31	4.01	2.33	5.14	2.57
Till	2.95	1.37	4.06	2.35	7.50	3.42
Aeolian	1.45	0.753	3.04	0.889	1.98	0.648
Average for zone	2.36	1.17	3.77	1.89	5.09	2.30

The carbon left in the residue was about the same for the lacustrine, alluvial-lacustrine, and till materials (Table 4). A smaller percentage was left in the residue of the aeolian soils. This was true for both the Ah and Bm horizons. Similar patterns were obtained for the soils of the Dark Brown and Thin Black soil zones, and, therefore, the data for these zones are not presented.

With two exceptions, the carbon contents of the various fractions of the till, lacustrine, and alluvial-lacustrine soils did not differ, but these contents were significantly larger than those of the aeolian soils. The H₁ fraction did not make this separation, whereas the EtOH-C₆H₆ fraction separated all four parent materials. The group of substances extracted by the EtOH-C₆H₆ chiefly includes oils and fats, long-chain fatty acids, and alcohols. Although these are inherent constituents of plant residues and microbial cells, Kosaka and co-workers (12) feel that this material is produced in the process of humification. For the entire H (H₁ + H₂ + H₃) and F (F₁ + F₂) fractions of both horizons the carbon content of the till was significantly larger than those of the lacustrine and alluvial-lacustrine soils. These in turn were significantly larger than that of the aeolian soils.

One Order of soils was studied and, therefore, large differences within the various fractions could not be expected. Parent material has been found to correlate with certain grass species, and it could therefore be postulated that

TABLE 3. CARBON OF VARIOUS HUMUS FRACTIONS EXPRESSED AS PERCENTAGE OF TOTAL ORGANIC CARBON OF SOIL (AVERAGE OF EIGHT PROFILES EACH ANALYSED IN DUPLICATE)

Zone:	Brown		Dark Brown		Thin Black	
Horizon:	Ah	Bm	Ah	Bm	Ah	Bm
EtOH-C ₆ H ₆	6.7	4.6	4.3	3.5	3.4	3.1
H ₁	6.7	5.3	6.5	4.5	8.1	5.3
H ₂	13.9	24.4	9.1	15.6	8.2	14.0
H ₃	4.6	7.9	4.0	5.3	3.3	5.1
F ₁	6.8	9.1	5.6	8.3	4.2	7.7
F ₂	24.2	35.0	17.2	23.0	12.7	13.8
Residue	35.4	16.6	53.8	39.1	61.9	50.9
% recovery	98.3	102.6	100.5	99.5	101.8	100.0

TABLE 4. CARBON OF VARIOUS HUMUS FRACTIONS WITHIN A ZONE, EXPRESSED AS PERCENTAGE OF TOTAL ORGANIC CARBON OF SOIL (AVERAGE OF TWO PROFILES AND DUPLICATE ANALYSES)

Zone:	Brown							
Horizon:	Ah				Bm			
Parent material:	Lacus-trine	Alluvial-lacustrine	Till	Aeolian	Lacus-trine	Alluvial-lacustrine	Till	Aeolian
EtOH-C ₆ H ₆	8.0	5.9	4.9	9.9	3.7	4.6	4.8	6.2
H ₁	4.5	4.9	6.8	13.0	4.5	3.6	5.0	10.0
H ₂	10.7	13.7	17.0	13.3	24.0	21.8	24.8	28.7
H ₃	5.4	3.6	5.2	4.2	7.5	8.5	8.3	6.7
F ₁	7.8	7.5	5.0	7.7	9.6	8.4	7.7	12.5
F ₂	27.8	21.1	21.9	29.4	29.2	33.9	38.3	34.8
Residue	38.5	39.6	37.3	23.7	21.1	22.3	18.3	3.3

certain qualitative and quantitative carbon differences do exist between soils formed from various parent materials. Most fractions did not show this. The summation of data of several fractions did give significant differences. A simpler procedure may be requisite in order to show the effect, either direct or indirect, of parent material on soil carbon.

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