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LIGHT FRACTION SOIL ORGANIC MATTER IN LONG-TERM AGROECOSYSTEMS

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INTRODUCTION

Soil organic matter (SOM) includes plant, animal, and microbial material in all stages of decay. The most decomposed SOM consists of a mixture of organic compounds closely associated with clay and silt in the soil. Soil organic matter is one of several criteria including bulk density, nitrogen, aggregation, and microbial activity which is used to estimate soil quality.

Soil organic matter plays a major role in maintaining soil structure, soil water infiltration, root development, and decreased soil erosion. It is a repository for crop nutrients, such as nitrogen, sulfur, phosphorus, and numerous minor elements. It gives color to the soil, increases water holding capacity, and resists changes in soil pH. It is not surprising that the amount and depth of SOM greatly impacts the productivity of both cultivated and uncultivated soils.

Soil organic matter accumulation is dependent on the balance between primary productivity (i.e. production of stems, roots and leaves) and biological decomposition of residue in the soil. Soil organic matter accretion is influenced by moisture and temperature. The rate of carbon accumulation is higher in moist temperate climates. The amount of SOM is inversely related to the amount of silt and clay in that soil (Christensen and Sorensen, 1985; Christensen, Bertelsen and Gissel-Nielsen, 1989). Nutrients, such as minerals in volcanic ash or in fertilizers, help to increase SOM by increasing vegetative productivity. Under similar climatic and edaphic conditions, grassland soils have higher SOM levels than do cultivated farmlands, even though residue input may be substantially less in the grassland. Crop management practices such as moldboard plowing, residue burning, and fallowing all decrease SOM.

Soil organic matter quality can be evaluated by several different methods. Density fractionation is utilized to isolate SOM that is not firmly associated with the mineral part of the soil. Soil is dispersed in dense organic liquids or inorganic salt solutions to separate different density fractions. The light fraction (LF) of SOM (predominantly the least decomposed material) is usually separated from whole soil by density fractionation in a liquid medium with a density between 1.6 and 2.2 grams per cubic centimeter (g/cm^3). The remaining SOM, or heavy fraction, consists of extensively decomposed organo-mineral complexes. The LF is generally considered to be a transitory SOM pool dominated by decomposing plant and animal residues (Greenland and Ford, 1964). It is relatively large in size compared to other soil organic matter components and insoluble in water. It contains organic material not recognizable as residue, but not yet highly decomposed. The LF may include micro-organisms and microfauna, but Ahmed and Oades (1984) suggested that total microbial biomass in the LF is insignificant.

The carbon-to-nitrogen (C:N) ratio in the LF is usually greater than C:N ratio for whole soil, indicating the significant influence of plant residues in this SOM pool (Greenland and Ford, 1964). The LF is also

enriched in carbohydrates relative to whole soils (Oades, 1972). It has been suggested by Christensen (1992) that the proportion of LF in the SOM provides a better and earlier indication of the consequences of soil management than SOM levels in whole soils. Cultivation of virgin sites greatly reduced the SOM LF in Australia (Dalal and Mayer, 1987).

We hypothesize that SOM LF is likely to be affected by land use, tillage, and other factors such as burning and fallow, in the Pacific Northwest. The objectives of this investigation were to isolate SOM LF from the soil of several long-term experiments at the Pendleton Agricultural Research Center and evaluate the relationship of SOM LF to long-term management practices.

EXPERIMENTAL

Soil samples were collected from long term experiments located on the Columbia Basin Agricultural Research Center 10 miles northeast of Pendleton, OR. These experiments have a documented history of tillage, cultivar, seeding date, soil amendments and yield. In addition, many soil parameters, including nitrate, ammonia, pH, extractable phosphorus, carbon and total nitrogen, are determined at regular intervals. Rasmussen and Smiley (1994) recently published a comprehensive description of the plots.

Samples were taken from the following experiments:

Grass Pasture (GP) - Maintained as permanent pasture since 1931, it is periodically reseeded with introduced grass cultivars, and occasionally fertilized. It was grazed until 1985. It has not been grazed since, but it is clipped once or twice a year. The clippings remain in the field.

Residue Management (CR) - Established in 1931, it is the most comprehensive of the experiments. The rotation is winter wheat/fallow, the tillage is moldboard plow and residue is burned in the spring. Nitrogen fertilizer treatments (0 or 80 lbs. N per acre) are applied about 10 days before seeding.

No-Till (SF) - Started in 1982, then modified in 1983 and 1988, it was cropped annually in wheat from 1982 to 1988, then converted to winter wheat/fallow. Wheat stubble is flailed and left in the field. There is no tillage, except fertilization. We selected two of five N rates (0 and 80 lbs. N per acre) for sampling.

Soil samples were collected in eight inch increments (0-8 and 8-16 in.), air dried, crushed and sieved (9.0 mesh screen). Plant residues and rocks were removed from the sample by hand. Soil moisture content was determined on a subsample.

We isolated the LF by the method of Gregorich and Ellert (1993). A weighed portion of soil sample was transferred to a polypropylene centrifuge tube and sodium iodide (NaI) solution (density = 1.7 g/cm^3) was added. The tubes were placed on a reciprocating shaker at 275 rpm for one hour at room temperature (72°F). After shaking, soil on the cap and tube walls was washed into the tube with NaI solution. The tubes were centrifuged at 1000 x gravity for 15 minutes at 60°F. The NaI solution and the LF were separated by filtration. The supernatant, with the suspended LF, was decanted into a glass vacuum filtration apparatus and rinsed with a dilute solution

of calcium chloride followed by distilled water. The LF was gently washed from the filter into an aluminum weigh boat using distilled water. The resulting slurry was dried at 140°F for 24 hours, or until dry, then weighed.

The soil was extracted a second time with another aliquot of NaI solution. The additional LF was collected by filtration as described above and added to the first LF isolated to give the total weight. Total C and N in the soil samples and in the extracted LF were determined by combustion in a Fisons CNS analyzer.

RESULTS AND DISCUSSION

The proportion of LF recovered from whole soils ranged from 0.04 percent in the CR soil (Table 1) to 0.61 percent in the GP soil. Light fraction isolated from an array of Australian soils ranged from 0.03 to 8.2 percent of the soil dry weight (Greenwood and Ford, 1964). Janzen (1987) found the LF to account for less than 0.4 percent of the soil weight in cultivated Canadian soils. In course, sandy German soils the LF made up 0.1 to 0.4 percent of the whole soil weight (Leuschner et al, 1981, reported by Christensen, 1992)

Table 1. Light fraction SOM in soil as affected by long-term crop management. Columbia Basin Agricultural Research Center, Pendleton. Soil samples taken 1994.

Depth	Nitrogen	LF[1]	C:N	C:N	N in LF[2]	C in LF[3]
(in)	(lbs/acre)	(%)	(LF)	(whole soil)	(%)	(%)
Residue Management Experiment (CR) Soil						
0-8	0	0.05	12.3	12.3	1.56	2.57
8-16	0	0.04	9.0	9.7	1.14	1.92
0-8	80	0.07	12.7	12.4	3.90	6.80
8-16	80	0.06	9.7	9.4	0.95	6.67
NoTill Experiment (SF) Soil						
0-8	0	0.23	22.2	13.5	2.97	4.87
8-16	0	0.14	17.7	10.3	1.11	1.82
0-8	80	0.28	23.2	13.3	2.71	4.70
8-16	80	0.19	22.9	10.5	0.96	2.11
Grass Pasture Experiment (GP) Soil						
0-8	0	0.61	15.4	10.9	5.17	7.31
8-16	0	0.43	17.7	9.8	4.35	7.86

[1] Percent LF in whole soil.
[2] Percent N in LF to total N in whole soil.
[3] Percent C in LF to total C in whole soil.

Accumulation of LF is favored by continuous vegetation. Whitehead and coworkers (1975) reported LF amounts of 0.4 percent and 5.4 percent of the soil weight in cultivated and in permanent pasture soil respectively. Garwood et al (1972) found that a temperate grazed grassland was able to maintain twice as much LF as under arable tilled soils. In our study, LF concentration in the grass pasture soil is more than twice that of any cultivated soil (Table 1).

The amount of LF decreased with depth in all management practices. The LF also increased with N addition. Undoubtedly, this increase is because of increased plant growth, due to N fertilizer additions, and to increased residue production.

The C:N ratio in the LF ranged from almost 10 to slightly over 23 and was generally higher than in native soil (Table 1). Carbon to nitrogen ratios of LF isolated by Greenland and Ford (1964) ranged from 12 to 30. Plant residues greatly influence the C:N ratio which causes it to be greater than that found in whole soil. This may explain why C:N ratios in the CR experiment were relatively low. Wheat stubble in this experiment is burned which greatly reduces the amount of residue available for the formation of SOM. In summary, we found that the concentration of SOM LF is distinctly different between cropping systems and a key indicator of management practices that will improve soil quality. The main relationships were: (a) continuous grassland has greater LF accumulation than does cultivated soil; (b) no-till management results in greater LF accumulation than does plowing and burning; and (c) there is an inverse relationship between LF and soil depth and a positive relationship between LF and N fertilization.

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