**Southern Regional Fact Sheet**

**Soil Testing & Plant Analysis**

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# INTERPRETING SOIL ORGANIC MATTER TESTS

Soil organic matter (SOM) is related to the productivity of a soil. Because of this fact, maintaining SOM is an objective of many sustainable crop production systems. However, SOM tests are difficult to interpret by the laboratory that performs the analysis and meaningless for most growers.

In the Southern U.S., 11 of the 13 state-supported public soil testing laboratories offer a SOM test upon request. North Carolina Department of Agriculture offers a "humic matter" test as an alternative. None of the public labs offers SOM as part of a standard soil fertility test, and none offers an interpretation for the grower. There is a reason for this omission. What does the test tell a farmer, a homeowner, a gardener, or a crop advisor about soil or crop management? Unlike the interpretation of soil pH or extractable soil P or K levels, there is no simple interpretation for SOM levels.

## Definitions

Soil organic matter comprises an accumulation of partially disintegrated and decomposed plant and animal residues and other organic compounds synthesized by the soil microbes as the decay occurs (Brady, 1990). Soil **humus** (or humic material) is that portion of SOM that is a heterogeneous mixture of organic compounds formed by degradation and synthesis. Soil humus makes up about 60-80% of SOM. The rest is less stable and partially decomposed organic residues. Humus is the stable fraction of SOM because it is relatively resistant to microbial attack. This is the fraction of SOM that is most responsible for cation exchange and interactions with soil-applied pesticides. Humic materials are generally classified into 3 groups:
(1) Fulvic acid which is low in molecular weight, light in color, soluble in both acid and alkali, and most susceptible to microbial attack (15-50 years); (2) Humic acid which is moderate in molecular weight and color, soluble in alkali but insoluble in acid, and intermediate in degradation potential (100+ years); and (3) Humin which is high molecular weight, dark in color, insoluble in both acid and alkali, and most resistant to microbial attack.

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The Southern Region Fact Sheet on Soil Testing and Plant Analysis series presents timely information of interest to users of soil testing and plant analysis services in the Southern Region of the U.S. It is reviewed by the Southern Extension and Research Activity Information Exchange Group #6 (SERA-IEG-6) on soil testing and plant analysis and published by each cooperating state's Agricultural Experiment Station and Cooperative Extension Service.

## Laboratory analysis

Most SOM values are derived from organic carbon (C) because the quantitative determination of SOM has high variability and questionable accuracy (Nelson and Sommers, 1982). Organic C analysis is reasonably accurate using the traditional wet digestion with acid-dichromate and heat (modified Walkley-Black). Modern instrumentation has allowed many labs to determine C using dry combustion in an inductive furnace and subsequent $CO_2$ analysis using thermal conductivity. When Walkley-Black digestion is used for C analysis, a conversion factor of 1.724 is used to convert organic C to organic matter. However, it is generally recognized that the value can range from 1.6 to 3.3 (Jackson, 1958, Nelson and Sommers, 1982). Loss-on-ignition techniques have also been used to estimate SOM. SOM is usually reported as a percentage on a dry weight basis and is usually greater than SOM determined by Walkley-Black.

## Factors affecting SOM

The amount of organic matter in surface, mineral soils can vary from less than 1% in coarse-textured, sandy soils to more than 5% in fertile, prairie grasslands. The amount is influenced by all soil forming factors. Jenny (1941) arranged the order of importance of these factors as:

*Climate > vegetation > topography = parent material > age*

Some general statements about SOM levels in virgin soils can be made based upon Jenny's work (Rasmussen and Collins, 1991):

1. *Grassland soils have higher SOM than forest soils.*
2. *SOM increases with increasing precipitation and decreases with increasing temperature.*
3. *Fine-textured soils have higher SOM than coarse-textured soils.*
4. *Somewhat poorly and poorly drained soils have higher SOM than well-drained soils.*
5. *Soils in lowlands have higher SOM than soils on upland positions.*

Most SOM is found in the zone of maximum biological activity, the topsoil or plow layer. Anything done to this layer will influence long-term buildup or depletion of SOM, e.g., tillage, crop rotation, erosion, cover crops, crop residue management, fertilization, organic amendments, etc. Table 1 lists ranges of SOM found in different soil orders.

## SOM and Soil Productivity

A highly productive soil will produce more total biomass than a less productive soil. If much of this biomass remains in the field, then the soil is likely to have a higher SOM content than a less productive soil. In this situation, a SOM test is redundant. It tells the grower what is already known, "The soil is more productive." Unlike extractable nutrients, soil pH, or soluble salts, there is no critical level below which crop yields are severely limited. Any factor that increases total biomass production will ultimately increase SOM to some point where climate, geography, and management practices limit further increases. The benefits of higher SOM are often mentioned in association with good soil and crop management: increased soil aggregation, improved drainage in fine textured soils, better water-holding capacity in sandy soils, higher cation exchange capacity, increased nutrient reserves, etc. Although most unproductive soils can be improved with large additions of organic matter (Wallace et al., 1990), maintenance of SOM for the sake of maintenance alone is not a practical approach to farming (Tisdale et al., 1985).

The terms, *soil quality* and *soil health* have recently been used in association with the sustainable agriculture movement (Doran et al., 1994: Magdoff, 1992). An attempt has been made to use traditional SOM tests or a test of some fraction of the SOM as an index of the total productivity or sustainability of a particular soil. This indexing has proven difficult because a simple interpretation of organic matter analyses or some fraction of the SOM isn't universally applicable.

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Table 1. Ranges in soil organic matter commonly found in the upper 6 inches of 8 major soil orders (from Brady, 1990).

| Soil order | Soil organic matter<br>Range | <br>Representative |
|---|---|---|
| | ---------------------% | ------------------- |
| Alfisols | 0.8-6.5 | 3.0 |
| Aridisols | 0.2-1.7 | 1.0 |
| Histosols | 20-98 | 80.0 |
| Mollisols | 1.5-6.5 | 4.0 |
| Oxisols | 1.5-5.0 | 3.0 |
| Spodosols | 1.5-5.0 | 3.5 |
| Vertisols | 1.5-3.0 | 2.0 |
| Ultisols | 1.5-4.0 | 2.0 |

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## Nutrient Applications

Soil organic matter is a huge reserve of potentially mineralizable nitrogen (N), sulfur (S), and other nutrients. Organic C is generally highly correlated with organic N. Early soil tests in Illinois were based on the assumption that approximately 2% of the total N (mostly organic N) would be mineralized during a growing season. This would be approximately 10 pounds N/acre/year for each 1% organic matter. The University of Missouri Soil Testing Laboratory adjusts N recommendations based upon SOM. The N requirements minus the N-supplying power of the soil based on SOM will indicate the N rate necessary to produce the yield goal for the selected crop (Table 2) (Buchholz, 1983).

Since most crops require rather large amounts of N (100-300 lb/acre) and because most soils of the southern U.S. contain less than 3% SOM (which will provide less than 30 lb. N/acre), most laboratories don't test for SOM for the purpose of making (or adjusting) a N fertilizer recommendation. Additionally, the estimated N release rate of SOM can be quite variable.

There may be opportunities to adjust the N rate applied to certain crops based upon SOM, but these correlations have not been developed to the point that specific recommendations can be made. Within a state or region, general statements accompanying a soil test report may take this factor into consideration. For example, recommended N for cotton in Alabama should be reduced ". . . where cotton follows a good crop of soybeans or on land where excessive growth has caused problems. . . " (Adams et al., 1994). South Carolina adjusts the N recommendation for corn depending upon soil texture, location, and legumes used in the rotation (Clemson University, 1982). These recognize that SOM has an impact on optimum N rate but no specific correlation has been established.

Table 2. Nitrogen credits for SOM used by the University of Missouri Soil Testing Laboratory (Buchholz, 1983).

| Soil texture | Soil cation exchange capacity | Nitrogen rate adjustment formula<br>Cool season crops | <br>Warm season crops |
|---|---|---|---|
| | --cmol/kg-- | --------------pounds N/acre------------- | |
| Sands - sandy loams | <10 | 20 * %SOM | 40 * %SOM |
| Silt loams - loams | 10-18 | 10 * %SOM | 20 * %SOM |
| Clay loams - clays | >18 | 5 * %SOM | 10 * %SOM |

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Because most of the S in surface horizons of well-drained agricultural soils of the humid, semiarid, temperate, and subtropical regions is present in organic forms, S deficiencies in crops are often associated with sandy soils low in organic matter (Tisdale et al., 1985). There are often high correlations between organic C and extractable and/or total S in soils (Mitchell and Blue, 1981). However, at this time, no public soil testing laboratory in the southern region of the U.S. is using a calibration of a SOM analysis to make S fertilization recommendations.

SOM in the form of humus enhances mineral breakdown and, in turn, nutrient availability. Organomineral complexes can also be formed with ions, particularly metallic ions such as $Fe^{3+}$, $Cu^{2+}$, $Zn^{2+}$, and $Mn^{2+}$, which will make them more available for plant uptake than the mineral form of these metals.

SOM and Cation Exchange Capacity

Soil humus has a much higher cation exchange capacity (CEC) than clay minerals common in soils of the southern U.S. (Table 3). Therefore, a little organic matter can greatly influence the CEC of a sandy, Coastal Plain soil whose clay fraction is dominated by kaolinite or hydrous oxides. This higher CEC may have consequences in how soil-test results for K, Mg, Ca, and other cations are interpreted. Many state soil testing programs recognize this effect by separating soils of the state into groups for interpretation. Groups may be separated by CEC as in Alabama (Adams et al., 1994) or separated as a result of the cumulative management effects of soils with different CEC's. For example, Georgia and South Carolina distinguish between the low CEC soils of the Coastal Plain and the higher CEC soils of the Piedmont. Therefore, accounting for the broad effects of SOM on the cation exchange capacity of soils of a physiographic region is generally accomplished by other soil-test calibration techniques. North Carolina separates .pa
soils into 3 classes based on NaOH-extractable humic matter: (1) mineral, (2) mineral-organic, and (3) organic (Tucker and Rhodes, 1987).

Table 3. Cation exchange capacity of organic and inorganic soil colloids at pH 7.0 (from Brady, 1990).

| Colloid | CEC (cmol/kg) |
|---|---|
| Humus (organic) | 300 |
| Vermiculite | 120 |
| Smectite | 90 |
| Fine-grained micas | 25 |
| Kaolinite | 5 |
| Hydrous oxides | 3 |

## Soil Pesticide Applications

The persistence, degradation, bioavailability, leachability, and volatility of pesticides is directly related to the nature and concentration of SOM (Schnitzer, 1991). Certain soil-applied herbicides are bound by SOM reducing their availability and requiring higher rates to achieve effective weed control. High SOM and its associated microbial activity may also lead to faster degradation of soil-applied herbicides. Therefore, some products specify rates based upon SOM (Table 4). These SOM ranges are generally broad and encompass large soil physiographic regions. For example, higher rates of many acetamides are recommended for soils with >3% organic matter. Most field crops in the southern U.S. are grown on soils with less than 2% organic matter. A grower with >3% organic matter would probably know this without a soil test. Bladex$^{TM}$ (Du Pont), on the other hand, has a labeled rate for preemergence broadcast application on corn that increases incrementally as SOM increases from 1% to over 5%. However, in general, only unique fields (those with heavy application of organic soil amendments) may need an organic matter test for herbicide applications.

## Conclusions

SOM is a valued component of any sustainable production system. Many production practices can influence the long-term buildup or depletions of SOM e.g. tillage, crop rotation, erosion, cover crops, crop residue management, fertilization, organic amendments, etc. Most research with SOM has focused on the effects of soil management on SOM, not the effect of SOM on management. Laboratory techniques are available that allow reliable estimations of SOM or humic matter in cultivated soils. These measurements, however, have little short-term value to the grower, except for adjusting rates of certain herbicides. Long-term increases in SOM in a particular field reflect a consequence of improved production practices and possibly, higher productivity.

Table 4. A list of some common herbicides with labeled rates dependent on SOM.

| Trade name* | Common name | SOM limitation |
|---|---|---|
| | Thiocarbamate | |
| Sutan+ | butylate | soils < 10% O.M. |
| Eradicane | EPTC | soils < 10% O.M. |
| Vernam | vernolate | >1% O.M. ; < 10% O.M. |
| Tillam | pebulate | soils +/- 10% O.M. |
| Ordram | molinate | ——— |
| Bolero | thiobencarb | ——— |
| | Triazine | |
| Bladex | cyanazine | <1%,2,3,4,5+ O.M. |
| Atrazine | atrazine | ——— |
| Princep | simazine | +/-1% -- 5%+ |
| Lexone/Sencor | metribuzin | <0.5-1% O.M. (+/-3%) |
| | Acetamides | |
| Lasso | alachlor | +/-3% O.M.; +/-10%+ |
| Dual | metolachlor | +/-3% O.M.; 6-20% O.M. |
| Frontier | dimethenamid | +/-3% + C.E.C. |
| | Dinitroaniline | |
| Balan | benefin | ——— |
| Prowl | pendimethalin | not muck soils |
| Sonalan | ethalfluralin | +/-5% O.M. ; <10% O.M. |
| Treflan | trifluralin | 2-5% O.M. ; 5-10% O.M. |
| Paarlan | isopropalin | ——— |
| | Imidazone | |
| Pursuit | imazethapyr | ——— |
| Scepter | imazaquin | ——— |
| | Substituted Urea | |
| Cotoran | fluometuron | ——— |
| Karmex | diuron | > 1% O.M. |
| Caparol | prometryn | > 1% O.M. |
| Lorox | linuron | 0.5-3% O.M. ; 3-6% O.M. |
| | Miscellaneous | |
| Command | clomazone | ——— |
| Zorial | norflurazon | ——— |
| Facet | quinclorac | ——— |
| Devrinol | napropamide | soils < 10% O.M. |
| Hoelon | diclofop-methyl | 0.5% ; 2-3% ; >3% O.M. |
| Broadstrike | flumetsulam | <3% O.M. ; >3% O.M. |
| Canopy | metribuzin+chlorimuron | 0.5-3% O.M. ; 3-5% O.M. |

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*Trade names are used only to give specific information. Agricultural Experiment Stations and Cooperative Extension Services In the southern region do not endorse or guarantee any product and do not recommend one product instead of another that might be similar.

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