Physical Characteristics of Kentucky Soils with Different Tillage Histories

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Introduction

No-till soils tend to have higher organic matter content compared to conventionally tilled soils. Organic carbon content is an important factor influencing soil chemical (pH, CEC, etc.) and physical (bulk density, compactibility, aggregate stability, etc.) properties. Continuous conventional tillage has been shown to have a negative effect on soil aggregate size and stability as compared to continuous no-tillage (Baldock and Kay, 1987). Soils with high aggregate stability are better aerated, more resistant to compaction, have higher water holding capacity, and provide better conditions for plant root growth.

The effect of various soil constituents on soil aggregate stability may differ in different soils. Chaney and Swift(1987) observed highly significant correlations between soil aggregate stability and organic matter content in 26 British soils and little or no correlation between aggregate stability and other soil constituents.

This study was initiated to determine the effect of different tillage histories on soil bulk density, aggregate stability, and organic matter content.

Materials and Methods

Soil samples of Lonewood loam (Fine-loamy, siliceous, mesic Typic Hapludult) were collected at 16 locations having different tillage histories in Russell County, Kentucky. Soil samples for chemical analysis and bulk density were taken from four depths in 5-cm increments. Nine sites had 10 to 20 years of no-tillage history, except for one field which had only two years in no-tillage. Four locations had a history of conventional tillage (up to 20 years), and three sods had not been tilled at all. Soil organic carbon was measured using a dry combustion analysis in a Leco CR-12 Carbon Analyzer.

Additional soil samples from 0 to 5 cm were taken in each location for aggregate stability measurement. These soil samples were crushed by hand while still slightly moist, air dried, and a 1 to 2 mm fraction separated. A single sieve modification of Yoder's (1936) method was used. Six g of aggregates was evenly layered into a I-mm sieve 7.5 cm in diameter. Samples were gradually wetted with a fine mist sprayer for 20 minutes. Then sieves were placed in a holder and submerged in water at room temperature. A motor raised and lowered sieves 1.5 cm, 20 times/min for 10 min. At the end of this time sieves containing the stable aggregates were dried in an oven at 110oC to determine the weight of stable aggregates. To separate sand particles from the stable aggregates the aggregates were wetted again and rubbed across the sieve screen with a rubber tipped rod until they disintegrated. Sand particles remaining on the screen were oven dried and weighed. Soil aggregate stability was expressed as % of aggregates that remained on the sieve.

Results and Discussion

Figure 1 shows the bulk density of soils with different tillage histories plotted versus % of organic carbon including data from four depths. Sod samples had higher variability of bulk density and organic carbon content compared to soils conventionally tilled. This was due to a rapid decrease of organic carbon content in the soil profile of sods. No-tillage soils varied greatly in both organic carbon content and bulk density. This was probably due to differences in the tillage histories of the fields. For example, the no-tillage field which had a bulk density of 1.71 g cm^{-3} and 0.56 % of organic carbon (Figure 1) has been under no-tillage only for 2 years following many years of rough use under conventional tillage. In contrast, a field with bulk density of 1.08 g cm^{-3} and organic carbon content of 2.13% (Figure 1) has been under no-tillage for over 20 years. Soils with long histories of no-tillage had values of organic carbon content and bulk density close to those of sods. In contrast, soils with short histories of no-tillage following years of conventional tillage were close to conventionally tilled soils in organic carbon content and bulk density. Similar results were reported by Douglas and Goss (1982). The bulk density varied from 0.95 to 1.71 g cm^{-3}. The lowest organic carbon was 0.56% in a no-tillage subsurface sample and the highest was 3.22 % in sods. The results had a relatively high r^2 of 0.72.

The relationship between soil aggregate stability and organic carbon content is shown in Figure 2. A two compartment equation was used to tit the results:

$$Y = -112.2 + 156.8X \ (X < 1.26) + 156.8 \times 1.26 \ (X > 1.26)$$

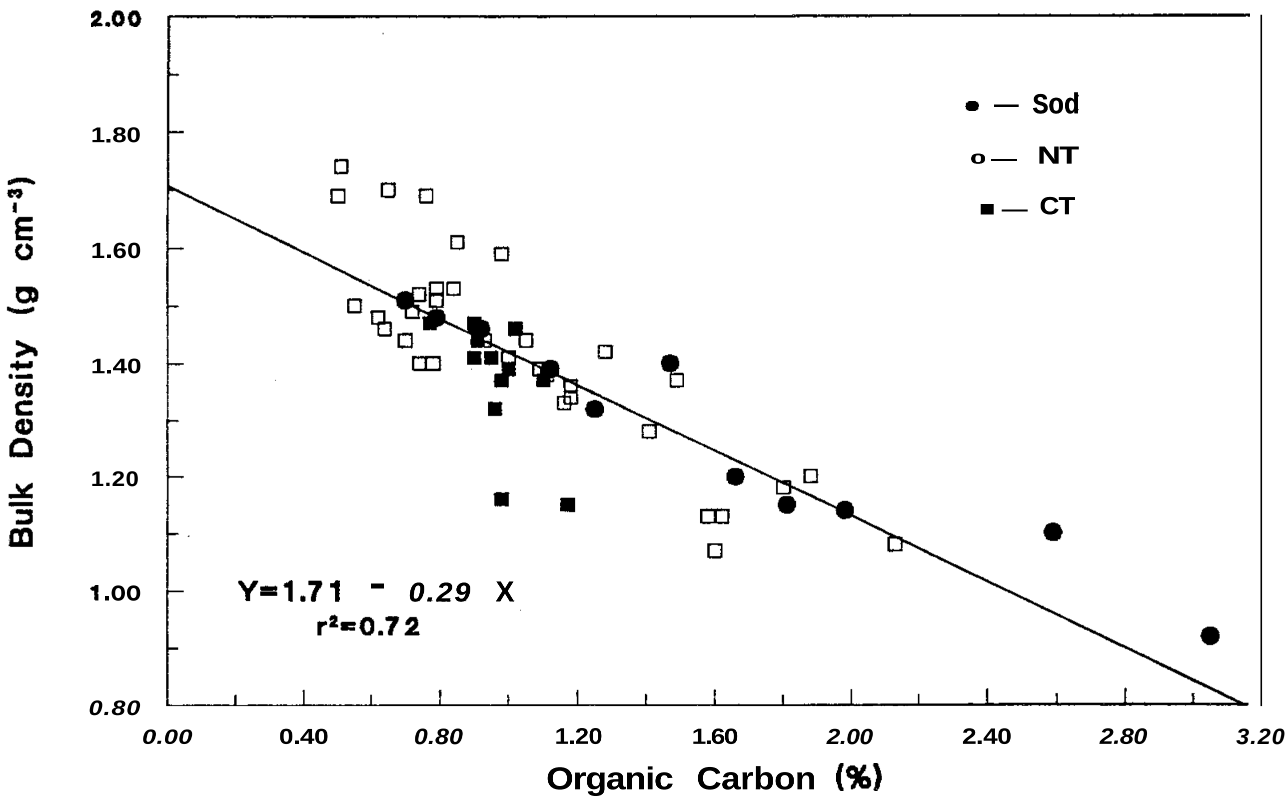

Figure 1. Relationship between bulk density and organic carbon percentage for Lonewood soil under different tillage systems.

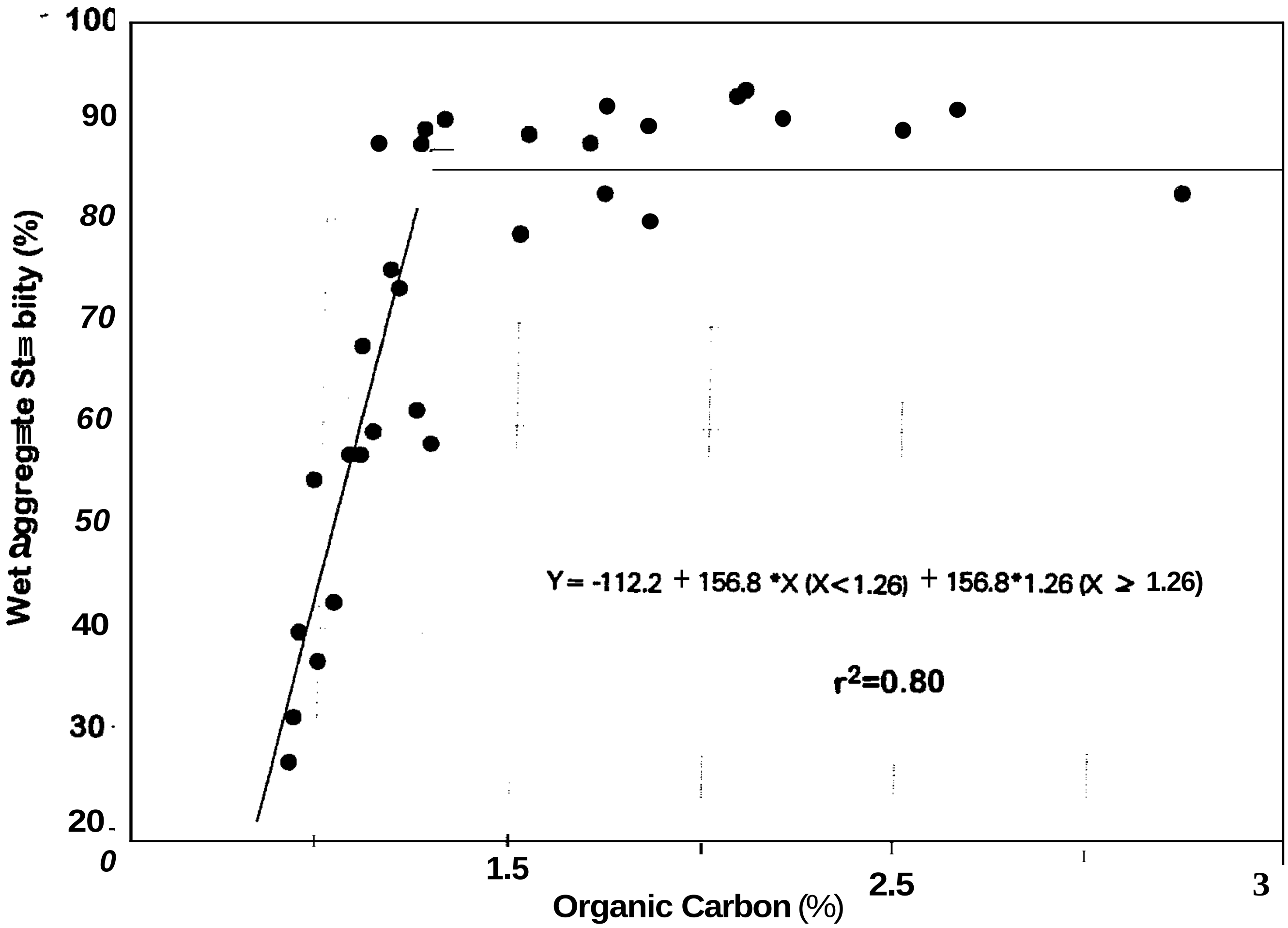

Figure 2. Relationship between wet aggregate stability and organic carbon content.

The intersection of the two lines occurred at 1.26 % organic carbon (Figure 2). It seems that this is a critical structural stability value in this soil. This value, probably, depends on the soil texture and chemical composition, and therefore, varies in different soil series. Aggregate stability increased linearly and rapidly as organic carbon percentage increased up to 1.26%. Past this point further increase in organic carbon content did not significantly affect soil aggregate stability.

These are preliminary results, and similar studies of other Kentucky soils are currently being conducted.

These results show even a slight increase in organic carbon content in soils low in organic carbon significantly improves their physical properties, however this effect is less prominent in soils relatively high in organic carbon.

Literature Cited

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