IMPACT OF GRASSLAND CONVERSION AND CROPPING DURATION ON SELECTED PROPERTIES OF ALFISOLS

PENGARUH KONVERSI LAHAN RUMPUT DAN LAMANYA MASA BUDIDAYA TANAMAN TERHADAP SIFAT-SIFAT ALFISOL

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ABSTRACT

Measuring soil characteristics differences due to land conversion and farming management is needed in order to understand the effects of cultivation on soils. A study was performed to determine the effects of cultivation on grassland and cropping duration on selected properties of alfisols collected from Arkansas, USA. The surface 15 cm of soils had a silt loam texture. Four adjacent fields were used for the study and included a virgin grassland and three cultivated fields that had been cropped for, 3, 14 and 32 years, respectively. The statistical analyses indicated that the magnitude of the soil properties varies with duration of cropping and depth interval. The amount of changes was dependent on soil property. The results indicated that soil color in the virgin grassland had values of hue of 10 YR and 7.5 YR and in cultivated field had values of hue 10 YR. The virgin grassland had a higher clay percentage as compared to the 32-year of cultivated field. However, these differences in clay content were found primarily at the deeper depth. The average profile content of C was 8.08 g kg^{-1} for the virgin grassland and 5.48 g kg^{-1} for cultivated soil. The pH in the virgin grassland was almost one unit lower than that of the 32-year cultivated field. In general, the values of particle density increased as the cropping duration increased. The changes such as increases in soil solution pH up to optimum pH are beneficial whereas decreases in total C content and clay content generally considered to be detrimental for maximum crop production.

Key words : carbon, cropping, soil color, grassland prairie, particle density

ABSTRAK

Kuantifikasi sifat-sifat tanah akibat proses konversi lahan dan pengolahan tanah diperlukan untuk memahami pengaruh aktivitas pengelolaan lahan terhadap karakteristik tanah. Penelitian ini dilaksanakan untuk menentukan pengaruh konversi lahan rumput ke lahan pertanian serta efek lamanya sistim budidaya tanaman dengan olah tanah konvensional terhadap beberapa sifat-sifat terpilih tanah alfisol yang diambil dari wilayah Arkansas, USA. Sampel tanah diambil dari kedalaman 0-15 cm dan memiliki tekstur lempung-debuan. Tanah dari empat tipe lahan telah digunakan dalam percobaan ini yang terdiri dari satu lahan rumput (*virgin grassland*) belum pernah dibuka untuk budidaya, dan tiga lahan yang sedang dalam aktivitas budidaya dengan pengolahan tanah konvensional selama 3, 14 dan 32 tahun. Tanaman yang dibudidayakan adalah padi, kedelai dan gandum. Analisis statistik menunjukkan bahwa nilai sifat-sifat tanah bervariasi tergantung dari masa dimulainya sistim pengolahan tanah konvensional dan kedalaman pengambilan sampel tanah. Hasil penelitian memberikan gambaran bahwa warna tanah pada lahan rumput memiliki nilai *hue* sebesar 10YR dan 7.5 YR dan lahan-lahan yang diolah mempunyai nilai *hue* 10YR. Tanah rumput mengandung konsentrasi liat lebih tinggi dibandingkan lahan-lahan yang diolah, terutama pada profil yang lebih dalam. Kandungan C rata-rata pada lahan rumput adalah 8.08 g kg^{-1}, sedangkan pada lahan budidaya adalah sebesar 5.48 g kg^{-1}. Lahan rumput memiliki nilai pH satu unit lebih rendah dibandingkan lahan yang telah diolah dan dibudidayakan selama 32 tahun. Secara umum nilai kerapatan jenis tanah meningkat seiring dengan bertambahnya durasi sistim pengolahan tanah. Perubahan sifat-sifat tanah seperti peningkatan pH hingga mencapai optimum tergolong menguntungkan, tetapi adanya penurunan kandungan C dan liat termasuk sifat yang merugikan dalam proses budidaya tanaman

Kata kunci : karbon, kerapatan jenis tanah, liat, pH, warna tanah

INTRODUCTION

In agriculture practices, land management are including land conversion, preparation of seed-beds and rootbeds, incorporation of amendments, control of weeds and pest, enhancement of infiltration and control of erosion (Schaver and Johnson, 1985). Many types of soil management, such as tillage are often used to accomplish these purposes. The soil may be loosened, granulated, compacted, crushed, inverted, sheared, shattered, etc., all of which affect the environmental condition of soil.

On a short-term basis, tillage may be beneficial to crop production and soil productivity (Baver *et al.*, 1973). However, the cumulative effect of these frequent tillage operation and cropping over an extended time interval lead to changes in soil physical, chemical and biological properties and may have detrimental effects on crop establishment and yield (Handayani and Coyne, 1995; Handayani, 1996).

Soil properties is defined as the magnitude of soil characteristics. The changes in soil properties can occur over long-term (more than a year) or short-term equal or less than a year) periods of time. Variation of soil properties as affected by tillage practices have been reported to be associated with total C, bulk density, total porosity and water retention (Cassel, 1983), saturated hydraulic conductivity (Scott *et al.*, 1994) and macroporosity (Carter, 1988). Changes in soil properties can be affected by tillage operations to convert the virgin land into cultivated fields and to prepare the growth media, such as planting, cultivating and chiseling. The magnitude of soil properties are also dynamic in virgin grasslands (never cultivated) where root growth, drying and wetting cycles, exudates, carbon turnover and biological activity may strongly effect the magnitude of soil properties.

These published studies have demonstrated that tillage affects the magnitude of soil properties. Therefore, the objective of this research was to determine the changes in selected soil properties due to grassland conversion and tillage duration, especially in alfisol. This study was unique because it involved rice, soybean and wheat as the dominant cropping systems using conventional tillage practice for at least 3 years

METODOLOGY

The soil samples was collected from the Fred Seiden-stricker Farm, which is located south of Hazen in Prairie Country, Arkansas, USA. The latitude is 34°N, the longitude is 91.5° W, and the average annual rainfall is 1338 mm. The soil is classified as an alfisols and the texture in the 0- to 0.15-m depth interval is silt loam. The soil in the study location is an association of Crowley and Calhoun series and has poor internal drainage (SCS, 1981; Scott and Wood, 1989). Four adjacent fields were sampled a prairie and three fields that had mostly been in rotation of rice (*Oryza sativa*), soybean [*Glycine max.* (L)] and wheat (*Triticum aestivum*) for 3, 14 and 32 years, respectively. Soil samples were collected at 15-m intervals along a transect at depth intervals of 0 to 0.05 m and 0.05 to 0.10 m before the crops were planted. Disturbed soil samples were collected and taken to the laboratory for analysis of particle size distribution, particle density, total carbon (TC) and pH in water and in $CaCl_2$. Particle density was determined on disturbed soil cores using the pycnometer method according to Blake and Hartor (1986). Particle size distribution was measured using the micropipette method according to Miller and Miller (1987). Total carbon content was analyzed by the dry combustion method (Scott and Wood, 1989). Soil pH in water was determined at a soil : solution ratio of 1: 2.5, and pH in $Ca\,Cl_2$ was determined by adding 0.1 mL of 1 M $CaCl_2$.

Statistical approach was considered in order to quantify variability of the soil properties due to tillage duration. The ANOVA was performed using a split-plot, since the fields and depth interval were fixed. The computations were carried out using SAS's GLM procedure.

RESULTS AND DISCUSSION

Soil properties, such total C, pH and soil texture of the soil profile in the virgin and 32 year field were analyzed to a depth of 0.77 m. The results are presented in Tables 1 and 2. This soil has low chroma (darker) dominant throughout the upper soil to a depth of 0.75 m or more, and high values (lighter) in the plow layer. Values of chroma of 3 or more indicates that the soil is saturated with water for short periods. The soil pH tends to be very strongly acid to slightly acid in the 0 to 1.40 m depth interval.

Table 1. Color, particle size distribution and textural class of the grassland and cultivated soil profiles.

Depth (m)	Color	Clay %	Sand %	silt %	Textural class
Grassland					
0-0.08	10YR 4/2	15.9	16.8	67.3	Silt loam
0.08-0.15	10YR 4/2	15.2	16.4	68.4	Silt loam
0.15-0.23	10YR 4/3	17.3	15.2	67.5	Silt loam
0.23-0.31	10YR 5/3	22.5	13.4	64.1	Silt loam
0.31-0.38	10YR 5/3	27.1	10.2	62.7	Silt loam
0.38-0.46	10YR 5/4	29.0	10.2	60.8	Silty clay loam
0.46-0.54	10YR 5/3	30.1	11.2	58.7	Silty clay loam
0.54-0.61	10YR 6/6	29.8	9.6	60.6	Silty clay loam
0.61-0.69	7.5 YR 5/6	28.8	10.4	60.8	Silty clay loam
0.69-0.77	7.5 YR 5/6	34.3	9.8	55.9	Silty clay loam
Cultivated field (32 year)					
0-0.08	10YR 4/3	15.8	14.0	70.2	Silt loam
0.08-0.15	10YR 4/3	15.6	15.8	68.6	Silt loam
0.15-0.23	10YR 4/3	19.3	18.6	62.1	Silt loam
0.23-0.31	10YR 4/2	20.6	18.4	61.0	Silt loam
0.31-0.38	10YR 5/2	21.7	17.5	60.8	Silt loam
0.38-0.46	10YR 5/2	21.6	19.7	58.7	Silt loam
0.46-0.54	10YR 5/2	18.3	16.0	65.7	Silt loam
0.54-0.61	10YR 4/2	23.4	18.2	58.4	Silt loam
0.61-0.69	10YR 4/2	21.7	19.1	59.2	Silt loam
0.69-0.77	10YR 5/2	20.6	18.1	61.3	Silt loam

The results of the profile characterization indicated that soil color in the grassland had values of hue of 10YR and 7.5YR. in the 0 to 0.61 m depth interval the hues were yellowish red and grayish brown (10YR). The soil color was redder and lighter below 0.61 m (7.5YR). Hues redder than 10YR are due to the red parent materials that remain red after citrate-dithionite extraction (Soil Survey Staff, 1975). In the grassland, the soil colors were lighter as depth of profile increased. Soil color in the profile depends upon water regime in the profile. The results from the particle size analysis indicated that the textural class of the profile was silt loam except for the grassland, the profile mean values of clay, sand and silt were 25.0 $\pm$ 6.8%, 12.3 $\pm$ 2.9% and silt in the 32-year field were 20.0 $\pm$ 2.5%, 17.5 $\pm$ 1.8% and 62.6 $\pm$ 4.1%, respectively.

Table 2. Total carbon and pH in water and salt of the grassland and 32 year of cultivated soil profiles

Depth (m)	Total Carbon g kg^{-1}	PH		ΔpH
		(H_2O)	($CaCl_2$)	
Grassland				
0-0.08	21.34	4.86	4.63	-0.23
0.08-0.15	12.61	4.66	4.38	-0.28
0.15-0.23	10.28	4.66	4.32	-0.34
0.23-0.31	7.54	4.69	4.36	-0.33
0.31-0.38	6.31	4.91	4.28	-0.63
0.38-0.46	5.65	5.01	4.30	-0.71
0.46-0.54	5.48	5.02	4.26	-0.76
0.54-0.61	4.30	5.15	4.36	-0.79
0.61-0.69	3.67	5.28	4.36	-0.92
0.69-0.77	3.66	5.47	4.52	-0.95
Cultivated field (32 year)				
0-0.08	11.22	5.35	5.11	-0.24
0.08-0.15	7.55	5.40	5.17	-0.23
0.15-0.23	6.17	5.47	5.17	-0.30
0.23-0.31	5.13	5.52	5.20	-0.32
0.31-0.38	4.47	5.60	5.19	-0.41
0.38-0.46	4.13	5.71	5.25	-0.46
0.46-0.54	4.08	5.75	5.29	-0.46
0.54-0.61	4.09	5.78	5.29	-0.49
0.61-0.69	4.00	5.82	5.31	-0.51
0.69-0.77	4.00	5.91	5.38	-0.53

The grassland had a higher clay percentage as compared to the 32-year field. However, these differences in clay content were primarily found at the deeper depths. From the textural analysis and color it appeared that these two soil profiles were from different soil series (SCS, 1981). However, since the study was conducted only on the 0 to 0.10 m depth interval, it is important to note that there was no statistical difference on the particle size distribution and especially in the clay content. Jenny (1941) noted that the alteration in the particle size distribution might also bring about soil compaction that hampers air and water circulation as well as tillage operation.

In general, total carbon content (C) decreased with increasing depth in the profile. Between the 0.61 and 0.77 m depths, total carbon contents of both fields were similar. The average profile content of C was 8.08 g kg^{-1} for the grassland prairie and 5.48 g kg^{-1} for the cultivated fields. The changes in carbon content near the surface were brought about primarily by those activities associated with rice, soybean and wheat cropping.

The loss of total carbon due to tillage practices found in this study was about 50% in the 0 to 0.8 m depth interval. This percentage of lost C was similar to the rates of loss of organic matter in the same location of 56% at the 0 to 0.05 m depth interval after 30 years in cultivation (Scott and Wood, 1989). Balesdent et al.(1988) and Handayani (1996) reported that an initial rapid loss of carbon in a grassland occurred due to the presence of an easily mineralizable component was dependent upon the type of cultivation and the clay fraction which contained both the most stable and some labile carbon. According to Handayani & Coyne (1995), changes in soil temperature and water regimes during cropping have a major effect on the changes in organic carbon content

These data showed that the average soil pH of the profile in water and in $CaCl_2$ was 5.00 ± 0.26 and 4.38 ± 0.11 in the grassland prairie and 5.63 ± 0.19 and 5.37 ± 0.08 in the 32-year field, respectively. The pH in the prairie was almost one unit lower than that of the 32-year field. The average ΔpH was –0.59 ± 0.27 in the prairie and –0.39 ± 0.11 in the 32-year field. These differences might be due to the different amounts of organic matter and clay in the profile

According to the SCS (1981), these soils were developed under well-distributed, high rainfall conditions. Therefore, the ground water may be deep most of the year but the B horizon has low hydraulic conductivity which restricts the downward movement of water and extends the period of saturation. Consequently, these conditions created an acid virgin soil. The higher pH in cultivated soils might be due to the flood irrigation of rice and soybean which in this area contains appreciable amounts of $Ca(CO_3)_2$ and perhaps to some additions of lime. This compound precipitates as a result of slow flow rates, higher soil and air temperatures and the presence of atmospheric CO_2 (Scott and Wood, 1989; Grossman and Pringle, 1987). In addition, precipitation of Ca and Mg from rice irrigation water pumped from the quartenary aquifer increased soil pH especially in areas near the field water inlet. These results can be contrasted with these of Lal *et al.* (1990) who reported that continuous no-till production of corn and soybean for 12 years in northwest Ohio caused a decline by 0.2 unit in pH measured in 1 : 1 soil : water suspension of 0-0.10 m layer. In comparison, 2 years of no-till following 10 years of plow-till decreased pH by about 0.05 unit in 0-0.10 m layer. Handayani (2001) reported that the pH values of the cultivated Muara Bangkahulu and Bentiring soils from South Sumatra were higher than the adjacent grassland or secondary forest areas due to the application of limestone.

The results of particle density among the four fields are presented in Table 3 and showed fairly constant values in both depth intervals. The particle density of the soil refers to the density of the solids and is expressed as the ration of the mass to the volume of the solids. These values exclude the pore space between the soil particles, consequently; no inferences can be made of the soil structure

Table 3. Particle density of the four different cropping duration on Alfisols .

Duration of tillage practice	Depth	
	0-0.05	0.05-0.10
	----- m -----	
0-year	2.62 ± 0.01	2.62 ± 0.02
3-year	2.61 ± 0.01	2.61 ± 0.05
14-year	2.66 ± 0.03	2.66 ± 0.04
32-year	2.66 ± 0.02	2.66 ± 0.02

The *ANOVA* shows that there was a highly significant effect of cropping duration of particle density. The values of particle density generally increased as the cropping duration increased. It appeared that there was a significant different of the mean of particle density after 3 years in cultivation. Slightly lower values of particle density were found in the grassland prairie (2.62 Mg m^{-3}) and 3-year field (2.61 Mg m^{-3}) and probably was due to the presence of organic matter (Scott and Wood, 1989). As soil organic matter decreases with duration of cultivation, the values of particle density remained fairly constant

CONCLUSIONS

Soil properties are altered by land management, however changes in magnitude differ among them. The results indicated that soil color in the grassland had values of hue of 10 YR and 7.5 YR and in cultivated field had values of hue 10 YR. The grassland had a higher clay percentage as compared to the 32-year of cultivated field. However, these differences in clay content were found primarily at the deeper depth. The average profile content of C was 8.08 g kg^{-1} for the grassland and 5.48 g kg^{-1} for cultivated soil. The pH in the grassland was almost one unit lower than that of the 32-year cultivated field. In general, the values of particle density increased as the cropping duration increased.

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