NO-TILL, RIDGE-TILL, AND CONVENTIONAL TILLAGE COTTON EFFECTS ON SOIL ORGANIC MATTER AND PH

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Abstract

Conservation tillage can reduce wind and water erosion while increasing water infiltration rates of soil. There is currently very little information on the effects of tillage in sub-tropical semi-arid environments on soil organic matter, pH, cation exchange capacity, or plant nutrient cycling within the rooting profile. Objectives of this study were 1) to determine the effect of no-tillage, ridge-tillage, conventional moldboard tillage systems on soil organic matter content, soil pH, sodium, potassium, magnesium, calcium, and cation exchange capacity (CEC), and 2) provide farmers with guidelines and information for implementing conservation tillage. After only six years the organic matter of the top 5 cm of soil was almost doubled with no-tillage (1.16% -vs-0.60%) compared with conventional moldboard tillage in a semi-arid, subtropical South Texas environment. Tillage was found to have little effect on soil pH, sodium, magnesium, calcium, or cation exchange capacity, but no-tillage and ridge-till did have greater concentrations of potassium near the surface (0-5 cm layer) than the conventional moldboard tillage treatment (906 -vs-681 ppm). The plant nutrient medium within the top one meter was affected by tillage.

Introduction

Many cotton producers in South Texas are retaining crop residue on the soil surface to reduce wind and water erosion, reduce wind and sand damage to seedling crops, and increase net returns by reducing tillage operations. While adoption of conservation tillage practices has many positive benefits, information on the effects of conservation tillage (no-tillage or ridge tillage) on effects on plant nutrients, organic matter, and pH is very limited for sub-tropical semi-arid conditions. It is generally recognized that greater organic matter in the soil layers can improve soil structure, increase water infiltration rates, and can alter nutrient availability to plants. Many of the soils of South Texas are alkaline with pH levels of 8 to 9.5 and have organic matter contents of less than 1%. Some fields that have had conventional tillage practices for many years have organic matter contents of less than 0.5%. Objectives of this study were 1) to determine the effect of no-tillage, ridge-tillage, conventional moldboard tillage systems on soil organic matter content, soil pH, sodium, potassium, magnesium, calcium, and cation exchange capacity (CEC), and 2) provide farmers with guidelines and information for implementing conservation tillage.

Materials and Methods

No-tillage, ridge-tillage, conventional moldboard tillage systems effects after six years on soil organic matter content, soil pH, sodium, potassium, magnesium, calcium, and cation exchange capacity (CEC) were examined. The experimental design was a randomized complete block with four replications. Plot size was 45 by 400 feet and six subsamples were taken from the row in each plot in September after six years of tillage practices had been in place. The cropping history of the land for each of the previous six years was spring cotton (planted in March and harvested in August) followed by fall corn (planted in August and harvested in January). Soil samples were taken at the study initiation (fall 1992) and soil variables within a replication was not different between tillage systems. The tillage systems were maintained for each crop for the two cropping seasons of each year. Soil samples were collected in September of 1998 which was after the cotton had been harvested, tillage treatments had been completed, and the fall corn had been planted but no fertilizer had yet been applied on the fall corn.

Results and Discussion

Soil organic matter content increased in the no-tillage treatments 93% above the conventional moldboard plow treatment after six years (Table 1) in the 0-5 cm depth (1.16% -vs- 0.60% humic organic matter). In only six years the organic matter in the upper 5 cm had almost doubled in the no-tillage when compared with moldboard tillage. While the ridge tillage organic matter content increased numerically it was not statistically different from the moldboard tillage treatment (0.86 % -vs- 0.60 %). At soil depths of 30-40 cm or 60-70 cm the organic matter content of the soil between tillage systems were not different. Tillage of soil and burying the crop residue enhanced the oxidation rate of the organic matter in the treatments where crop residue was mixed with the soil (conventional moldboard tillage and ridge-tillage) although the ridge-tillage had only a shallow mixing of soil as a result of cultivation of the crop during the growing season. Soil pH varied with depth in the soil profile ranging from 7.7 near the soil surface to 7.9 at depths of 80-100 cm but did not differ between tillage treatments (Table 2).

Sodium content of soil is of concern to producers because of the poor quality of Rio Grande irrigation water available which can range from 700 to over 1600 ppm soluble solids during the growing season. Especially when two crops per year are produced, the potential to increase sodium in the soil profile is enhanced. The conventional tillage system had a moldboard plow mix the top 45 cm of soil twice a year following each crop harvest. Other tillage systems had very little or no mechanical mixing of soil. There were no

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differences in sodium content between tillage system (Table 3) at any depth after six years. Sodium content was generally greater near the soil surface and decreased with depth to 100 cm.

Potassium content of soil at 0-5 cm was greatest with the conservation tillage treatments (906 ppm for both ridge-till and no-till) and smallest (681 ppm) in the conventional tillage (Table 4). As soil depth increased, the quantity of potassium did not differ between tillage treatments. In the 80-100 cm depth range, potassium content ranged from 350 ppm in the no-till to 438 in the conventional tillage treatment. Although no potassium had been added to these soils in the past 8 years, the surface layer (5 cm) accumulated a higher level, probably due to plant cycling of potassium being brought upward from the roots to shoot material during the growing season. The conservation tillage systems leave most of the crop residue which contains potassium, near the surface while the moldboard tillage system continues to mix the surface layers as well as crop residue into the upper 45 cm soil profile.

Magnesium content of soil varied with depth with the greatest concentrations being near the soil surface (431-475 ppm at 0-5 cm depth) and lowest at the 80-100 cm soil depth (238-288 ppm). In general there was very little difference between tillage treatments for magnesium content within a single soil profile depth range (Table 5).

Calcium content of soil did not differ between tillage treatments and ranged from 5775 ppm to over 8500 ppm (Table 6). Plants need calcium for cell elongation and division, stalk strength, fruit, and grain development. There have been many studies measuring the acidification of soils in humid regions and the subsequent leaching of calcium, but little data is available on the effects of tillage on calcium movement within the soil rooting profile in a semi-arid subtropical environments with alkaline soils.

Cation exchange capacity (CEC) did not differ with tillage system or depth of soil in any of the treatments. CEC was determined using the summation method by calculating the sum of the individual cations displaced from the soil. Perhaps if the ammonium acetate extraction method had been used which extracts the water-soluable and rapidly exchangeable fractions of the alkali and alkaline earth cations by displacement the NH_4^+ from the exchangeable sites differences between tillage systems would be apparent. While CEC can affect nutrient uptake and movement to and from plants, it is important to note that no detrimental effects were found by reductions in tillage with no-till or ridge-till systems.

The soil is a plant nutrient medium and it is important to know how and if we alter the makup of this nutrient medium by changing tillage systems. Results of this study indicate that we can greatly change the organic matter in the surface layers of soils in a relatively short period of time (6 years) by retaining crop residue on the soil surface and by not mixing the surface layers with deeper soil layers which can increase oxidation of the organic matter in the soil.

Table 1. Tillage effects on soil organic matter after 6 years, at Weslaco, TX (1992-98).

	spring cotton/fall corn % O.M. depth cm			
	0-5	30-40	60-70	80-100
Conventional	0.60 b	0.40 a	0.29 a	0.17 b
Ridge till	0.86 ab	0.40 a	0.28 a	0.19 ab
No-till	1.16 a	0.50 a	0.29 a	0.25 a

Comparisons are made within a column using a Waller-Dancans K-ratio "T"-test (∝=0.05)

Table 2. Tillage effects on soil pH after 6 years, at Weslaco, TX (1992-98).

	spring cotton/fall corn soil pH depth cm			
	0-5	30-40	60-70	80-100
Conventional	7.7 a	7.8 a	7.9 a	7.9 a
Ridge till	7.7 a	7.9 a	7.9 a	7.9 a
No-till	7.7 a	7.8 a	7.9 a	7.9 a

Comparisons are made within a column using a Waller-Dancan K-ratio "T"-test (∝=0.05)

Table 3. Tillage effects on sodium (Na) after 6 years, at Weslaco, TX (1992-98).

	spring cotton/fall corn Sodium (ppm) depth cm			
	0-5	30-40	60-70	80-100
Conventional	425 a	369 a	319 b	319 a
Ridge till	431 a	513 a	563 a	475 a
No-till	413 a	356 a	363 b	456 a

Comparisons are made within a column using a Waller-Dancans K-ratio "T"-test (∝=0.05)

Table 4. Tillage effects on potassium (K) after 6 years, at Weslaco, TX (1992-98).

	spring cotton/fall corn Potassium (ppm) depth cm			
	0-5	30-40	60-70	80-100
Conventional	681 b	563 a	463 a	438 a
Ridge till	906 a	594 a	513 a	356 a
No-till	906 a	550 a	450 a	350 a

Comparisons are made within a column using a Waller-Dancans K-ratio "T"-test (∝=0.05)

Table 5. Tillage effects on magnesium (Mg) after 6 years, at Weslaco, TX (1992-98).

	spring cotton/fall corn Magnesium (ppm) depth cm			
	0-5	30-40	60-70	80-100
Conventional	431 a	369 a	294 a	275 a
Ridge till	463 a	394 b	300 a	288 a
No-till	475 a	300 ab	244 a	238 a

Comparisons are made within a column using a Waller-Dancans K-ratio "T"-test (∝=0.05)

Table 6. Tillage effects on calcium (Ca) after 6 years, at Weslaco, TX (1992-98).

	spring cotton/fall corn Calcium (ppm) depth cm			
	0-5	30-40	60-70	80-100
Conventional	6381 a	6325 a	6956 b	8038 a
Ridge till	6238 a	7194 a	8631 a	8506 a
No-till	5775 a	7313 a	6725 b	6613 a

Comparisons are made within a column using a Waller-Dancans K-ratio "T"-test (∝=0.05)

Table 7. Tillage effects on cation exchange capacity C.E.C. meq/100g after 6 years, at Weslaco, TX (1992-98) using the summation method.

	spring cotton/fall corn C.E.C. depth cm			
	0-5	30-40	60-70	80-100
Conventional	39.1 a	37.7 a	39.8 b	44.9 a
Ridge till	39.2 a	42.2 a	49.4 a	47.9 a
No-till	36.9 a	42.0 a	38.3 b	37.9 a

Comparisons are made within a column using a Waller-Dancans K-ratio "T"-test (∝=0.05)