Tillage, physical properties of Coto clay and the yields of plantain and sweet potato[1]

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ABSTRACT

The only physical property of Coto clay found to be affected by the tillage method was soil resistance, which was greater for the no-till than for the other tillage treatments. The upper 10 cm were the most affected. Tillage methods did not affect plantain yields; thus, minimum tillage can be recommended for this crop. On the other hand, significantly higher sweet potato yields were obtained when the soil was plowed and disced twice.

INTRODUCTION

Excessive tillage with heavy equipment can adversely affect soil structure. For this reason and because of the high cost of fuel and hand labor, traditional tillage practices have been closely examined by research scientists in recent times.

The results of tillage experiments conducted in Puerto Rico have been variable and highly dependent on soil conditions and on the crop. No significant yield differences were obtained by Vicente-Chandler et al. (11) from no-till and from conventional tilled plots. The crops they used were tobacco (*Nicotiana tabacum* L.), sugarcane (*Saccharum officinarum* L.), plantains (*Musa* spp.), taniers (*Xanthosoma* spp.), yams (*Dioscorea* spp.), corn (*Zea mays* L.) and beans (*Phaseolus vulgaris* L.). Similar results were obtained by Abruña et al. (1) when they compared yields of taniers from no-till plots and conventional tilled plots.

Lugo et al. (8) and Rivadeneira (10) obtained higher tanier yields when they used conventional tillage. Lugo et al. (9), working on a Mollisol, observed that tillage was not necessary for either corn or beans. They obtained, however, higher yields of pepper when the soil was plowed four times at a 45-cm depth. They reported that differences in penetrometer measurements were not statistically significant. On the

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penetrometer measurements were not statistically significant. On the other hand, Irizarry and Rodríguez (7) obtained higher yields of plantain cultivar Maricongo from plowed plots than from no-till plots in an Aquic Tropudults at the Corozal Agricultural Research and Development Center.

Among the advantages of minimum tillage are the reduction of soil erosion losses and of production costs. The adoption of this technique, however, is not always possible for all crops and in all soils (4). This paper reports data obtained in an attempt to evaluate different tillage practices with different crops in an Oxisol.

MATERIALS AND METHODS

The experiment was established September 1983 at the Isabela Agricultural Research and Development Center. The soil is classified as Coto (clayey, kaolinitic, isohyperthermic, Tropeptic Eutrustrox) (2). It is deep, moderately acid and permeable. The test crops were plantain (*Musa acuminata* × *M. balbisiana* AAB, Cv. Maricongo) and sweet potato (*Ipomoea batatas* L. Lam., cv. Miguela).

The experiment consisted of a split plot arrangement of a randomized complete block with three replications. Four land preparation treatments were assigned to the main plots, and two crop treatments to the subplots.

The land preparation treatments were 1) no till; 2) plowing and discing twice at a 15-cm depth, with a 7-day interval between operations; 3) four plow disc operations with a 7-day interval between operations at a 45-cm depth; and 4) one chisel plowing at a 30-cm depth, once. The sub-plot treatments were 1) plantains in rows 1.83 m apart and 1.52 m apart within the row, and 2) sweet potato vines planted in rows 0.91 m apart along the row.

A 10-5-15 granular fertilizer was applied for plantains in the first, third and ninth month after planting at a rate of 170, 277 and 340 g per plant, respectively (6). For sweet potato a 6-6-12 granular fertilizer was used at a rate of 1120 kg/ha 2 weeks after planting (5). Overhead irrigation was used as needed.

Soil samples were taken from each plot 1, 12, 24 and 40 weeks after plowing at depths of 0 to 10, 10 to 20 and 20 to 30 cm. For each sample the following determinations were made: pH (glass electrode), organic matter (Walkey-Black), aggregate stability (sieves), bulk density (undisturbed soil sample), water content (oven), and soil resistance (penetrometer) at field capacity (2).

RESULTS AND DISCUSSION

Table 1 shows yield data for sweet potatoes and plantains. No significant differences in plantain yields were measured. However, yields of

TABLE 1.—*Effect of four tillage methods on the yield of plantain and sweet potato*

Treatments	Sweet potato (marketable)	Plantains
	kg/ha	
No-till	5299.66 b[1]	19538.50 a
Plowed 2 times	8775.66 a	18229.35 a
Plowed 4 times	5342.33 b	15120.65 a
Chisel plow	5220.33 b	17987.38 a

[1] Means followed by the same letter do not differ at the 5% probability level.

sweet potatoes from the plots plowed and disced twice were greater than those from the other tillage treatments.

There were no significant differences among the tillage treatments in soil pH, organic matter content, aggregate stability, bulk density or water content (table 2). Similar results were obtained by Blevins (3). Plots used in this experiment had been fallow for at least 3 years, which probably contributed to the stabilization of most of the physical and chemical properties. Soil resistance was the only physical property that differed among the tillage treatments (table 3). At a depth of 0 to 10 cm the no-till treated plots had the highest soil resistance, and the plots plowed 4 times, the lowest throughout the experiment. These results agree with the findings of Lugo et al. (8). Smaller differences in soil resistance among the tillage treatments were observed at greater soil depths. Until the 20th week, the plots disced twice had the lowest soil resistance. This lower soil resistance may help to explain how sweet

TABLE 2.—*Effect of four soil tillage methods on some chemical and physical properties of Coto clay*

Treatments	Depth	pH	Organic matter	Aggregate stability	Bulk density	Water content
	cm		%	%	*g/cm³*	%
No-till	0–10	5.4	2.29	62.39	1.39	26.07
	10–20	5.4	3.36	54.61	1.37	——
	20–30	5.0	1.72	42.81	1.34	——
Plowed 2 times	0–10	4.9	2.42	54.28	1.22	25.21
	10–20	4.9	1.52	56.27	1.41	——
	20–30	4.9	2.04	54.00	1.38	——
Plowed 4 times	0–10	5.1	1.51	45.40	1.17	26.55
	10–20	5.1	3.23	54.36	1.37	——
	20–30	5.1	1.18	45.43	1.34	——
Chisel plow	0–10	6.0	1.33	52.94	1.27	25.56
	10–20	5.5	1.33	50.31	1.33	——
	20–30	5.4	1.18	32.11	1.31	——
		NS[1]	NS	NS	NS	NS

[1] Not significant at the 5% probability level (Duncan multiple range).

TABLE 3.—*Effect of four different tillage methods on soil resistance of Coto clay*

Treatments	Depth	Soil resistance		
		Week		
		1	20	40
	cm	*kg/cm²*		
No-till	0–10	14.06 a[1]	21.68 a	38.66 a
Plowed 2 times		4.09 b	11.71 c	33.98 b
Plowed 4 times		7.03 b	9.38 c	28.71 c
Chisel plow		7.02 b	17.59 b	31.05 bc
No-till	10–20	13.65 a	22.35 b	33.98 ab
Plowed 2 times		7.61 b	21.68 b	36.32 a
Plowed 4 times		7.61 b	16.40 c	30.47 b
Chisel plow		10.54 ab	29.43 a	34.56 ab
No-till	20–30	21.68 a	28.70 b	37.73 ab
Plowed 2 times		15.81 b	35.15 a	38.08 a
Plowed 4 times		15.81 b	23.43 c	33.39 b
Chisel plow		19.33 ab	30.46 b	38.08 a

[1] Means followed by the same letter do not differ at the 5% probability level.

potatoes, a root crop with a 5-month growing cycle, produced the greatest yield in the plots disced twice. It has been demonstrated that tillage can be beneficial for root crops, especially in clayey soils (8, 10). It appears from these data, that soil resistance in Oxisols may be a better indicator of soil compaction than bulk density.

Plantain yields did not differ in the four tillage treatments, a finding that suggests that this crop may not be as sensitive to soil compaction as sweet potatoes. The results obtained by Irizarry and Rodríguez (7) in an Ultisol are different, perhaps because of better physical conditions of the Oxisol used in the experiment herein reported as compared with those of the Corozal soil. Results from this research indicate that good plantain yields can be obtained with no-till or minimum-till in Coto and similar Oxisols, and perhaps in other soils with characteristics similar to those of Coto clay.

RESUMEN

Labranza, propiedades físicas de una arcilla y los rendimientos de plátano y batata

Se midieron los efectos de 4 métodos de labranza sobre las propiedades físicas del suelo Coto (Oxisol) y los rendimientos de plátano[5] y batata.[6] Los tratamientos fueron los siguientes: 1) sin labranza; 2) arado y rastrillado 2 veces a 15 cm. cada semana; 3) arado y rastrillado 4 veces a 45 cm. cada semana; y 4) labrado con arado de cinceles una sola vez a 45 cm.

[5] *Musa acuminata* × *M. balbisiana* AAB.

[6] *Ipomoea batatas* (L.) Lam.

Los datos de las propiedades físicas del suelo se tomaron a las 1, 12, 24 y 40 semanas después de sembrar a profundidades de 0–10, 10–20 y 20–30 cm. Se midió el pH, la materia orgánicca, la estabilidad de los agregados, la densidad aparente del suelo, la resistencia a la penetración y el contenido de humedad.

La labranza no afectó significativamente ninguna de las propiedades físicas, excepto la resistencia a la penetración, la que fue mayor en el tratamiento sin labranza. Los primeros 10 cm. de profundidad fueron los más afectados. La labranza no mejoró los rendimientos de plátano, lo cual indica que en un Oxisol se pueden obtener buenos rendimientos de este cultivo con la labranza mínima. Por el contrario, los mayores rendimientos de batata se obtuvieron cuando se labró convencionalmente, lo que indica que en este Oxisol, y quizás en otros suelos de condiciones similares, es necesario arar el suelo para obtener buenos rendimientos. Aparentemente, en los Oxisol, la resistencia a la penetración es un mejor índice de la compactación que la densidad aparente.

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