

High Crop Yields Produced with or without Tillage on 3 Typical Soils of the Humid Mountain Region of Puerto Rico¹

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INTRODUCTION

Erosion is a serious problem in the Humid Mountain Region of Puerto Rico which comprises more than half of the Island. Plowing or cultivating this steep land, or even walking on it after it has been loosened, causes large downhill movement of soil simply in response to gravity (see fig. 1). On loose Utuado soil, for example, up to 50 percent of the erosion losses from cultivated land were accounted for by gravity erosion³. Soil loosened by cultivation is also readily washed away by runoff. Since the typical soils of this Region have excellent physical condition, it is likely that the benefits of plowing and cultivation are limited to weed control, which can be attained through the proper use of herbicides.

The present study determined the effect of tillage on yields of the major crops of Puerto Rico, on three typical soils of the Humid Mountain Region.

MATERIALS AND METHODS

The experiments were conducted on three clay soils—Cialitos, Mucara, and Catalina—on about 30-percent slopes, at three locations in the Humid Mountain Region. The Catalina and Mucara soils had been in unfertilized pastures and the Cialitos soil in shaded coffee for the past 10 years. All crops—tobacco, sugarcane, plantains, tanniers, yams, corn, sweetpotatoes, beans—were intensively managed with the best known practices. Annual rainfall averaged about 65 inches, and was fairly well distributed, except for a dry period in January, February, and March.

Tilled and untilled treatments were compared in a paired-plot design with five replications for each crop. The tilled plots were thoroughly worked to about 8 inches. Weeds were removed from the untilled plots by carefully

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³ Vicente-Chandler, J., and Smith, Richard M., Principles and practices of bench terracing in Puerto Rico, *J. Soil & Water Conserv.* 6(3): 134-45, 1951.

scraping the soil surface with a hoe. Thereafter, weeds in all plots were controlled by light hoeing. Individual plots were $\frac{1}{300}$ acre in size.

Yields produced by each plot were measured and the chemical and physical properties of the soil in each experiment determined.

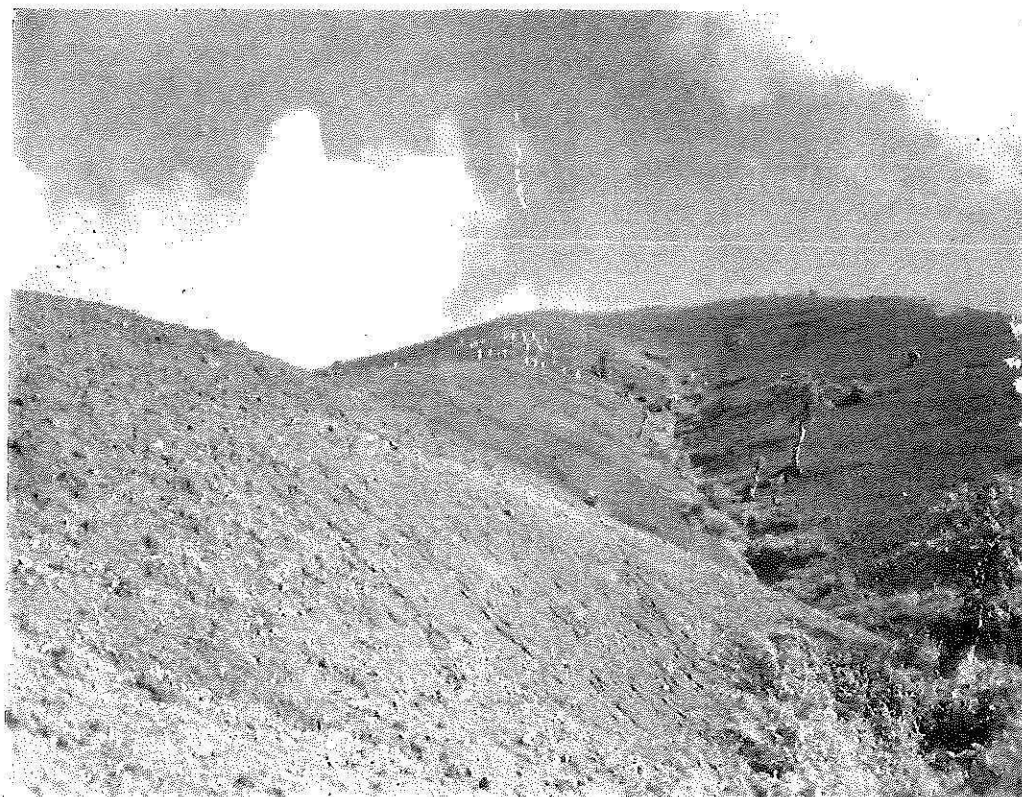


FIG. 1.—Flowing or cultivating, or even walking on lands such as this field being planted to tobacco, causes large downhill movement of soil. Soil loosened by cultivation is also readily washed away by runoff. The data presented in this paper show that just as high yields can be produced on these lands by planting directly in the undisturbed soil as with complete land preparation.

RESULTS AND DISCUSSION

All three soils have excellent physical condition, as shown by bulk densities averaging 1.05 with 15.5 percent of the pores drained at $\frac{1}{3}$ -atm. pressure, and are high in organic-matter content and exchange capacity (table 1). These values are typical of soils of this type throughout the Mountain Region. The Cialitos and Catalina soils are more acid and deeper than the Mucara, which is about 2 feet deep over partly decomposed rock. These soils also differ from Mucara in that they are high in free iron oxides and have kaolinitic rather than beidellitic clay minerals.

TABLE 1. Characteristics of the surface 6 inches of soil at the 3 experimental sites in the Humid Mountain Region of Puerto Rico

Soil characteristic	Catalina clay (Orocovis)	Mucara clay (Orocovis)	Cialitos clay (Adjuntas)	Average
Bulk density (gm./cc.)	0.98	1.09	1.07	1.05
Pores drained at $\frac{1}{3}$ -atm. pressure (percent)	16.4	14.5	15.7	15.5
Organic matter (percent)	4.8	4.7	5.9	5.1
Exchange capacity (meq./100 gm. of soil)	14.5	20.0	17.9	17.5
Exchangeable bases (meq./100 gm. of soil)	4.6	13.2	6.7	8.2
pH	5.0	5.6	5.0	5.1

TABLE 2. The effect on crop yields of tilling 3 typical soils of the Humid Mountain Region: Values are averages of 5 replicate plots of 1 crop on each soil type

Crop	Yield unit	Catalina clay, 1962-63		Mucara clay, 1963-64		Cialitos clay, 1964-65		Average	
		Tilled ¹	Un- tilled ²	Tilled ²	Un- tilled ²	Tilled	Un- tilled	Tilled	Un- tilled
		Tobacco	Cwt. cured tobacco/acre	15.6*	13.8*	17.2	16.5	23.9	23.3
Sugarcane	Tons cane/acre	49.6	48.6	29.4*	35.6*	79	74	52.7	52.7
Plantains	Number/acre	26,500	24,500	26,800	21,960	29,600	28,000	27,333	25,820
Do.	Cwt./acre	175	152	172	169	192	184	180	168
Taniers	Cwt./acre	67	74	119	136	117	96	101	102
Yams	Cwt./acre	142	135	133	121	81	81	118.7	112
Corn	Cwt. dry corn per acre	35	37	60	55	—	—	47.5	46
Sweetpotatoes	Cwt./acre	90	85	—	—	115	92	102.5	88.5
Green beans	Cwt./acre	—	—	—	—	35	34	35	34

¹ Soil thoroughly worked to a depth of 8 inches.

² Asterisks indicate differences in yield are statistically significant.

Just as high yields of these widely different crops were generally produced on all three soils with no tillage as when the soil was thoroughly tilled (table 2). The only two exceptions were tobacco on Catalina clay, which produced 15-percent higher yields with tillage, and sugarcane on Mucara clay, which produced 21 percent higher yields without tillage.

Differences in crop yields in the three experiments are ascribed to sea-

sonal and climatic variations since the trials were run at different times and locations. High crop yields were produced in almost all cases. In general, adequate moisture was present during germination, and emergence was similar in the tilled and untilled plots. Crusting of the surface soil was much more pronounced in the tilled plots.

These data suggest that crops can be produced on steep mountain slopes with different systems of "minimum tillage". For example, all vegetation could be killed with herbicides, the desired crop planted directly in the undisturbed soil, and later weed growth controlled by the application of postemergent herbicides and/or hand-weeding. Although much research and testing under farm conditions have yet to be done, preliminary trials⁴ appear promising.

In one trial tobacco planted in sod which had been killed by the application of 5 pounds of Dalapon⁵ and 2 pounds of 2-4-D per acre, and thereafter uncultivated, yielded 1,540 pounds of cured tobacco per acre compared to 1,350 pounds in well-plowed plots cultivated twice during the growing season. In another trial, yams growing in undisturbed but weed-free soil treated with 5 pounds of Simazine per acre immediately after planting and receiving no further cultivation, yielded 186 hundredweights of tubers per acre compared to 193 hundredweights in well-tilled plots hand-weeded 4 times during the 11-month growing season.

In another experiment plantains were planted in sod previously weed-killed by the application of 6 pounds of Dalapon and 2 pounds of 2-4 D per acre 2 weeks before planting, followed by an application of PCP in diesel oil immediately after planting. Four months later the field was sprayed with 6 pounds of Dalapon per acre, followed by an application of pentachlorophenol in diesel oil 2 weeks later. At 7 months the field was again sprayed with Dalapon at the rate of 6 pounds per acre. Just as high yields were produced with this system as in well-tilled plots hand-weeded 4 times during the crop year. Cost and man-days of labor required for land preparation and weeding were substantially lower with this system than with the standard method of plowing and hand cultivation.

Such systems of minimum tillage, based on the use of herbicides applied with a simple knapsack sprayer, would have many advantages over the present practice of repeatedly plowing the steep mountain lands with oxen, followed by hoeing to control weeds after the crop is planted.

⁴ Unpublished information obtained by the authors. Deep appreciation is expressed to Dr. Héctor Cibes, Plant Physiologist of the Agricultural Experiment Station, University of Puerto Rico, for his advice and help in conducting these trials.

⁵ Trade names are used in this paper solely to provide specific information. Mention of a trade name does not constitute nor imply a guarantee, warranty, or endorsement by the U. S. Department of Agriculture or the Puerto Rico Agricultural Experiment Station over other similar products not mentioned.

The greatest advantage would be a decrease in the current severe erosion losses from these steep, cultivated slopes. In addition, ditches or diversion channels would not be destroyed or filled with loose earth during plowing or cultivation, as is now the case. The use of such systems also would seem a much more promising approach to the problem of increasing the productivity of labor in the Mountain Region, than attempting partly to mechanize cultivation of the steep, irregular, often rocky mountain lands.

Although limestone cannot be mixed with the soil unless a tillage operation is included, Abruña *et al.*⁶ have shown that limestone moves deep into the soil profile when surface liming is followed by heavy fertilization, as required by all crops in Puerto Rico. Harvesting large root crops such as yams could be difficult when grown in undisturbed soil.

SUMMARY

Yields of tobacco, sugarcane, plantains, taniens, yams, corn, sweetpotatoes, and beans were similar under tillage and no-tillage systems on three typical soils of the Humid Mountain Region of Puerto Rico. All three soils had excellent physical condition, with bulk densities averaging 1.05 and with 15.5 percent of the pores drained at $\frac{1}{3}$ atmospheres of pressure. These data suggest that no tillage is necessary for production of widely different crops in the area, if weeds and grasses are controlled by herbicides. If crops can be grown without tillage, the erosion problems that normally plague this area can be greatly reduced.

RESUMEN

Se estudió el efecto de dos sistemas de cultivo, sobre los rendimientos de tabaco, caña de azúcar, plátanos, yautías, ñames, maíz y habichuelas, en tres suelos típicos de la Región Montañosa y Húmeda de Puerto Rico: En un caso se roturó el suelo por completo y en el otro se dejó sin arar. En ambos casos se erradicaron los yerbajos. Los tres suelos eran de excelentes condiciones físicas, como lo indica su peso-volumen que promediaba 1.05, y un 15.5 por ciento de sus poros que desaguaban a una presión de $\frac{1}{3}$ de atmósfera.

Excepto en algunos casos de menor importancia, los rendimientos de las diversas cosechas fueron tan altos bajo un sistema de cultivo como bajo el otro. Es posible que el sistema de un cultivo mínimo, aparejado al uso de yerbicidas, ofrezca las ventajas siguientes sobre el sistema tradicional de arar con bueyes. Reducen la erosión del suelo y permite el uso más eficiente de la mano de obra.

⁶ Abruña, F., Vicente-Chandler, J., and Pearson, R. W., Effects of liming on yields and composition of heavily fertilized grasses and on soil properties under Humid Tropical conditions, *Soil Sci. Soc. Amer. Proc.* 28(8): 657-61, 1964.