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TILLAGE RESIDUAL EFFECTS ON A CROP ROTATION OF TARO, CABBAGE AND EGGPLANT IN OXISOL, ULTISOL AND VERTISOL SOILS IN PUERTO RICO

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ABSTRACT: An experiment was established to evaluate several tillage treatments and their residual effect on a crop rotation that included taro, cabbage and eggplant. The experiment was established at three ecologically different locations with three different soil series and orders. At two locations (Ultisol and Vertisol soils), the treatments were conventional tillage; conventional tillage - no beds; deep till + conventional tillage; and deep till. At the third location (Oxisol soil) the treatments were no-till; conventional tillage; deep till + conventional tillage; and deep till. Taro was planted after soil preparation according to the treatments. The crops that followed in the rotation were planted no-till in the same plots. A fifth treatment, in which all crops in the rotation were planted under conventional tillage, was used as a check. In the Oxisol soil, taro yields in the no-till plots were significantly lower than yields in any of the other treatments. There were no yield differences among the other treatments. In the Ultisol soil, the higher taro yields were obtained in plots where no beds were raised (deep till and conventional – no beds); whereas in the Vertisol soil the lowest yields were obtained in the deep tilled plots. Yields of cabbage and eggplant were not significantly different among treatments in the Oxisol and Ultisol soils. In the Vertisol soil, cabbage yields were significantly higher in plots with the continuous conventional tillage. The results suggest a positive residual effect from the tillage operations performed prior to planting the taro crop in the Ultisol. The good physical properties of the Oxisol soil probably contributed to the lack of differences in cabbage and eggplant yields.

Keywords: Tillage, crop rotation, conservation tillage, tropical soils

INTRODUCTION

Soil management techniques that result in efficient use and conservation of land resources are being adopted because they are less erosive, less costly and in many cases more profitable for crop production. In Puerto Rico the use of these cultural practices has been limited to crops such as fruit trees, coffee (*Coffea arabica*), plantains and bananas (*Musa* spp.). In experiments conducted in Puerto Rico with root crops, legumes and vegetables, the response to conservation tillage has varied considerably, depending on soil type, location and crop. Experiments conducted in a Mollisol suggested that watermelon (*Cucumis melo*), tomato (*Lycopersicon lycopersicum*) and pigeon pea (*Cajanus cajan*) could be grown with minimum or even no tillage (Lugo-Mercado et al., 1987). Irizarry and Rodríguez (1984) obtained higher yields of plantain from plowed plots than from no-till plots in an Ultisol; whereas, Martínez-Rivera et al. (1987), in an Oxisol, obtained similar plaintain yields with no-till as with conventional tillage. However, in the same experiment, sweet potato yields were significantly higher when the soil was plowed and disced twice than when it was no-till. Response to tillage was observed in yam (*Dioscorea alata*) planted in Ultisol and Vertisol soils but not in an Oxisol soil, thus indicating that a more efficient tillage preparation was required in heavier soils to

maximize tuber yields (Lugo et al., 1993). Furthermore, deep rooted crops sensitive to sub-surface compaction may need sub-soiling or deep plowing. However, sub-soiling studies in Puerto Rico and elsewhere have provided mixed results. Most recently, studies have been conducted to evaluate tillage effects on pasture growth (Ramos-Santana et al., 2006).

MATERIALS AND METHODS

A tillage-rotation experiment was established in Oxisol, Ultisol and Vertisol soil orders at the Isabela, Corozal and Lajas substations of the Agricultural Experiment Station, University of Puerto Rico, respectively. Crops in the rotation were taro (*Colocasia esculenta*), cabbage (*Brassica olaracea*), and eggplant (*Solanum melongena*). Tillage treatments at Isabela were 1) no-till (undisturbed); 2) conventional tillage (plowed twice at a depth of 20 to 30 cm, and harrowed, raised beds); 3) deep tillage + conventional (plowed to a depth of over 30 cm, then conventionally tilled); and 4) deep tillage (plowed to a depth of over 30 cm, no beds). At Corozal and Lajas, tillage treatments were 1) conventional tillage with no beds; 2) conventional tillage; 3) deep till + conventional tillage; and 4) deep till. Tillage treatments were applied before planting the first crop of the rotation. For studying tillage residual effects, all other crops of the rotation were planted no-till into the same plots. The order of the crops in the rotation was according to their tillage requirements in decreasing order, taro-cabbage-eggplant. A fifth treatment (continuous conventional), in which plots were conventionally tilled for all the crops in the rotation was used as a check.

Untreated taro cormels were planted at a planting distance of 61 cm within the row and 91 cm between rows. Gramoxone® and Round Up® were used for weed control in addition to hand weeding. Irrigation was applied as necessary. Cabbage was planted after harvesting taro at a planting distance of 91 cm within rows and 30 cm between plants. No tillage operations were performed prior to transplanting cabbage plantlets, except in the control plots. Eggplant plantlets were transplanted after cabbage was harvested at a planting distance of 91 cm within rows and 30 cm between plants. No tillage operations were performed prior to transplanting eggplant, except in the control plots. Because of problems with the irrigation system the experiment at Lajas was discontinued after cabbage harvest.

RESULTS AND DISCUSSION

A general description of each soil is summarized in Table 1. Significant differences in taro yield were observed among tillage treatments and crop response varied with location (Table 2). At Isabela, taro yield was significantly lower in the no-till plots with an average yield of 3,690 kg/ha. There were no significant differences among the other treatments; however, there was a tendency for higher yields when the soil was deep tilled, 11,460 kg/ha. At Corozal the higher taro yields were obtained in plots where no beds were raised with 13,470 and 12,750 kg/ha for deep till and conventional + no beds, respectively. At Lajas, the lowest yields were obtained in the deep tilled plots with 4,180 kg/ha. As in previous experiments, response to tillage treatments varied with location and differences in soil type.

Table 1. General soil description

Location	Soil Series	Taxonomic Classification	Clay (%)	Silt (%)	Sand (%)
Corozal	Corozal	Fine, mixed, semiactive, isohyperthermic Aquic Hapludults	46.4	31.6	22.0
Isabela	Coto	Very-fine, kaolinitic, isohyperthermic Typic Eutrustox	62.9	9.5	27.6
Lajas	Fraternidad	Fine, smectitic, isohyperthermic Typic Haplusterts	48.4	28.6	23.0

Table 2. Effect of tillage on taro yields at Corozal, Isabela and Lajas

Tillage treatment	Corozal kg/ha	Isabela kg/ha	Lajas kg/ha
No-Till	--	3,690 b	--
Conventional	7,410 b	8,520 a	8,580 b
Conventional + no beds	12,750 a	--	13,160 a
Deep-Till	13,470 a	11,460 a	4,180 c
Deep-Till + conventional	8,050 b	11,400 a	10,970 ab
Continuous conventional	8,600 b	10,120 a	10,570 ab

Cabbage was the second crop of the rotation; yield data for the three locations are presented in Table 3. At the three locations, the highest cabbage yields were observed in the continuous conventional treatment with 25,391; 22,505; and 20,001 kg/ha for Corozal, Isabela and Lajas, respectively. The differences in yield among treatments were not significant at the Corozal and Isabela locations. At Lajas, the continuous conventional treatment yielded significantly higher than the other treatments. However, overall average yield at Lajas was significantly lower than at Corozal or Isabela. Smectite is the predominant type of clay in the Fraternidad soil series of Lajas. Tillage management in this soil has proven to be difficult because of the swelling and shrinking of the 2:1 clays. The difference in yield observed between the continuous conventional tillage and all other treatments may be related to the wetting and drying periods to which the soil had been exposed throughout the study. In the continuous conventional treatment the soil was tilled before planting cabbage, whereas all other treatments were performed prior to planting the first crop in the rotation. When the soil is not aerated before planting compaction of the soil due to the wetting and shrinking effect may be a concern.

Table 3. Effect of tillage on cabbage yields at Corozal, Isabela and Lajas

Tillage treatment	Corozal kg/ha	Isabela kg/ha	Lajas kg/ha
No-Till	--	16,243	--
Conventional	15,775	18,778	4,345 b
Conventional + no beds	7,248	--	4,481 b
Deep-Till	22,557	18,433	1,426 b
Deep-Till + conventional	12,788	15,849	4,804 b
Continuous conventional	25,391	22,505	20,001 a

The third crop of the rotation was eggplant. Table 4 shows yield data results from the Corozal and Isabela locations. No significant differences were observed among treatments or among locations for eggplant yield. These results suggest the presence of a positive residual effect from the tillage operations performed prior to planting taro at Corozal. The lack of differences in eggplant yield is possibly due to the good physical properties of the soils at these locations. Even though these soils vary in their clay and silt content, the type of clay may be responsible for the residual tillage effect. The mixed type of mineralogy in the Corozal soil and the kaolinite present in the Coto soil provided structure stability throughout the whole rotation.

Table 4. Effect of tillage on eggplant yields at Corozal and Isabela

Tillage treatment	Corozal kg/ha	Isabela kg/ha
No-Till	--	17,039
Conventional	17,702	15,836
Conventional + no beds	14,547	--
Deep-Till	19,565	17,861
Deep-Till + conventional	17,278	20,728
Continuous conventional	18,761	15,166

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