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A COMPARISON OF TILLAGE AND ZERO-TILLAGE AT DIFFERENT FERTILIZER LEVELS ON SWEET POTATO PRODUCTION ON A CLAYEY SOIL

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INTRODUCTION

In the Caribbean most crops are produced under the rainfed system of crop production. The soil is normally tilled and planted in time for the start of the wet season. An earlier-than-expected start to the wet season can interfere with land preparation. This is particularly marked on the heavier clay soils where the wetness of the soil prevents it from being trafficked by machinery, or makes it difficult to produce a suitable soil tilth. It is difficult to predict the start of the wet season and the intensity of the early rains. It is, therefore, advantageous if crops can be grown without tillage. This will also reduce the cost of land preparation.

Zero-tillage or no-till has been used to grow crops successfully both experimentally and commercially in the U.S.A. (Crosson, 1981) and in the tropics (Gerik and Morrison, 1984; Hayward et al., 1980; Lal, 1980; Lal et al., 1978). Most of the work has been on the lighter textured soils e.g. sandy loams and loams, where there is less mechanical impedance to root penetration of the untilled soil. It is generally felt that the no-till system is not applicable to the heavier soils, or will result in very poor yields.

One of the major disadvantages of the no-till system is weed control. Tillage buries seeds of weeds and weeds themselves and reduces weed growth. The success of no-till requires the use of good herbicides. Gramoxone (paraquat) has been used widely (Akobundu, 1977) but the continuous use of this herbicide can lead to the build up of weed species which are difficult to kill.

Mulching forms an integral part of the no-till system. For this reason the system has been termed conservation tillage in the U.S.A. because it was developed as a method of cultivating sloping land and preventing or limiting soil erosion. Mulching also serves as a means of weed control, conserving soil water, reducing soil temperatures and improving soil structure (Lal, 1974; Lal, 1978; Greenland, 1981). Simpson and Gumbs (In press) have shown that no-till plus mulching of a heavy clay soil in Guyana progressively increases the yield of maize probably as a result of the improvement of soil properties.

Root crops require a loose, friable soil in which to grow. However, such soils are very limited in Trinidad. Soils which have been allocated for food crop production in Trinidad are generally the heavier clay loams. Since most crop production will take place under the rainfed system in the foreseeable future, this study was undertaken to investigate the effect of zero-tillage on sweet potato (**Ipomoea batatas**) production on a clay loam. Since the yield of sweet potato is strongly influenced by nitrogen and potassium fertilization, the study also examined the effects of two levels of nitrogen and three levels of potassium at an adequate level of phosphorus.

MATERIALS AND METHODS

Location, Soil Type and Field Layout

This trial was conducted at the Orange Grove National Company in Trinidad. The soil type was the Pasea clay loam (Fluvaquentic Dystropepts). Sugar cane was customarily grown on the site for many years but the area has been allocated for food crop production. Prior to planting this trial the area was used for growing sorrel (**Hibiscus sabdariffa** L.).

The field was laid out in 10 metres wide centered beds separated by drains about 60 cm wide.

Treatments and Experimental Design

The crop was sweet potato (**Ipomoea batatas** cv 049). The treatments were all combinations of:

- Tillage by chisel ploughing followed by harrowing (T_1) versus no-tillage (T_0).
- Two levels of nitrogen (100 and 200 kg/ha N; N_1 and N_2).
- Three levels of potassium (150, 200 and 250 kg/ha K; K_1, K_2 and K_3).

The trial was laid down as a split-plot design with tillage as main plots and fertilizer levels as sub-plots. Each sub-plot was 10 m wide and 9 m long and the main plot was 10 m wide and 60 m long with 1 m spacing between sub-plots and 5 m between main plots. All plots received phosphorus at 100 kg/ha P.

Planting and Cultural Operations

The field was sprayed with Round-up (glyphosate) herbicide one week prior to planting. Sweet potato slips were dipped in an Aldrex solution before planting at a spacing of 1 m between rows and 30 cm within rows. The trial was planted in August 1983 and harvested in January 1984.

Before the sweet potato plants had covered the ground subsequent weed control was done by spraying with Fusilade (fluazifop-butyl) for the control of grasses, and careful spot spraying with Gramoxone for the control of broad leaf weeds.

Sweet potato was sprayed weekly with Decis for the control of **Megastes grandalis** Guen and other insect pests. This, however, did not fully control **M. grandalis**.

Plant Growth and Yield

Six plants per plot were sampled at random eight weeks after planting and fresh and dry weights of stems, leaves and roots were determined by drying at 65ºC.

At harvest an area of 3 m x 4 m was selected at random in each plot and all tubers harvested. The tubers were counted, washed, graded by size into marketable and non-marketable tubers and weighed.

RESULTS AND DISCUSSION

Soil Physical Parameters

Table 1 shows some relevant soil properties of Pasea silty clay loam. The total silt and clay content was 66-69% in the top 30 cm of the soil, making the soil behave more like a clay than a loam. The soil has high resistance to penetration when dry and the bulk density measured under these conditions was about 1.48 gm/cm^3. The soil, however, swells and softens on wetting which facilitates planting and root growth.

Table 1. Selected soil properties of Pasea silty clay loam

Depth cm.	pH	Particle Size Distribution % oven dry soil				Bulk Density gm/cm^3	CEC1/	TEB2/
		Coarse Sand	Fine Sand	Silt	Clay		m.e./100 gm soil	
0-15	5.5	0	30	29	40	1.47	7.5	5.5
15-30	5.3	0	33	26	40	1.49	6.8	4.2

1/ CEC is cation exchange capacity.
2/ TEB is total exchangeable bases.

The soil is acid with moderate to low fertility, and needs to be fertilized adequately for good crop production. The cation exchange capacity and base status are low.

Plant Growth

Table 2 gives data on the mean weights per plant sampled eight weeks after planting. The data show taht significantly higher (P=0.05) fresh and dry weights of stems and leaves were produced on the no-till plots (T_0) than on the till plots (T_1). Although the weights of roots were slightly higher in till plots the differences were not significant. The no-till plots were generally wetter than the till plots and this seems to have encouraged greater adventitious root development on the stems of the plants and greater stem and leaf production.

Table 2. Mean weights per plant sampled 8 weeks after planting

Treatment	Fresh Weight (gm)		Dry Weight (gm)	
	Stems + Leaves	Roots	Stems + Leaves	Roots
T_o N_1 PK_1	1035.5	40.9	102.3	7.7
T_o N_1 PK_2	1059.3	41.0	123.4	8.6
T_o N_1 PK_3	1206.3	31.1	132.5	5.6
T_o N_1 PK_1	1284.6	42.0	149.1	8.4
T_o N_2 PK_2	1518.9	42.4	163.0	8.6
T_o N_2 PK_3	1187.8	34.4	118.3	6.5
Mean	1215.4*	38.6	131.4*	7.6
T_1 N_1 PK_1	820.1	40.9	93.1	8.2
T_1 N_1 PK_2	868.6	42.8	94.9	8.2
T_1 N_1 PK_3	1031.1	42.4	108.6	9.4
T_1 N_1 PK_3	718.4	34.1	75.1	7.4
T_1 N_2 PK_1	1169.7	40.9	120.1	8.8
T_1 N_2 PK_2	1224.5	37.7	129.1	6.5
Mean	972.1	39.8	103.5	8.1

* Indicates means are significantly different (P=0.05)

The effects of N, P and K on plant grwoth are shown in Table 3. The higher level of nitrogen increased plant growth on both till and no-till plots but only the differences in fresh weight and dry weight of stems and leaves on no-till plots were significant (P=0.05).

Table 3. Effect of nitrogen and potassium under zero and conventional tillage on fresh and dry weight yields of stems and leaves and roots

Treat-ment	Fresh Weight (gm)		Dry Weight (gm)	
	Stems + leaves	Roots	Stems + leaves	Roots
	Effect of nitrogen under zero tillage (T_o)			
N_1	1100.4	37.6	119.4	7.3
N_2	1330.4*	39.6	143.5	7.8
	Effect of nitrogen under conventional tillage (T_1)			
N_1	906.6	42.0	98.9	8.6
N_2	1037.5	37.6	108.1	7.6
	Effect of potassium under zero tillage (T_o)			
K_1	1160.1	41.5	125.7	8.1
K_2	1289.1	41.7	143.2	8.6
K_3	1197.1	32.8	125.4	6.1
	Effect of potassium under conventional tillage (T_1)			
K_1	769.3	37.5	84.1	7.8
K_2	1019.2	41.9	107.5	8.5
K_3	1127.8*	40.1	118.9	8.0

* Indicates means are significantly different (P=0.05)

Under no tillage the medium level of K (200 kg/ha) produced the highest weights of stems and leaves and of roots but the differences were not significant. With tillage the 250 kg/ha K produced the highest weights but only the difference in weights of stems and leaves between K_1 and K_3 was significant (P=0.05).

Marketable Tuber Yield

Table 4 shows the tuber yields of the different treatments. Tillage gave a significantly higher (P=0.05) yield per plant, weight per tuber, number of tubers per plant and yield per hectare. The yield of tuber per hectare with tillage was about twice as much as the yield without tillage.

Table 4. Marketable yield of sweetpotato tubers at final harvest

Treatment	Yield/plant (kg)	Weight/tuber (kg)	No. of tubers/ plant	Yield (tonnes/ ha)
$T_o\ N_1\ PK_1$	0.249	0.140	1.67	7.35
$T_o\ N_1\ PK_2$	0.275	0.145	1.73	7.83
$T_o\ N_1\ PK_3$	0.320	0.162	1.88	9.56
$T_o\ N_2\ PK_1$	0.256	0.140	1.67	7.53
$T_o\ N_2\ PK_2$	0.219	0.131	1.44	6.27
$T_o\ N_2\ PK_3$	0.282	0.162	1.56	8.19
Mean	0.267	0.147	1.66	7.79
$T_1\ N_1\ PK_1$	0.439	0.175	2.38	13.29
$T_1\ N_1\ PK_2$	0.537	0.210	2.42	16.32
$T_1\ N_1\ PK_3$	0.423	0.194	2.01	12.76
$T_1\ N_2\ PK_1$	0.531	0.234	2.19	16.31
$T_1\ N_2\ PK_2$	0.587	0.211	2.81	18.01
$T_1\ N_2\ PK_3$	0.519	0.203	2.38	15.96
Mean	0.506*	0.205*	2.37*	15.44*
$N_1\ PK_1$	0.344			10.32
$N_1\ PK_2$	0.406			12.08
$N_1\ PK_3$	0.372			11.16
$N_2\ PK_1$	0.394			11.92
$N_2\ PK_2$	0.403			12.14
$N_2\ PK_3$	0.401			12.08

* Indicates means are significantly different at (P=0.05).

The higher level of nitrogen tended to depress tuber yield under the no-tillage system but to increase tuber yield under tillage. Howev4r, only the difference in yield per hectare with tillage was significant (P=0.05) (Table 5).

Table 5. Effect of nitrogen and potassium under zero and conventional tillage on tuber yields

Treatment	Yield/plant (kg)	Weight/tuber (kg)	No. of tubers/ plant	Yield (tonnes/ ha^{-1})
	Effect of nitrogen under zero tillage			
N_1	0.281	0.149	1.76	8.25
N_2	0.252	0.144	1.56	7.33
	Effect of nitrogen under conventional tillage (T_1)			
N_1	0.466	0.193	2.27	14.12
N_2	0.546	0.216	2.46	16.76*
	Effect of potassium under zero tillage (T_o)			
K_1	0.253	0.140	1.67	7.44
K_2	0.247	0.138	1.59	7.05
K_3	0.301	0.162	1.72	8.88*
	Effect of potassium under conventional tillage (T_1)			
K_1	0.485	0.205	2.29	14.80
K_2	0.562	0.211	2.62	17.17*
K_3	0.471	0.199	2.20	14.36

* Indicates means are significantly different (P=0.05)

Increasing the potassium level from 150 to 250 kg/ha increased tuber yields with zero tillage but with tillage the intermediate level of 200 kg/ha gave the highest yields (Table 5). Only the differences in yield/ha were, however, significant.

SUMMARY AND CONCLUSIONS

While no-tillage on this clay loam soil enhances early growth of sweet-potato stems and leaves it does not significantly increase early root growth and reduces final tuber yield by 50% compared with conventional tillage. Without tillage the recommended nitrogen and potassium levels are 100 kg/ha N and 250 kg/ha K; with tillage, 150 kg/ha N and 200 kg/ha K are best.

Although the yield of sweet potato is substantially greater with tillage than without tillage on this soil type, the possibility of growing the crop successfully without tillage may make it economically feasible for farmers to grow a crop in the wet season when it may be difficult to traffic the soil with machinery or where machinery is unavailable for tillage. It could also increase the number of crops produced in the wet season in Trinidad which lasts from May to December. The economics need to be assessed.

REFERENCES

Akobundu, I.O. 1977. Advance in weed control in conventional and no-tillag(maize. Proc. 7th Annual Conf. Weed Science (Nigeria) 7: 10-18.

Crosson, P. 1981. Conservation tillage and conventional tillage: A comparative assessment. Published by the Soil Conservation Soc. of Amer. (Iowa), 35 pp.

Gerik, T.J. and Morrison, J.E. Jr. 1984. No-tillage of grain sorghum on a shrinking clay soil. Agron. J. 86: 71-76.

Greenland, D.J. 1981. Soil management and soil degradation. J. Soil. Sci. 32: 301-322.

Hayward, D.M., Wiles, T.L. and Watson, G.A. 1980. Progress in the development of no-tillage systems for maize and soya beans in the tropics. Outlook on Agric. 10: 255-261.

Lai, R. 1974. Soil temperature, soil moisture and maize yield from mulche(and unmulched tropical soil. Plant and Soil 40: 128-143.

Lal, R. 1978. Influence of within and between row mulching on soil temperature, soil moisture, root development and yield of maize in a tropical soil. Field Crops Res. 1: 127-139.

Lal, R. 1980. No-tillage farming in the tropics. In "No-tillage research: Research reports and reviews". In: R.E. Phillips et al. eds.): pp. 103-117.

Lal, R., Wilson, G.F., and Okigbo, B.N. 1978. No-till farming after various grasses and leguminous cover crops on a tropical alfisol: I. Crop performance. Field Crop. Res. 1: 71-84.

Simpson, L.A. and Gumbs, F.A. 1986. A system of crop and soil management for the wet season production of food crops on a heavy clay soil in Guyana. 1. Effect of mulching and tillage on soil properties and crop yields. 2. Effect of mulching and tillage on germination, growth, nutrient uptake and yield. Trop. Agric. (Trin.) (In press).