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Studies on Soil and Water Management for Small Farmers on Flat Heavy Soils in the Caribbean

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A survey was done in selected ateas with clay soils in Trinidad and Guyana to gain further insights into the soil and water management problems on small farms. The survey showed that many farmers, especially in Guyana, expend large amounts of energy using hand tools in weed control and land preparation. Farmers had problems in timing tillage operations due to the weather, unavailability of equipment and cost of tillage. The limitations to land preparation, fertility and water management and weed control are highlighted. The potential of reduced tillage methods, for soil and water conservation and stable continuous soil productivity, is discussed. Results of tillage studies in Trinidad and Guyana are summarised. Suggestions for future research to obviate the limitations to increased use of reduced tillage methods are discussed.

Clay soils are widespread in the Caribbean. They are difficult to manage under the humid tropical conditions that are experienced in Guyana and Trinidad. In these countries a large proportion of the soils has been used for the production of sugar cane, rice and tree crops. Many small farmers occupy these soils and cultivate mainly food crops. The soils are suitable for rice production and techniques have been developed for cultivating sugar cane. The sugar industry utilizes heavy machinery for land preparation. A range of tillage implements are used and several passes are made before the land is ready for planting. Drainage in the wet season is a problem and the cambered bed (bedding system of drainage) has traditionally been used. Over the years the cambered bed is being replaced by the ridge and furrow system. In Guyana, flood fallowing for periods of six to nine months has been used as a technique for soil structure improvement and stabilization in sugar cane production. This technique is, however, suitable only for large scale operations.

Clay soil management practices which utilize heavy equipment, flood fallowing and perhaps the cambered bed are not suitable for small farming. Thetefore there is a need to develop techniques of soil management suitable for the small farmers who are engaged in food crop production. Although reduced tillage has always been used by the subsistence farmer, *e.g.*, in shifting cultivation, the trend has been to encourage conventional tillage.

There has, however, been a reexamination of the suitability of conventional tillage methods in the tropics (Lal, 1979) in view of the rapid loss of soil productivity, accelerated soil erosion, and deterioration of soil structure.

Johnson et al. (1982) have also expressed the need for custom prescribed tillage (CPT) by which tillage operations are proposed on the basis of climate, soil, crop and socioeconomic considerations. Employing similar philosophy, researchers at IITA in Nigeria and at ICRISAT in India have demonstrated suitable reduced and improved tillage systems for soil and water conservation and management in those areas.

The extreme form of reduced tillage is zero-tillage or no-tillage. Here the only soil disturbance is that done to plant the seed. Weeds are controlled by herbicides, and fertilizers and amendments are placed on the soil surface or in the mulch cover. Mulch is essential in no-tillage for the conservation of soil, watet and fertilizer, the suppression of weeds and the optimization of soil temperature. There has been little research on reduced tillage in this region.

The soil management techniques which are used by small farmers have not been documented and a survey was therefore conducted to determine their current soil and water management practices. The findings were used in developing a research program for all-year crop production for small farmers.

The survey findings and some of the research results are presented in this paper.

Survey of Current Soil and Water Management Practices of Small Farmers

The survey of 50 small farmers in Trinidad and 23 in Guyana was carried out by enumerators using questionnaires. The results of the survey revealed the following:

Tillage

In Guyana, small farmers either used the traditional hand tools (hoe, fork, spade, cutlass) in land tillage and in the formation of ridges and furtows, or they made three passes with the plough, followed by finishing operations with hand tools.

In Trinidad, land preparation was mainly done by contractors. The tillage implement combinations varied with the crop and soil type. Disc ploughing, followed by one or two passes with the rotortiller, was the most common practice. Farmers owning tractors used them mainly for transport. Animal drawn implements and hand tractors were not widely used.

In both territories, the main limitations in land preparations were: unavailability of equipment at critical times, timing of operations, and the high cost of land preparation (estimated in 1982 to be about US$400/ha to brushcut, disc-plough, rotorill and ridge).

In Guyana, in particular, farmers lacked the financial resources for these operations and this limited the area of land that was prepared annually.

Weed Control

Weed control prior to tillage was generally by brushcutting, hand weeding and burning. In Trinidad, brushcutting and

widescale use of gramoxone (paraquat) were popular. During crop growth, weed control was generally by hoeing. In Trinidad, however, inter-row cultivation using a rotoriller mounted on a hand tracror and the application of Gramoxone with a shield were sometimes used.

Fertilization

The maintenance of soil fertility varied with location and crop. Compound fertilizers, mainly 13:13:20 in Trinidad and 15:15:15 in Guyana, were widely used. Many farmers also used supplimentary nitrogen fertilizer and in Trinidad foliar applicarion of nurrients to vegetables was widespread. The unavailabiliry of fertilizers in Guyana limited their use. In both terrirories fertilizer used was based mainly on experience since fertilizer recommendarions were lacking. Organic matter was used by about 30% of the farmers for vegerable cultivation in both countries. Lime was used by 10% and 30% of the farmers interviewed in Trinidad and Guyana, respecrively. Several placement merhods were used for fertilizer and pen manure, *viz.*, broadcast (rice); band (sugar cane); holes (vegetables and root crops); side dressing (vegetables and root crops) and circle (tree crops). Manure and lime were generally incorporated into the soil before planting.

Farmers rested the land for 6 to 24 months to rebuild soil fertility during bad weather, or when they could not cultivate all their land.

Water Management

The farmers interviewed were all aware of water management problems. In all areas farmers paid special atrention to drainage and employed a range of bed/drain layours. These included: cambered beds (4 ro 8m wide); ridges (0.75 to 2m wide) on flat land or along cambered beds; flat beds (1.5 to 4m) with box drains between beds (*i.e.* drains that are square or rectangular in cross section); and ridges and furrows on flat beds with field drains between beds.

The reasons given by the farmers for the use of the bed system include:

1. Tradirion,
2. To provide extra drainage,
3. To provide access for crop culrure, and
4. To limit compacrion in cropped areas.

Farmers complained of the costs of consrructing and maintaining infield drains and the lack of maintenance of main drains by the relevant authorities.

All farmers interviewed in Guyana used some form of irrigation during the dry season. Fifry percent (50%) of farmers interviewed in Trinidad had access to irrigation watet, but the distribution of water was a major problem in all areas.

Several farmers (20% in Trinidad and 30% in Guyana) owned pumps which were mainly used for lifting warer from the canal onto the field. Hoses, buckets and watering cans were then used for applying water to vegetable crops. Flood irrigation was used in eddoes and rice production, but furrow irrigation was absent as the land was not graded to accommodate this practice. Approximately 87% of the farmers interviewed in Guyana used grass mulch for moisture conservation. Lack of irrigation was cited as a major constraint to dry season cropping.

Research Needs for Soil and Water Management

In view of the survey findings, and our knowledge of the other problems encountered by small farmers on heavy soils in the Caribbean, there is a pressing need for invesrigations of the following:

1. The frequency with which conventional tillage is required;
2. The zonal tillage vs. conventional tillage concept to determine the minimum soil disturbance needed to provide a suitable seedbed;
3. The benefits and the optimum amounts of mulch required under various situations for soil and water conservation;
4. The potential of animal drawn implements for tillage and weed conrtol in energy deficient territories;
5. Comparisons of the various methods of fertilizer and manure application for the various tillage methods;
6. Timing, rates and frequency of fertilizer and manure application for the various tillage/soil management cropping systems;
7. Suitable crop rotations to maintain soil fertility and suppress the build-up of weeds, pests and diseases; and
8. The timing of application of the minimum amount of irrigation for economic, dry season crop production.

RESULTS

A research program, with financial assistance from the Swedish Agency for Research Cooperation with Developing Countries (SAREC), was initiated at the University of the West Indies to invesrigate some of the research needs listed above. Two aspects of the research program are reported in this paper:

1. The effect of tillage, mulching and field layout (infield drainage systems) on the performance of two rest crops, cowpea (*Vigna unguiculata*) and maize (*Zea mays*); and
2. The testing of a soil and crop management system suitable for the production of maize and cowpea by small farmers on the Frontland Clay Soils of Guyana, under the rainfall regime of coastal Guyana.

Our research to date provides some information of crop performance with teduced tillage under local conditions. In Trinidad on a loam soil (Orthoxic tropudulr), yields of a cowpea without tillage were as good as, or better than, tilling with a hand rototiller (Table 1). However, on a clay loam soil (Aquic eutropepr) with impeded drainage, cowpea growth and yield were similar under no-tillage and conventional tillage (disc ploughing and rotorilling) during the wer season (Table 2). In an earlier study with maize grown on clay loam in the wer season, yields were better with ploughing and rototilling than no-tillage or tillage with a hand tractor (Lindsay et al., 1983). This may have been the result of the better drainage with conventional tillage.

TABLE 1. Effect of mulch and tillage on cowpea seed yields on a loam in 1981.

Tillage	Seed yield kg ha^{-1}	
	Trial I	Trial II
Hand rototilled	937.0	1080.3
No-till bare	1013.0	709.5
No-till & mulch	732.3	730.3
LSD (0.05)	203.9	237.3

TABLE 2. Yellow seed yield (kg/ha) of cowpea under two rillage regimes on Cunupia clay loam.

Tillage treatment	Pod yield
Disc plough and rotovate	1102.3
No-till and mulch	1028.6
(P = 0.05)	NS

In the dry season on the clay loam soil, 1,500 kg/ha of dry cowpea seeds were obtained with no-tillage. This yield was not significantly different from the 1,460 kg/ha from tilled plots. No-tillage required less irrigation per kg of yield and hence had a better water use efficiency.

In Guyana, on a heavy clay soil, no significant differences were obtained for three tillage regimes (Simpson and Gumbs, in press). The tillage systems were T1) disc-ploughing followed by one pass of a heavy harrow (reduced tillage), T2) T1 followed by one pass of a light harrow (conventional tillage) and, T3) T2 followed by chisel ploughing (conventional deep tillage). The results of this study are not dissimilar to those reported earlier by Lindsay and Osei-Yeboah (1982) on the Aquic eutropept in Trinidad for cowpea and maize. Moreover, there was no significant yield increase for these two crops grown on ridges compared to flat planting on this soil in Trinidad. These latter results are, however, contrary to the findings of Krantz et al. (1978) on Vertisols at ICRISAT. The tillage/soil management method which gives the best cost : benefit ratio should therefore be employed.

In coastal Guyana there are two wet and two dry seasons per year. The mid-year rainy season is longer and more intense than the end of year (December-January) rainy season. With the prevailing climatic conditions, cowpea is found to be more suited to the less intense rainfall at the end of year planting season. Maize, however, is suited to both seasons, but is normally planted in the mid-year season because the rainfall is more reliable.

Several systems are presently being tested which allow the cowpea/maize rotation to be tested with or without mulch and tillage in the rainy seasons. Some of the results (Table 3) of these studies indicate that major economic benefits can be gained by using a vegetative mulch for cowpea production in the end of year planting season. The benefits of mulching in the mid-year season appear to depend on the level of rainfall. When rainfall is high, particularly at planting, soil moisture under the mulch is excessive and this affects germination and growth of maize. Under more moderate rainfall conditions mulching can be beneficial to maize production.

A comparison of no-tillage and conventional tillage for cowpea and maize production indicate comparable yields, particularly for cowpea in the end of year planting season. No-till maize is affected by excess moisture and the level of N-fertilization. It has, however, been shown that under moderate rainfall, and high N-fertilization of maize, it is possible to reduce or perhaps even eliminate tillage of the heavy frontland clays of Guyana for producing cowpea and maize.

CONCLUSIONS AND RECOMMENDATIONS

A survey of the soil and water management practices of small farmers in Trinidad and Guyana has shown that they lack basic information for optimizing yields. Although solutions to several of the problems are known and can be implemented, others require national effort. There is, hence, an urgent need to disseminate available information and to demonstrate proven soil and water management practices to our farmers. In an attempt to mitigate some of the limitations highlighted in the survey, a research program has been initiated. Preliminary results have shown the potential of reduced tillage to give comparable yields to those obtained by conventional tillage. These findings hold much promise for maintaining or improving soil productivity and increasing crop yield in these areas. Selecting and growing crops at the time of year when the climatic conditions are suitable is also a recommended solution. There is also the need for long term studies over a wider soil and climatic zone, as well as the integration of weed control, fertilizer use and water management for the benefit of regional agriculture.

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TABLE 3: Effect of tillage and mulch on the yields of cowpea/maize rotation on a heavy clay soil during four planting seasons (1981-1982) in Guyana.

Crop/tillage treatment		Seed yield kg ha^{-1}	Crop/tillage treatment	Yield kg ha^{-1}
Trial I 1981	Cowpea		Maize following cowpea	
	Till + mulch (10 cm)[a]	545.0*	No-till + previous mulch	1595[b]
	Till bare	444.3	Till bare	4226
			Till + mulch (10 cm)[a]	2600
			No-till + mulch (10 cm)	2175
				LSD (0.05) 1623
Trial II 1982	Till bare	495.1	Till bare	974.3[c]
	Till + mulch (5 cm)[a]	500.3	No-till + previous mulch	1650.7
	Till + mulch (10 cm)	660.9	No-till + previous mulch	1867.3
		LSD (0.05) 50.4		LSD (0.05)187.4

[a] Depth of mixed grass mulch
[b] Cob yield 10% moisture
[c] Seed yield 10% moisture
* Significant at 5% level of probability