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John Cracknell

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SOIL AND WATER CONSERVATION IN THE WINDWARD ISLANDS

1. Steep slopes under mixed stands of bananas and tree crops

THE WINDWARD ISLANDS GROUP, comprising Grenada, St Vincent, St Lucia and Dominica form part of the chain of the Lesser Antillies. The Windwards are of volcanic origin and are very mountainous, rising in one case to 3,800 feet above sea level within two miles of the coast. The major crop is bananas, produced on small holdings for export to the UK. Coconuts are also widely grown and, to a lesser extent, other permanent tree crops.

Soil erosion during heavy rainstorms is a major problem, and clearing of land in central forest reserves is reducing base flow levels in rivers.

Improvements in soil and water conservation can be achieved through biological control measures, ie reafforestation, establishment of permament tree crops, etc. Increasing pressure on land, however, is requiring that control measures allowing more intensive land use be identified. One possibility is the use of conservation bench terraces. Terraces 12 feet–15 feet wide are cut at regular intervals on a slope. The area between terraces is left in the original slope and can be planted to a permanent tree crop. The terraced area is available for production of crops that require clean cultivation. A percentage of flat land is thus made available for production of crops that would pose a severe erosion hazard if cropped on the untreated slope. Water conservation is improved, and there are possible benefits to be derived from reductions in leaching of fertilisers and plant nutients.

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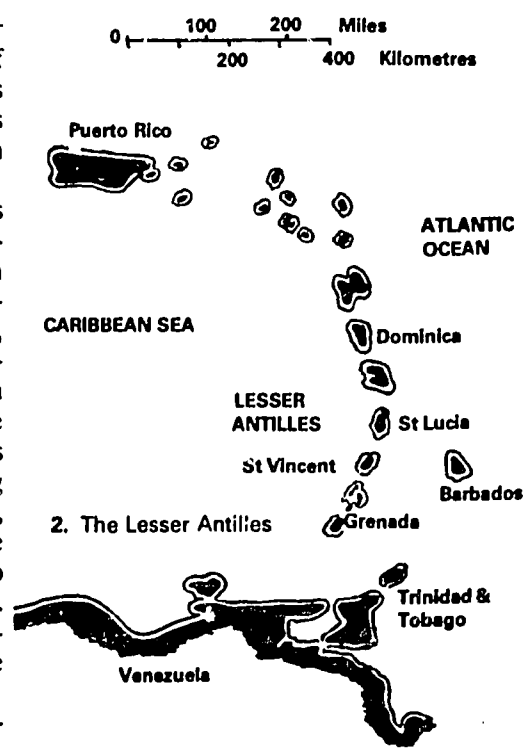
THE WINDWARD ISLANDS, Dominica, St Lucia, St Vincent and Grenada form the southern part of the Lesser Antilles, a chain of islands stretching northwards from Venezuela to Puerto Rico (fig. 2). Dominica, the largest, is about 750 sq km; St Vincent, the smallest, about 336 sq km.

Climate is tropical, modified by oceanic influences. Rainfall varies with altitude from 1250mm to in excess of 5000mm per annum. Short duration rainstorms with very high rainfall intensities are common. The islands are volcanic and very mountainous, with slopes in excess of 30° being common. The main peak of Dominica, Diablotins, rises to 1420m, within 6.5km of the coast.

Agriculture is the mainstay of the island economies. Bananas are grown for export to the UK, with coconuts, citrus and other tree crops being produced to a lesser extent. Root vegetables and other staples are grown for local consumption. Intercropping of bananas with tree crops and roots is very widely practised by small farmers — pure stands are only established on the large estates.

To date, almost all the limited areas of flat alluvial land have been operated by large estate owners. Although action is now being taken to redistribute the better lands to some extent, many small growers cultivate excessively steep hillside lands. Soil erosion is taking place as steep slopes are cleared and planted, erosion rates being higher under crops requiring clean cultivation, eg, sweet potatoes, than under tree crops. There are pockets of land where cropping is no longer possible due to loss of topsoil. These areas will become more extensive unless control measures are implemented.

Allied to the problem of soil ero-



2. The Lesser Antilles

sion is that of water conservation. Clearing of the rain forest is resulting in falling base flow levels in rivers during the dry season and flash flooding in the wet season. The islands are dependant upon surface water for domestic and industrial supplies. Further stress will be placed upon these already limited supplies as island economies develop.

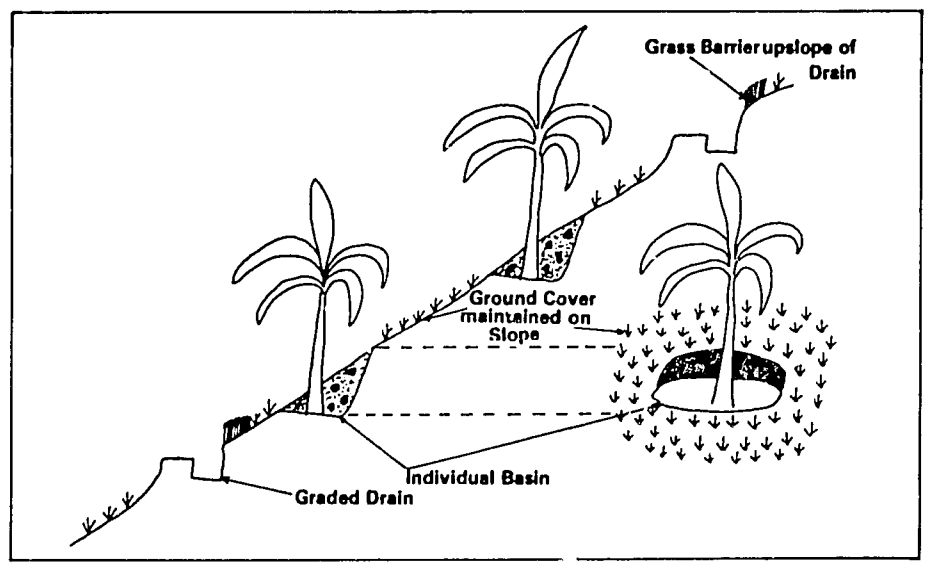
Erosion processes and effects

Sheet erosion takes place when loose soil particles on a slope unprotected by vegetation are agitated by raindrops. There is a net soil movement down the slope. Rills and gullies form when uncontrolled water flows across the soil surface. Landslides occur when the soil mass on a slope becomes saturated. Major damage can result (fig. 3).

In extreme cases, erosion damage may prevent crop production[1]. It is fortunate that many soils of the Windwards are formed from volcanic ashes. Cultivation of the deep friable subsoil is possible after topsoil has been lost, although yields may be depressed to unprofitable levels[2].

The loss of production on eroded land is only one of the costs related to erosion. Roadside drain cleaning, damage by landslides, cleaning of silted water intakes are some of the costs to island economies arising from erosion.

3. Landslide damage to a major road



4. Individual basins, drains, grass barriers and cover plants

An approach to soil conservation

Hudson[3] is correct when he states that the main cause of erosion is inappropriate cropping, and that control is best effected by a change, eg, from arable to tree crops. Pressure on land in the Windwards is such that these changes cannot be made in all cases. There is a need to identify physical conservation measures that can be implemented under current cropping patterns. If conservation programmes are to be successful they must not require changes that small farmers are unwilling socially and unable financially to make.

This is not to say, however, that physical conservation measures can be applied on all slopes. There are lands currently being cultivated that are only suitable for forestry irrespective of whatever conservation measures may be applied. This can be the only sensible long term use.

Physical conservation measures

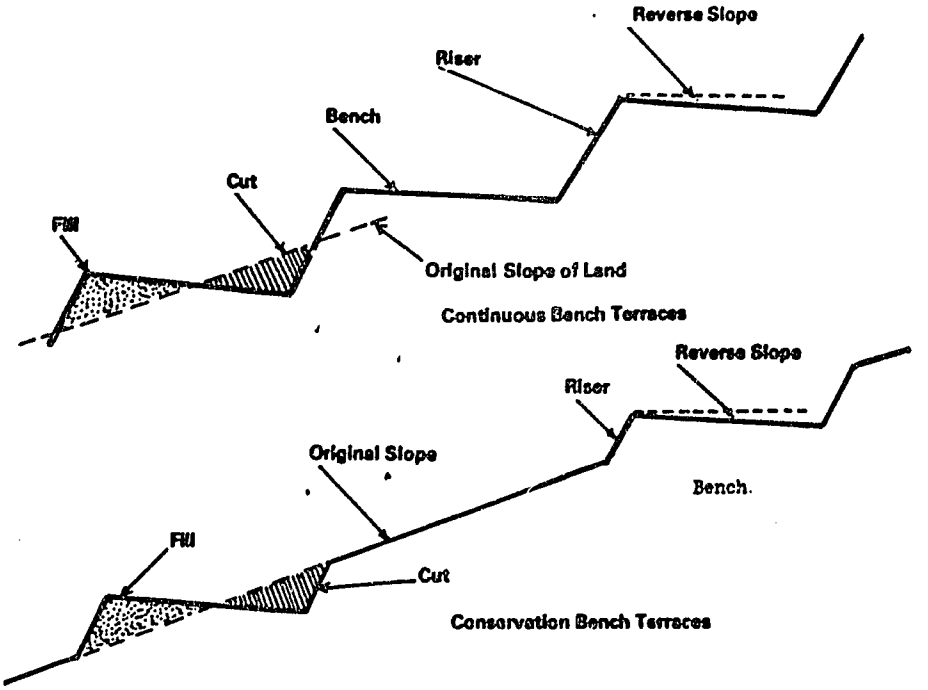
Conservation measures investigated in the Windwards have been tried and proven elsewhere. This article does not describe new techniques, rather the adaptation of known techniques to a particular situation.

Work in Jamaica[4] indicates that erosion can be minimised under a combination of individual basins, cover plants, grass barriers and graded drains (fig. 4). Indigoforea has been suggested as a suitable cover plant, and Simmonds[5] lists other shade tolerant species with potential. Khus-khus grass (vetiver zizanoides) has been used in the Windwards as a grass barrier upslope of the drain. Drains are graded on a slope of 1 in 100 to feed into a down-slope water course.

Soil cover is maintained at all times, and any soil movement downslope is arrested by the grass barrier. Overland flow of water is broken by the drain and channelled to the waterway. In some cases, mechanical protection of the downslope waterway may be necessary. Further investigation of this aspect of the system is needed in the Windwards.

Tree crops can be included under this system, but roots and clean cultivated crops are a problem. The writer has investigated the possibility of adapting conservation bench terraces, as opposed to continuous benches, to fit cropping patterns in the Windwards. Continuous benches are 'steps' cut consecutively on the hillside, whilst conservation benches require an area of the original slope to be left between terraces (fig. 5). Conservation benches were developed in semi-arid areas of the USA as a method of 'water harvesting', with run-off from the slope being collected and conserved on the terrace. The slope is not cultivated, cropping being confined to the terraces.

A system which required a large



5. Forms of terraces

percentage of land to remain uncultivated would be unacceptable in the Windwards. An alternative is to establish low erosion hazard crops being confined to the terrace (fig. 1). This should improve conservation whilst allowing the traditional mixed stands of tree crops, bananas and roots to be established.

Stability of the riser (fig. 5) is a problem in terracing schemes. Risers higher than 1.25m to 1.5m tend to be unstable and prone to slumping. Riser height increases with slope for a given width of terrace. For a given slope and width of terrace, riser height for conservation benches is half that of continuous benches. Conservation benches can therefore be cut on much steeper slopes than continuous benches.

Terrace spacing is governed by the tree crop to be established on the slope. Trees which develop a fairly dense canopy eg, citrus, require 7m to 10m, otherwise they will shade crops on the terrace. Trees with a less dense canopy, eg, coconuts, can be established in about 5m.

Conservation benches' 3.25m to 4.25m wide have been cut on trial plots in the Windwards using a Caterpillar D4D or D6C tracklayer. Terracing with hand labour is extremely expensive, and can only really be justified if part of a Government supported employment creation scheme. Terraces are graded at 1 in 100 to drain from a downslope ridge line to a watercourse, and given a backslope of 1 in 10. The riser can be protected with local grasses.

In 1978 John Cracknell was appointed Soil and Water Engineer in the Windward Islands, and returned to the UK in late 1981. After five years at Newcastle University as a student and research worker, he had joined the staff of the UK's Overseas Department of the National Institute of Agricultural Engineering. Whilst at the NIAE he was involved in projects in the Yemen Arab Republic and Jordan.

The limited experience to date indicates about 25 tractor hours per hectare for a D6 cutting terraces at 5m spacing. For other spacings allow 2.5 tractor hours per 100m of bench cut. Some hand labour is needed for finishing, and mechanical protection of the water may be necessary in some cases.

Erosion should be reduced on conservation benches if crops that are clean cultivated are confined to the terrace. Leaching of fertilizers will be less on terraces and there will be some measure of moisture conservation. Recent studies[6] have shown strong correlation between slope and toppling and snapping of mature banana plants. In the longer term there may be potential for limited mechanisation on terraces.

Justifying soil conservation

Developments in soil conservation in the Windwards will involve long term programmes to educate farmers and the general public to recognise the problem of erosion. Further in-field demonstrations of techniques for controlling erosion will be needed to back these educational programmes — the work outlined here is only a first step.

Soil conservation is difficult to justify in financial terms to the grower, particularly where cropping continues and reduced yields are accepted as normal. Controlled subsidies will be needed to encourage growers to invest in conservation works. Subsidies can, however, be damaging if they come to be regarded as payment for work on private lands.

The short term returns to conservation works in the Windwards may not be great, particularly where tree crop establishment is a major component. The long term benefits could, however, be substantial if depression of yields can be countered and damaged lands returned to full production.

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Enthusiasm grows for reduced tillage in dryland areas —a US view

cultivation

Nearly a year ago, at a seminar run by the US National Association of Wheat Growers, a firm consensus of opinion predicted increased adoption of reduced tillage. We present here a shortened version of some of those opinions, describing experiences which may be applicable to many tropical dryland areas.

John Rea, Touchet, Washington, and Robert Paris, Dighton, Kansas, addressing approximately 450 farmers at a Monsanto-sponsored presentation examining new techniques in reduced tillage, contended that 'a combination of misconceptions and adherence to tradition has accounted for the slow adoption rate of reduced tillage practices'. While the abandonment of moldboard ploughs appears to be widespread in many areas of the US, opinion was that 'the switch is long overdue'.

Both Rea and Paris started reducing tillage on their own farms about 40 years ago and have watched the method evolve. They believe that growers should have few problems using it. 'The potential for yields and cropping systems are limitless with reduced tillage', says Paris, 'Reduced tillage dryland farming is far ahead of any other system'.

Paris, who farms 2,800 acres of wheat and milo, became interested in reduced tillage programmes in the 1930s, when intensive tillage and high winds turned most of the Great Plains into a dust bowl. Today, he will till his fallow fields once or twice only for seedbed preparation. All weed control is accomplished through the use of Roundup herbicide, sprayed at the low 12-ounce rate in 5–10 gallons of water per acre, once or twice during the fallow season or just prior to planting.

Trash protects soil

Similarly, Rea became interested in reduced tillage when he saw the effect that high winds could have on his Ritzville sandy loam soils. 'There are areas of the farm where wind can strip away all the topsoil in one day', he said, remembering the years when he clean-tilled parts of his 16,000-acre wheat farm. He realised that a trash cover and rough cloddy soil texture could protect his soil through the winter months, when erosion was most severe. For control of his weeds, mostly volunteer wheat and cheatgrass, Rea relies on a single early spring application of Roundup herbicide at the 12-ounce rate in 3 to 10 gallons of water. The treatment eliminates the need for weed control by cultivation which may need three or four trips. He also uses a Noble sweep to set a moisture line.

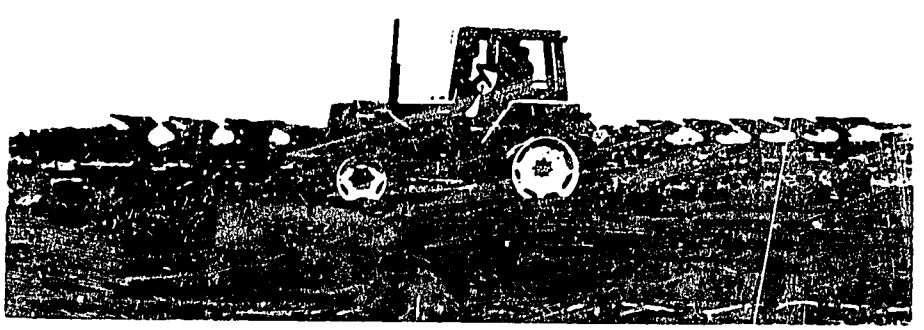
Advantages outweigh obstacles

Rea and Paris conceded that they encountered serious problems when they first entered into reduced tillage programmes. Until recently, the chemicals on the market were not totally effective, because they worked by defoliating the weeds. This left roots unscathed and ready to regrow. Planting technology was also relatively primitive. No one had the answers about modification of conventional planters to avoid clogging and inadequate seed/soil contact.

Today, however, many of these problems have been worked out and herbicide programmes have been developed to control the broad spectrum of weeds found in fallow fields. Satisfactory weed control and limited soil disturbance often provide better moisture conservation, a key issue in Walla Walla County, Washington (10-inch average yearly rainfall) and Dighton, Kansas (16-inch average).

'Our biggest problem is managing water. If we could find a way to hold on to every available inch of moisture, we'd get higher yields and beat the problems of soil erosion', Paris asserted. Most of his land is composed of a Richfield loam or Harney silt loam, two soils with low water infiltration rates. They are simply unable to absorb the moisture from the high intensity rainfalls common to the area. With reduced tillage there's less evaporation and more ground shading. In addition, the trash on the soil surface can effectively trap rain and snow, giving the soil more time to absorb moisture. The result is higher yields. Paris aims at 34–60bu/acre wheat and about 40–70bu/acre milo, both slightly above the local average.

All right for some — but not for drylands, say US farmers



More water = more wheat

'What you can see in my fields is that extra inch or so of water which I save by cutting tillages', Paris says. 'Fertiliser helps us to a point. But, if you don't have the moisture — or if you're allowing your soil to erode — you won't get the crop'.

Rea also has experienced improved yields from reduced tillage programmes. 'It's inevitable', he said, 'because every inch of moisture means three to five more bushels of wheat'. He also enjoyed other significant benefits. Field work is minimised, mainly because it takes less time to spray Roundup than to till. He applies the Roundup either by ground or air, depending on weather and soil conditions, and estimates that this has cut his labour requirements by a third.

The reduced tillage programme also limits machinery wear-and-tear, he estimated saving being approximately 250 hours on each Caterpillar tractor per year, or one can extend the life of a tractor by three to five years'. Taking these factors into account, Rea concluded that the cost of converting to reduced tillage, most often cited by farmers as the reason for their reluctance, is far lower than estimated — and the cost benefits are higher.

'I can use one application of Roundup, which costs less than $10. That eliminates up to three cultivations, each of which costs $4.50. Already, I'm ahead', he said, 'But when you take into account better soil conditions and yields, reduced labour requirements and lower equipment depreciation, there is no way that conventional practices can even come close to reduced tillage'.

An agronomist's view

Phil Stahlman, agronomist at Fort Hayes Experimental Station, Hays, Kansas, said that growers must sit down and assign realistic figures to such factors as machinery depreciation, labour, soil moisture loss and erosion. They will probably see that reduced tillage is far less costly in terms of capital input, and more beneficial in terms of yields and soil and moisture conservation.

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