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Soil and Water Conservation Problems in Pineapple Plantations of South Ivory Coast

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1. Introduction

In the last few years, pineapple plantations in the south Ivory Coast have been greatly extended, requiring a more sophisticated mechanization and, as a result, making more acute the soil and water conservation problems, eg awkward tillage because of deep rills, uprooted plants, dales flooded with sand and water.

Considering soil protection as an integral part of the agro-system, a multi-disciplinary research team of the Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM) and Groupement d'Etudes et de Recherches pour le Développement de l'Agronomie Tropicale (GERDAT) have been studying for five years biological techniques (various crop residue management and tillage systems) to reduce soil erosion and nutrient waste by leaching. Some practical conclusions can be drawn from the numerous data collected on plots under natural and artificial rainfall and on blocks of two major plantations.

2. The Problem

The climate is very drastic in the Abidjan area of the Ivory Coast with a mean annual rainfall (Ham) of 2100 mm and a mean annual value of Wischmeier's erosivity index (Ram - in American units) of 1200. Half of the annual erosivity occurs in two months (May 15 - July 15). By way of compensation, Wischmeier's K index of erodibility for the ferrallitic soils derived from Tertiary sand ranges from 0.05 to 0.15, the exact value being a function of the organic matter and clay contents (Roose, 1973). The lack of available land compels the planters to cultivate unsuitable slopes up to 26% steepness. In spite of that, soil and water losses remained until 1970 at a low level thanks to alternated strip cropping (20m wide) and contour ridging. From that time, the use of a long armed boom sprayer has led to the neglect of strict contour cultivation in order to widen the strips up to 34 m and to reduce the number of the grass covered embankments. Moreover the number of field roads has increased, resulting in a serious aggravation of damage.

Since 1974, the profit margin has decreased and planters try to economize fertilizers, labour, machinery and agricultural practices. Pineapple cultivatation provides an important amount of plant residue (more than 25 metric tons/ha of dry matter at 105°C) which is burnt in small plantations. In large estates (more than 100 ha), crop residue is incorporated in the soil before deep ploughing (to 0.40 m). Experiments were carried out to compare the effects of three various residue managements:

- burnt residue combined with shallow ploughing (to 0.20 m);
- burnt residue combined with ploughing;
- surface residue combined with a zero-tillage (mulch).

3. Experimental Results

Experimental data were collected on 12 runoff plots (bare or planted in pineapple with 3 residue managements and 3 slopes) under simulated (6 to 12 rains by plot) and natural rainfalls (3 cycles = 4 years).

3.1 Water losses Analysis of the data for bare plots confirms an unusual property of that sandy soil which is determined by splash crust, namely the infiltration rate increases as a function of slope steepness and slope length (Table 1).

The results on the planted plots emphasize the profitable effect of the funnel shaped pineapple plant on the average infiltration rate as determined for the 3 rainfall cycles: it ranges from 94% to 100% as a combined function of management, slope steepness and date of planting. On plots planted 5 months before simulated rainfall was applied, the minimum infiltration intensity for saturated soils was measured.

According to the data Lafforgue and Naah (1976) (Table 2), runoff cannot be reduced to zero, except by early planted crops and

Slope steepness	4%	7%	20%
Rate of infiltration (average for three cycles under natural rain)	60%	69%	77%

Slope length	1 metre	2 metres	5 metres	10 metres
Rate of infiltration (under simulated rain)	73%	71%	77%	80%

Table 1. Slope steepness and slope length effects on infiltration rate

	bare	burnt residue	buried residue	surface residue	
I_N (mm/h (as a function of slope steepness)	9-13	12-27	40	48	120

Table 2. Effect of crop management on minimum infiltration intensity (1_N) (Lafforgue and Naah, 1976).

Date of planting	burnt residue	buried residue	surface residue
August	.003	.008	.0001
November	.008	.035	.0001
May	.028	.040	.0001

Table 3. Effect of crop management on C x P factor (average for 3 slopes)

Slope	burnt residue	buried residue	surface residue
4%	.014	.008	.007
7%	.011	.003	.002
20%	.013	.070	.008

Table 4. Effect of slope steepness on C x P factor (average of 3 crop cycles)

mulching, because the intensity-duration curves show that rains of 126 mm/h during 5 minutes, 92 mm/h during 30 minutes and 30 mm/h during 3 hours can occur with a yearly return period (Brunet-Moret, 1967).

3.2 Soil losses Simulated rainfall studies on plots of various sizes show that the slope length factor for this sandy soil is $L = \lambda^{0.32}$ (instead of $L = \lambda^{0.5}$ in the universal soil loss equation; Wischmeier and Smith, 1960).

From experiments conducted from May 75 to January 79, the values of the C x P factor can be drawn for the crop cycle of 15 months, ie not taking into account the ratoon crop. An additional analysis of the data leads to a calculation of C x P for each crop stage. Results are shown for a planting density of 66,000 plants/ha (Tables 3 and 4), cultivated on the contour without ridging.

Table 3 shows that early planted crops of pineapple provide an excellent protection (30% ground cover at planting and 80% 6 months after; see Figure 1). This cover effect seems to be most effective for medium slope (Table 4).

3.3 Nutrient losses The study of N-K-Ca-Mg dissolved in runoff water during rainfalls thirty minutes after urea and potassium sulphate pulverisation shows that the potential losses of nutrients in runoff are low and depend on runoff volume and thus, on residue management. Losses are 0% with mulching, 1 to 8% with buried residue and 1 to 25% with burnt residue. But this does not mean that nutrients are not lost by leaching in drainage water (Roose and Asseline, 1978). They may therefore still be unavailable to the pineapple plants.

3.4 Field observations Numerous field observations have shown that two main factors encourage the rill erosion: runoff from the gentle slopes at the tops of the hills where, as mentioned, infiltration rate is the lowest (Table 1); and plantation roads of which there are 300 km in the major estate, with a catchment area > 100 ha. Running diagonally a lot of roads pick up runoff water from uphill fields and often appear unsuitable for drainage. Water is stored at low points and overflows damage the blocks below.

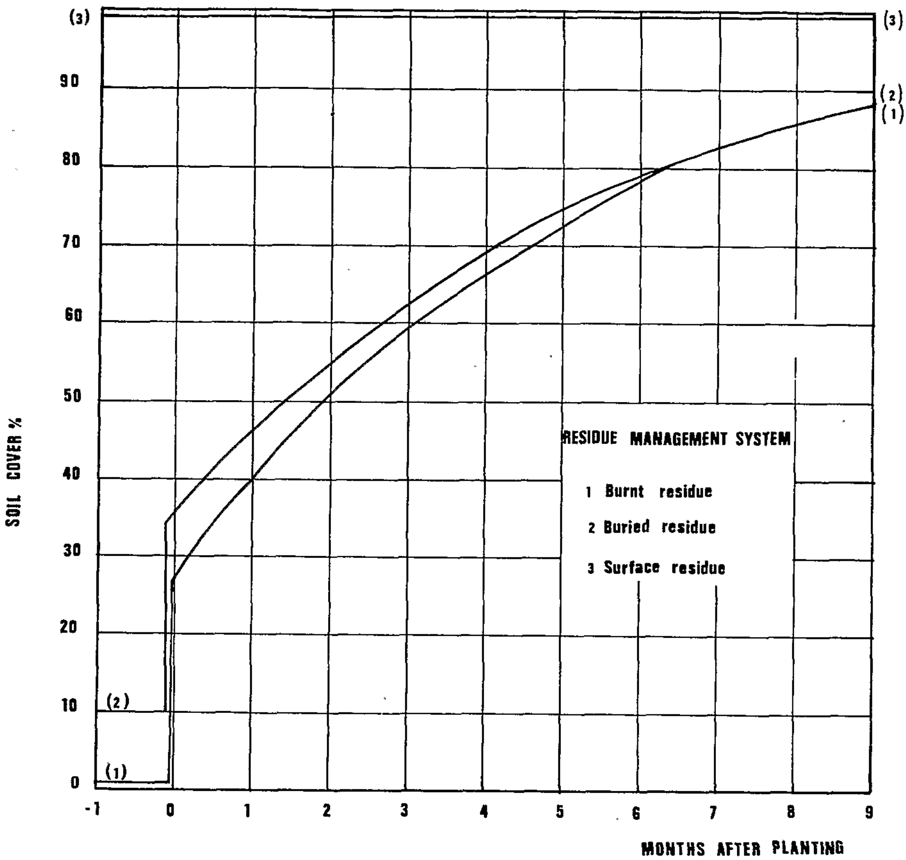

Figure 1. Total cover (plants and residues) during the first months after planting of pineapples.

4. Practical Conclusions

Once every runoff and erosion factor is isolated thanks to experimental and field observations, a protection plan can be drawn up.

The primary objective is to reduce runoff on plantation roads. A good grass cover should be established provided a serious maintenance and control programme is introduced to protect the fields from weed encroachment. Main roads could be reverse-slope designed with grass waterways running to managed outlets.

On early planted pineapple fields, erosion and runoff are kept at a low level despite the erosivity of rainfalls and slope steepness. However, runoff from gently sloping hill tops can encourage gully

Date of planting	slope	Suitable management	Notes
July – November	all	burnt residue (small estate with moderate equipment)	weak leaching whereas nutrients from residue encourage a fast growth – but waste of 175 kg N/ha
		buried residue	need of suitable machinery – better rootage than for mulching in dry conditions
December – March	gentle to medium	buried residue	risks of leaching after burning
	steep	surface residue	risks of pest problems for mulching; a deeper ploughing than 0.20 m is more suitable for infiltration during rainy season
April – June	all	no planting, or if economical reasons surface residue	if planting is dictated by economic reasons (factory supply, export)surface residue management can be used provided an increase of fertilizers, pesticides, nematocides is maintained; mulch reduces pesticide effects and increases leaching.

Table 5. Crop management selection

erosion below. The cheapest solution to this should be to select the most suitable management practices taking into account the combination of several variables such as tillage, plant residue use, date of planting and slope steepness (Table 5). It can be noticed that surface residue management allows the reduction of cultivation on the contour. The working of the soil by rotavator or rigid teeth after gyrogrinder combined with surface residue management would decrease the risks of nematodes and root diseases associated with mulching and local suitable adaptations would bring a good solution in numerous circumstances. On the other hand, tied-ridging cultivation would be effective on gentle slopes if surface residue cannot be established.

The lengthening of strips is not the major problem but this represents a soil loss increase of 18.5%.

5. General Conclusion

The major conservation problem in pineapple plantations comes originally not from the pineapple fields, but from the defective road drainage. This can easily be improved by reverse slope designing and grass covering. The selection of crop residue management according to the date of planting and slope steepness reduces soil and water losses to a negligible level by ensuring a sufficient cover. These conservation practices that we called 'biological techniques' seem the best adapted to the conditions of the tropical areas. If the rainfall erosivity is higher than in the temperate zones (Ram = 1200 in Abidjan, Ivory Coast (Roose, 1977a) compared with 20 to 120 in Belgium (Laurant and Bolline, 1978)), by way of compensation, the residue production is sometimes much more important (25 t/ha for pineapple in Ivory Coast compared with 1.7 - 7.4 t/ha for corn in the Great Plains of the USA (Skidmore, Kumar and Larson, 1979)).

In most cases, the lack of financial and technical means prevents the construction of terracing works, which are expensive and also hard to maintain. Biological techniques should be integrated in the general estate planning as a possible answer to the peculiar socio-economic and ecological conditions of the tropics (Roose, 1977b).

References

Brunet-Moret Y, 1967. Etude générale des averses exceptionnelles en Afrique Occidentale: République de Côte D'Ivoire. ORSTOM-CIEH, Paris, 20p multigr.

Lafforgue A and Naah E, 1976. Exemple d'analyse expérimentale des facteurs du ruissellement sous pluies simulées. *Cah ORSTOM sér Hydrol* 13(3), 195-237.

Laurant A and Bolline A, 1978. Caractérisation des pluies de Belgique du point de vue de leur intensité et de leur érosivité. *Pédologie* 28(2), 214-232.

Roose E J, 1973. Dix-sept années de mesures expérimentales de l'érosion et du ruissellement sur un sol ferrallitique sableux de basse Côte d'Ivoire. Contribution à l'étude de l'érosion hydrique en milieu intertropical. ORSTOM, Abidjan 125p multigr. Thèse Doct Ing Fac Sciences Abidjan n° 20.

Roose E J, 1977a. Use of the universal soil loss equation to predict soil erosion in West Africa. In *Soil erosion: prediction and control.* Soil Conservation Society of America, 60-74.

Roose E, 1977b. Adaptation des méthodes de conservation des sols aux conditions écologiques et socio-économiques de l'Afrique de l'Ouest. *L'Agron Trop* 32(2), 133-140.

Roose E and Asseline J, 1978. Mesures des phénomènes d'érosion sous pluies simulées aux cases d'érosion d'Adiopodoumé. Les charges solide et soluble des eaux de ruissellement sur sol nu et diverses cultures d'ananas. *Cah ORSTOM, sér Pédol* 16(1), 43-72.

Skidmore E L, Kumar M and Larson W E, 1979. Crop residue management for wind erosion control in the Great Plains. *J Soil and Water Cons* 34(2), 90-94.

Wischmeier W H and Smith D D, 1960. A universal soil-loss estimating equation to guide conservation farm planning. *7th Intern Cong Soil Science vol I* 418-425.