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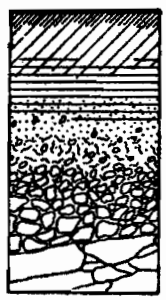
SOIL AND WATER CONSERVATION PROBLEMS IN PINEAPPLE PLANTATIONS OF SOUTH IVOIRY COAST

(PROJET DE COMMUNICATION A LA CONFERENCE INTERNATIONALE SUR LA CONSERVATION DES SOLS : " CONSERVATION 80 ". 21-25 JUILLET 1980 SILSOE - GRANDE - BRETAGNE)

PEDOLOGIE EXPERIMENTALE



OFFICE DE LA RECHERCHE SCIENTIFIQUE ET TECHNIQUE OUTRE - MER

CENTRE D'ADIOPODOUMÉ - CÔTE D'IVOIRE

B.P.V 51 - ABIDJAN

Septembre 1979

SOIL AND WATER CONSERVATION PROBLEMS IN PINEAPPLE PLANTATIONS OF SOUTH IVORY COAST

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Soil scientists ORSTOM, 1979**

1. INTRODUCTION

For few years, pineapple plantations of South Ivory Coast have been greatly extended, requiring a more sophisticated mechanization and, as a result making, more accute soil and water conservation problems (awkward tillage because of deep rills, plants uprooting, dales flooding with sand and water...).

Considering soil protection as an integral part of the agro-system, a multi-disciplinary research team of ORSTOM (1) and GERDAT (2) have been studying for five years biological techniques (various crop residue management and tillage system) to reduce soil erosion and nutrients waste by leaching. Some practical conclusions can be drawn out of numerous data collected on plots (under natural and artificial rainfalls) and on the blocks of two major plantations.

2. THE PROBLEM

The climate is very drastic in Abidjan area (Ham = 2100 mm, Ram = 1200 mm) (3) ; half of the annual erosivity is distributed within two months (May 15 - July 15). By way of compensation, the K index (4) of the ferrallitic soils

from tertiary sand ranges from 0.05 to 0.15 as 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 till 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 neglect the strict contour cultivation to widen the strips (up to 34m) and to suppress the grass covered embankments. It increased moreover the number of field roads, hence a serious aggravation of damages. Pineapple cultivation 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 (0.40m). Experiments were carried out to compare the effects of three various residue managements :

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

Indeed, since 1974, the profit margin is getting thinner and planters try to economize fertilizers, labour, machinery and agricultural practices.

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

- on bare plots :

Analysis of data are confirming an unusual property of that sandy soil determined by splash crust : the infiltration rate is an increasing

function of slope steepness and slope length.

TABLE I

- on planted plots

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

TABLE II

According to LAFFORGUE and NAAH (1976) datas, runoff cannot be reduced to nought (except by early planted crops and mulching), since the curves "intensity x duration" 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

Rainfall simulation on plots of various sizes let state the slope length factor for this sandy soil :

$L = \lambda^{.32}$ (instead of $L = \lambda^{.5}$ in the universal soil loss equation).

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

TABLE III

TABLE IV

Table III shows that early planted crops of pineapple provide an excellent protection (30% of cover at planting, 80% 6 months after ; see fig. 1).

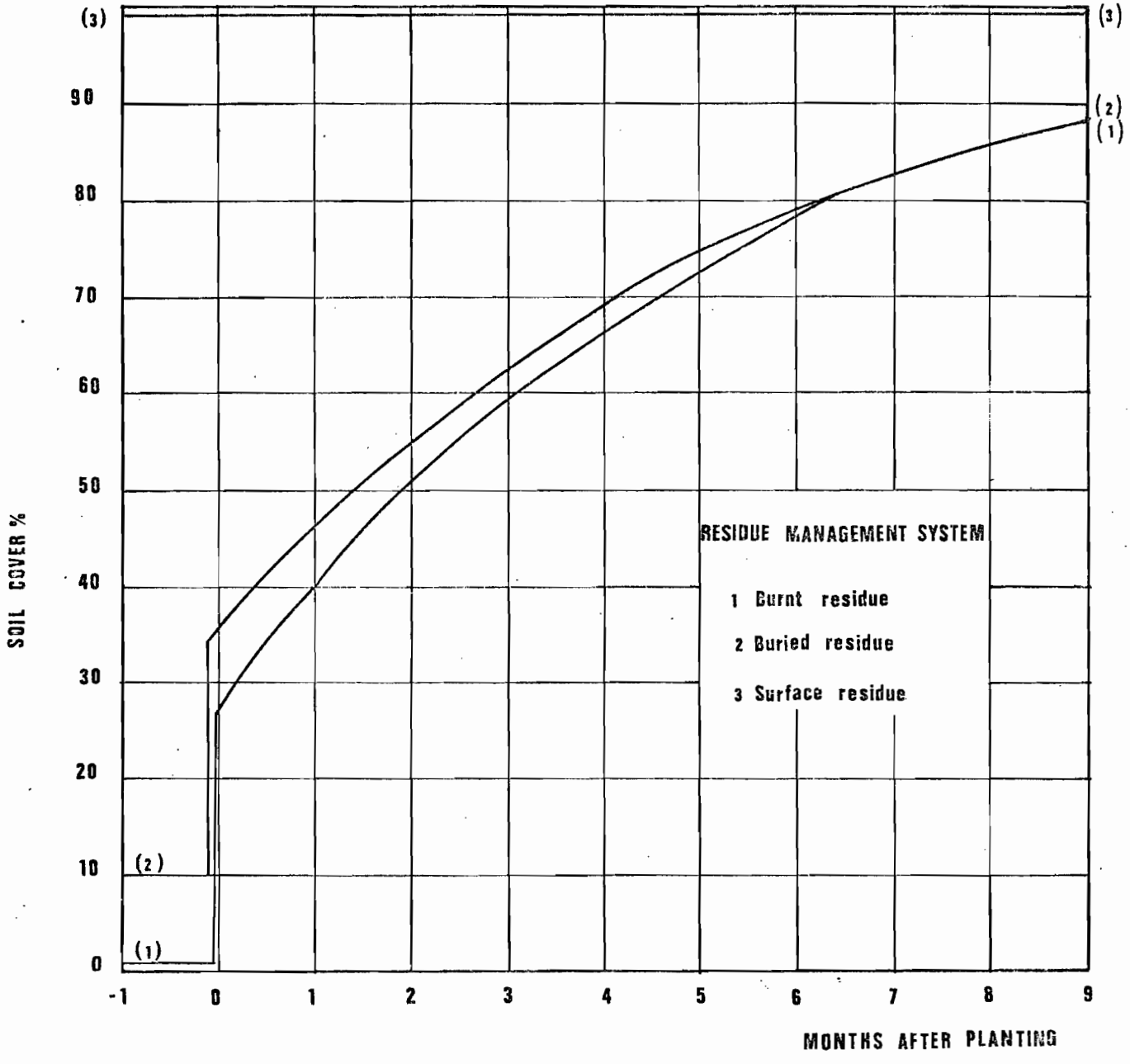

FIGURE: 1 TOTAL COVER (PLANTS + RESIDUES) DURING THE FIRST MONTHS AFTER PLANTING

This cover effect seems the most effective for medium slope (Table IV).

3.3. Nutrient losses

The study of N-K-Ca-Mg solved in runoff water during rainfalls 30 minutes after urea and potassium sulfate pulverisation shows that the potential losses of nutrients in runoff are low and depending on runoff volume and thus, on residue management (0% if mulching, 1 to 8% if burried and 1 to 25% if burnt residue). But that does not mean that nutrients are not lost for pineapple plants by leaching in drainage water (ROOSE, ASSELINE, 1978).

3.4. Field observations

Numerous field observations have drawn the statement that two main factors encourage the rill erosion :

- runoff from the gentle slope tops of the hills where, as mentioned, infiltration rate is the lowest (Table I).
- plantations roads (300 km in the major estate - 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, damaging therefore the blocks below.

4. PRACTICAL CONCLUSIONS

Once every runoff and erosion factor isolated thanks to experiment and field observations, a protection plan can be drawn :

1) The primary objective is to reduce runoff on plantation roads. A good grass cover should be established provided a serious maintenance and control to protect the fields from weeds encroachment. Main roads could be reverse slope designed with grass water ways running to managed outlets.

2) 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 gentle sloped tops can encourage the gully erosion below. The cheapest solution should be to select the most suitable management taking into account the combination of several variables such as tillage, plant residue use, date of planting and slope steepness.

TABLE V

It can be noticed that surface residue management allow the suppression of cultivation on contour. The work of the soil (by rotavator or rigid teeth after gyrogrinder) combined with surface residue management would decrease the nematods and rots deseases risks of mulching and local suitable adaptation would bring a good solution in numerous circumstances. On the other hand, the tie-ridging cultivation would be effective on gentle slopes if surface residue cannot be established.

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

5. GENERAL CONCLUSION

The major conservation problem in pineapple plantation comes originally not from the pineapple field, but from the defective road drainage that can be easily improved by reverse slope designing and grass covering. The selection of crop residue management according to the date of planting and slope steepness reduces besides to a negligible level soil and water losses by ensuring a sufficient cover. These conservation practices that we call "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, 1977) ; Ram = 20 to 120 in Belgium (LAURANT et BOLLINE, 1978)), by way of compensation, the residues production is sometime much more important : 25 t/ha for pineapple in Ivory Coast, 1.7 - 7.4 t/ha for corn in the Great Plains of the USA (SKIDMORE, KUMAR et LARSON, 1979).

In most cases, the lack of financial and technical means prevent the construction of terracing works, expensive and hard to be maintained as well.

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, 1977 b).

FOOT NOTES

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(1) ORSTOM : French Office of Research Overseas - Office de la Recherche Scientifique et Technique Outre-Mer.

(2) GERDAT : Groupement d'Etudes et de Recherches pour le Développement de l'Agronomie Tropicale.

(3) Ham : annual average rainfall amount.

(3) Ram : annual average erosivity index in English units of Wischmeier's equation.

(4) K index : erodibility of soils of the Wischmeier's equation.

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Table I Slope steepness and slope length effects on infiltration rate

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

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

Table II Effect of crop management on minimum infiltration intensity (I_N)

(LAFFORGUE, NAAH, 1976)

	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 III Effect of crop management on C x P factor (average 3 slopes)

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

Table IV Effect of slope steepness on C x P factor (average 3 cycles)

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

Table V Crop management selection

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 economical reasons (factory supply, export...), surface residue management can be used provided an increase of fertilizers, pesticides nematicides. Mulch reduces pesticide effects and increases leaching.