INTRODUCTION

In the earliest cropping systems, a long period of fallowing makes it possible for soils impoverished by a short period of cropping to recover both a certain level of chemical fertility and good physical properties. This system called shifting cultivation is still largely widespread in sparsely populated tropical zones (FAO, 1974). In Europe, a first agricultural revolution allowed to reduce the period of fallowing and to intensify the agricultural production through a close association between breeding and farming including tilling, manuring and rotation between degrading and restructurating crops (temporary grassland and cereals). In the early century, industrialization brought new modifications to agriculture. Mechanization helps to release manpower for the preparation of the seedbed, weeding and harvesting. Mineral fertilization contributes to plant nutrition, but crop

degradation. Breeding is concentrated in special areas close to the farm where it becomes a pollutant. However, one is not long in observing that soil physical properties are only partly and temporarily improved by til-

Canche in order to cope with the situation. (MASSON, PELLETIER, 1979 ; DOUAY et al., 1980).

The impact of mechanization on soil degradation is such a widespread problem all over the world that it seems necessary to describe here the results of a light approach to this problem in a country region.

METHODOLOGY

Cultivators are not interested in undertaking on a local basis highly sophisticated researches on processes of erosion. But they need to determine the extension and economic influence of erosion, the causes and factors of soil degradation. They would like to get the most adequate but the less demanding conservation practices with a view to the development of a modern and profitable agriculture. Therefore, we made successive approaches to the problem in order to specify it and modify gradually the reaction of cultivators towards the erosion risks and the possible changes in the current farming practices with a view to reaching a steady production which will be better adapted to the local ecological and socio-economic conditions.

Three investigations have been made successively :

E_1 at the level of the local administration of the Val de Canche in order to evaluate the extension of damages caused by erosion in the most affected zone of the department.

E_2 at the level of the cultivators and plots in order to look for the reasons for the change in the intensity of erosion since about ten years.

E_3 at the level of the North-Pas de Calais region by studying the historical, geomorphological and soil data related to phenomena of erosion visible in the field and in aerial photographs.

Simultaneously, various agricultural experts (INRA, ORSTOM and INA*)

INRA = Institut National de la Recherche Agronomique.
ORSTOM = Office de la Recherche Scientifique et Technique Outre Mer.
INA = Institut National Agronomique.

ploughed horizon (30cm) (cf. description of a profile as an appendix). Simultaneously, the rotation which included two years of cereals and one year of sugar-beets has been increased with industrial plants whose soil cover is low, sowing is late and crop residues are small (sugar-beet, potatoe, maize and various vegetables for cannery). Intermediate crops, green manuring and temporary grasslands have been given up : only humid soils are exploited as permanent grasslands (MASSON, PELLETIER, 1979).

The region gets a rather moderate oceanic temperate climate. The mean minimum temperatures drop from 13°C in July to 1.4°C in January and ma-

prepare the seedbed. The increase in weight and the number of passes by the different kinds of equipment can only increase hydraulic discontinuities and the compactness of deep horizons. Since then, it seems that the increase in the intensity and frequency of phenomena of erosion in the north of France is related to the development of mechanization, the dissociation of breeding and cultivation and the increasing areas covered with degrading crops rather than to an hypothetic change in the rainfall pattern. Finally, the third investigation and the mapping of soil erodibility in the whole department showed that the organic matter content is the lowest and soils are the most degraded where the mechanized industrial cultivation has been introduced since a longer period of time, such is the case of the regions of ARTOIS and CAMBRAISIS. In the other sub-regions, sheet and gully erosion exist but are limited in space, either for geomorphological reasons (slopes are short or too gentle) or for reasons of land use practices (meadows, bush, hedges or old embankments which absorb or reduce runoff).

B. The infiltration tests in the field

A first serie of tests showed that the increase in runoff varies with the cropping system such as the old system where breeding is closely re-

trailers.

In the second serie of field tests, a study was made on the influence of soil pulverization on the shooting of a cereal as well as on runoff during the preparation of the seedbed.

The results of Table II show that the more pulverized topsoil is through successive vibro-driven or rapid passes of various types of harrow, the higher runoff is and the less likely are the cereal seeds to germinate (asphyxia) and go through the sealing crust.

DISCUSSION

Despite the low erosivity of rainfalls (R = 50) and their homogeneous annual distribution, one can observe numerous phenomena of erosion, runoff and sedimentation in the zone of loessial plateaus in the North of France. They most often occur in winter on denuded and very saturated soils likely to be subject to alternations of frost and thaw ; sometimes, erosion occurs in spring (May-June) on hardly sowed fields when the soil has been too much pulverized. Similar phenomena occur in Belgium (De PLOEY, 1979, BOLLINE, 1982) and England (MORGAN, 1979).

These phenomena of erosion are not new in France since a survey made by HENIN and GOBILLOT (1950) revealed that 4 to 5 millions of hectares were subject to erosion. On the contrary, what is recent (since 10 to 20 years) is the frequency of inundations and gullying as well as the considerable damages resulting from : - the change in rotation (fewer residues in soil),

- a more advanced and heavier mechanization (as soils are degrading) and more frequent operations in order to remedy the increase

matter to soil (fewer cereals, burnt straws and dilution of organic matter by means of deep tilling).

In tropical regions, the disastrous effects of the highly mechanized crops occur more rapidly (G. MARTIN, 1963 ; CHARREAU and FAUCK, 1970) as a result of the more aggressive climatic conditions (ROOSE, 1977) and the more rapid mineralization of organic matter (ROOSE, 1980). Soils are compacted, waterlogged and give rise to sealing crusts over a few years. In Senegal, one could observe serious phenomena of erosion even on gentle slopes (< 2 %) two years after land clearing. In the forest zones of the Ivory Coast, mechanized cultivation raises similar problems (BLIC, 1976, BLIC and MOREAU, 1977).

However, it is obvious that it is not possible nowadays to consider the suppression of mechanization for socio-economic reasons. Therefore, one must try to reduce its degrading influence by limiting the number of passes and the weight of the different kinds of equipment and by using biological methods together with smooth mechanical methods in order to better exploit soils without degrading them. This solution is possible nowadays as long as soil has not been too eroded, which is generally the case in temperate regions where phenomena of erosion are less intense than in mediterranean or tropical regions.

CONCLUSIONS

Heavy agricultural mechanization degrades the soil physical properties on the surface and in depth and finally reduces soil productivity in tropical regions where degradation is very rapid or in temperate regions where it is slower. Mechanization often leads to use more and more frequently heavier and heavier equipment in order to achieve a deeper mellowing of soil whose structure is degrading. However, the resulting macroporosity does not last long in instable environments such as loess if the structure

grass).

Finally, it will be necessary to restore the balance between the rotation of degrading plants and that of restructurating plants or to find out

Table I : Influence of the cropping system on the soil degradation and runoff during a one hour simulated rain of 33mm in winter.

Treatments	Horsepower traction Winter barley	Permanent grassland	Broken grassland	Tilling Stubble ploughing Subsoiling	Tilling Stubble ploughing No subsoiling	Heavy equipment after harvesting Endives	 potatoes
Depth of ploughing	17cm	-	25cm	25cm	25cm	30cm	30cm
Tillage pan	0	0	+	+ (interrupted)	+ +	+ + +	+ + +
Soil surface conditions	cloddy	compacted over 15cm	small clods	small clods	small clods	crusted	crusted
Green cover	80 %	100 %	7 %	10 % Stubble	10 % Stubble	11 % Residues	11 % Residues
Runoff							
Delay in mn	69'*	16'	15'	15'	4'	1'	2'
Runoff in mm	0mm	2mm	9mm	5mm	14 mm	23mm	28mm
Mean KR in %	0 %	6 %	27 %	15 %	42 %	85 %	85 %
Final KR in % after 60mn	0 %*	24 %	48 %*	30 %*	73 %	91 %	98 %
Number of test	16	58	57	4	6	2	14

* The stable minimum infiltration rate has not been obtained after 60 minutes of rainfall. Rains are simulated on acid brown soils in loessial plateaus. The slope is lower than 5 % - KR = runoff coefficient = depth of runoff/depth of rainfall.

FIG .1. GEOMORPHOLOGICAL AND GEOLOGICAL DIAGRAM

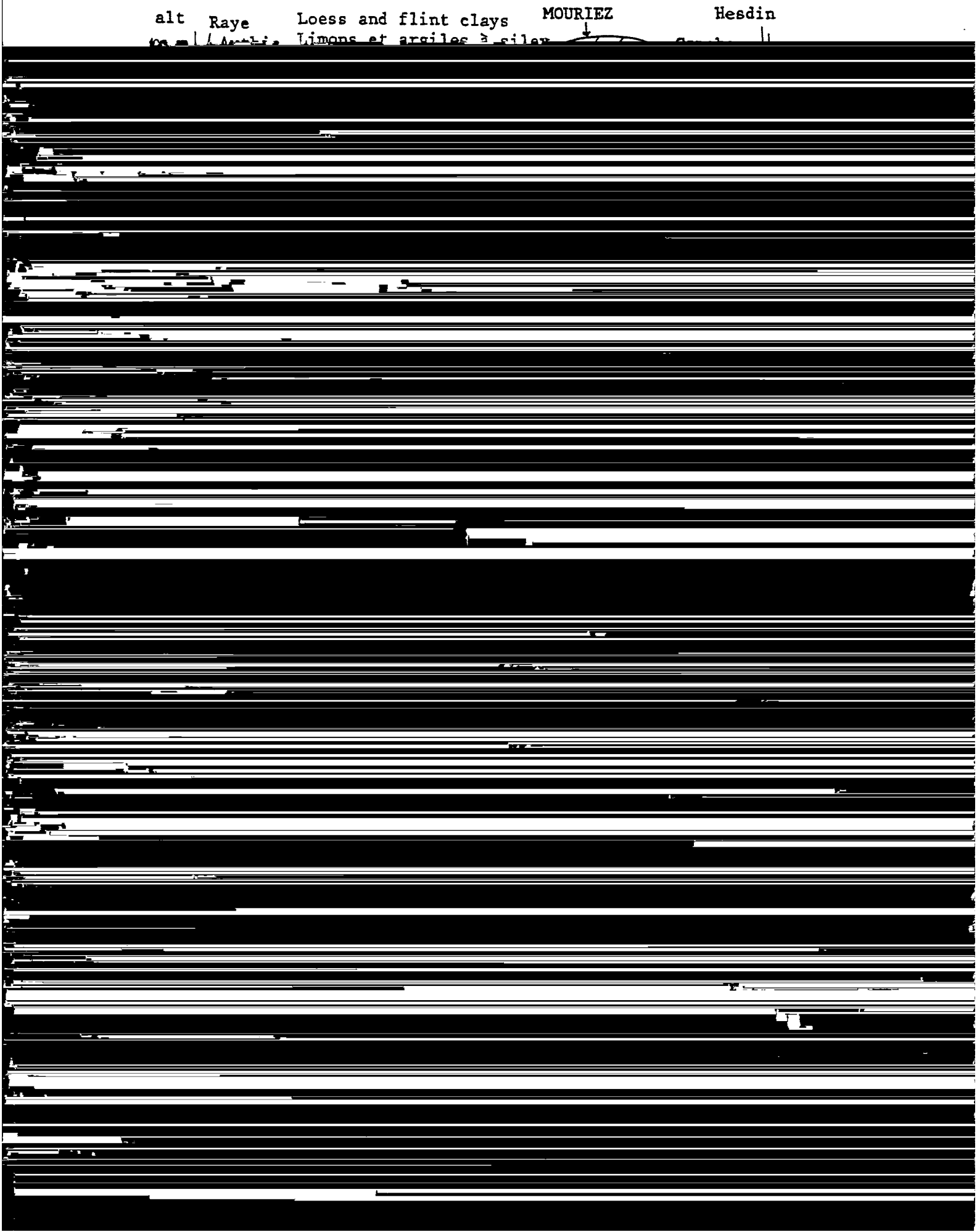

Table II : Influence of the intensity of soil tilling on the shooting of wheat and on runoff during a one hour simulated rain of 33mm. Acid brown soil on loam : Campagne-lez-Hesdin , March 1982.

Treatment	Tilling + sowing	Tilling Harrow 4cm Coupled sowing	Tilling More rapid harrow 8km/h	Tilling 1 vibro-driven cultivator 1 sowing	Tilling 2 vibro-driven cultivators Sowing
Number of passes	2	2	2(more rapid)	3 (deeper)	4
Number of shootings/ m2 *	127	114	109	73	59
Runoff ** mm	1,6	9,1	12,5	18,8	21,7
Runoff ** %	5 %	28 %	38 %	57 %	66 %

Sources * DERANCOURT (1982) ** MASSON (1982)

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Annexe 1 - Quick profile description of a brown leached soil of the Mouriez plateau (North of France).

The description was made by Mr. MASSON in Marsh 1981 on a wet field of cereals, 4 % slope, on the plateau near Mouriez.

0 to 1 cm Sealing crust (thick variation from 1 to 4 centimeters).

1 to 25 cm Ap, horizon : brownish grey (7.5 YR 4/4), silty loam low or-