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Work of soil and risks of agricultural erosion: Case of the itinerary technical cereal on tray of Mostaganem-Northwest Algeria

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Abstract

With a semi-arid Mediterranean climate and viticulture vocation, the tray of Mostaganem (North-West of Algeria) has become a region of great crops. Subject to increase mechanization and inappropriate tillage practices, farm lands are exposed to erosion that seriously weighs the physical and socio-economic contexts. An itinerary technique (cereal) is chosen to study along the slope, surface and deep structural changes of soil, humidity and the fine particles (<2 µm). Thus, consideration of the surface shows a strong soil erodibility partly linked to the action of implements and a rain erosivity accentuated by lack of vegetation in the rainy season.Culural profiles observations show the small depth of tillage affecting mostly superior horizon. Average horizon, wet, rich in fine particles and barely reached by tools impedes any move to lower horizon which is very compact without variability. With this kind of technical itinerary, fine elements losses estimated to (3 t/ha/year) result closely from the characteristics of the physical environment but also the conditions of its exploitation. In case of more important spatial-temporal unit's extrapolation, the consequences will be even more harmful if improvement actions are not undertaken.

Keywords: Erosivity, erodability, structural state, technical itinerary, cereal, tray of Mostaganem, tillage.

Introduction

The tray of Mostaganem is characterized by a semi-arid Mediterranean climate, a relatively hilly relief and poor and fragile farmlands exposed to inappropriate cultural practices. Their vulnerability to erosion that seriously threatens the environment is partly due to the conversion of vineyards in great crops. Almost naked during a good part of the year, the soil undergoes an insufficiency in the refunds of crop residues, resulting, in superficial horizons, in a lower rate of organic matter, guaranteeing a good structural stability. In view of the role of vegetation in soil protection against water erosion surface (Freddy et al., 2004) and the risk of erosion due to tillage (Revel et al., 1995), the chosen technical itinerary for our study is that of a cereal. Responding rather to the agronomic requirements, this one consists of a set of alternating farming operations, often by rain episodes. All this takes place chronologically, determined by natural factors (soil - climate) and the needs of the plant. At each event, Hallaire et al. (2002) estimate that the soil is the object of a structural modification, allowing to detect any incidence on the symptoms of erosion. Therefore, the object of the study is to show, throughout this technical itinerary the determining role of tillage on the risks of agricultural erosion. From this point, a simultaneous monitoring of the evolution of the surface state, humidity, the fine fraction and the apparent density, allowed us to characterize the structural state of soil,

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created by the tool and its behavior against rain (Le Bissonnais, et al., 2005). Thus, soil erosion is quantified through the losses of fine elements (<2µm) collected outside the plot (catchment).

Material and Methods

Choice of Study Site

Located in the West part of the plateau (Figure 1), the experimental plot already presents some effects of tillage, a slope varying from 2,5 to 7 percent, traces of erosion (limestone outcrops and traces runoff) and damaged soil with sandy-loamy texture, poor in organic matter. With a viticultural vocation, formerly, it was fragmented into several agricultural parcels separated by real regulators hedges runoff (Blavet et al., 2004). Removing these obstacles to make profitable an increased mechanization, and to transform it into a large plot, increasing thus, the runoff critical distance (Lixadru, 1968). Work period lasts between September and February.

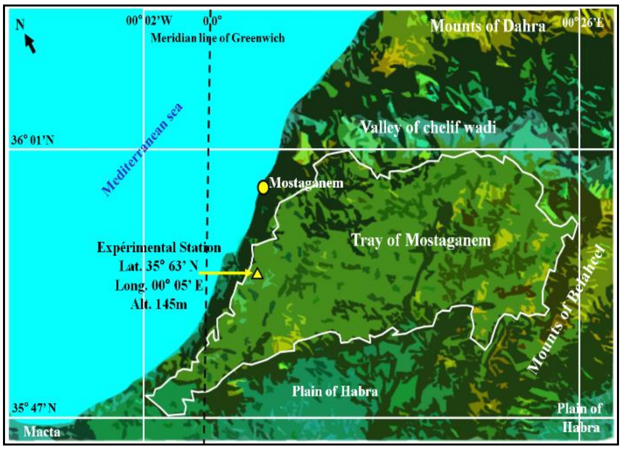

Figure 1. Situation map of the study zone

Experimental Protocole

Within the study plot, worked in the direction of contour, an experimental site constituting the catchment, has been defined on a surface of 960 m² whether 60 m x 16 m. Events track has been executed since soil preparation for the establishment of culture (cereal) until obtaining vegetative cover with high interception (Freddy et al. 2004). Thus, the work consists in following along the slope, in surface and through the different horizons, the evolution of the structural state of soil (Figure 2). To avoid all disturbance of the hydrodynamic system of the plot, all observations and measures were performed before and after each crop operation or rainfall episode, on the one hand, and, on the other hand, the catchment area on plots of 1m² arranged in series along the slope with 5, 15, 30, 50, 55, and 60 m according to chronological order of events of the technical itinerary.

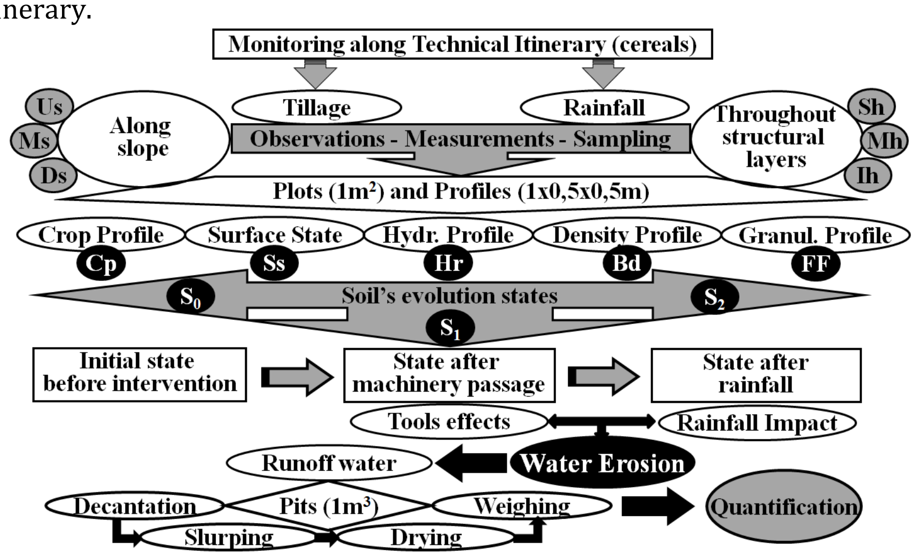

Figure 2. Experimental approach

The parameters taken into consideration for the description of the state surface have been the object of a based notation on a quantitative assessment, based on the estimation of the recovery rate of the soil surface by its components. And, given the multitude of data and their quantitative and qualitative character and their sense of evolution, a principal components analysis (P.C.A.) has allowed to determine links, more or less narrow, that maintain the variables together and that explain how they are structured and how to allocate their individuals. The Crop profiles have been digged to a depth of 50cm and a width of 100cm. The observation step has been described according to the approach used by de Blic (1990) and mapped to the delimitation of morphological units. From each structural stratum, 03 soil samples, taken by the cylinder or by an auger, then analyzed in the laboratory, were used to determine the vertical evolution of humidity, the fine fraction (< 2 µm) and the structural porosity for which, respective profiles have been established (Kay et al., 2002).

For the estimation of soil losses after each rain, a conventional system of recycling the laden runoff water has been introduced in the downstream of the catchment. This is a device consisting of 06 pits of 1 m^3 water proofed and covered with a polyethylene film. After settling and siphoning, the sediment load is recovered, dried, weighed and analyzed to assess quantitatively and qualitatively the loss of land, following the interaction Soil-Tool-Rain.

Results and Discussion

Climate Overview of the Study Zone

The intensity, the volume and energy of rainfall, combined with the state surface of the soil from cultural practices, play an important role in erosion.The ETP is more important than precipitation during the long hot and dry period (Figure 3) of Mediterranean climate where the soil has a larger deficit. This increases its storage capacity and the absorption of precipitation, while diminishing the runoff and erosion force. Erratic rains cause high spatio-temporal concentration, and thereof, accentuates the volume of potential runoff and erosion (Auzet et al., 2005).

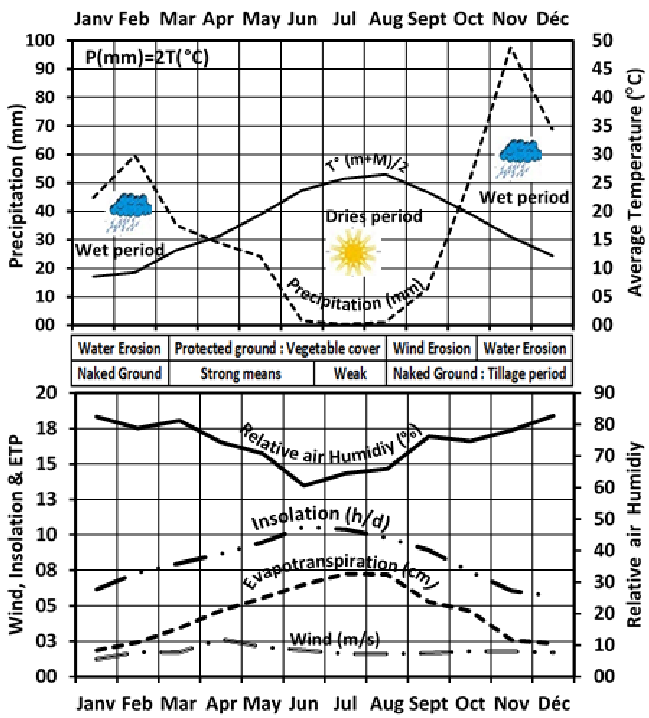

Figure 3. Climatic's data of study zone (2000-2012)

The Evolution of State Surface

The data collected were subjected to statistical treatment: the P.C.A. for the elements of the state surface. The principle of the P.C.A. is to transform the variables "p" (the elements of the state surface) initial quantitatives, all more or less correlated between them, in new quantitatives "p" (effects of the tool and the impact of rain on the state surface) variables, uncorrelated. A unique representation in the plan of the first two axes (1 & 2) has been, therefore, on its own sufficient for its construction (Figure 4). Correlation plays an important role between factorial axes and variables, whose representation can explain these axes by giving them a meaning or quantification. Thus, the most related variables to axis 1 characterize the impact of rain or more precisely the symptoms of erosion. On the other hand, those related to axis 2, represent the effects of the tool on the structural state of the soil. We can notice an opposition between these two groups of variables ; when some progress, others decrease, illustrating a clear structural degradation of the soil surface. On The first axis, we have on the one hand, those representing the development of the phenomenon of erosion (incisions, deposits materials, slaking crust and stones), and on the other hand, those that materialize the destruction of clods in general and especially those of small size (M < 3cm and M 3-6cm) and reducing porosity (empty centimetric) (Figure 4).

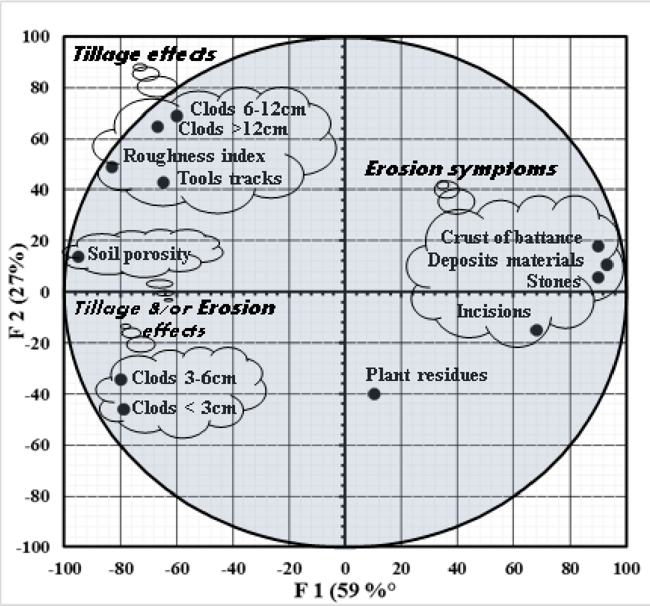

Figure 4. Correlations Circle (PCA results)

On the second axis, we find especially the biggest clods (M > 12 cm and M 6-2cm) characterizing a coarser fragmentation of the state surface due to the passage of the moldboard or disc plow. Practically, they are uncorrelated or very weak with the behavior of the structural state of the soil against rain (Figure 4). The contrast between the vegetation and these two categories of clods can be explained by the more deeply work of these tools which are translated by its translates. The tool marks appear mainly on aspects of big clods and disappear with their progressive destruction by rain. As an additional variable, the roughness index, moderately shown on the main plan, contributes almost as much to the axis 1 to axis 2, reflecting both a surface roughness created by the tool as the one designed by rain. Its position on the graph near the big clods corresponds to a high roughness opposed to that characterized by small colds symbolizing part of their destruction.The result is a clear distinction between variable directions (discrimination), bringing out respective roles of the rain on the structural state of the soil surface (incisions, deposits materials, slaking crust and stones) and that of the tool (roughness, different categories of clods, empty and tool traces). The P.C.A., also allowed to put in evidence the decisive role of the tillage tool on its structural state (Blavet et al. 2004) and, on the other hand, that of the showers on the symptoms of erosion to put in relief the existing relationship between them (Marques da Silva et al. 2004).

Vertical Evolution

This is the humidity evolution, the fine fraction and the apparent density (Figure 5). All throughout of the technical itinerary, the inferior (Hi) is characterized by a very small variation of its water status and its apparent density (Ad) in reason a lack of structural evolution relative to that other horizons that, they know more perturbations (Strudley et al., 2008). This solid state reflected by strong apparent density (Figure 5), can be explained by an accumulation of fine particles that colgs the voids, reducing the structural porosity. This state of fact, is checked during two successive rainy periods Mi_1 and Re_2, occurred after a ploughing effected using a disc plow (Mi_1). The most variations are located in the first horizons Hs and Hm. Undergoing directly the impact of rain, they constitute a permanent action zone of tillage tools in general and those performing a superficial work in particular. Thus, the humidity varies much during a rainy period after ploughing (disc plow or plowshare) after a superficial tillage with cover crop. It puts in relation structural state created and the capacity of water retention of the horizon in question (Lipies et al., 2006). Thus, for the type of action, each instrument tillage, plays a major role in accentuating or reduction of this variability. If we still consider the first two horizons, we see that for the same event, any decrease in the fine fraction corresponds to a departure of fine elements. This is usually due to leaching to the underlying horizon which knows that at the same time, corresponding an increase to an input.

The evolution study of water states, granulometric and the apparent densities was used to assess respectively the infiltration capacity of each horizon, leaching of the fine fraction and locate the packed areas (Figure 5). It has also to raise the incidence of this type of technical route on the structural state of the soil promoting the phenomenon of erosion.

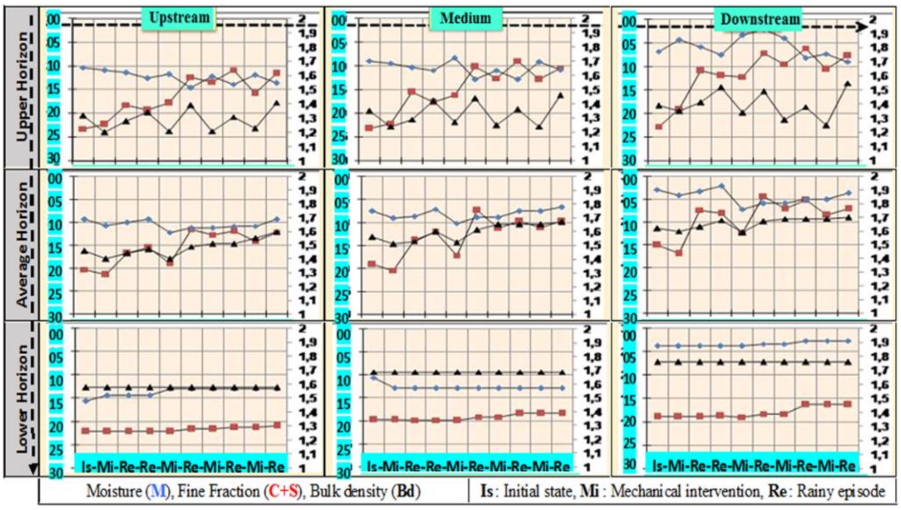

Figure 5. Evolution of humidity, fine fraction and apparent density

Manifestations of Erosion

Defined as a loss of soil due to water, water erosion is composed of set of complex and interdependent processes that provoke detachment and the transport off-plot in a place of depository, a particles composed primarily of abiotic fine elements for and biotic essential to soil fertility (Figure 6). Thus, until obtaining a canopy which can protect the soil surface (catchment) and reduce its erodibility against the rainfall erosivity (Freddy et al. 2004), a measures concerning soil loss were performed after each rainfall episode may cause runoff. The quantities of soil collected reflectat at the same time rainfall aggressiveness, their history, the sensitivity of the soil to their damaging action and slope. Everything still remains function values of infiltrability the structural state created by the tool. As accumulated at the end of experimental period (Figure 6), quantities of eroded land (0,26 t/ha) are not negligible in the case of extrapolation to spatio-temporal units more importants. Their consequences will be even more harmful if the problem is not seriously taken at consideration.

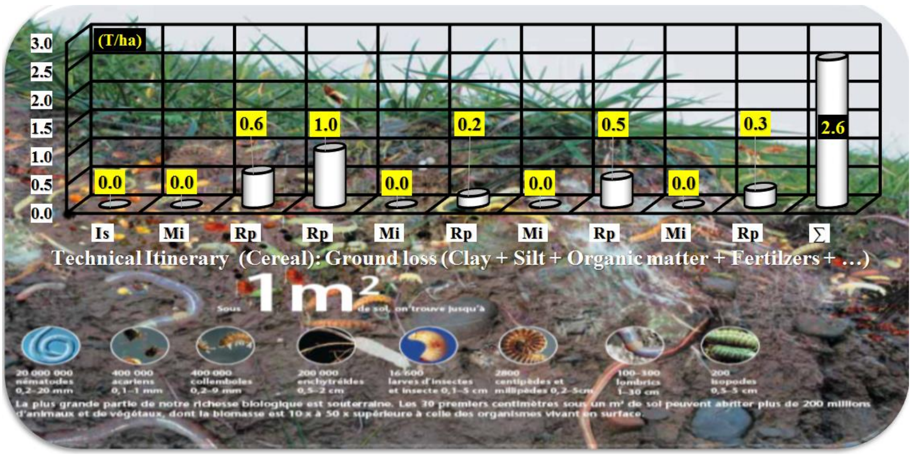

Figure 6. Impact of itinerary technical on soil losses

The excessive tillage increases the erosion risk by wind and water, because it defeated structure and decreases the amount of plant and residues covering the topsoil (Figure 7).

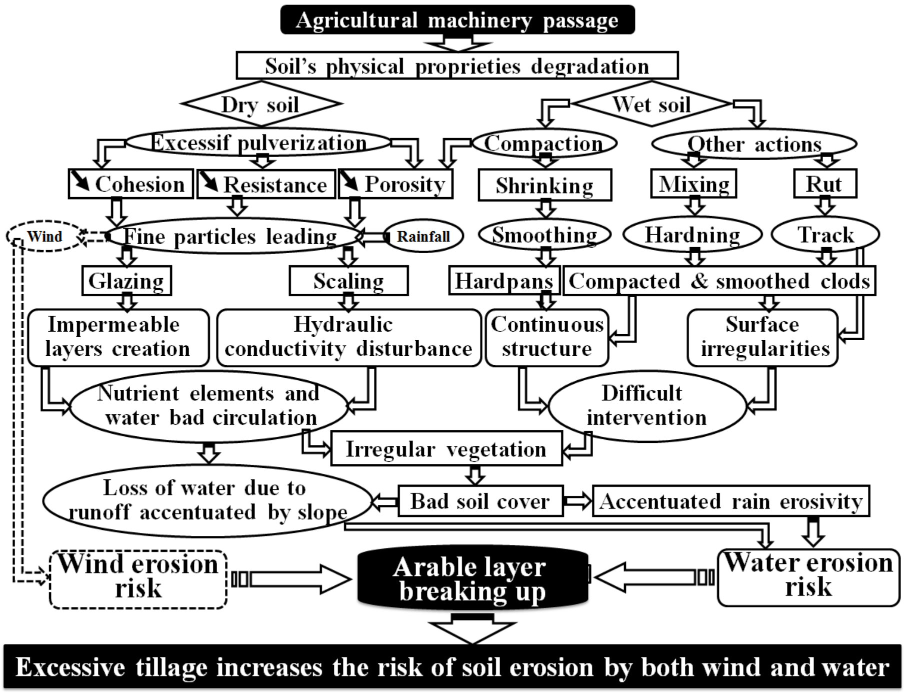

Figure 7. Impacts of agricultural machinery passages on the risk of erosion

Conclusion

Characterized by a set of cultural practices justified by agronomic objective, technical route in question gives a trend with the down of the fine fraction and humidity at the two first horizons. In addition a lower rate of organic matter guarantees a good structural stability. This depletion in fine elements, increases hugely its sensibility to compaction. The influence of this type of system on the erosion in the region varies much more in time according to the violence rainy, of canopy development and states created by the various passages tools that in space along the slope.

Thus some solutions are conceivable such as reducing the swiftness and the depth of tillage, the size of tillage instruments and the plots (Santiago-Romero, 2001). The modification in the methods of tillage it is only a means of their preservation. Thus, three important aspects of soil management can improve soil conservation efforts in the cultivated fields: the management of crop residues, the roughness of the soil surface and erosion attributable to tillage.

It can also fight against erosion by using systems more appropriate culture (Kribaa et al. 2001) and (Basic et al., 2004). It should especially encourage the adoption of conservation methods (Wilson et al. 2004) and the management strategies known, elaborate new erosion control techniques, improve the dissemination of information to producers, to monitor the development of erosion risk (Tallen et al. 2001) and attract the attention of policy-makers on this issue (Verheijen et al. 2009). The results of soil erosion are the loss of its functions and, ultimately the loss of soil it self.

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