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Working Group 2 – Key thresholds for soil erosion

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The significance of soil surface characteristics in soil erosion

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Aggregate stability as an indicator of interrill erosion processes

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Sediment and interrill erosion characteristics are related with soil properties that are generally referred as erodibility concept. In this work we assume that erodibility may be described by aggregate stability measurements. Thus the aim of this study is to examine the relationship between aggregate stability, soil erodibility and sediment size distribution together with soil surface characteristics observation.

This study is based on rainfall simulations at 1 m² scale.

20 different French cultivated soils were selected so as to cover a wide range of aggregate stability and soil erodibility. The texture ranges from sand to clay loam and silt with a majority in silt loam texture. The organic matter content ranges from 2 to more 6 g/100 g.

The aggregate stability tests are performed with the procedure presented by Le Bissonnais (1996) in order to characterize original soil. Rainfall simulations are performed on air-dried soils in small plots of 0.25 m² (0.5 × 0.5 m) with a 5 % slope. The rainfall intensity is about 30 mm.h⁻¹. For each experiment, runoff volume and sediment discharge are measured and two sorts of runoff samples are collected: one for aggregate size distribution, another for primary particle size distribution. Aggregate size distribution of sediment transported in runoff flow is assessed with a laser diffraction particle sizer. Others samples are chemically dispersed and analyzed as well for primary particle size distribution.

The results of aggregate stability tests are related with the parameters that characterize erosion sub-processes, e.g. time to runoff, runoff coefficient, sediment concentration and sediment size distribution. First results on clay soil show that the main part of aggregates transported by runoff flow is less than 500 µm size. There is also a temporal evolution of the aggregates size distribution.

Keywords: soil erosion, rainfall simulation, aggregate stability, sediment, detachment



Aggregate stability as an indicator of soil crusting, soil erodibility and sediment characteristics for interrill erosion

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Sediment and interrill erosion characteristics are related with soil properties that are generally referred as erodibility concept. In this work we assume that erodibility may be described by aggregate stability measurements. The aim of this study is to examine the relationship between aggregate stability and soil erodibility through aggregate size distribution parameter.

I. Materials and methods

Characteristics of the soils studied

Two soils with contrasted erosion behaviour were used in this study: a clay loam slightly sensitive to erosion and silt loam more unstable.

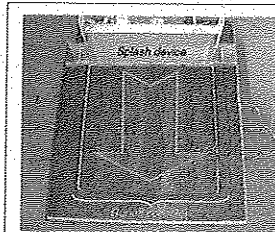
	Clay g / 100 g	Fine silt g / 100 g	Coarse silt g / 100 g	Fine sand g / 100 g	Coarse sand g / 100 g
Clay loam	33,5 %	29,5 %	33 %	2 %	2 %
Silt loam	13 %	14 %	46,5 %	25,5 %	6 %

Size distribution of the two soils studied.

Experimental device

✓ Rainfall simulation

Particle size distribution impacts of interrill erosion processes were assessed by analysing aggregate size distribution of particles resulting from rainfall simulations at 0,25 m² scale. Two types of samples are collected during the rainfall simulation: a splash device permits to collect particles splashed from the soil surface and a runoff collector to catch particles transported by the flow. Three repetitions were performed for each soil type.



- Rainfall conditions**
 - Sprinkler
 - rainfall intensity = 30 mm/h
- Soil surface conditions**
 - Air-dried soil sieved at 2 cm
 - Initial stage: aggregated seedbed
 - 5 % slope
- Measurements**
 - Micro-tensiometers for infiltration measurements
 - Camera for keeping track of soil surface evolution
 - Acquisition of soil surface DEM by a profile laser scanner
- Sampling**
 - Splash and runoff samples are also used to determine organic matter content and primary particle size distribution. The same measurements are performed on samples from the final soil surface.

Structure of the 0,25 m² rainfall simulation plot

✓ Aggregate stability tests

Aggregate stability was assessed by the procedure presented by Le Bissonnais (1996). This methodology combines three treatments having various wetting conditions and energies. Each treatment corresponds to a specific mechanism of aggregate breakdown.

Fast wetting treatment

SLAKING

Slow wetting treatment

DIFFERENTIAL SWELLING

Stirring treatment

MECHANICAL BREAKDOWN by RAINDROP IMPACT

Aggregate size distribution determination

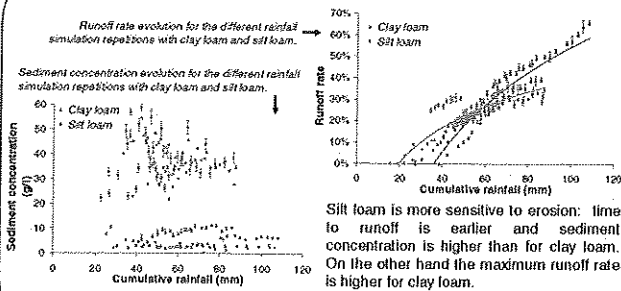
Samples:

- Soil fragments resulting from aggregate stability treatments
- Particles (aggregates and primary particles) splashed and transported by runoff

- with a laser diffraction sizer for particles less than 500 µm size
- by sieving (2000, 1000 and 500 µm sieves) for particles more than 500 µm size

II. First results

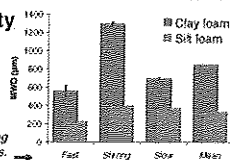
Erosion characteristics



Aggregate stability

Silt loam is highly unstable while clay loam is more stable. For both soils fast wetting treatment products finer fragments and stirring treatment products coarser ones.

Mean Weight Diameter (MWD) of the soil fragments resulting from the different aggregate stability measurement treatments.



Aggregate stability is a good indicator of erosion processes through aggregate size distribution comparison. It gives information about i) the size of soil fragments produced by breakdown and ii) selectivity of the erosion processes, i.e. splash and transport by runoff.

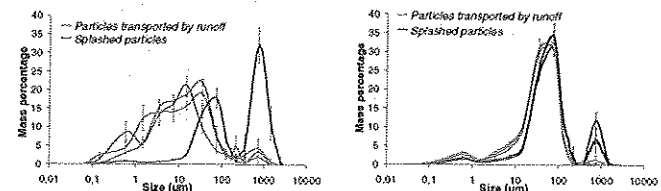
However this study allows to focus on temporal evolution of the aggregate size distribution during a rainfall event. First results show an enrichment in coarser particles with the runoff rate increase for clay loam. No temporal evolution has been still observed for silt loam.

Le Bissonnais, 1996: Aggregate stability and assessment of soil crustability and erodibility. I. Theory and methodology. European Journal of Soil Science, 47, 425-437.

Aggregate size distribution

✓ Splashed particles and particles transported by runoff

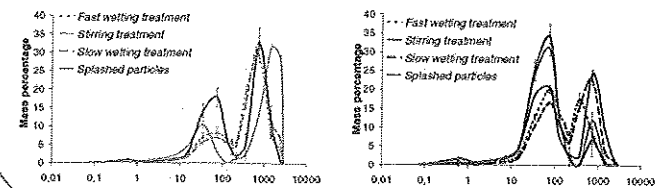
For the two soil types, the aggregate size distributions of splashed particles is coarser than the aggregate size distributions of particles transported by runoff. This difference is greater for clay loam than for silt loam. The high variability of the mass percentages values for clay loam is due to a pronounced temporal evolution for both particles transported by runoff and splashed.



Aggregate size distribution of eroded particles from clay loam. Aggregate size distribution of eroded particles from silt loam. N.B.: Each curve is a mean from values obtained for samples collecting at different time during rainfall simulation repetitions.

✓ Comparison with aggregate stability treatments

The aggregate size distributions of splashed particles show similar modes with the size distribution of the fragments resulting from aggregate stability treatments, in particular fast and slow wetting treatments for clay loam, and stirring and slow wetting treatments for silt loam. The mass percentage of the finer mode is greater for splashed particles than for aggregate stability treatments. These differences can be attributed to: i) a selectivity for finer particles of splash runoff respect to breakdown, ii) different sensitivity to breakdown mechanisms for the 2 soils.



Aggregate size distribution of fragments resulting from aggregate stability treatments on clay loam.

Aggregate size distribution of fragments resulting from aggregate stability treatments on silt loam.