# Aggregate stability as an indicator of interrill erosion processes

Sophie Leguédois, Yves Le Bissonnais, Odile Duval

COST 623 "Soil Erosion and Global Change" Workshop
Working Group 1 – Linking processes across temporal and spatial scales
Working Group 2 – Key thresholds for soil erosion

International Symposium

# The significance of soil surface characteristics in soil erosion

20th – 22th September 2001

University Louis Pasteur, Strasbourg, France

## Book of Abstracts

organized by

RIDES group
Ruissellement, Infiltration et Dynamique des Etats de Surface du Sol
(network of several research groups of CNRS, INRA, IRD and Universities)

Supported by

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Sophie Leguédois, Yves Le Bissonnais, Odile Duval

INRA - Unité de Science du Sol, Avenue de la Pomme de Pin, BP 20619, Ardon,45166 Olivet cedex France – Tel: 02.38.41.78.00 – Fax: 02.38.41.78.69 E-mail : sophie.leguedois@orleans.inra.fr

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

S. Leguédois, Y. Le Bissonnais, I. Cousin, O. Duval

INRA, Unité de Science du Sol, Avenue de la Pomme de Pin, BP 20619 Ardon, 45166 Olivet Cedex, France

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<br>g / 100 g | Fine silt<br>g / 100 g | Coarse silt<br>g / 100 g | Fine sand<br>g / 100 g | Coarse sand<br>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.*

✓ Aggregate stability tests

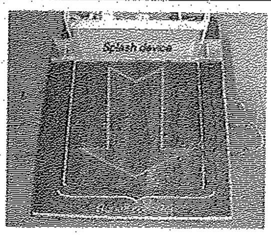
Aggregate stability was assessed by the procedure presented by Le Bissonnais (1996). This methodology combines three treatments having various wetting conditions and energies. Each treatment corresponds to a specific mechanism of aggregate breakdown.

| *Fast wetting treatment* | *Slow wetting treatment* | *Stirring treatment* |
|---|---|---|
| ⇩ | ⇩ | ⇩ |
| SLAKING | DIFFERENTIAL SWELLING | MECHANICAL BREAKDOWN by RAINDROP IMPACT |

### 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 size distribution determination

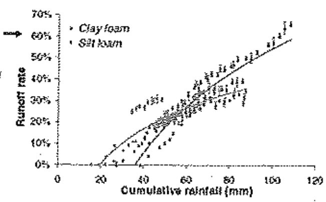
Samples:
• Soil fragments resulting from aggregate stability treatments
• Particles (aggregates and primary particles) splashed and transported by runoff

➡ • 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

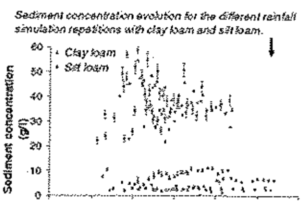
## II. First results

### Erosion characteristics

*Runoff rate evolution for the different rainfall simulation repetitions with clay loam and silt loam.*




*Sediment concentration evolution for the different rainfall simulation repetitions with clay loam and silt loam.*



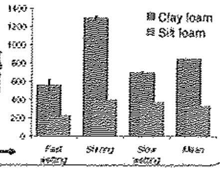

Silt loam is more sensitive to erosion: time to runoff is earlier and sediment concentration is higher than for clay loam. On the other hand the maximum runoff rate is higher for clay loam.

Meanwhile the low sediment concentration values for this soil lead to soil losses lower than silt loam. Soil losses are about 0,1 g/min for clay loam and 1 g/min for silt loam.

### 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.

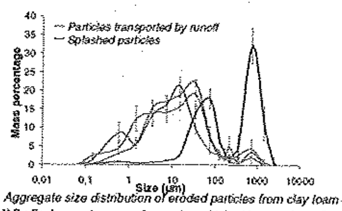



*Mean Weight Diameter (MWD) of the soil fragments resulting from the different aggregate stability measurement treatments.*

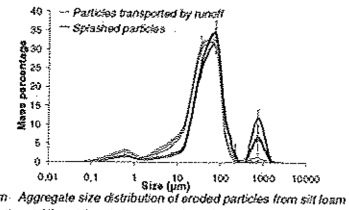
### Aggregate size distribution

✓ 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*

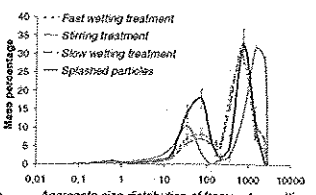



*Aggregate size distribution of eroded particles from silt loam*

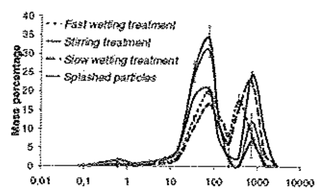
N.B.: Each curve is a mean from values obtained for samples collecting at different time during rainfall simulation repetitions.

✓ 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.*

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.*