Aggregate Stability
Methods comparison

Mirjam Pulleman, Safya Menasseri (SUSTAIN),
Jack Faber, Jaap Bloem (ECOSOM)

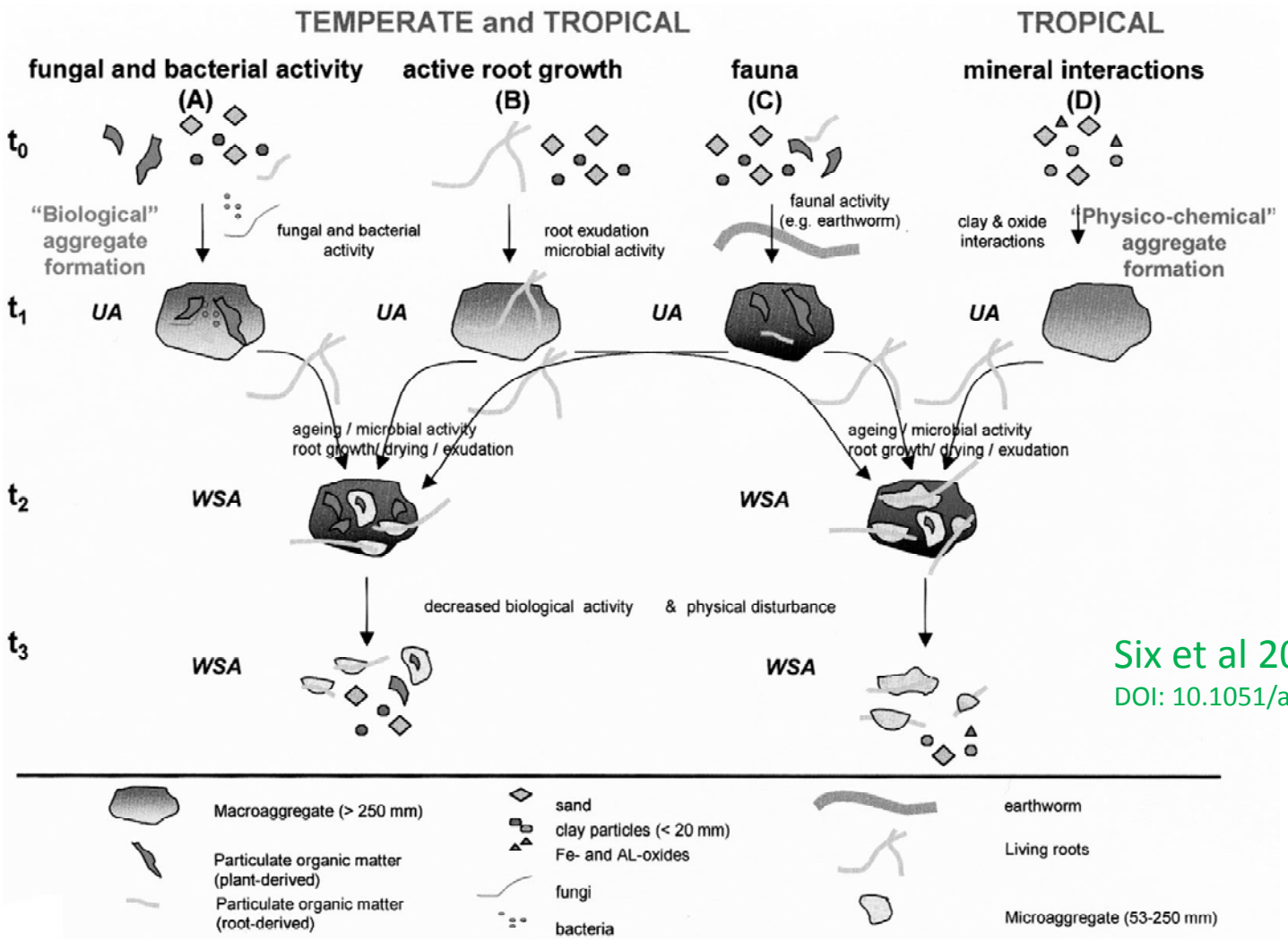
Aggregate stability

- Relevant for ecosystem functions and services
  - soil erosion control
  - seed germination, root development
  - water infiltration
  - physical protection of soil organic matter (GHG mitigation)

Aggregate stability

- Controlling factors
  - Soil mineralogy and soil texture
  - Soil organic matter content
  - Soil organisms
  - Physical processes (drying-wetting, frost)
  - Mechanical disturbance (e.g. soil tillage)

Aggregate stability



Six et al 2002

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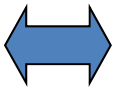
Which mechanism is revealed at which scale ?

- The mechanisms of <u>aggregation</u> and <u>stabilization</u> that are influenced by the studied <u>agricultural practice</u>
  - The porosity is reduced
  - The hydrophobicity at the surface of the aggregate is increased

  The rate of wetting is decreased
  - The cohesion between particles and micro-aggregates is increased



- Which factors vary among sites
  - Type of soil / soil community
  - Water content at sampling date
  - Cropping system
    - Crops in rotation
    - Conventional, integrated, organic system
  - Type of tillage
    - Standard tillage, Non-Inversion/Reduced tillage
  - Fertilization
    - Mineral, organic

Resistance to wet sieving, to slaking, to slow wetting, to fast wetting, to mechanical breakdown, …

Why a method comparison?

- Different research groups use different methods, depending on culture, research question, time availability => How can we draw common conclusions on the relations between soil management and soil structure ?
  - Which method performs best (sensitivity, time, process simulation)?
  - Ability to link the results obtained between the different methods ?
  - How do the results relate with ecosystem functions ?

Different Methods

Method	Origin	Objective	Dry sieving	Size fractions used for stability assessment	Pre-treatment	Sieve sizes	Stability measure
Le Bissonais (ISO)	FR	Multiple	Yes	3-5 mm		6; 2000-50 um	MWD
		- Microcracking			- Slow wetting		
		- Slaking			- Fast wetting		
		- Shaking after pre-wetting in ethanol			- Mechanical breakdown		
Six' (based on Elliot 1986)	USA	More adapted to the study of physical protection of SOM	No	Whole soil	- Fast wetting	2mm, 250 um, 53 um	% WSA, MWD
Eijkelkamp (machine)	NL	More adapted to erosion research	Yes	1-2 mm, 2-4 mm	- Fast wetting	250 um	Stable fraction (after dispersal in NaOH)

Méthode Le Bissonnais, 1996

Dried (40°C) aggregates 3-5 mm

Slow wetting test (microcracking)

Fast wetting (slaking)

Shaking after pre-wetting in ethanol (Mechanical breakdown)

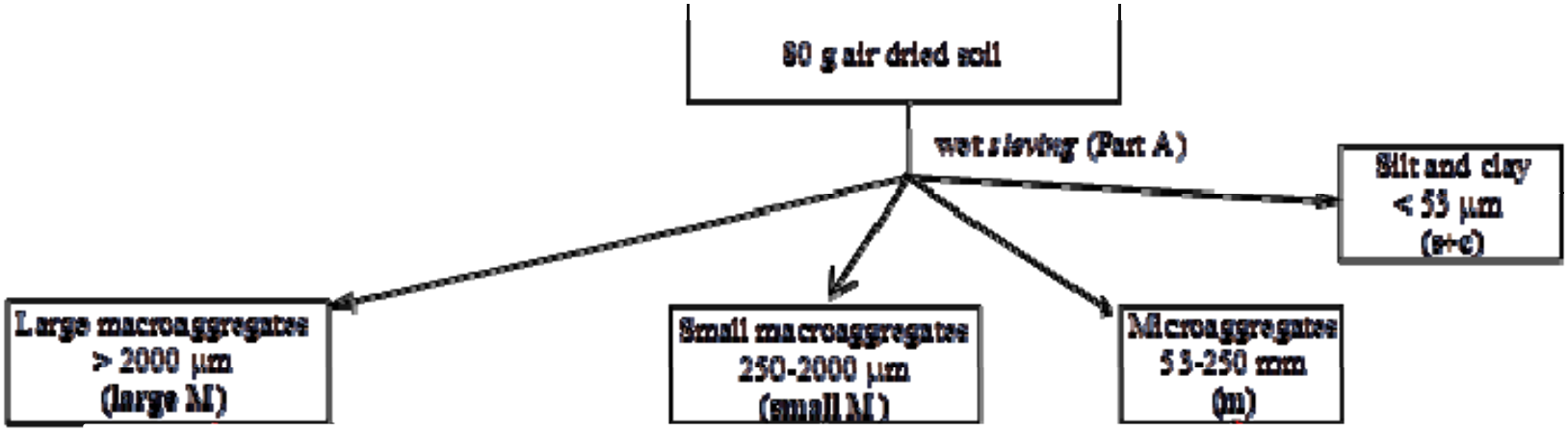
Hénin apparatus (helicoïdal movement)

2000µm

50 µm

Mean **W**eight **D**iameter (mm) =
Σ [(mean diameter between 2 sieves) x (% weight of particules retained on the sieve)] / 100

Six' Method


80 g air dried soil
wet sieving (Part A)
Silt and clay
< 53 µm
(s+c)
Large macroaggregates
> 2000 µm
(large M)
Small macroaggregates
250-2000 µm
(small M)
Microaggregates
53-250 mm
(m)

Eijkelkamp Method

Dry sieving:

- > 4 mm
- 4 - 2 mm
- 2 – 1 mm
- 1 - 0.5 mm
- < 0.5 mm

H_2O

NaOH

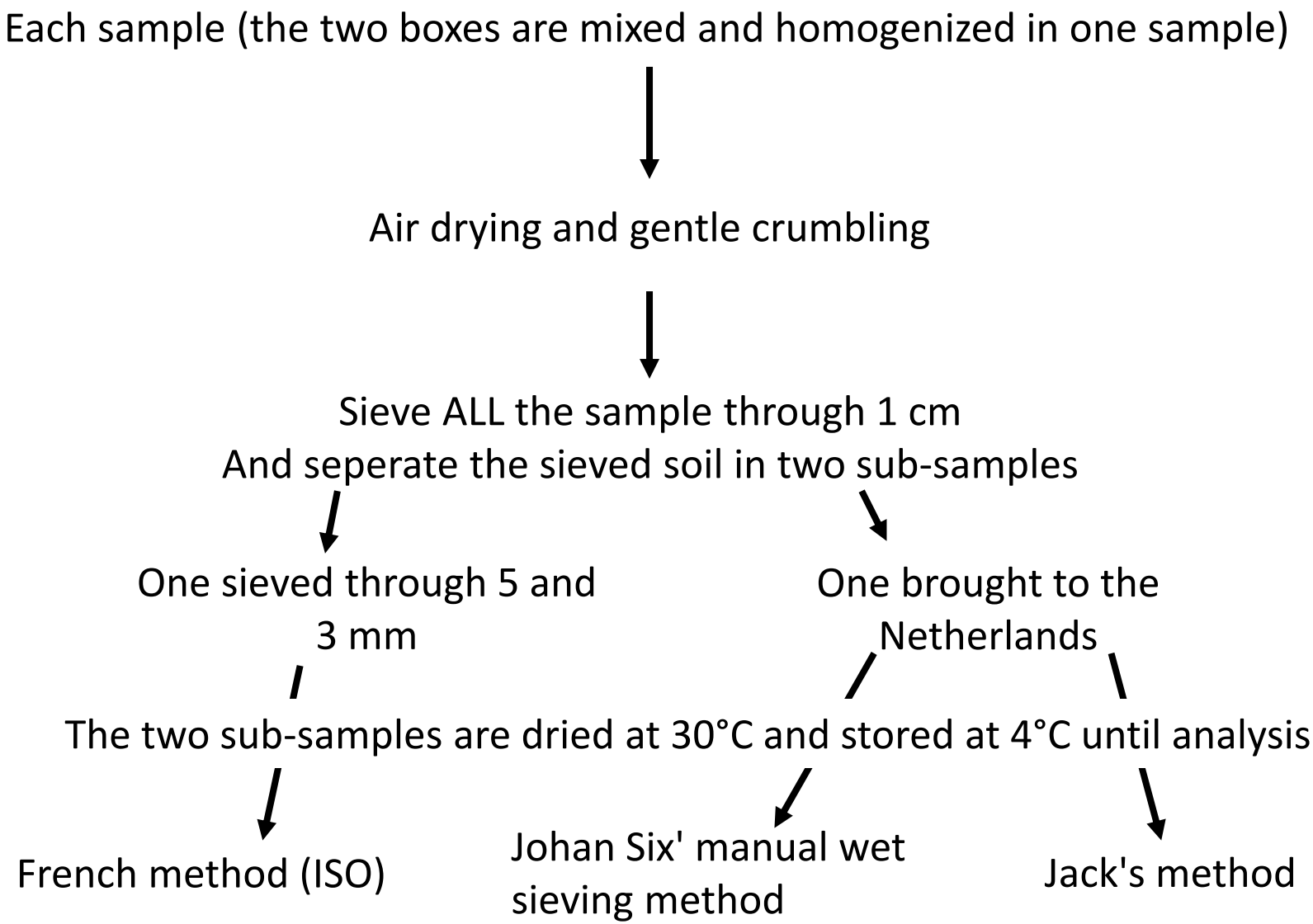
Calculation of MWD_dry

Calculation of Stable fraction

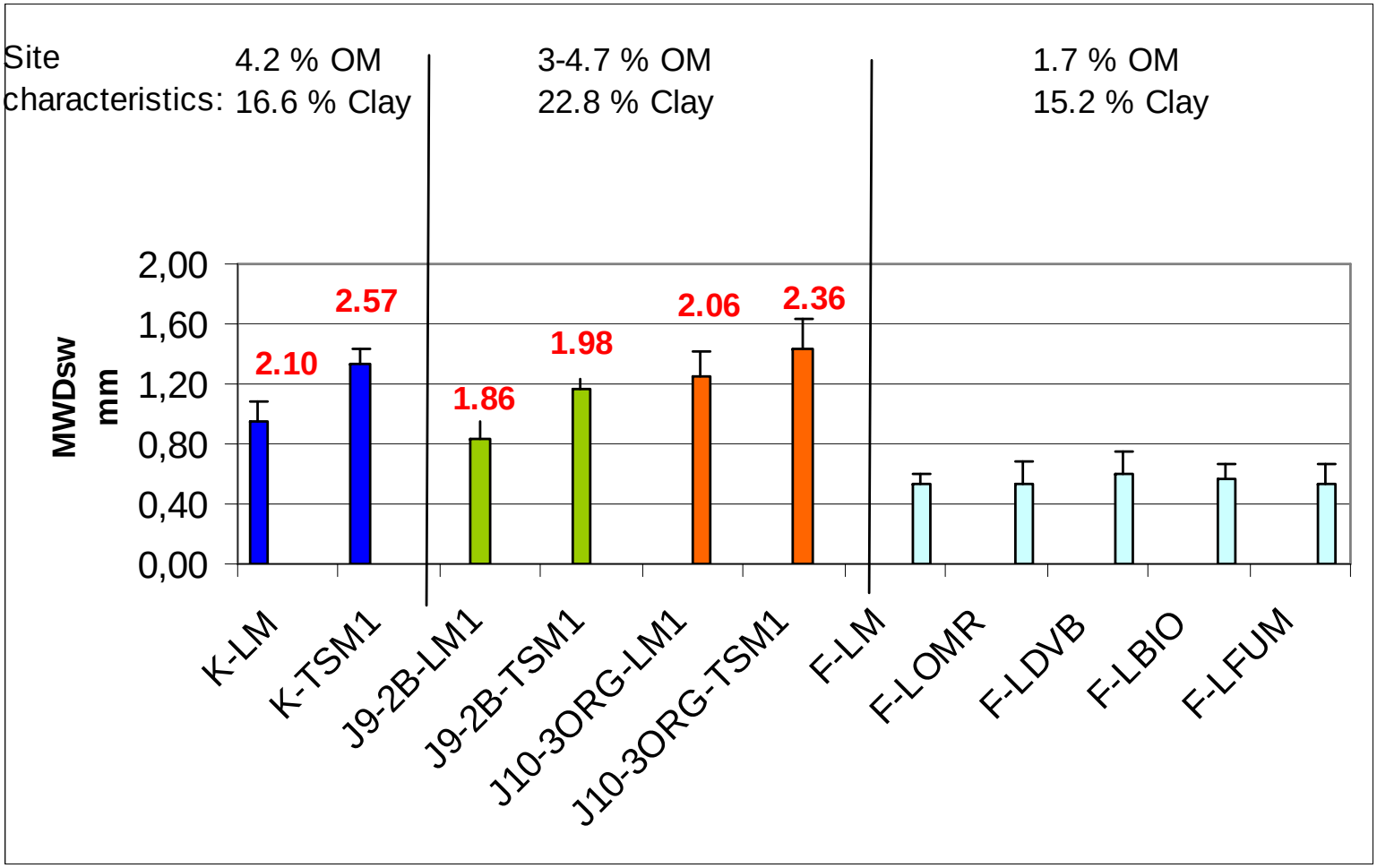
Soils Used

Field site:	FKA (Kerguennec)		Grignon	Lelystad Conv		Lelystad Organic	
Treatments:	Superficial	Labour	All 5 OM treatments	Mouldboard Plough	Non Inversion Tillage	Mouldboard Plough	Non Inversion Tillage
Depth (cm):	0-7 & 7-12	0-12	0-10	0-10 & 10-20	0-10 & 10-20	0-10 & 10-20	0-10 & 10-20
Method							
Le Bissonais (ISO)							
- Slow wetting	X	X	-	X	X	X	X
- Fast wetting	X	X	-	X	X	X	X
- Mechanical breakdown	X	X	-	X	X	X	X
Six' method	X	X	X	0-10	0-10	-	-
Eijkelkamp	-	_	X	?	?	X	X

Sample’s preparation



Results obtained with the Le Bissonais method (Slow wetting test)



Values in red represent SOC analyzed on the 3-5 mm aggregates samples

Results – Six' method

		MWD (mm)		MWD (mm) stone corrected	
Kerguennec	ST (0-7 cm)	1.14	n.a	0.60	n.a
	ST (7-12 cm)	0.94		0.56	
	Labour (0-12 cm)	0.79		0.45	
Grignon	T	0.40	ns		
	OMR	0.35			
	DVB	0.40			
	BIO	0.34			
	FUM	0.40			
Lelystad	Non Inversion Tillage	0.40	*		
Conventional	Mouldboard Plough	0.30			

Conclusions

- Too preliminary....

How to proceed?

DATA ANALYSIS

- Analyse all data sets, calculate different metrics (MWD, stable fraction, %WSA, DI)
- Is the rank between sites and treatments the same for all the different methods ?
- How do the methods compare in terms of sensitivity (treatment differentiation)?
- can we propose a "mathematical relation" between the results obtained with the different methods?

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Comparison of different aggregate stability approaches for loamy sand soils

Selen Deviren Saygın[a,*], Wim M. Cornelis[b,c], Gunay Erpul[a,d], Donald Gabriels[b,c]

[a] Department of Soil Science and Plant Nutrition, Faculty of Agriculture, University of Ankara, 06110 Diskapi, Ankara, Turkey
[b] Department of Soil Management, Ghent University, Coupure Links 653, B 9000 Ghent, Belgium
[c] UNESCO Chair on Eremology, Ghent University, Coupure Links 653, B 9000 Ghent, Belgium
[d] Earth Sciences Application and Research Center of Ankara University, Ankara, Turkey

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ABSTRACT

The bio-dynamic relations of soil aggregate stability, as a widely accepted soil quality indicator, with the physical, chemical and biological soil properties are very complicated in the soil system, and there exist many methods of measuring the soil aggregate stability to establish these relations. This study aimed to evaluate different aggregate stability methodologies for loamy sand soils. The applied aggregate stability methods of the research chiefly involved sieving soil samples through either multiple sieves or a single sieve using operations of wet sieving, dry sieving, pre-wetting, slow wetting, fast wetting and mechanical breakdown. These were used either alone or in combination, and the methods were compared in terms of a detachability index (DI), which is the ratio of the Mean Weight Diameter after wet sieving (MWD_W) to that before wet sieving (MWD_D). The statistical analysis showed that the mean values of the DI for wet sieving by multiple sieves, fast wetting and mechanical breakdown varied significantly ($^*P < 0.05$) from other methods. Clearly, depending upon the magnitude and extent of aggregate destructive forces, the DI changed significantly, and simulating diverse physical processes which could operate sequentially or simultaneously resulted in different consequences in terms of the aggregate stability.

detachability index (DI) calculated using the Mean Weight Diameter (MWD, mm) was introduced to make more consequential comparisons among the methods. DI is the ratio of MWD after wet sieving (MWD_W) to MWD before wet sieving (MWD_D) (Eq. (4)).

$$DI = \frac{MWD_W}{MWD_D} \quad (4)$$

Table 3
The Pearson correlation values between DI values calculated from the applied methods.

Methods	DI values				
	M_I Pearson correlations	M_{II}	M_{III}	M_{IV}	M_V
M_{II}	0.243 NS				
M_{III}	0.026 NS	0.664***			
M_{IV}	0.144 NS	−0.262 NS	−0.134 NS		
M_V	−0.008NS	−0.625***	−0.512**	0.537***	
M_{VI}	0.220 NS	−0.228 NS	−0.112 NS	0.424**	0.360*

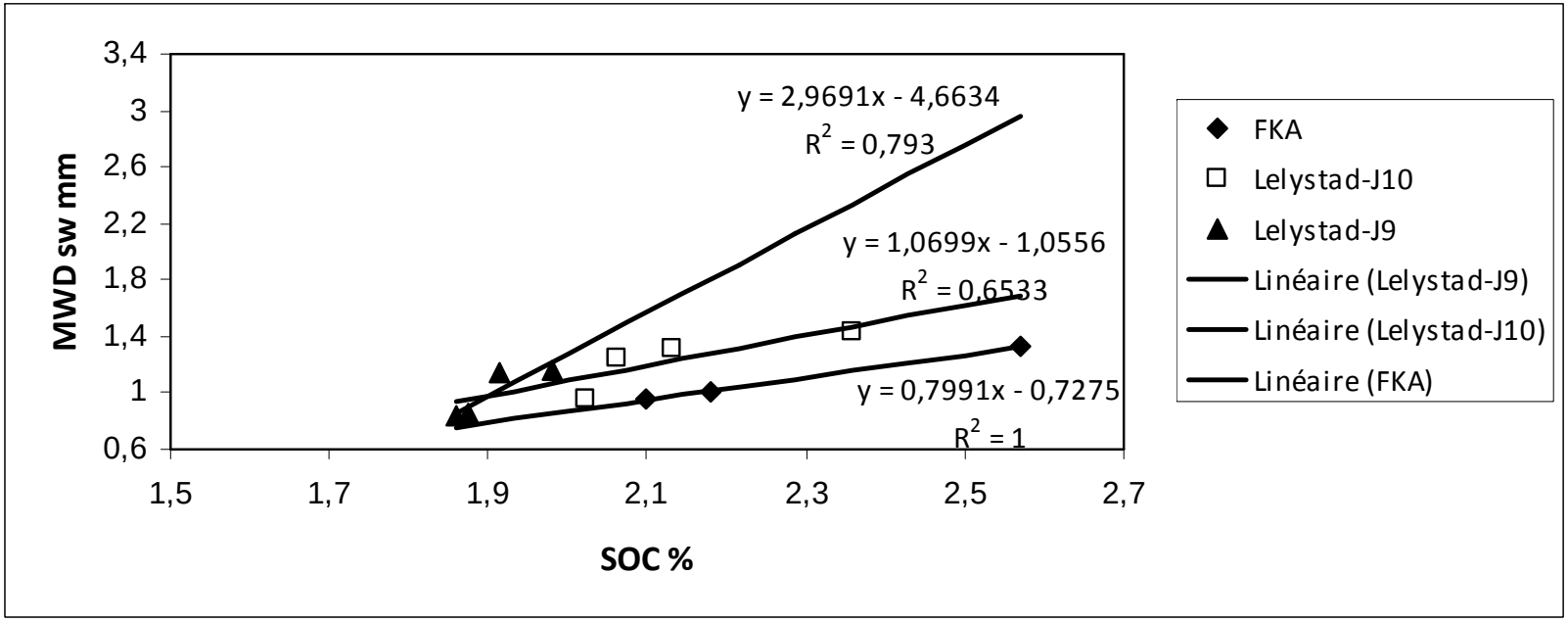
Saygin et al 2012

- Methods that take the size distributions of soil aggregates by dry sieving into consideration could work much better, compared to the methods that used pre-selected aggregate size
- The physical basis for the different methods is different

How to proceed?

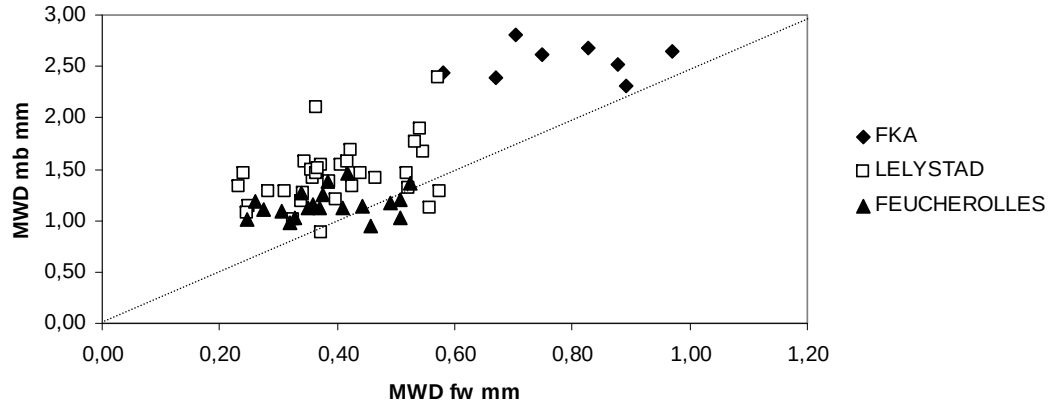
- Since this physical basis is different: how can we link the methods?
- Explain the physical basis; there is value in this!
- Ability of the scientist to build a typology of situations (internal factors and external factors) on a basis of « which method is more convenient depending on the situation »
- Which relationship exist between the aggregate stability and some factors that can explain it (e.g. SOC, texture, management, carbon input)
- Test relationships with ecosystem functions such hydraulic conductivity.

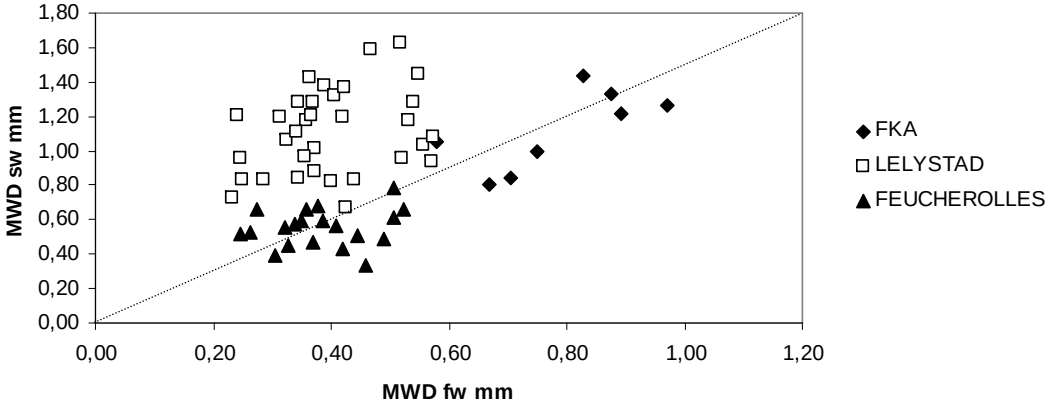
Relationship between MWD and SOC %

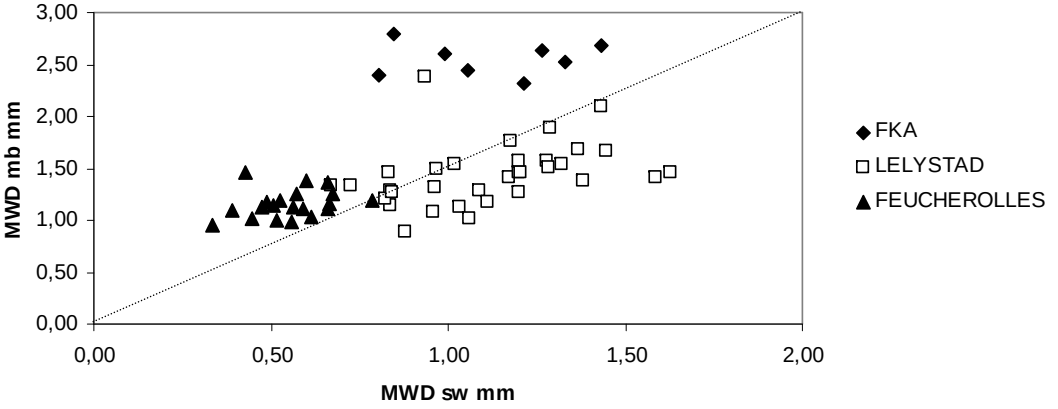


The slope has the highest value for the site with the lowest SOC : the response of MWD due to the increase of SOC induced by the change of tillage depends on the original SOC that characterizes each site.

Comparison between the different tests of the Le Bissonnais's method







Sw-Slow wetting
Fw-Fast wetting
Mb-Mechanical breakdown