SOIL AGGREGATE DISTRIBUTION BY DRY SIEVING

A Practical Guide for Comparing Crop Management Practices

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International Maize and Wheat Improvement Center

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The International Maize and Wheat Improvement Center, known by its Spanish acronym, CIMMYT® (www.cimmyt.org), is a not-for-profit research and training organization with partners in over 100 countries. The center works to sustainably increase the productivity of maize and wheat systems and thus ensure global food security and reduce poverty. The center's outputs and services include improved maize and wheat varieties and cropping systems, the conservation of maize and wheat genetic resources, and capacity building. CIMMYT belongs to and is funded by the Consultative Group on International Agricultural Research (CGIAR) (www.cgiar.org) and also receives support from national governments, foundations, development banks, and other public and private agencies. CIMMYT is particularly grateful for the generous, unrestricted funding that has kept the center strong and effective over many years.

Soil aggregate distribution by dry sieving

1. Introduction

From a physical perspective, the soil matrix is generally conceptualized as being constituted by soil aggregates (filled spaces) or secondary soil units, and pores (empty spaces) (Soil Science Society of America, 1997; Lal and Shukla, 2004). Dry sieving provides an indirect measure of field aggregate size distribution that can be expressed as mean weight diameter (MWD_{ds}) (van Bavel, 1949), or as a percentage of aggregates. Aggregates can be divided into large macro-aggregates (>2 mm), small macro-aggregates (250 µm – 2 mm), micro-aggregates (53–250 µm) and free silt + clay (<53 µm) (Six et al., 2004).

Factors that differ between studies and lead to variation in results include the sieve load, duration of the sieving treatment (particularly on fragment sizes larger than 16 mm and smaller than 4.75 mm), as well as the number and size of sieves (Díaz-Zorita et al., 2007). To allow comparison, these factors must be kept constant between samples. However, the disintegrating forces that occur during sample taking, preparation, and analysis do not duplicate the field phenomena. Consequently, the relationship between aggregate-size distribution obtained in the laboratory and that existing in the field is somewhat empirical (Kemper and Rosenau, 1986).

Various authors have reported that dry sieving provides a measure of soil erosion. Chepil (1953) stated that resistance to wind erosion is positively related to the percentage of dry soil structural units greater than 0.84 mm. However, the percentage of these aggregates would vary as a result of disturbance intensity (i.e., strength and duration) during dry sieving. The application of stress to soil fractures the soil matrix in zones where the bonds between particles are weaker than the force of the applied stress. Consequently, the size of fragments will depend upon the applied stress (Díaz-Zorita et al., 2002). Given the variability of methodologies applied and the complexities of processes related to wind erosion, the relationship between dry sieving and soil erosion is unclear.

2. Materials and Equipment

- Shovel
- Large rectangular sampling boxes or paper bags
- Marker, and labels if boxes are used
- 8 mm sieve for sample preparation
- Sieves with openings of 4.00, 2.00, 1.00, 0.50, 0.25 and 0.053 mm, lid and container
- Brush
- Metal trays of known weight
- Precision balance
- Stopwatch
- Machine to shake samples
- Datasheet and pencil

3. Procedure

3.1 Field sampling

Field sampling for soil structure studies must be undertaken carefully to avoid structure disruptions which will distort results. When making comparisons between different management practices, all samples should be collected on the same day (i.e., observed variability in soil structure of soils which have similar water content may be a result of different management practices). Samples should be obtained using a shovel to avoid compression and disturbance of the sample (which occurs when using an auger) and ensure minimum wall surface area to volume ratio to decrease the risk of compaction. Only the part of the sample not touch by the shovel may be used. Avoid any activities, such as hammering the shovel, which can result in sample disruption. Then samples are placed in rigid large sampling boxes or paper bags that have been appropriately labeled. Avoid layering the samples as this would cause compression of soil. Prior to analysis, samples should be stored in a controlled environment (i.e., constant temperature and humidity).

3.2 Sample preparation

After field sampling, air-dry samples at room temperature for a few hours and then gently break large clods (>5 cm) along natural planes of weakness into natural aggregates. The samples are then air-dried for 2 weeks before being passed through an 8 mm sieve to remove coarse plant residues, roots and any stones >8 mm. Take a sub-sample of 200-300 g for further analysis. Thoroughly mix the sample before taking the sub-sample to ensure you obtain a representative sub-sample.

3.3 Measurement

Place sieves in a stack (i.e., 4.00, 2.00, 1.00, 0.50, 0.25 and 0.053 mm) with the largest mesh size on top and a closed recipient at the bottom. Pour the sample onto the top sieve. The stack is then placed within the machine with the top sieve covered by a lid (Figure 1). Secure the stack of sieves tightly in the machine and shake them at a speed of 210 cycles min^{-1} for 5 minutes (Figure 2). Afterwards, empty the sieves onto their corresponding metal trays. Ensure you have weighed and marked these trays in advance. It is advisable to write the corresponding mesh size on each tray. Clean the sieves with a brush to ensure that all soil is collected on the trays and no soil remains on the sieves. Next, weigh the trays with soil and record the weight. After sieving, the samples can be stored for use in other experiments or as a back-up in case there are errors in the data.

4. Calculations

$$MWD_{ds} = \sum_{i=1}^{n} \langle d \rangle_i \, w_i$$

Where:

MWD_{ds} = mean weight diameter (mm) of dry sieved soil

d = mean diameter of each size fraction size *i* (mm) (e.g., soil found in 2.00 mm sieve has 4.00 mm as maximum diameter and 2.00 mm as minimum diameter. Thus, mean diameter for such sieve is 3.00 mm). For the selected group of sieves, mean size fractions are: 6.00 mm, 3.00 mm, 1.50 mm, 0.75 mm, 0.375 mm, 0.1515 mm, and 0.0265 mm.

w = proportion of total sample weight occurring in the size fraction *i*

n = number of size fractions

Figure 1. Machine used to shake dry soil samples.

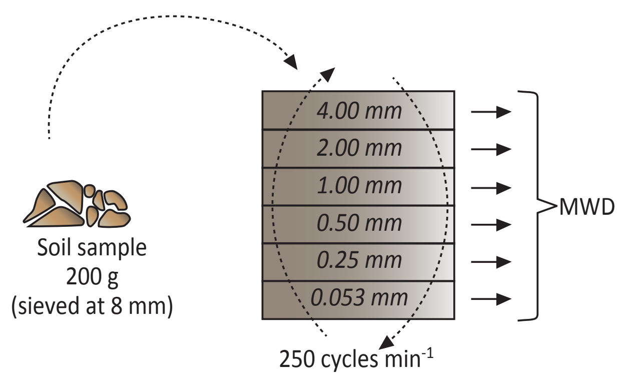

Figure 2. A 200 g soil sample (left) is introduced at the top of the stack (right) of sieves and shaken for 5 min. Soil left in each sieve is weighed and mean weight diameter (MWD) is then calculated.

5. Worked Example

Dry sieving a sample yielded the following results:

Sample No.	Diameter Sieve (mm)	Weight Plate (g)	Weight Plate + Soil (g)
17	4.00	15.70	19.10
17	2.00	15.71	36.97
17	1.00	15.90	50.63
17	0.50	15.81	51.50
17	0.25	15.78	47.09
17	0.053	15.76	54.02
17	0	16.02	41.39

Firstly, the weight of the fractions was calculated by subtracting the weight of the plate from the total weight of the plate + soil. Then the total weight of the soil in the sample (sum of all fractions: 190.02 g) and the proportion of each weight fraction (weight of soil in fraction/total sample weight) was calculated. Finally, The MWD was calculated according to the formula:

$$MWD_{ds} = \sum_{i=1}^{n} \langle d \rangle_i \, w_i$$

=(6×0.02)+(3×0.11)+(1.5×0.18)+(0.75×0.19)+(0.375×0.16)
+(0.1515×0.2)+(0.0265×0.13)=0.95 mm

All data and calculations are summarized in the following table:

Sample	Diameter Sieve (mm)	No. Plate	Weight Plate (g)	Weight plate + soil (g)	Weight Soil (g)	Average sieve diameter (mm)	Soil (%)	MWD
17	4.00	153	15.70	19.10	3.40	6	0.02	.
17	2.00	152	15.71	36.97	21.26	3	0.11	.
17	1.00	155	15.90	50.63	34.73	1.5	0.18	.
17	0.50	154	15.81	51.50	35.69	0.75	0.19	.
17	0.25	156	15.78	47.09	31.31	0.375	0.16	.
17	0.053	157	15.76	54.02	38.26	0.1515	0.20	.
17	0	158	16.02	41.39	25.37	0.0265	0.13	0.95

6. References

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Data Sheet – Dry Sieving

Sampling date: ……../……..../……….. Page: ……../……...

Measurement date: ……../……..../……….. Experiment: ______________________________

Sample	Sieve (mm)	Plate No.	Weight plate (g)	Weight plate + soil (g)
	4			
	2			
	1			
	0.250			
	0.053			
	0			
	4			
	2			
	1			
	0.250			
	0.053			
	0			
	4			
	2			
	1			
	0.5			
	0.250			
	0.053			
	0			
	4			
	2			
	1			
	0.250			
	0.053			
	0