Influence of tillage on soil surface roughness structure and surface porosity

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1.Soil Surface Roughness (SSR)

Soil erosion is a complex phenomenon involving the detachment and transport of soil particles, storage and runoff of rainwater, and infiltration. The relative magnitude and importance of these processes depends on several factors being one of them surface micro-topography, usually quantified trough soil surface roughness (SSR). Surface soil porosity and SSR can be altered by tillage operation. Even though the surface porosity is an important parameter of a tilled field, however, no practical technique for rapid and non-contact measurement of surface porosity has been developed yet.

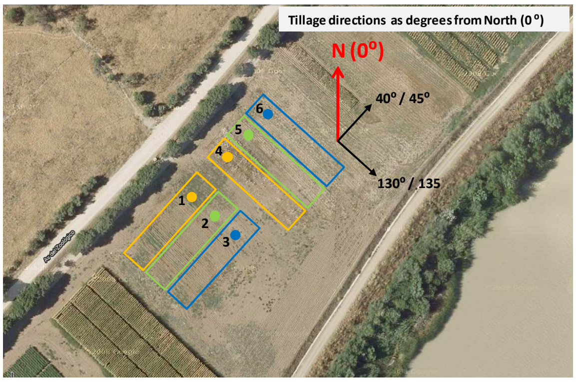


Figure 1. Field experiment during 25th May 2011 oriented in orthogonal directions: Moldboard (DEM1 & DEM4), Chisel (DEM2 & DEM5) and Roller (DEM3 & DEM6).

3. Structure Function (SF)

The elevation data were evaluated with the structure function which focuses on the absolute values of the differences that occur in the data over arbitrarily large or small scales, Eq. 1

$$S(q,s)=\left\langle \left|(z_i(x,y)+\Delta s)-z_i(x,y)\right|^q \right\rangle \qquad (1)$$

being

$$\left|(z_i(x,y)+\Delta s)-z_i(x,y)\right| \approx \left| z_i(x,y)-\begin{pmatrix} z_i(x+s,y)+z_i(x,y+s)+ \\ z_i(x-s,y)+z_i(x,y-s) \end{pmatrix} \Big/ 4 \right| \qquad (2)$$

If the process z(x,y) is scale-invariant and self-similar or self-affine over some range of space lags (s), then the qth-order structure function is expected to be:

$$S(q,s) \approx s^{\zeta(q)} \qquad (3)$$

where is the scaling exponent and a monotonically non-decreasing function of q. The behavior described by Equations 1 and 2 is called "multiscaling" because each statistical moment is scaling with a different exponent. Therefore, a hierarchy of exponents can be defined using SF to obtain the generalized Hurst exponent H(q):

$$H(q)=\frac{\zeta(q)}{q} \qquad (4)$$

2.Data Adquisition

Different surface roughness were obtained on a loamy alluvial soil, applying three tillage treatments : a moldboard plough, a chisel and a roller (Figure 1).

Within each of the 6 plots an area 900x900 mm was scanned using a laser scanner of 0.1 mm resolution with a grid of 7.2 x 7.2 mm. From them the digital elevation model (DEM) of each of the surfaces was obtained (Figure 2A). At the same time, three soil samples at 5 cm depth of each tillage treatment were extracted and a 3D image obtained using CT-Scan (Figure 2B).

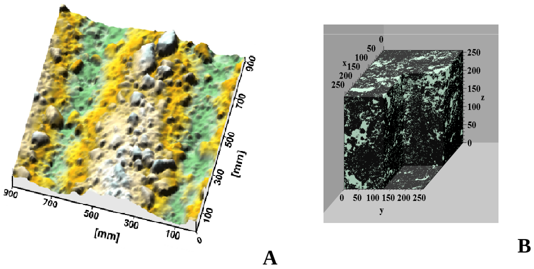
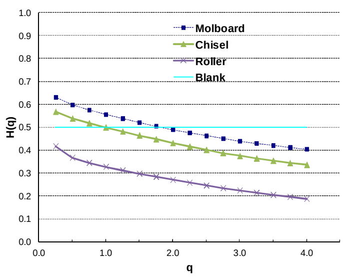


Figure 2. Example of digitalized images (DEM) at field experiments (A) and a 3D image of soil sample at 5 cm depth (B).

4. Results

Figure 3.- Generalized Hurst exponent (H(q)) for each tillage tool. The Blank represents the uncorrelated elevation variations. Hurst index (HI) is H(q=2) and conservative index (*H*) is H(q=1).



Tool	*H*	HI	Elevations			ϕ (%)
			Average	SD	VAR	
Molboard	0.55	0.49	76.0	28.2	794.9	29.0
Chisel	0.50	0.43	59.9	22.7	520.4	15.0
Roller	0.33	0.27	48.3	14.6	218.2	8.5
Blank	0.50	0.50	10.0	8.0	64.0	5.0

Table 1. Structure parameters, descriptive statistics and soil porosity (ϕ) with different tillage tools: conservative index (H), Hurst index (HI). The SD of Elevations is used as SSR index.

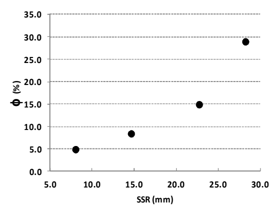


Figure 4.- Soil porosity at 5 cm depth (ϕ) vs soil surface roughness (SSR = SD Elevations).

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References

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