CRACKING

A Practical Guide for Comparing Crop Management Practices

CIMMYT

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International Maize and Wheat Improvement Center

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Cracking

1. Introduction

Soil cracking can occur when wet or moist soil dries and is common in soils with a high swell-shrink clay content. Evaporation of soil pore water leads to a build-up of negative pressure which results in a reduction of soil volume. As this pressure is exerted in all directions, the shrinking also occurs in all directions and cracking occurs (Kleppe and Olston, 1985). Cracks are a unique feature in soils with strong shrink-swell potential and are used as one of the criteria in defining Vertisols. Soil cracks not only provide an opportunity for water recharge during rains in soils that are otherwise slowly permeable (Mitchell and Van Genuchten, 1992), but also extend the soil–air interface into the soil profile, potentially increasing water loss from the profile through evaporation (Ritchie and Adams, 1974). The amount of soil cracking influences water runoff and infiltration, with an increase in the frequency and size of cracks leading to a significantly higher infiltration rate (Stirk, 1954; Battany and Grismer, 2000). The amount of cracking in a soil is influenced by the initial bulk density, clay content, organic carbon content and cation exchange capacity of the soil. Cracking can allow a rapid flow of water, nutrients and pesticides into the subsoil, making them inaccessible for shallow plant roots and potentially leading to groundwater pollution (Arnold et al., 2005).

2. Materials and Equipment

- Cord (60 cm)
- Steel rod (2 mm diameter)
- Meter ruler
- Calipers
- Data sheets and pencil
- Two sticks/rods (1 m length)
- Metal wire to subdivide the measurement area
- Two people: one to measure and one to make maps and record data

3. Procedure

This method was adapted from Bandyopadhyay et al. (2003). In plots consisting of beds, the sampling area is defined by the width of the bed and a length of 1 m, whereas in plots planted on the flat, sampling width is a multiple of the row spacing, or an arbitrarily chosen distance when the crop is not planted in rows. In both cases, two measurements are taken per plot. As an example, when plots consist of 8 beds of 0.75 m in width and 13 m in length one measurement is taken in furrow 3 and bed 4 and another one in furrow 5 and bed 6. Each sampling area is 0.75 × 1 m. The area is chosen so that the border is a crop row (Figure 1). To facilitate measurements, the sampling area is divided into 6 subareas. Firstly, it is divided between the furrow portion of the plot (from crop row to crop row) and the bed portion of the plot (between the two crop rows). Secondly, these two sections are further divided into 3 equal parts of 0.333 m. Obviously, when there is only one crop row on the bed (for instance maize), there is no need to distinguish between furrow and bed.

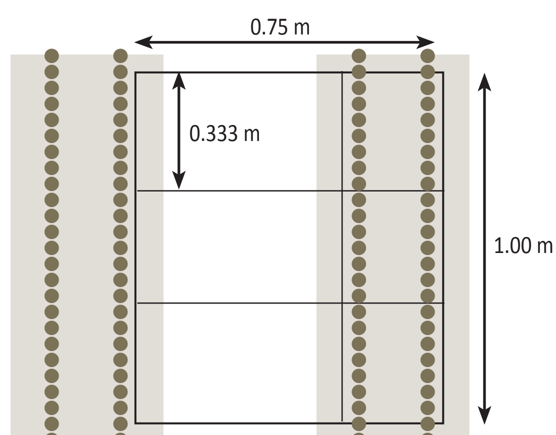

Figure 1. Measurement area in a plot with beds of 0.75 m.

The measurement area in the furrow is defined using the two sticks/rods of 1 m. The metal wire is shaped into a square of the required dimensions and used to mark the first area (Figure 2). The residue is removed (if there is any present). A map is made of all the cracks deeper than 2 cm and wider than 2 mm (see Figures 2 and 3). The apparent length on the soil surface, the depth and the width of each mapped crack are recorded:

- First the apparent length on the soil surface of each crack is measured with a cord laid along the crack (Figure 4). At the same time, a letter is assigned to each crack on the map (Figure 3).
- Then the depth of the crack is measured every 10 cm along the course of the crack (so one measurement for a crack length of 10 cm, 2 for 20 cm, etc.) using the steel rod by inserting it until it offers resistance to further penetration. Put your thumb and index finger on the rod level with the soil surface. Take out the rod and use the ruler to determine the depth of the crack.

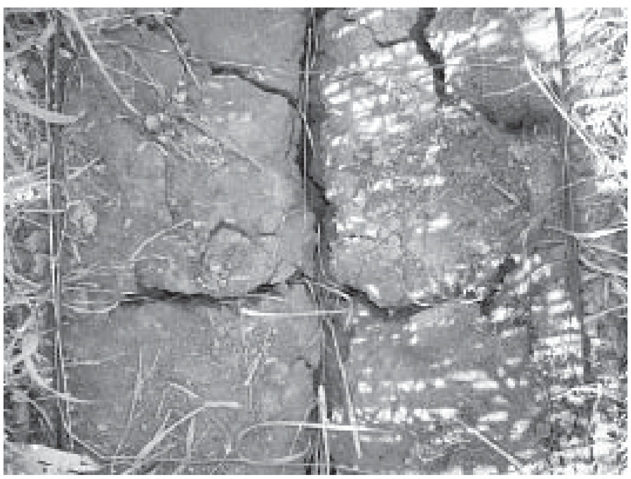

Figure 2. Example of a sampling area marked by a metal square.

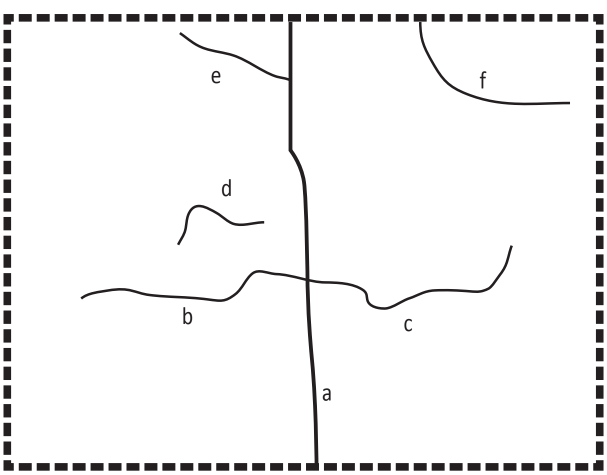

Figure 3. The map corresponding to Figure 2.

- The width of the crack is measured at the same points at a depth of 1 cm below the surface using calipers (Figure 5). One centimeter of depth for this measurement has been chosen to avoid exaggerated widths caused by surface disturbance.

The procedure is repeated for each of the measurement areas and all data are recorded in the included format.

Figure 4. Measurement of crack length.

Figure 5. Measurement of crack width.

4. Calculations

The volume (V, cm³) and surface area (SA, cm²) of each crack is computed using the following equations, assuming a triangular shape of the cracks (Sharma et al. 1995):

$$V = \sum 0.5wdl$$

$$C = \sum [\, (0.5w)^2 + d^2]^{½}$$

$$SA = \sum 2Cl$$

Where:

w = width of the crack (cm),

d = depth of the crack (cm),

l = length of the (part of the) crack (cm),

C = parameter based on w and d (cm)

Firstly, the length of a crack is divided by the number of depth (and width) measurements that were taken for that crack. V, C and SA are calculated for each part of the crack and then all separate V and SA values are added to calculate V and SA for the whole crack. Ultimately, the total volume and surface area of all cracks in the measured area (e.g., 0.75 × 1.00 m) is calculated.

5. Worked Example

An example is given for the same measurement area as depicted in Figure 2. The data recorded in the field can be found in Table 1.

For crack 'a':

There are three parts with a length of 32/3 = 10.7 cm

C is calculated for each part:

$$C_{a1} = [\, (0.5 \text{ x } 1.9)^2 + 6^2]^{½} = 19.2 \text{ cm.}$$

$$C_{a2} = [\, (0.5 \text{ x } 2.4)^2 + 6^2]^{½} = 6.1 \text{ cm.}$$

$$C_{a3} = [\, (0.5 \text{ x } 1.4)^2 + 14^2]^{½} = 14.0 \text{ cm.}$$

The total surface of crack 'a' is calculated:

$$SA = \sum 2Cl = (2 \times 19.2 \times 10.7) + (2\times 6.1 \times 10.7) + (2\times 14.0 \times 10.7)$$
$$= 129.6 + 130.5 + 299.0 = 559.2 \text{ cm}^2$$

The total volume of crack 'a' is:

$$SA = \sum 0.5\,wCl = (0.5\times 6\times 10.7) + (0.5\times 2.4\times 6\times 10.7) + (0.5\times 1.4\times 14\times 10.7)$$
$$= 60.8 + 76.8 + 104.5 = 242.1 \text{ cm}^3$$

Using the same approach, the surface and volume of each crack is calculated. The surface and volume of all the cracks are added to calculate the total crack surface and volume in the measurement area: SA = 1457.4 cm² and V = 534.1 cm³

Table 1. Field data recorded in the measurement area in Figure 2.

Crack	a	b	c	d	e	f
Length (cm)	32	19	19	9	7	11
Depth (cm)	6	9.5	6.5	2	7	6
	6	2	15			
	14					
Width (cm)	1.9	1.5	1.4	0.4	0.9	1.5
	2.4	1.4	1.3			
	1.4					

6. References

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	a	b	c	d	e	f	g	h	i	j	k	l	m	n		
L III															III	
D III																
W III																
L II															II	
D II																
W II																
L I															I	
D I																
W I																

Cracking was measured in three consecutive areas (I, II, III), each with a length of 33.3 cm and a width of ………………
The letters indicate the measured crack. L = length (cm), D = depth (cm), W = width (cm); D and W are measured approximately every 10 cm along the length of the crack.

Cracking Experiment: plot: [ ] bed # / [ ] furrow between beds # Date: