# SOIL WATER CONTENT

## A Practical Guide for Comparing Crop Management Practices

CIMMYT

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CIMMYT[MR]
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 Water Content

## 1. Introduction

The water content of a soil is a complementary and necessary indicator in many soil analyses. Soil water content has traditionally been expressed as the ratio of the mass of water present in a sample to the mass of the sample after it has been dried to constant weight, or as the volume of water present in the total volume of the sample. Computations of water content on a volume basis require a correct measure of bulk density (Gardner, 1986). Given spatial and temporal variability of water levels within soil, taking a high number of replicated measures is highly recommended. Bulk density is less variable over time than water content, so it is sufficient that bulk density is measured only once before beginning the measurements. Ensure that you take into account the fact that agronomic treatments can cause a change in soil bulk density and bulk density tends to be spatially variable. Ideally, bulk density should be determined for each experimental plot with several measurement repetitions per plot. There are several methods to determine soil water content. We will focus here on the most basic method for which no special equipment is required. This is the gravimetric determination of soil water content through obtaining soil samples.

## 2. Materials and Equipment

- Probe
- Motor oil (new oil) if the soil is sticky
- Oven
- Weighing scales
- Metal cans
- Piece of cloth
- Stick/rod
- Datasheet and pencil

## 3. Procedure

### 3.1 Field sampling

The field sampling is conducted using a soil probe, which can be either a simple one-piece soil probe or one composed of a tapered tube and sliding hammer. The choice of probe depends on soil conditions, especially humidity, and the sampling depth. In a hard, dry soil a probe with a sliding hammer will be necessary. The use of both types of probes will be explained here. Sampling depths will depend on the research objectives, the soil being studied and other practical constraints. In the examples outlined here, samples are taken to a depth of 60 cm in 15 cm increments but suitable sampling depth and increments have to be determined for each study. In preparation, it is useful to record on a map of the experiment which soil sample is to be placed into each of the numbered metal cans and to arrange the cans in the order you will be taking the soil samples.

### 3.2 Use of a probe with sliding hammer

The tip of the probe is greased in motor oil and pushed a short way into the soil. The hammer is inserted into the probe and used to hammer the tube into the ground. Once the tip of the tube is at the required sampling depth, the hammer is removed and then used as a handle by locking the protrusions at the beginning of the tube into the corresponding notches in the hammer. The tube is then turned once in a clockwise direction to loosen the probe, do not turn in the other direction or the soil sample will fall out. Thereafter, the probe is pulled from the soil. The tube is turned upside down and the soil sample removed. If the sample does not slide out you can use a stick to push it through. Put each sample in a marked metal can and carefully close the can to avoid water evaporating from the sample (Figure 1). When many samples need to be obtained from one location, you can consider sampling more than one sampling depth at one time. In this instance empty the tube onto a piece of cloth, lay the tube next to the soil core and use it as a ruler to divide the sample into the required sampling depths (Figure 2).


**Figure 1. The four steps in sample collection: a) greasing the tip, b) hammering in the probe, c) pulling out the probe, and d) placing the sample in a metal can.**

**Figure 2. To improve efficiency more than one sampling depth can be sampled at once. This involves spreading the sample onto a piece of cloth or plastic and using the probe as a ruler to divide the sample into the correct fractions.**

## 3.3 Use of a regular soil probe

Regular probes can be used for smaller sampling depths when the soil is not hard. These probes are easier to use and cheaper, but are damaged more easily in hard soils. To use this type of probe, first grease the tip with motor oil as this will avoid mud sticking to the probe. Then push the probe into the soil to the required sampling depth, turn the probe once clockwise and pull it out. Take out the soil cylinder and place it in a marked metal can, record which sample is in each can (Figures 3 and 4). Repeat the same procedure for the following samples and always re-grease the tip.

**Figure 3. Equipment: soil probe, the soil sample and a can of oil.**

**Figure 4. The use of a soil probe in the field.**

## 3.4 Measurement

For each of the soil samples obtained from either the regular or sliding hammer soil probes, weigh the wet soil sample in its can (thus the weight of the cans must be known prior to adding the soil samples) and record the data. Open the can and oven-dry for 24 h at 105°C. Once dried, weigh the sample in its can to obtain the dry weight and record this data.

## 4. Calculations

Soil bulk density (sampling not described in this protocol) is calculated as follows:

$$SBD = \frac{S_{dry}}{Vol}$$

Where:

SBD = soil bulk density (g/cm$^3$)

$S_{dry}$ = oven-dried soil sample (g)

Vol = volume of the metal ring (cm$^3$)

Gravimetric water content (GM) is calculated as follows:

$$GM = \frac{(S_{wet} - S_{dry})}{S_{dry}} \text{ x } 100$$

Where:

GM = gravimetric water content (%)

$S_{wet}$ = wet soil sample (not including can weight) (g)

$S_{dry}$ = oven-dried soil sample (not including can weight) (g)

Volumetric water content (VM) is calculated as follows:

$$VM = \frac{(S_{wet} - S_{dry})}{S_{dry}} \text{ x SBD}$$

Where:

VM = volumetric water content (g cm$^{-3}$)

$S_{wet}$ = wet soil sample weight (not including can weight) (g)

$S_{dry}$ = oven-dried soil sample weight (not including can weight) (g)

SBD = soil bulk density (g cm$^{-3}$)

## 5. Worked Example

A soil sample was collected in a metal can weighing 30.00 g. The weight of the wet sample and the can was 180.45 g and a dry weight with the can was 147.62 g. A bulk density of 1.20 g cm$^{-3}$ was determined in a previous measurement.

The gravimetric water content of the sample is:

$$GM=\frac{(S_{wet} - S_{dry})}{S_{dry}} \text{ x } 100 = \frac{(150.45-117.62)}{117.62} \text{ X } 100=27.9\%$$

The volumetric water content of the sample is:

$$VM=\frac{(S_{wet} - S_{dry})}{S_{dry}} \text{ x } SBD = \frac{(150.45-117.62)}{117.62} \text{ X } 1.20=0.335 \text{ g/cm}^3$$

## 6. References

Gardner, W.H., 1986. Water content, in: Klute, A., Campbell, G.S., Jacson, R.D., Mortland, M.M., Nielsen, D.R. (Eds.), Methods of Soil Analysis. Part I, ASA and SSSA, Madison, WI, USA, pp. 493–544.

**Data Sheet – Soil Water Content** **Page ……./…….**

Measurement date: ……../………/……….. Experiment: ____________________________

| Plot | Depth (cm) | Nr. Metal Can | Wet weight metal can + soil (g) | Dry weight metal can + soil (g) |
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