

What is in your topsoil?

By Margaret Caldecott

As many of you are aware, topsoil is the most important part of your field. Its functions range from supplying nutrients to soil stability to water holding capacity. So what is in that top layer of soil that is so important? I am sure you can list most items including: organic matter, N, P, K, micronutrients, microorganisms, water, air, and gases but do you have a grasp of how much? This article will present some average nutrient and microorganism biomass contents in topsoil and show you how to calculate your own nutrient reserves.

It is very difficult to give accurate quantifications of macronutrients in the soil as there are numerous factors that influence these levels, mainly, the bedrock that the soils are formed on, the fertilization history of the field, and/or natural processes (leaching, rain, lightning, etc).

When discussing what is in your topsoil, you need to first identify the amount of soil we are talking about. In research, the term hectare-furrow-slice (HFS) is used to identify how much an amount of soil weighs. So what is a HFS? It is an area 100 m by 100 m and 15 cm deep which calculates to a weight of soil equaling 2 000 000 kg and having a volume of 1500 m³ (Miller, 2007).

In terms of total nitrogen (TN), estimates range from 2000-20 000 kg TN/ha. If you have a clay soil, values can be as much as 1200 kg TN/HFS, whereas soils formed over granite bedrock are much lower, ranging from 2-200 kg TN/HRS (van Straaten, 2007). Soluble organic N (SON) is 0.3-1.5% of the TN (6-300 kg SON/ha) (van Straaten, 2007). Phosphorus reserves in the soil are much lower and the available P for plant uptake is minimal. Estimates have indicated that total P is 3000-5000 kg P₂O₅/HFS (1320-2200 kg P/HFS) but less than 1% of that is available (van Straaten, 2007). The amount of potassium in the soil is much greater than N and P. Some estimates range from 30 000-50 000 kg K/HFS, but much of that K, like P, is unavailable (van Straaten, 2007). Table 1 provides the amount of selected micronutrients and other essential nutrients in soils. Again, the availability of each of these nutrients is variable.

Table 1: Other selected nutrients in the soil and factors that influence availability

Nutrient	Amount* (mg/kg)	Amount ** (kg/HFS)	Factors that impede availability
Sulphur	433	n/a	low organic matter, coarse texture
Calcium	19 600	n/a	acidic soils
Magnesium	8 300	n/a	acidic soils
Boron	38.3	22	pH>7, sandy, dry soils, high organic matter content
Chloride	485	22	no impedances
Copper	25-60	45	high organic matter, anaerobic soils, pH>7
Iron	32 000	56 000	well drained sandy soils, alkaline soils
Manganese	761	22 000	dry, well drained soils, pH>7

Nutrient	Amount* (mg/kg)	Amount ** (kg/HFS)	Factors that impede availability
Molybdenum	1.92	5	dry, well drained soils, pH<5.5, sand or silt texture, high sulfates
Nickel	33.7	45	no impedances
Zinc	60	110	high P levels, anaerobic conditions, pH>8, sand or silt texture
Cobalt	12	18	pH>7, sand or silt texture, well drained soils
Selenium	0.1-2	n/a	anaerobic acidic soils, very low availability in general
Silicon	330 000	n/a	very acidic soils
Sodium	10 600	n/a	anaerobic soils

*van Straaten, 2007

** Brady and Weil, 2002

To put these values into perspective, let's look at how much the average 150 bu/ac grain corn crop removes from the soil reserves. Much of the nutrients used by the crop will be extracted from the top 15 cm of soil. Nitrogen, P, and K removal are 112-168 kg N/ha, 28-33 kg P/ha, 36-61 kg K/ha, respectively (Ontario, 1998). One can see how soil reserves can be depleted quickly and how we can grow 200+ bu/ac corn which would remove even more nutrients. With these values in mind, you can see why it is important to do soil tests for nutrient inventories.

There are millions of little critters in soil, which validates the 'don't eat the dirt' lecture! In the top 15 cm of soil there are microflora and fauna which include bacteria, fungi, algae, actinomycetes, protozoa, nematodes, mites, earthworms, and other small fauna. Table 2 provides the quantity of each of these flora and fauna in the soil.

Table 2: Soil microflora and fauna in top 15 cm of soil (Brady and Weil, 2002)

Organism	Biomass* (kg/ha)
bacteria	400-5000
fungi	1000-15 000
algae	10-500
actinomycetes	400-5000
protozoa	20-200
nematodes	10-150
mites	5-150
earth worms	100-1500
other	15-250

* biomass is on a live weight bases.

Knowing what is in your soil is a fairly simple calculation. What a soil test will give you is your nutrient or organic matter in parts per million (ppm) or %. So there are some conversions necessary and fortunately they are simple. All you need to know is:

$$\begin{aligned} 1 \text{ ppm} &= 1 \text{ mg/kg} \\ \% * 10\,000 &= \text{mg/kg} \end{aligned}$$

(from communications with O'Halloran, 2008)

So here is an example of how to know how much P is in your top 15 cm of soil.

- Given a soil test value of 13 ppm or 13 mg/kg
- weight of soil is 2 000 000 kg
- 13 mg/kg * 2 000 000kg =2 600 000 mg P or 2.6 kg P/HFS

Having an understanding of what is in your topsoil is critical for proper soil management. Using the calculations above you can get an idea of what is in your field. There may seem to be a *tonne* of nutrients in soil, but not all of those nutrients are available to your crop. Understanding what conditions reduce nutrient availability (Table 1) and how much a crop will remove from the soil reserves each year is not an easy task, but it is worth while to investigate. Knowing your soil nutrient reserve situation will help maximize yields and help maintain the sustainability of your practices.

Notes:

Brady, N.C. and Weil, R.R. 2002. *The Nature and Properties of Soils*. Pearson Education Ltd.

Miller, J.C. 2007. *Laboratory Manual Soil 0100 Principles of Soil Science*. Can be found at nsac.ca/pas/staff/cmi/soil0100/manl_07.pdf.

O'Halloran, I. 2008. University of Guelph, Ridgetown Campus.

Ontario, 1998. *Soil Fertility Handbook*. Queen's Printer for Ontario.

van Straaten, P. 2007. *Agrogeology: The use of rocks for crops*. Enviroquest Ltd.