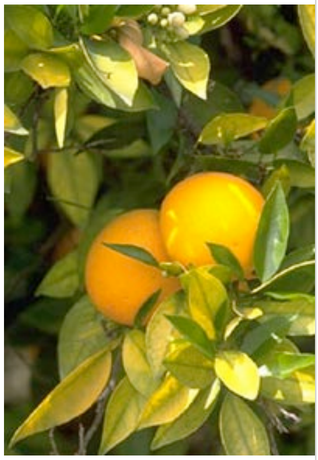
Sydney Environmental & Soil Laboratory

Specialists in Soil Chemistry, Agronomy and Contamination Assessments



WHAT'S WRONG WITH THE BASE CATION SATURATION RATIO CONCEPT?

How much fertiliser do you need to apply? Do a soil test and the results will tell you what's there. Then decide what should be there and add the difference. But how do you determine what should be there?

Two approaches are commonly used: the Base Cation Saturation Ratio (BCSR) concept and the nutrient sufficiency concept.

BASE CATION SATURATION RATIO

The BCSR was first proposed in the USA in the 1930s. It considers three of the four base (or basic, as opposed to acidic) cations, namely calcium (Ca^{2+}), magnesium (Mg^{2+}) and potassium (K^{+}). The fourth is sodium (Na^{+}), which the calculations neglect. (The main acidic cations are hydrogen, H^{+}, and aluminium, Al^{3+}.) The basic concept of the BCSR is that there is an ideal ratio of each of Ca^{2+}, Mg^{2+}, K^{+} and H^{+} in relation to cation exchange capacity (CEC).

The CEC of a soil is its total capacity to hold onto exchangeable (as opposed to fixed and unavailable) cations. CEC increases with clay content and organic matter content. So the more clay or organic matter a soil holds, the more cations it can hold. These cations represent a pool of available plant nutrients. The BCSR is simply a number that expresses how much of the CEC is taken up by each of Ca^{2+}, Mg^{2+}, K^{+} and H^{+}. For example, if the content of Ca^{2+} represents 20% of the CEC, Mg^{2+} 20%, K^{+} 10% and H^{+} 10%, then collectively they represent 60% of the CEC. Therefore, a further 40% of the CEC is still available and, under the BCSR concept, should be filled up.

The original proponent of BCSR, William Albrecht, of Missouri, USA, maintained that the cations should be maintained in a ratio of 65% Ca : 10% Mg : 5% K : 20% H. (This was later broadened to ranges of 65%–85% Ca^{2+} : 6%–12% Mg^{2+} : 2%–5% K^{+}, with H^{+} making up the balance.) The principle is that this ratio maintains ideal amounts of each base cation for optimum plant growth. This is based on the idea that imbalances in one cation can cause problems with other cations (true, but as it turns out, not relevant).

(Note that BCSR doesn't apply to other nutrients, such as nitrogen, phosphorus and trace elements.)

REALITY DOESN'T MATCH THEORY

BCSR sounds scientific, but unfortunately it is not borne out by either theory or practice. First, the 65:10:5:20 ratio of cations is scale-independent. This ratio can be satisfied for a CEC of 5 meq/100 g (typical of a sandy soil with low nutrients) or of 250 meq/100g (typical of a rich compost). Although the *ratio* remains the same, the total nutrient content of the compost is obviously much greater than that of the sandy soil. So BCSR doesn't take into account actual quantities of available nutrients. This can lead to oversupply of nutrients (and thus a waste of money) if the BCSR indicates a deficiency of one or more when there is already more than enough for optimum plant growth.

Trials in the USA showed that crop yields were unaffected by large changes in cation ratios (they focused on Ca:Mg, which was good at anywhere from 0.25:1 to 32:1!) (Kelling and Peters 2004). In fact, the plants' own cation ratios were more or less constant on different soils, indicating that plants will take up what they need, if the soil holds enough.

In addition, simply adding nutrients to a soil at a certain ratio doesn't mean that the cations are present at that ratio or that plants will take them up at that ratio.

THEORY FALLS DOWN IN ACIDIC SOILS

Further, the BCSR considers only 4 of the 6 major cations, neglecting Na^{+} and Al^{3+} in the balance, and ignoring the effects of H^{+} and Al^{3+} on soil pH and therefore nutrient availability. At low pH (caused by too much H^{+} or Al^{3+}), CEC is drastically reduced, so a BCSR analysis of an acidic soil will reveal (erroneously) that you need to add more Ca, Mg and K fertiliser. Instead, you need to add lime.

NUTRIENT SUFFICIENCY MAKES MORE SENSE

The alternative approach is to add enough of each nutrient so that the plant can achieve optimum growth. Simple and straightforward. You can work this out from a soil test (and a plant tissue test to show what plants are actually taking up). If local experience shows that a certain cation, say K, needs to be present at 50 mg/kg soil, and a test shows that it is present at 30 mg/kg, you can simply add enough K fertiliser to bring it up.

This approach offers the additional advantage that it applies to all nutrients, not just the base cations, so we don't need to use two different strategies to manage nutrients.

Bear in mind when requesting a soil test that if the lab tests only for base cations (which is less than total cations, which in turn is less than total nutrients), it is not giving you a complete picture of your soil. Only when you have a complete picture can you make the best decision on how to fertilise.

FURTHER READING

Barker B. 2007. Soil test methodologies affect recommendations: Part II. Top Crop Manager.

Bowden W, Strahan R, Gilkes R, Rengel Z. 2001. Calcium:magnesium ratios; are they important? Department of Agriculture and Food WA.

Kelling KA, Peters JB. 2004. The advisability of using cation balance as a basis for fertilizer recommendations. Proc 2004 Wisconsin Fertilizer, Aglime and Pest Management Conference, 366–371.

SESL. 2008. What is cation exchange capacity?

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