Managing constraints and maintaining optimal nutrient availability

Managing nutrients on the farm is critical to general plant health and pest management. If a soil has good tilth, drainage, adequate amounts of organic matter (OM), limited subsurface compaction, and sufficient water, plants should be healthy and have expansive root systems. This enables plants to efficiently take up nutrients and water from the soil and to use those nutrients to produce higher yields.

Generalized effective pH on bacteria growth and solubility of plant nutrients

![Figure 1. Relationship between soil pH and availability of nutrients and optimal bacteria growth in the soil solution. Modified from Brady and Weil (1999).](image-url)

The best single strategy for nutrient management is to build OM in a soil in order to realize the cascading positive effects on a range of physical, biological and chemical properties. Specific examples of management that promote nutrient availability (solubility) includes maintaining optimal pH (Fig. 1) through lime or wood ash applications, and adding organic material to help immobilize (make less soluble) aluminum and heavy metals. Cover crops can be used to make P more available to the following crop. Another option is to grow plants which can associate with mycorrhizal fungi to facilitate increased P availability as well as other nutrients and water. In general, improved understanding of the suite of soil fertility factors that can limit crop productivity is important to realize appropriate soil and nutrient management decisions.
Standard Nutrient Analysis

Basic protocol

**Analysis Method:** For extractable phosphorus (P) and potassium (K) and for magnesium (Mg), iron (Fe), manganese (Mn) and zinc (Zn), nutrients are extracted from soil by shaking the sample with Modified Morgan’s solution. After shaking, the extraction slurry is paper filtered, and the filtrate is analyzed on an inductively coupled plasma emission spectrometer (ICP, Spectro Ares). CASH does not produce a traditional Land Grant University nutrient recommendation. Instead, P, K, Mg, Fe, Mn, and Zn are scored for sufficiency or excess to identify potential constraints.

The pH of a suspension of two parts water to one part soil is determined by a pH electrode probe, using a Lignin pH robot.

**Scoring function**

Scoring function graphs are shown to the right for pH, (Fig. 2a) and extractable phosphorus (P) and potassium (K) (Fig. 2b) on coarse, medium, and fine textured soils. Scoring functions were combined for all classes because no effects due to texture were observed in the data set. For pH, a score of 100 is assigned for values between 6.4-7.3 and 5.3-6.3 for normal and acidic crops, respectively. Concentration values for P between 3.5-21.5 ppm and ≥ 74.5 ppm for K are given a maximum score of 100. Scores are not crop specific.

The micronutrient rating in the CASH Summary Report is reported as one score from determining the mean of the four sub-scores for Mg, Fe, Mn and Zn. To being, each individual micronutrient value is assigned a sub-score of either ‘0’ (sub-optimal) or ‘100’ (optimal), independent of texture (Table 1a). Next (1b), if the mean of all four micronutrient sub-scores are adequate the subscore is 100 which also equates to an overall micronutrient score of 100 (excellent). However, if one micronutrient is deficient or excessive, the mean of all four subscores is 75 which equates to an overall micronutrient score of 56 (moderate). If a combination of two, three, or four micronutrients are deficient or excessive, the mean subscore is 50, 25 or 0, respectively, and equates to an overall score of 11, 4 or 0.

**TABLE 1 a - b.** The optimal ranges for secondary nutrients and micronutrients for all soil textural classes.

<table>
<thead>
<tr>
<th>MICRO-NUTRIENT</th>
<th>SUBSCORE (ppm)</th>
<th>MEAN OF MICRO-NUTRIENT SUB-Scores</th>
<th>OVERALL MICRO-NUTRIENT SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>&lt; 33</td>
<td>≥ 33</td>
<td>100(1 all adequate)</td>
</tr>
<tr>
<td>Iron</td>
<td>&gt; 25</td>
<td>≤ 25</td>
<td>75 (3 of 4)</td>
</tr>
<tr>
<td>Manganese</td>
<td>&gt; 50</td>
<td>≤ 50</td>
<td>50 (2 of 4)</td>
</tr>
<tr>
<td>Zinc</td>
<td>&lt; 0.25</td>
<td>≥ 0.25</td>
<td>25 (1 of 4)</td>
</tr>
</tbody>
</table>

For more comprehensive overview of soil health concepts including a guide on conducting in-field qualitative and quantitative soil health assessments, please download the Cornell Soil Health Manual at bit.ly/SoilHealthTrainingManual.

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