Cornell University
School of Integrative Plant Sciences

Soil Health Series

Fact Sheet Number 20-12

Standard Nutrient Analysis

The Comprehensive Assessment of Soil Health (CASH) measures pH and extracts plant macro- and micronutrients to estimate plant nutrient availability using a traditional soil fertility analysis package for the Northeast. Measured levels are interpreted in our framework for sufficiency and excess but are not crop specific. The measured values for pH, extractable phosphorus and potassium are scored and integrated into the CASH report. Selected secondary nutrients and micronutrient (magnesium, iron, manganese, and zinc) analyses are combined into one rating for the report.

How nutrient analysis relates to soil function

Nutrient availability is critical to crop production. Of the eighteen elements needed by plants, only three—nitrogen (N), phosphorus (P), and potassium (K)—are commonly deficient in soils. Deficiencies of micronutrients such as magnesium (Mg), sulfur (S), boron (B), manganese (Mn) and zinc (Zn) can occur, but are not common. Crops do not grow well if nutrients are not present at the right time of the season in sufficient quantities and in reasonable balance to one another. When plants are unhealthy they are more susceptible to disease, loss of yield, and poor crop quality which leads to reduced economic returns.

Likewise, excessive nutrient application may create problems that lead to poor plant growth and environmental degradation. These concerns have resulted in more emphasis on better management of N and P as their excessive use contributes to surface and groundwater pollution and to greenhouse gas emissions.

In particular, management of soil N can be challenging as its availability in the soil changes rapidly as influenced by weather, physical soil condition, microbial activity, and the abundance of organic materials. Therefore N is not included in the CASH report as N's availability is dynamic and changes rapidly throughout the season.

Conventional soil nutrient analyses are based solely on chemical extraction and are used to recommend the type and quantity of nutrients to add through amendments as well as whether pH needs to be adjusted for improved nutrient availability from the soil. This approach has been used to guide farmers since the middle of the last century. Until very recently, the influence of physical and biological processes on plant nutrient availability have not been taken into account.

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

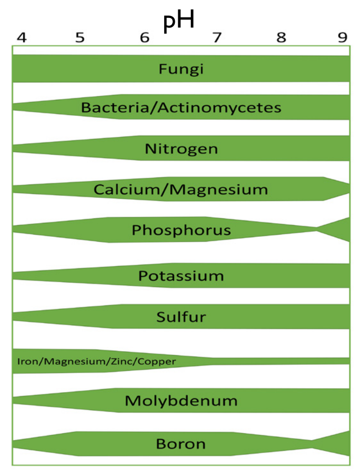


FIGURE 1. Relationship between soil pH and availability of nutrients and optimal bacteria growth in the soil solution. Modified from Brady and Weil (1999).

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 Arcos). 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 subscores 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.

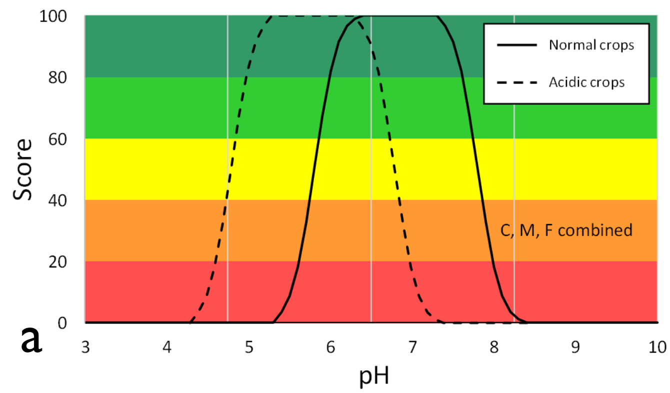
a

MICRO-NUTRIENT	SUBSCORE (ppm) 0	100
Magnesium	< 33	≥ 33
Iron	> 25	≤ 25
Manganese	> 50	≤ 50
Zinc	< 0.25	≥ 0.25

b

MEAN OF MICRO-NUTRIENT SUB-SCORES	OVERALL MICRO-NUTRIENT SCORE
100(all adequate)	100
75 (3 of 4)	56
50 (2 of 4)	11
25 (1 of 4)	4
0 (0 of 4)	0

The red, orange, yellow, light green and dark green shading below reflects the color coding used for the ratings on the soil health report summary page.



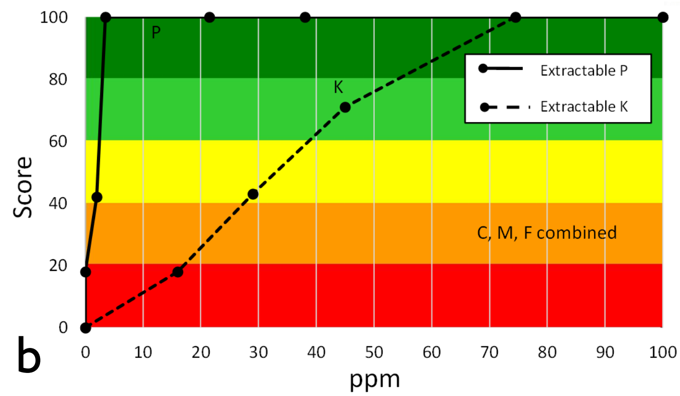


FIGURE 2 a - b. Scoring function graphs for pH (a) and extractable phosphorus and potassium (b) for Coarse (C), Medium (M) and Fine (F) textural classes. If all four micronutrients are optimal, the Micronutrient Score is 100 (very high). If all four are sub-optimal, the score is 0.

For a 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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For more information contact:

Cornell University
Soil Health Laboratory
bit.ly/SoilHealthContacts

Harold van Es
Robert Schindelbeck
Aaron Ristow, Kirsten Kurtz and Lindsay Fennell

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