Sampling, Nutrient Analysis, and Recommendations

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General Procedure

• sample collection
  – goal: a representative sample

• sample analysis
  – goal: accurate

• interpretation of results
  – relevant decision support system
Soil Sample Collection

• sampling tool
  – do not use a brass, bronze, or galvanized tool
  – a soil probe is the best
• a clean plastic bucket
• sample bags or boxes
Define a Management Unit

• an area with a similar complex of soils
• an area which has been and will be managed similarly
  – same crops
  – same fertility regime
  – same stocking rate (pastures)
• an area that will be managed separately from any other area
• no limit on acreage
Can more than one field be a management unit?

Soil samples must be collected from all fields in the management unit to form the composite sample.

Photo Courtesy of USDA-NRCS
Unbiased Sampling Pattern

- natural variability
  - soil formation processes
- man-made variability
  - uneven application of nutrients (intentional or unintentional)

walk in a zig-zag pattern across field and take sample at predetermined, regular intervals
Grid Sampling – Fertility Mapping

- superimpose grid on field
- common size of 2.5 acres
- take 5 – 10 cores in circle around intersection of grid
Sampling with Known Variability

• grid sample is difficult in a small or irregularly shaped field

• sample based on known variability

• if an area cannot be sampled and managed separately, it is best to sample the largest and/or most productive section

Sample separately or ignore outliers

Wet spot
Old manure storage area
Soil Sample Collection

• avoid unusual areas
  – scrape away surface residues, not surface soil
  – 15 to 20 locations per management unit
  – sample to plow layer depth (~8 in.) for traditional fertility testing and Fall Soil Nitrate Test (FSNT)
  – other applications may require different sampling depths
    • surface pH (herbicide breakdown) (2 inches)
    • PSNT (12 inches)
Soil Sample Collection (cont.)

- mix well in clean plastic bucket or specialized mixer
- mix it some more
- take a subsample (about 1 pint)
- air dry soil -- NEVER heat in oven.
- package and label with field identifier
Soil Sampling in Pastures

Unique sampling issues with open-grazed pastures:

• some areas are devoid of vegetation and have accumulations of manure on the soil surface

• sample from forage production areas and avoid denuded areas
Soil Tests Extract Plant-available Forms of Nutrients

- **STABLE POOL**
  - (soil minerals, humus)
  - Very slow

- **LABILE POOL**
  - (exchangeable cations, sorbed anions, rapidly mineralizable organic matter)
  - Very fast

- **SOIL SOLUTION**
  - (plant-available nutrients)

  - micro-organisms
  - plants
Figure 5-4  The soil phosphorus cycle. An overview of the physical, chemical, and microbiological processes controlling the availability of P to plants and P transport in runoff or leaching waters. (Adapted from Gachon, 1969.)
“Total” vs. “Available” Nutrients

• plants take up inorganic soluble phosphate
  – desorbed from clay minerals and oxides of Fe and Al
  – dissolved from primary and secondary minerals
  – mineralized from organic P

• soil P is approximately >99% unavailable
Soil Chemical Analysis

Procedures & Extractants

• multiple
• variable
• not interchangeable
• not standardized

– differences in procedure yield different results
Soil Chemical Analysis

Incorrect concept of “available” nutrients as a discrete fraction in soil:

Unavailable

Available

Correct concept of nutrient availability as a continuum in soil:

Increasing availability

A

B

C
Soil Chemical Analysis (cont.)

Examples of different soil P extractants

<table>
<thead>
<tr>
<th></th>
<th>Bray P</th>
<th>Mehlich 3 P</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_w$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 cm$^3$ soil</td>
<td>1.7 cm$^3$ soil</td>
<td>2.5 cm$^3$ soil</td>
</tr>
<tr>
<td>50 ml solution</td>
<td>20 ml solution</td>
<td>25 ml solution</td>
</tr>
<tr>
<td>Distilled H$_2$O</td>
<td>0.03 $N$ NH$_4$F</td>
<td>0.2 $N$ CH$_3$COOH</td>
</tr>
<tr>
<td></td>
<td>0.05 $N$ HCl</td>
<td>0.25 $N$ NH$_4$NO$_3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.015 $N$ NH$_4$F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.013 $N$ HNO$_3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.001 $M$ EDTA</td>
</tr>
<tr>
<td>Shake 60 min.</td>
<td>Shake 5 min.</td>
<td>Shake 15 min.</td>
</tr>
<tr>
<td>Filter</td>
<td>Filter</td>
<td>Filter</td>
</tr>
</tbody>
</table>

Shake 60 min.
Filter
Soil Chemical Analysis (cont.)

A = Mehlich 3 (30 ppm)
B = Bray P1 (15 ppm)
C = Distilled Water (2 ppm)

From *The Mid-Atlantic Nutrient Management Handbook*
Reasons for Differences in Results from Soil Test Labs

• Using different chemical extractants or soil testing methods
  – Mehlich 1, Mehlich 3, Olsen, Morgan, Modified Morgan, Bray 1, Bray 2, distilled water

• Different units
  – lbs/acre, ppm, Index

• Differences in basis of expression (potassium vs. potash)
  – original MD recommendations given on the basis of fertilizer equivalents (phosphate - \( \text{P}_2\text{O}_5 \) and potash - \( \text{K}_2\text{O} \))
Soil Sample Exchange

• Seven labs participated in soil sample exchange

• All samples (665) used in the exchange were collected at plow layer depth (~8 in.)

• Lab specific calculations were developed to convert results to Maryland FIV scale
Compatible Labs

Labs whose soil test data can be converted to the UME equivalent include (but are not limited to):

- A & L Eastern Analytic
- Agri-Analysis
- Brookside
- Penn State
- Spectrum Analytic
- University of Delaware
- Waters
- AgroLab *
Converting to the FIV Scale

Soil Fertility Management

SFM-4
Revised August 2006

CONVERTING AMONG SOIL TEST ANALYSES FREQUENTLY USED IN MARYLAND
Philosophies of Soil Test-based Recommendations

• maintenance or “buildup”
  – fertilize the soil

• sufficiency
  – fertilize the crop

• cation ratio
  – fertilize for the “ideal ratio” of cations
Maintenance or “Build Up”

• rapid increase to “Optimum” or “High” soil test levels
  – annual application of nutrient to replace crop removal
  – conservation of the soil’s nutrient supply

• application of nutrients regardless of soil test level
Maintenance or “Build Up”

• disregards soil’s buffering (storage) capacity

• potential for over-fertilization during maintenance phase

• potentially economically and environmentally wasteful
Sufficiency Approach

• fertilize the crop

• *apply enough nutrients to provide for optimum response at given soil test level*

• identify the soil test “critical level” above which there is no further yield response to applied nutrient
  – recommend applying fertilizer only when soil test level is below the critical level
  – if soil test is below the critical level, fertilizer rate recommendations based on crop response calibration studies
Sufficiency Approach

• calibration studies are long-term, conducted over years, soil types, environments, weather conditions

• tends to be conservative - less fertilizer recommended at higher soil test levels

• not applicable to nitrogen in humid East
Hybrids: Combining Approaches

• increasingly a hybrid of “fertilize the soil” and “fertilize the crop” has been used

• most labs include a maintenance component in recommendations
Cation Saturation Ratio

• fertilize to create an “ideal ratio” of exchangeable cations in the soil

• 65% Ca, 10% Mg, 5% K, 20% H & Al

• does not consider P or S

• limited validity
Cation Saturation Ratio Approach

- calibrated for only several soil types
- may result in unrealistic fertilizer recommendations
- ignores relative availability and focuses only on ratio of nutrients
- simple and easy - no local knowledge of soils necessary
Soil Samples → Black Box → Nutrient Recommendations

- Philosophy or approach?
- In what region was basic research conducted?
- In what regions are the recommendations applicable?
- What extractants are used?
Manure Sample Collection
Manure sampling

• Sampling manure is as critical and challenging as sampling soil.
  – Application rate will be based on analysis
  – A reliable analysis requires a representative sample
Steps in Manure Sampling

   - Before application
     - from various depths & locations in a pile
     - from agitated liquid storage facility
   - During loading
   - During spreading

**NOTE:** Include bedding in the sample to the same extent as it exists in the pile.
Steps in Manure Sampling

2. Mix composite sample very well.

3. Sub-sample composite.

4. Package and ship to lab.
   - plastic resealable bags (double bagging recommended)
   - plastic bottles or jars (never glass)
Liquid manure

- ideally, agitate/mix storage thoroughly before sampling
  - minimum of 5 samples
- best time to sample is during field application
Sampling Manure on Pastures

Should you collect manure deposited on pasture by animals?

NO, but manure must be sampled and analyzed if it is collected & utilized (land applied).
Manure Chemical Analysis

• many commercial agricultural labs test manure
• analysis is TOTAL elemental content
  – organic matrix is destroyed
• nitrogen
  – need additional information
  • manure – request $\text{NH}_4^- \text{N}$
  • biosolids, WWTP effluents – request $\text{NH}_4^- \text{N}$ and $\text{NO}_3^- \text{N}$
Estimating PAN in Organic Materials

• mineralization rates are the heart of this estimation (see Infocard)

• PAN(%) = (% NH$_4$-N x $f_{con}$) + (% N$_{org}$ x $F_{min}$)

• include NO$_3$-N if –
  – meaningful (effluents), or
  – required (biosolids)

• ammonium content is required
Plant Tissue Analysis

• Laboratory analysis of total elemental content of plant tissue
  – Basis of recommendation for perennial fruit crops
  – For routine monitoring of crop nutritional status
  – For diagnosing nutritional problems
  – For determining nutrient removal
  – As a basis of a recommendation on high P soils
What is a Block?

• An area within an orchard that:
  – consists of plantings of the same age, species and variety
  – has the same or similar soil types
  – can be managed as one unit

• A block is best determined by the orchard manager.
An Area in a Hypothetical Orchard...

Gala Apples (4 yrs)  Golden Delicious Apples (4 yrs)  Golden Delicious Apples (7 yrs)  Fuji Apples (7 yrs)

Murrill gravelly loam  Road  Creek  Thurmont gravelly loam

A  B  C

Cherries (7 yrs)  Fuji Apples (7 yrs)
Plant Tissue Sample Collection

• know your source of interpretive data, first
  – sample the correct part of the plant
  – sample the appropriate growth stage

• know the requirements and constraints of your comparison database
Sample Collection for Perennial Fruit Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Time to Sample</th>
<th>Number of Samples/Plant Part</th>
<th>Location on Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blueberries</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; week of harvest</td>
<td>40 leaves (detach petioles)</td>
<td>Current season’s growth</td>
</tr>
<tr>
<td>Brambles</td>
<td>Aug 1&lt;sup&gt;st&lt;/sup&gt; – Aug 20&lt;sup&gt;th&lt;/sup&gt;</td>
<td>60 leaves (detach petioles)</td>
<td>Non-fruiting canes</td>
</tr>
</tbody>
</table>
Unbiased Sampling Patterns
Monitoring Plant Nutrient Status: The Next Step after Soil Tests

- know source of interpretive norms

- plant part & stage of growth are critical
  - corn - leaf ear; initial silk
  - cucumbers – flower to small fruit set; 5th leaf from growing tip
  - soybeans – prior to pod set; most recent leaf
Using Plant Tissue to Troubleshoot

• sample “healthy” and “deficient” areas for comparison

• do not need an interpretive database
Plant Analysis for Accurate Nutrient Removal Data

• many pubs show “typical” amounts of nutrient removal

• actual removal will vary; average values may underestimate removal

• P removal is one of the allowable rates in Phosphorus Site Index & Phosphorus Management Tool
Regional Study of Nutrient Removal
(AJ v. 95, 2003)

• Mid-Atlantic study of nutrient removal of corn grain
• 1998 & 1999; 23 site years; 10 hybrids
• could benefit farmers on high P soils to test grain for P content
• 0.22% to 0.54%
• mean – 0.4%
Chemical Analysis of Plant Tissue

Total elemental content

• typically expressed as a percentage of dry weight

• similar to waste analysis in that organic matrix is destroyed
Plant Nutrient Recommendation Philosophies

Critical Nutrient Range (CNR)

• the nutrient concentration below which plant yield or quality is unsatisfactory

• assumes the plant integrates all soil, weather, and environmental factors

• looks at one nutrient at a time rather than the interactions
Plant Nutrient Recommendation Philosophies

Diagnosis and Recommendation Integrated System (DRIS)

- balance of nutrients within the plant is critical for attaining maximum performance
- requires multi-element analysis of samples
- requires extensive field calibration
- calibrated reference databases are not available for most crops
- looks at the nutrient balance
Soil Testing for Nitrogen in the Humid East -

• N cycle is a microbially drive dynamic cycle
• Which pools of soil N should be measured?
• What soil N is plant available? ...and when?
• How do we deal with weather influences?
Nitrogen Soil Tests

A nitrogen soil test works, if....

• used for the right crop
• conducted at the right time of year
• conducted at the right stage of plant development
• used in conjunction with appropriate fertilizer management practices
• a representative soil sample is collected
Pre-sidedress Soil Nitrate Test (PSNT)

An in-season nitrate test that can be used as a tool to help growers decide if they should apply sidedress nitrogen to their corn crop.
Pre-sidedress Soil Nitrate Test (PSNT)

Requirements

- corn (grain and silage) and only corn
- for fields that have received organic applications or where forage legumes were grown the previous year
- less than 50 lb N/acre applied prior to sidedress
- 12 inch soil sample
- 30 to 40 cores per management unit
- sample when corn is 6 to 12 inches tall
- critical level = 21 ppm NO$_3^-$N
Soil Nitrate & Corn N Uptake

Soil Nitrate Concentration

Corn N Accumulation

Planting 12” tall Tasseling Harvest

Soil Nitrate Corn N Uptake

Soil Nitrate
Corn N Accumulation

Time (Weeks)
New Soil Nitrate Test! (2013)

Fall Soil Nitrate Test (FSNT)

• wheat and barley
• 8-inch sampling depth
• interpretation depends analytical methods
  - lab grade analysis
  - field grade equipment

Recent research has demonstrated that winter wheat and barley grain yields and economic return to fertilizer applications are not reliably improved by a fall nitrogen application when an adequate amount of nitrate already exists in the soil.

Regulations effective October 2012 require that farmers who plant wheat and barley for grain production must test for soil nitrate concentration before they may apply nitrogen in fall.
Adaptive Nitrogen Management
(beyond the initial recommendation)

• chlorophyll meter
  – 6 leaf stage
  – reference area

• late season corn stalk nitrate test (CSNT)
  – assessment of N management program
  – between ¼ milk-line (before silage harvest) to about 3 weeks
    after black layer formation
  – 8 inch segment starting 6 inches above ground

• ramp strip calibration
  – in-field assessment (visual or with optical device)
  – incorporates seasonal influences on N availability