Managing Crop Nutrition

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Why is Crop Health Important in Farming?

Crop Health affects:
- Production yield
- Crop quality
- Profitability
Achieving Balanced Nutrition

- Provide plant with essential nutrients
- Avoid over or under applying inputs
- Balance $\$ input with maximum yield output
Nutrition: More Isn’t Always Better

![Crop Response To Fertilizers Application](smart-fertilizer.com)
Liebig's Law of the Minimum

* Plant growth is not controlled by not having the most or total nutrients.
* Plant growth is dependent on the nutrient in shortest supply.
Least Abundant Nutrient Greatly Affects Crop Productivity
Essential Plant Nutrients

* Plant food nutrients
  * Primary (macro) nutrients
  * Secondary nutrients
  * Micronutrients.
* Each are equally important
* Balance is key
* Needed to help the crop complete its lifecycle
How do you know what your crop needs?

Visual Assessments
Soil and Tissue Testing
Etc.
Nutrition CSI
Healthy

Phosphate-deficient

Potassium-deficient

Nitrogen-deficient
Mobile Nutrients

* Nutrients that move to areas where it is lacking.
* Moves from older leaves to younger tissue
* Results in discoloring in older leaves
  * Nitrogen
  * Phosphorus
  * Potassium
  * Magnesium
  * Chloride
  * Molybdenum
Immobile Nutrients

* These nutrients **cannot** move
* Deficiencies will appear in younger leaves
  * Boron
  * Calcium
  * Copper
  * Iron
  * Manganese
  * Nickel
  * Sulfur
  * Zinc **
New Growth

Normal leaf

Severe nitrogen deficiency (white/yellow tiny leaves)

Calcium deficiency (or might be K, Mg overdose) twisted pale new growth

Iron deficiency (yellowing of entire plant)

Magnesium deficiency (dark veins lighter leaf tissue)

Potassium deficiency (pin-holes form in leaf that enlarge with a yellowing edge, leaf is otherwise normal looking)

Early signs of nitrogen deficiency (old leaves yellow and are reabsorbed from tip to stem)

Phosphate deficiency (older leaves yellow, and parts of the leaf is reabsorbed leading to dead patches, the leaf falls off rather quickly, looks similar to early nitrogen deficiency)

*** Purple-ish in Hawaii

Hydrophytesblog.com
Primary Nutrients: Nitrogen, Phosphorus, and Potassium

- NPK is not in abundance in certain soil systems
- Most frequently applied nutrients
- Applied in larger quantities than other crop nutrients
Nitrogen

* Vital for vegetative plant growth
* Directly involved in photosynthesis
* Necessary for formation of amino acids
* Building blocks of protein
* Essential for plant cell division
* Aids in production and use of carbohydrates
* Affects energy reactions in the plant
* Etc.
Vegetative growth
Phosphorus

* Promotes early root formation and growth
* Involved in photosynthesis, respiration, energy storage and transfer, cell division, and enlargement
* Improves quality of fruits, vegetables, and grains
* Vital to flower and seed formation
* Helps plants survive harsh winter conditions
* Increases water-use efficiency
* Hastens maturity
* Etc.
Potassium

- Improves quality of seeds and fruit
- Increases disease resistance
- Carbohydrate metabolism and the break down and translocation of starches
- Tuber and fruit development
- Essential to carbohydrate and protein synthesis
- Increases photosynthesis
- Increases water-use efficiency
- Important in fruit formation
- Activates enzymes and controls their reaction rates
- Etc.
Fruit Development
Fruit Quality
Secondary Nutrients: Calcium, Magnesium, and Sulfur

* Calcium, Magnesium and Sulfur are often times adequate in certain soil systems
* Applied in lower quantities than other primary nutrients
Calcium

* Utilized for continuous cell division and formation
* Aids translocation of photosynthesis from leaves to fruiting organs
* Increases fruit set
* Involved in nitrogen metabolism
* Reduces plant respiration
* Essential for nut development in peanuts
* Etc.
Aids translocation of photosynthesis from leaves to fruiting organs
Increases fruit set
Reduces bruising
Utilized for continuous cell division and formation
Involved in nitrogen metabolism
Reduces plant respiration
Stimulates microbial activity
Etc.

Calcium
Magnesium

* Key element of chlorophyll production
* Improves utilization and mobility of phosphorus
* Activator and component of many plant enzymes
* Increases iron utilization in plants
* Influences earliness and uniformity of maturity
Micro Nutrients

* Boron, chlorine, cooper, iron, manganese, molybdenum, zinc, nickel, cobalt, etc.
* Used in very small amounts
* Important to plant development
* Work "behind the scene" as activators
Boron

- Essential for seed and cell wall formation
- Promotes maturity
- Necessary for sugar translocation
- Affects nitrogen and carbohydrate
- Etc.
Iron

- Promotes formation of chlorophyll
- Acts as an oxygen carrier
- Reactions involving cell division and growth
Zinc

- Aids plant growth hormones and enzyme system
- **Necessary for chlorophyll production**
- Necessary for carbohydrate formation
- Necessary for starch formation
- Aids in seed formation
Some sugarcane lands in Hawaii (Oxisols) are known to have Manganese toxicity issues. Toxicity can occur when plants take up too much nutrients.
Visual Assessment Test
What is wrong with this plant?
Understanding Your Soil
Soil Test

* Samples run about $15-20 / sample
* pH and SALINITY
  * Salinity can serve as an indicator of over application of fertilizers, manures, etc
* EXTRACTABLE NUTRIENTS: (Ca, Mg, P, K)
* Organic Carbon (OC); Total Nitrogen (N); Boron (B); Additional Extractable Micronutrients
*
Accurate & Representative Sampling
Results are only as good as your sampling program
# Soil/Plant Analysis Report

**Client:** SUGANO, JARI  
**Address:** 919 CALIF AVENUE, WAHIAWA, Hawaii 96786

**Date Reported:** 01/18/2013  
**Agent:** NO AGENT, Office: NONE
**NONE**

## Sample Information
- **Job Control No.:** 13-132700-001  
- **Map Unit:**  
- **Plant Grown:** None  
- **Plant to be grown:** None  
- **Send Copy To:**  
- **Date Received:** 1/17/2013  
- **Soil Series:** HEAVY SOIL  
- **Can you till 4-6 in.**? No  
- **Soil Depth (in.):**  
- **Test Results Only?** No  
- **Latitude:**  
- **Longitude:**

## Test Results and Interpretation

### HEAVY SOIL

<table>
<thead>
<tr>
<th>Soil Analysis</th>
<th>Results</th>
<th>Expected</th>
<th>Very Low</th>
<th>Low</th>
<th>Sufficient</th>
<th>High</th>
<th>Very High</th>
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<tbody>
<tr>
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<td>250</td>
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<tr>
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<td></td>
<td>125</td>
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<td>4.8</td>
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<tr>
<td>Mg ppm</td>
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<tr>
<td>Total N %</td>
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<td>350</td>
<td>555</td>
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<td>250</td>
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<td>Salinity EC</td>
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### Plant Analysis

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</table>
Importance of Taking a Soil Sample

- Understand what nutrients are available in soil
- Understand what nutrients are lacking in soil
- Helps calculate fertilizer needs
- Helps soil fertility management
- Help increase profits
- Minimize crop losses

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### Knowing Crop Nutrient Needs

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
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<tbody>
<tr>
<td>Lettuce</td>
<td>70</td>
<td>15</td>
<td>110</td>
</tr>
<tr>
<td>Cucumber</td>
<td>50</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>Taro</td>
<td>350</td>
<td>150-200</td>
<td>500-600</td>
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<tr>
<td>Watermelon</td>
<td>170</td>
<td>25</td>
<td>150</td>
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Resources:
- CTAHR Lettuce Production Guidelines for Hawaii
- CTAHR Taro: Mauka to Makai
- CTAHR Farmer’s Bookshelf
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<tr>
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<tr>
<td>Mn ppm</td>
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### ADSC Recommendations

**Recommended Nitrogen inputs**

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<thead>
<tr>
<th><strong>Fertilizer and Lime Recommendations</strong></th>
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<tbody>
<tr>
<td><strong>Total Nutrient Requirement (lbs/Acre):</strong></td>
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<tr>
<td>Nitrogen: 175</td>
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<tr>
<td><strong>Fertilizer / Lime Material</strong></td>
</tr>
<tr>
<td>Fertilizer: 46-0-0</td>
</tr>
<tr>
<td>Lime Material: Coral Limestone</td>
</tr>
</tbody>
</table>

**Adjust pH levels**
Nutrients in soil ≠ plants will be able to take them up
Important to evaluate the crop uptake in a nutrient management program
Tissue sampling shows what the plant has actually taken up
Importance of Tissue Testing

- Provides a snap shot of nutrient uptake in plants
- Indicator of soil nutrients levels
- Confirm of rule out deficiency / toxicity issues
- Accurate sampling is important
  - Specific guidelines for each crop
    - Location on plant
    - Crop cycle
Plant Tissue Test

* Samples Run about $25-30 / each
* All of the following nutrients: (B, Ca, Cu, Fe, Mg, Mn, P, K, Na, Zn)
* Total Nitrogen (N); Nitrates (No3-N); Sulfur (S); Silicon (Si); Other Elements
| ITEM | Sample Lab No. | Description | Anal. Code | % | ug/g | N  | P  | K  | Ca | Mg | Na | S  | Fe  | Mn  | Zn  | Cu  | B   | Mo  | Al  | NO3-N | NH4-N | NO2-N | Si  |
|------|---------------|-------------|-------------|----|------|----|----|----|----|----|----|----|----|-----|-----|-----|------|------|------|-----|
| 1    | 121-2390      |             | T1.2        | 4.45 | 0.42 | 3.24 | 0.91 | 0.28 | 0.03 | 149 | 235 | 35 | 13 | 102 |
| 2    |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 3    |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 4    |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 5    |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 6    |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 7    |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 8    |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 9    |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 10   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 11   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 12   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 13   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 14   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 15   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
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| 19   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 20   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 21   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
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| 26   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 27   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
| 28   |               |             |             |      |      |     |     |     |     |     |     |     |     |     |     |     |      |      |      |     |
Table 1. Taro leaf blade nutrient concentrations associated with deficiency, sufficiency, and toxicity.

<table>
<thead>
<tr>
<th>Mineral element</th>
<th>Measured in</th>
<th>Deficiency range</th>
<th>Sufficiency range</th>
<th>Toxicity range</th>
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<tbody>
<tr>
<td>N</td>
<td>%</td>
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<td>4.0–4.5</td>
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<tr>
<td>P</td>
<td>%</td>
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<td>0.3–0.5</td>
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</tr>
<tr>
<td>K</td>
<td>%</td>
<td></td>
<td>3.2–5.5</td>
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<tr>
<td>Ca</td>
<td>%</td>
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<td>0.7–1.5</td>
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<tr>
<td>Mg</td>
<td>%</td>
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<td>0.2–0.5</td>
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<td>S</td>
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<td>20–50</td>
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<td>Mn</td>
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</tbody>
</table>

* Actual deficient, sufficient, and toxic concentrations of elements in leaf blades may vary depending on taro variety, environmental conditions, and quantities of other nutrients present. * Sufficiency ranges are based on concentrations of elements in leaf blades of healthy taro plants grown under upland or wetland conditions (Uchida, 2000). * Osorio et al. (2002). * Silva, J.A. (personal communications). * Miyasaka (1979). * Austin et al. (1994) found that 0.14% Mg was associated with 95% of maximum growth. * Kelly and Jansen (unpublished) showed that 0.18% S was associated with 95% of maximum growth. * Hill et al. (1998). * Ares et al. (1996) found that a range of 55–70 ppm Fe was associated with 95% of maximum growth. * R.T. Hamasaki (personal communications). * Taro is tolerant to high levels of Mn and foliar concentrations between 1400–2000 ppm have been observed without detrimental effects. * Miyasaka and Webster (1984). * O’Sullivan et al. (1996). * Hill et al. (2000) found levels ranging from 14–18 ppm Cu in taro plants supplied with sufficient Cu. Foliar Cu concentrations cannot be used to predict toxicity, because they did not increase in leaf blades under toxic Cu levels.

Resources: Nutrient Deficiencies and Excesses in Taro
Susan C. Miyasaka, Randall T. Hamasaki, and Ramon S. de la Pena
Why do we need to manage our soils and crop inputs?
Build up due to over farming/ application may result in long term negative effects
Ways to Feed the Crop

- Complete or individual fertilizers
- Soil or foliar applications
- Granular or water soluble
- Conventional vs. organic inputs
N - P - K
Nitrogen - Phosphorus - Potassium

N - P_2O_5 - K_2O

Photo credit: www.ncagr.gov; www.lifeandlawns.com
N-Nitrogen
P-Phosphorus
K-Potassium
Complete vs. Mono-Fertilizers

Photo credit: https://mydbsupply.com; boltakarachi.blogspot.com
Nitrogen Fertilizers

* Urea (46-0-0)
* Ammonium sulfate (21-0-0)
* Potassium nitrates (13-0-44)
* Calcium nitrate (15-0-0)
  * 24 % Ca
Phosphorus Fertilizers

- Triple super phosphate
- Rock phosphates
- Ammonium phosphates

N-P-K
Potassium Fertilizers

* Potassium chloride
* Potassium sulfate
* Potassium magnesium sulfates

N-P-K
Calcium Fertilizers

- Ag lime
- Calcium sulfate, gypsum
- Calcium nitrate
- Superphosphates
  - Single superphosphates adds ~18-21% Ca
  - Triple superphosphate adds ~12-14% Ca
Magnesium Fertilizers

- Magnesium sulfate (epsom salts)
- Magnesium oxides
All Fertilizers Are Not Equal

* When would you use these types of fertilizers?
  * 46-0-0
  * 10-30-10
  * 10-5-40
Calculating Fertilizer Inputs

* 50 Pounds x 10% nitrogen = 5 pounds of N
* 50 pounds x 10% P2O5 (P) = 5 pounds of P2O5
* 50 pounds x 10% K2O (K) = 5 pounds of K2O
Example:

If you want to apply 50 pounds of N/acre using urea (46-0-0)

\[
X \text{ (amount of urea)} \times 46\% = 50 \text{ pounds of N}
\]

\[
X = 50 \text{ pounds of N} / 46\%
\]

Solution: 109 pounds of Urea to apply 50 pounds of N/acre
Different Types of Fertilizers

Photo credit: Cornell edu, www.daytonnursery.com ; www.shopfarmingarden.com
Soil applications vs. Foliar Applications
Granular Applications

* Side dressing
* Top dressing
* Banding
* Broadcasting
* Etc
Nutrients need to be in ionic form in order for plants to utilize them.
Foliar Applications

* Fertigation (with irrigation)
* Foliar applications
* Etc.
How Foliar Applications Work

* Plant takes up nutrients via epidermis and stomata
* More stomates on the underside of leaves
* Apply in early morning or evenings
  * Stomates are open
  * Humidity is higher
* Fine mist application is preferred
* Seek optimal spray coverage
Organic & Sustainable Soil Amendments

- Made of natural products
- Not man-made products
- Fertility based on:
  - Crop tillage
  - Crop rotation
  - Manures
  - Compost
  - Cover cropping systems
  - Micro-organisms
  - Etc.
2. **Prohibited** sources of nitrogen are as follows (but not limited to):
   a. any material listed as prohibited §Subpart G of the RULE;
   b. sewage sludge.

B. Phosphorus

1. **Allowed** sources of phosphorus are as follows (but not limited to):
   a. colloidal, soft rock, and hard rock phosphate;
   b. mycorrhizae to activate rock phosphate;
   c. bone meal;
   d. bat guano;
   e. phosphorus-accumulating cover crops, *i.e.*, buckwheat, brassicas, and legumes;
   f. compost;
   g. worm castings; or
   h. other materials not prohibited by the RULE.

2. **Prohibited** under any circumstance
   a. any material listed as prohibited in §Subpart G of the RULE.

C. Potassium

1. **Allowed** sources of potassium are as follows (but not limited to):
   a. wood ashes provided that the material burned has not been treated or combined with any prohibited substances;
   b. rock dusts (basalt, granite, feldspar, greensand);
   c. sulfate of potash magnesia (langbeinite);
   d. natural potassium sulfate;
   e. kainite;
   f. recycled potassium-rich organic matter;
   g. potassium-concentrating cover crops, *i.e.*, bracken fern, comfrey, and fennel;
   h. humates;
   i. ash from burning plant and animal material provided it meets conditions of §205.203(d)(4) of the RULE; or
   j. Other materials not prohibited by the RULE.
Organic Nutrient Inputs

Compost
Understand composition of compost
Compost Tea

* Solution made from compost materials
* Nutrient content changes with compost quality
Cover Crop System

Photo credit: J Deenik
Nitrogen Fixing Plants
Locally Available Crop Fertilizers

- Fish Bone Meal
- Kaneohe Bay Seaweed
- Vermicompost
- Etc.

Photo credit: www.midweek.com, www.rootsgardensupply.com
Manures
Soil Amendment Effect on Marketable Yield of Sweet Corn
Harvest Date: 5/29/2008

Figure 1. Soil amendment effect on sweet corn yield for the 2008 planting season.
Deenik, Sugano, Fukuda, 2008
Yield Comparisons for 2007 and 2008 Crops

Figure 2. Comparison of yield between 2007 and 2008 Kahuku Corn growing seasons.

Deenik, Sugano, Fukuda, Shimabuku 2008
Figure 2. Soil treatment effects on marketable Manoa lettuce yields. Bars with the same letter are not significantly different from each other. Deenik & Fukuda, 2008
Locally grown seaweed
Nutrition starts here
...and then there are fertilizer timing schedules to consider

Pre-plant

Nitrogen

Potassium
Farming Resources

- CTAHR Website
- CTAHR publications
- CTAHR agents
- Learn by doing
Achieving Balanced Nutrition

- Provide plant with essential nutrients
- Avoid over or under applying inputs
- Balance $$ input with maximum yield output
Plant Nutrient Management in Hawaii’s Soils

Approaches for Tropical and Subtropical Agriculture

Today’s approach to crop production considers not only the effects of fertilizer applications on crop yield and quality but also includes awareness of the potential of fertilizer nutrients to adversely affect the environment. Managing crop nutrient allocation deliberately and carefully takes on special significance in Hawaii, where imposed nutrient inputs are costly and the environment—particularly the underground aquifer and coastal waters—is vulnerable to pollution.

This book contains a distillation of decades of CTAHR research on soils, fertilizers, and crop nutrient needs, written for the lay reader and intended to provide a solid base of knowledge for the various agricultural activities. While the text makes reference to Hawaii’s soils and climate conditions, the basic information is transferable to similar tropical and subtropical locations throughout the world.

Contents

- Managing fertilizer nutrients to protect the environment and human health
- Sampling and analysis of soils and plant tissues
- Efficient nutrition for plant growth: nutrient functions and deficiency symptoms
- Recommended plant tissue nutrient levels for some vegetables, fruits, and ornamental foliage and flowering plants in Hawaii
- Use of information from soil surveys and classification
- How fertilizer recommendations are made
- Interpreting soil and tissue analysis data: definition of “low,” “sufficient,” and “high” nutrient levels
- Collection and interpretation of data for selecting soil and plant tissue analysis
- Fertilizer selection
- Soil quality and soil health
- Plant tolerance of low soil pH, soil aluminum, and soil manganese
- Inorganic fertilizer materials
- Biological fertilizer use: nature’s partnership for sustainable agricultural production
- Macronutrient and plant nutrition
- Organic soil amendments for sustainable agriculture: organic sources of nitrogen, phosphorus, and potassium
- Fertilizer management and fertilization
- Soil and water quality

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