PURDUE EXTENSION | HORTICULTURE & LANDSCAPE ARCHITECTURE

Nutrient Management for Vegetable Crops: Diagnostic Tools

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Indiana Horticulture Congress 2017

January 11, 2017

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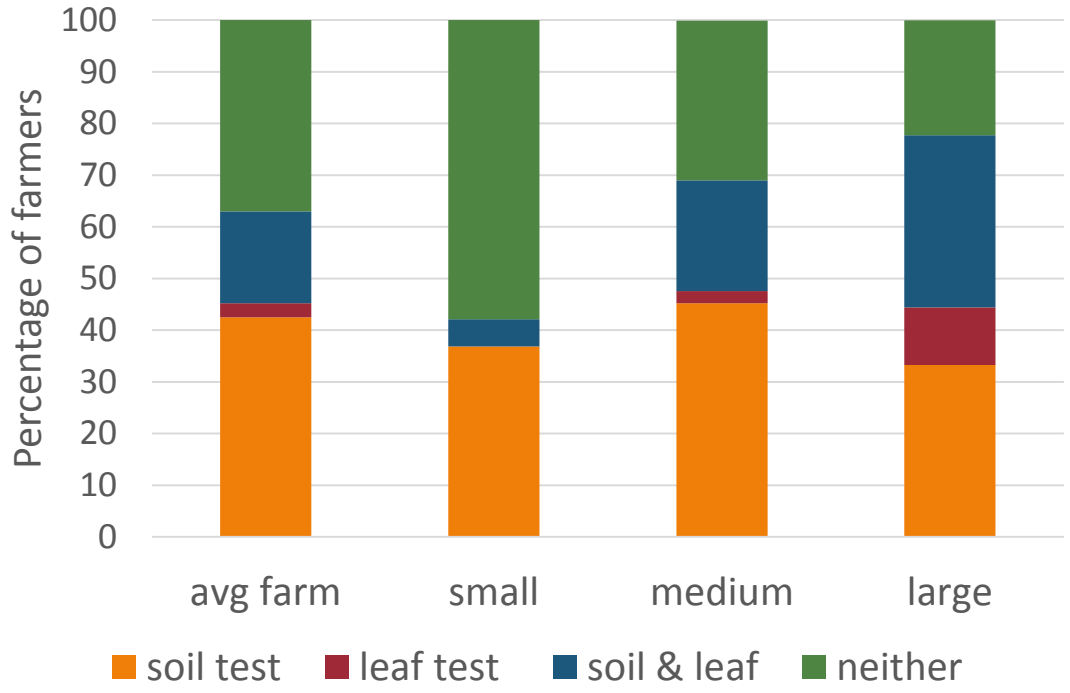
Outline of Presentation

- **Diagnosis of Nutrient Disorders**
- **Soil Health**
  - Characteristics of a healthy Soil
  - Comprehensive Assessment of Soil Health, the Cornell Framework
  - Equipment Needed and Soil Sampling Steps
  - Soil Sample Collection Methodology
  - Timing of sampling and frequency
  - Intense Sampling
- **Soil Test Report**
  - Interpretation of Standard Soil Test Results
- **Plant Analysis**
  - **Plant Tissue Analysis**
    - What and When to Sample
    - Sampling and Handling Procedures
    - Interpretations
  - **Petiole Sap Testing (N and K)**
    - Guidelines
    - Procedures

Tests Used by Growers to Determine Fertilizer Application Needs



Results from 2012 survey where 89 vegetable farms in Indiana responded

- 42% of farms use soil tests
- Very few farms use leaf tests
- Almost 20% use soil and leaf tests
- Over 35% don't use any test

Data source: Purdue 2012 survey of MarketMaker Growers

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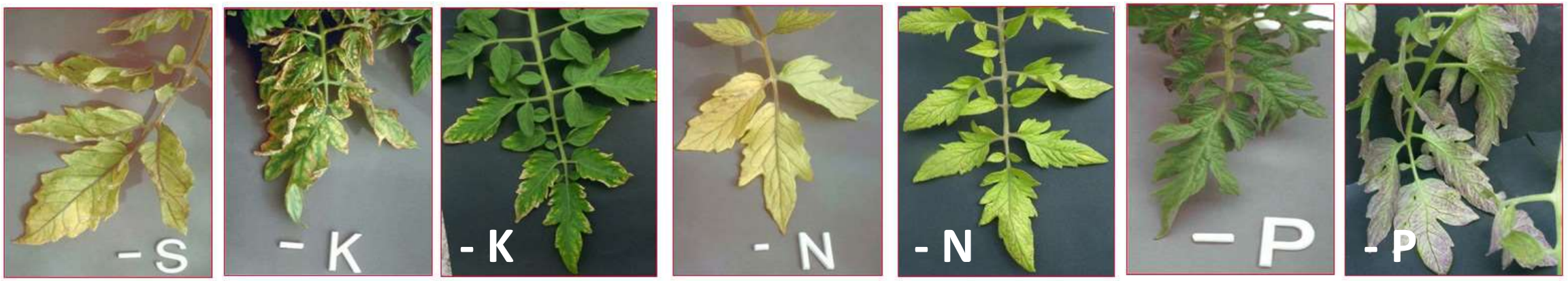
Source: http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/



Key to Visual Diagnosis of Nutrient Disorders

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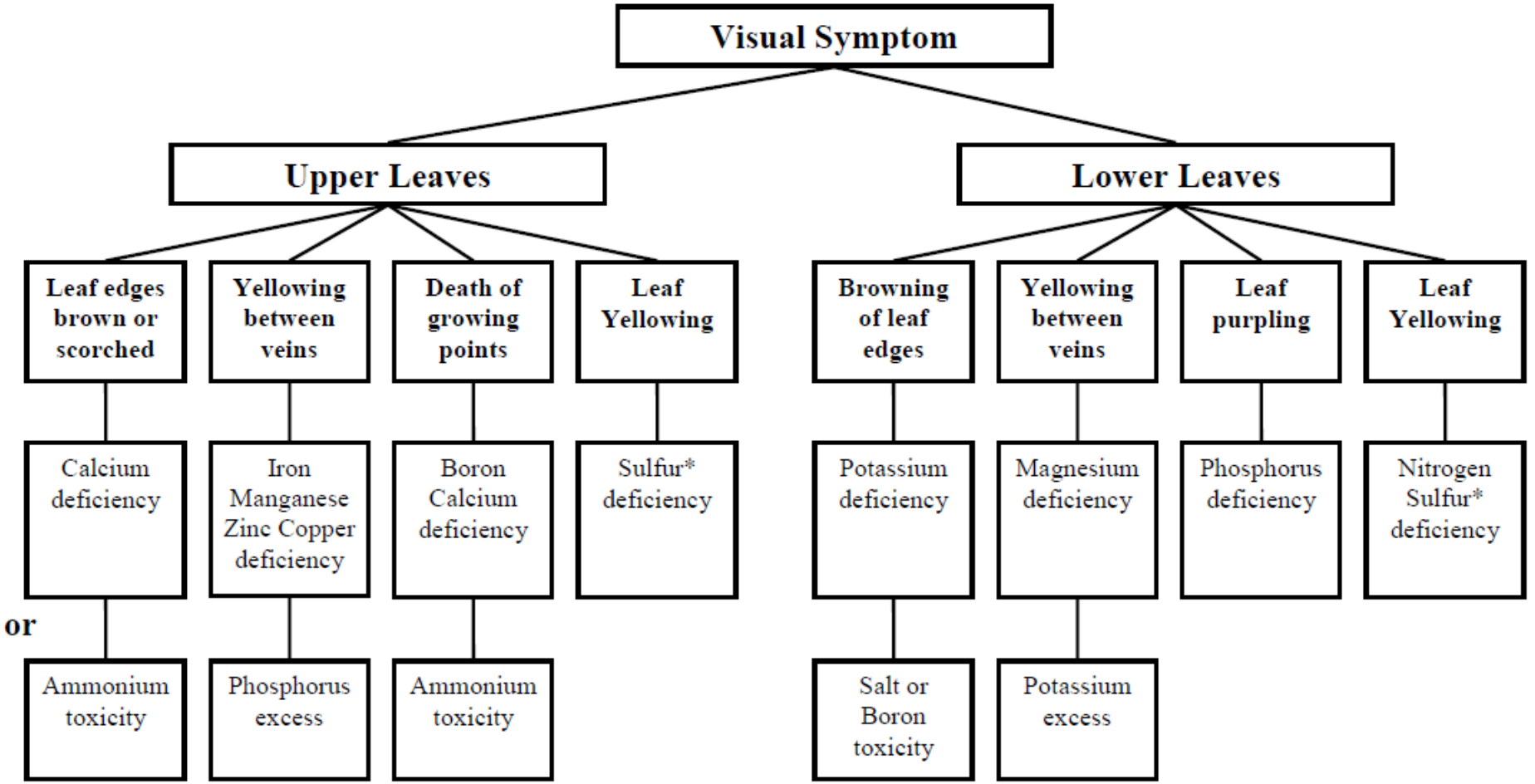
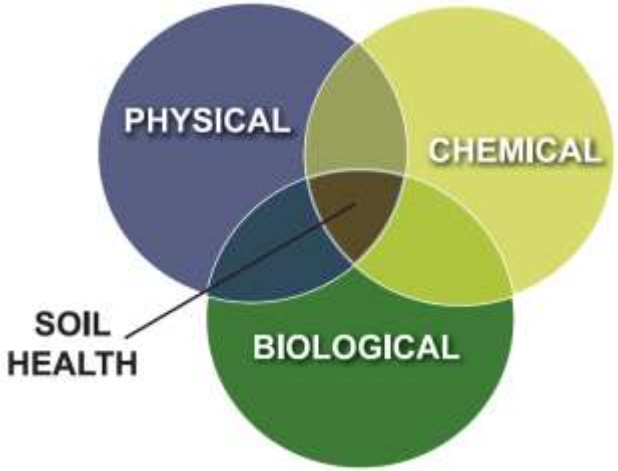


* Sulfur deficiency usually appears as yellowing of both upper and lower leaves

Source: N. Mattson. Cornell University. Adapted from: Bierman P.M. and C.J. Rosen. University of Minnesota. http://www.extension.umn.edu/garden/fruit-vegetable/diagnosing-nutrient-disorders/



Adapted from Rodale Institute

What is Soil Health?

A modern consensus definition: “the continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals and humans”

Concept that deals with the integration and optimization of chemical, physical, and biological processes of soil that are important for sustained productivity and environmental quality

Source: Comprehensive assessment of soil health-The Cornell Framework Manual

Soil Health

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Characteristics of a Healthy Soil

- **Good soil tilth**.....crumbly, well structured, dark with organic matter, and no large hard clods
- **Sufficient depth**.....depth of profile through which roots can grow
- **Good water storage and drainage**.....healthy soil has large, stable pores to take water in
- **Sufficient supply, but not excess of nutrients**
- **Small population of plant pathogens and insect pests**
- **Large populations of beneficial organisms**.....cycling of nutrients, decomposition of OM, etc.
- **Low weed pressure**
- **Free of chemicals and toxins that may harm the crop**.....either lacking or can detoxify
- **Resistant to degradation**.....well aggregated fully diverse soil is more resistant to erosion, drought, vehicle compaction, disease outbreak, etc.
- **Resilience when unfavorable conditions occur**.....will rebound quickly after negative event

Source: http://www.css.cornell.edu/extension/soil-health/manual-print.pdf

Cornell Comprehensive Assessment of Soil Health, four measures

- **Active Carbon……**assesses how much food is available for soil microorganisms to eat
  - … Small subset of the total organic matter. Largely material that was part of living plants in the last 2 to 10 years.
  - … active carbon is maintained by continuously feeding the soil with plant matter
- **Soil Respiration…..**measure of soil-microbe activity
  - … Value can vary over the course of a year or rotation. Generally high if the soil microbes have been fed continuously
- **Soil Protein Index…..**measure of the nitrogen that is available for mineralization
  - … Can be a significant contributor to crop nitrogen needs
  - … Supports the growth of the microbial population during the growing season
  - … Not enough, soil respiration will not increase and the microbes won't be able to take advantage of the active carbon
- **Wet Aggregate Stability…..**measures how well soil aggregates are held together by organic glues
  - … Most glues are formed by rhizosphere microbes
  - … Index high if processes that form and stabilize soil aggregates are proceeding faster than those that destabilize aggregates
  - … Microbes in the rhizosphere depend on carbon compounds secreted from the roots, not just active carbon in the soil

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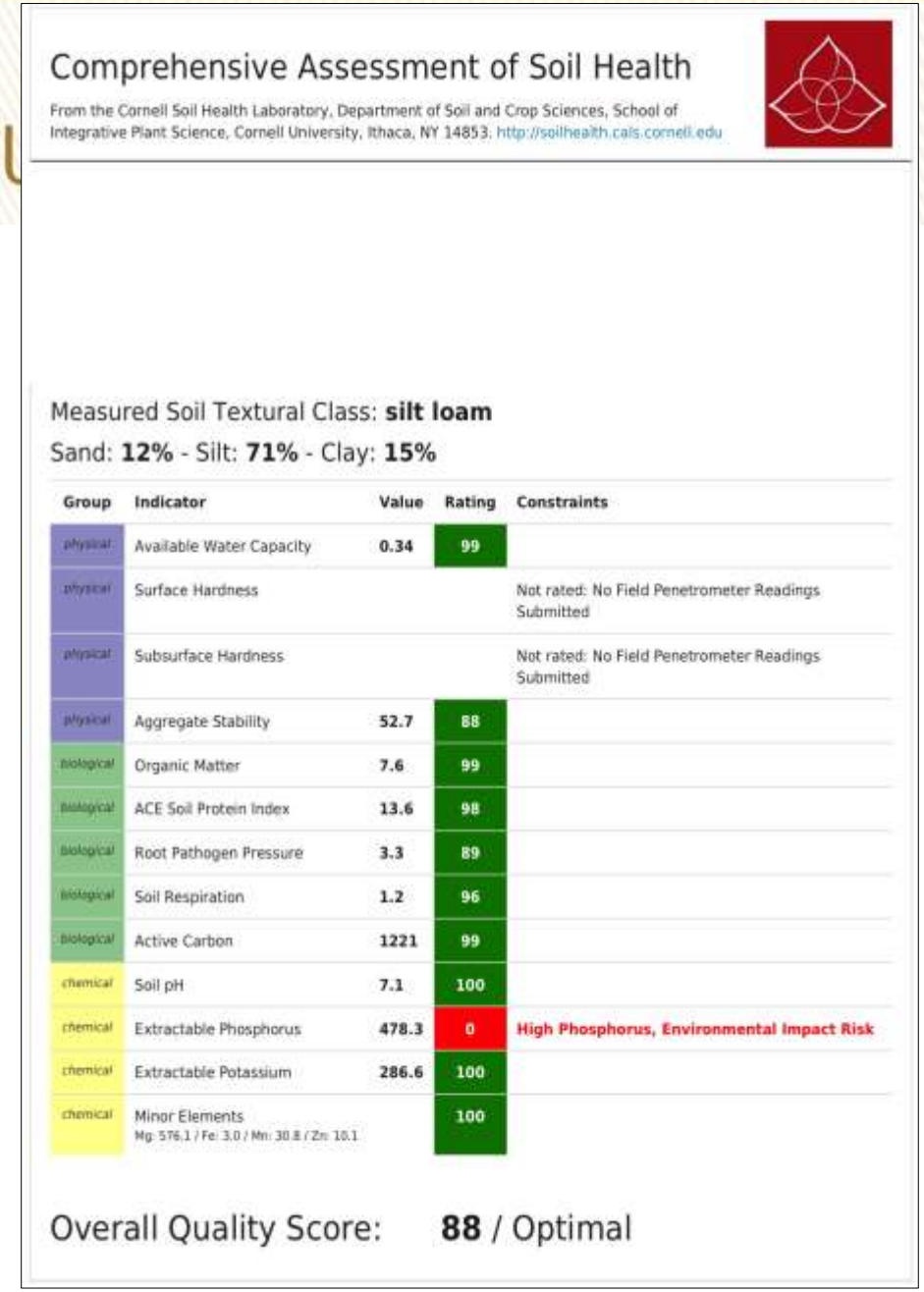
Source: http://www.css.cornell.edu/extension/soil-health/manual-print.pdf

Ratings: scale of 0 to 100, where higher scores are better. Ratings are color coded.

- Red (20 or less) indicate a constraint to proper soil functioning
- Orange and yellow (between 20 and 60), important in addressing current or potentially developing soil health problems
- Green and dark-green (60 or higher) indicates high scores, which suggest optimal or near optimal functioning.

Overall quality score:

- less than 40 is regarded as very low to low
- 40-60 is medium
- 60-80 is high
- and 80 to 100 is regarded as very high



Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Measured Soil Textural Class: **silt loam**

Sand: **12%** - Silt: **71%** - Clay: **15%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.34	99	
physical	Surface Hardness			Not rated: No Field Penetrometer Readings Submitted
physical	Subsurface Hardness			Not rated: No Field Penetrometer Readings Submitted
physical	Aggregate Stability	52.7	88	
biological	Organic Matter	7.6	99	
biological	ACE Soil Protein Index	13.6	98	
biological	Root Pathogen Pressure	3.3	89	
biological	Soil Respiration	1.2	96	
biological	Active Carbon	1221	99	
chemical	Soil pH	7.1	100	
chemical	Extractable Phosphorus	478.3	0	High Phosphorus, Environmental Impact Risk
chemical	Extractable Potassium	286.6	100	
chemical	Minor Elements Mg: 576.1 / Fe: 3.0 / Mn: 30.8 / Zn: 10.1		100	

Overall Quality Score: **88** / Optimal

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Basic Soil Health Analysis Package
Cost: $54 per sample
Sample size: 3 cups
Recommended applications: field crops, dairy, lawns
Includes these tests:

- Soil pH, Organic Matter, Modified Morgan Extractable P, K, and micronutrients
- Wet Aggregate Stability
- Soil Respiration
- Surface, sub-surface hardness interpretation (Optional: You provide the penetrometer readings.)

Standard Soil Health Analysis Package
Cost: $110 per sample
Sample size: 4 cups
Recommended applications: organic production, vegetable crops, problem diagnosis, home gardens
Includes these tests:

- Soil pH, Organic Matter, Modified Morgan Extractable P, K, micronutrients
- Soil Texture
- Active Carbon
- Wet Aggregate Stability
- Soil Respiration
- Autoclave-Citrate Extractable (ACE) Protein Test
- Available Water Capacity
- Surface, sub-surface hardness interpretation (Optional: You provide the penetrometer readings.)

Extended Soil Health Analysis Package
Cost: $155 per sample
Sample size: 6 cups
Recommended applications: urban/ suburban gardens, problem diagnosis, soil health initializing, home gardens, landscaped areas
Includes Standard Soil Health Analysis Package plus:

- Add-on Soluble Salts
- Add-on Heavy Metal Screening
- Add-on Bean Root Bioassay

Timeframe: 4 – 6 weeks

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Soil Sample Collection Methodology

- Evaluate field for differences in soil characteristics. Consider productivity, topography, texture, drainage, color of topsoil and past management
- Composite sample can represent up to 10 or 15 acres on uniform fields and 5 acres on rolling land
- Sample non-uniform fields separately
- Well mixed sample consists of 20 soil cores from a given area
- Sample 6-8” deep for annuals and 10-12” deep for perennials in a zigzag pattern
- Place composite sample (1 pint of mixture of subsamples) in a sample bag
- Send one sample for soil health test and another for soil chemical test

Soil Sampling Steps

Spade, soil auger or probe

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Source: http://www.css.cornell.edu/extension/soil-health/manual-print.pdf

Timing of Sampling and Frequency

- Samples can be taken any time of the year, when temperatures, soil moisture and field conditions permit
- To track soil test values it is best to sample soil at the same time of the year
- Having soil test results available in the fall or early winter enables the development of a soil fertility management plan in a timely manner
- Might be beneficial to sample several times at certain points in the crop rotation

Intense Sampling

- Advances in fertilizer spreader technology have made it possible to vary the amount of fertilizer applied to various parts of the field on the basis of available nutrient levels
- Main approach has been grid sampling
- Development of nutrient management map with test values
- One sample for every two acres

- NRCS Soil Quality Test Kit….
  https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=nrcs142p2_053873

Soil Test Report

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Standard Soil Test Report

Sample ID	Lab Number	Organic Matter %	Phosphorus		Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Soil pH	Buffer pH	CEC meq/100g	Percent Cation Saturation				
			Bray-1 Equiv ppm-P	Bray P2 ppm-P								% K	% Mg	% Ca	% H	%Na
1	1001	2.8	90 VH	126 VH	198 H	245 H	1550 M	15 VL	7.0		10.4	4.9	19.7	74.8		0.6
2	1002	1.4	123 VH	165 VH	147 H	90 H	500 L	15 VL	6.1	6.9	4.9	7.7	15.3	51.1	24.5	1.3
3	1003	1.5	103 VH	155 VH	155 H	115 H	700 M	15 VL	6.1	6.9	6.1	6.5	15.7	57.2	19.6	1.1
4	1004	2.3	58 VH	86 VH	209 H	260 H	1250 M	15 VL	6.7	6.9	10.2	5.2	21.2	61.2	11.7	0.6
5	1005	1.1	89 VH	103 VH	133 H	90 H	750 H	15 VL	6.9		5.0	6.8	15.1	75.3	1.5	1.3
6	1006	2.1	46 H	69 H	174 H	185 H	1150 M	15 VL	6.6	6.9	9.0	5.0	17.1	63.9	13.3	0.7
7	1007	2.1	67 VH	93 VH	240 VH	200 H	1150 M	15 VL	6.9		8.2	7.5	20.3	69.9	1.5	0.8
8	1008	2.3	76 VH	97 VH	186 H	145 M	1050 M	15 VL	6.2	6.9	8.2	5.8	14.7	64.0	14.6	0.8
9	1009	1.8	39 H	42 M	102 M	140 M	1050 M	15 VL	6.7	6.9	7.9	3.3	14.7	66.1	15.1	0.8
10	1010	2.3	49 H	61 H	181 H	310 H	1800 M	15 VL	7.6		12.1	3.8	21.3	74.3		0.5

VL = Very Low *L* = Low *M* = Medium *H* = High *VH* = Very High

Sample ID	Sulfur S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Soluble Salts mmhos/cm	Nitrate NO_3-N ppm	Ammonium NH_4-N ppm	Bicarb-P P ppm		Chloride Cl ppm		Comments
1	8 M	5.9 H	50 VH	70 VH	1.6 H	0.6 M	0.3 VL	16 M	8 L	45 H		50 L		
2	9 M	5.3 H	41 H	60 VH	1.0 M	0.2 VL	0.1 VL	18 M	9 L	62 VH		41 L		
3	8 M	8.8 H	41 H	36 H	1.1 M	0.3 VL	0.2 VL	16 M	8 L	52 VH		41 L		
4	6 L	4.3 M	49 H	37 H	1.4 H	0.4 L	0.2 VL	12 M	6 L	29 H		49 L		
5	7 L	3.4 M	37 H	30 H	0.8 M	0.2 VL	0.1 VL	14 M	7 L	45 H		37 L		
6	5 L	3.9 M	44 H	34 H	1.1 M	0.3 VL	0.2 VL	10 M	5 L	23 M		44 L		
7	5 L	4.7 M	46 H	37 H	1.0 M	0.3 VL	0.2 VL	10 M	5 L	34 H		46 L		
8	6 L	3.8 M	48 H	41 H	1.0 M	0.2 VL	0.1 VL	12 M	6 L	38 H		48 L		
9	5 L	2.7 L	43 H	24 H	0.9 M	0.2 VL	0.1 VL	10 M	5 L	20 M		43 L		
10	4 L	3.6 M	52 VH	22 H	1.2 H	0.4 L	0.2 VL	8 L	4 VL	25 M		52 L		

Interpretation of Standard Soil Test Results…terms

- **ppm (parts per million)**
  - Equivalent to pounds of nutrient per million pounds of soil
  - One acre of mineral soil 6 to 7 inches deep weighs about two million pounds
  - To convert parts per million readings to pounds per acre, multiply by two.
- **Cation Exchange Capacity (CEC), meq/100g (milliequivalents per 100 grams)**
  - Clay complex is negatively charged
  - Soil cations including Ca^{2+}, Mg^{2+}, K^{+} and H^{+} can be expressed in terms of their relative ability to displace other cations
  - Example: One meq of K is able to displace exactly one meq of Mg.
- **mmhos/cm (millimhos per centimeter)**
  - Used to measure the amount of soluble salts in soil. At 2 mmhos/cm soil is considered saline

Interpretation of Standard Soil Test Results

- **Organic Matter**
  - … Amount of decomposed plant, animal residues in a soil (%); darker color associated with high organic matter (test > 3.5%)
- **P1 (Weak Bray) Phosphorus**
  - … Phosphorus that is readily available to plants (20 to 50 ppm is adequate for most vegetable crops, but depends on location)
- **P2 (Strong Bray) Phosphorus**
  - … Phosphorus that is readily available and part of the active reserve phosphorus in a soil (40 to 60 ppm is a desirable level)
- **Sodium Bicarbonate Phosphorus**
  - … Readily available phosphorus in calcareous soils (15 ppm or more is desired)
- **Potassium**
  - … Measure of available potassium in a soil (150 to 300 ppm is adequate for most vegetable crops)

Interpretation of Standard Soil Test Results…continue

- **Magnesium and Calcium**
  - … Calcium deficiencies are rare when the soil pH is adequate. Magnesium deficiencies are more common. These basic cations are closely related to soil pH. Magnesium levels exceeding 50 ppm are adequate for most crops. Calcium levels at 1000 to 2500 ppm is adequate.
- **Sodium…**
  - … Not an issue in Indiana
- **Soil pH**
  - … Active acidity or alkalinity (pH of 6.0 to 7.0 on mineral soils and for organic soils 5.0 to 5.5)
- **Buffer pH**
  - … Soil's potential acidity; lower buffer pH represents a larger amount of potential acidity (more lime needed to increase soil pH)
- **Soluble Salts**
  - Excessive concentrations of various salts can develop in soils

Interpretation of Standard Soil Test Results…continue

- **CEC (Cation Exchange Capacity)**
  - … CEC measures the soil's ability to hold nutrients such as Ca^{2+}, Mg^{2+}, and K^{+} as well as other positively charged ions (Na^{+} and H^{+}). CEC will vary with the kind and amount of clay and percent of organic matter. Between 5 to 35 meq/100g soil is optimal.
- **Percent Base Saturation**
  - … Proportion of the CEC occupied by a given cation or a combination of cations, referred to as bases (Ca 40-80%, Mg 10-40%, K 1-5%).
- **Sulfur**
  - … Measure of sulfate-sulfur, readily available form preferred by plants (optimum levels usually range from 15 to 20 ppm)
- **Micronutrients**
  - … Available levels are rated from very low to very high. Crop response after application is influenced by factors i.e. soil pH, soil type, physical properties, moisture and crop variety
  - … Zn 1 to 3 ppm, Mn 6 to 12 ppm, Fe 11 to 16 ppm, Cu 0.5 to 1.5 ppm, B 0.7 to 1.0 ppm, Mo 0.11 to 0.20 ppm

Basic Soil Package

ID	Description	With Recommendations	Without Recommendations
S1	Organic Matter, Available Phosphorus, Exchangeable Potassium, Magnesium, Calcium, Soil pH, Buffer pH, Cation Exchange Capacity, Percent Base Saturation of Cation Elements	$9.35	$8.35
S1A	S1 plus Strong Bray Phosphorus	$10.75	$9.75
S1B	S1 plus Sodium Bicarbonate Phosphorus	$11.75	$10.75
S1AB	S1 plus Strong Bray & Sodium Bicarbonate Phosphorus	$13.25	$12.25
S2	S1 plus Soluble Salts and Sodium	$13.75	$12.75
S3	Sulfur, Zinc, Manganese, Iron, Copper, Boron	$10.00	$10.00
S4	Zinc, Manganese, Iron, Copper	$8.50	$8.50
S5	Sulfur, Zinc	$5.00	$5.00
S6	Sulfur, Zinc, Manganese, Boron	$8.50	$8.50
S7	Zinc, Manganese, Boron	$7.00	$7.00

Soil Physical Measurements

Description	
Sand Classification (USDA Size Limits by Wet Sieving)	$40.00
Sand Classification (USGA Size Limits by Wet Sieving)	$48.00
1/3 plus 15 Bar Moisture Limits by Pressure Membrane	$40.00
Additional Pressure Limits (0.1, 1.0, 3, 5, 10 Bar) Each	$25.00
Bulk Density (Disturbed Soil)	$12.00
Particle Size Analysis (%Sand, %Silt, %Clay, and Textural Classification by Hydrometer Method)	$18.00
Particle Size Analysis (ASTM D422)	$120.00
Particle Size Analysis (ISDH Septic System Site Evaluation)	$40.00
Coarse Fragments (>2mm)	$17.00
Coarse Fragments (ASTM D422)	$75.00

Pre-sidedress Nitrate Test (PSNT)

- Useful for estimating nitrogen supply during the growing season
- Sample soil shortly before rapid crop growth and sidedressing or topdressing
- Dry sample quickly or freeze and send to soil analysis lab
- Guidelines from the Northeast:
  - Sweet corn no sidedressing needed if NO_3-N > 20-25 ppm in top 12 inches
  - Pumpkin, winter squash, cabbage, peppers: no sidedressing needed if NO_3-N > 25-30 ppm in top 12 inches

Reference: Using the Pre-Sidedress Soil Nitrate Test to Improve Nitrogen Management in Vegetable Cropping Systems. Spargo, Mangan, and Howell, 2013. https://soiltest.umass.edu/fact-sheets/using-pre-sidedress-soil-nitrate-test-improve-nitrogen-management-vegetable-cropping

Plant Analysis

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Plant Tissue Analysis …..What and When to Sample

- Can be helpful to diagnose in-season plant growth problems
- Can also help to adjust long-term nutrient management plan
- Diagnosing suspected deficiency or toxicity problems – collect samples from affected plants and from healthy plants for comparison
- Low levels of nutrients in the plant does not always mean that it is not available in the soil
- Use results together with soil test results to determine whether the problem is nutritional
- Usually the leaf with petiole or just the petiole alone is sampled
- Proper time and plant part to sample, consult i.e. Nutrient Management for Commercial Fruit & Vegetable Crops in Minnesota (BU-05886) and your lab where you plan to send samples
    - http://www.extension.umn.edu/garden/fruit-vegetable/nutrient-management-for-commercial-fruit-and-vegetables-in-mn/

Plant Tissue Analysis …..Example of Sampling Procedures

Crop	Stage of Growth	Plant Part Sampled	Approx. # of Plants or Leaves to Sample
Cantaloupe	Early Fruiting	Fifth Leave from tip	25
Carrots	Midgrowth	Young Mature Leave	25
Cucumbers	Early Fruiting	Fifth Leave from tip	20
Eggplant	Early Fruiting	Young Mature Leave	15
Lettuce	Heads, half-size	Wrapper Leave	20
Peppers	Early Fruiting	Young Mature Leave	20
Pumpkin/Squash	Early Fruiting	Young Mature Leave	15
Tomatoes	First Mature Fruit	Young Mature Leave	20
Watermelons	Midgrowth	Young Mature Leave	15

http://www.extension.umn.edu/garden/fruit-vegetable/nutrient-management-for-commercial-fruit-and-vegetables-in-mn/

Plant Tissue Analysis …..Sampling and Handling Procedures

- Representative sample should not represent more than 10 acres of even uniform land
- Consult Univ. of Minnesota Extension pub. BU-05886 for the number of plants or leaves required per sample
- Do not sample damaged leaves or leaves sprayed with foliar fertilizer
- Avoid sampling dirty or dusty leaves (rinse quickly in demineralized or distilled water)
- Sample should be dried as rapidly as possible (forced air drying at 150 – 170°F preferred, but air drying also permissible)
- Transport samples in loose fitting paper or cloth bags
- Consult your closest laboratory before sampling and shipment

Plant Tissue Analysis …..Example of Nutrient Concentration Ranges

Crop	N	P	K	Ca	Mg	S	Fe	B	Cu	Zn	Mn	Mo
	%						ppm					
Cantaloupe	1.4-5.5	0.30-0.80	4.0-5.0	2.3-3.0	0.35-0.80	0.25-1.0	40	50-300	25-60	7-30	20-200	50-250
Carrots	2.5-3.5	0.20-0.30	2.8-4.3	1.4-3.0	0.30-0.50	-	50-300	30-100	5-15	25-250	60-200	0.5-1.5
Cucumbers	4.5-6.0	0.30-1.25	3.5-5.0	1.0-3.5	0.30-1.00	0.30-0.70	50-300	25-60	5-20	25-100	50-300	-
Eggplant	4.2-5.0	0.45-0.60	5.7-6.5	1.7-2.2	0.25-0.35	-	-	20-30	4-6	30-50	15-100	-
Lettuce	2.5-4.0	0.40-0.60	6.0-8.0	1.4-2.0	0.50-0.70	-	50-500	30-100	7-10	26-100	30-90	>0.1
Peppers	3.5-4.5	0.30-0.70	4.0-5.4	0.4-0.6	0.30-1.50	-	60-300	30-100	10-20	30-100	26-300	-
Pumpkin / Squash	4.0-6.0	0.35-1.00	4.0-6.0	1.0-2.5	0.30-1.00	-	60-300	25-75	6-25	20-200	50-250	-
Tomatoes	4.0-6.0	0.25-0.80	2.9-5.0	1.0-3.0	0.40-0.60	0.40-1.20	40-200	25-60	5-20	20-50	40-250	-
Watermelons	2.0-3.0	0.20-0.30	2.5-3.5	2.5-3.5	0.60-0.80	-	100-300	30-80	4-8	20-60	60-240	-

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http://www.extension.umn.edu/garden/fruit-vegetable/nutrient-management-for-commercial-fruit-and-vegetables-in-mn/

Or MSU Extension Bulletin E2934. Nutrient recommendation for Vegetable Crops in Michigan

Plant Tissue Tests….estimates

Plant Tissue Tests Packages	Analysis cost
Regular analysis: nitrogen, phosphorus, potassium, calcium and magnesium + drying and grinding	$17
Regular analysis plus micro nutrients: copper, iron, manganese and zinc + drying and grinding	$23
Complete nutrient analysis package: regular+ micros + boron, molybdenum and sulfur + drying and grinding	$30
Micro nutrients only: copper, iron, manganese and zinc	$12
Individual analyses (per nutrient)	
Nitrogen (TKN)	$10
Phosphorus (P)	$5
Potassium (K)	$5
Calcium (Ca) or Magnesium (Mg)	$5
Iron (Fe) or Copper (Cu) or Zinc (Zn) or Manganese (Mn) Write the element/s to be analyzed	$5
Boron	$5
Chloride	$6.50
Nitrate-N	$8

Petiole (leaf stem) Sap Testing (N and K) …..Guidelines

- **Time of day**
  - … Readings consistently between 11 a.m. and 2 p.m. will yield most consistent results (nitrate-N levels peak)
  - … Do not collect samples after a rain or irrigation event of 1 inch or more in the past 24 hours, or when temperatures are high (>95°F) or humidity (>90% RH) is high for several days
  - … Standardization of temperature and weather conditions when sampling will provide best test results
- **Leaf age**
  - … Sample uppermost, recently matured leaves—those leaves that have reached maximum size and have changed from a juvenile light green color to a dark green color
- **Leaf part**
  - … In most crops, the petiole is easy to identify. For tomatoes, which have compound leaves, the petiole is the whole leaf stem with all the small petiolules (and tiny leaflets) stripped off
- **Number of leaves**
  - … Sap sample needs to be representative of the field or area being tested
  - … Usually about 25-30 leaves per sample

Petiole Sap Testing (N and K) …..Sampling Procedures

- Prevent moisture loss after picking; remove petiole immediately and place in plastic bag in cooler with ice
- Petioles should be chopped and mixed, and a subsample used to crush
- Use a garlic press to extract the sap
- Do not store expressed sap for long periods of time (unless frozen)
- Analyze within 1-2 hours
- Horiba Cardy or Laqua meters are popular equipment for sap-testing

Source: www.specmeters.com

- Meters are sensitive to temp. changes; frequent recalibration is necessary through the day
- Not as precise as lab tests
- Relatively simple, give immediate results, and are particularly useful for making timely adjustments in fertilizer application rates when using fertigation

Field Tomato Petiole Sap Guidelines-Univ. of Florida

Stage	NO_3-N (ppm)	NO_3 (ppm)	K (ppm)
First buds	1000-1200	4300-5150	3500-4000
First open flowers	600-800	2600-3400	3500-4000
1-inch fruits	400-600	1700-2600	3000-3500
2-inch fruits	400-600	1700-2600	3000-3500
First harvest	300-400	1300-1700	2500-3000
Second harv.	200-400	850-1700	2000-2500

Conversion factor:
ppm NO_3 x 0.226 = ppm NO_3-N
ppm NO_3-N x 4.43 = ppm NO_3

Hochmuth, G., Maynard, D., Vavrina, C., Hanlon, E., and Simonne, E., 2015. Univ. of Florida Extension Pub. HS964. Plant tissue analysis and interpretation for vegetable crops in Florida. http://edis.ifas.ufl.edu/pdffiles/EP/EP08100.pdf

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Literature Resources

- Soil quality for Environmental Health. University of Illinois at Urbana-Champaign. http://soilquality.org/home.html
- Comprehensive Assessment of Soil Health. Cornell University. https://soilhealth.cals.cornell.edu/
- NRCS Soil Quality Test Kit…. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=nrcs142p2_053873
- Using the Pre-Sidedress Soil Nitrate Test to Improve Nitrogen Management in Vegetable Cropping Systems. Spargo, Mangan, and Howell, 2013. https://soiltest.umass.edu/fact-sheets/using-pre-sidedress-soil-nitrate-test-improve-nitrogen-management-vegetable-cropping

Literature Resources

- Nutrient Management for Commercial Fruit & Vegetable Crops in Minnesota (BU-05886). University of Minnesota. http://www.extension.umn.edu/garden/fruit-vegetable/nutrient-management-for-commercial-fruit-and-vegetables-in-mn/
- Michigan State University, Extension Bulletin E2934. Nutrient recommendation for Vegetable Crops in Michigan. http://msue.anr.msu.edu/resources/nutrient_recommendations_for_vegetable_crops_in_michigan_e2934
- Knott's Handbook for Vegetable Growers, 5th Edition. http://extension.missouri.edu/sare/documents/KnottsHandbook2012.pdf

THANK YOU

Questions?

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