Berry Crop Soil and Nutrient Management – The Basics

NORTHEAST SARE
Sustainable Agriculture Research & Education

Utility of Soil and Tissue Testing…

- Pre-plant
  - Maximize soil health ⇒ maximize plant establishment and longevity
    - Identification and remedy of soil constraints
    - Soil pH adjustment
    - Addition and incorporation of required nutrient inputs
- Post-plant
  - Optimize profitability
    - Avoid costly over or under fertilization
    - Optimize crop yield and quality
    - Protect the environment

Types of Soil and Tissue Testing

- Standard Soil Test
  - Used in established plantings in concert with tissue analysis to determine nutrient status of plants
  - Used in established plantings for diagnostic testing when nutrient imbalances are suspected
- Cornell Soil Health Test
  - Used pre-plant to identify soil health constraints
    - Includes standard soil test
  - Used in established plantings for diagnostic testing when soil health issues are suspected
- Tissue Analysis
  - Used in established plantings in concert with standard soil test or soil health test to determine nutrient status of plants.

Routine vs. Diagnostic Testing

Routine

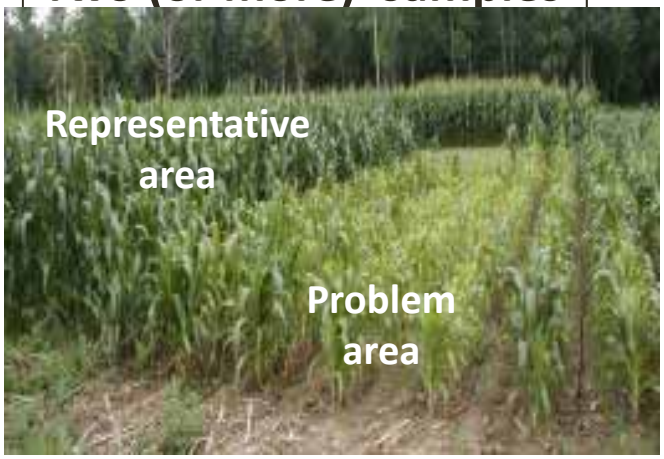
- Lime and fertilizer recommendations for plant maintenance
- No known history of fertility or soil health problems

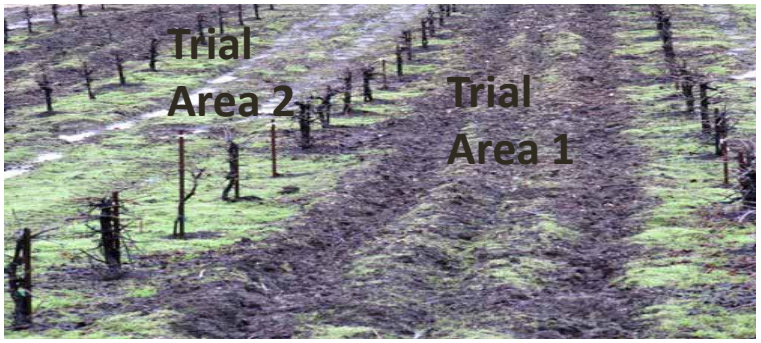
Diagnostic

- Suspected nutrient imbalance or soil health issue
  - Use paired samples, “good” and “bad” areas to confirm problem.
  - Consider adding soluble salts package if marginal leaf burning/necrosis is present
  - Use plant tissue analysis to further assist in diagnosis

Sampling Strategy

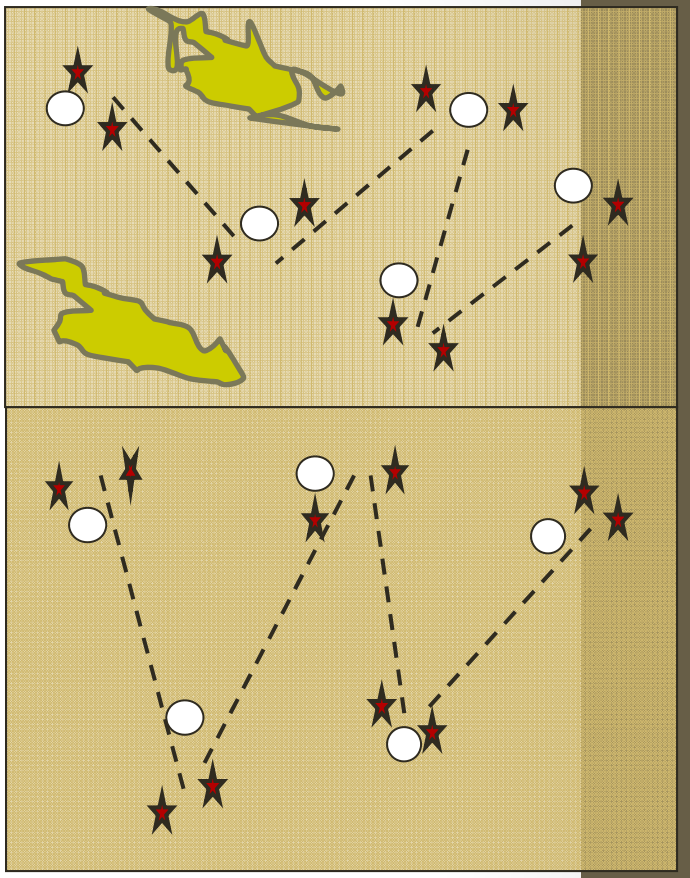
Uneven field-
Two (or more) samples





Trial area 1- "poor"

Trial area 2- "ideal"



Determine which field features will be sampled:

- by soil type
- by management practice
- by crop growth and yield

"benchmark area" sample (native)

About Standard Soil Tests…

- Different soil testing labs use various extractants to estimate the amount of plant-available nutrients
- Numbers can vary greatly between labs depending on which extractant is used
- Do not use values from one lab with recommendations from another lab

Agro-One Standard Soil Test

Dairy One

Agro-One Soils Laboratory
730 Warren Road, Ithaca NY 14850
Phone: 800-344-2697 • Fax: 607-257-1350
soil@dairyone.com
www.dairyone.com

- Soil test packages and nutrient guidelines for the Northeast
  - *Maryland, New Hampshire, New York, Pennsylvania, and Vermont*
- New York customers also have the option of an Agro-One analysis with Cornell recommendations*

*Cornell recommendations are based on a modified Morgan extractant and have been developed for each berry crop.

Sampling Tools

- Stainless steel probe or auger
  - Iron contamination (rust) can be an issue
  - Shovels/spades – generally not a good idea
    - Wedge-shaped samples not representative
    - Edges need to be trimmed off
    - Slower, more difficult to get good sample
- Clean plastic pail for mixing
  - Zinc contamination may be a problem when used galvanized pails or sampling tools
- Agro-One sample boxes and forms

Probe…

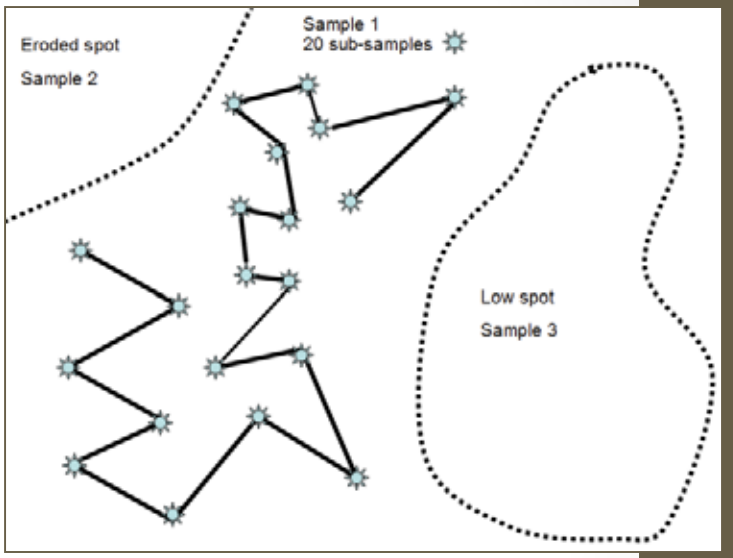
- Probes for dry soils with few rocks
  - Collect a continuous core through the entire sampling depth
  - Minimum disturbance of the soil
  - Faster in good conditions
  - Easier on your back
  - May use lubricant to prevent plugging of probe
    - WD 40, PAM, Dove dish soap, Silicone
    - Do not use if micronutrient deficiency suspected
  - Prices range from $50 to $1,000 for standard soil test probes/kits

… or Auger?

- Auger for rocky or wet soils
  - Wet soil sticks to auger flights but still works
  - Power drill may be used if doing a lot of samples
  - DIY plastic container with hole in center collects soil as auger pulls it out.

Soil Sampling Guidelines

- Sample each “management area” separately
- Remove top 1 inch or organic matter/debris
- Take sub-samples in zigzag pattern in each management area
  - 8-10 subsamples if < 2 acres
  - 10-20 subsamples if > 2 acres
- Pre-plant Berries
  - Surface 0 – 8” (rooting depth for most berry crops)
- Established plantings
  - Sample to 8” depth
  - Use in conjunction with tissue analysis

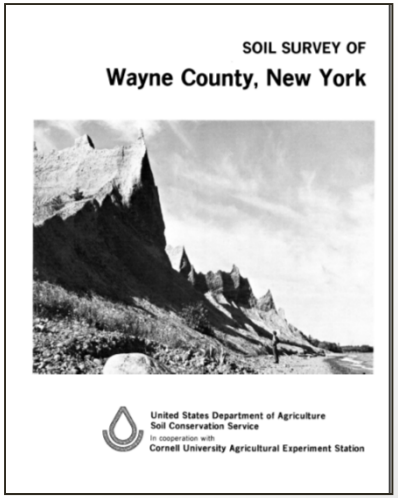


Soil Sampling Guidelines

- Subsamples
  - Discard organic “matt” on top and soil below 8 inches
  - Mix subsamples completely in clean plastic pail
    - Remove large stones, break up clods before mixing
    - If muddy, dry then mix
  - Air dry wet samples in thin layer on clean surface
    - No heater, fan OK
    - Plastic or stainless steel tray or box…
  - Ship in container provided
    - Include all necessary forms with requested information completed

How to Find Soil Series Names

- Soil Series Name is required for Agro-One nutrient guidelines in NY
  - Use mapping tools to identify soil series
    - http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
  - iPhone app!
    - http://itunes.apple.com/us/app/soil-web-for-the-iphone/id354911787?mt=8
  - County soil map
    - No longer in print
    - Local CCE offices often have copies on hand…



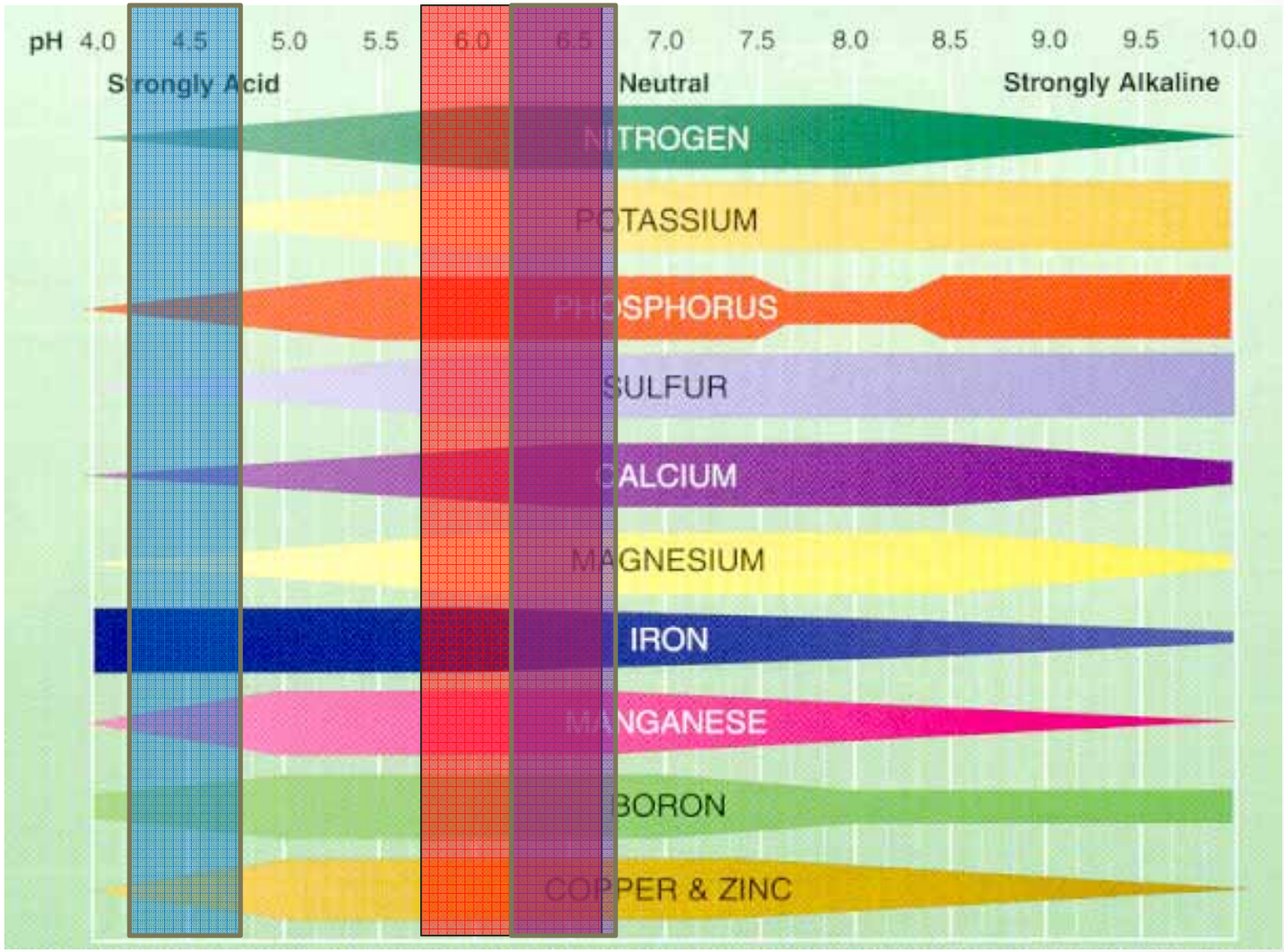
Interpreting Soil Test Results

- Check your soil pH – is it right for the berry crop you're growing?
  - Strawberries and Raspberries – 6.2 to 6.5
  - Blueberries - 4.2 to 4.5
- Do your macro-nutrient levels (N, P and K) fall in medium range or above?
- What's your soil organic matter content? (3% or higher best for berry crops)
- Soil calcium
  - Should be 2,000 lb/A or less for blueberries
- Soil aluminum
  - high levels (> than 300 lb/A) of this nutrient are toxic to berries
  - The problem is greater in acid soils
  - Do not use aluminum based fertilizers i.e. aluminum sulfate

If pH is not within a desired range, then the ability of the plant to take up nutrients will be compromised.

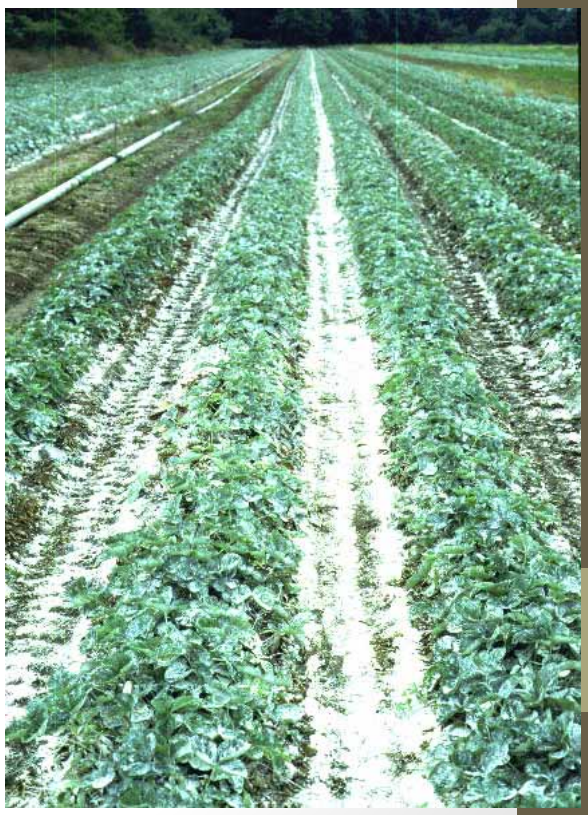
A WORD ABOUT SOIL pH

Soil pH and Nutrient Availability



Modifying Soil pH

- Sulfur can be used to lower pH and lime can be used to raise pH Soil pH modification is best accomplished pre-plant
  - Changing soil pH after planting is extremely slow and difficult
- **Significant time is required for lime or sulfur to affect the pH (6 months or longer)**
- For more information on modifying pH see the NRAES Production Guide for the Berry Crop in question.



Component	Mod. Morgan ppm	Mod. Morgan lbs/acre	Morgan Equiv. lbs/acre	Soil Test Levels
				Very Low / Low / Medium / High / Very High
Phosphorus (P)	4	8	9	**********
Potassium (K)	88	176	175	**********
Calcium (Ca)	1,802	3,605		**********
Magnesium (Mg)	302	603		**********

Water		Calcium Chloride		No Till		Organic Matter (%)	Nitrate-N (ppm)	HWS Boron (lbs/acre)	Soluble Salts (mmhos/cm)	Total N (%)
pH	Buffer pH	pH	Buffer pH	pH	Buffer pH					
6.1	5.9					4.6		0.9		

Other Nutrients, Mod. Morgan, lbs/acre								
Sodium (Na)	Aluminum (Al)	Sulfur (S)	Zinc (Zn)	Manganese (Mn)	Iron (Fe)	Copper (Cu)	Boron (B)	Molybdenum (Mo)
	62.6		0.5	14.6	5.6			

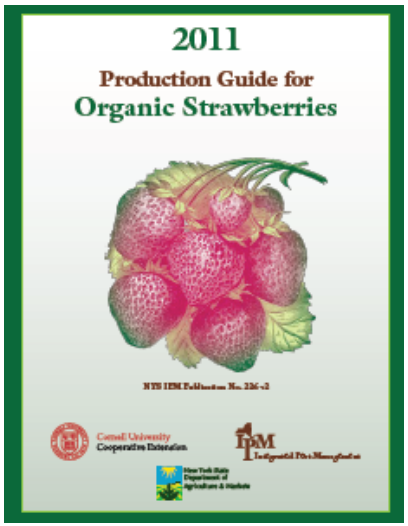
Soil Fertilizer Recommendations		tons / acre	lbs / acre			lbs / 1000 sqft			
Year	Crop	Lime	N	P_2O_5	K_2O	Lime	N	P_2O_5	K_2
1	Strawberries, Spring	0.0	100	25	0	0.0	2.3	0.6	0.

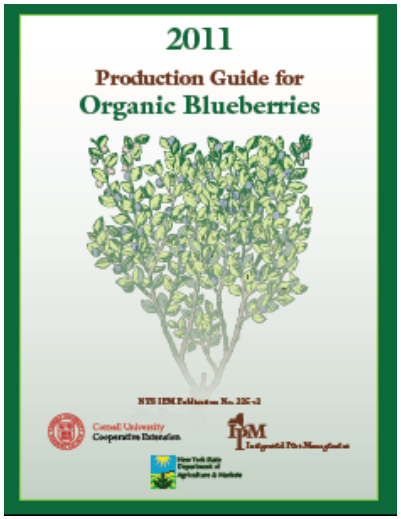
Comments

Nutrient recommendations provided by Cornell University.
These are general comments. Always consult with your crop advisor for recommendations specific to your farm.
For assistance interpreting your report, contact your local Cooperative Extension office at 607-272-2292.
Yr1 Apply 80 lbs/acre of N in July, and another 20 lbs/acre the first of September. Do not apply N in early spring except on sandy soils.
Yr1 Apply fertilizer uniformly around the plants or through drip irrigation. Do not allow granules to remain on leaves. Do not fertilize when leaves are wet.
Yr1 The best time to apply potassium and phosphorus fertilizers is in the fall before mulch is applied.
Yr1 Use both a soil test and leaf analysis to adjust nutrient levels.

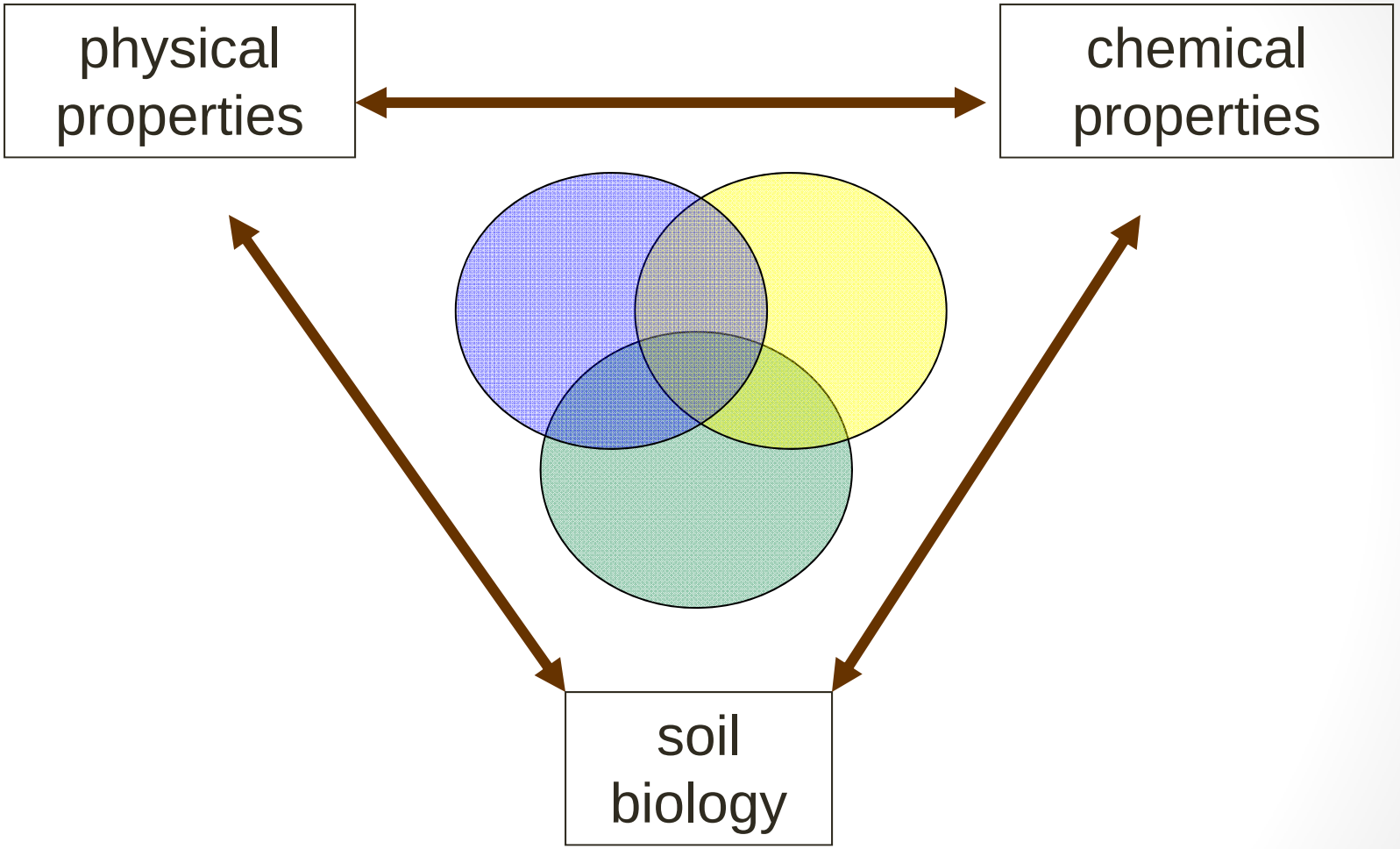
Organic vs. Conventional

- Recommendations are mostly THE SAME whether one is organic or conventional
- The difference is in the source of the fertilizer/amendment to be applied – not the recommended amount
  - a few exceptions depending on release rate
- http://www.nysipm.cornell.edu/organic_guide/





INTERACTION



These soil properties also interact with the growth of plants creating a complex ***soil ecology***

Cornell Soil Health Test

Cornell Nutrient Analysis Lab (CNAL),
G01 Bradfield Hall, Ithaca, NY 14853
(607) 255-4540
Soil Health Coordinator: Bob Schindelbeck (607) 227-6055, rrs3@cornell.edu
E-mail: soilhealth@cornell.edu
Website: http://soilhealth.cals.cornell.edu

- Basic Package ($45)
  - Recommended for :
    - conventional grain and forage crops
    - non-agricultural applications (landscaping, site remediation, etc.)

- Standard Package ($75)
  - Recommended for:
    - vegetable production
    - organic production
    - problem diagnosis in landscaping and other urban applications
    - ***first-time soil health assessment***

Soil Health is…

"the capacity of the soil to function…."

(Doran and Parkin, 1993)

… chemically, biologically and physically.

Characteristics of Healthy Soils

- Good tilth
- Sufficient (but not excess) nutrients
- Sufficient depth
- Good water storage and drainage
- Free of chemicals that might harm plants
- Low populations of plant disease and parasitic organisms
- High populations of beneficial organisms
- Low weed pressure
- Resistance to being degraded
- Resilience (quick recovery from adverse events)

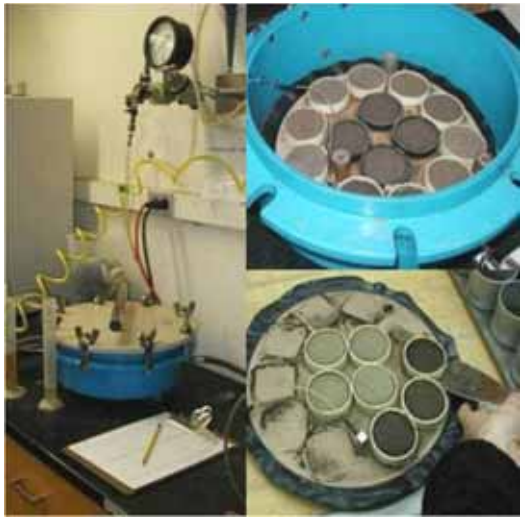
General Signs of Poor Soil Health

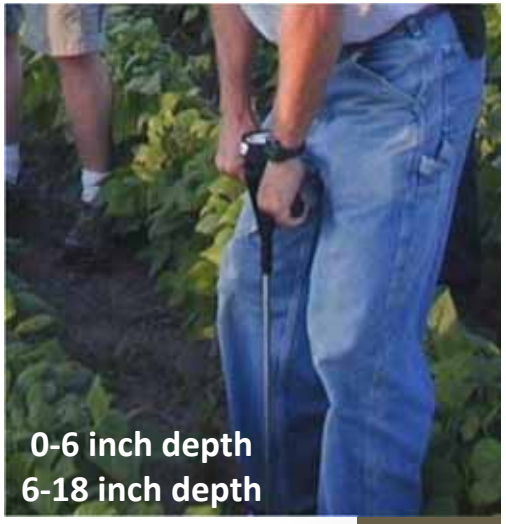
- Plowing up cloddy soil and poor seedbeds
- Hard soil (at planting, etc.)
- Rapid onset of stress or stunted growth during dry or wet periods
- Poor growth of plants
- Declining yields
- High disease pressure
- Signs of runoff and erosion

An Example of Interaction

Hard soil reduces rooting:

- **Compacted, dense soil layers** restrict rooting volume to **exploit water** and **nutrients**
- **Compacted soil suppresses beneficial biological processes**
- **Poor drainage reduces rooting and aerobic biological processes**
- **Compaction** increases **root diseases** and **denitrification** losses



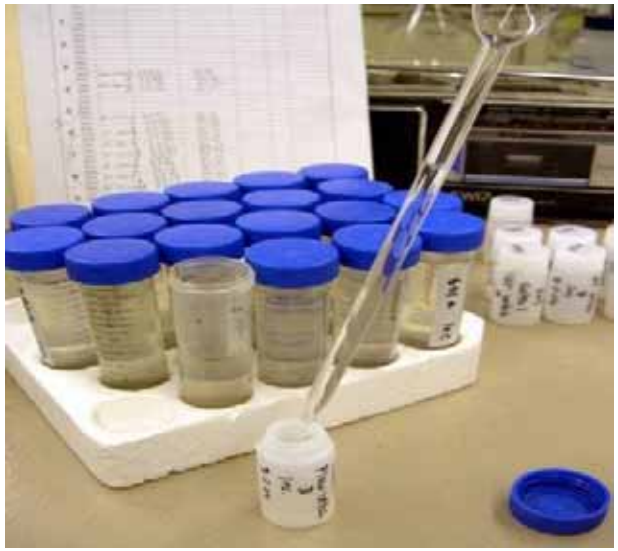


Rapid Soil Texture Wet Aggregate Stability Available Water Capacity Field Penetration

Cornell Soil Health Test Analyses (plus Chemical tests)

Active Carbon test

Potentially Mineralizable N



Root Health rating

Cornell Soil Health Test Guidelines

- You will need:
  - 2 5-gallon buckets/containers (one for soil, one for supplies)
  - 1 zip-loc bag (large 1-gallon)
  - 1 600 ml plastic beaker (3 cup capacity)
  - Permanent marker and pen
  - Trowel or spade
  - Penetrometer
  - Grower and field information sheet
  - Clipboard (if desired)

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Cornell Soil Health Assessment 2012

FIELD AND FARM INFORMATION

SOIL INFORMATION ★Remember: 4-6 cups of soil are needed!★

CROP INFORMATION (see back of this sheet for Crop Codes)

FIELD PENETROMETER DATA COLLECTION (use SMALL 1/2" tip)

Cornell Soil Health Test Guidelines

- Sampling is done roughly in the same manner as for the standard soil test with these exceptions:
  - Sample in spring when soil is at field capacity
  - Use a trowel or spade to sample soil as a larger volume of soil is required for this test.
  - Make 5 stops across the field, collecting 2 subsamples at each stop. Mix subsamples thoroughly.
  - Take 2 penetrometer readings (0-6” and 6-18” depths) at each subsample location. Record on form.
  - Place 6 full cups (1.5 quarts) mixed soil into zip-loc bag labeled with field name/ID and date.
  - Keep samples out of direct sunlight; preferably in cooler in field.
  - Store in cold room or refrigerator; ship as soon as possible.

Interpreting Soil Health Test Results

- The report is a management guide, not a prescription.
- Different management approaches can be used to mitigate the same problem.
- In addressing some soil constraints, management practices can affect multiple indicators.
- Soil health changes slowly over time.

HEALTH TEST REPORT

14 years fall plow
Corn for grain
Clay loam

	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	22.3	10	aeration, infiltration, rooting
	Available Water Capacity (m/m)	0.13	25	water retention
	Surface Hardness (psi)	42	94	
	Subsurface Hardness (psi)	390	1	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	3.9	42	
	Active Carbon (ppm) [Permanganate Oxidizable]	614	27	Soil Biological Activity
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	6.3	2	N Supply Capacity
	Root Health Rating (1-9)	3.2	75	
CHEMICAL	pH (see Nutrient Analysis Report)	6.1	67	
	Extractable Phosphorus (see Nutrient Analysis Report)	2.6	44	
	Extractable Potassium (see Nutrient Analysis Report)	78.8	100	
	Minor Elements (see Nutrient Analysis Report)		100	
OVERALL QUALITY SCORE (OUT OF 100):			48.9	Low

Soil Textural Class:==> clay loam

SAND (%): 21.0 *SILT (%): 42.0* *CLAY (%): 37.0*

CORNELL SOIL HEAL

14 years No till
Corn for grain
Clay loam

	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	72.3	94	
	Available Water Capacity (m/m)	0.18	50	
	Surface Hardness (psi)	153	60	
	Subsurface Hardness (psi)	218	73	
BIOLOGICAL	Organic Matter (%)	5.3	82	
	Active Carbon (ppm) [Permanganate Oxidizable]	556	19	Soil Biological Activity
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	14.5	99	
	Root Health Rating (1-9)	5.0	63	
CHEMICAL	pH (see Nutrient Analysis Report)	5.8	44	
	Extractable Phosphorus (see Nutrient Analysis Report)	5.0	100	
	Extractable Potassium (see Nutrient Analysis Report)	78.8	100	
	Minor Elements (see Nutrient Analysis Report)		100	
OVERALL QUALITY SCORE (OUT OF 100):			73.7	High

Soil Textural Class:==> silt loam

SAND (%): 27.7 *SILT (%): 52.6* *CLAY (%): 19.7*

Approach for a Successful Soil Management Strategy

- Assess your soil's health to identify constraints
- Make changes in management strategies that work for your farm, and that address specific constraints
- Experiment on your farm to see what works in your situation… (start small)
- Adapt many resources of information to your farm
- Build healthy soils to increase resiliency to extremes

About Tissue Analysis…

- Directly measures amount of nutrients in leaves
- Sufficiency ranges known or estimated from other crops
- Alerts grower when nutrient levels are approaching sufficiency/deficiency
- Corrective action may be taken before symptoms occur
- Used to fine tune annual nitrogen application rates
- Used to rule out possible nutritional causes of poor plant performance

Agro-One Plant Tissue Analysis

Agro-One Soils Laboratory
730 Warren Road, Ithaca NY 14850
Phone: 800-344-2697 • Fax: 607-257-1350
E-mail: soil@dairyone.com Website: www.dairyone.com

Service package	Crops	Type of Report	Price per sample
180[a]	Form P[b] Tree Fruit and Small Fruit	Cornell interpretation and nutrient guidelines provided	$24.00
180	Form PTA[c] Field Crops	Results only at this time [e)]	$24.00
180	Form PTV[c] Vegetables and Hops	Results only at this time [e)]	$24.00
161 Nitrate-N	All	Results only at this time [e)]	$10.00

a) Service Package 180 includes total N, K, P, Ca, Mg, Mn, Fe, Cu, B, Zn and S
b) Cornell plant tissue analysis interpretation & guidelines are available for Fruit only at this time.
c) Plant tissue analysis reports for vegetables, hops & field crops show results only. No interpretation or nutrient guidelines available at this time.
d) Go to http://www.uvm.edu/extension/cropsoil/wp-content/uploads/HopFertilityManagementNE.pdf for more information on Hops
e) Interpretive nutrient levels for plant analysis are available for many agronomic and horticultural crops at http://www.aasl.psu.edu/Plt_nutrients.htm

When to Collect Leaves?

- Strawberry—first regrowth after renovation, youngest full-sized leaves (July)
- Blueberry—just before or during harvest, leaves from middle of this year's shoot, full sun (July-Aug)
- Raspberry—primocanes, youngest full-sized leaves (early Aug)

Generally best to avoid times when plant resources are being directed to fruit

How to Collect a Leaves?

- Sample healthy leaves that are well exposed to light.
- Leaves should represent the average condition of the planting and should not be damaged by: disease; insects; weather or mechanical injury.
- **AVOID** mixing leaves from different cultivars.
- **DO NOT** mix leaves from plants of different ages.
- **A minimum of 50 grams (~ 2 oz) fresh weight from a minimum of 30 leaves are needed per sample.**
- If possible, each leaf should be taken from a different plant within the sampled area
- Process for analysis as soon as possible

Preparing Leaves for Analysis

- Use distilled water for washing and rinsing the samples.
- **Gently** and **lightly** scrub the leaves together in distilled water.
- Change the water if it becomes dirty **or** after 8 to 10 samples (whichever occurs first).
- Shake to remove excess water and immediately rinse the sample in clean distilled water.
- Rinse again and shake.
- Transfer sample to paper bag, with top open and dry at room temperature until the leaves are brittle.
- **NOTE: DO NOT let leaves to stand in water – complete the washing and rinsing process in one minute or less.**

Standard Foliar Nutrient Ranges

	Strawberries		Raspberries		Blueberries	
Nutrient	**Deficient below**	**Sufficient**	**Deficient below**	**Sufficient**	**Deficient below**	**Sufficient**
Nitrogen	1.9%	2.0 - 2.8 %	1.9%	2.0 - 2.8%	1.7%	1.7 - 2.1%
Phosphorus	0.2	0.25 - 0.4	0.2	0.25 - 0.4	0.08	0.1 - 0.4
Potassium	1.3	1.5 - 2.5	1.3	1.5 - 2.5	0.35	0.4 - 0.65
Calcium	0.5	0.7 -1.7	0.5	0.6 - 2.0	0.13	0.3 - 0.8
Magnesium	0.25	0.3 - 0.5	0.25	0.6 - 0.9	0.1	0.15 - 0.3
Boron	23	30 -70 ppm	23	30 - 70 ppm	20	30 - 70 ppm
Manganese	35	50 - 200	35	50 - 200	25	50 - 350
Iron	40	60 - 250	40	60 - 250	60	60 - 200
Copper	3	6 - 20	3	6 - 20	5	5 - 20
Zinc	10	20 - 50	10	20 - 50	8	8 - 30

Plant Tissue Analysis Report

with Cornell Nutrient Guidelines

Agro-One
730 Warren Road
Ithaca, NY 14850
Phone: (800) 344-2697
Fax: (607) 257-1350
www.dairyone.com

Cornell University College of Agriculture and Life Sciences

Dairy One

Farmer In the Dell
High-Ho Dairy-O Rd
E-I-E-I-O, NY 123456

Lab Sample ID	16888350
Crop	Blueberries
Variety	
Age	Young nonbearing (1-3 years)
Market	Fresh
Sampled	08/07/2011
Tested	08/19/2011
Statement ID	Dell Blueberry #1
Description	LIBERTY

Element	DM Basis	Satisfactory Range	Deficient	Low	In Range	High	Excessive
Nitrogen	1.51 %	1.7 - 2.1 %					
Potassium	.61 %	0.4 - 0.65 %					
Phosphorus	.081 %	0.1 - 0.18 %					
Calcium	.46 %	0.3 - 0.8 %					
Magnesium	.111 %	0.15 - 0.3 %					
Manganese	169 ppm	50 - 500 ppm					
Iron	56.4 ppm	70 - 300 ppm					
Copper	1.66 ppm	5 - 15 ppm					
Boron	36 ppm	30 - 50 ppm					
Zinc	7.9 ppm	10 - 30 ppm					

Additional Elements	As Sampled Basis	Dry Matter Basis
% Sulfur	.08	.15

Nitrogen: Increase rate of nitrogen application by 10% for each 0.1% that sample is below 1.7%. The best source of nitrogen is urea or ammonium sulfate. Apply half of the annual rate at bloom and the other half 6 weeks later.

Potassium: Continue present potassium program.

Phosphorus: Although level is outside the desired range, modification is unlikely to have an economic impact.

Calcium: Satisfactory

Magnesium: Although level is outside the desired range, modification is unlikely to have an economic impact.

Manganese: Satisfactory - No correction needed.

Iron: Low iron is the first symptom of high soil pH. For permanent correction, apply 400 lbs/acre sulfur annually until proper pH is obtained. For temporary correction, apply a foliar spray of 2 lbs/100 gallons-acre iron chelate in late summer and again after bloom the following year, but check product label and follow its recommendation. If conditions persist for several consecutive years and soil pH is within desired range, apply 25 lbs/acre iron chelate or 15 lbs/acre ferrous sulfate to soil in early spring.

Copper: Usual recommendation would be to apply a post-bloom and post-harvest spray of 2.0 lbs/100 gallons-acre copper chelate, but check product label and follow its recommendation. If the condition persists for several consecutive years and soil pH is within desired range, apply 30 lbs/acre copper sulfate to the soil in late fall or fertigate according to label directions. Fertigation can be an efficient method of delivering copper to the plant. Copper is often low in blueberry plantings.

Boron: Satisfactory

Zinc: Usual recommendation would be to apply a post-bloom, post-harvest and late summer spray of 2.0 lbs/100 gallons per acre zinc chelate, but check product label and follow its recommendation. If conditon persists for several consecutive years and soil pH is within desired range, apply 10 lbs/acre zinc sulfate to soil surface in early spring. Fertigation can be an efficient method of delivering zinc to the plant. Zinc is often low in blueberry plantings.

Unless otherwise indicated, recommendations assume the soil pH is 4.0 to 4.8. If the pH is outside this range, recommendations may not be effective.

K/Mg ratio = 5.5 (Acceptable level is less than 4.0)

P/Zn ratio = 103 (Acceptable level is less than 140)

For greatest accuracy, samples should consist of recently expanded leaves sampled from mid-July through mid-August.

Multiply recommendations in lbs/acre by 0.015 to obtain ounces/plant.

When following a recommendation to apply a chelate make sure formulation you use is labeled for use with your particular crop. (One gallon equals 8.3 pounds)

4J

*Corresponding soil test: (lb/A)

Soil pH = 5.2		
Phosphorus (P)	low	(2)
Potassium (K)	high	(254)
Calcium (Ca)	high	(4,233)
Magnesium (Mg)	high	(465)
Iron (Fe)		(46)
Manganese (Mn)		(193)
Zinc (Zn)		(3)
Aluminium (Al)		(126)
Organic Matter	6%	

*Morgan

Recommendations:

- Apply 50 lb Mg/A as sulfates of Mg.
- Apply 200 lb sulfur early spring and again late fall for next 3 years.
- Foliar iron may be needed until desired pH range is reached.

Protocol for Tissue Analysis Interpretation

- Ensure that the soil pH is within the correct range
- Assess the status of the planting to determine if something other than nutrients could be limiting growth (disease, drought)
- Check the status of boron
- Look for specific nutrients that might be deficient
- Check for interactions/imbalances that exacerbate low nutrient levels
- Derive recommendations

Interpreting Tissue Analysis Test Results

- Tissue analysis tests are not meaningful for fertility guidelines unless the soil pH is within the correct range
- Soil test results do not always correlate with foliar test results for a variety of reasons
- Tissue analysis tests are useful for diagnosis, but not for detailed guidance unless growth and yield are good.
- Applying nutrients may result in a decrease in foliar concentrations under certain circumstances
- Correcting deficiencies or imbalances in established plantings is more difficult than amending soils prior to planting

Nitrogen Needed Annually

- Rate is determined by:
  - Crop
  - Plant age
  - Irrigation status
  - Mulching status
  - Leaf analysis results

See Cornell Pest Management Guidelines for Berry Crops (http://ipmguidelines.org/BerryCrops/) for guidelines to annual rates (50 – 100 lbs N/acre-year)

Nutrients Required after Establishment

- In many cases, no additional P, K, Mg or Ca will be required if the soil test recommendations were followed.
- Supplemental K and B may be required on sandier soils.
- Small amounts of sulfur may be required to maintain a low pH in some soils where blueberries are grown.

A leaf analysis will provide guidance on supplemental fertilizers after the planting is established.

Do not rely on the soil test for post-plant recommendations that do not involve soil pH.

Let's Review…

Don't rely on visual symptoms or what you've always done in the past . . .

- Prior to planting
  - Cornell soil health test
    - Includes Agro-one standard soil analysis and more!
- After plants are established
  - Annual tissue (leaf) analysis
  - Additional soil testing as needed every 2-3 years

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