MSU EXTENSION 2017 BEGINNING FARMER WEBINAR SERIES

Getting started with crop nutrient management

April 3, 2017 7pm

MICHIGAN STATE UNIVERSITY | Extension

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906-387-2530

Photo: Michael Trolove

Previous webinars:

- Managing soil, irrigation and fertilization interactions, 4/1/15
- Compost production and use for the small to mid-size farm, 4/13/16

- *2012 – 2016 webinars can be found on the MSU Extension Beginning Farmer Webinar Series webpage*

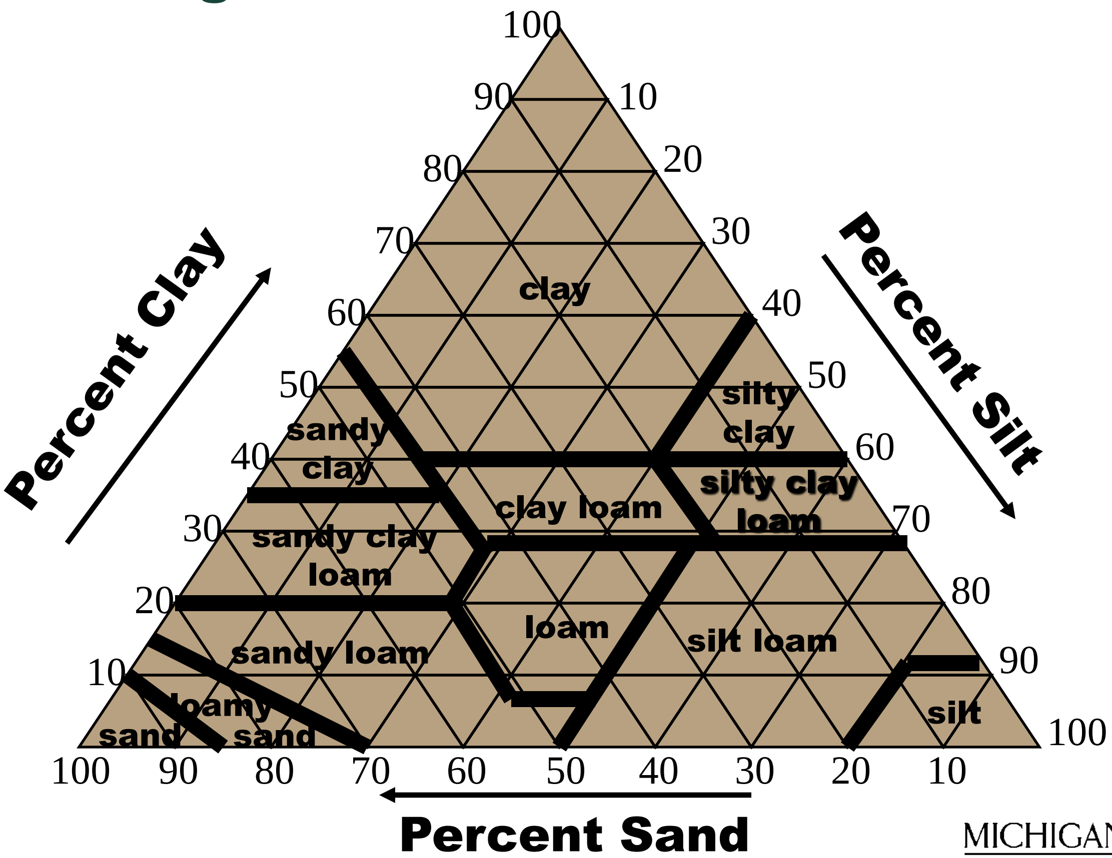
Tonight's agenda

- Determine crop nutrient needs
- Determine current soil fertility level
- Strategies for immediate and long-term improvement
- Fertilizers: synthetic, organic, compost, other amendments
- Application and timing

Soil Texture

- Sand: 2 – 0.05mm
- Silt: 0.05 – 0.002mm
- Clay: <0.002mm

Soil texture triangle:



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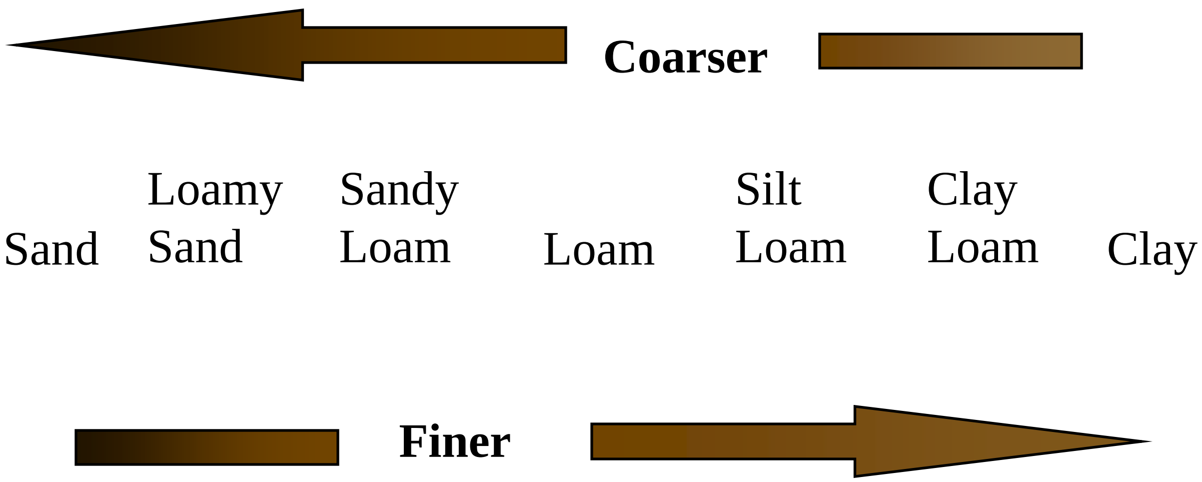
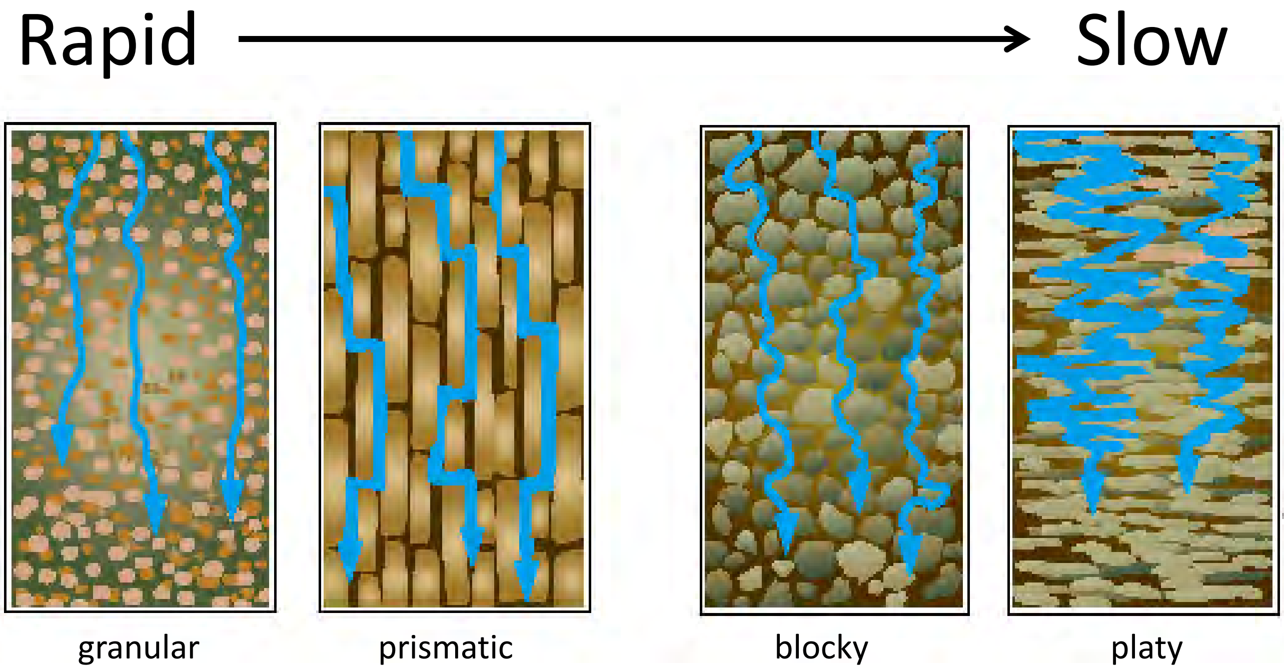
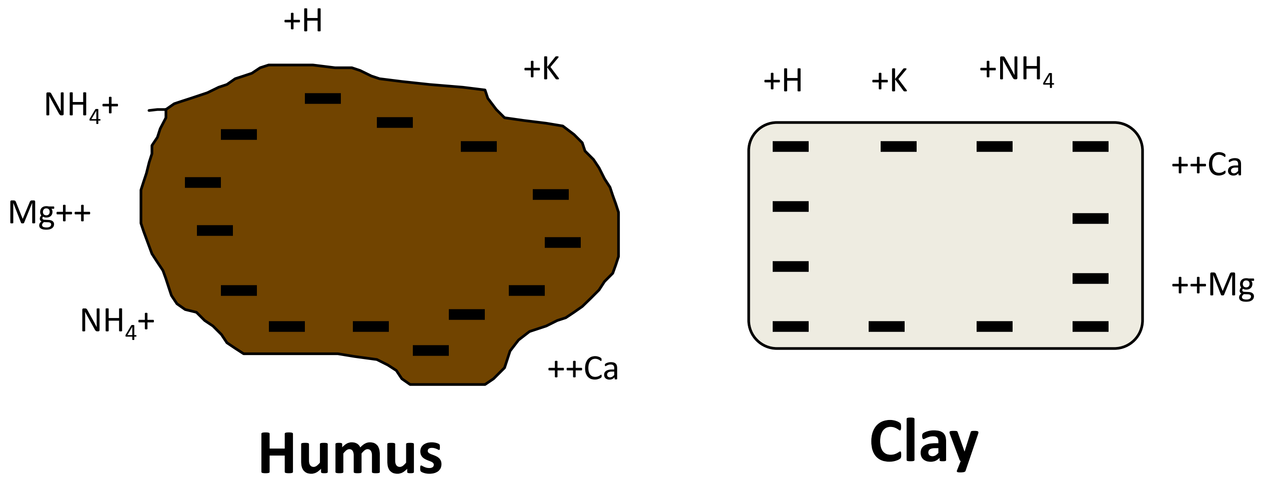

Coarser
Sand
Loamy Sand
Sandy Loam
Loam
Silt Loam
Clay Loam
Clay
Finer

Permeability



Water movement through soils is influenced by soil structure, density, and the amount and size of pore space.

Cation Exchange Capacity



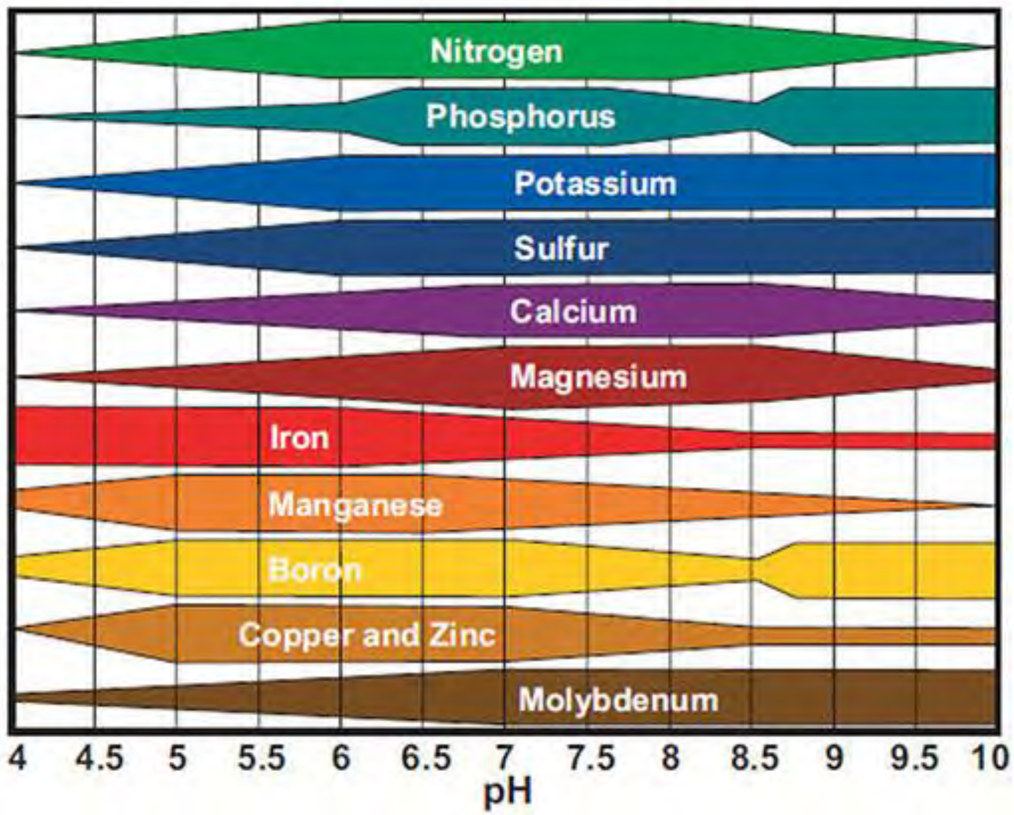
Cation Exchange Capacity

CEC	
1 - 5	• Very low with not much clay or humus
6 - 10	• Intermediate loamy texture or sandy with more humus
10+	• Progressively more clay and/or humus
20+	• Probably an organic soil

Soil pH

Low pH interferes with P, K, S, Ca, Mo uptake

High pH interferes with P, Fe, Mn, B, Z, Cu uptake



Common challenges to soil fertility

- Low fertility native soil
- Undesirable soil texture
- Low soil OM
- Erosion
- Compaction
- Past cropping practices

Essential Plant Nutrients

- Non-mineral nutrients
  - –Carbon (C)
  - –Hydrogen (H)
  - –Oxygen (O)
- Mineral macronutrients
  - –Major nutrients
    - Nitrogen (N)
    - Phosphorus (P)
    - Potassium (K)
  - –Secondary nutrients
    - Calcium (Ca)
    - Magnesium (Mg)
    - Sulfur (S)

Essential Plant Nutrients (cont.)
Micronutrients

- Boron (B)
- Chloride (Cl)
- Copper (Cu)
- Iron (Fe)
- Manganese (Mn)
- Molybdenum (Mo)
- Zinc (Zn)

Determine crop nutrient needs

- MSU Extension E2904: "Nutrient Recommendations for Field Crops in MI"
- MSU Extension E2934: "Nutrient Recommendations for Vegetable Crops in MI"
- MSU Extension E486: "Secondary and Micronutrients for Vegetable and Field Crops"

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Nutrient Recommendations for Field Crops in Michigan

Table 3. Nutrient removal in harvested portions of several Michigan field crops.

Crop		Unit	N	P_2O_5	K_2O
			— lb/unit of yield —		
Alfalfa	(Hay)[1]	ton	45	13	50
	(Haylage)	ton	14	3.2	12
Barley	(Grain)	bu	0.88	0.38	0.25
	(Straw)	ton	13	3.2	52
Beans (dry edible)	(Grain)	cwt	3.6	1.2	1.6
Brassica forage		ton	11	5.0	22
Bromegrass	(Hay)	ton	33	13	51
Buckwheat	(Grain)	bu	1.7	0.25	0.25
Canola	(Grain)	bu	1.9	0.91	0.46
Clover	(Hay)	ton	40	10	40
Clover-grass	(Hay)	ton	41	13	39
Corn	(Grain)	bu	0.90	0.37	0.27
	(Stover)	ton	22	8.2	32
	(Silage)	ton	9.4	3.3	8
Millet	(Grain)	bu	1.1	0.25	0.25
Oats	(Grain)	bu	0.62	0.25	0.19
	(Straw)	ton	13	2.8	57
Orchardgrass	(Hay)	ton	50	17	62
Peppermint	(Oil)[2]	lb	2.0	1.1	4.0
Potato	(Tubers)	cwt	0.33	0.13	0.63
Rye	(Grain)	bu	1.1	0.41	0.31
	(Straw)	ton	8.6	3.7	21
	(Silage)	ton	3.5	1.5	5.2
Sorghum	(Grain)	bu	1.1	0.39	0.39
Sorgh.-Sudangrass	(Hay)	ton	40	15	58
	(Haylage)	ton	12	4.6	18
Soybean	(Grain)	bu	3.8	0.8	1.4
Spearmint	(Oil)[2]	lb	2.0	1.1	4.0
Spelt	(Grain)	bu	1.2	0.38	0.25
Sugar beet	(Roots)	ton	4.0	1.3	3.3
Sunflower	(Grain)	bu	2.5	1.2	1.6
Timothy	(Hay)	ton	45	17	62
Trefoil	(Hay)	ton	48	12	42
	(Seed)	cwt	3.0	1.25	1.25
Wheat	(Grain)	bu	1.2	0.63	0.37
	(Straw)	ton	13	3.3	23

[1] Biomass yields assume the following moisture contents: corn silage – 65%; corn stover at grain harvest – 25 to 30%; hay – 18%; straw – 15%.

[2] Nutrient removal is based on hay harvested, which is estimated from oil produced.

Nutrient Recommendations for Field Crops in Michigan

- E2904 Table 3. Page 8
  - Nutrient removal in harvested portion of Michigan field crops

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Nutrient Recommendations for Vegetable Crops In Michigan E2934

Table 3. Nutrient removal in the harvested portion of Michigan vegetable crops.

Crop	N	P_2O_5	K_2O
	- - - - lb/ton - - - -		
Asparagus crowns	13.4	4.0	10.0
Asparagus, new planting	13.4	4.0	10.0
Asparagus, established	13.4	4.0	10.0
Beans, snap	24.0	2.4	11.0
Beets, red	3.5	2.2	7.8
Broccoli	4.0	1.1	11.0
Brussels sprouts	9.4	3.2	9.4
Cabbage, fresh market	7.0	1.6	6.8
Cabbage, processing	7.0	1.6	6.8
Cabbage, Chinese	7.0	1.6	6.8
Carrots, fresh market	3.4	1.8	6.8
Carrots, processing	3.4	1.8	6.8
Cauliflower	6.6	2.6	6.6
Celeriac	4.0	2.6	6.6
Celery, fresh market	5.0	2.0	11.6
Celery, processing	5.0	2.0	11.6
Cucumber, pickling			
hand harvested	2.0	1.2	3.6
machine harvested	2.0	1.2	3.6
Cucumber, slicers	2.0	1.2	3.6
Dill	3.5	1.2	3.6
Eggplant	4.5	1.6	5.3
Endive	4.8	1.2	7.5
Escarole	4.8	1.2	7.5
Garden, home	6.5	2.8	5.6
Garlic	5.0	2.8	5.6
Ginseng	4.6	1.2	4.6
Greens, leafy	4.8	2.0	6.0
Horseradish	3.4	0.8	6.0
Kohlrabi	6.0	2.6	6.6
Leek	4.0	2.6	4.8
Lettuce, Boston, bib	4.8	2.0	9.0
Lettuce, leaf	4.8	2.0	9.0
Lettuce, head	4.8	2.0	9.0
Lettuce, romaine	4.8	2.0	9.0
Market garden	6.5	2.8	5.6
Muskmelon	8.4	2.0	11.0
Onion, dry bulb	5.0	2.6	4.8
Onion, green	5.0	2.6	4.8
Pak choi	7.0	1.6	6.8
Parsley	4.8	1.8	12.9
Parsnip	3.4	3.2	9.0
Peas	20.0	4.6	10.0
Pepper, bell	4.0	1.4	5.6
Pepper, banana	4.0	1.4	5.6
Pepper, hot	4.0	1.4	5.6
Potato	6.6	2.6	12.6
Pumpkin	4.0	1.2	6.8
Radish	3.0	0.8	5.6
Rhubarb	3.5	0.6	6.9
Rutabaga	3.4	2.6	8.1
Spinach	10.0	2.7	12.0
Squash, hard	4.0	2.2	6.6
Squash, summer	3.6	2.2	6.6
Sweet corn	8.4	2.8	5.6
Sweet potato	5.3	2.4	12.7
Swiss chard	3.5	1.2	9.1
Tomato, fresh market	4.0	0.8	7.0
Tomato, processing	4.0	0.8	7.0
Turnip	3.4	1.2	4.6
Watermelon	4.8	0.4	2.4
Zucchini	4.6	1.6	6.6

Soil Sampling

- Collection of soil from a field or areas in a field in a manner that will result in a composite sample that is representative of the soil(s) in the field or delineated areas in a field.

Soil Sampling

- The first step in determining the fertility status of the soil(s) in a field and…
- A very important part of soil testing.
  - Equal to if not more important than the laboratory analysis.
  - Without a good representative soil sample the lab results are meaningless.
- There is greater variability in sampling than analysis.

The Challenge !!!

- How to get 1 or 2 lbs of soils to be a good indicator of the soil fertility status of 1, 20, 30 or 40 million pounds of soil.
  - Contained in 0.5, 10, 15 or 20 acres
  - (30' X 90' hoophouse ⇨⇨123,400 lbs soil)
- 1 acre to a depth of 6.67 inches weighs approximately 2 million pounds.

Need to Have the Right Tools.

- Soil Probe or Auger
- Clean Plastic Buckets

  Procedure

- Take cores to depth of tillage.
- 15 to 20 cores per sample.
- No tillage:
  - –0-3 for pH
  - –0-8 inches for complete tests

To Do A Good Job of Soil Sampling, Understand …

- The nature of the soil(s) in the field.
  - Soil texture
  - Drainage patterns
  - Topography
- The management history of the field.
  - Crop rotation
  - Tillage
  - Application patterns of inputs.
    - Fertilizer
    - Lime
    - Manure

Also understand that…

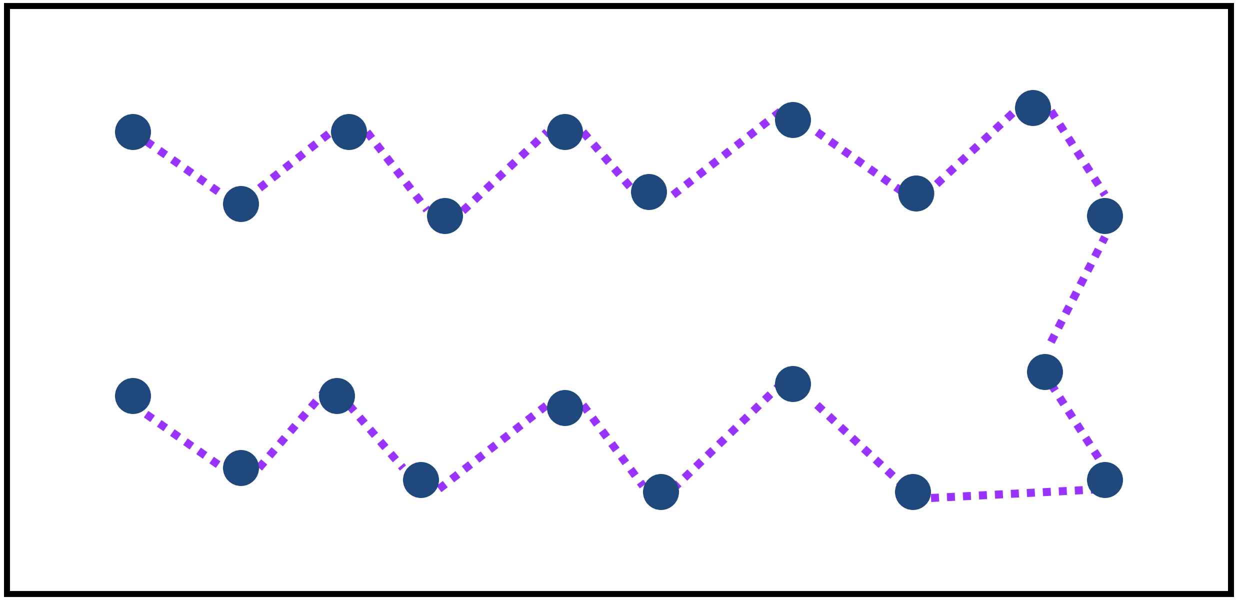
- The fertility status of soil in a field is variable.
- Soil sampling is an averaging process.

Variation in soil test values

	pH	P ppm	K ppm	Mg ppm
Average	6.2	30	78	133
High	7.7	68	156	515
Low	5.2	8	32	9

Sampling a Field

1. Random Sampling



Delineating Areas to Sample

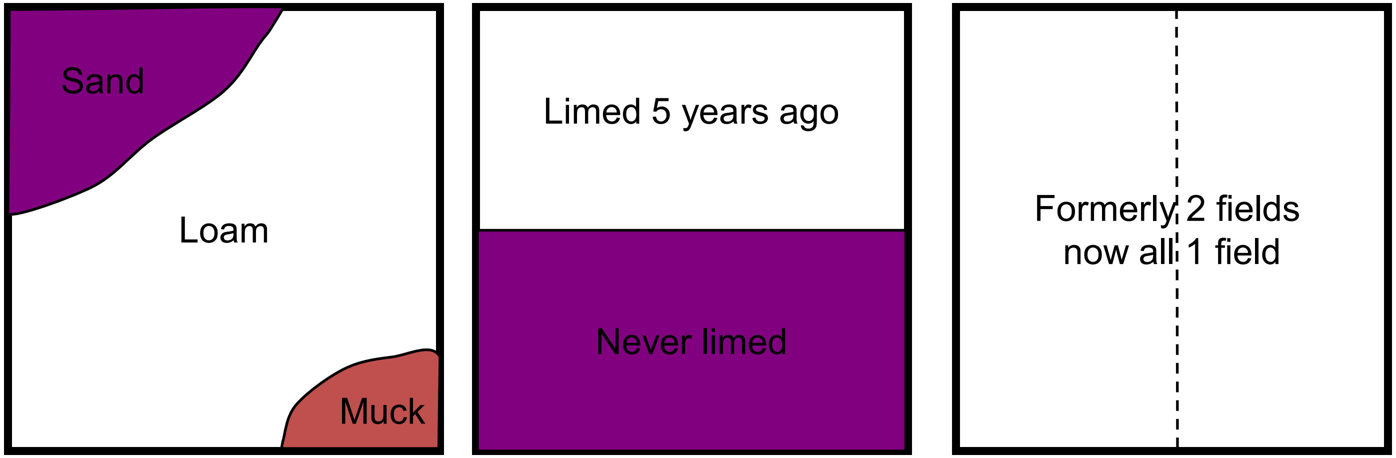
- Use soil survey map
- Use topography
- Use management history
- Use observations of growth
- Use yield maps
- Planting beds

http://websoilsurvey.nrcs.usda.gov/app/

Sampling a Field

Topography

Management History



3 composite samples 2 composite samples 2 composite samples

Costs associated with Soil Sampling

- **<u>Whole Field</u>**(30 acres)
  - 15 acres per sample = 2 samples
  - 4 samples per hour @ $12/ hr
- $ 5.00 … sampling +
- <u>$24.00 … analysis</u>
- $29.00 per 30 acres = $0.97 per acre.
  - … prorated over 2 years = $0.49 /A /yr
  - … 3 years = $0.32 /A /yr
  - … 4 years = $0.24 /A /yr

Frequency of Sampling

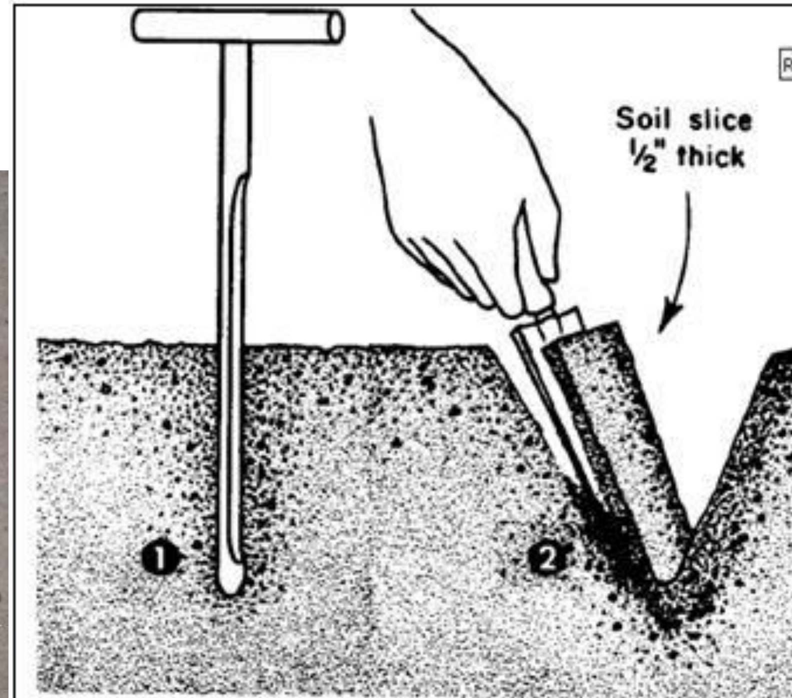
- More frequent sampling provides more information
  - Develop a history
  - Every 2-3 years for whole field sampling
  - Every 3-4 years for more intense sampling

Time of Sampling

- Sample same time of year
- Sample same point in rotation

Potential Benefits Associated with Soil Testing

- Improved crop yields
- Lower total fertilizer bill
- Better match of nutrient inputs with soil/ crop need.
- Participation in Government programs
- Reduced risk for adverse impact on environment



1. Sampling probe provides uniform sampling cores—easy to use—saves time—best tool for sampling farm soils.
2. Use a narrow (1½ inch) garden dibble to take a slice of soil ½ inch thick.

MSU Soil and Plant Nutrient Laboratory

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EXTENSION

MICHIGAN STATE UNIVERSITY
SOIL AND PLANT NUTRIENT LABORATORY

FEE SCHEDULE

Prices effective April 1, 2013

MICHIGAN STATE UNIVERSITY
SOIL & PLANT NUTRIENT LAB
PLANT & SOIL SCIENCES
1066 BOGUE ST. ROOM A81
EAST LANSING, MI 48824-1325
PHONE: 517-355-0218
FAX: 517-355-1732
Website: www.psm.msu.edu/SPNL

HOURS: 8:00 am to 12:00 pm, 1:00 pm to 5:00 pm
Monday – Friday (Closed Tuesdays July - March)

GROWER/HOMEOWNER SAMPLES

1a. Regular field soil test — $11.00
pH, lime requirement, P, K, Ca, Mg
(no county recommendations)

1b. Regular lawn and garden soil test — $22.00
pH, lime requirement, P, K, Ca, Mg
organic matter, hand texture & recommendations

1c. Zinc-Manganese Sticker – pre-paid — $7.00
(pre-pays Zn-Mn test – saves $1.00 per sample)
sold in minimum of ten (10) sticker lots.

Samples coming into the lab not in pre-paid boxes – Add $1.00 per sample for boxing fee.

2. Micronutrient tests

Zinc	Zn	$4.00
Manganese	Mn	$4.00
Copper	Cu	$4.00
Iron	Fe	$4.00

3. Saturated Media Test (Greenhouse Analysis) — $25.00
(for artificial growth media, and general quality analysis of compost) pH, soluble salts, Nitrate-N, P, K, Ca, Mg, Na, Cl and nutrient balance

4. Supplemental Soil Tests

		With Regular Test	Alone
PSNT	Pre-sidedress Nitrate-N		$10.00
PSNT+NH_4	with Ammonium-N		$13.00
NO_3-N	Nitrate-Nitrogen	$8.00	$10.00
NO_3+NH_4	with Ammonium-N	$11.00	$13.00
Na	Sodium	$5.00	$7.00
Cl	Chloride	$8.00	$10.00
EC	Soluble Salts	$5.00	$6.00
OM	Organic Matter	$5.00	$6.00
	Organic Matter stickers (pre-paid sold in minimum quantity of 10 sticker lots)		
pH	pH	included	$5.00
TKN	Total Nitrogen	$18.00	
CEC	CEC by Ammonium saturation	$35.00	
B	Boron	$9.00	
S	Sulfur	$9.00	
PB	Lead	$28.00	
Arsenic		$28.00	

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MSU SOIL TEST INFORMATION SHEET

ACCURACY OF RECOMMENDATIONS DEPENDS ON THE COMPLETION OF THIS FORM

www.psm.msu.edu/SPNL

MICHIGAN STATE UNIVERSITY
SOIL AND PLANT NUTRIENT LABORATORY
EAST LANSING, MICHIGAN 48824-1325
(517) 355-0218

GROWER NAME ______ COMMENTS/Company Name ______

STREET, ROUTE ______

CITY ______ MI ______ ZIP CODE

E-MAIL ADDRESS ______

COUNTY ______ No. of Samples ______ Date Received ______

WRITE APPROPRIATE NUMBERS IN BOXES

USE CROP CODES FROM BACK PAGE

PRICE OF WHEAT ______ PRICE OF CORN ______

BLUEBERRY AGE ______

TESTS REQUESTED

GROWER SAMPLE IDENTIFICATION	PREVIOUS CROP	1ST YEAR CROP	YIELD GOAL	2ND YEAR CROP	YIELD GOAL	PREVIOUS LEGUME % STAND	TILLAGE DEPTH (INCHES)	SAMPLING DEPTH (INCHES)	ACRES REPRESENTED	MANURE APPLIED (GAL)	IRRIGATED Y/N	TESTS REQUESTED
E X A M P L E	1 0 2	1 2 2	1 6 0	1 5 2	6 0	6 0	1 2	0 9	1 1	5000		X 2 3
												1 2 3
												1 2 3
												1 2 3
												1 2 3
												1 2 3
												1 2 3
												1 2 3

Tests in addition to standard test require extra fee.

Mail directly to the MSU Soil and Plant Nutrient Laboratory, 1066 Bogue St., Room A81, Michigan State University, East Lansing, MI 48824-1325.

Agronomic Crops

Code	Crop Description
101	Alfalfa seeding
102	Alfalfa hay
104	Barley
105	Barley/legume seeding
107	Beans, dry edible
108	Beans, azuki
109	Beans, edamame
111	Brassica forage
113	Bromegrass hay
114	Buckwheat
116	Canola
118	Clover seeding
119	Clover hay
120	Clover-Grass hay
122	Corn
123	Corn silage
124	Corn, seed
126	Grass, cool season CRP
127	Grass, warm season CRP
128	Grass/Legume CRP
129	Millet
130	Hops
131	Oats
132	Oats/legume seeding
133	Oats for cover
136	Orchardgrass
137	Pasture - Extensive Grazing
138	Pasture - Intensive Grazing
140	Peppermint
142	Potato
144	Rye
145	Rye for cover
146	Rye silage
148	Sorghum
149	Sorghum-Sudangrass hay
150	Sorghum-Sudangrass haylage
152	Soybean
154	Spearmint
156	Spelts
158	Sugar Beets
160	Sunflower
162	Timothy hay
164	Trefoil seeding
165	Trefoil hay
166	Trefoil seed production
168	Wheat
169	Wheat/legume seeding
172	Wildlife Forage - Legume
173	Wildlife Forage - Brassica
174	Switchgrass
175	Teff

Vegetable Crops

Code	Crop Description
201	Asparagus crowns
202	Asparagus, new planting
203	Asparagus, established
205	Beans, snap
206	Beets, red
208	Broccoli
209	Brussels Sprouts
211	Cabbage, fresh market
212	Cabbage, processing
213	Cabbage, Chinese
215	Carrots, fresh market
216	Carrots, processing
218	Cauliflower
219	Celeriac
221	Celery, fresh market
222	Celery, processing
224	Cucumber, pickling-hand harvest
225	Cucumber, pickling-machine harvest
226	Cucumber, slicers
228	Dill
229	Eggplant
231	Endive
232	Escarole
233	Garden, Home
234	Garlic
236	Ginseng
237	Greens, leafy
238	Horseradish
240	Kohlrabi
241	Leek
243	Lettuce, Boston, Bibb
244	Lettuce, leaf
245	Lettuce, head
246	Lettuce, Romaine
248	Market Garden
249	Muskmelon
251	Onion, dry bulb
252	Onion, green
254	Pak Choi
256	Parsley
257	Parsnip
259	Peas
261	Pepper, bell
262	Pepper, banana
263	Pepper, hot
265	Pumpkin
266	Radish
268	Rhubarb
269	Rutabagas
270	Spinach
271	Squash, hard
272	Squash, summer
274	Sweet Corn
275	Sweet Potato
277	Swiss Chard
279	Tomato, fresh market
280	Tomato, processing
282	Turnip
284	Watermelon
286	Zucchini

Fruit Crops

Code	Crop Description
301	Apple
303	Apricot
305	Blueberry, new planting
306	Blueberry, established 1-8 years
307	Blueberry, established 8+ years
308	Cherry
309	Chestnut
311	Cranberry
312	Fruit Trees
314	Grape
316	Grass Cover - Orchard
318	Orchard - new
320	Peach
322	Pear
324	Plum
326	Raspberry
328	Strawberry

Turf

Code	Description
401	Athletic Field, bluegrass
402	Athletic Field, ryegrass
404	General Grounds
405	Lawn, bluegrass
406	Lawn, fescue
407	Lawn, ryegrass
408	Lawn, mixed grasses
410	Golf Fairways
411	Golf Greens
412	Golf Tees
413	Sand Based Rootzones Establishment
414	Sand Based Rootzones Mature
415	Turf, low maintenance
420	Sod Production

Flowers, Shrubs, Trees

Code	Description
501	Flowers, Cut
502	Flower Beds, annuals
503	Flower Beds, perennials
504	Flower Bulbs
505	Ground cover
506	Roses
511	Shrubs, deciduous - home
512	Shrubs, narrowleaf evergreen - home
513	Shrubs, broadleaf evergreen - home
516	Trees, deciduous - home
517	Trees, narrowleaf evergreen - home
518	Trees, broadleaf evergreen - home
521	Shrubs, deciduous - nursery
522	Shrubs, narrowleaf evergreens - nursery
523	Shrubs, broadleaf evergreens - nursery
526	Trees, Christmas
527	Trees, deciduous - nursery
528	Trees, narrowleaf evergreens - nursery
529	Trees, broadleaf evergreens - nursery

Interpreting standard soil test reports

- Get profile of available plant nutrients
- Basic soil chemistry
  - pH and lime index
  - Phosphorus
  - Potassium
  - Magnesium
  - Calcium
  - Cation exchange
  - % exchangeable bases

Common add-ons:
- *Organic matter*
- *Zinc*
- *Manganese*

Sample MSU Soil Test Report

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MICHIGAN STATE UNIVERSITY
SOIL AND PLANT NUTRIENT LABORATORY
EAST LANSING, MICHIGAN 48824-1325
(517) 355-0218

SOIL TEST REPORT FOR:	CONSULTANT
	CHIPPEWA COUNTY MSUE 300 COURT STREET SAULT SAINTE MARIE MI 49783 906-635-6368

DATE	LAB #	COUNTY	Previous Crop	ACRES	FIELD ID	SOIL	TEXTURE
8/26/2014		Chippewa	Apple	1	3	Mineral	

SOIL NUTRIENT LEVELS			Below Optimum	Optimum	Above Optimum
[1]Soil pH 6.5	Lime Index 69.0				
[2]Phosphorus (P)	23	ppm	■■■■■■■		
[3]Potassium (K)	37	ppm	■■		
[3]Magnesium (Mg)	22	ppm	■■■■■■		

ADDITIONAL RESULTS:					Optional Tests:							
		% of Exchangeable Bases			Micronutrients (ppm)							
[3]Calcium (Ca)	CEC (meq/100 g)	K	Mg	Ca	B	Cu	Mn	Zn	Fe	Organic Matter %	Nitrate-N ppm
244	2.6	3.0	12.7	84.3							

RECOMMENDATIONS FOR: *apple*

Limestone: 2 ton/A

Nitrogen (N): 50 lb/A

Phosphate (P_2O_5): 53 lb/A

Potassium (K_2O): 165 lb/A

MESSAGES

Magnesium tests low; apply dolomitic lime.

Adjust the nitrogen rate to obtain desired growth.

Magnesium tests low: Broadcast 50 - 100 lb Mg/ acre or 1 to 2 lb Mg per 1000 sq ft

For established trees, soil test levels are a general indicator of the soil fertility status and nutrient need. Leaf tissue analysis is a better i for adjusting these nutrient recommendations

Nutrient requirements may vary with tree size and age. Consult your county extension agent for more precise nutrient recommendatio

New food plot

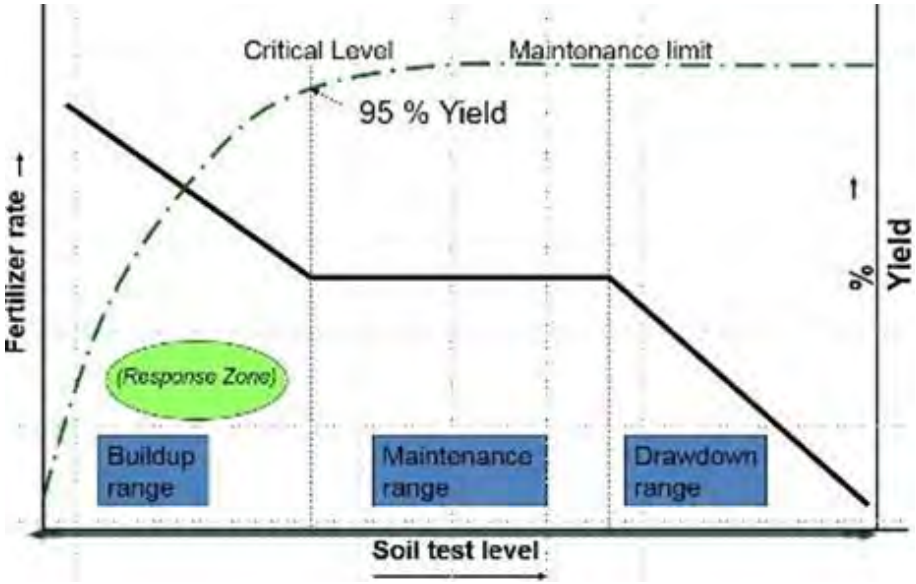
Test Methods: 1- 1:1 soil:water pH, 2- Bray P1 Extractant, 3- 1N Ammonium Acetate Extractant

Client name : 3

1. Surface apply about 10 lbs dolomitic lime per 1000 square feet around the apple trees.
2. For apple trees: In spring, apply about 6 lbs 19-19-19 and 5 lbs 0-0-60 fertilizer per 1000 square feet around base of trees.

Jim Isleib
U.P. Crop Production Educator
MSU Extension – Alger County
906-387-2530
isleibj@anr.msu.edu

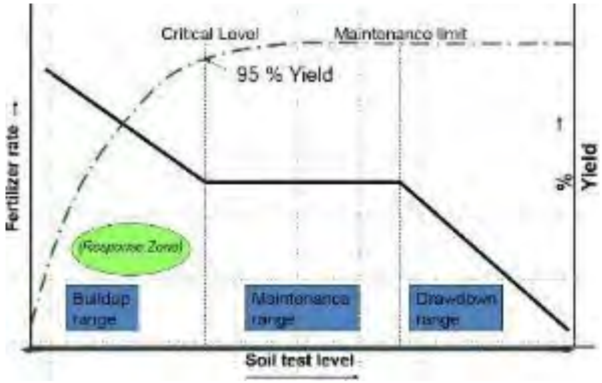
Maintenance Range



- Where we want to be long term.
- Adequate levels
- Good opportunity for top yields
- Apply to meet crop removal only
- Provides flexibility for managing inputs.
  - …without inputs or with inputs less than crop removal
  - …minimal impact on yield

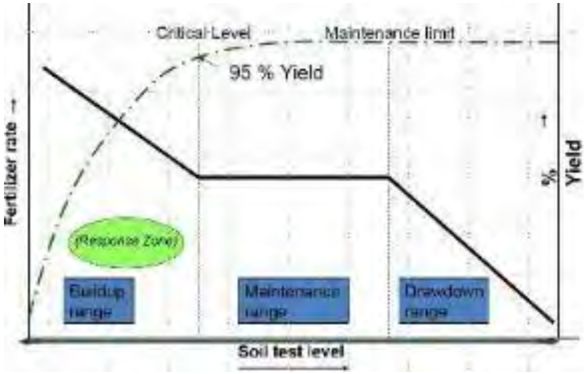
What is the impact of applying less than maintenance P?

- Phosphorus …
- **On average, for each 16 - 20 lbs P_2O_5 removed beyond maintenance the soil test P level will decrease 1 ppm.**
- Sandy soils ~ 8:1
- Clay loams ~ 30:1



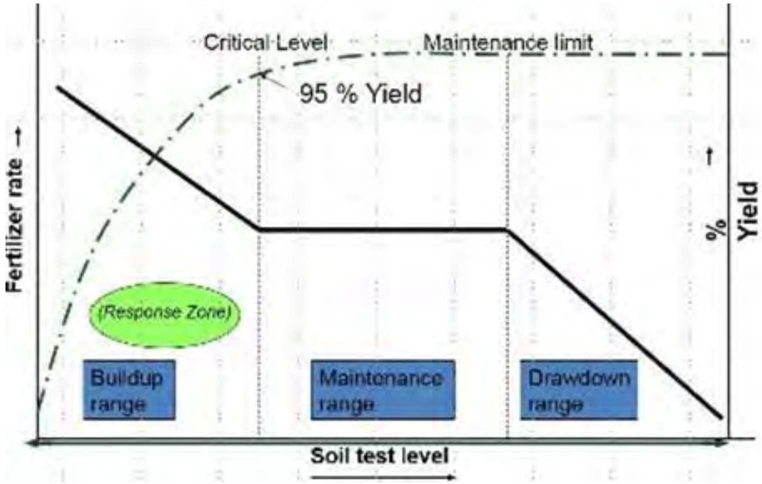
What is the impact of applying less than maintenance K?

- Potassium …
- **On average the soil test K level will decrease 1 ppm for each 8 - 10 lbs K_2O removed beyond maintenance.**
- Sandy soils ~ 4:1
- Clay loams ~ 14:1



Draw Down Zone

- Soil levels of P and K are more than adequate for crop production.
- Probability of yield response to applied fertilizer is very low.
- Use no more than starter amounts of P & K. If applying manure, be careful about building up the soil P level.

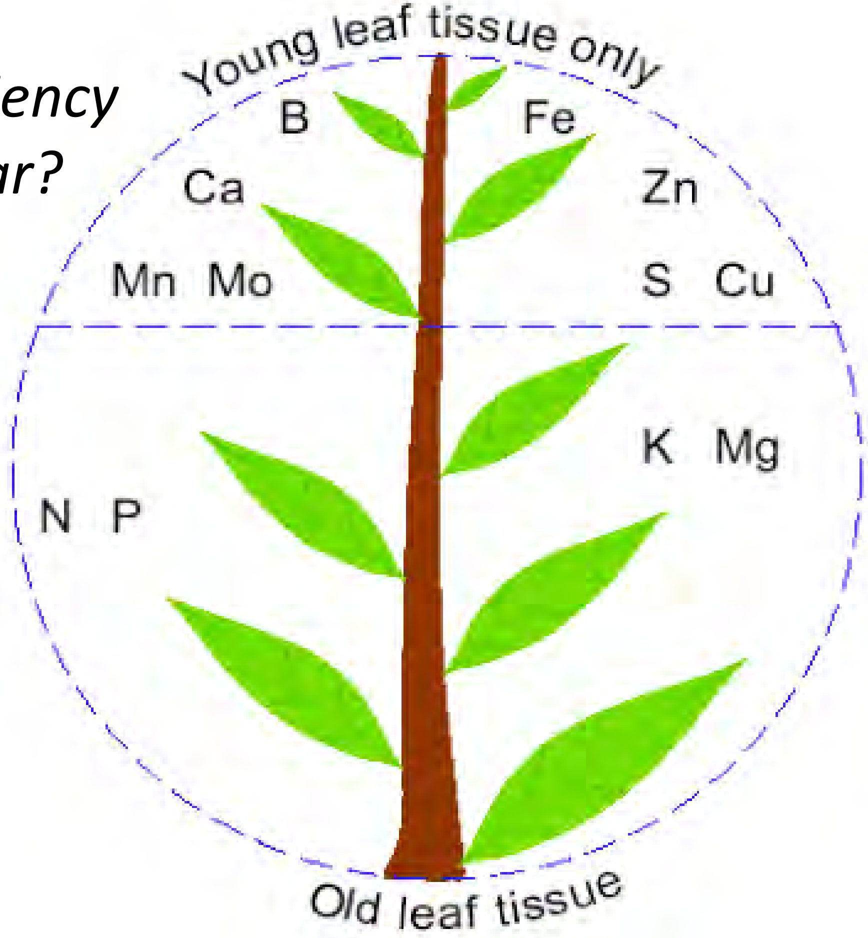


MSU on-line fertilizer recommendation program

- When you want to re-designate a crop or yield goal, using the same soil test report
- http://maec.msu.edu/fertrec/

Mobility of nutrients in the plant

Where will deficiency symptoms appear?



Why tissue sample?

- Verify visual deficiency
- Identify nutrient shortage before symptoms appear
- Quantify effect of nutrient addition
- Determine nutrient-supplying capacity of soil
- Study relationship of applied:uptake:yield

- $24/sample

How to tissue sample

- Fresh tissue
- Sample should be kept dry or refrigerated
- Protect sample from contamination
- Follow sampling guide for area, amount and timing
  - MSU Soil and Plant Nutrient Laboratory “plant tissue sampling guide:

PLANT TISSUE SAMPLING GUIDE

Crop & Stage of Growth	Number of Plants to Sample	Plant Part to Sample
CORN, SWEET		
Prior to tasseling	15	5th leaf from growing tip
Tasseling to end of silking	15	5th leaf from growing tip <u>or</u> ear leaf
CUCUMBER	15	5th leaf from growing tip
LETTUCE, HEADING TYPES		
Prior to heading	15	Most recent fully developed leaf
Heading	15	Most recent fully developed leaf
LETTUCE, LEAF TYPES	15	Most recent fully developed leaf
Up to 5 leaf stage	20	Whole plant tops
Beyond 5 leaf stage	20	2 most recent fully developed leaves
PEA	30	Most recent fully developed leaf
PEPPER	20	Most recent fully developed leaf
POTATO	30	Petiole of most recent fully developed leaf
PUMPKIN	15	Leaf blade & mid-rib from most recent fully developed leaf

Common N Deficiency Symptoms

- N deficiency results in chlorosis (a yellowing) of the leaves.
- Chlorosis starts first on the oldest leaves and then develops on younger leaves as the deficiency becomes more severe.
- Slow growth; stunted plants; fewer leaves
- Less tillering in small grains and other grasses
- Lower protein
- Early maturity, limiting yield potential
- Higher moisture content in corn grain at maturity

Nitrogen Credits from Crop Residues

Previous Crop	N Credit
	- lb N/ac –
Alfalfa, established	**40 + (% stand)**
Alfalfa, seeding	40 + 0.5(% stand)
Clover, established	**40 + 0.5(% stand)**
Clover, seeding	20 + 0.5(% stand)
Trefoil, established	40 + 0.5(% stand)
Barley + legume	30 + 0.5(% stand)
Oats + legume	30 + 0.5(% stand)
Wheat + legume	30 + 0.5(% stand)
Dry edible beans	**20**
Soybeans	**30**
Grass Hay	40

Warncke and Dahl, 2003

P Deficiency Symptoms in Plants

- P is mobile, so deficiency symptoms occur in the older leaves
- Stunted in Growth
- Abnormal dark-green color, especially broadleaf plants (ex. Sugarbeets) and stunted growth
- Reddish -purple color (Severe deficiency symptom)
  - Often seen in early spring on low phosphorus sites.
  - Often as soils warm, phosphorus deficiency symptoms disappear.

K Deficiency Symptoms in Plants

- K is the 3rd most frequently deficient nutrient
- K is mobile and readily transferred from older leaves to young plant tissue
    - Deficiency symptoms appear first on the lower leaves as yellowing or necrosis of margins & progress toward the top, although K deficiency can occur in new leaves of fast-maturing crops like cotton & wheat
- On corn and other grasses, chlorosis and necrosis occur along the leaf edges first

K symptom Cont'

- On alfalfa, white spots occur on the leaf edges
- Broad leaf plants like soybean & potato, chlorosis and necrosis occur along the leaf margins of mature leaves.
- Lodging
- Adequate K can increase yields by decreasing or preventing crop damage caused by diseases, insects, and viral infections

Micronutrient Deficiency Sypmtoms

- Color change in upper leaves, terminal bud remains alive
  - S, Zn, Fe, Mn, Cu, Cl, Mo
  - Symptoms have many similarities
  - Diagnosis challenging without tissue analysis

Sulfur

- Tied to protein
- Widespread use of ammonium sulfate in the past, and industrial deposits used to make deficiencies rare
- Also supplied by microbial decomposition of SOM

Sulfur

- Legumes grown on sandy soils, low in SOM, are most likely to be deficient
- Environmental clean up and limited use of ammonium sulfate has made S deficiency of more concern
- Tissue test, not soil test, is best way to determine deficiency
- Levels in plants are 0.31-0.50 percent

Figure 2. Sulfur-deficient dark red kidney beans. Light–green color and reduced growth, left. Resembles nitrogen deficiency. Plants mature early. Normal plant, right.

Figure 3. Sulfur-deficient corn. Light green plants growing on sandy soil low in organic matter. Plants usually grow out of the deficiency as the roots penetrate the subsoil.

Boron

- Like nitrate, exists as a water soluble anion
- Subject to same losses as nitrate
- Alfalfa, other legumes, cole crops are responsive to B
- Soil Organic Matter (SOM) supplies B
- Plant levels are 31-80 ppm

Boron

- Recommendations based upon crop response and soil type (forage legumes grown on sandy soil)
- Broadcast 1-2 pounds with topdressed fertilizer:

Boron application:

- Boron may be blended into dry fertilizers such as 0-0-60 or 0-14-42.
- Boron fertilizers include borax (11% boron) and borate granular (14% boron). Solubor (20% boron liquid) is foliar applied and must be applied at recommended rate for specific crops.
- Application of 9 lbs Borax per acre will supply 1 lb boron per acre
- For gardeners, about 4 teaspoons borax per 1000 square feet is equivalent to 1 lb boron per acre
- Dry boron fertilizers should be broadcast along with other fertilizers and worked into soil.
- Boron fertilizer should not be applied if grasses, including hay, pasture, turf, small grains or corn are sown immediately following application.
- Manure generally contains .03-.08 lbs boron per ton, more if composted

Figure 24. Boron-deficient alfalfa. Yellow to reddish yellow discoloration of the upper leaves. Often confused with leafhopper damage, which also causes yellowing of the tips of leaves.

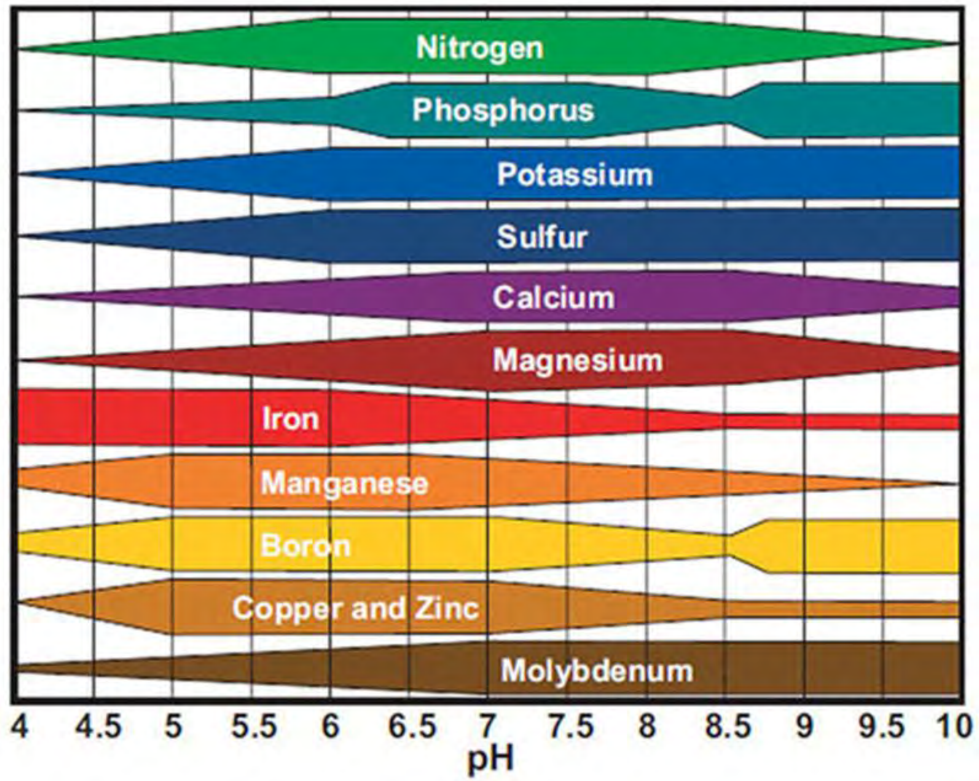
Remember!

- Deficiency symptoms:
  - are not often clearly defined
  - always indicate severe starvation, not slight or moderate starvation
- Many crops start losing yields before signs start showing
- “Hidden hunger” may reduce yields and quality of crop

More on secondary and micronutrients

Soil pH impact on nutrient availability

- **Low** soil pH has major impact on availability of:
  - Phosphorus
  - Calcium
  - Magnesium
  - Molybdenum
- **High** soil pH has major impact on availability of :
  - Phosphorus
  - Iron
  - Manganese
  - Boron
  - Copper
  - Zinc



Agronomic Crops

	Mn	B	Cu	Zn	Mo	Fe
Corn	med	lo	med	hi	lo	med
Barley	med	lo	med	lo	lo	med
Oats	hi	lo	hi	lo	lo	med
Rye	lo	lo	lo	lo	lo	
Wheat	hi	lo	hi	lo	lo	lo
Potato	hi	lo	lo	med	lo	
Brassica	lo	med	lo			
Dry beans	hi	lo	lo	hi	med	hi

Vegetable and fruit crops

	Mn	B	Cu	Zn	Mo	Fe
Apple	lo	hi	med	med		
Blueberry	lo	lo	med			
Carrot	med	med	med	lo	lo	
Spinach	hi	med	hi	hi	hi	hi
Table beet	hi	hi	hi	med	hi	hi
Cabbage	med	med	med	lo	med	med
Sweet corn	hi	med	med	hi	lo	med

Testing for secondary and micronutrients

Soil testing

- Mg
- Ca
  - *Included in 'normal' soil test reports along with P and K*
    - Soil type/CEC can indicate capacity to 'hold' cations (+)
    - Sulfur soil test is not a dependable indicator
    - S and B are anions (-)

Tissue analysis

- S
- Mn
- B
- Cu
- Zn
- Mo
- Fe

TABLE 1.
Nutrient sufficiency ranges for corn, soybeans, alfalfa, wheat, sugar beets, potatoes and vegetables.

ELEMENT	CORN Ear leaf sample of initial silk	SOYBEANS Upper fully developed leaf sampled prior to initial flowering	ALFALFA Top 6 inches sampled prior to initial flowering	WHEAT Upper leaves sampled prior to initial bloom	SUGAR BEETS Center fully developed leaf sampled in midseason	VEGETABLES Top fully developed leaves	POTATOES Petioles from most recently matured leaf sampled in midseason
Percent (%)							
Nitrogen	2.76-3.50	4.26-5.50	3.76-5.50	2.59-3.00	3.01-4.50	2.50-4.00	2.50-4.00
Phosphorus	0.25-0.50	0.26-0.50	0.26-0.70	0.21-0.50	0.26-0.50	0.25-0.80	0.18-0.22
Potassium	1.71-2.50	1.71-2.50	2.01-3.50	1.51-3.00	2.01-6.00	2.00-9.00	6.00-9.00
Calcium	0.21-1.00	0.36-2.00	1.76-3.00	0.21-1.00	0.36-1.20	0.35-2.00	0.36-0.50
Magnesium	0.16-0.60	0.26-1.00	0.31-1.00	0.16-1.00	0.36-1.00	0.25-1.00	0.17-0.22
Sulfur	0.16-0.50	0.21-0.40	0.31-0.50	0.20-0.40	0.21-0.50	0.16-0.50	0.21-0.50
Parts per million (ppm)							
Manganese	20-150	21-100	31-100	16-200	21-150	30-200	30-200
Iron	21-250	51-350	31-250	11-300	51-200	50-250	30-300
Boron	4-25	21-55	31-80	6-40	26-80	30-60	15-40
Copper	6-20	10-30	11-30	6-50	11-40	8-20	7-30
Zinc	20-70	21-50	21-70	21-70	19-60	30-100	30-100
Molybdenum	0.1-2.0	1.0-5.0	1.0-5.0	0.03-5.0	.15-5.0	0.5-5.0	0.5-4.0

Types of micronutrient fertilizers

Dry

- Incorporated into granules
- Blended with N-P-K (sticker may be needed)
- Soluble (ground applied as liquid)

Liquid

- Ground applied
- Foliar applied
  - Absorbed through leaves.
  - More readily available than soil-applied, but not continuous
  - Good to supplement soil application or correct mid-season deficiencies

TABLE 4.
Suggested rates and sources of secondary and micronutrients for foliar application.[2]

Element	Lbs. element per acre	Suggested source
Calcium (Ca)	1-2	Calcium chloride or calcium nitrate
Magnesium (Mg)	1-2	Magnesium sulfate (Epsom salts)
Manganese (Mn)	1-2	Soluble manganese sulfate or finely ground manganese oxide
Copper (Cu)	0.5-1.0	Basic copper sulfate or copper oxide
Zinc (Zn)	0.3-0.7	Zinc sulfate
Boron (B)	0.1-0.3	Soluble borate
Molybdenum (Mo)	0.06	Sodium molybdate (2 ounces)
Iron (Fe)	1-2	Ferrous sulfate

[2]Use a minimum of 30 gallons of water per acre.

From MSU Extension bulletin E-486 "Secondary and Micronutrients for Vegetables and Field Crops"

"Soil health" testing

- Solvita CO_2 respiration test
  - Basic, do-it-yourself test kits
  - 'Burst' version requiring lab submission
- Cornell Soil Health Assessment $45 basic test
- Phospholipid fatty acid (PLFA) analysis
- Aggregate stability
- Earthworm number and diversity counts
  - 0-1 per shovelful of top foot of soil ⇨ poor
  - 2-10 per shovelful of top foot of soil ⇨ medium
  - 10+ per shovelful of top foot of soil ⇨ good
    - *Source: Center for Environmental Farming Systems, N Carolina State University*
- "Haney" soil test: A new procedure including chemical, physical and biological properties of soils

Sample Cornell Soil Health Test report (interpretation information on the Cornell Soil Health Test website)

CORNELL SOIL HEALTH TEST REPORT (COMPREHENSIVE)				
Name of Farmer: Bob Schindelbeck				Sample ID: G140
Location: Cornell University Musgrave Research Farm, Poplar Ridge, NY 13026				Agent: Bob Schindelbeck
Field/Treatment: G140 Plot 1A Long term tillage trial				Agent's Email: rrs3@cornell.edu
Tillage: 9+ inch				Given Soil Texture: silty
Crops Grown: COG/COG/COG				Date Sampled: 4/16/2009
	Indicators	**Value**	**Rating**	**Constraint**
PHYSICAL	Aggregate Stability (%)	38	56	
PHYSICAL	Available Water Capacity (m/m)	0.09	[illegible]	water retention
PHYSICAL	Surface Hardness (psi)	66	[illegible]	
PHYSICAL	Subsurface Hardness (psi)	350	[illegible]	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	2.6	[illegible]	energy storage, C sequestration, water retention
BIOLOGICAL	Active Carbon (ppm) [Permanganate Oxidizable]	585	44	
BIOLOGICAL	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	5.2	[illegible]	N Supply Capacity
BIOLOGICAL	Root Health Rating (1-9)	3.2	[illegible]	
CHEMICAL	*pH	7.9	[illegible]	Toxicity, Nutrient Availability (for crop specific guide, see CNAL report)
CHEMICAL	*Extractable Phosphorus (ppm) [Value <3.5 or >21.5 are downscored]	6.5	[illegible]	
CHEMICAL	*Extractable Potassium (ppm)	48	[illegible]	
CHEMICAL	*Minor Elements		56	
OVERALL QUALITY SCORE (OUT OF 100):			46.1	Low
Measured Soil Textural Class:==> silt loam				
SAND (%): 41.7		*SILT (%): 53.6*		*CLAY (%): 4.7*
Location (GPS): Latitude=> 42.732892 Longitude=> -76.659594				

* See Agro-One report for recommendations

Applying Lime

A Word about Lime…

- “Lime” refers to any material intended to raise soil pH
- Calcium carbonate (calcite) and magnesium carbonate (dolomite) are most common materials
- “Pelletized” lime is fine-ground lime stuck together with a binder
- Hardwood ash has approx 50% lime capacity (dry)

Lime

- Still the first place to spend limited fertilizer $
- Why?
  - Improves CEC on sandy soils
  - “Frees up” soil P in clay soils
  - Increases availability of N, P, K and other plant nutrients
  - Supplies Ca and Mg
  - Promotes better soil microbial activity, soil structure and tilth
  - Promotes longevity of legume stands

☞ Amount recommended depends on lime quality and depth of incorporation

Adjusting soil pH (up)

- Use of "ag lime" to increase pH (reduce acidity)
  - Calcitic lime – higher in calcium
  - Dolomitic lime – higher in magnesium
- Quality of ag lime affects its effectiveness
  - Chemistry of limestone material
  - Fineness of grind (finer is better)
- Placement, depth and thoroughness of incorporation of ag lime is important
- Alternatives to ag lime:
  - Industrial woodash
  - Other approved industrial by-products

Adjusting soil pH (down)

- Use of elemental sulfur or sulfur compounds to reduce pH (increase acidity)
  - Usually for specialty crops – blueberries, rhododendrons, etc
- Elemental sulfur most cost effective
  - Plan ahead
  - Involves biological processes – about a year
- Iron sulfate or Aluminum sulfate
  - Faster reacting
  - Requires 7X amount as elemental sulfur

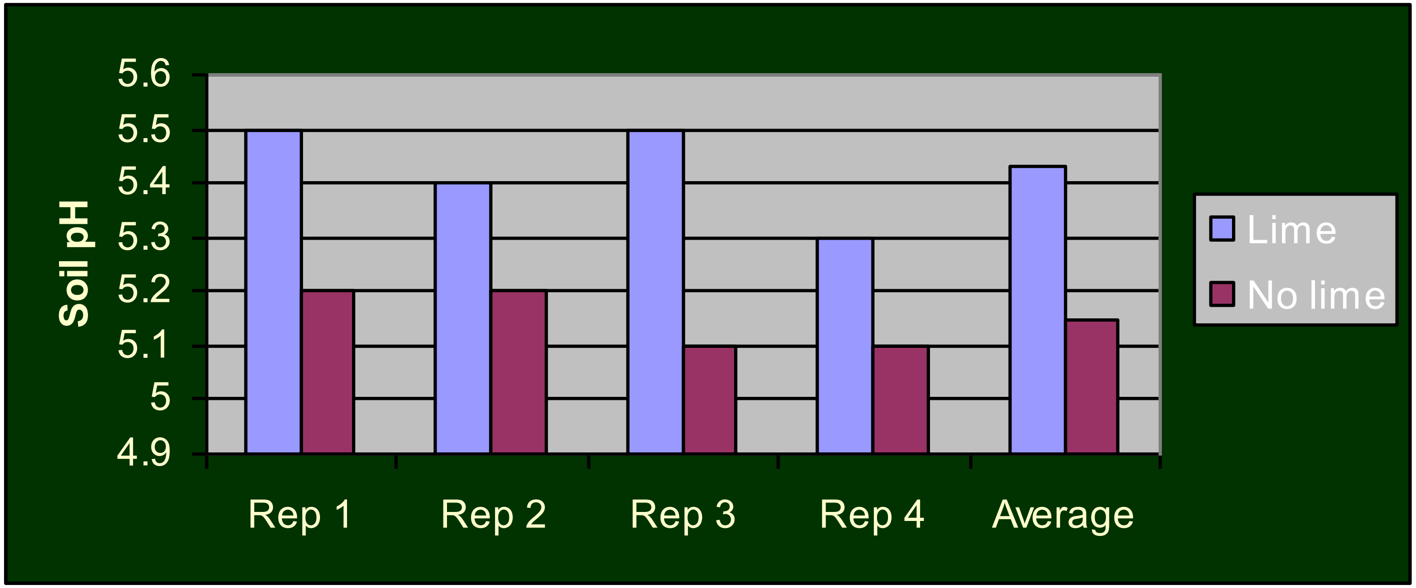
Lime Analysis (Dry)

- Source: Cedarville
- Liming material analysis
  - 103.8% Neutralizing Value
  - 44.9% $MgCO_3$
  - Sieve analysis: 73% passing 8 mesh
  - 28% passing 60 mesh
  - 28% passing 100 mesh

Lime Application Rate

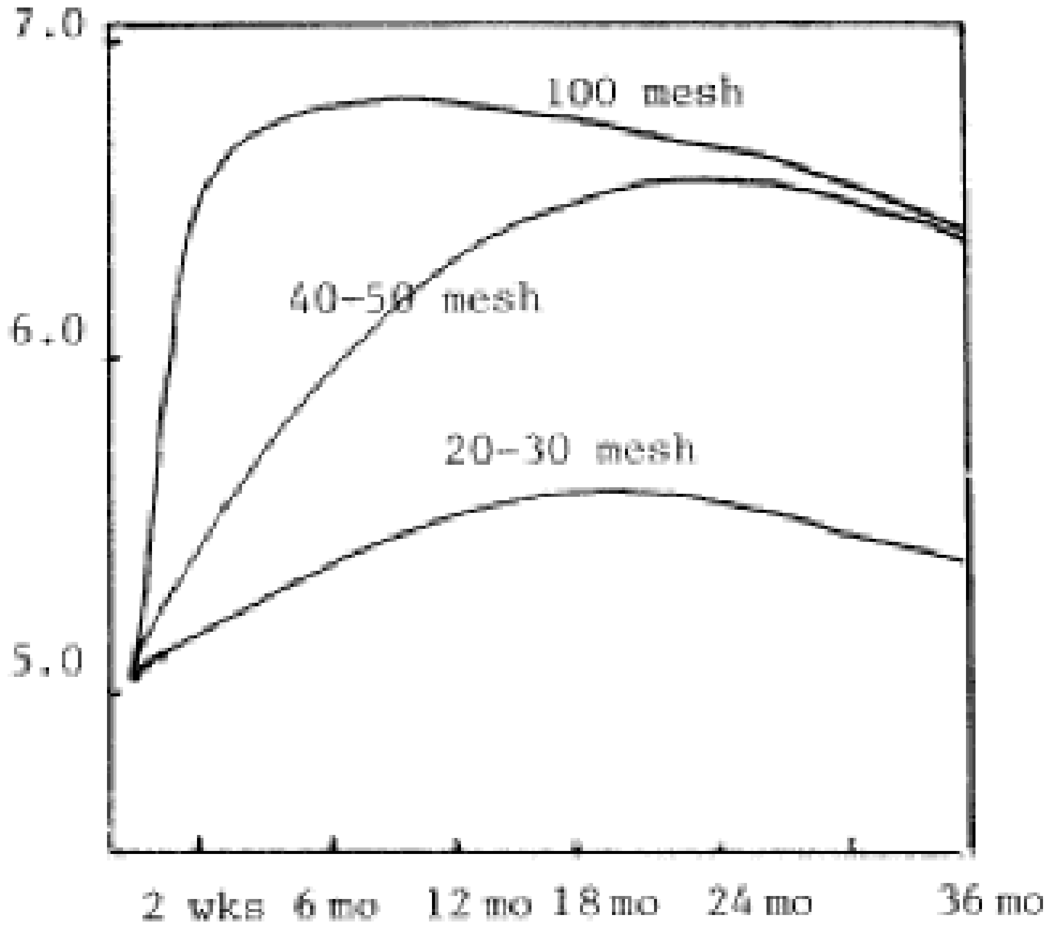
- 6.4% moisture as applied
- Attempted application rate: 2 tons/acre
- Estimated application rate 1.75 tons/acre (1.6 tons/acre dry material)
- Estimated “90%” Lime equivalent applied: 0.93 tons/acre

pH Change


5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
Soil pH
Rep 1
Rep 2
Rep 3
Rep 4
Average
Lime
No lime

Calcitic vs. Dolomitic Lime

- **Calcitic Lime**
  - $CaCO_3$
  - <5% $MgCO_3$
  - Builds soil calcium, raises soil pH
- **Dolomitic Lime**
  - 15% - 45% $MgCO_3$
  - 55% - 85% $CaCO_3$
  - Builds soil magnesium and calcium
  - No problems if used where Mg is not limiting


7.0
6.0
5.0
100 mesh
40-50 mesh
20-30 mesh
2 wks
6 mo
12 mo
18 mo
24 mo
36 mo

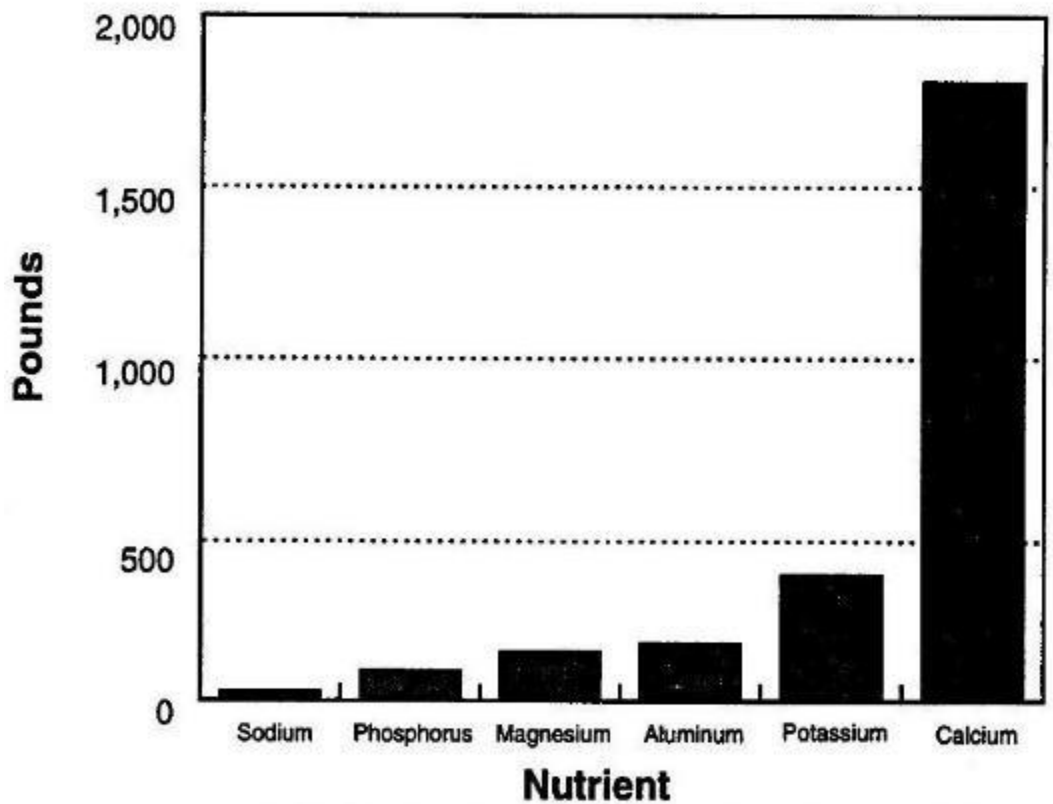
Three U.P. Limes Compared

Source	%NV	%MgCO3	%Mst.	% passing 8 mesh	% passing 60 mesh	% passing 100 mesh	Amt needed for 3T/a rec.
A	98.4	39.4	1.4	99.7	50.6	49.7	3.6 T/a
B	95.4	2.8	13.4	95.6	90.6	75.8	3.5 T/a
C	103.8	44.9	0	72.7	28.1	27.8	5.1 T/a

☞ *Does lime quality make a difference?*

Applying Woodash

Pounds of nutrient per acre in five tons of wood ash.



Nutrient content calculated as average of 12 different wood ashes.
(See appendix tables for more detailed information.)

From: Sustainable Agricutlure Fact Sheet # 2279 "Using Wood Ash on Your Farm", U. of Maine Coop. Ext.

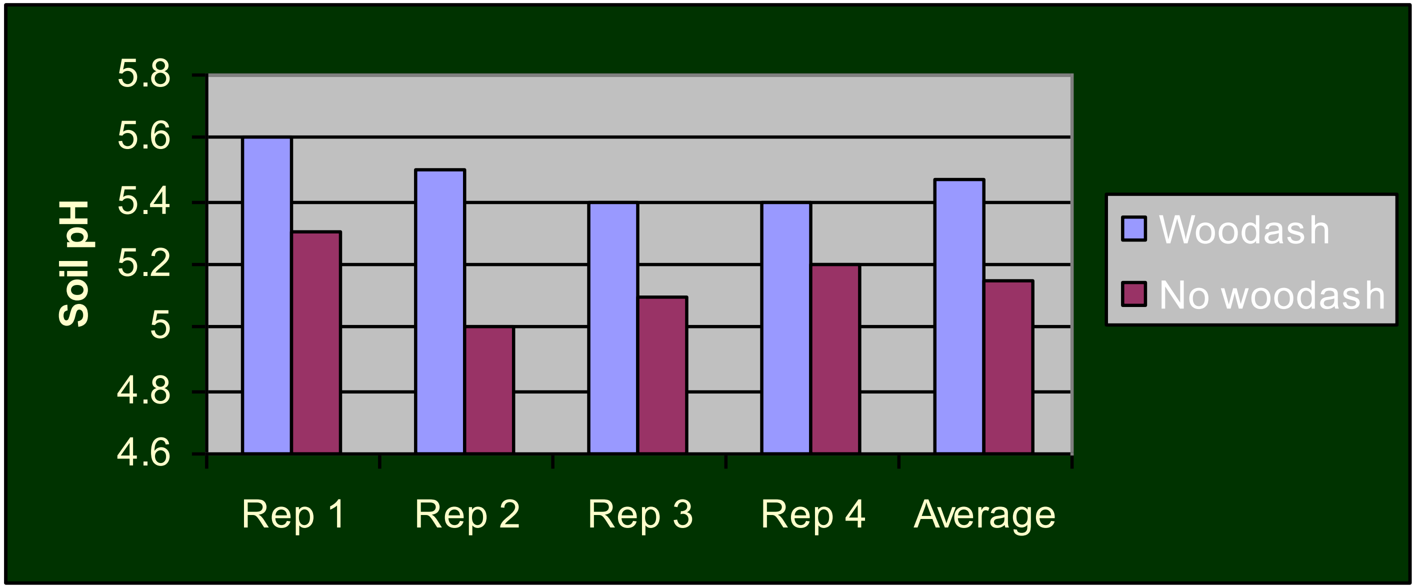
Woodash Analysis (Dry)

- Liming material analysis
  - 76.1% Neutralizing Value
  - 2.6% $MgCO_3$
  - Sieve analysis: 94% passing 8 mesh
  - 59% passing 60 mesh
  - 59% passing 100 mesh
- Fertilizer analysis: 0.6%P, 3.0%K, 30.2%Ca,
  - also Na, Zn, Mn, Cu, Fe, B, Mb, Al
- Source: Timber Products, Alger County

Woodash Application Rate

- 36% moisture as applied
- Measured application rate: 1.0 tons/acre (0.6 tons/acre dry material)
- "90%" Lime equivalent applied: 0.3 tons/acre
- Nutrients applied: 18# P_2O_5, 46# K_2O,10# Mg, 387# Ca per acre + micronutrients

pH Change


Soil pH
5.8
5.6
5.4
5.2
5
4.8
4.6
Rep 1
Rep 2
Rep 3
Rep 4
Average
Woodash
No woodash

Soil building plan for very poor soils

A. In spring, sow buckwheat, sorghum/sudangrass, millet, oats or some other spring-seeded annual crop with adequate lime and fertilizer.
B. Work this crop into the soil in early August. It may need to be mowed before tilling.
C. Sow fall rye in mid-late August. Rye will be very attractive to wildlife and regrow vigorously in spring. Rye is an excellent "scavenger" crop and will be able to extract plant nutrients unavailable to many other crops. These nutrients will become available to the following crop as the rye residue decomposes later.
D. Work the rye into the soil in May
E. Repeat the process for another year, or prepare the soil for a semi-permanent seeding (clover, alfalfa, grass, etc)

What happens to my fertilizer?

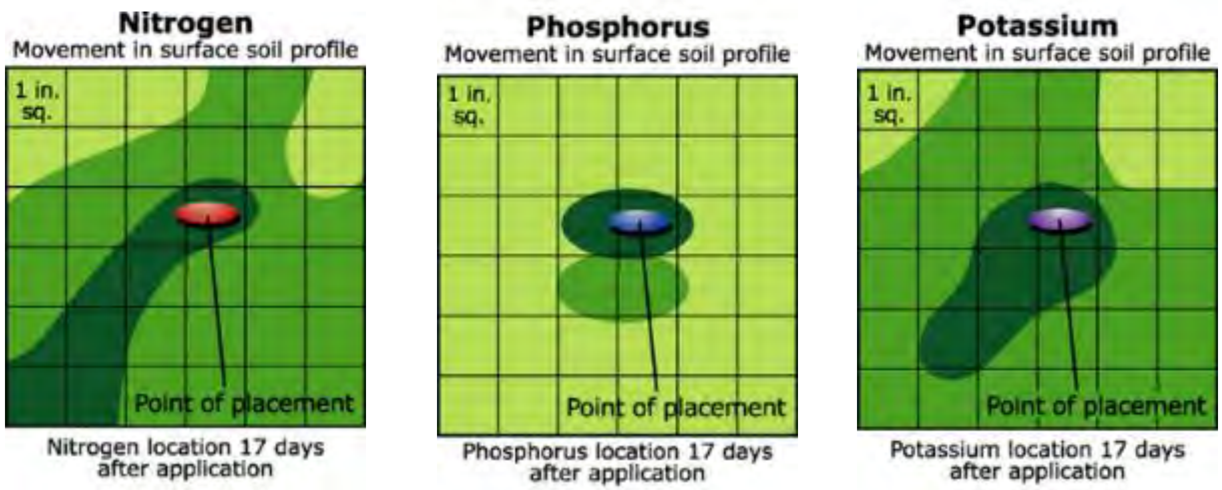
Step 1: Contact between plant-nutrients and root surface

a) Root interception
b) Mass flow
c) Diffusion

Step 2: Plant-nutrient uptake

a) Passive uptake
b) Active uptake

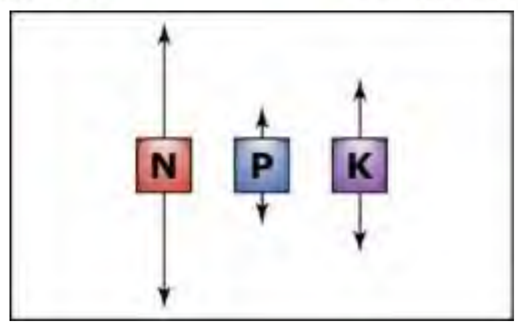
Relative Movement of N, P, K in the Soil



High concentration

Medium concentration

No effect



What about organic recommendations?

- Baseline ‘basic’ soil test + OM very valuable
- Much more complex
- Every system unique
- Know nutrient types and amounts in amendments

Soil Organic Matter

- Typical Michigan soil baseline = 4% SOM
- Annual tillage reduces SOM to a ‘plateau’ of 2%
  - Water holding capacity – SOM can hold up to 90% of its own weight in water.
  - Nutrient holding capacity – SOM can hold up to 20X compared to sand/silt/clay. 1% SOM can release up to 20 lbs N, 5 lbs P_2O_5, 20 lbs K_2O and 2 lbs S each year and buffers soil pH. Most nutrients are released during warmer weather.
  - Soil structure – SOM improves soil particle aggregation, water infiltration, reduced erosion

Biological activity

- Soil biology
  - Solvita soil respiration test

Cover Crop Species	Solvita Reading Basal CO_2 Respiration (CO_2-C ppm)	Significant difference	Relative Biomass Rating*	Relative Weed Suppression Rating*
Annual Rye	32.93	A	2	3
Chickling vetch	32.40	AB	1	2
Sunn Hemp	29.70	ABC	9	9
Egyptian Wheat	27.33	BCD	7	7
Diverse Mix	26.24	CD	5	5
E. Cabbage	24.82	CDE	4	6
I.F. Collards	24.71	CDE	6	4
Cowpeas	23.18	DE	8	8
Buckwheat	19.32	E	3	1

* (1 = excellent, 9 = poor)

Solivta test results from UPREC cover crop trial 2014

Testing for Soil health/quality

- Soil health/quality
  - NRCS soil quality test
  - Cornell soil health test
  - Bio-systems, Joe Scrimger, Marlette, MI
  - ATTRA: "Alternative Soil Testing Laboratories"
    https://attra.ncat.org/attra-pub/viewhtml.php?id=285

Strategies for building long-term soil fertility and health

- Building up soil organic matter
- Tillage practices
- Rotations
- Long-term fertilizer/lime strategy

Soil trench, Ontonagon Co MSUE Field Day, Sept 2016

Chatham cover crop after grazing, Aug 2013

Building up soil OM

1. **Maintain cover** Keep the soil covered with living plants as much as possible. Avoid 'brown' periods of bare soil. Live roots in the soil as much as possible is the goal.

Red clover in corn, MSU Kellogg Biological Station

Buckwheat, MSUE cover crop demo, Rudyard MI, 2014

Building up soil OM

2. **Reduce tillage and traffic** Minimize activities that compact the soil profile, including tillage and heavy traffic. No-till planting is an option to accomplish this where possible. Try to contain unavoidable heavy traffic flow to 'sacrifice' areas if possible, using a designated lane through fields.

Building up soil OM

3. **Addition of organic material** Animal or green manures added to the soil will replace organic matter lost to oxidation when soils are cultivated. It will not only add plant nutrients to the soil, but contributes to the diversity of microbial activity and can improve soil structure.




1% increase in SOM =
$750/acre of free nutrients

1% increase in SOM = **3.2 times increase in water holding capacity**

SOM increases from **1 to 3%** → **water holding capacity doubles**, regardless of soil texture

Legumes in mixed hay

MSU Soil Test Report 'boilerplate' language for clover-grass hay:

- ***6 or more legume plants per sf*** no N needed.
- ***4-5 legume plants per sf*** 50 lbs N per acre (ex: 108 lbs 46-0-0).
- ***2-3 legume plants per sf*** 100 lbs N per acre (ex: 217 lbs 46-0-0).
- ***Less than 2 legume plants per sf*** 150-200 lbs N per acre

Split application suggested.

Legumes in pasture

MSU Soil Test Report 'boilerplate' language for clover-grass pasture:

- ***Over 30% legume*** no N needed.
- ***Less than 30% legume*** Apply 100 lbs N per acre (50 lbs N after 2nd grazing cycle and 50 lbs N in mid-late August if moisture is adequate and fall grazing is needed.)
- ***2-3 legume plants per sf*** 100 lbs N per acre (ex: 217 lbs 46-0-0).
- ***Grass only pasture*** 40-50 lbs N at green-up and after each grazing, expect last

Determining legume stand – low % legume

- The following photos are from "Visual reference guide for estimating legume content in pastures", Forage and Grazinglands, Edward Rayburn

5% legume, 82% grass, 13% weeds 2950 lbs dry matter/A

6% legume, 52% grass, 43% weeds 1180 lbs dry matter/A

Determining legume stand – med % legume

25% legume, 75% grass
1400 lbs dry matter/A

25% legume, 73% grass, 2% weeds 3230 lbs dry matter/A

Determining legume stand – hi% legume

40% legume, 27% grass, 33% weeds 1880 lbs dry matter/A

46% legume, 41% grass, 13% weeds 3230 lbs dry matter/A

Get more legumes into your field…

- In grass or mixed grass/legume forage, increasing legume component reduces, or eliminates, the need for nitrogen fertilizer
- How to accomplish this?
  - Frost seed red clover and/or birdsfoot trefoil on grazed land. Not recommended in coarse textured soils.
  - Drill seed into existing hay fields or pastures
  - Improve grazing practices
  - Include adequate legume seed into new hayfield or pasture seedings

Fertilizers and amendments

- 1st big decision:

Conventional ?

or

Organic ?

Conventional examples

Urea *(46-0-0)*

ESN – *'environmentally sensitive nitrogen'* *(44-0-0)*

Conventional fertilizers: Pro's & Con's

- Pro:
  - Convenience
  - Concentration of nutrients
  - Cost per unit of available nutrient
  - 'Quick release'
  - Standardized nutrient content
  - Precision of application
  - Ability to 'blend' nutrients & micronutrients
  - Multiple formulations (dry granular, liquid, foliar)
- Con:
  - No organic matter
  - High salt concentration
  - Potentially imbalanced
  - Potential damage to soil organisms
  - Price fluctuates based on cost of energy
  - Environmental hazard potential if mis-used
  - Manufactured/mined products

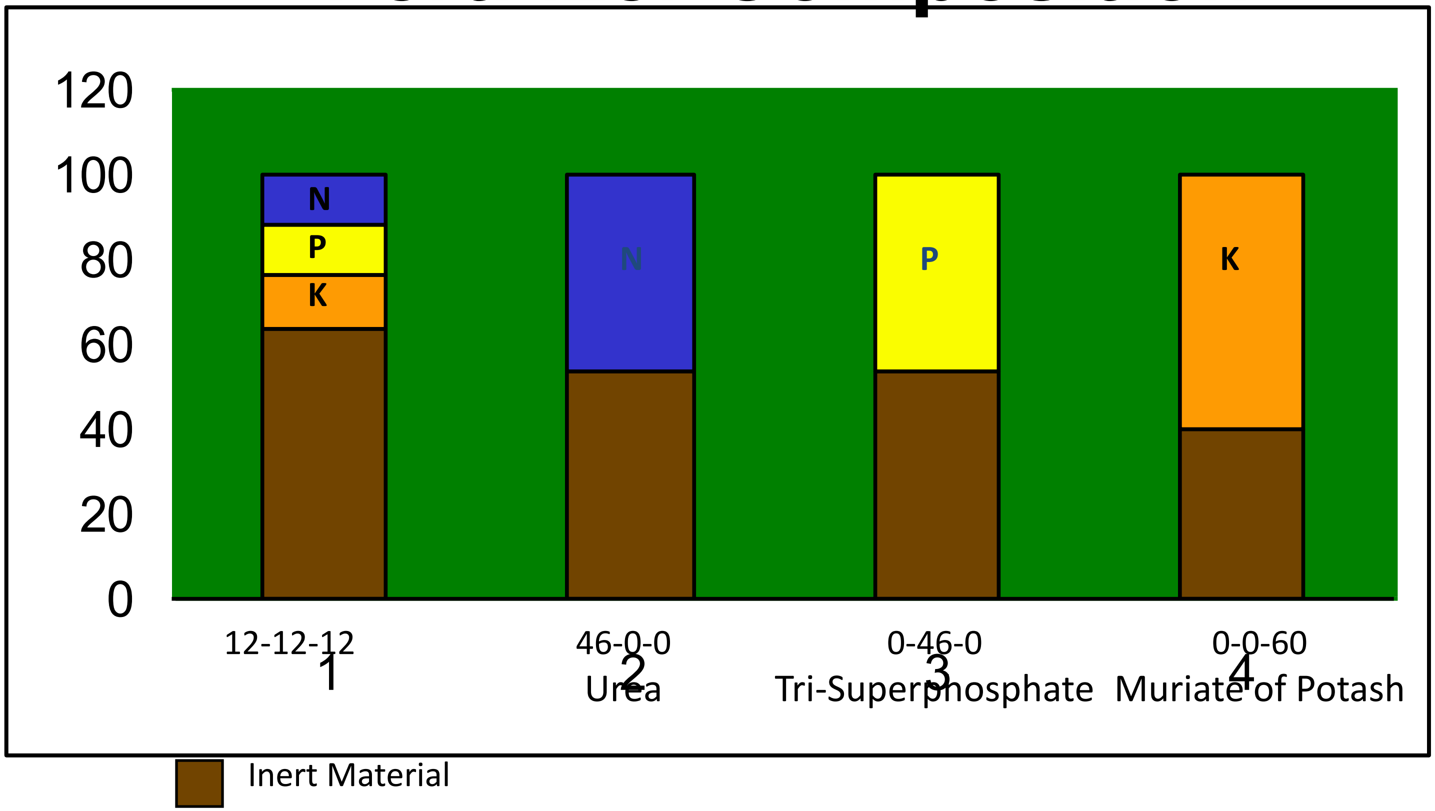
Conventional fertilizers - examples

- 46-0-0 - urea: 46% nitrogen ($18.22/100#)
- 0-45-0 - triple superphosphate: 45% P_2O_5 ($19.49/100#)
- 0-0-60 - muriate of potash: 60% K_2O ($21.24/100#)

- Blends:
  - 19-19-19
  - 20-10-20
  - 18-46-0
  - 0-14-42
  - 8-32-16
  - ….custom blends

Micronutrients:
- Boron
- Zinc
- Sulfur
- Copper
- Iron
- Molybdenum
- Manganese
- Magnesium
- Calcium

Fertilizer Composition



Organic example – manure compost

Organic fertilizers: Pro's & Con's

- Pro:
  - Natural, not manufactured
  - Contain multiple plant nutrients
  - Farm produced (manures, cover crops)
  - Build soil organic matter
  - Encourage soil biological diversity
  - Improve water-holding capacity
  - Allow a more self-contained system
  - Slow-release of nutrients
- Con:
  - Handling large volumes
  - Low nutrient concentration
  - Availability
  - Cost per unit of nutrient, especially if purchased
  - Variable nutrient content

Manure nutrient characteristics

'Book values'

- better than no info, but not as good as on-farm sampling
- MWPS-18 "Manure Characteristics"
- University resources
    - Animal manure as a plant nutrient resource – Purdue
    - Understanding manure: Differences in manure type and nutrient characteristics – Univ of Wisc
- Michigan Right to Farm Manure Management GAAMP – MDARD

Table 11. Estimated solid manure characteristics.
Use only for planning purposes. These values should not be used in place of a regular manure analysis

Livestock Stages	Production					Units	Concentration			
	Manure	Total N	NH_3-N	P_2O_5	K_2O		Total N	NH_3-N	P_2O_5	K_2O
	(lb/yr)						lbs/ton of manure			
Farrowing	4,800	34	7	14	10	per pig space	14	3	6	4
Nursery	480	3	1	2	1	per pig space	13	5	8	4
Grow-Finish	2,100	17	6	9	5	per pig space	16	6	9	5
Breeding-Gestation	2,000	9	5	7	5	per pig space	9	5	7	5
Feeder Pig	4,540	23	11	16	9	per sow space	10	5	7	4
Farrow-Finish	17,140	120	51	69	43	per sow space	14	6	8	5
Per Pig Sold	950	7	3	4	2	per pig sold	14	6	8	5
Dairy Cow	28,000	140	28	42	84	per mature cow	10	2	3	6
Dairy Heifer	13,000	65	13	20	46	per head capacity	10	2	3	7
Dairy Calf	3,000	15	3	5	8	per head capacity	10	2	3	5
Veal Calf	2,200	10	6	3	7	per head capacity	9	5	3	6
Dairy Herd	40,200	181	40	80	141	per mature cow	9	2	4	7
Beef Cows	13,400	47	20	27	47	per mature cow	7	3	4	7
Feeder Calves (500 lbs)	7,000	32	11	14	28	per head capacity	9	3	4	8
Finishing Cattle	11,800	65	24	41	65	per head capacity	11	4	7	11
Broilers	18	0.41	0.11	0.48	0.32	per bird space	46	12	53	36
Pullets	22	0.53	0.10	0.39	0.30	per bird space	48	9	35	27
Layers	39	0.66	0.23	0.99	0.51	per bird space	34	12	51	26
Tom Turkeys	46	0.92	0.18	1.15	0.69	per bird space	40	8	50	30
Hen Turkeys	46	0.92	0.18	1.15	0.69	per bird space	40	8	50	30
Ducks	60	0.42	0.15	0.54	0.33	per bird space	17	4	21	30

Table 8. Estimated liquid pit manure characteristics.
Use only for planning purposes. These values should not be used in place of a regular manure analysis

Livestock Stages	Production (lb/yr)					Units	Concentration (lbs/1,000 gallons of manure)			
	Manure	Total N	NH_3-N	P_2O_5	K_2O		Total N	NH_3-N	P_2O_5	K_2O
Farrowing	11,500	21	11	17	15	per pig space	15	8	12	11
Nursery	1,000	3	2	2	3	per pig space	25	14	19	22
Grow-Finish (deep pit)	3,500	21	14	18	13	per pig space	50	33	42	30
Grow-Finish (wet/dry feeder)	2,500	22	15	16	12	per pig space	75	50	54	40
Grow-Finish (earthen pit)	3,500	13	10	9	8	per pig space	32	24	22	20
Breeding-Gestation	7,000	21	10	21	20	per pig space	25	12	25	24
Farrow-Finish	37,500	126	72	108	103	per production sow	28	16	24	23
Sow Per Pig	2,000	7	4	6	6	per pig sold per year	28	16	24	23
Farrow-Feeder	10,000	25	13	22	23	per production sow	21	11	18	19
Dairy Cow	54,000	200	39	97	123	per mature cow	31	6	15	19
Dairy Heifer	25,000	96	18	42	84	per head capacity	32	6	14	28
Dairy Calf	6,000	19	4	10	17	per head capacity	27	5	14	24
Veal Calf	3,500	11	9	9	17	per head capacity	26	21	22	40
Dairy Herd	73,000	271	53	131	193	per mature cow	31	6	15	22
Beef Cows	30,000	72	25	58	86	per mature cow	20	7	16	24
Feeder Calves	13,000	39	12	26	35	per head capacity	27	8	18	24
Finishing Cattle	25,500	89	24	55	79	per head capacity	29	8	18	26
Broilers	83	0.63	0.13	0.40	0.29	per bird space	63	13	40	29
Pullets	49	0.35	0.07	0.21	0.18	per bird space	60	12	35	30
Layers	130	0.89	0.58	0.81	0.51	per bird space	57	37	52	33
Tom Turkeys	282	1.79	0.54	1.35	0.98	per bird space	53	16	40	29
Hen Turkeys	232	1.67	0.56	1.06	0.89	per bird space	60	20	38	32
Ducks	249	0.45	0.24	0.36	0.33	per bird space	22	5	15	8

Book values vs on-farm manure

	N Lbs/1000 gal	% of book value	P Lbs/1000 gal	% of book value	K Lbs/1000 gal	% of book value
Book value (MWPS-18: liquid pit – dairy herd)	31		15		22	
Nachtman Farm	15	48	8	53	22	100
Tuisnstra Farm	24	77	11	73	29	132
Lindberg Farm	35	113	18	120	54	245
Kronemeier Farm	32	103	14	93	29	123

REPORT NO. F10349-6002
ACCOUNT NUMBER 19646

A & L GREAT LAKES LABORATORIES, INC.

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QUALITY ANALYSES FOR INFORMED DECISIONS

TO: CALHOUN CO MSU EXTENSION SVC
315 W GREEN ST - COUNTY BLDG
MARSHALL, MI 49068-1518

FOR: BLOOM FARMS

ATTN: NATALIE RECTOR

LAB NUMBER: 53668
MANURE TYPE: DAIRY, LIQUID PIT
SAMPLE ID: ADL 3

MANURE ANALYSIS REPORT

DATE SAMPLED: 11/17/2010
DATE RECEIVED: 12/15/2010
DATE REPORTED: 12/17/2010 PAGE: 1 of 2

PARAMETER	UNIT	ANALYSIS RESULT	TOTAL POUNDS PER 1,000 GAL**	FIRST YEAR AVAILABILITY ® POUNDS PER 1,000 GAL
Moisture	%	73.84	6150.9	
Solids	%	26.16	2179.1	
Nitrogen, Total (TKN)	%	0.410	34.2	21.6 *
Nitrogen, Ammonium (NH4-N)	%	0.196	16.3	16.3 *
Nitrogen, Organic (N)	%	0.214	17.8	5.3 *
Phosphorus (P)	%	0.082	15.7 (as P2O5)	15.7 (as P2O5) *
Potassium (K)	%	0.319	31.9 (as K2O)	31.9 (as K2O) *
Sulfur (S)	%	0.06	4.8	2.7 #
Magnesium (Mg)	%	0.20	16.3	9.2 #
Calcium (Ca)	%	0.67	56.2	30.7 #
Sodium (Na)	%	0.09	7.8	
Aluminum (Al)	ppm	340	2.8	
Copper (Cu)	ppm	9.4	0.1	0.1 #
Iron (Fe)	ppm	1568	13.1	8.5 #
Manganese (Mn)	ppm	52	0.4	0.3 #
Zinc (Zn)	ppm	44	0.4	0.2 #

® Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993
# Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Benefits of composting

- Improves soil structure, adds organic matter and nutrients, enhances soil microbial community, balances pH, attracts earthworms, reduces manure volume.

Jim's old bin

(which he liked)

Jim's Tumbler

(which he didn't like)

Simple "Heap"

18 cu. ft./100 square ft.

(40 cu. ft. compost on 15’X15’ plot

Synthetic Fertilizer (6lbs 19-19-19)

Burt Twp. Compost demo garden, July 16, 1994

No Fertilizer

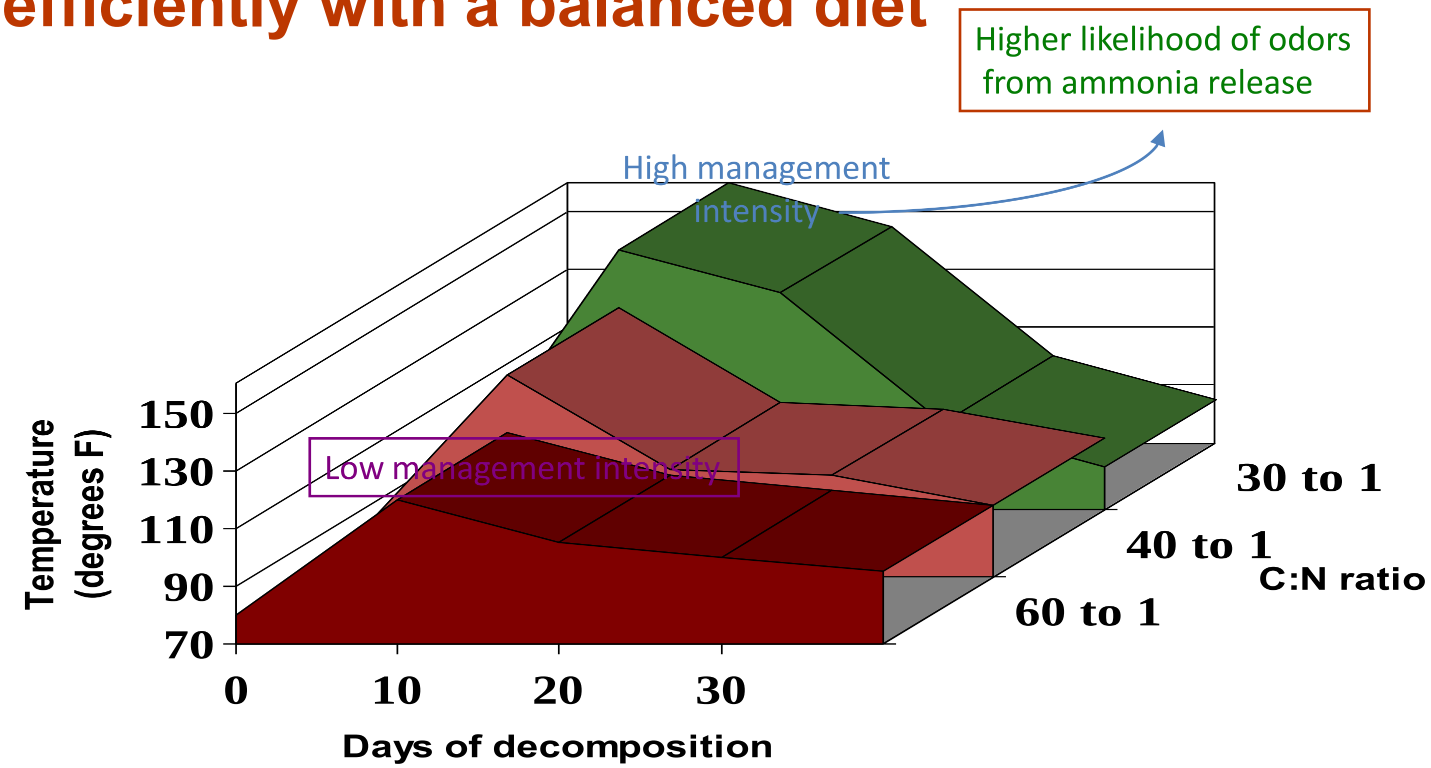
Compost

Compost Tea

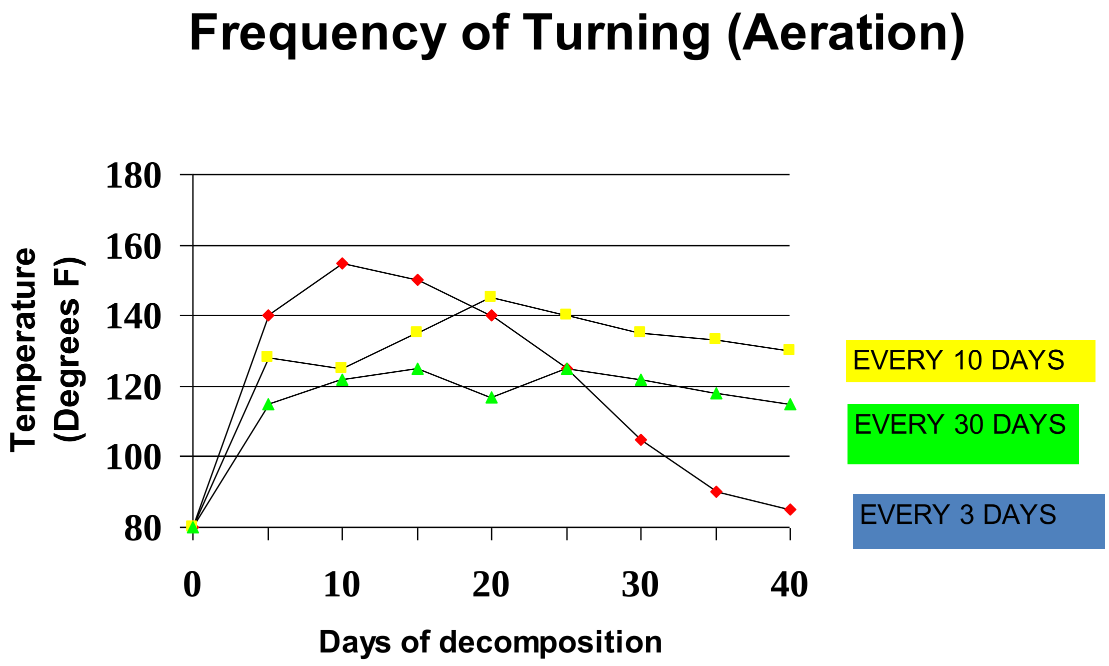
- Makes the benefits of compost go further
- Helps to suppress foliar diseases
- Increases available nutrients to plants
- Speeds the breakdown of toxins
- Enriches the soil with beneficial microorganisms

Effect of C:N Ratio on Compost Temperature

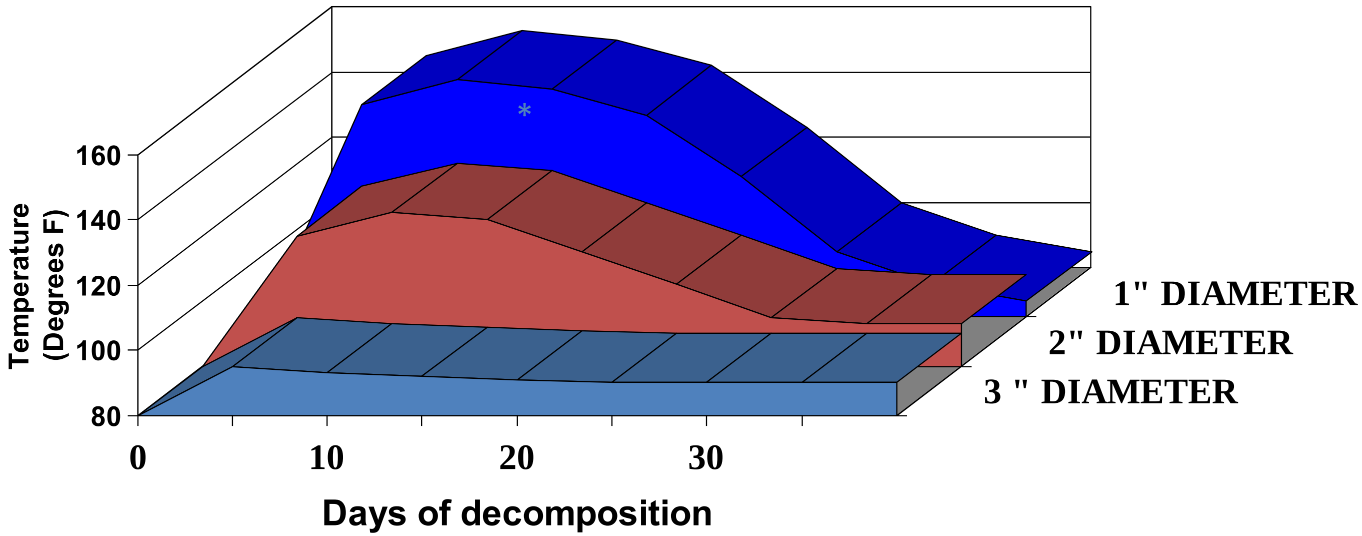
Microorganisms function most efficiently with a balanced diet



Effect of Aeration on Compost Temperature



Effect of Particle Size on Compost Temperature



* Small particle size >less air flow >less O_2 > odors?

Table 1: Approximate nutrient content and availability of some organic materials.*				
Material	**% Nitrogen**	**% Phosphate**	**% Potash**	**Availability**
Steamed bonemeal	0.7-4.0	18-34	----	slow-med.
Compost	1.5-3.5	.5-1.0	1.0-2.0	slow
Dried blood	12	1.5	0.57	med.-fast
Cattle manure**	0.25-2.0	0.15-0.9	0.25-1.5	med.
Horse manure**	0.3-2.5	0.15-2.5	0.5-3.0	med.
Sheep manure**	0.6-4.0	0.3-2.5	0.75-3.0	med.
Swine manure**	0.3	0.3	0.3	med.
Poultry manure**	1.1-2.8	0.5-2.8	0.5-1.5	med.-fast
Peat	1.5-3.0	0.25-0.5	0.5-1.0	very slow
Sawdust	0.2	0.1	0.2	very slow
Milorganite	0.5	2-5	2	med.
Sewage sludge (activated)	2-6	2-7	0-1	med.
Sewage sludge (digested)	1-3	0.5-4.0	0-.05	slow
Wood ashes	0	1-2	3-7	rapid
*The nutrient content of most organic materials is quite variable and depends upon the specific source and how the material has been handled and stored.				

Crop rotation

- Why rotate?

To manage pests and maintain soil fertility

  - Break plant disease and insect cycles
  - Add organic matter to soil
  - Add nutrients to soil
  - Increase biodiversity of soil microbe community
  - Prepare soil for most important crop in rotation

- Rotation is important in all systems
  - Hoophouses, truck gardens, larger vegetable and field crop production, hay & forage

Rotation methods

- Rotate by vegetable or field crop families
- Alternate vegetables with field/forage crops
- Rotate between cash crops and cover crops
- Rotate old hayfields into annual grain crop with underseeding when renovating hayfields
- Annual cover/conditioner crop for grazing or hay (year 1) + annual grain crop with underseeding (year 2) when renovating hayfields
- Include winter wheat or rye in rotation to balance field work schedule

Soil improvement benefits of cover/conditioner crops

- Provide nitrogen
- Add organic matter
- Improve soil structure
- Reduce soil erosion
- Provide weed control
- Manage nutrients
- Add to soil microbial diversity
- Furnish moisture-conserving mulch

Legume cover crops

Alfalfa

Crimson clover

Hairy vetch

Red clover

Oriental mustard

Non-legume cover crops

Barley

Buckwheat

Oats

Cereal rye

Oilseed radish

Wheat

Other possible soil amendments

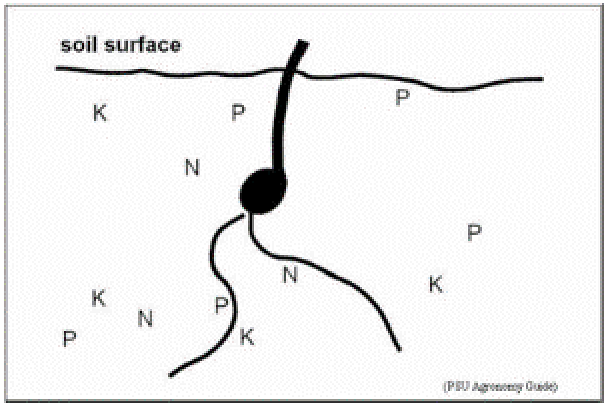
- Municipal biosolids
  - Processed sewage – state regulated
  - New processes generate improved biosolid product
  - High nutrient value, economical
- Industrial by-products
  - Paper mill sludge
  - Sugar beet lime / pulp
  - Spent grain
- Industrial wood ash
  - Excellent alternative to lime (typically ½ lime value)
  - Contains significant potassium and other nutrients
  - Fast acting
  - Beware of live embers!

Availability varies by location in state.
Carefully research any opportunities.

Fertilizer placement

Broadcast

- Applied on surface across entire field
- For ‘topdressing’ N on perennial grass, P & K on perennial legumes – rely on rain to work nutrients into soil
- If applied before annual crop in conventional tillage, incorporate immediately to avoid losses – runoff, erosion, volitalization



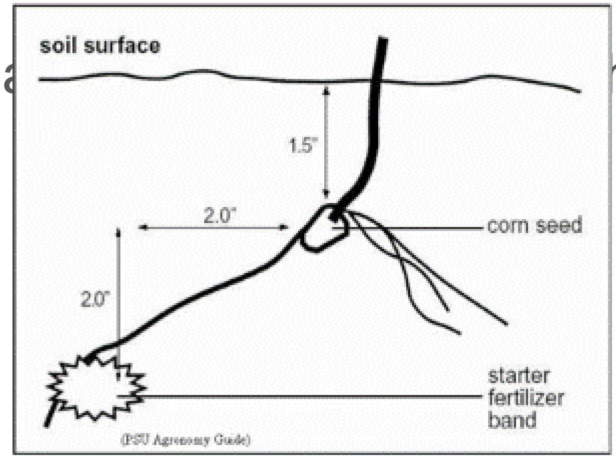
Broadcast pros and cons

- Pro
  - Fast and easy
  - Good for topdress

- Con
  - Lower use efficiency than banded
  - Possible poor uniformity of application

Band application or ‘starter’

- Often 2” over and 2” down from seed placement – corn, small grains, forages
- Close enough to efficiently supply young plants with nutrients
- Not so close as to dama n salt burn



Band application pros and cons

- Pro
  - Jumpstarts early growth
  - Cost effective way to improve nutrient use efficiency
  - Liquid or granular can be used

- Con
  - Require extra handling of fertilizer and frequent fill-ups
  - Can be phytotoxic if too much, too close

Sidedress application

- Application between the rows of growing crops
- Common in UP potatoes, corn 12-24”(?)
- PSNT to determine potential yield response to N sidedress
- UAN (dribble or inject), anhydrous ammonia, granular

Sidedress pros and cons

- Pro
  - PSNT can be used to decide if worthwhile
  - Hi N efficiency, because N is applied to rapidly growing crop when N is needed most

- Con
  - Timing (late June?) can interfere with other activities
  - Injection is slow (drop nozzles for ‘dribbling’ are faster)
  - Anhydrous ammonia has safety risks (handling, transport, theft)

UWEX A3587 “Looking at Dairy Manure Application Rates”

BMP's for land application of manure

- Follow MDARD Gaamps
- Be aware of sensitive areas
  - Wells – public and private
  - Surface water
  - Surface drainage inlets
  - Sinkholes
  - Property lines
  - Public roads

Thanks for participating!

Final questions?

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