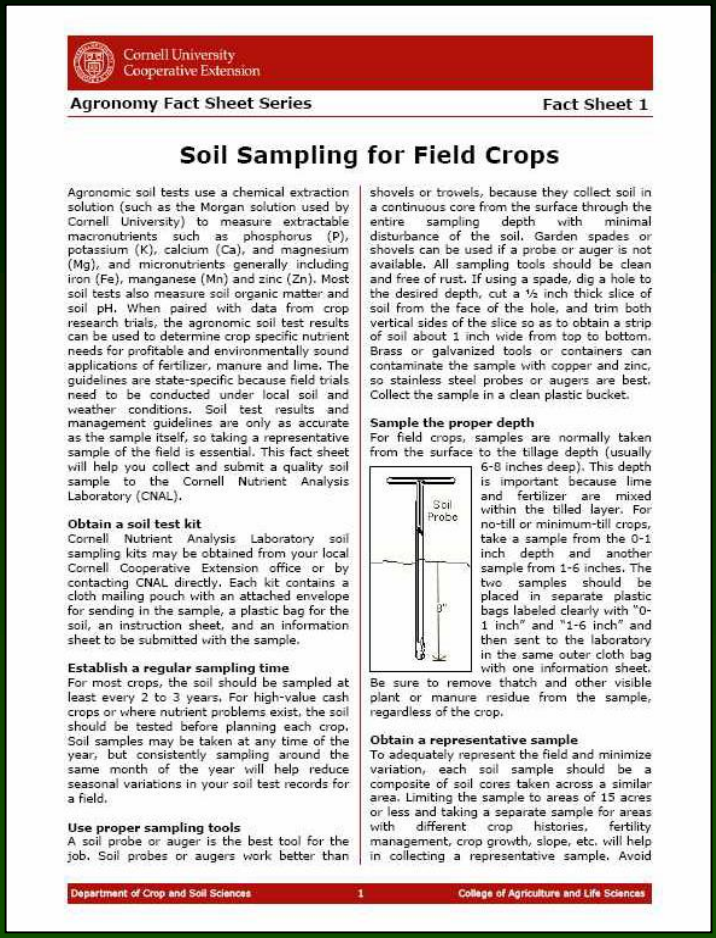
Soil Testing, Plant Analysis, and Manure Testing

Basic NRCCA Training Competency Area 3/4



Cornell University Cooperative Extension

Agronomy Fact Sheet Series — Fact Sheet 1

Soil Sampling for Field Crops

Agronomic soil tests use a chemical extraction solution (such as the Morgan solution used by Cornell University) to measure extractable macronutrients such as phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg), and micronutrients generally including iron (Fe), manganese (Mn) and zinc (Zn). Most soil tests also measure soil organic matter and soil pH. When paired with data from crop research trials, the agronomic soil test results can be used to determine crop specific nutrient needs for profitable and environmentally sound applications of fertilizer, manure and lime. The guidelines are state-specific because field trials need to be conducted under local soil and weather conditions. Soil test results and management guidelines are only as accurate as the sample itself, so taking a representative sample of the field is essential. This fact sheet will help you collect and submit a quality soil sample to the Cornell Nutrient Analysis Laboratory (CNAL).

Obtain a soil test kit
Cornell Nutrient Analysis Laboratory soil sampling kits may be obtained from your local Cornell Cooperative Extension office or by contacting CNAL directly. Each kit contains a cloth mailing pouch with an attached envelope for sending in the sample, a plastic bag for the soil, an instruction sheet, and an information sheet to be submitted with the sample.

Establish a regular sampling time
For most crops, the soil should be sampled at least every 2 to 3 years. For high-value cash crops or where nutrient problems exist, the soil should be tested before planning each crop. Soil samples may be taken at any time of the year, but consistently sampling around the same month of the year will help reduce seasonal variations in your soil test records for a field.

Use proper sampling tools
A soil probe or auger is the best tool for the job. Soil probes or augers work better than shovels or trowels, because they collect soil in a continuous core from the surface through the entire sampling depth with minimal disturbance of the soil. Garden spades or shovels can be used if a probe or auger is not available. All sampling tools should be clean and free of rust. If using a spade, dig a hole to the desired depth, cut a ½ inch thick slice of soil from the face of the hole, and trim both vertical sides of the slice so as to obtain a strip of soil about 1 inch wide from top to bottom. Brass or galvanized tools or containers can contaminate the sample with copper and zinc, so stainless steel probes or augers are best. Collect the sample in a clean plastic bucket.

Sample the proper depth
For field crops, samples are normally taken from the surface to the tillage depth (usually 6-8 inches deep). This depth is important because lime and fertilizer are mixed within the tilled layer. For no-till or minimum-till crops, take a sample from the 0-1 inch depth and another sample from 1-6 inches. The two samples should be placed in separate plastic bags labeled clearly with "0-1 inch" and "1-6 inch" and then sent to the laboratory in the same outer cloth bag with one information sheet. Be sure to remove thatch and other visible plant or manure residue from the sample, regardless of the crop.

Obtain a representative sample
To adequately represent the field and minimize variation, each soil sample should be a composite of soil cores taken across a similar area. Limiting the sample to areas of 15 acres or less and taking a separate sample for areas with different crop histories, fertility management, crop growth, slope, etc. will help in collecting a representative sample. Avoid

Department of Crop and Soil Sciences 1 College of Agriculture and Life Sciences

Mart Ros and Quirine Ketterings

November 29, 2017

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

Soil fertility & nutrient management

Six Competency Areas:

1: Basic Concepts of Plant Nutrition

2: Basic Concepts of Soil Fertility

3: Soil Testing and Plant Tissue Analysis

4: Nutrient Sources, Analyses, Application Methods

5: Soil pH and Liming

6: Nutrient Management Planning

Outline

- Soil Testing
- Plant Tissue Analysis
- Manure Testing

Soil Testing

- Soil testing is the basis for P, K, Mg, B, Zn recommendations

Soil Testing

An agronomic soil test is an

INDEX of nutrient availability.

Something we can measure that is correlated with a likeliness of a crop response.

A meaningful indicator.

Soil Testing

An agronomic soil test is NOT a measure of the total amount of a nutrient in the soil

E.g. a random soil sample from our database:

Total P =	Cornell Morgan test P =
550 mg/kg (1100 lbs/acre)	32 mg/kg (64 lbs/acre)

Soil Testing

An agronomic soil test is NOT a measure of the total amount of soil nutrient available to the crop

E.g. we grew a 25 ton corn crop without additional P

Cornell Morgan test P =
15 lbs P/acre

Removed with 25 ton corn crop =
25*2000*0.35*0.27/100=47 lbs P/acre

Soil Testing

An agronomic soil test is an

INDEX of nutrient availability.

Something we can measure that is correlated with a likelihood of a crop response.

So, without locally applicable crop response data, a soil test is useless!!!

Soil Testing

An agronomic soil test is an *INDEX* of nutrient availability

Morgan P (lbs/acre)	Inter-pretation	Response likely?	Recommendation
1-3	Low	Yes	Add extra P
4-8	Medium	Yes	Add extra P
9-39	High	No	Limit P to small starter only
40+	Very high	No	No extra P needed

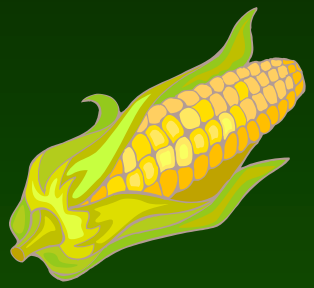
Three Fertilizer Recommendation Approaches

1. Nutrient maintenance
2. Cation saturation ratio
3. Sufficiency (yield response)

Nutrient Maintenance

Nutrient Maintenance:

Recommendation = nutrient export from field.



	relative fertility	
	low	high
Yield (bu/acre)	93	161
Nitrogen (lb N/acre)	112	173
Phosphorus (lb P_2O_5/acre)	20	78
Potassium (lb K_2O/acre)	57	146

Nutrient Maintenance

Disadvantages:

- Discounts soil supplying capacity.
- Ignores non-agronomic losses.
- Requires data on yield and nutrient content.

Advantage:

- Does not require soil sampling.
- Requires data on yield and nutrient content…

Cation Saturation Ratio

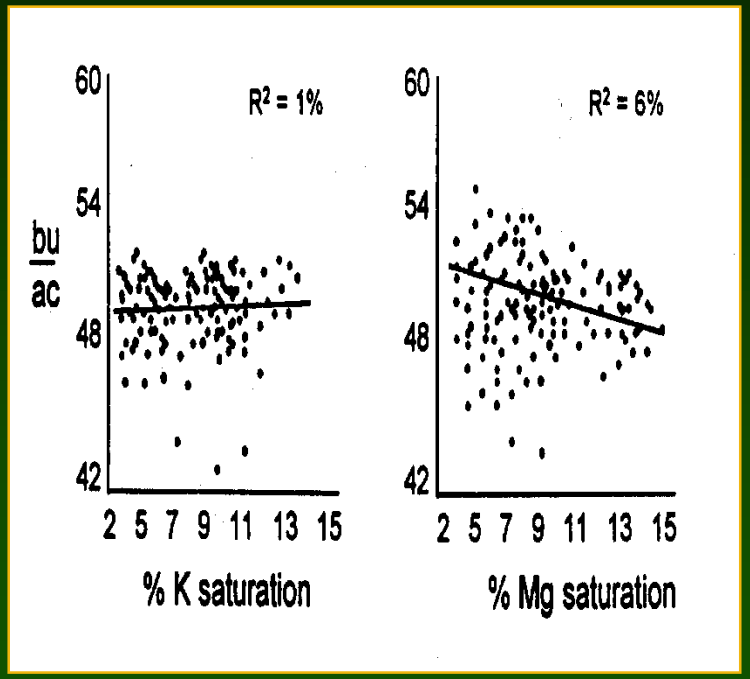
Assumes there is an ideal distribution of exchangeable cations (Ca, Mg and K):

	Ca^{2+}	Mg^{2+}	K^{+}	H^{+}
New Jersey:	65	10	5	20
Missouri:	75	10	2.5-5	

Cation Saturation Ratio

Disadvantage:

- Several studies show poor relationships with yield.
- K saturation estimates are not always reliable
- At high pH, corrections are very expensive.

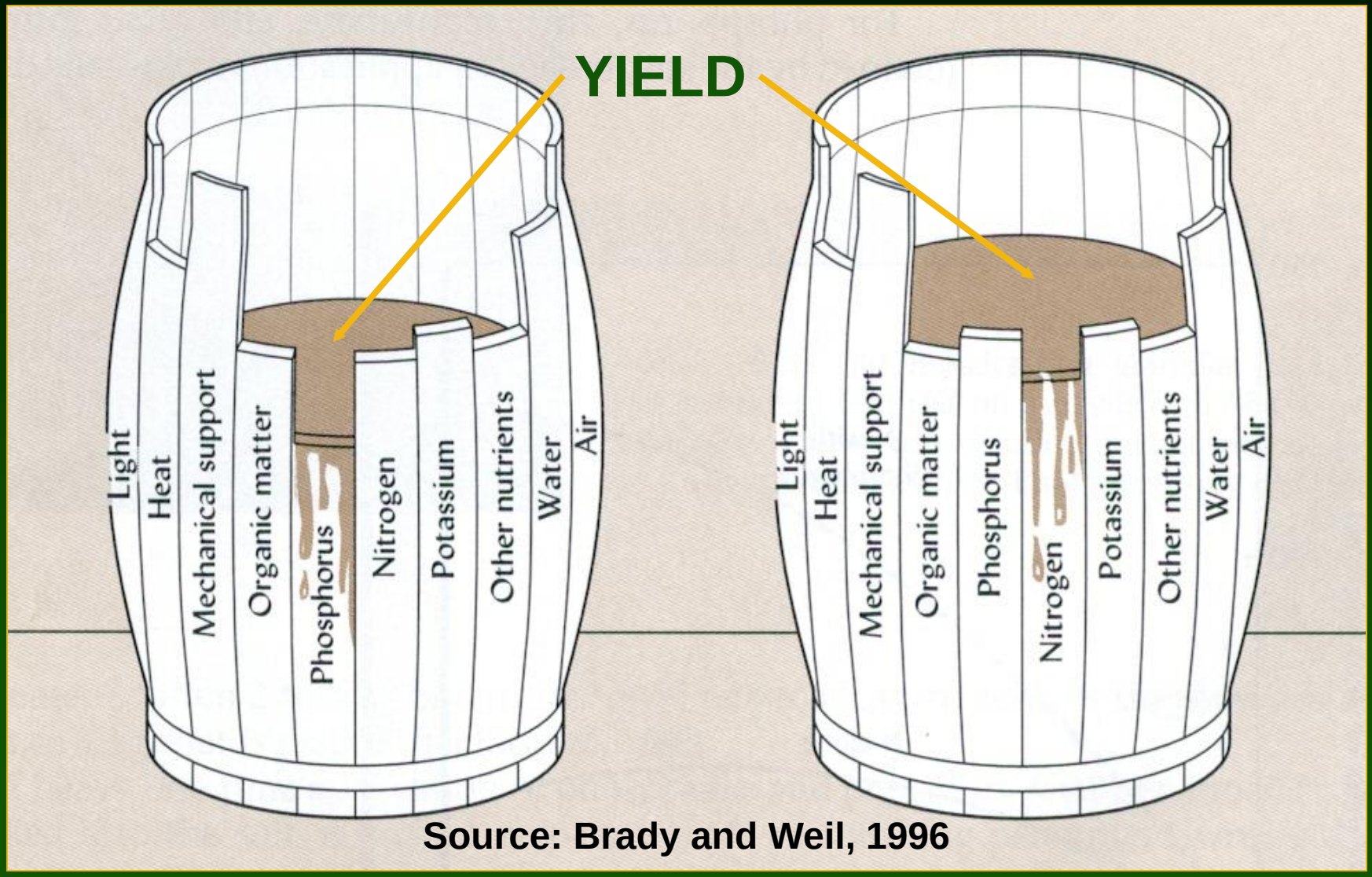


Liebhardt, W.C. 1981. Soil Science Society of America Journal 45:544-549.
McLean, E.O 1977. ASA Special Publication no. 9.
McLean, E.O., and M.D. Carbonell. 1972. SSSA Proceedings 36:927-930.

Sufficiency (Yield Response)

1. Method used by most university laboratories and Land Grant Universities.
2. Based on limiting factor concept.
3. Derived from studies that reveal no yield response to an applied nutrient above a certain critical soil test level.
4. Based on long-term calibration of soil tests with local field yield response data.

Limiting Factor Concept

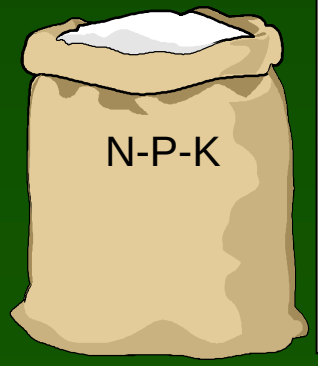


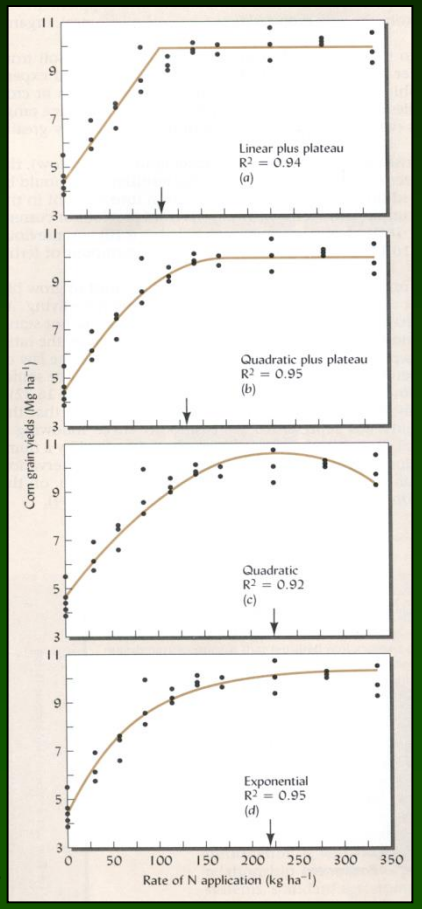
Source: Brady and Weil, 1996

Sufficiency (Yield Response)

Steps in a soil testing program:

1. Soil sampling
2. Soil analysis in a laboratory
3. Interpretation (low, medium, high, very high)
4. Recommendation





1. Soil Sampling

To obtain an accurate soil test:

1. Use the right sampling tool:
   Probe or auger and a clean plastic bucket.
2. Take 2-3 subsamples/acre across uniform fields (<15 acres).
   Avoid sampling when the soil is very wet.
   Scrape away surface litter.
   Take equal amounts for each subsample.
   Take cores to plow depth (no-till: 0-1 + 0-6 or 8”)
   Sample between rows, avoid fence rows.
   Remove stones, wood, trash.
3. Mix subsamples and take a 1 cup subsample.
4. Label sample and note down label and location.

1. Soil Sampling

To generate the best soil record database:

- ✓ Always take samples in the same time of the year
- ✓ Test annually or every other year
- ✓ Stick to the same lab

Regulatory requirement:

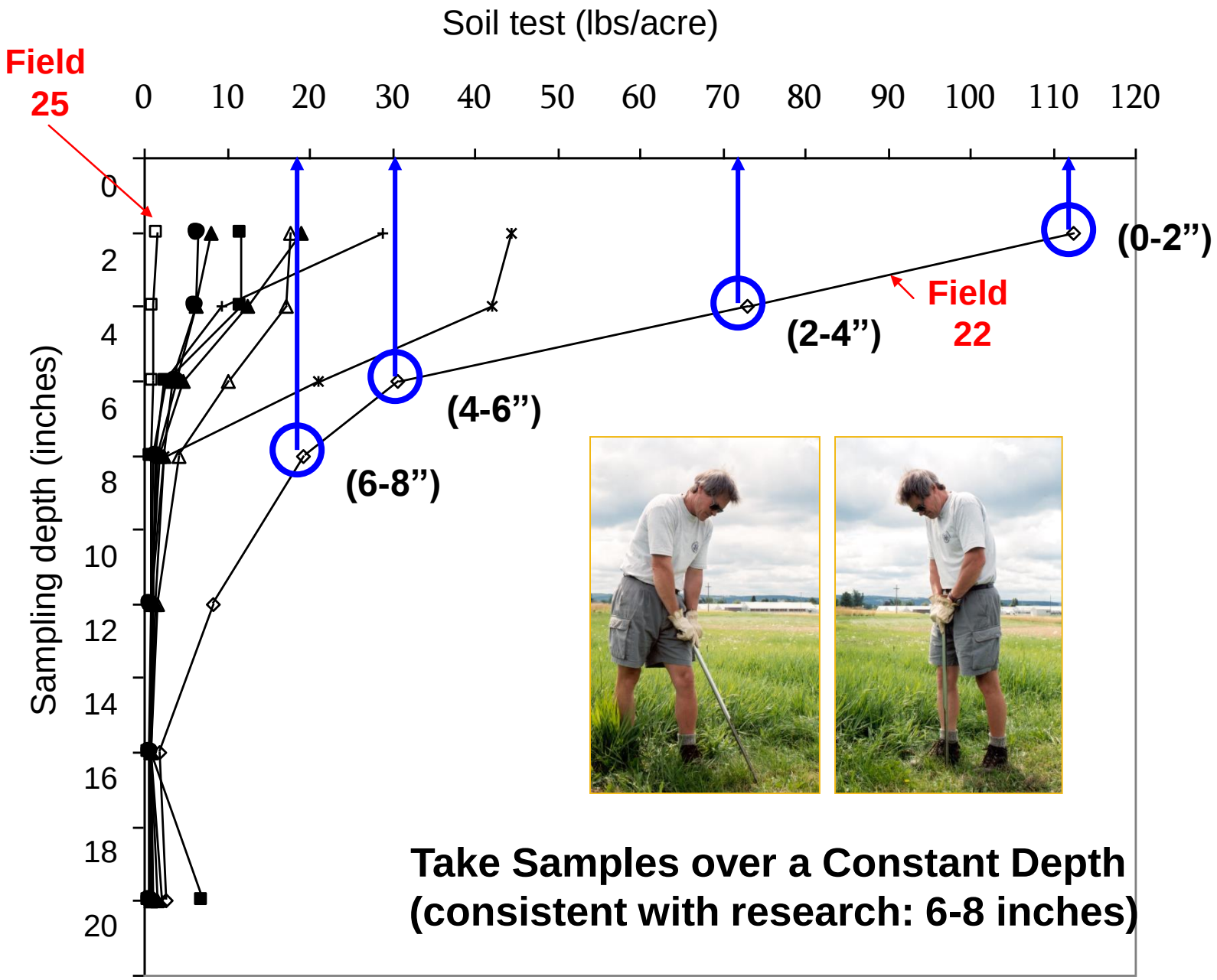
- ✓ Test at least once in 3 years.

Depth of Sampling:

Depth:
- 6 to 8 inches deep

Exceptions:
- PSNT: 12 inches

No-till pH testing:
- 1 inch
- 6 inches


Soil test (lbs/acre)
Field 25
0 10 20 30 40 50 60 70 80 90 100 110 120
Sampling depth (inches)
0 2 4 6 8 10 12 14 16 18 20
(0-2”)
(2-4”)
(4-6”)
(6-8”)
Field 22
Take Samples over a Constant Depth
(consistent with research: 6-8 inches)

1. Soil Sampling

Sampling Density in the Field:

Conditions	Number of cores/acre
Spring/summer sampling	3
Fall/winter sampling before manure spreading	1-2
Planning to convert Mehlich-3 to Morgan STP	3
Fall sampling after manure spreading	2-3
Annual sampling*	1-2

* Mehlich-3 to Morgan conversion may provide unsatisfactory results across years. When using a conversion, one sample/acre annually is only a substitute if the accuracy of the conversion equation has been checked (i.e. sample is split, sent in for both Morgan and Mehlich-3 analysis, and the true Morgan and the estimated Morgan compare well).

1. Soil Sampling

Generally, one sample should not represent more than 15 acres (unless past sampling shows minimal differences).

What causes variability?

- Soil forming processes
- Fertilizer applications
- Manure spreading
- Tillage systems

1 acre equals about 2 million pounds of soil!!
One soil sample is less than half a pound!!

1. Soil Sampling

Soil testing can NEVER be more accurate…

than the soil sample you take!

2. Soil Analysis

Where to send the soil sample?

- ✓ Soil analyses can be done by any laboratory that has a good quality control system in place.

However…

- ✓ Methods for analyses may differ and this can have important consequences for interpretations and recommendations.
- ✓ CAFO plans in New York limit lab choice to those with conversion equations (to Morgan equivalents).

2. Soil Analysis

Laboratory:	Reported soil test P:
A	36 lbs/acre
B	41 lbs/acre
C	256 ppm (512 lbs/acre)
D	210 ppm (420 lbs/acre)

2. Soil Analysis

Soil test results depends on:

1) Nature of the extract
2) Shaking time
3) Solution to soil ratio
4) Analytical procedure/instruments used
5) Way of reporting results (ppm or lbs/acre, P or P_2O_5)
    - 1 ppm = 2 lbs/acre
    - 1 lb P/acre = 2.3 lbs P_2O_5/acre

2. Soil Analysis

SOIL TESTS FOR PHOSPHORUS

- Morgan's solution
  - pH 4.8 sodium acetate.
  - Developed for NE soils.
- Modified Morgan's
  - pH 4.8 ammonium acetate.
  - Used in Vermont.
- Mehlich III
  - Acetic acid, nitric acid, ammonium fluoride and EDTA.
- Bray I
  - Ammonium fluoride and HCl.
  - For Midwest soils with rock phosphate.

2. Soil Analysis

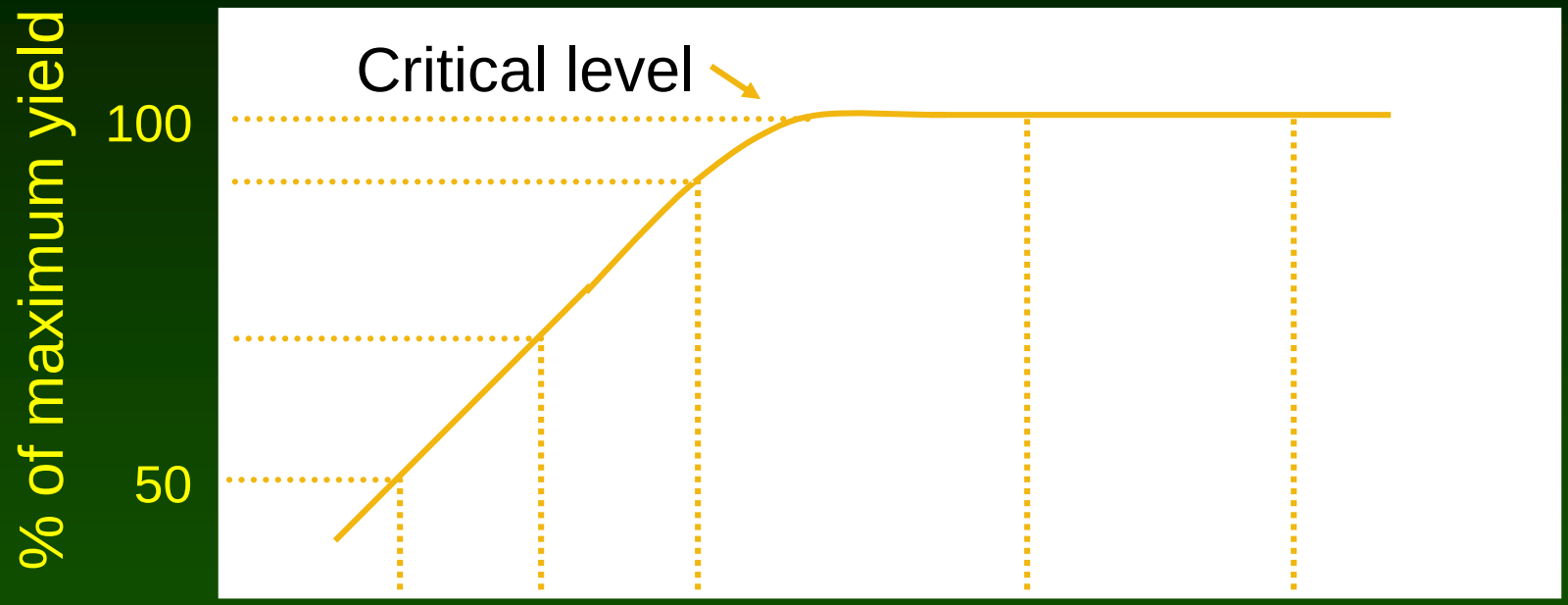
Laboratory:	Reported soil test P:
A	36 lbs/acre
B	41 lbs/acre
C	256 ppm (512 lbs/acre)
D	210 ppm (420 lbs/acre)

2. Soil Analysis

Laboratory:		Reported soil test P:
A	Morgan	36 lbs/acre
B	Modified Morgan	41 lbs/acre
C	Mehlich-3	256 ppm (512 lbs/acre)
D	Bray-1	210 ppm (420 lbs/acre)

3. Interpretation

Soil tests classifications indicate whether or not adding a nutrient is likely to result in a yield increase.

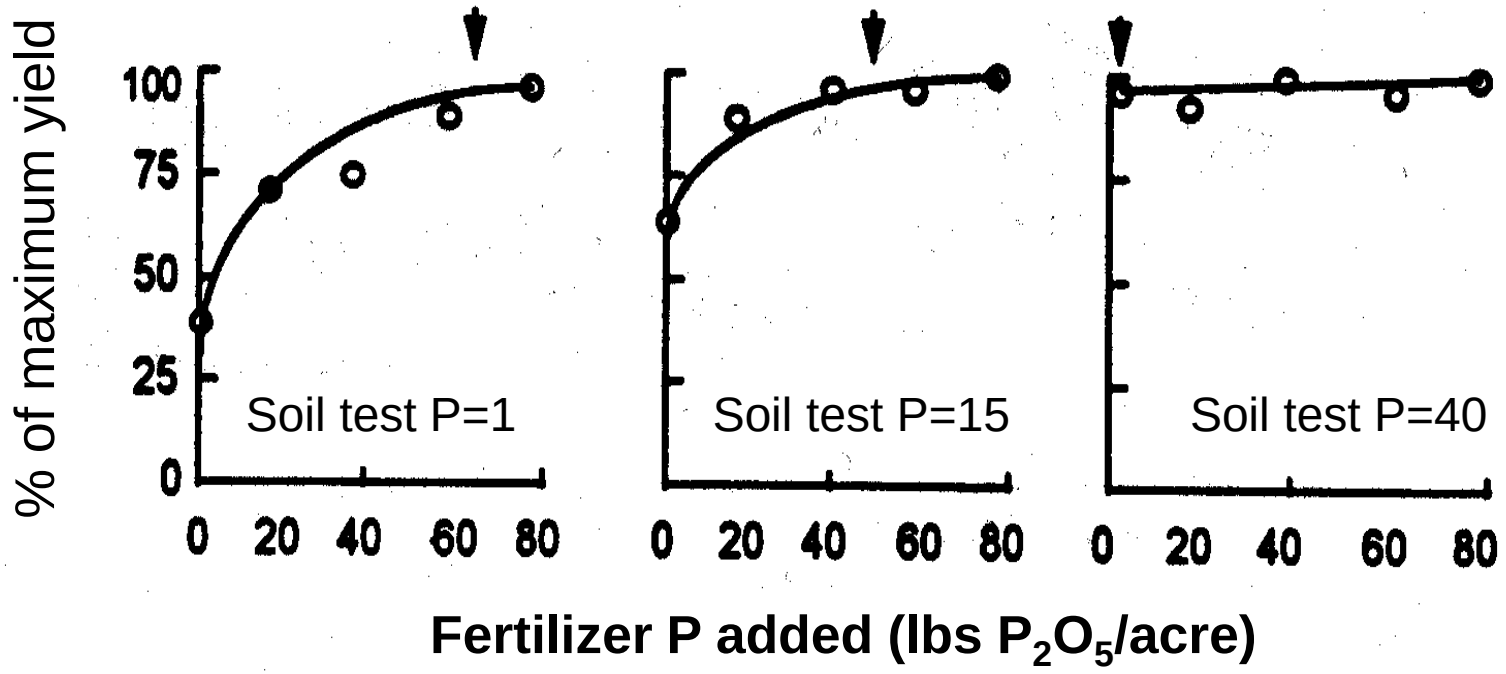


Soil test: Very low low medium/optimum high very high

Fertilizer response likely. Response to fertilizer not likely.

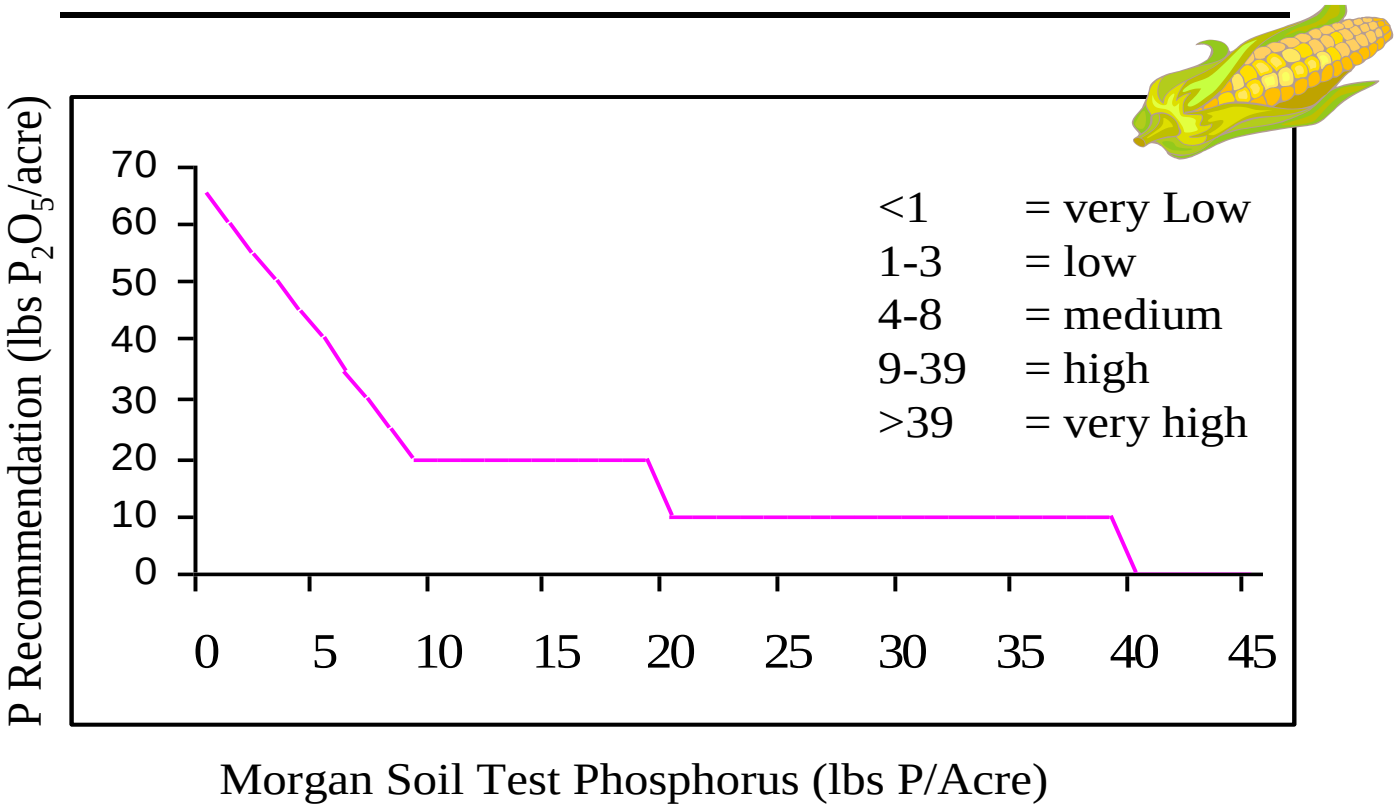
4. Recommendation

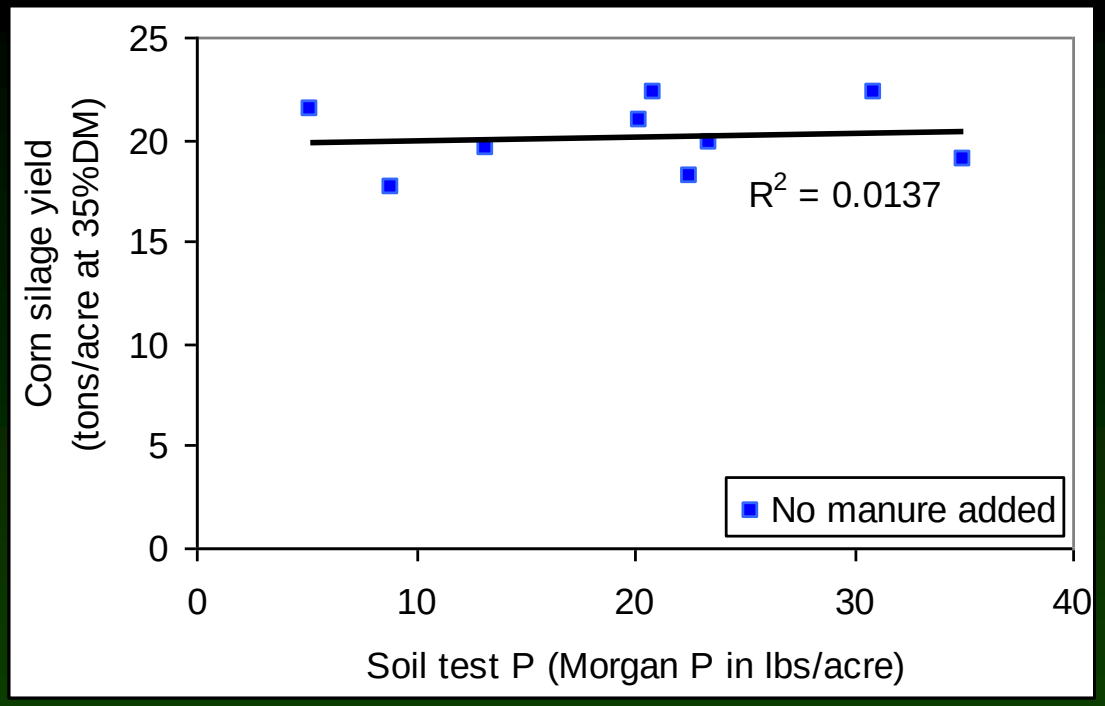
For deficient soils, determine how much needs to be added to reach optimum yield.

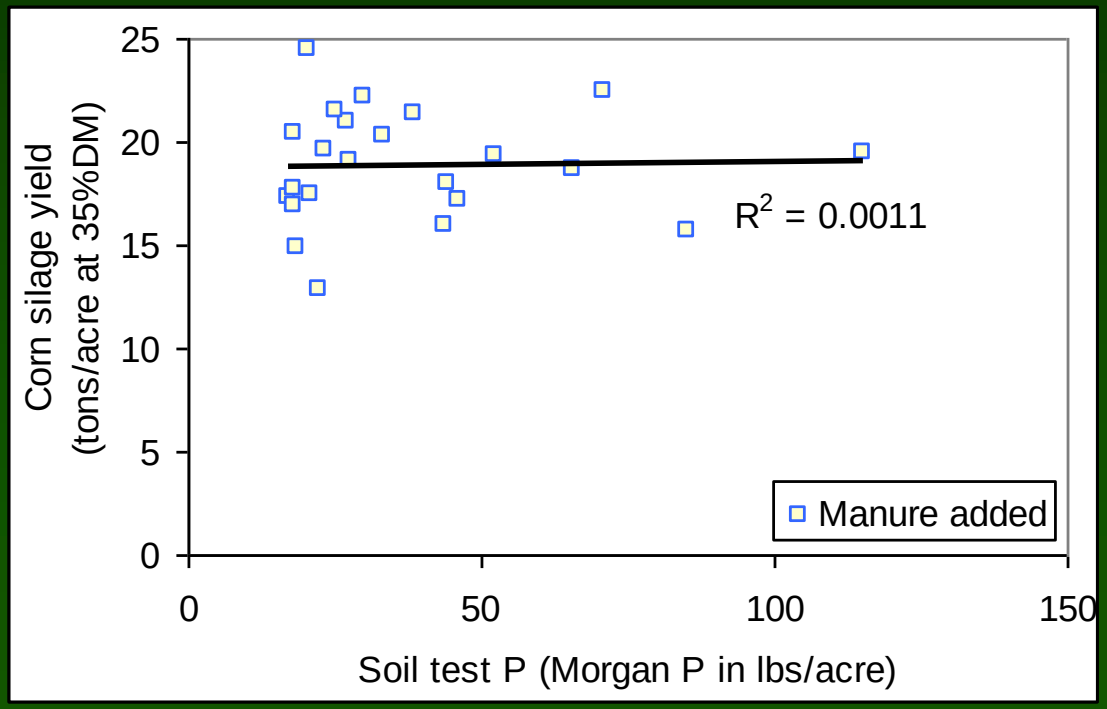


4. Recommendation

Cornell P recommendations for corn







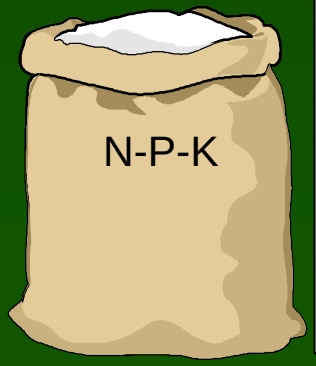
Building P levels beyond the agronomic critical value does not result in higher crop yields…it does increase the risk of loss of P to the environment.

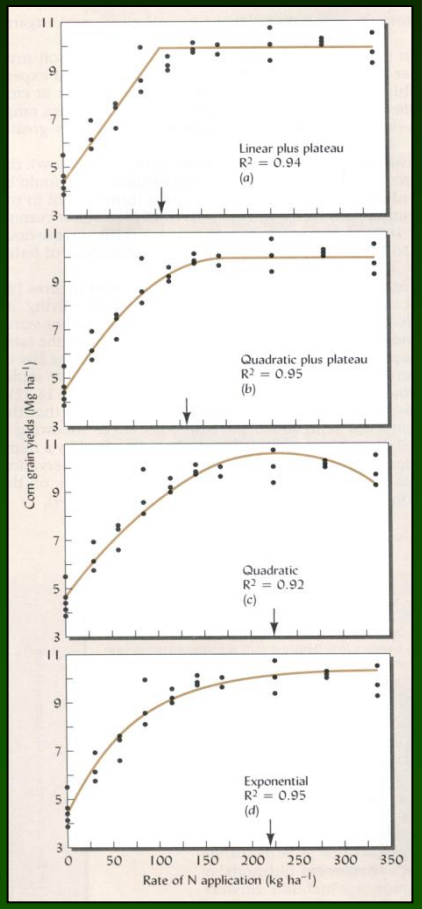
Soil Testing

Sufficiency (Yield Response)

Steps in a soil testing program:

1. Soil sampling
2. Soil analysis in a laboratory
3. Interpretation (low, medium, high, very high)
4. Recommendation



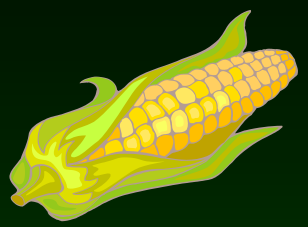


Soil Testing

- Soil testing is the basis for P, K, Mg, B, Zn, recommendations

But, for potassium, interpretations and recommendations are soil type specific

K Guidelines are Soil Specific



K_2O to be added (lb/acre)

Classification	Soil management group				
	I	II	III	IV	V
very low	50	60	80	120	120
low	40	60	70	80	90
medium	30	40	50	50	60
high	20	20	25	25	30
very high	0	0	0	0	0
	C	Si	SiL	L	Sa

Nitrogen Guidelines

- ✓ Most universities in the NE do not use a soil nitrogen test because nitrate is very mobile and soil nitrate tests do not correlate well with N supply from the soil.
- ✓ Nitrogen requirements are based on yield potential, N supply from the soil and other organic N sources (composts, animal and green manures) and N uptake efficiency.
- ✓ Exception: Pre Sidedress Nitrate Test.

PSNT

- Nitrate test for corn
- Predicts organic N to be mineralized
- Cannot be used if broadcast /pre-plant N is applied
- Should be use to find fields where extra N is not needed ($$ savings)
- Some states determine applications rates based on PSNT results; others, use the PSNT as indicator only.

12 inch cores

Sample when corn is 6-12” tall

PSNT Interpretation in NY

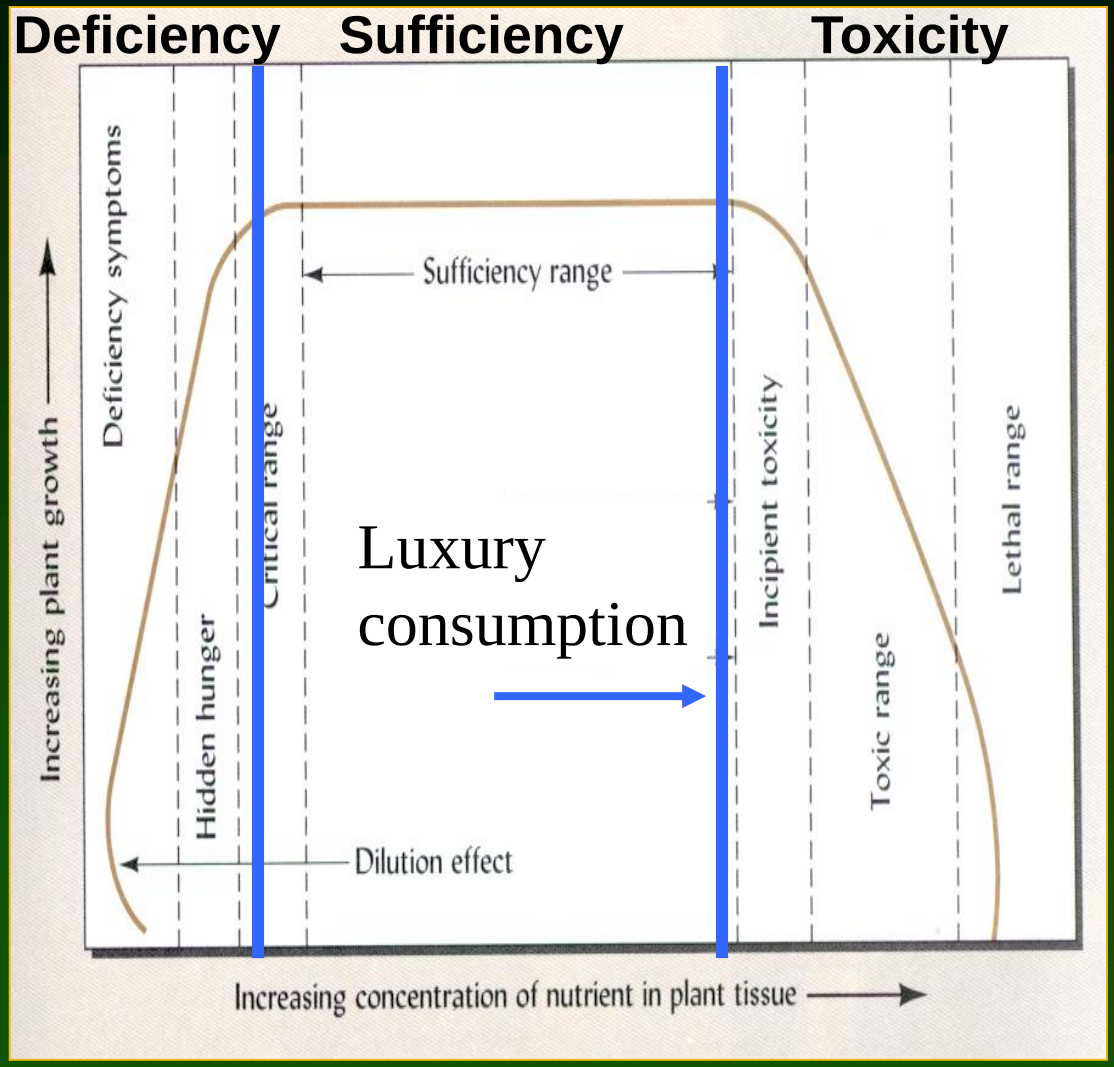
- <21 ppm:
  calculate N requirement minus N applied pre- or at planting.
- ≥25 ppm:
  no sidedress N needed
- 21-24:
  12% chance of a response

Outline

- **Soil Testing**
- **Plant Tissue Analysis**
- **Manure Testing**

Plant Tissue Testing

1. Most common for fruit trees and other perennial crops
2. Used to fine-tune a recommendation
3. Used to determine deficiency, sufficiency or toxicity of a nutrient



Plant Tissue Testing

Plant tissue nutrient interpretations depend on:

1. Species
2. Plant part
3. Time of sampling

Tree fruits:

- Time: between 60 and 70 days after average petal fall day
- Part: the middle of the current season's terminal shoots

Strawberries:

- Time: within the first 6 weeks after harvest
- Part: healthy leaves, well exposed to light

Alfalfa:

- Time: bud to 10% bloom
- Part: leaves from the top 6 inches of the plant

Three New Soil/Plant Test

- Corn Stalk Nitrate Test (CSNT)
- Illinois Soil Nitrogen Test (ISNT for soil organic N supply potential)
- Soil Sulfur Test for alfalfa

Outline

- **Soil Testing**
- **Plant Tissue Analysis**
- **Manure Testing**

Manure Nutrient Content

Manure Sampling

- NRCS 590 standard says 1x per year or more if needed to account for operational changes. CAFO may be different depending on the state
- Sample from the spreader.
- Take 5+ samples while loading over a couple days…fridge between days.
- Mix the samples into a jar and send to the lab (~1 lb composite sample). Keep a running average per manure system
- Manure analysis should include:
  - Total N, Organic-N, Ammonium-N, P_2O_5, K_2O, Total solids

Manure Nutrient Availability

- Potassium (K)
  - Much of the K excreted in dairy manure is in urine and therefore is highly available.
  - 100% of K in manure can be credited in the crop year applied
- Phosphorus (P)
  - Regular soil testing (3 years or more frequently) will assess manure P availability.
  - NY guidelines: manure can be used to meet crop requirements when requirement is ≥ 20 lbs P_2O_5 per acre
    - If <20, then catch with 0-20 lbs P_2O_5 in the corn starter band

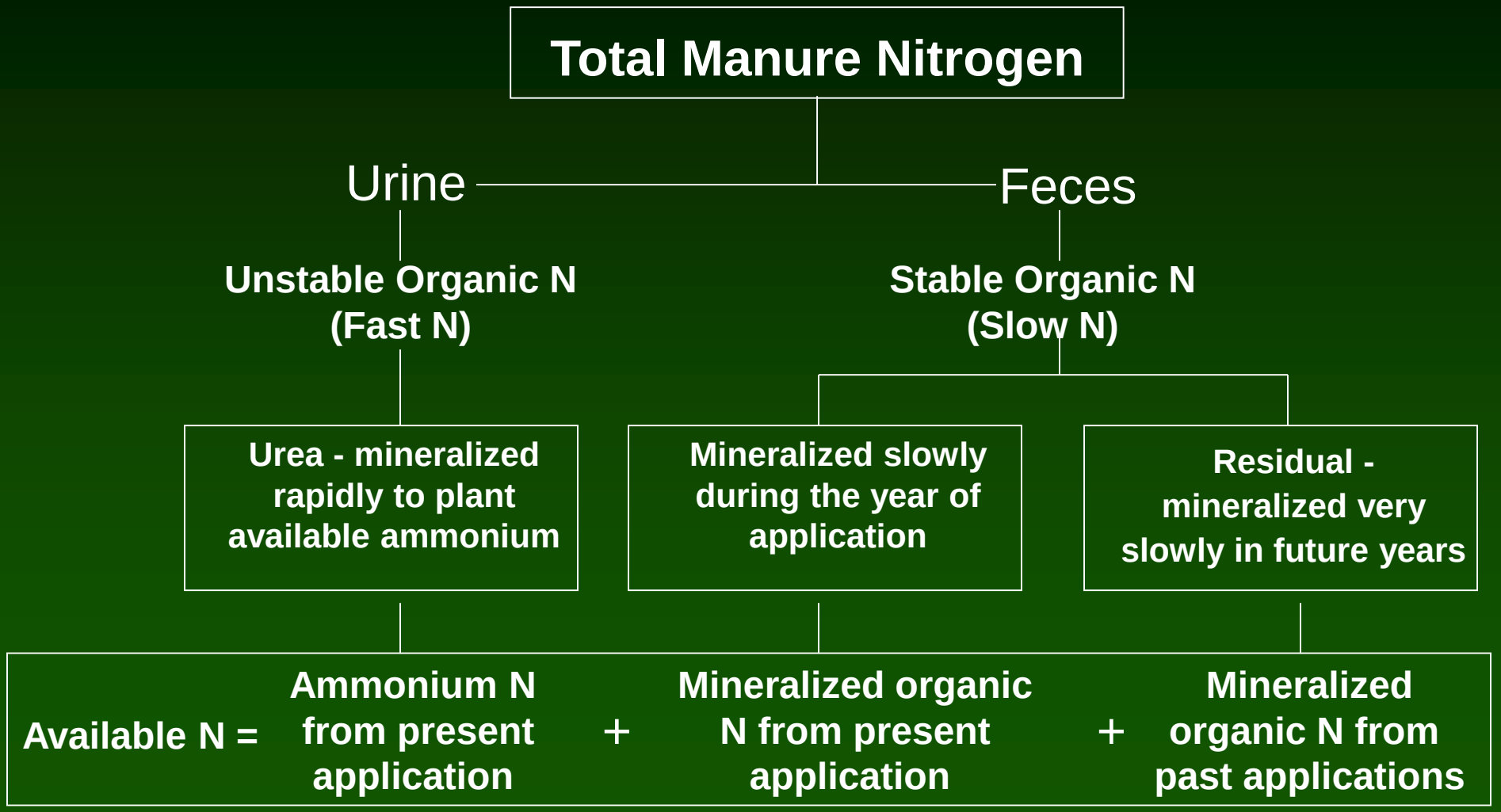
Manure Nutrient Availability

N credits from manure are based on:

- Initial nutrient content
- Rate of applications
- Past applications
- Time and method of application
  - Spring versus fall application
  - Incorporation versus surface application

Use the N charts in fact sheet for NY

N Availability of Manure



N Availability of Manure

Total Manure Nitrogen

Urine — Feces

Ammonium N

Time of manure application	% available
During the growing season as sidedress injection for row crops	100
Spring season. Reduce number by 12 for each day incorporation is delayed	65
All other conditions	0

Organic N: mineralized during the year applied

Dry matter content of the manure	% available
Less than 18%	35
Equal to or greater than 18%	25

Organic N: (residual) mineralized from past applications

From manure applied	% available
1 year ago	12%
2 years ago	5%

Example: N Need: 125 lbs/acre

- Fall applied:
  - Surface or incorporated
  - 16,500 gallons/acre
  - Supplies 132 lbs P_2O_5
- Spring applied:
  - incorporated
  - 7,000 gallons/acre
  - Supplies 56 lbs P_2O_5
  - surface applied
  - 16,500 gallons/acre
  - Supplies 132 lbs P_2O_5

At 1 cow/acre, if corn ground gets most of the manure, more than 7,000 gallons/acre needs to be spread to empty the storage!

http://nmsp.cals.cornell.edu/software/calculators.html

Total N Applied vs Taken Up

- 16,500 gallons/acre:
  - Fall:
    - Total applied: 495 lbs N/acre!
    - About 250 lbs organic-N
      - Credit ½ to crop
    - About 250 lbs NH_4-N
      - Credit 0 to crop
      - Incorporated or not
    - **25% N use efficiency**
  - Spring incorporated:
    - Total applied: 495 lbs N/acre
      - Credit 125 lbs org-N
      - Credit 160 lbs NH_4-N
      - Can crop use all 285 lbs?
- 7,000 gallons/acre:
  - Spring incorporated:
    - 210 lbs N/acre
    - 105 lbs organic-N
      - Credit ½ to crop
    - 105 lbs NH_4-N
      - Credit 2/3 to crop
    - **60% N use efficiency**

Outline

- **Soil Testing**
- **Plant Tissue Analysis**
- **Manure Testing**

Nutrient Management Spear Program

Cornell University
Nutrient Management Spear Program

SEARCH: go
NMSP Cornell more options

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The vision of the Cornell University's Nutrient Management Spear Program is to assess current knowledge, identify research and educational needs, conduct applied, field and laboratory-based research, facitilate technology and knowledge transfer, and aid in the on-farm implementation of beneficial strategies for field crop nutrient management, including timely application of organic and inorganic nutrient sources to improve profitability and competitiveness of New York State farms while protecting the environment. For more information about our program activities see our Program Report.

News RSS

- 11/15/2017: Call for Action: Participate in Whole Farm Nutrient Mass Balance Assessments. Input Data Sheets, and Input Data Sheet Instructions, Posted on the MNB Project Page.
- 11/14/2017: Impact Story: NYFVI Project with NMSP and Industry Evaluates Sensor Technology for Nitrogen Management.
- 8/22/2017: Student Impact Story: Cornell Sustainable Animal Agriculture Internship Gave Nikki Luijben from the Netherlands a Unique Learning Experience.
- 7/28/2017: What's Cropping Up? Series: Phosphorus and the Environment Article 4: Greatly Improved Nutrient Efficiency Demonstrates New York Dairy Farmers' Environmental Stewardship.
- 7/17/2017: What's Cropping Up? Series: Phosphorus and the Environment Article 3: Protecting Our Lakes: Shoreline Septic System Concerns.
- 6/21/2017: What's Cropping Up? Series: Phosphorus and the Environment Article 2: Setting the Record Straight: Comparing Bodily Waste Between Dairy Cows and People.
- 6/21/2017: What's Cropping Up? Series: Phosphorus and the Environment Article 1: An Introduction to Phosphorus.
- 5/25/2017: Cornell CALS Announcement: Northeast Region Phosphorus Index Project. ASA/SSSA/CSSA and ICCA Announcement: A Better Way to Manage Phosphorus.

Featured Links

- New York On-Farm Research Partnership
- Cornell Nutrient Guidelines for Field Crops
- Agronomy Factsheets
- Impact Statements
- Nutrient Management Tutorials

Featured Articles

- Whole Farm Nutrient Mass Balances in Summary; Feasible Whole Farm Nutrient Mass Balances; Change in Nutrient Mass Balances over Time for 54 New York Dairy Farms; Trends in Nutrient Mass Balances on Four New York Dairy Farms.
- Northeast Region Certified Crop Adviser (NRCCA) Manual: Pest Management; Crop Management; Soil & Water Management; Soil Fertility and Nutrient Management.

Upcoming Events

- 2017 NRCCA Annual Training. DoubleTree, Syracuse, NY. November 28-30, 2017.
- 2018 ASA/CSSA International Annual Meeting. Baltimore, MD, November 4-7, 2018.
- 2019 SSSA International Soils Meeting. San Diego, CA, January 6-9, 2019.

Photo Gallery

Jobs and Scholarships

- NMSP Undergraduate Student Summer Internships. Email: qmk2@cornell.edu to Inquire for Summer Internships and Work During Semesters.

NMSP Laboratory

- Submission Form ISNT, CSNT, Cornell S-Test. Address for Samples: NMSP Laboratory, c/o Quirine Ketterings or Sanjay Gami, 323/317 Morrison Hall, Animal Science, Cornell University, Ithaca NY 14853.
- CSNT Sampling Instructions (2016).
- NMSP Laboratory Manual (2017).

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http://nmsp.cals.cornell.edu/