This PDF is a version of an online module that is part of the Principles for Transitioning to Organic Farming project. For all of our educational materials, please visit:

http://organictransition.umn.edu/

This project is funded by a grant from the Organic Transitions Program, part of the USDA National Institute of Food and Agriculture, under Grant Number 2013-51106-21005.

# Soils (Part 1): Fertility in Organic Systems

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under grant number 2013-51106-21063.

Authors

Adria Fernandez

John Lamb

Kristine Moncada

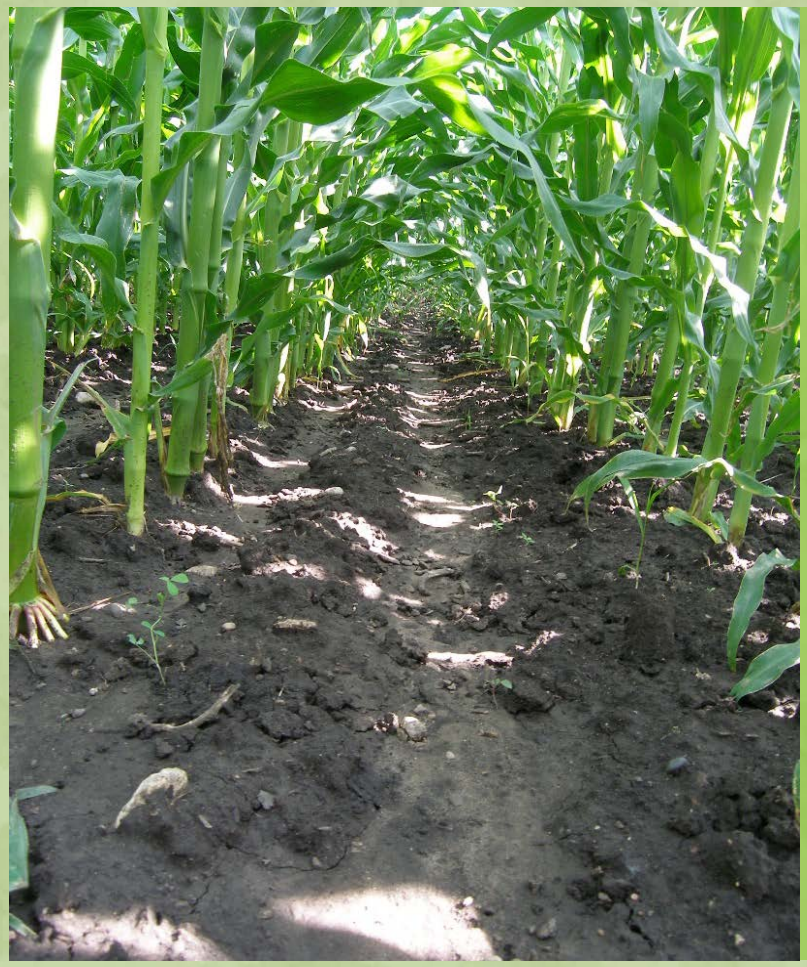
Constance Carlson

Craig Sheaffer

# Fertility in Organic Systems

I. Crop nutrition
II. Organic fertility principles
III. Meeting organic standards
IV. Building fertility through transition

# Crop Nutrition

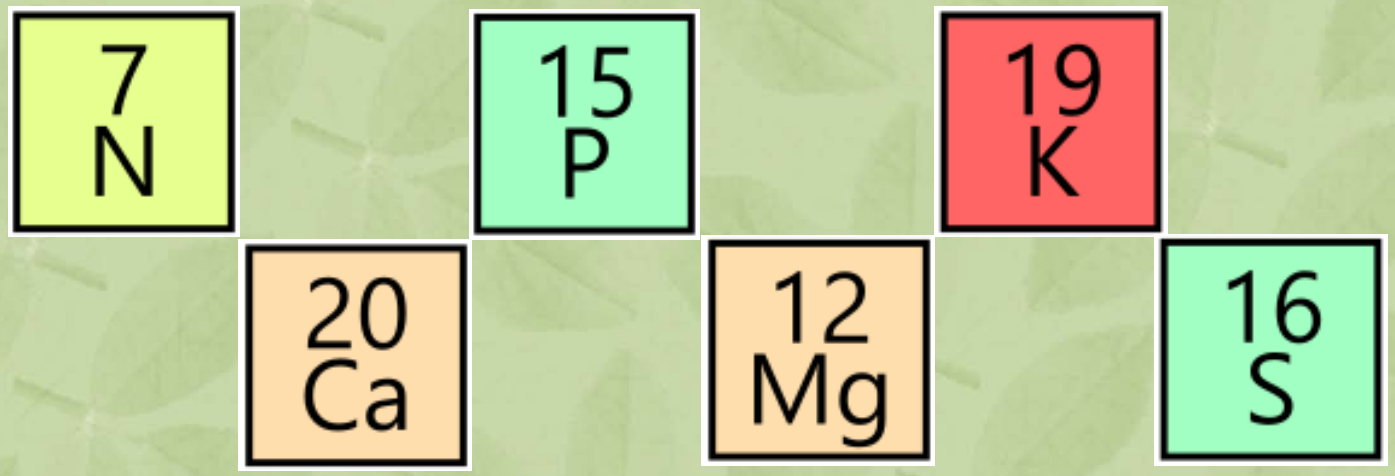


A. Macronutrients and micronutrients
B. Nutrient deficiency
C. Nutrient availability
D. Adjusting pH

# Soil-Derived Macronutrients

Macronutrients (need larger amounts)

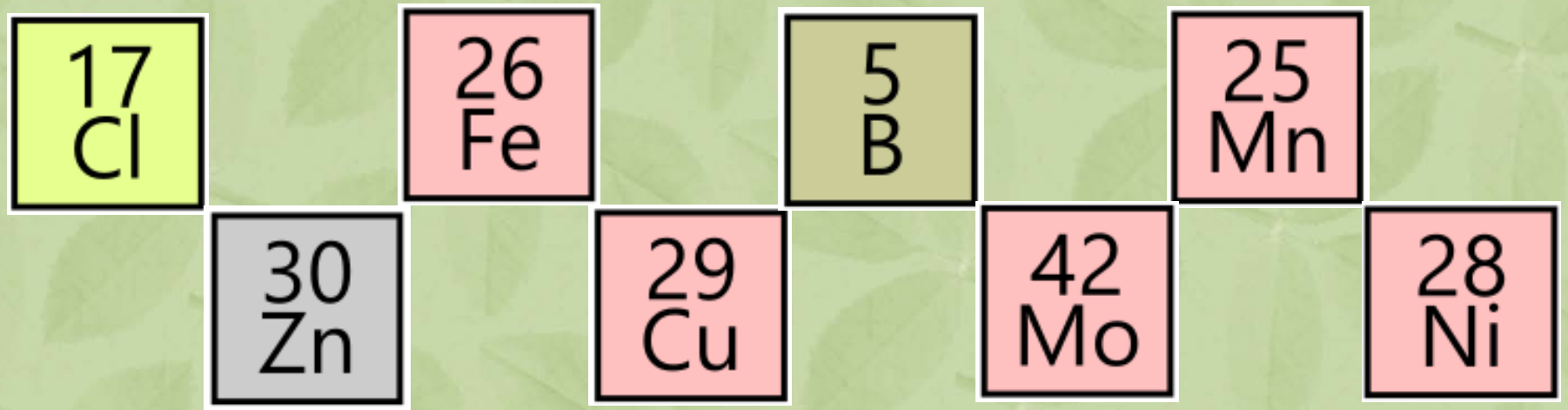
- Nitrogen
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Sulfur



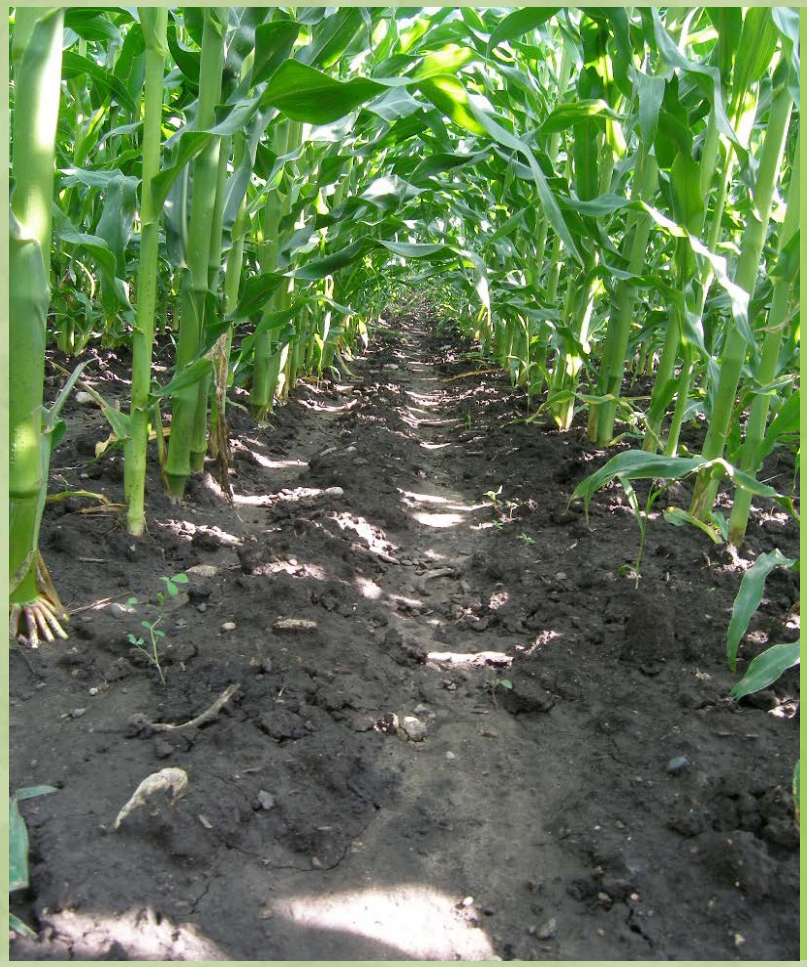
# Soil-Derived Micronutrients

Micronutrients (need smaller amounts)

- Chlorine
- Iron
- Boron
- Manganese
- Zinc
- Copper
- Molybdenum
- Nickel



# Crop Nutrition



A. Macronutrients and micronutrients
B. Nutrient deficiency
C. Nutrient availability
D. Adjusting pH

# Nutrient Deficiencies

- Occur when nutrients are either not present or unavailable
- Symptoms can often be observed

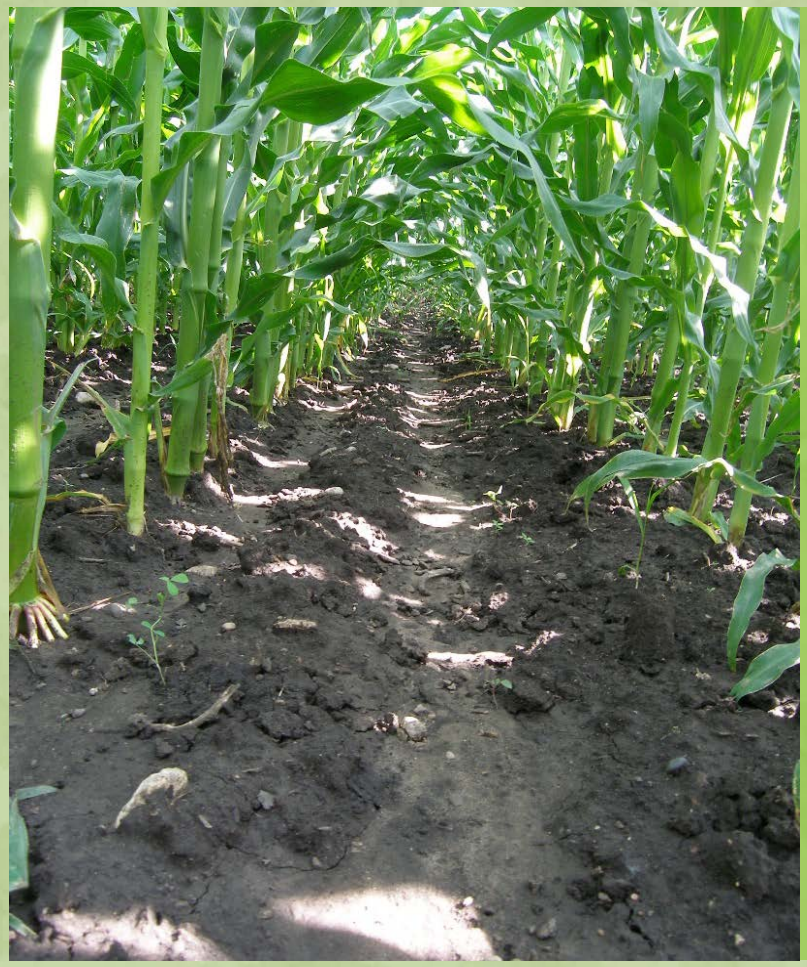
P-deficient corn seedlings

N deficiency in edlings

# Nutrient Deficiencies

- Documented by tissue testing
  - Should confirm with soil tests before amending

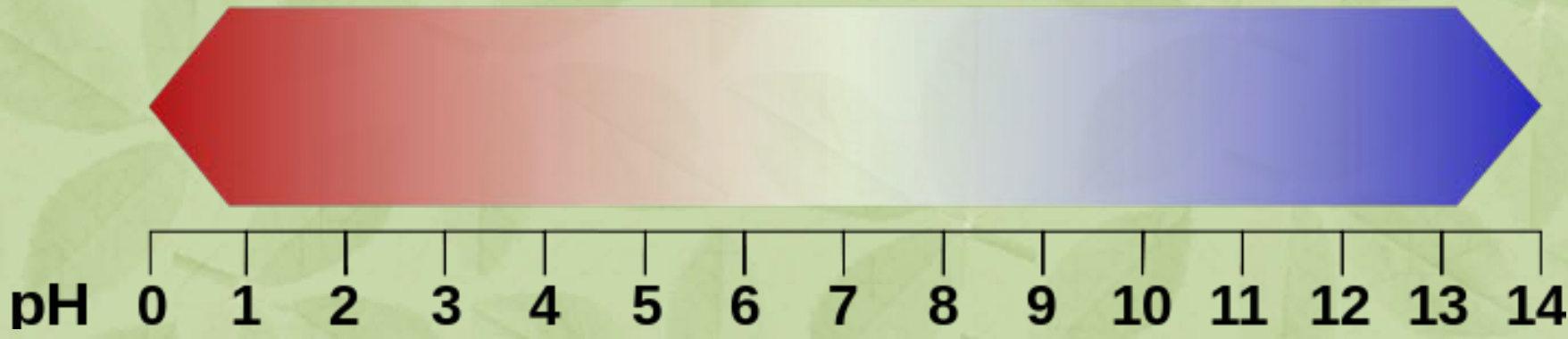
# Crop Nutrition



A. Macronutrients and micronutrients
B. Nutrient deficiency
C. Nutrient availability
D. Adjusting pH

# Nutrient Availability

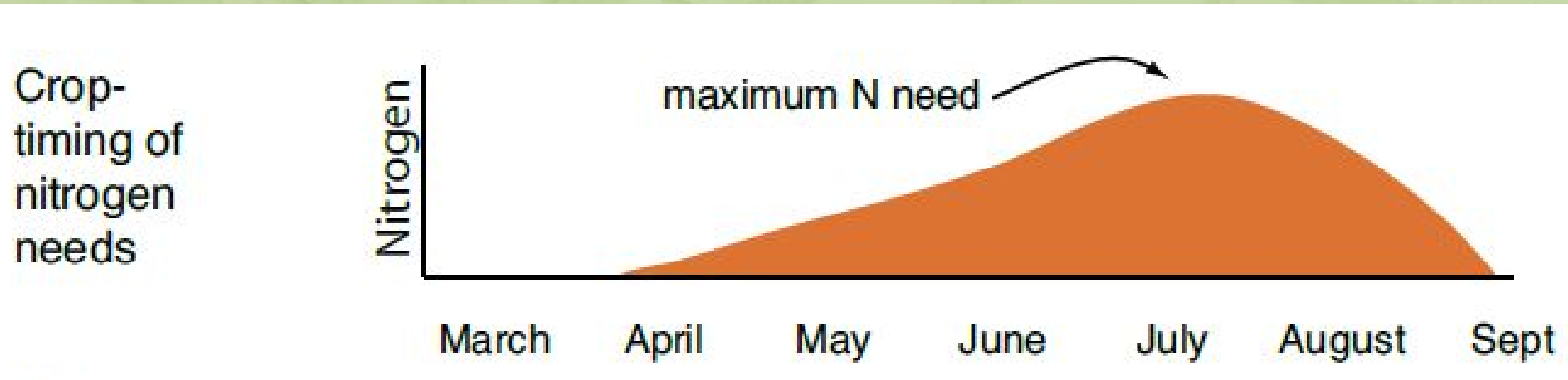
1. Accessible chemical forms
   - Nutrients in forms that can reach and be taken up by roots
2. pH
   - Affects nutrient binding to soil



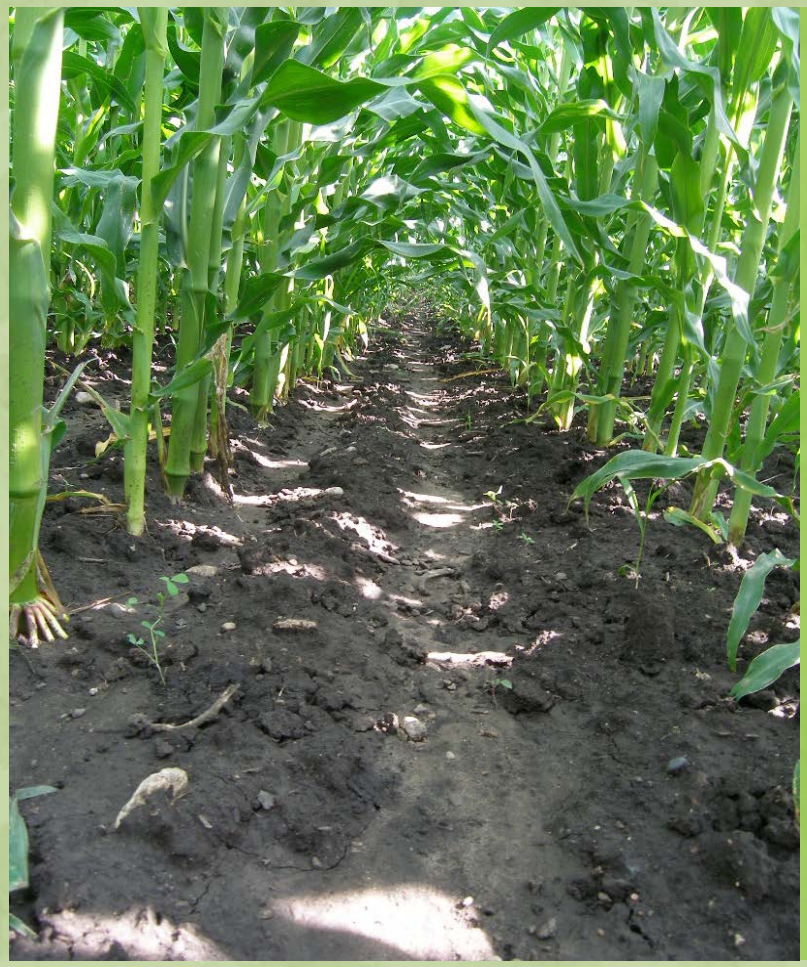
# Nutrient Availability

## 3. Timing

– Nutrient release from fertilizers must coincide with crop need



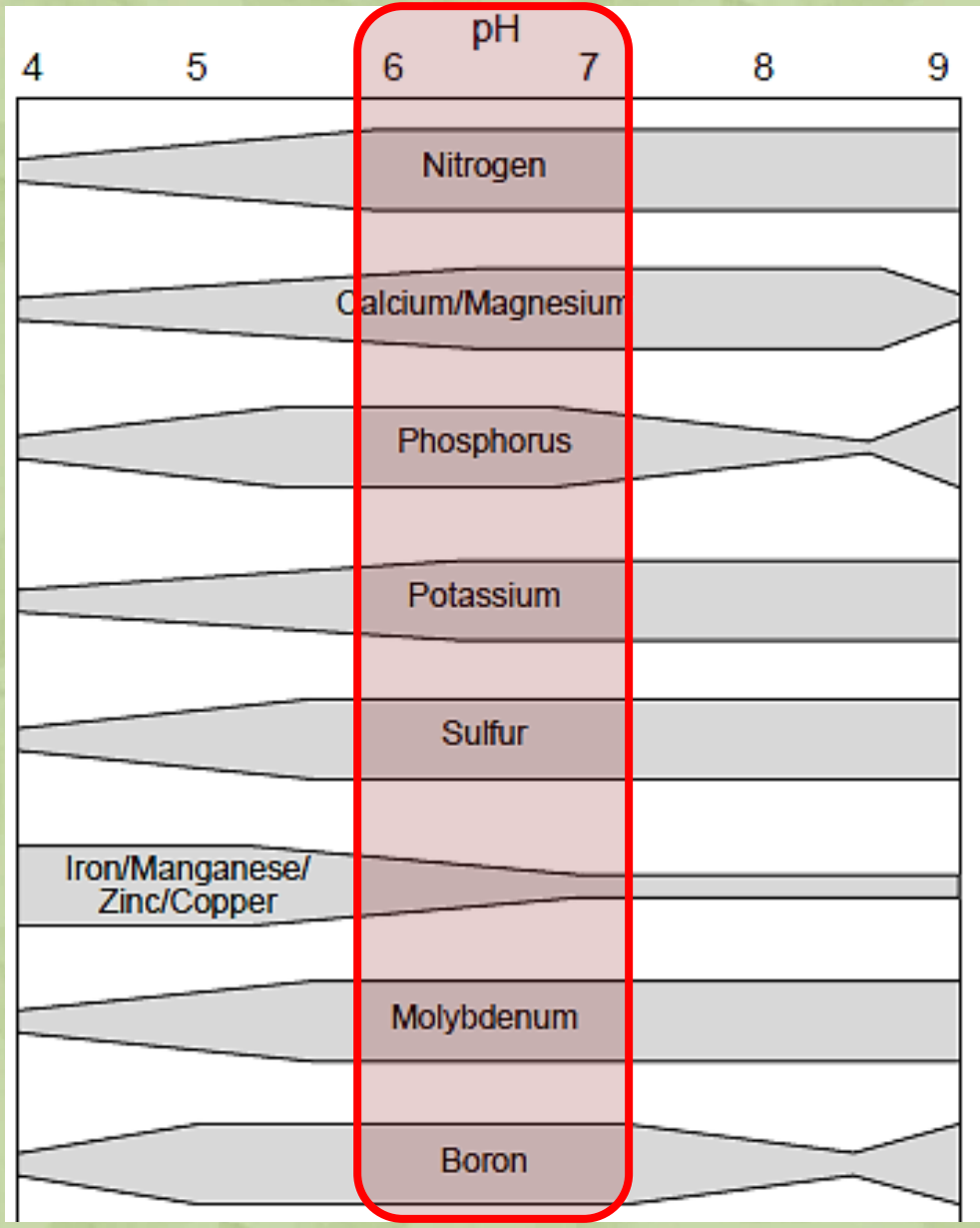
# Crop Nutrition



A. Macronutrients and micronutrients
B. Nutrient deficiency
C. Nutrient availability
D. Adjusting pH

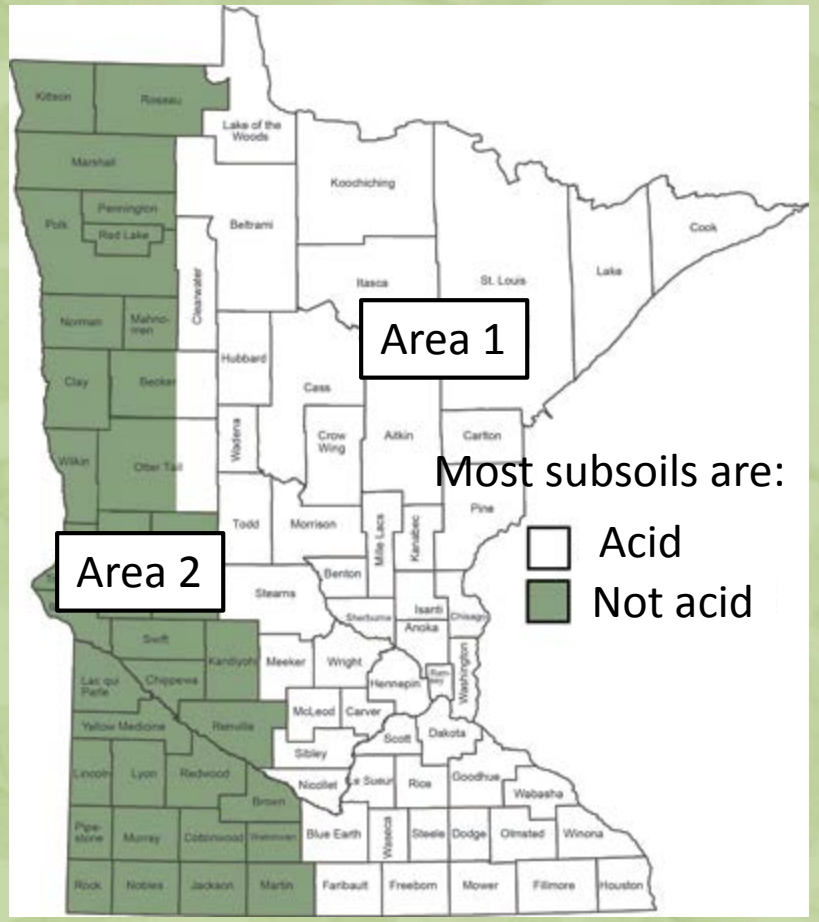
# Adjusting pH

- Different nutrients respond differently
- Crop pH needs differ
  - Target is 6.0 for most crops; 6.5 for alfalfa
- Most common intervention is raising pH (reducing acidity) with lime



# Lime Application

- Lime often needed in eastern MN
- Apply appropriate rates
- Lime also supplies calcium (some sources include magnesium)
- Choose permitted lime sources



# Lime Sources

**Allowed**

- Limestone (mined calcium carbonate)
- Dolomite (magnesium carbonate)

**Prohibited**

- Quicklime (calcium oxide)
- Burnt dolomite (magnesium oxide)
- Slaked lime (calcium hydroxide)
- Milk of magnesia (magnesium hydroxide)
- Lime from paper mill sludge or other recycled materials
- Synthetic additives (e.g. anti-caking agents)

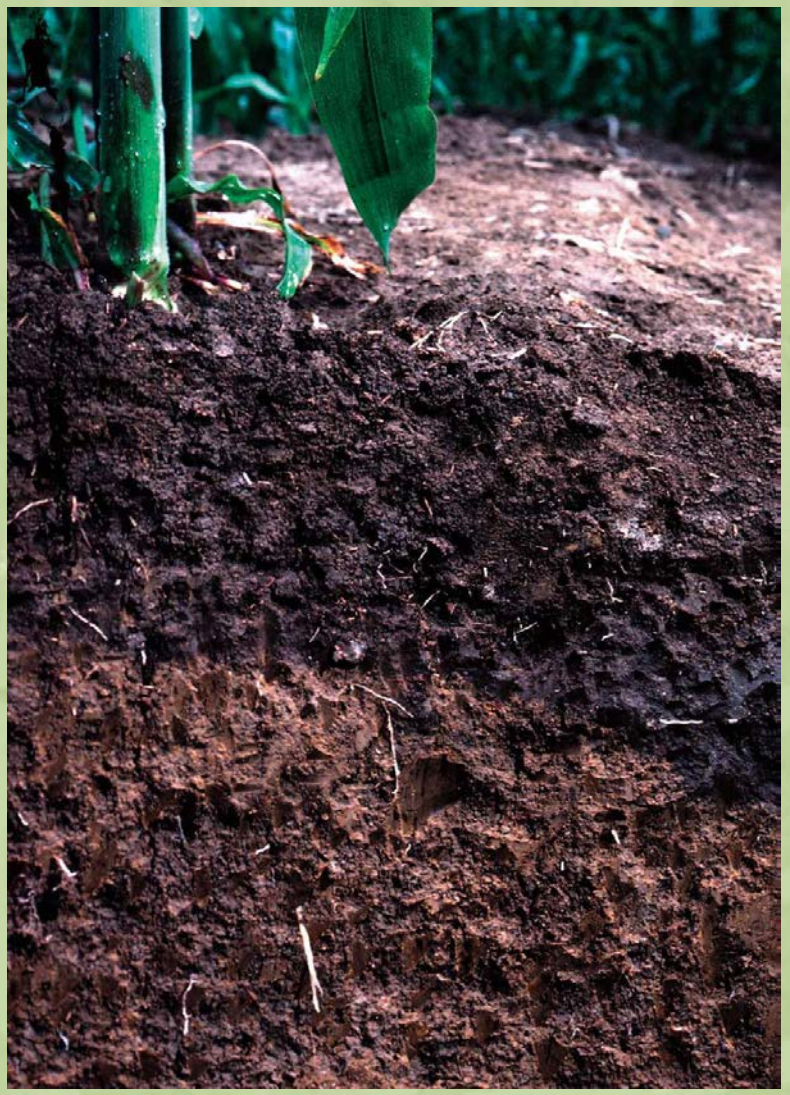
# Fertility in Organic Systems

I. Crop nutrition
II. Organic fertility principles
III. Meeting organic standards
IV. Building fertility through transition

# Organic Fertility Principles

- Managing fertility through rotation
- Building soil organic matter
- Slow-release nutrient sources
- Conserving nutrients
- On-farm nutrient sources

# “Feed the soil, not the crop”



# Managing Fertility through Rotation

- Diverse crops for diverse functions
  - Managing fertilizer demand
  - Biological N fixation
  - Holding nutrients in system
  - Keeping soil covered and protected

# Soil Organic Matter

- Carbon-based material derived from decomposition of biomass
- Basis for nutrient cycling
  - Supports decomposer organisms
  - Nutrients present in varying forms and levels of availability

# Humus

- Stable soil organic matter
- Reservoir of nutrients
- Supports good soil tilth
  - Soil structure and ease of tillage
  - Aeration
  - Water infiltration and water holding capacity
  - Resistance to erosion

# Slow-release Nutrient Sources

- Low soluble nutrient content
  - Plant residues
  - Compost
- Nutrients gradually released by microbes into plant-available forms

# Conserving Nutrients

- Nutrients are exported in crop harvest
  - Retain straw, stover, residues, and other biomass on-farm

# Conserving Nutrients

- Prevent erosion, runoff, and leaching
  - Cover crops and perennials provide physical protection
  - Winter-hardy crops scavenge and hold nutrients
  - Conservation tillage prevents soil loss

Eroded topsoil

# On-Farm Nutrient Sources

- Legumes (N from atmosphere)
- Livestock (nutrients from crops/pasture via manure)

# Fertility in Organic Systems

I. Crop nutrition
II. Organic fertility principles
III. Meeting organic standards
IV. Building fertility through transition

# Meeting Organic Standards

- Organic requirements
- Permitted inputs
- Prohibited inputs

# Organic Requirements

"Must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials"

"Must manage plant and animal materials to maintain or improve soil organic matter content"

# Meeting Certification Requirements

- All applications of fertilizers, lime, other amendments must be documented in your Organic System Plan
- Certifiers may differ in interpretation of guidelines: when in doubt, ask!

# Organic Standards: Permitted Materials

- Naturally occurring, non-synthetic substances
  - Limited specific exemptions for synthetic substances
- Organic Materials Review Institute (OMRI) provides updated status of generic and commercial products

# Use of Permitted Materials

# Organic Standards: Prohibited Materials

- Synthetic substances unless specifically exempted
- Sewage sludge
- Substances derived from GMOs
- Certain toxic natural substances

# Fertility in Organic Systems

I. Crop nutrition
II. Organic fertility principles
III. Meeting organic standards
IV. Building fertility through transition

# Building Fertility through Transition

- Supporting crop yields
- Monitoring soil health
- Finding appropriate recommendations

# Supporting Crop Yields

- Fertility can dip in transition as the soil is beginning to be “fed”
- Ensure adequate nutrients to crops during transition

# Monitoring Soil Health

- Must maintain or improve soil health
- Must record outcomes of soil health practices
- Track by:
  - Yield trends
  - Soil testing
  - Plant tissue testing
  - Metrics recommended by your certifier

# Soil Testing

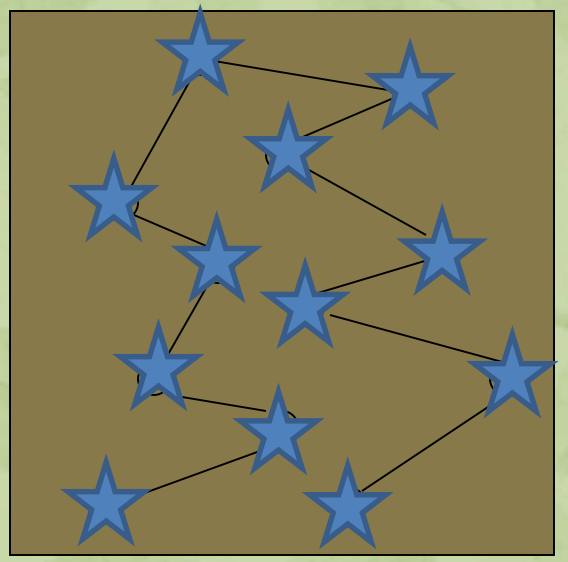
- Helps to determine existing fertility
- Can guide crop choice in transition
- Monitor fertility throughout transition and afterward
  - Ensure that practices are improving fertility long-term

# When and How to Test Soil

- Test before planting
  - Manage nutrient deficiencies proactively
  - When crop deficiency symptoms appear, yield has already been lost

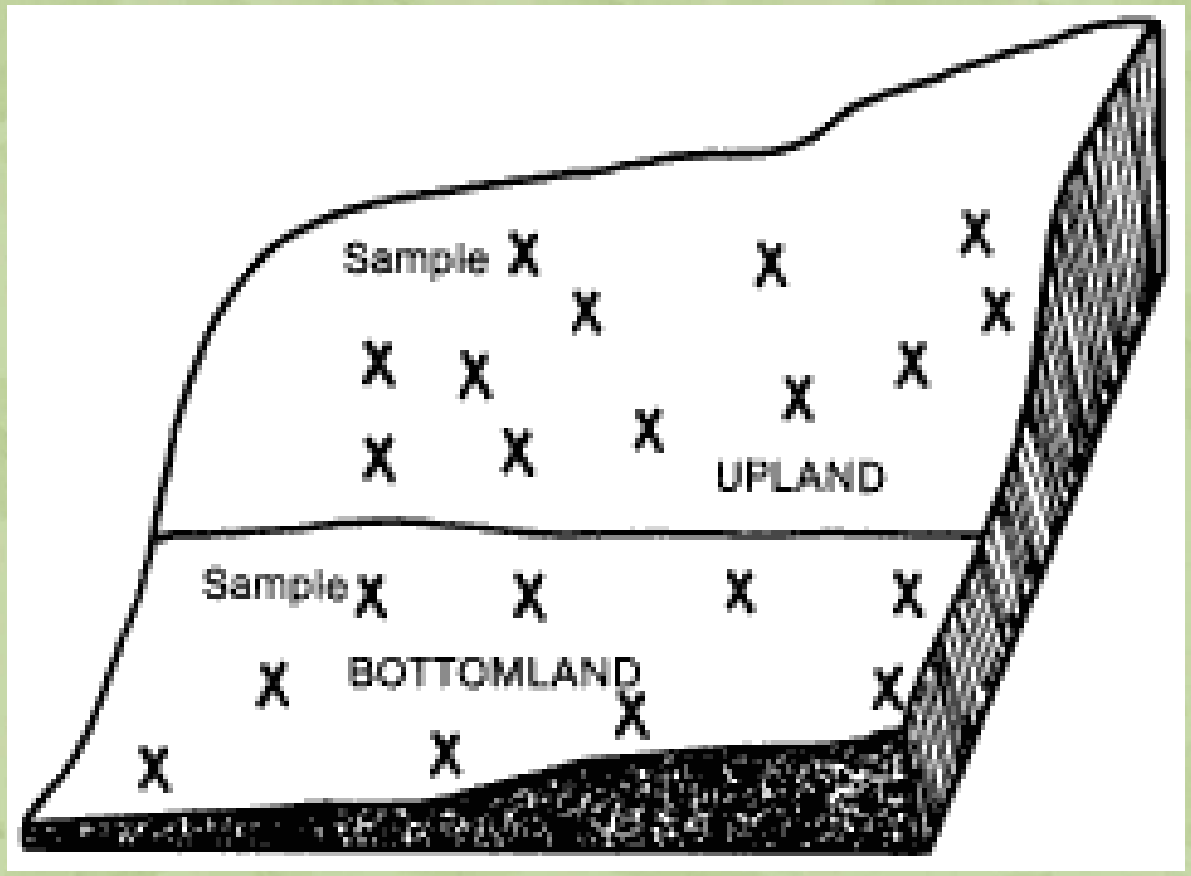
# When and How to Test Soil

- Representative sample of field
  - Divide field into uniform areas (<20 A for level fields; <5 A for hilly)
  - Collect 15-30 cores in a zigzag pattern across each area
  - Sample to 6-8 inches



Sampling pattern for rectangular area

# Field Sampling Pattern




Field divided into appropriate areas

# Finding Appropriate Recommendations

- Testing labs
  - May recommend amendments (lime, minerals) and rates based on test results
  - Some amendments in organic require tests documenting deficiency
- University Extension
- Not all recommendations will be appropriate for organic
  - When in doubt, ask your certifier!

# Summary – Soils (Part 1)

- **Build and maintain soil organic matter**
- **Test to address deficiencies proactively**
- **Check with your certifier!**

# Resources

- National List of allowed and prohibited substances for organic farming
- List of manure testing labs – Minnesota Department of Agriculture
- Field soil sampling instructions – University of Minnesota
- Worksheet for calculating manure application – University of Minnesota
- Composting instructions – eXtension
- Organic Production Guide – ATTRA
- Guide to permitted inputs – NRCS
- Can I Use this Input on My Organic Farm? – eXtension

# Fertility in Organic Systems

I. Crop nutrition
II. Organic fertility principles
III. Meeting organic standards
IV. Building fertility through transition

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under grant number 2013-51106-21005.

# References


Baker, B. 2009. Can I Use this Fertilizer on My Organic Farm? http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_045863.pdf

Eghball, B., and J. F. Power. 1999. Phosphorus-and nitrogen-based manure and compost applications corn production and soil phosphorus. *Soil Science Society of America Journal* 63: 895-901.

Evans, J., et al. 2001. Net nitrogen balances for cool-season grain legume crops and contributions to wheat nitrogen uptake: a review. *Australian Journal of Experimental Agriculture* 41: 347-359.

Fernandez, A. L., C. C. Sheaffer, D. L. Wyse, C. Staley, T. J. Gould, and M. J. Sadowsky. (2016). Associations between soil bacterial community structure and nutrient cycling functions in long-term organic farm soils following cover crop and organic fertilizer amendment. *Science of the Total Environment*, *566*: 949-959.

Kaiser, D., Fernandez, F., Lamb, J.A., Coulter, J.A., and B. Barber, 2016. Fertilizing corn in Minnesota. University of Minnesota Extension AG-FO-3790-D. University of Minnesota, St. Paul, MN.

# References (cont.)

Kumar, K., and M. G. Kuan. 2000. Biological nitrogen fixation, accumulation of soil nitrogen and nitrogen balance for white clover (Trifolium repens L.) and field pea (Pisum sativum L.) grown for seed. Field Crops Research 68: 49-59.

Lamb, J., S. Huerd, and K. Moncada. 2010. Soil Health. Chapter 3 in Risk Management for Organic Producers. Moncada, K. and C. Sheaffer, editors. University of Minnesota, St. Paul, MN.

Lamb, J., C. Sheaffer, and K. Moncada. 2010. Soil Fertility. Chapter 4 in Risk Management for Organic Producers. Moncada, K. and C. Sheaffer, editors. University of Minnesota, St. Paul, MN.

Peterson, T. A, and M. P. Russelle. 1991. Alfalfa and the nitrogen cycle in the Corn Belt. *Journal of Soil and Water Conservation* 46: 229-235.

USDA-AMS. 2017. National Organic Program. 7 C.F.R. §205.