Preparing a New Generation of Illinois Fruit and Vegetable Farmers

a USDA NIFA Beginning Farmer and Rancher Development Program Project
Grant # 2012-49400-19565

http://www.newillinoisfarmers.org

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Growing a New Generation of Illinois Fruit and Vegetable Farmers

USDA NIFA Beginning Farmer and Rancher Development Program
Grant # 2012-49400-19565

Introduction to soils

J. D. Kindhart & Ellen Philips

March 2015

new ILLINOIS fruit & vegetable FARMERS

Soil

- This definition is from Soil Taxonomy, second edition

- Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment.

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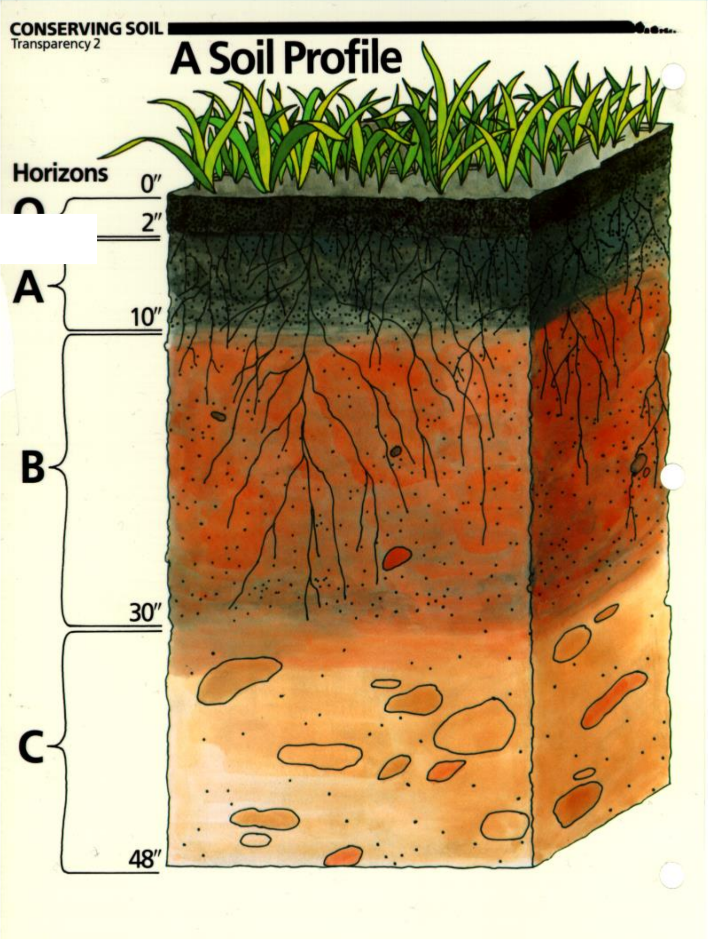
Ideal Soil Profile

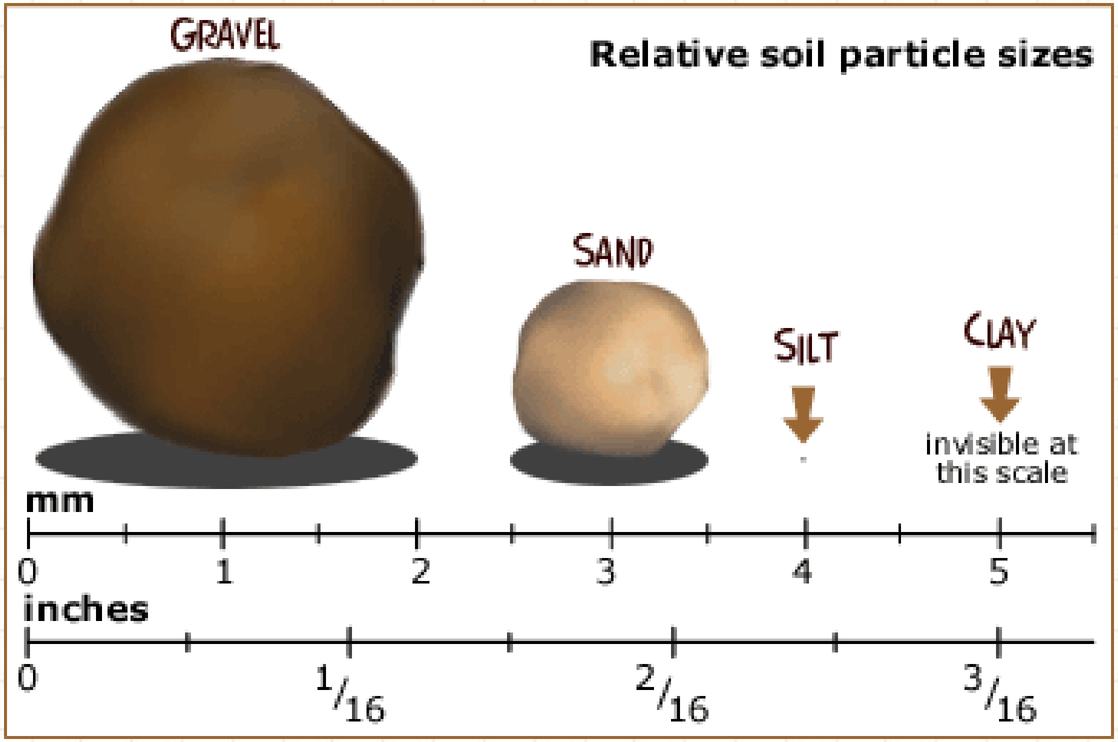
0 feet - surface



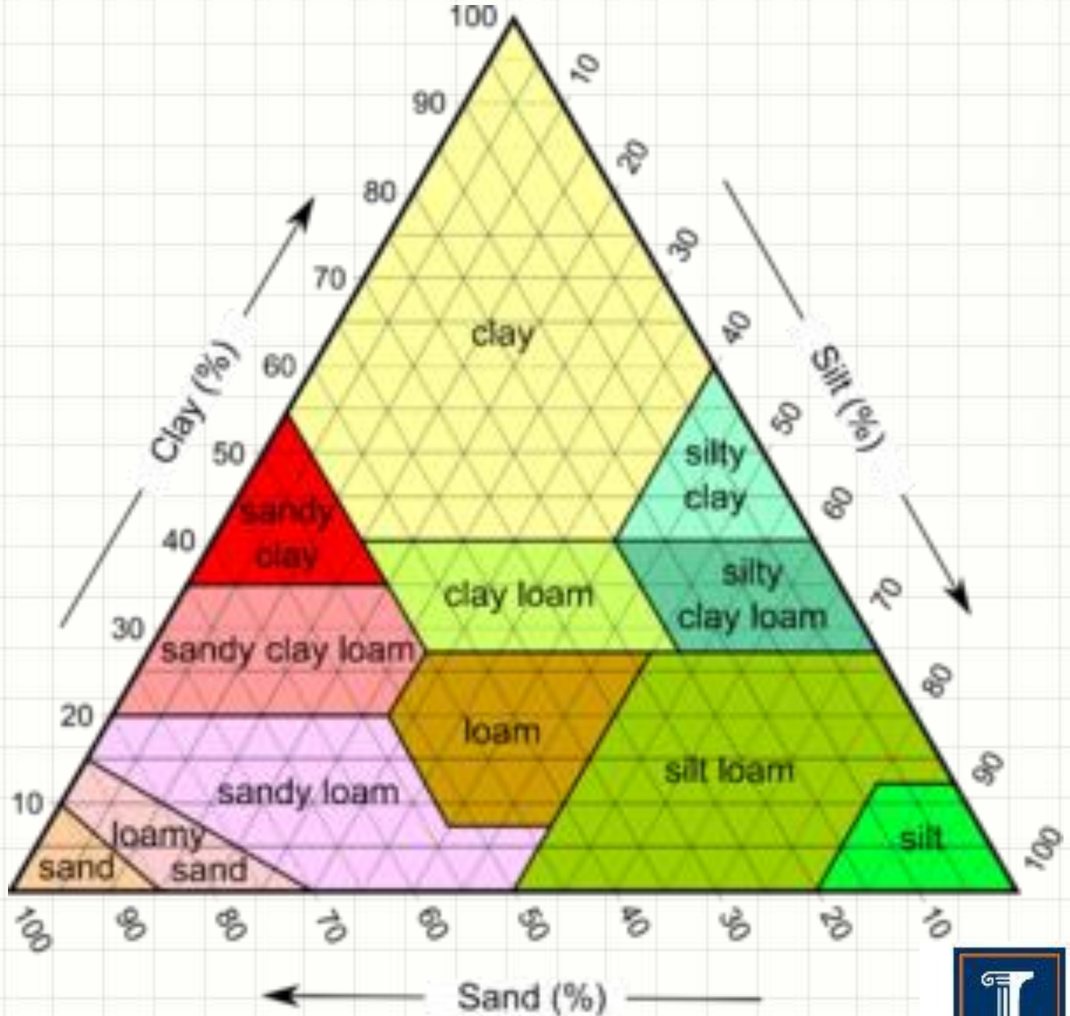
2 inches to 5+ feet

Soil Horizons

- (O horizon)
- A horizon
  - Topsoil
- (E horizon)
- B horizon
  - Subsoil
- C horizon
  - Substratum
  - Parent Material
  - Regolith
  - Bedrock


Relative soil particle sizes
GRAVEL
SAND
SILT
CLAY
invisible at this scale
mm
0
1
2
3
4
5
inches
0
1/16
2/16
3/16

Soil Texture



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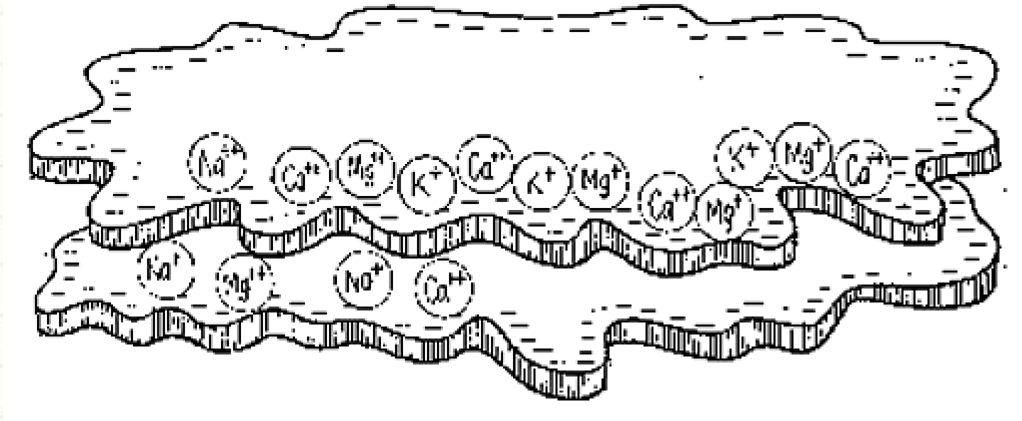
Cation Exchange Capacity: CEC



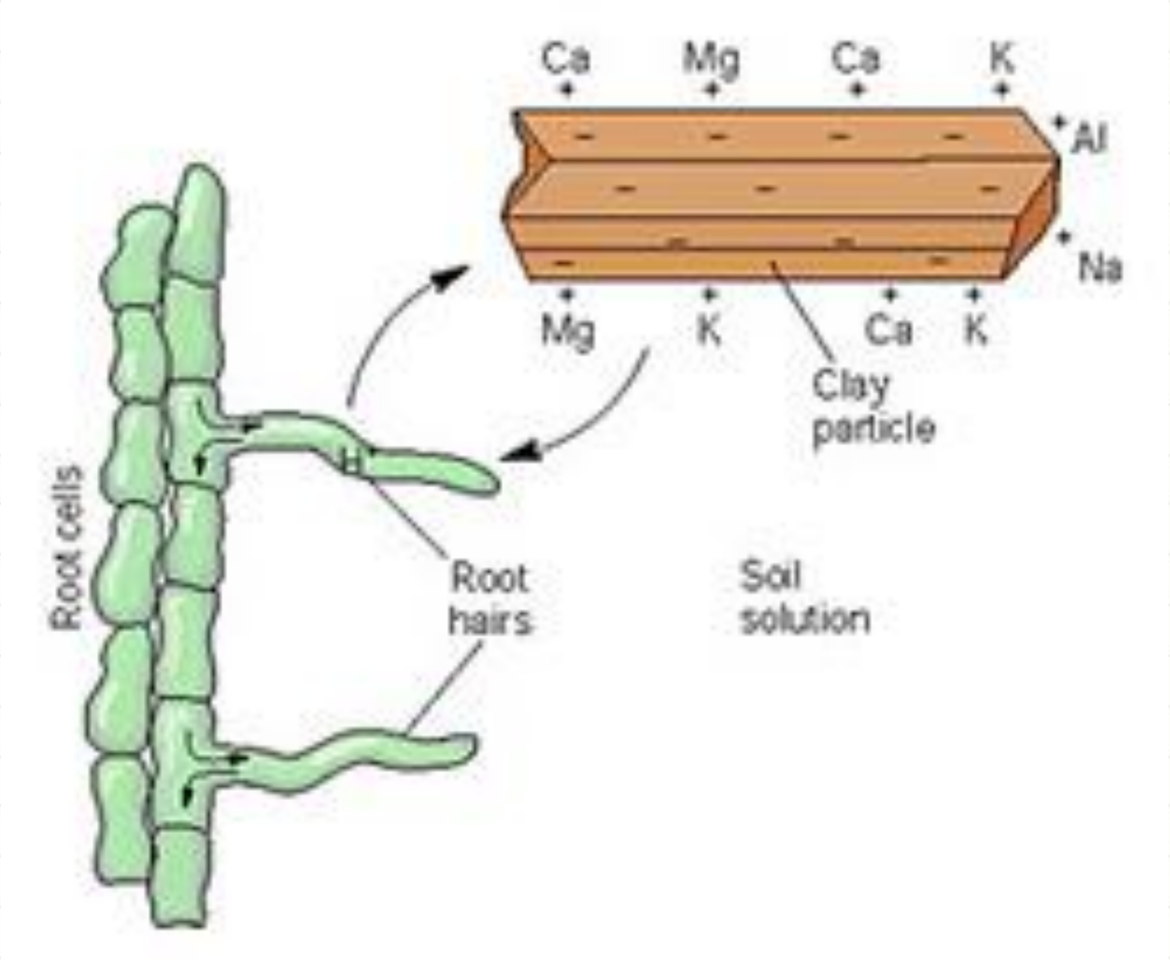
16 Essential Nutrients

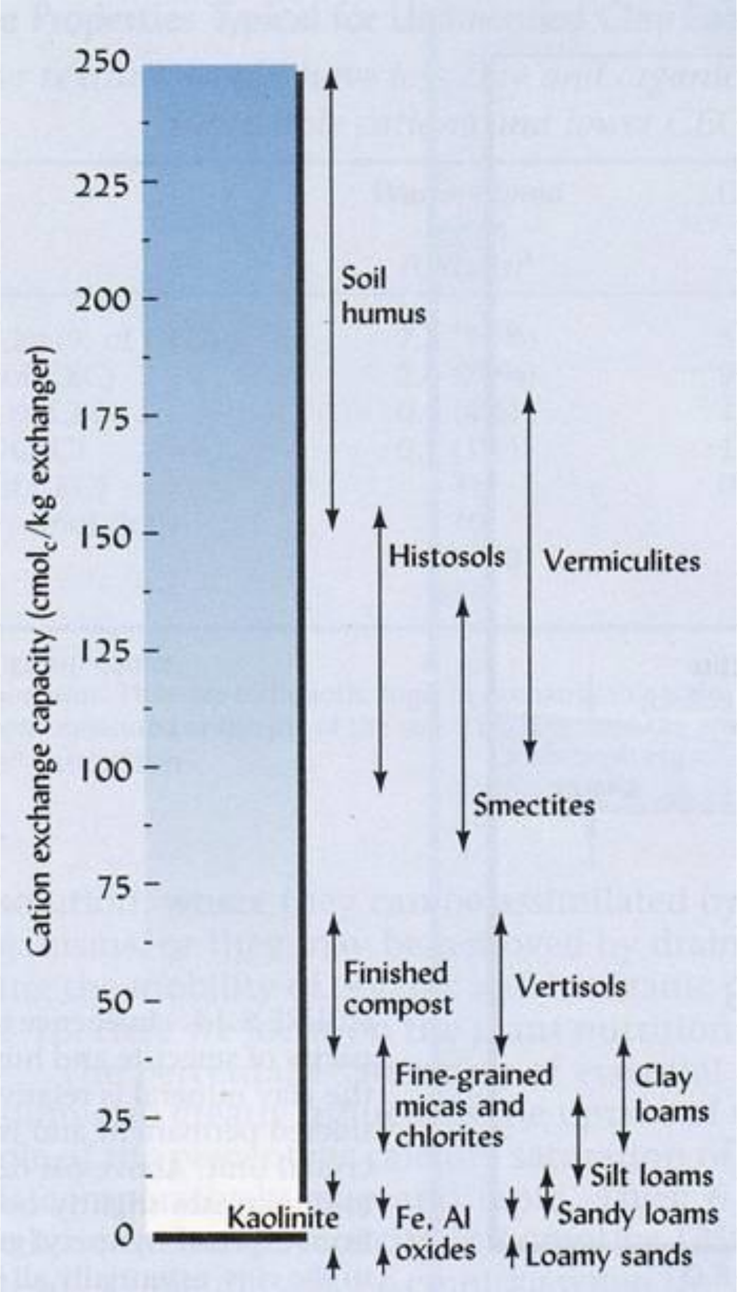
- **Structural Nutrients**
  - **Carbon (C)**
  - **Oxygen (O)**
  - **Hydrogen (H)**

- Major (macro) nutrients
  - Nitrogen (N)
  - Phosphorus (P)
  - Potassium (K)

- **Secondary nutrients**
  - **Calcium (Ca)**
  - **Magnesium (Mg)**
  - **Sulfur (S)**

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


Ca
Mg
Ca
K
Al
Na
Mg
K
Ca
K
Clay particle
Root cells
Root hairs
Soil solution



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Cation Exchange Capacity (CEC)

- The total number of exchangeable cations a soil can hold
  - amount of its negative charge

Soil Texture	CEC Range (meq/100 g soil)
organic soils	> 50
clays	25-50
silts	8-30
sands	5-15

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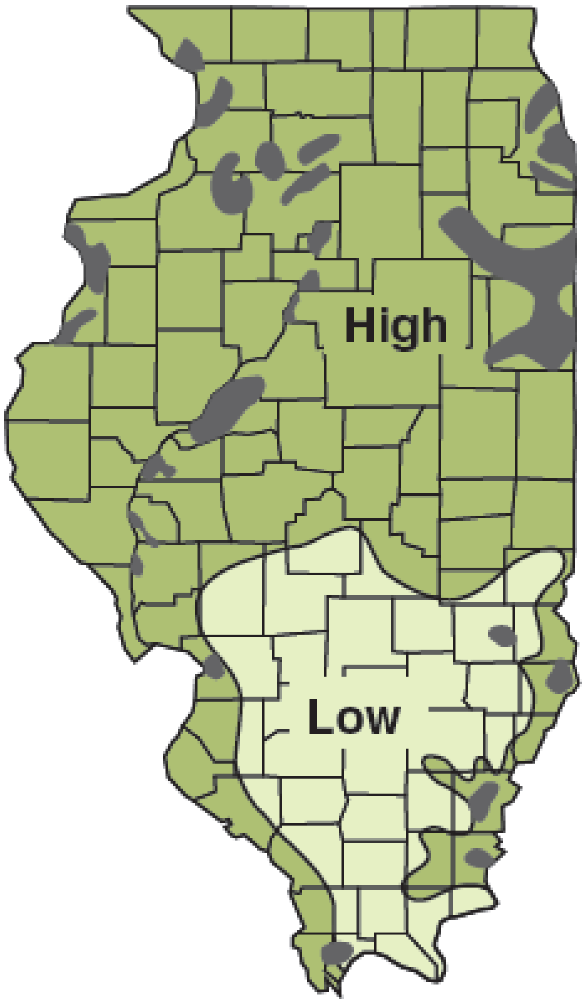
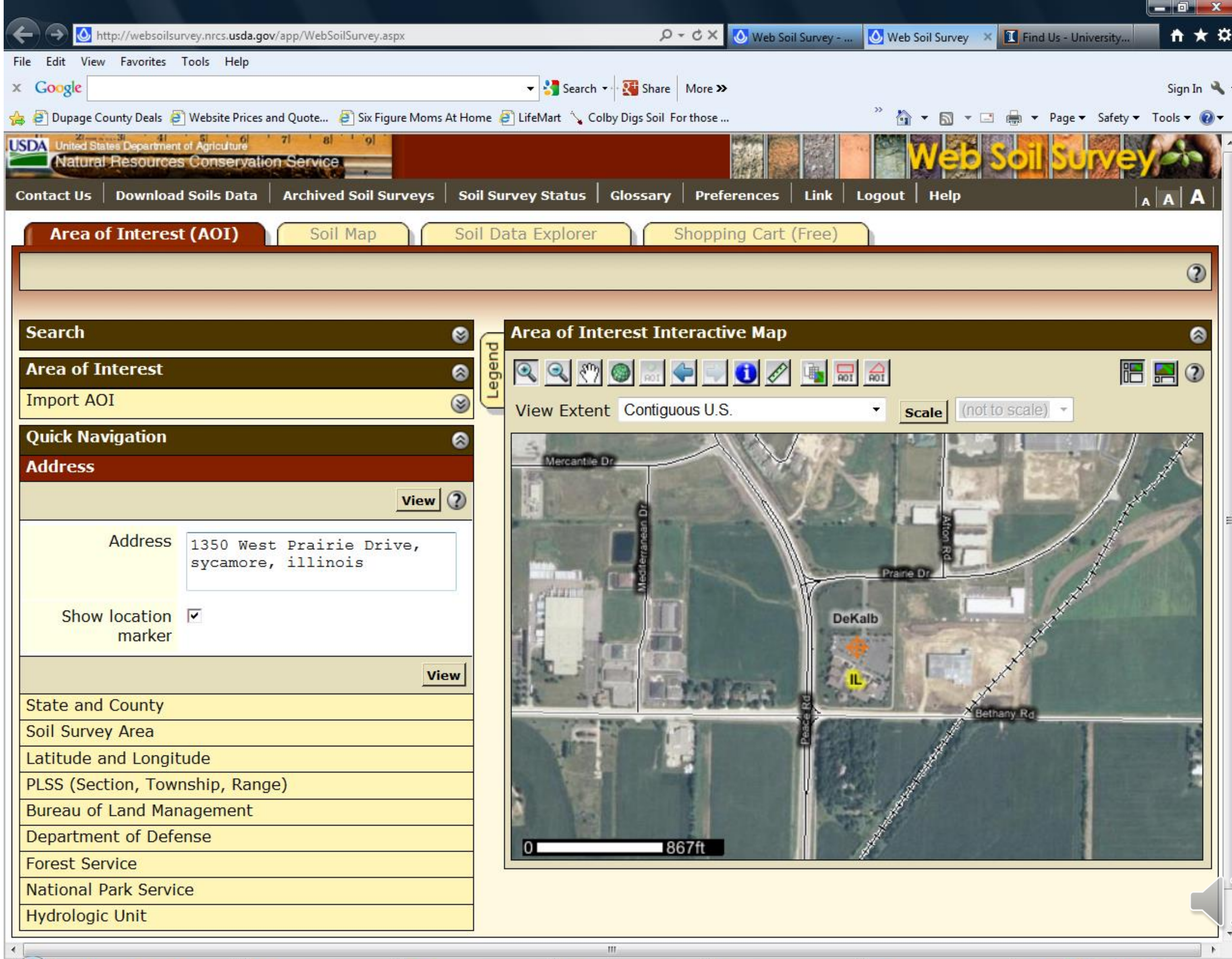


Figure 8.7. Cation-exchange capacity of Illinois soils. The darkest areas are sands with low capacity.

What Soil is on Your Property?

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



http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
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Website Prices and Quote...
Six Figure Moms At Home
LifeMart
Colby Digs Soil For those ...
Page Safety Tools
USDA United States Department of Agriculture
Natural Resources Conservation Service
Web Soil Survey
Contact Us
Download Soils Data
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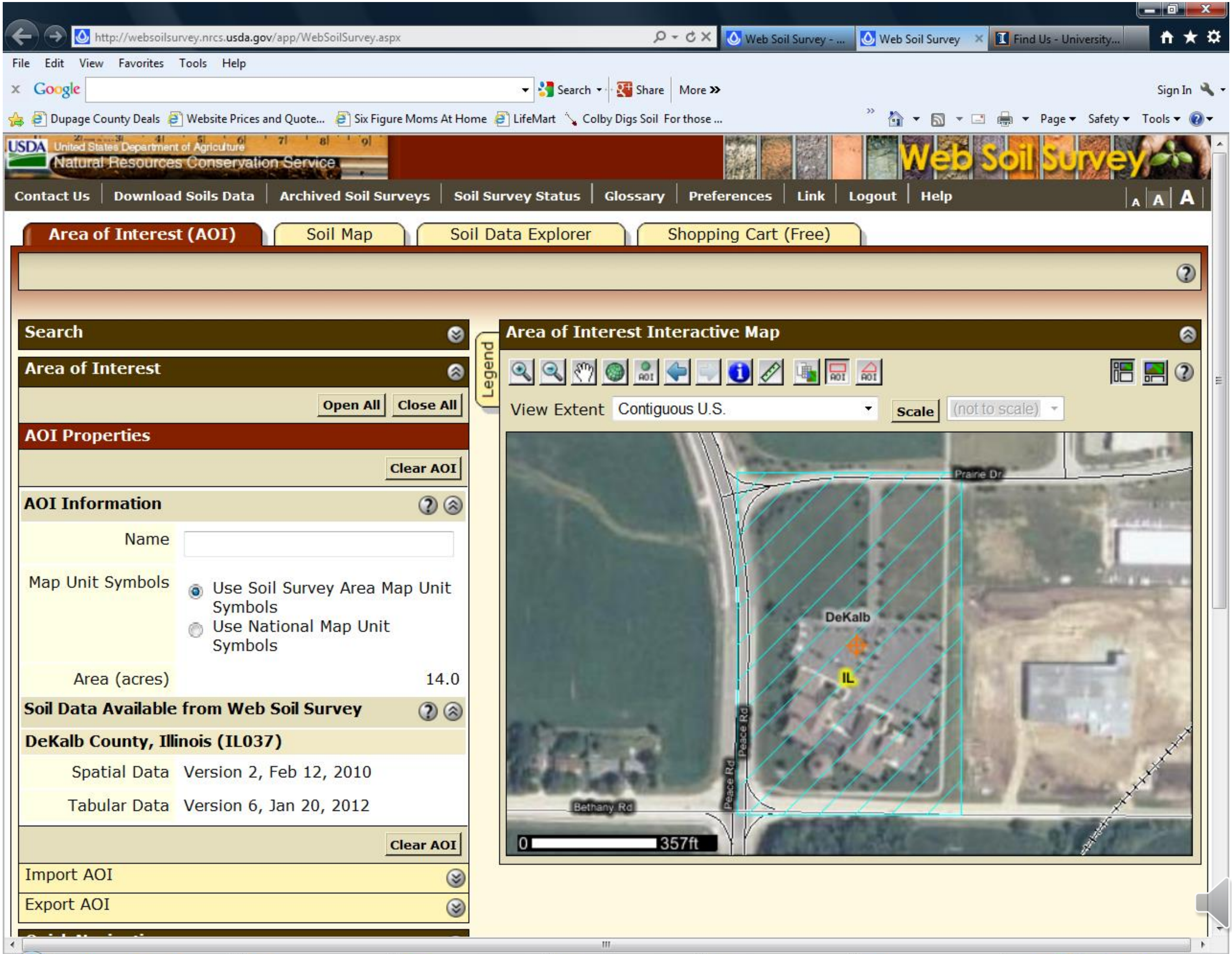
Soil Survey Status
Glossary
Preferences
Link
Logout
Help
Area of Interest (AOI)
Soil Map
Soil Data Explorer
Shopping Cart (Free)
Search
Area of Interest
Import AOI
Quick Navigation
Address
View
Address
1350 West Prairie Drive, sycamore, illinois
Show location marker
View
State and County
Soil Survey Area
Latitude and Longitude
PLSS (Section, Township, Range)
Bureau of Land Management
Department of Defense
Forest Service
National Park Service
Hydrologic Unit
Legend
Area of Interest Interactive Map
View Extent
Contiguous U.S.
Scale
(not to scale)
Mercantile Dr
Mediterranean Dr
Alton Rd
Prairie Dr
DeKalb
IL
Peace Rd
Bethany Rd
0
867ft



http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
Web Soil Survey - ...
Web Soil Survey
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Share
More »
Sign In
Dupage County Deals
Website Prices and Quote...
Six Figure Moms At Home
LifeMart
Colby Digs Soil For those ...
Page Safety Tools
USDA United States Department of Agriculture
Natural Resources Conservation Service
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Soil Survey Status
Glossary
Preferences
Link
Logout
Help
A A A
Area of Interest (AOI)
Soil Map
Soil Data Explorer
Shopping Cart (Free)
Search
Area of Interest
Open All
Close All
AOI Properties
Clear AOI
AOI Information
Name
Map Unit Symbols
Use Soil Survey Area Map Unit Symbols
Use National Map Unit Symbols
Area (acres) 14.0
Soil Data Available from Web Soil Survey
DeKalb County, Illinois (IL037)
Spatial Data Version 2, Feb 12, 2010
Tabular Data Version 6, Jan 20, 2012
Clear AOI
Import AOI
Export AOI
Legend
Area of Interest Interactive Map
View Extent Contiguous U.S.
Scale
(not to scale)
Prairie Dr
DeKalb
IL
Peace Rd
Bethany Rd
0 357ft

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

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USDA United States Department of Agriculture
Natural Resources Conservation Service

Web Soil Survey

Contact Us | Download Soils Data | Archived Soil Surveys | Soil Survey Status | Glossary | Preferences | Link | Logout | Help

Area of Interest (AOI) | Soil Map | Soil Data Explorer | Shopping Cart (Free)

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Map Unit Legend

DeKalb County, Illinois (IL037)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
154A	Flanagan silt loam, 0 to 2 percent slopes	6.9	49.0%
512B	Danabrook silt loam, 2 to 5 percent slopes	7.1	51.0%
Totals for Area of Interest		**14.0**	**100.0%**

Legend

Soil Map

Scale (not to scale)

Warning: Soil Map may not be valid at this scale.

You have zoomed in beyond the scale at which the soil map for this area is intended to be used. Mapping of soils is done at a particular scale. The soil surveys that comprise your AOI were mapped at 1:12,000. The design of map units and the level of detail shown in the resulting soil map are dependent on

DeKalb County, Illinois

Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*dS/m*	
154A—Flanagan silt loam, 0 to 2 percent slopes								
Flanagan	0-18	17-23	—	5.6-7.3	0	0	0	0
	18-38	26-31	—	5.6-7.3	0	0	0	0
	38-45	19-26	—	5.6-7.3	0	0	0	0
	45-49	15-21	—	6.1-7.8	0-10	0	0	0
	49-60	8.5-21	—	7.4-8.4	15-40	0	0	0
512B—Danabrook silt loam, 2 to 5 percent slopes								
Danabrook	0-13	16-23	—	5.6-7.3	0	0	0	0
	13-33	19-28	—	5.1-7.3	0	0	0	0
	33-50	11-18	—	5.6-7.8	0-20	0	0	0
	50-60	7.9-11	—	7.4-8.4	15-40	0	0	0

Description — Chemical Soil Properties

Chemical Soil Properties

This table shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

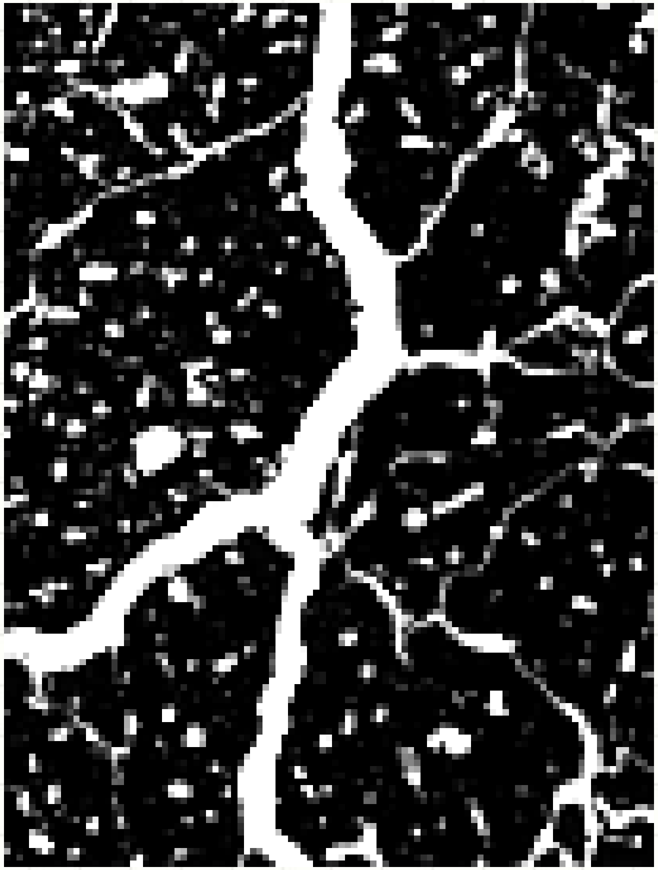
Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of extractable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Some Factors Influenced by Soil Type

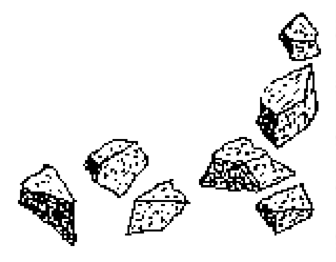
- Plant Selection: grow adapted varieties
- Irrigation: Soil types directly impacts plant available water
- Drainage
- Fertilizer recommendation
- Yield potential
- Herbicides: read label for special instructions

SOIL STRUCTURE

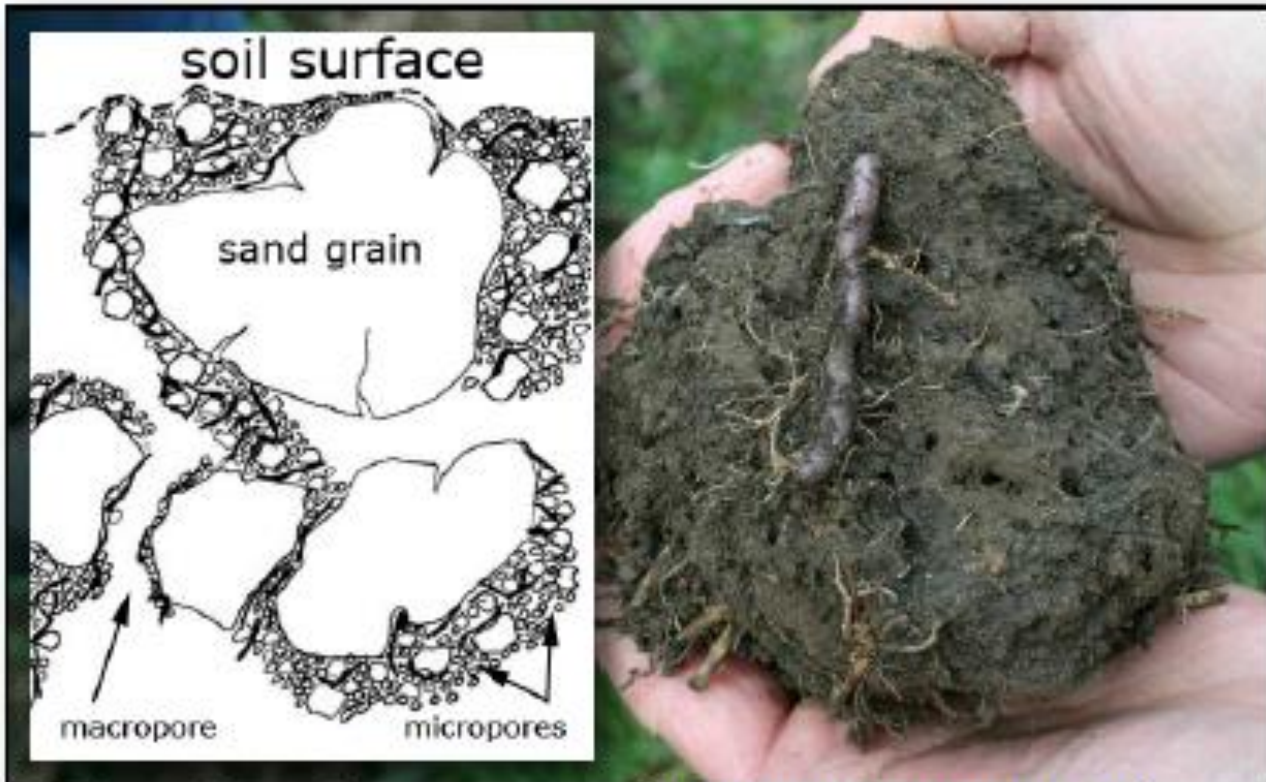


Relationship between structure and porosity

Granular structure



Blocky structure



High residue and cover crops contribute organic matter to soil, while no-till management helps protect organic matter and allow accumulation. Organic matter provides food for earthworms and other soil biota. All play a role in developing or protecting soil structure and macropores to help soil function at a high level. Inset shows relationship of macro- and micropores to soil aggregates.

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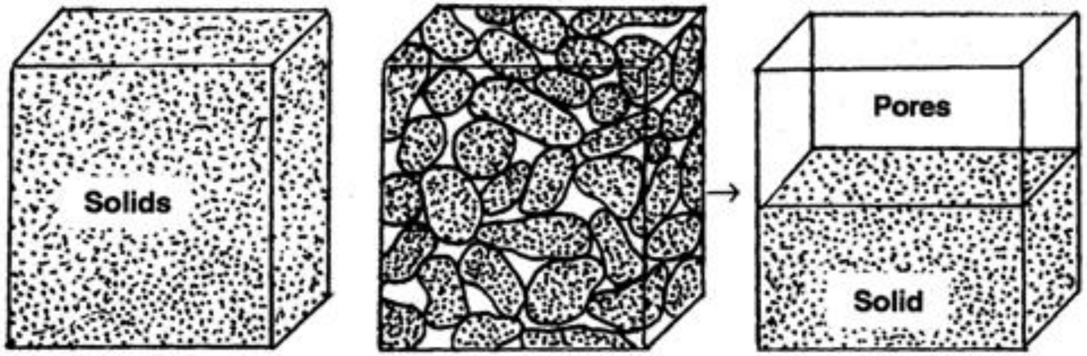
Bulk Density



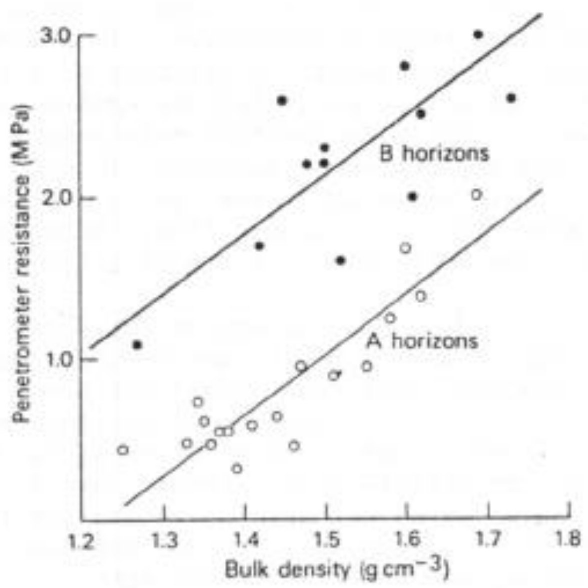
Particle Density

100% solid
Weight = 2.66 g
Volume = 1 cm^3

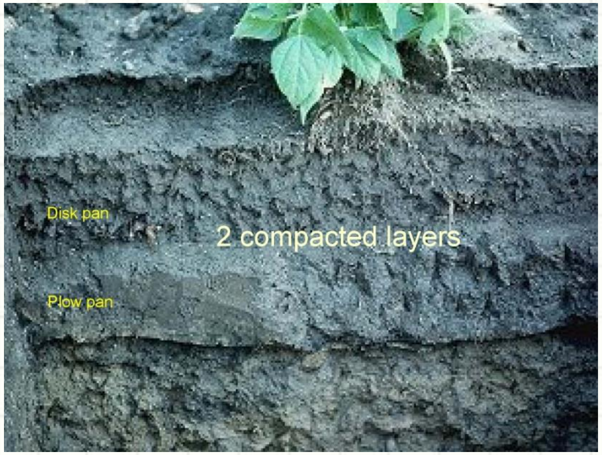
Bulk Density

50% solid, 50% pore space
Weight = 1.33 g
Volume = 1 cm^3

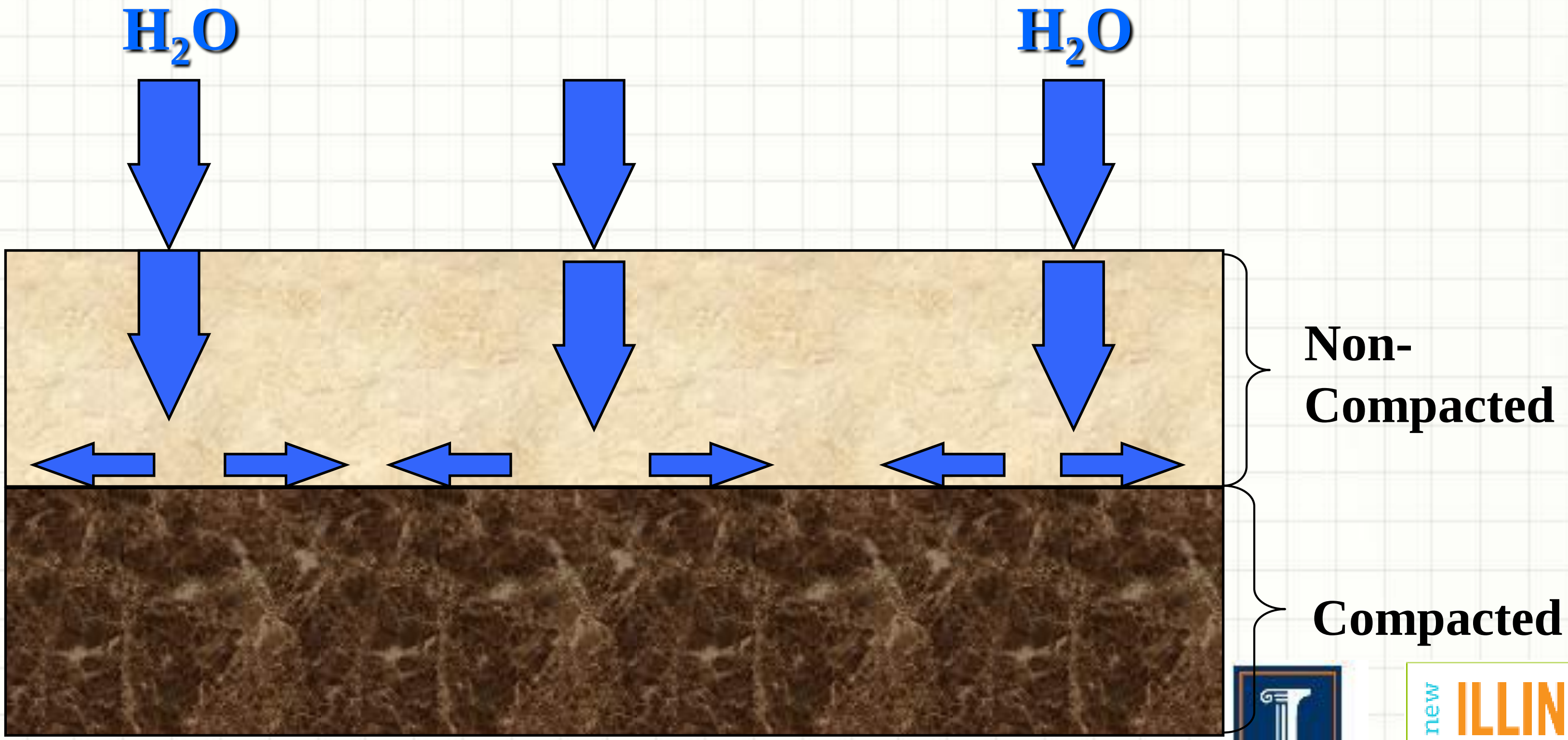
Penetrometer



Compacted Zone



Impermeable Layer

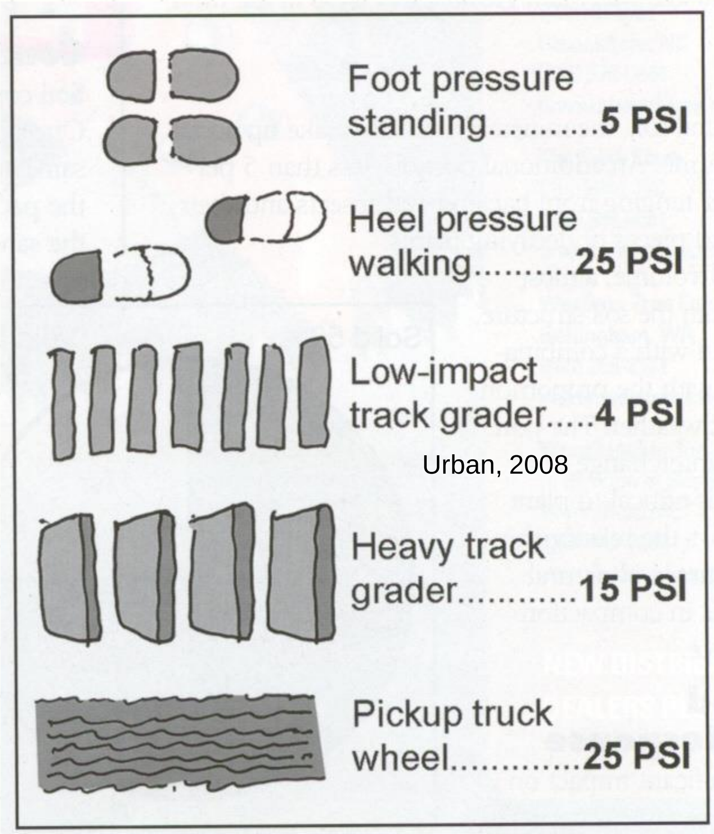


Preventing and Repairing Compaction

- Break up compacted layer
  - Double digging
  - Sub soiling
  - Core aeration of lawns
- Plant deep rooted plants
  - Tillage radish
  - Annual Ryegrass

Preventing and Repairing Compaction

- Prevent further compaction
  - Minimize Tillage
    - Minimize Rototilling
    - Vary depth of tillage each year
  - Minimize walking on soil
    - Raised beds guide traffic
  - Do not drive cars or other vehicles across soil
    - Develop drive aisles



Urban, 2008

Interpreting Soil Test Results

REPORT NUMBER

REPORT DATE　　ACCOUNT

RECEIVED DATE

Midwest Laboratories, Inc.

13611 "B" Street • Omaha, Nebraska 68144-3693 • (402) 334-7770 • FAX (402) 334-9121
www.midwestlabs.com

IDENTIFICATION

AGPRO SYSTEMS INC
DON MISCHNICK/D KINSEY
242 PR 3341
BIG SANDY TX 75755-4658

SOIL ANALYSIS REPORT

INFO SHEET: 169258

LAB NUMBER *205*	SAMPLE IDENTIFICATION	ORGANIC MATTER (MODIFIED LOI) percent / RATE	PHOSPHORUS P1 (WEAK BRAY) 1:7 ppm / RATE	PHOSPHORUS P2 (STRONG BRAY) 1:7 ppm / RATE	PHOSPHORUS BICARBONATE P ppm / RATE	POTASSIUM K ppm / RATE	MAGNESIUM Mg ppm / RATE	CALCIUM Ca ppm / RATE	SODIUM Na ppm / RATE	pH SOIL pH 1:1	pH BUFFER INDEX	CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED) % K	% Mg	% Ca	% H	% Na
		1		2		3	4		5	6	7	8			9		

NEUTRAL AMMONIUM ACETATE (EXCHANGEABLE): POTASSIUM, MAGNESIUM, CALCIUM, SODIUM

LAB NUMBER *205*	NITRATE-N (FIA) SURFACE ppm	SURFACE lbs/A	SURFACE depth (in)	SUBSOIL 1 ppm	SUBSOIL 1 lbs/A	SUBSOIL 1 depth (in)	SUBSOIL 2 ppm	SUBSOIL 2 lbs/A	SUBSOIL 2 depth (in)	Total lbs/A	SULFUR S ICAP ppm / RATE	ZINC Zn DTPA ppm / RATE	MANGANESE Mn DTPA ppm / RATE	IRON Fe DTPA ppm / RATE	COPPER Cu DTPA ppm / RATE	BORON B SORB. DTPA ppm / RATE	EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm / RATE
			11								12	13	14	15	16	17	18	19

REV. 12/03

The above analytical results apply only to the sample(s) submitted. Samples are retained a maximum of 30 days.

University Extension UNIVERSITY OF MISSOURI COLUMBIA

Soil Test Report

Soil Testing Laboratory
23 Mumford Hall, MU
Columbia, MO 65211
Phone: (573) 882-0623

or

Soil Testing Laboratory
P.O. Box 160
Portageville, MO 63873
Phone: (573) 379-5431

Serial no. M9999	Lab no. 9969999	
Area 015	County 010	Region 3
Submitted 06/10/96	Processed 06/12/96	

A

FIELD INFORMATION			
Field ID	Hill top field	Sample no.	1
Acres 40	Last Limed Not known	Irrigated	No
Last crop	019 Cool-Season Grass Pasture		

Soil sample submitted by:

This report is for:

Example Report
University of Missouri
Columbia, MO 65211

B SOIL TEST INFORMATION — **C** RATING

		Value	Very low	Low	Medium	High	Very High	Excess
pH_s	(salt pH)	4.9	*******					
Phosphorus	(P)	22 lbs/acre	**********************					
Potassium	(K)	303 lbs/acre	*********************************					
Calcium	(Ca)	2091 lbs/acre	***************************					
Magnesium	(Mg)	278 lbs/acre	**************					
Sulfur	(SO_4-S)	ppm						
Zinc	(Zn)	ppm						
Manganese	(Mn)	ppm						
Iron	(Fe)	ppm						
Copper	(Cu)	ppm						

Organic matter	2.2 %	Neutralizable acidity	6.0 meq/100g	Cation Exch. Capacity	12.8 meq/100g
pH in water		Electrical Conductivity	mmho/cm	Sodium (Na)	lbs/a
Nitrate (NO_3-N) Topsoil	ppm	Subsoil	ppm	Sampling Depth Top	inches Subsoil inches

D NUTRIENT REQUIREMENTS

E Cropping options	**F** Yield goal	N	P_2O_5	K_2O	Zn	S
		G Pounds per acre				
Alfalfa/Grass Establishment	0	20	55	0		
Clover/Grass Establishment	0	20	45	0		
Alfalfa/Grass Hay	6	0	80	235		
Cool-Season Grass Pasture	150 CD/A	90	30	20		

LIMESTONE SUGGESTIONS **H**	
Effective neutralizing material (ENM)	1,395
Effective magnesium (EMg)	

I

To determine limestone needs in tons/acre, divide ENM requirements by the guarantee of your limestone dealer.

When N requirement for cool-season grass exceeds 90 lbs/acre, apply 2/3 of it during the eriod from December through February, and the remainder in August.

Do not use nitrogen on spring seedlings of legumes after May 1st because of potential weed competition.

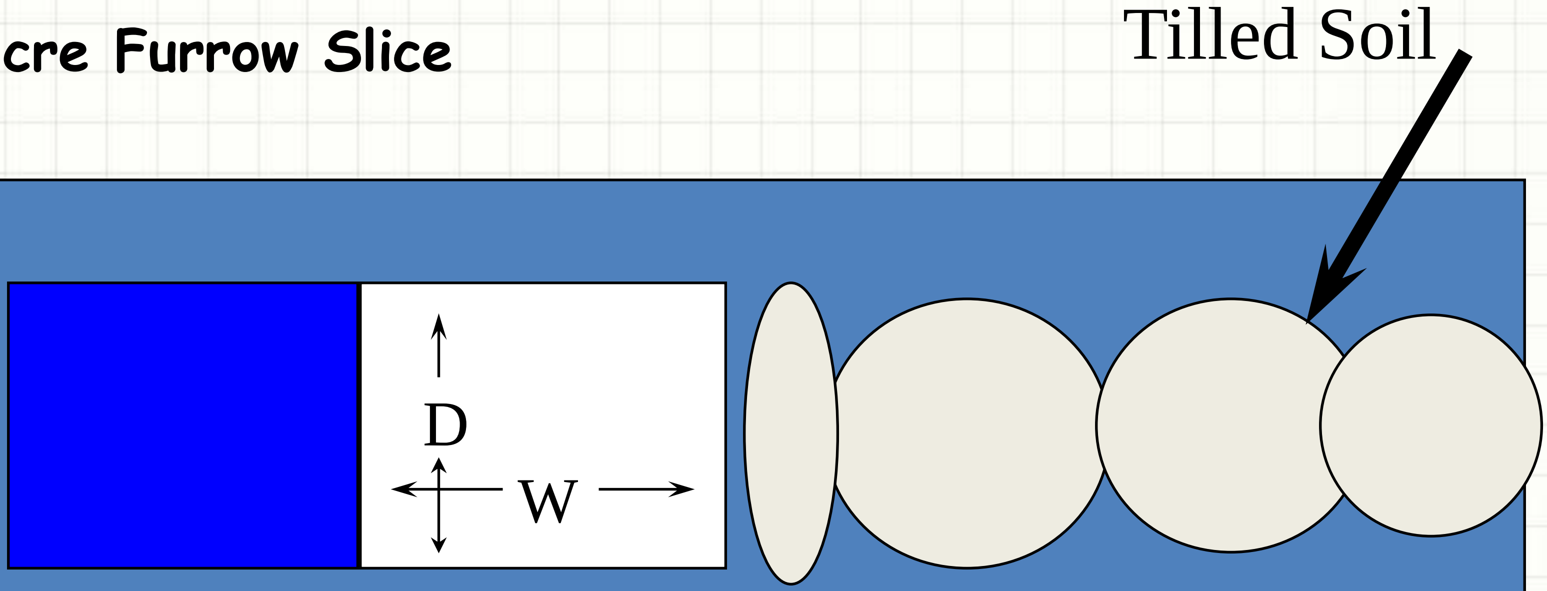
Area Agronomy Specialist Agronomy Specialist Phone (573) 882-1000

White - Farmer, Yellow - ASCS, Blue - Firm, Pink - Extension MP 189 Revised 1/96 Signature

University of Missouri, Lincoln University, U.S. Department of Agriculture & Local University Extension Councils Cooperating
equal opportunity institutions

$$\text{Pounds/A} = \text{ppm} \times 2$$

Acre Furrow Slice

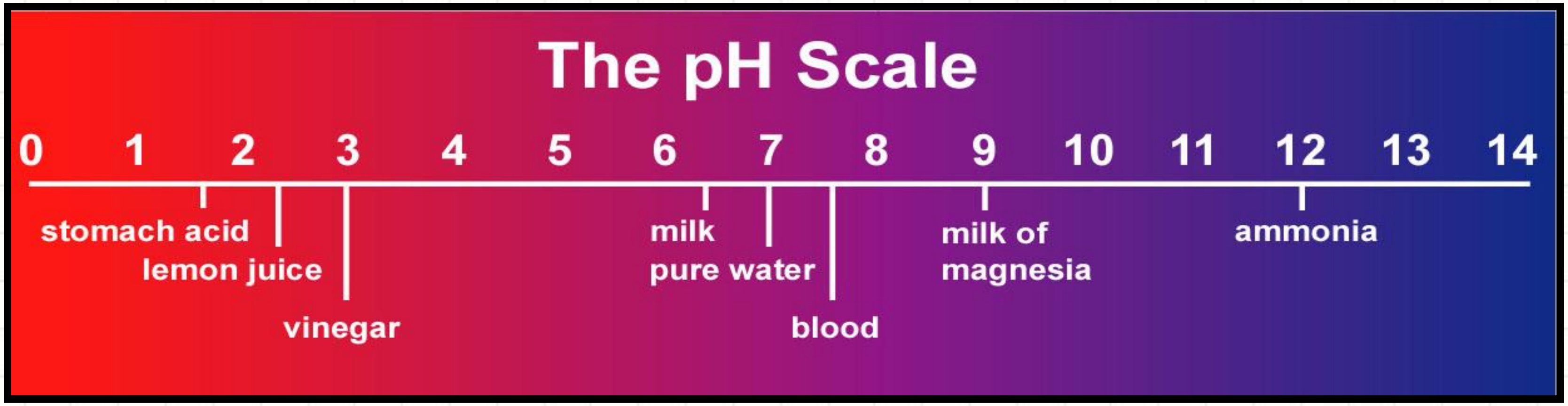


AFS = D x W = 2,000,000 pounds

Recommendations

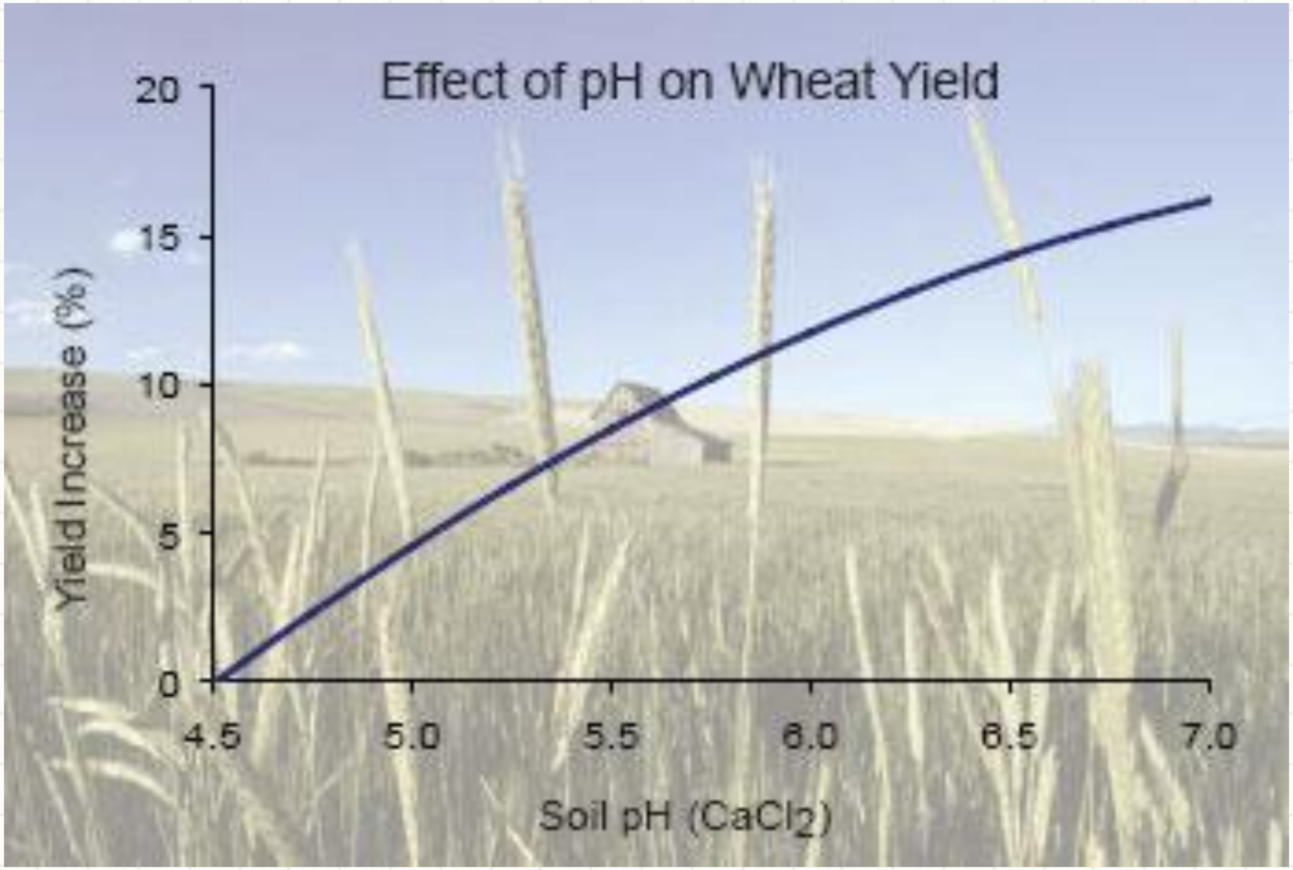
Soil pH

- Measure of alkalinity or acidity on a scale of 0 - 14



Acidic **Neutral** **Alkaline**

Adjusting pH



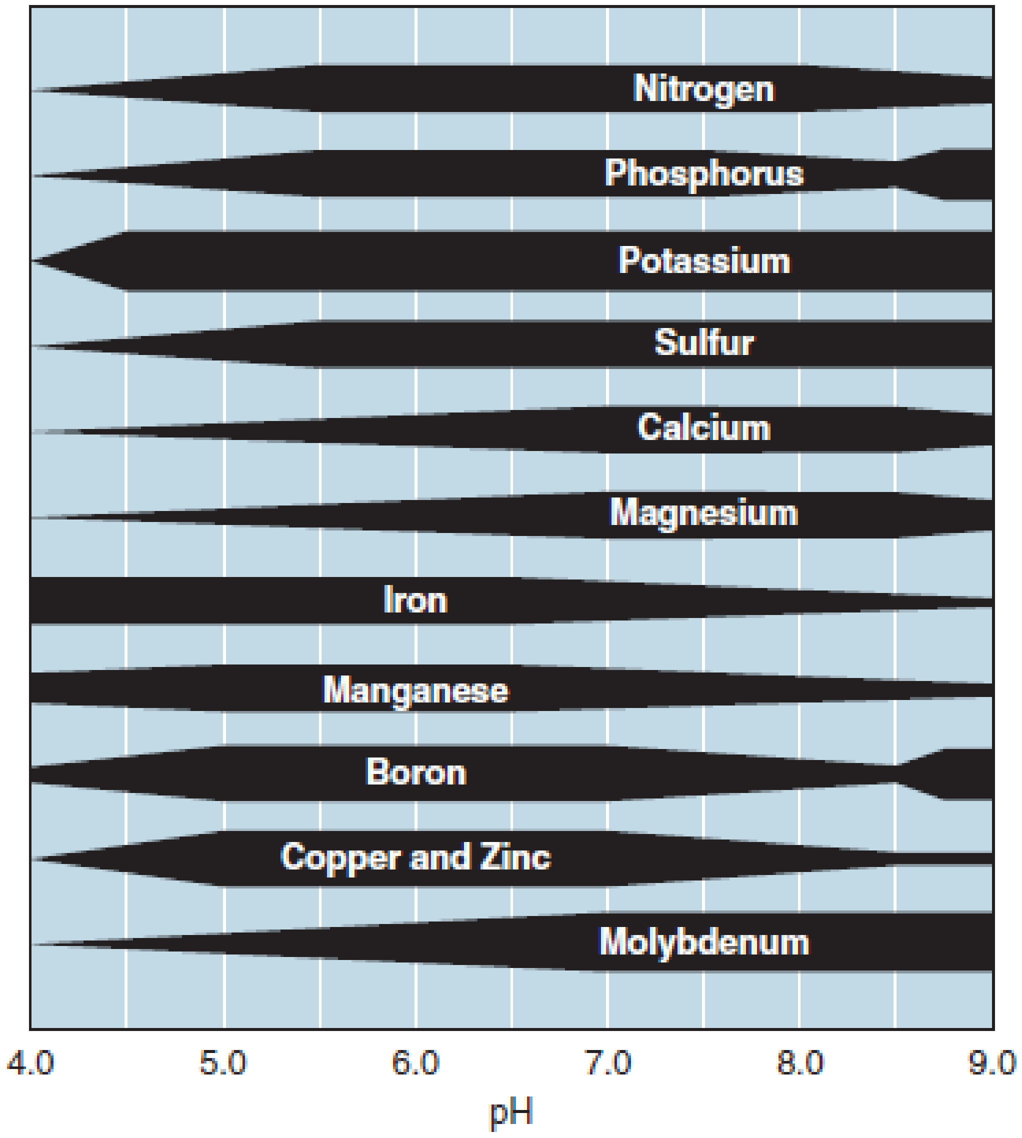


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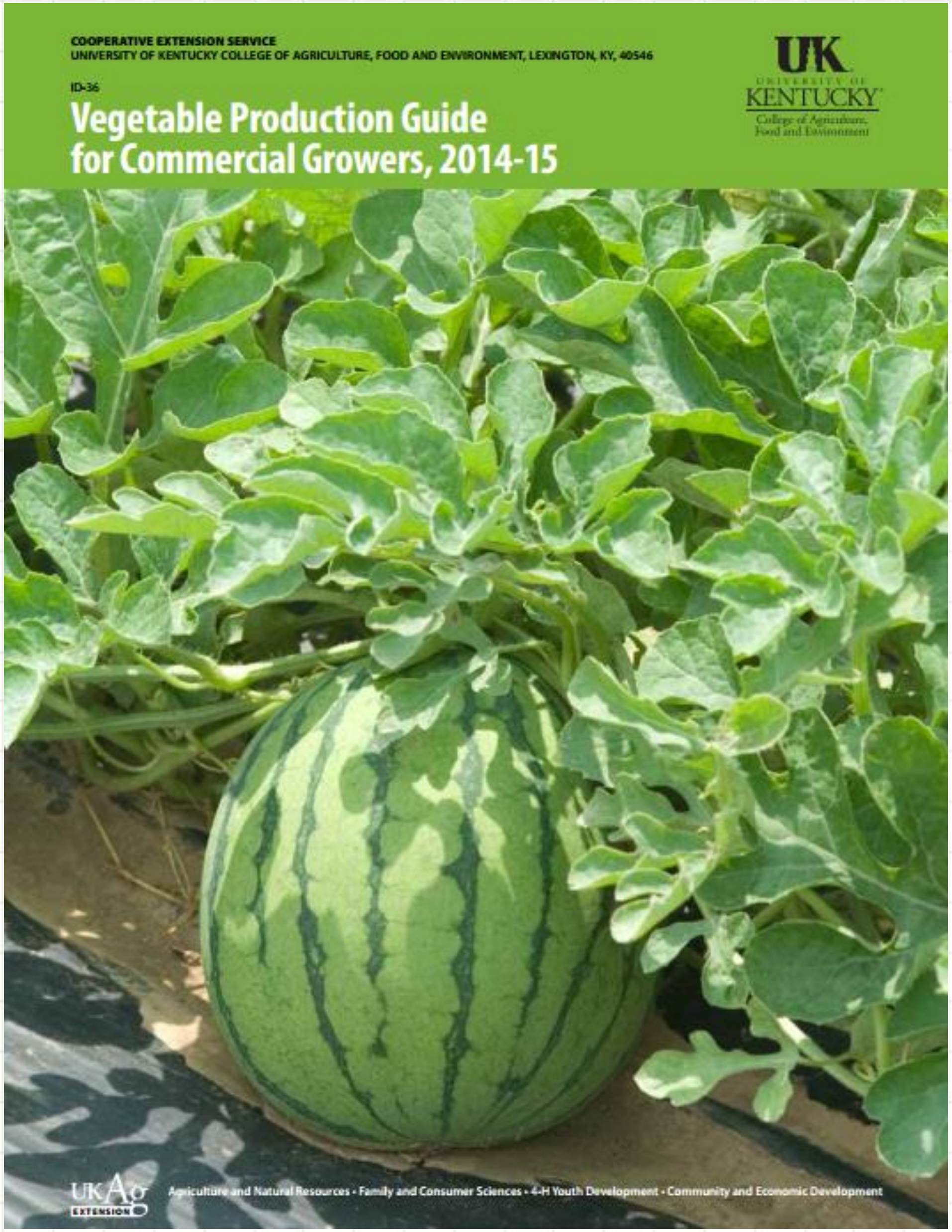
Table 8.3. Suggested limestone rates based on soil type, pH, cropping system, and 9-inch depth of tillage.

Soil type[a]	Soil pH value																					
	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	7.0
Tons of typical limestone[b] to apply to grain farming systems																						
A	8.0	8.0	8.0	8.0	8.0	8.0	7.8	7.0	6.3	5.5	4.8	4.0	3.3	2.5	1.8	1.0	Optional					
B	8.0	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0	Optional					
C	6.6	6.3	5.9	5.5	5.1	4.8	4.4	4.0	3.6	3.3	2.9	2.5	2.1	1.8	1.4	1.0	Optional					
D	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	Optional					
E	4.0	3.6	3.2	2.8	2.4	2.0																
Tons of typical limestone[b] to apply to forage farming systems (alfalfa, clover, lespedeza)																						
A	11.0	11.0	11.0	11.0	11.0	11.0	11.0	10.3	9.6	8.9	8.1	7.4	6.7	6.0	5.3	4.6	3.9	3.1	2.4	1.7	1.0	Optional
B	11.0	11.0	11.0	10.4	9.9	9.3	8.8	8.2	7.7	7.1	6.6	6.0	5.4	4.9	4.3	3.8	3.2	2.7	2.1	1.6	1.0	Optional
C	10.0	9.6	9.1	8.7	8.2	7.8	7.3	6.9	6.4	6.0	5.5	5.1	4.6	4.2	3.7	3.3	2.8	2.4	1.9	1.5	1.0	Optional
D	6.0	5.8	5.5	5.3	5.0	4.8	4.5	4.3	4.0	3.8	3.5	3.3	3.0	2.8	2.5	2.3	2.0	1.8	1.5	1.3	1.0	Optional
E	6.0	5.4	4.9	4.3	3.8	3.2	2.7	2.1	1.6	1.0												

Note: If plowing is less than 9 in., reduce the amount; if it is more than 9 in., increase it. A chisel plow, disk, or field cultivator rather than a moldboard plow may not mix limestone deeper than 4 to 5 in.; for no-till or pasture systems, use the equivalent of a 3-in. tillage depth (one-third of the amount suggested).

[a]Soil A: Dark-colored silty clays and silty clay loams (CEC > 24). Soil B: Light- and medium-colored silty clays and silty clay loams; dark-colored silt and clay loams (CEC 15–24). Soil C: Light- and medium-colored silt and clay loams; dark- and medium-colored loams; dark-colored sandy loams (CEC 8–15). Soil D: Light-colored loams; light- and medium-colored sandy loams; sands (CEC < 8). Soil E: Muck and peat. Soil color is usually related to organic matter.Light-colored soils <2.5% organic matter; medium-colored soils 2.5–4.5% organic matter; dark-colored soils >4.5% organic matter.

[b]Typical limestone: 10% of the particles are greater than 8-mesh; 30% pass an 8-mesh and are held on 30-mesh; 30% pass a 30-mesh and are held on 60-mesh; and 30% pass a 60-mesh. A calcium carbonate equivalent (total neutralizing power) of 90%. Effective neutralizing value (ENV) of this material is 46.35 for 1 year after application, and 67.5 for 4 years after application. To correct the rate of application based on the ENV of the material available, follow calculations in the worksheet on page 98.



http://www2.ca.uky.edu/agc/pubs/id/id36/id36.pdf

UNIVERSITY OF ILLINOIS EXTENSION

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FERTILIZER: *Tomatoes*

The following fertilizer rates are to be used only as guidelines. Research at the University of Kentucky and at the University of Tennessee indicates that there is no yield increase from using more than 60 lb/A K_2O or 60 lb/A of P_2O_5 when soil test P and K levels are high.

Soil Test Results *(lb/A)*		**Fertilizer Needed** *(lb/A)*
Phosphorus		**Phosphate** *(P_2O_5)*
Low	<31	181-240
Medium	31-60	61-180
High	61-80	1-60
Very High	>80	0
Potassium		**Potash** *(K_2O)*
Low	<201	121-250
Medium	201-300	61-120
High	301-450	1-60
Very High	>450	0
Basal nitrogen where tomatoes:		**N**
1. follow grass-legume or legume sod		30
2. follow grass sod		50
3. are grown on continually cropped land		60

Supplemental applications: On bare ground plantings, apply an additional 30 lb of nitrogen/A as a sidedressing when the first fruits are golf-ball size. A second sidedress application of 30 lb N may also be desirable two or three weeks later, depending on the crop's growing condition. For plasticulture with drip on medium-textured soils, apply all recommended phosphorus and potassium requirements prior to laying plastic mulch. See fertigation table for N application rates.

FERTIGATION RECOMMENDATIONS (Nitrogen only): *Staked Tomatoes*

Based on a total season N recommendation of 150 lb actual N/A with 50 lb N/A applied preplant and the remaining N (150 - 50 = 100 lb) divided into equal amounts to be fertigated on a weekly basis (100 lb ÷ 10 weeks = 10 lb of N per week). Both moderate (75 lb) and high (100 lb) fertigated N rates are provided below. For harvest seasons extending beyond 10 weeks from transplanting, a maintenance dose of 1 to 1.5 lb N (3 to 4.5 lb ammonium nitrate) per week is adequate. The doses listed for 1,000 plants are based on a plant population of 4,200 plants/A (i.e., rows on 6 ft centers in 5-row blocks and plants 18 in apart). IMPORTANT: If a UK soil test indicates your site is "at risk" for ripening disorders (Hartz ratio), you should alternate fertigations using ammonium or calcium nitrate with potassium nitrate fertigations (see Potassium Fertigation table).

Total Fertigated N Requirement[1]	**Actual N/wk** *(lb/A)*	**Ammonium Nitrate** *(lb/A/wk)*	**Ammonium Nitrate** *(lb/1,000 plants/wk)*	**Calcium Nitrate** *(lb/A/wk)*	**Calcium Nitrate** *(lb/1,000 plants/wk)*
75 lb/A	7 lb 8 oz	22 lb 6 oz	5 lb 5 oz	48 lb 6 oz	11 lb 8 oz
100 lb/A	10 lb	30 lb	7 lb	64 lb 8 oz	15 lb 6 oz

[1] *Fertigation can begin 10 to 14 days after transplanting and assumes 50 lb N/A was applied preplant and starter fertilizer was used.*

FERTIGATION RECOMMENDATIONS (Nitrogen + Potassium): *Staked Tomatoes*

Potassium nitrate supplies both nitrogen and potassium and can be used as a substitute for ammonium or calcium nitrate. It is especially important to fertigate with a potassium source if a UK soil test indicates that your site is "at risk" for ripening disorders (Hartz ratio).

Recommendations below are based on a total of 125 to 150 lb N/A for the season with 50 lb N/A applied preplant. The remaining (125-50) = 75 or (150-50) = 100 lb divided into equal amounts to be fertigated on a weekly basis for 10 weeks. This is either 7.5 or 10 lb of N/A/week. Both moderate (75 lb) and high (100 lb) fertigated N rates are given below. For harvest seasons extending beyond 10 weeks from transplanting, a maintenance dose of 1 to 1.5 lb N (11.5 lb potassium nitrate) per week is adequate. The doses listed for 1,000 plants are based on a plant population of 4,200 plants/A (i.e., rows 6 ft on center in 5-row blocks and plants 18 inches apart).

Total Fertigated N Requirement	**Actual N/wk** *(lb/A)*	**Potassium Nitrate** *(lb/A/week)*	**Potassium Nitrate** *(lb/1,000 plants/wk)*	**Potassium Nitrate: K provided** *(lb/A/wk)*	**Potassium Nitrate: K provided** *(lb/1,000 plants/wk)*
75 lb/A	7 lb 8 oz	57 lb 11 oz	13 lb 12 oz	25 lb 6 oz	6 lb 1 oz
100/lb/A	10 lb	76 lb 15 oz	18 lb 5 oz	33 lb 14 oz	8 lb 1 oz

Problems more commonly found in specialty crops

- Phosphorus scores too high
- Advising on foliar feeding
- Nutrients out of balance?
- “Disease” associated with fertility

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Other differences

- Fertilizer materials used
- Timing of application
- Method of application
- Fertilizer input expenses are normally not that significant in the overall cost of production
- Excess fertilizer may result in problems beyond the simple waste of money

Tools in addition to soil testing utilized by Illinois specialty crop producers

- Tissue analysis
- Petiole sap meters
- Visual inspection

To reach us

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If you have questions ...

- University of Illinois Extension Local Food Systems and Small Farms team
  - http://web.extension.illinois.edu/smallfarm/
- USDA's Start2Farm site
  - http://www.start2farm.gov/