How to Help Yourself Become a Continuous No-Tiller

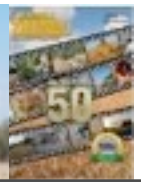
Sjoerd W. Duiker
Penn State University

January 9, 2013

The Need

"Before World War II, we stood arraigned as the most wasteful people in all history. Nowhere else, except in the fabled Garden of Eden, had a people taken such a rich, virgin territory and in a short three centuries ruined large parts of it for all time and semi-destroyed other parts, while busily trying to do away with the rest. We were not husbandmen in the best sense of the word. We were miners." Homestead and Fite, 1955. 'The Agricultural Regions of the United States.' p. 24



The Problem

- Tillage – hoe, disk, moldboard
- One-crop agriculture
  - 1600 - Tobacco in the Chesapeake Region
  - 1793 - Cotton in the South
  - 1837 – Corn in the Midwest
  - 1870 - Wheat in the Plains and Palouse

The Results

- In the Chesapeake, after 2-3 years of tobacco and a few years of corn and wheat farmers moved on to the new fields

- It was estimated that the Potomac carried annually 1.7 billion lbs of dissolved nutrients and 470 million lbs of sediment to the Chesapeake Bay, while the James carried 3-4 million cubic yards from north of Richmond and the Roanoke 3-4 million tons from the Piedmont.

From " Craven, 1925. Soil exhaustion as a factor in the agricultural history of Virginia and Maryland, 1606-1860".p.28

http://d.lib.ncsu.edu/collections/catalog?f[location_facet][]=North+Carolina&page=140

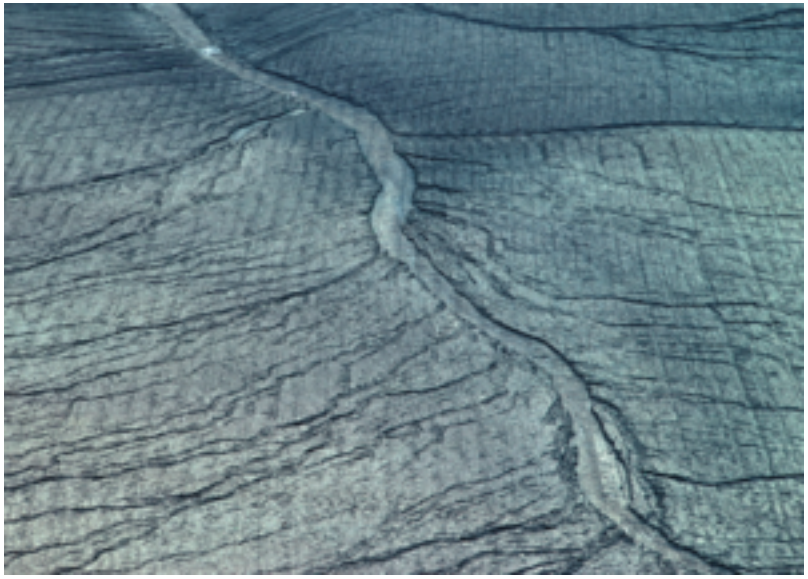
Devastation in the South

- In the South soil degradation in continuous cotton took its toll – as a result 1000s of miles of gullies ran through the South.
- In the Southern Piedmont average soil erosion was estimated at 7 inches.
- Unproductive soil reverted back to brush, grassland, or pine plantations as cotton moved west.

Severely eroded Alabama farm. Courtesy USDA-NRCS, 1937.

Soil Mining in The Midwest

- In the Midwest, erosion took its toll and soil organic matter content was mined – the Morrow Plots, IL show that in 50 years up to 46,000 lbs/A of soil carbon was lost from organic matter, releasing 3300 lbs of N, 400 lbs of P, and 400 lbs of S. Soils eroded but effects noticeable only after many decades or centuries.



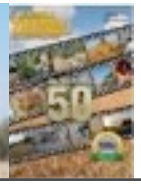
NRCS Image Gallery picture NRCSIA99124

Devastation in the Plains

- 60% of farmers in northern Plains went bankrupt between 1925-31
- 2.5 million people moved out of Plain States after Dust Bowl years (1930-36).
- In the Palouse 10% of land lost all topsoil, and 60% of the land lost ¼-¾ of the topsoil.

http://www.drought.unl.edu/kids/impacts/1934.htm



How to To Become Husbandmen

- Our mindset is our first need!
- Soil degradation remains a threat of national proportions
- The buffer of virgin land is gone
- The demands from the land will increase
- Shallow or deep tillage combined with 'one crop agriculture' were at the base of the problem

Dust storm, TX Panhandle, Dec 19, 2012
Courtesy Ray Archuleta

Mudrain, Arkansas, Dec 2012
Courtesy Greg Roth

How to To Become Husbandmen

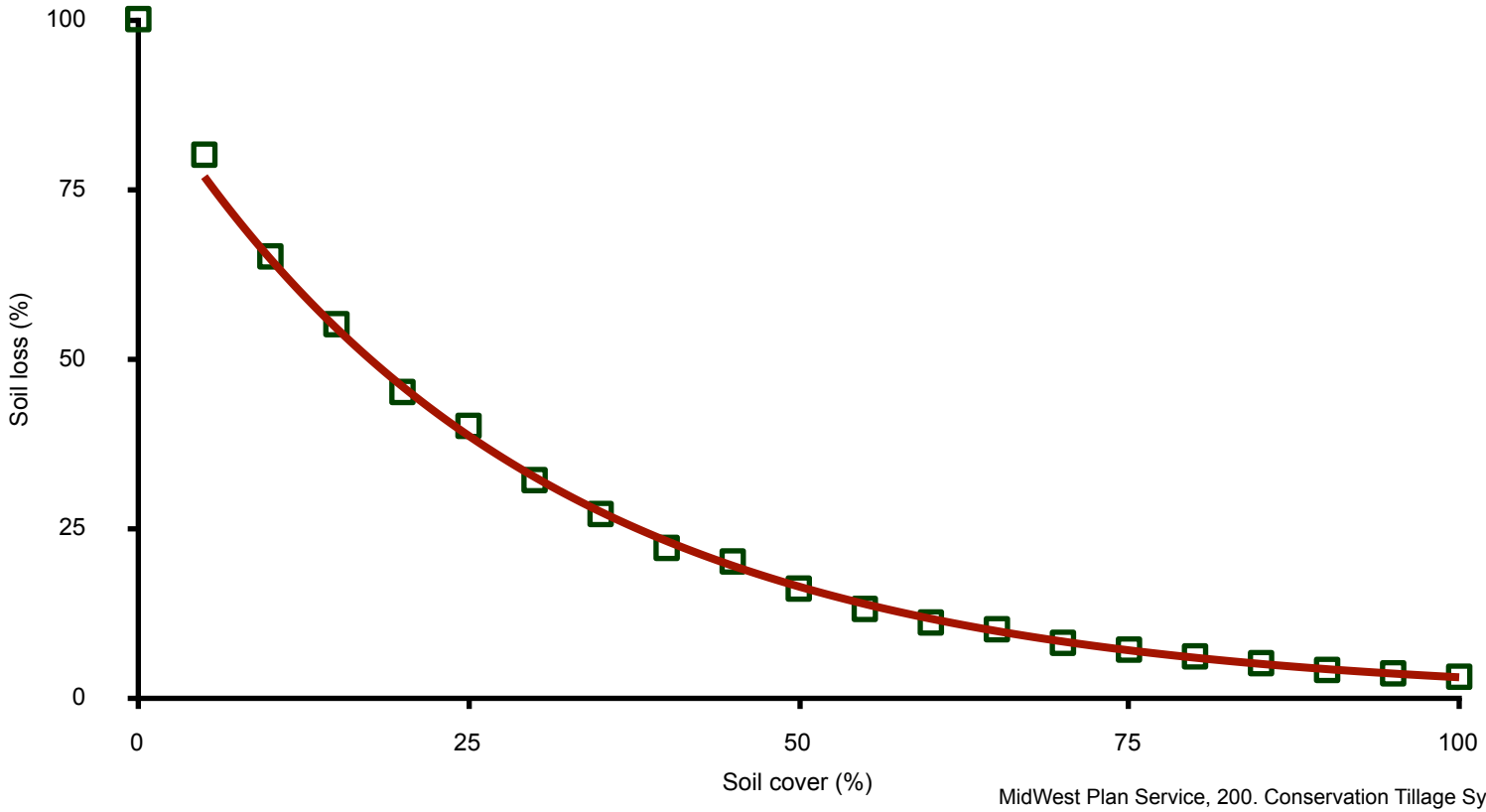
How to To Become Husbandmen

- ✓ Eliminate the tillage conundrum:
  - ✓ Limit soil movement to eliminate tillage erosion
  - ✓ Mulch cover to control water/wind erosion
  - ✓ Mulch to increase infiltration/reduce evaporation

How to To Become Husbandmen

- ✓ Eliminate the tillage conundrum:
  - ✓ Limit soil movement to eliminate tillage erosion
  - ✓ Mulch cover to control water/wind erosion
  - ✓ Mulch to increase infiltration/reduce evaporation
- ✓ Eliminate 'one-crop agriculture':
  - ✓ Organic mulch and continuous living root systems to favor soil biological activity and profile modification
  - ✓ Diverse crop rotations to help improve soil, manage nutrients, weeds, pests and diseases.

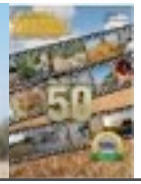
Mulch Cover for Erosion Control



MidWest Plan Service, 200. Conservation Tillage Systems and Manageme

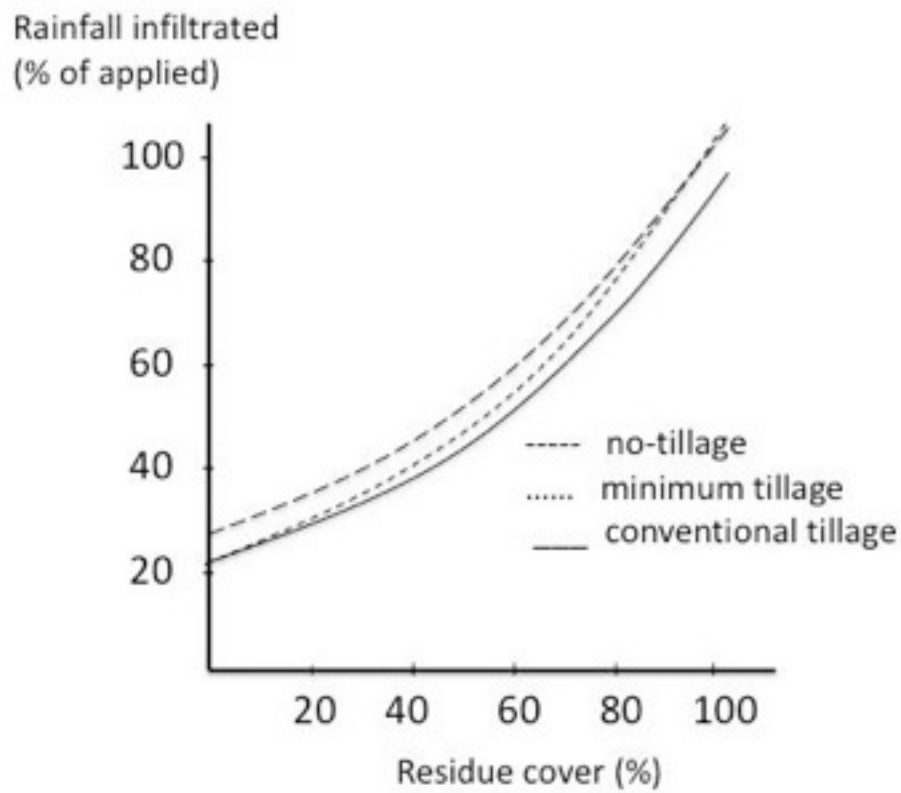

Chisel/Disk
No-Till
Our Challenge : How to Maintain Enough Residue!
Zone-Till
Moldboard

Tillage in Rotation Decreases Residue Levels



High Mulch Cover for Increased Infiltration

More than 70% cover results in greatly increased infiltration



Roth et al., 1988. Effect of mulch rates and tillage systems on infiltrability and other physical properties of an Oxisol in Parana, Brazil. Soil Tillag

High mulch and "0" soil disturbance Effect on avg Annual Runoff (") from Watersheds

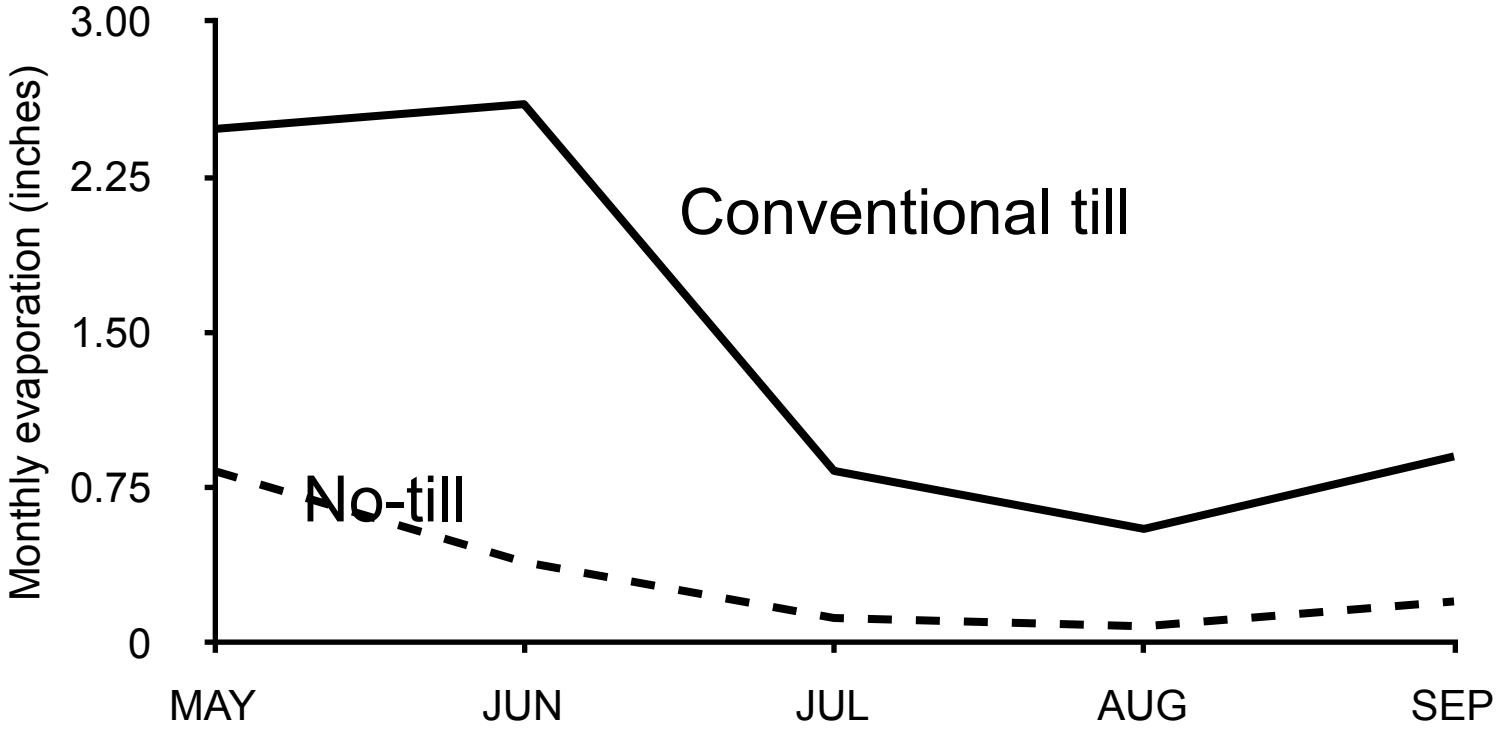
Permanent high-mulch no-till vs bare w. moldboard plow

	No-Till	Conventional Till
1979	0.1	5.5
1980	0.2	12.5
1981	0.0	5.6
1982	0.4	4.4
Average	0.2	7.0
% of precip	0%	16%

Shipitalo and Edwards, 1998. Runoff and erosion control with conservation tillage and reduced-input practices on cropped watersheds. Soil Tillage Res 46:1-12

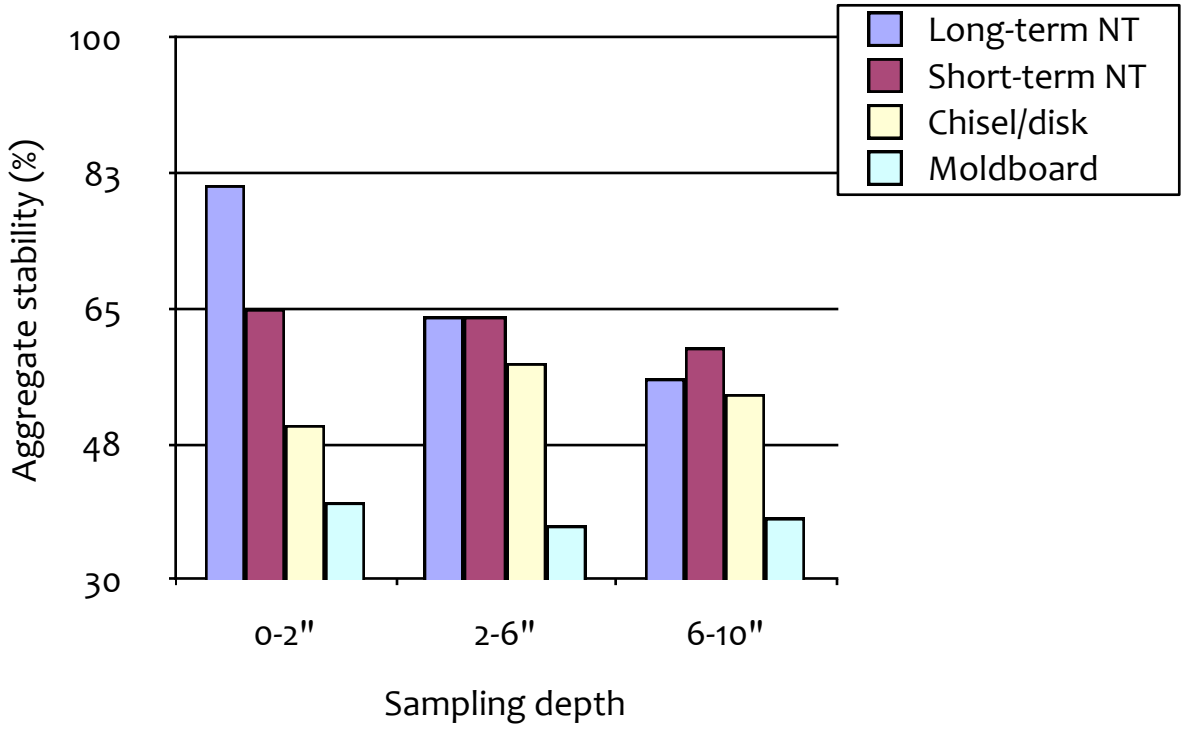
Coshocton, OH, no till was on 9% slope, conventional till on 6% slope. Average rainfall 42 inches

High Mulch Cover for Evaporation Reduction



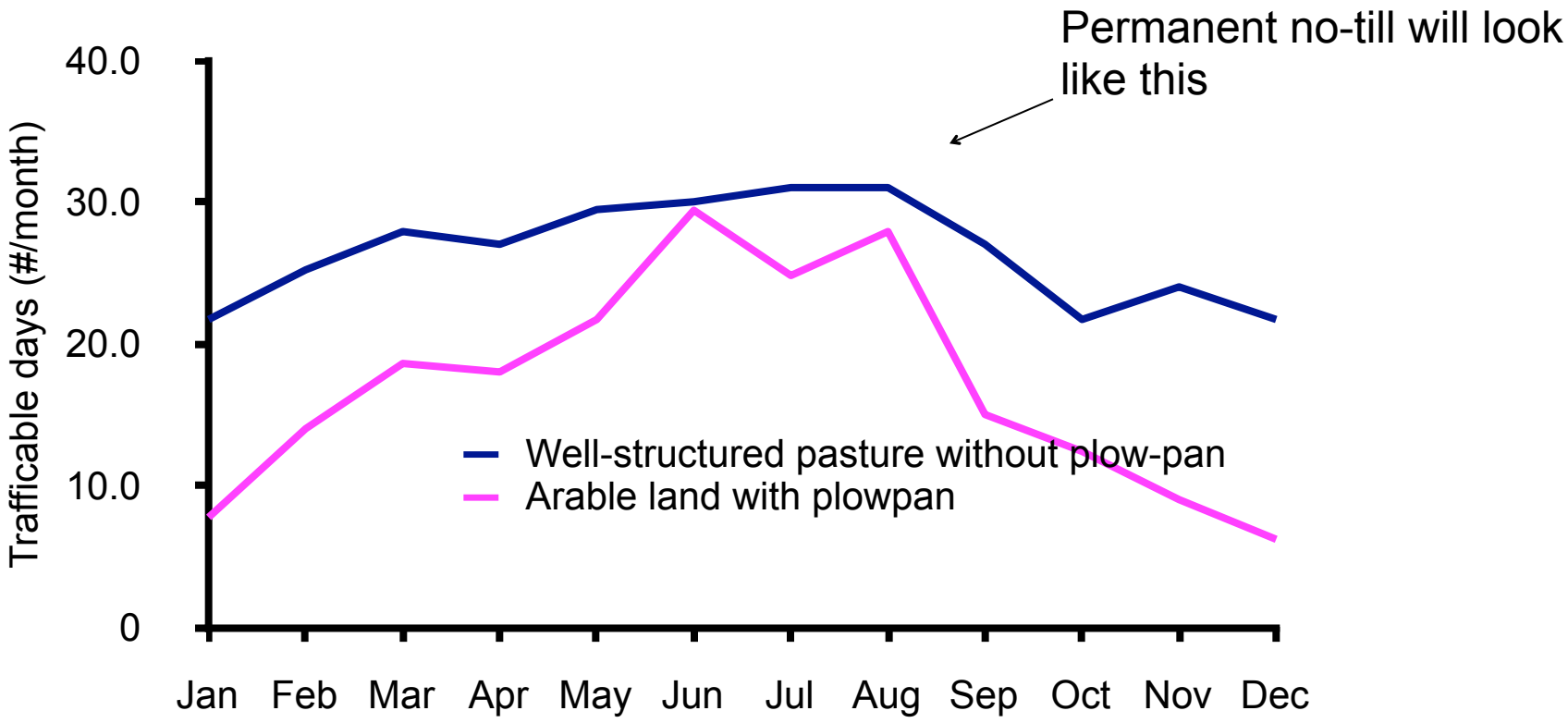
Phillips,1984. Soil moisture. P.66-86 in 'No-Tillage Agriculture'. Van Nostrand and Reinhold, New York.

Permanent No-Till for Improved Surface Aggregation

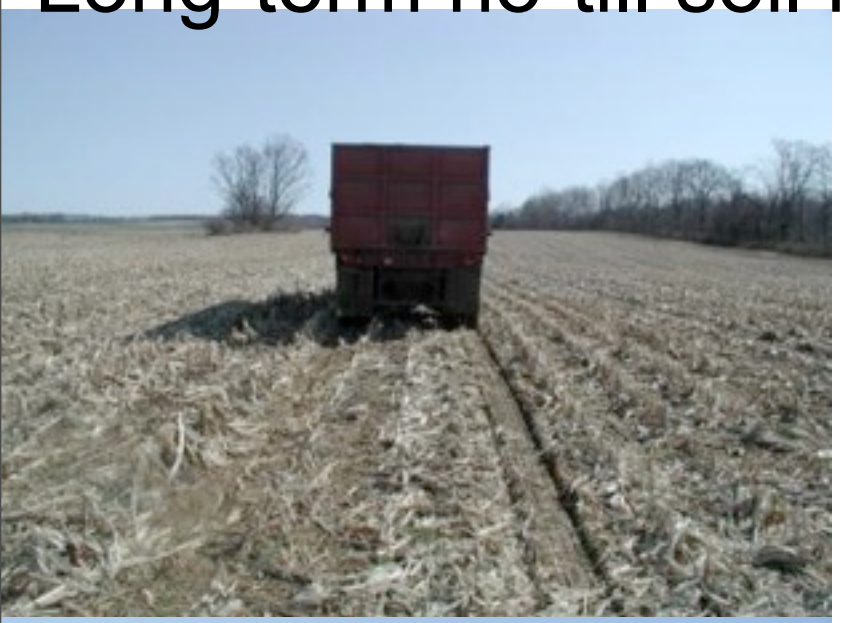


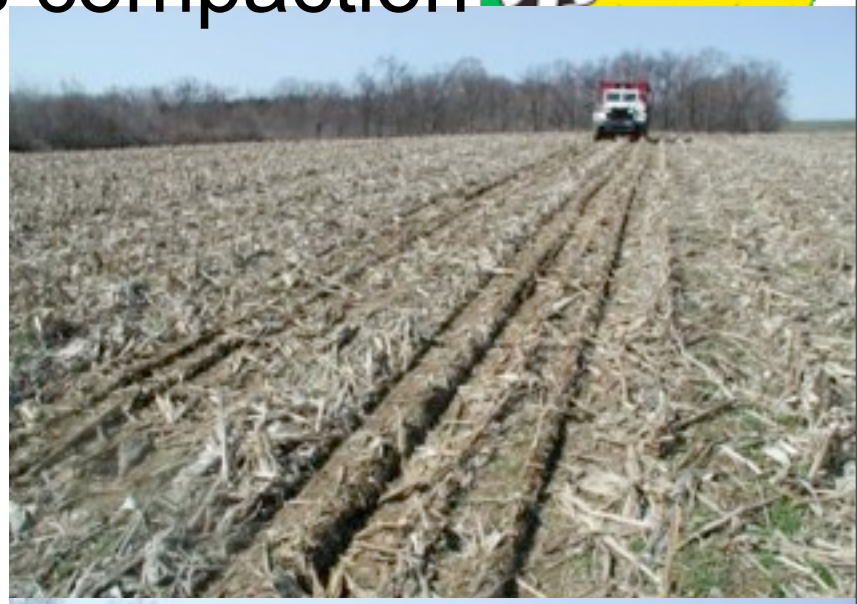
Data from long-term tillage study, Penn State University

Permanent No-Till for Improved Trafficability

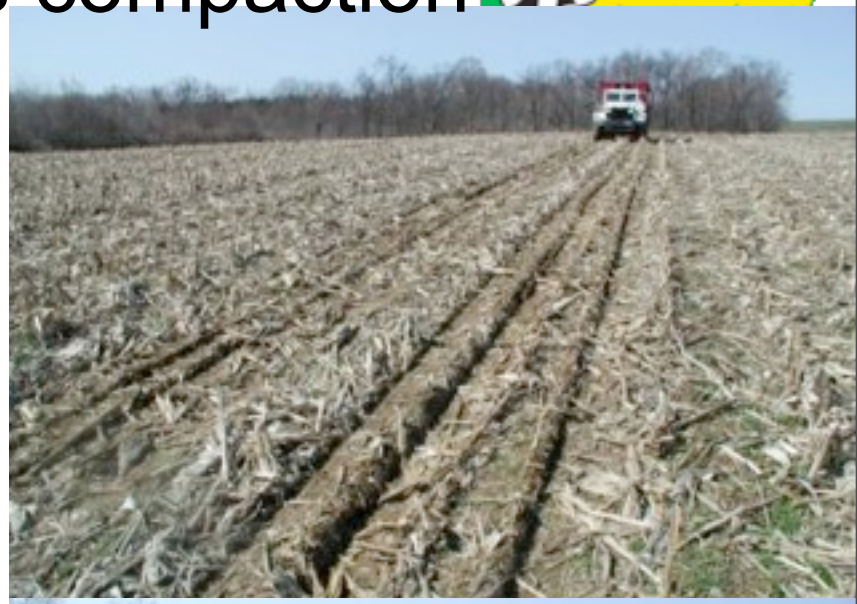


Long-term no-till soil resists compaction

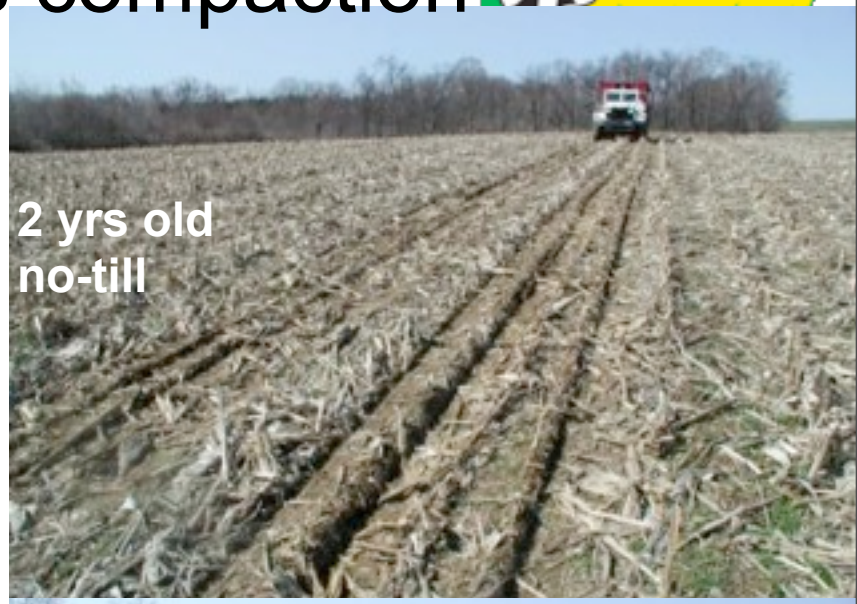




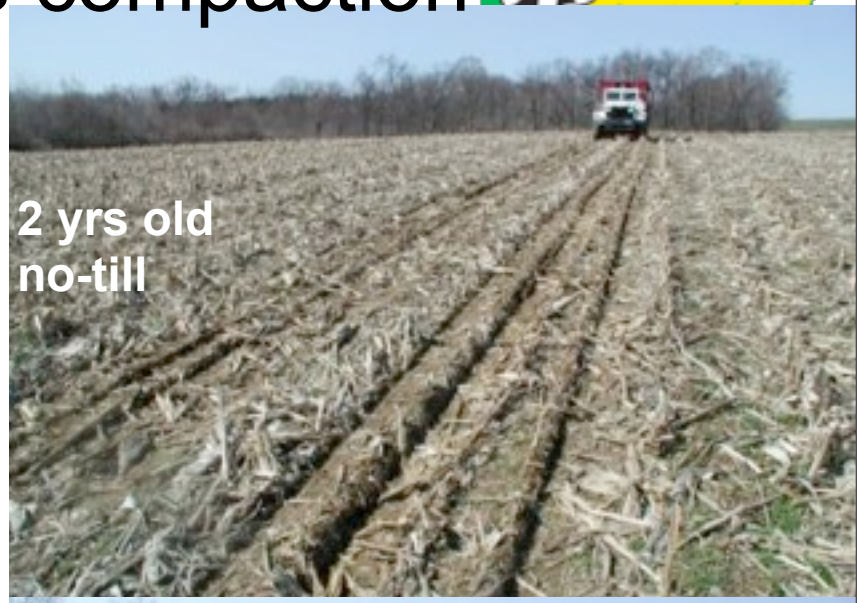
Long-term no-till soil resists compaction



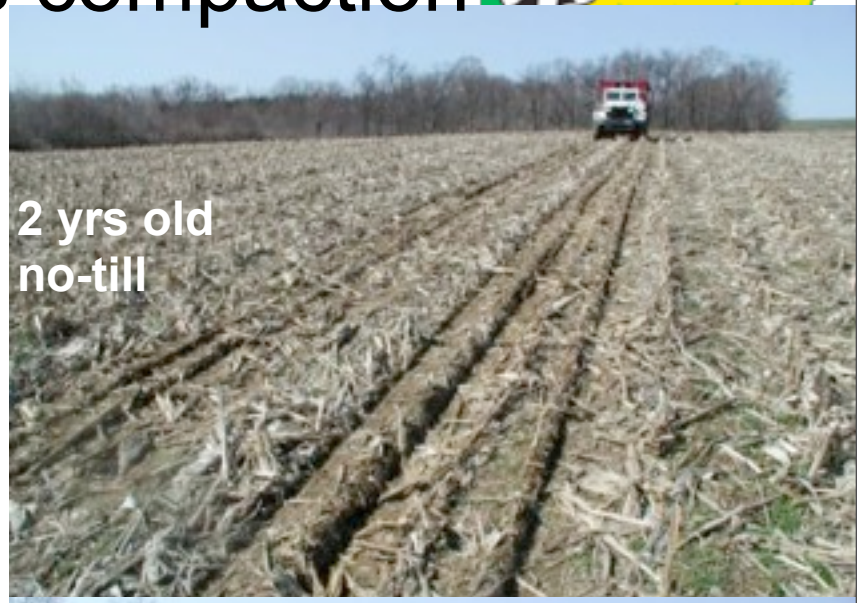
Long-term no-till soil resists compaction



Long-term no-till soil resists compaction



Long-term no-till soil resists compaction



Long-Term No-Till and Diversity to Improve Earthworm Populations

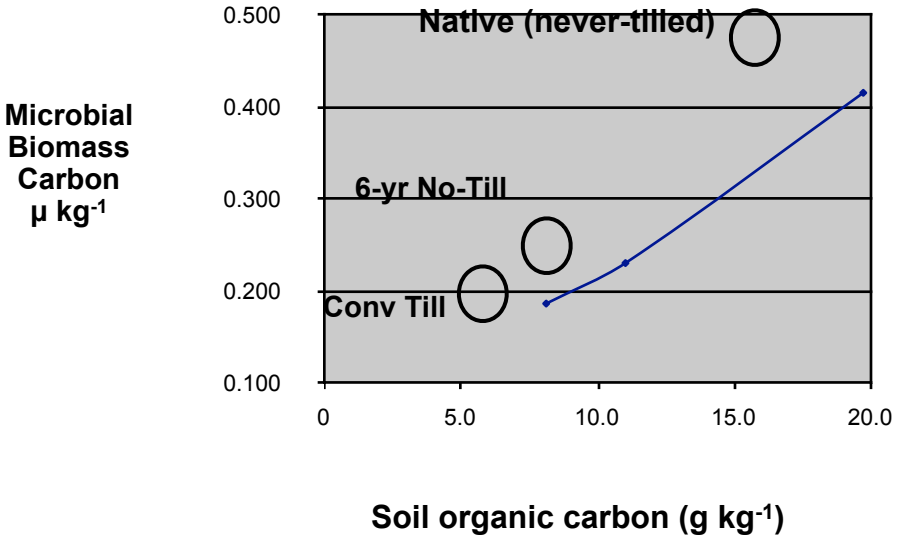
	No-Till	Plow
Cont.Corn	75,000	40,000
Cont. Soybean	500,000	230,000
Clover/Ryegrass	2,000,000	
Pasture+manure	5,000,000	

Data from Indiana
Crop and management systems continuous for at least 10 years

Kladivko. Earthworms and crop management. AY 279, Purdue University.

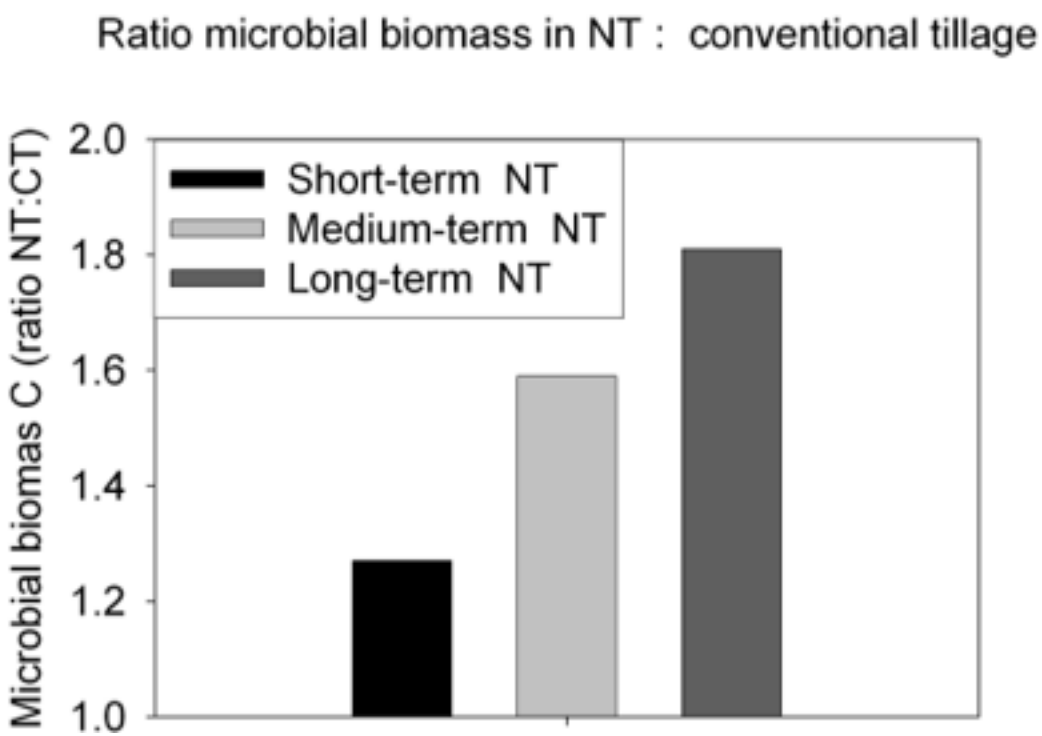
Permanent No-Till to Build Humus and Stimulate Microbial Life

Data from Long-Term Ecological Research, MI



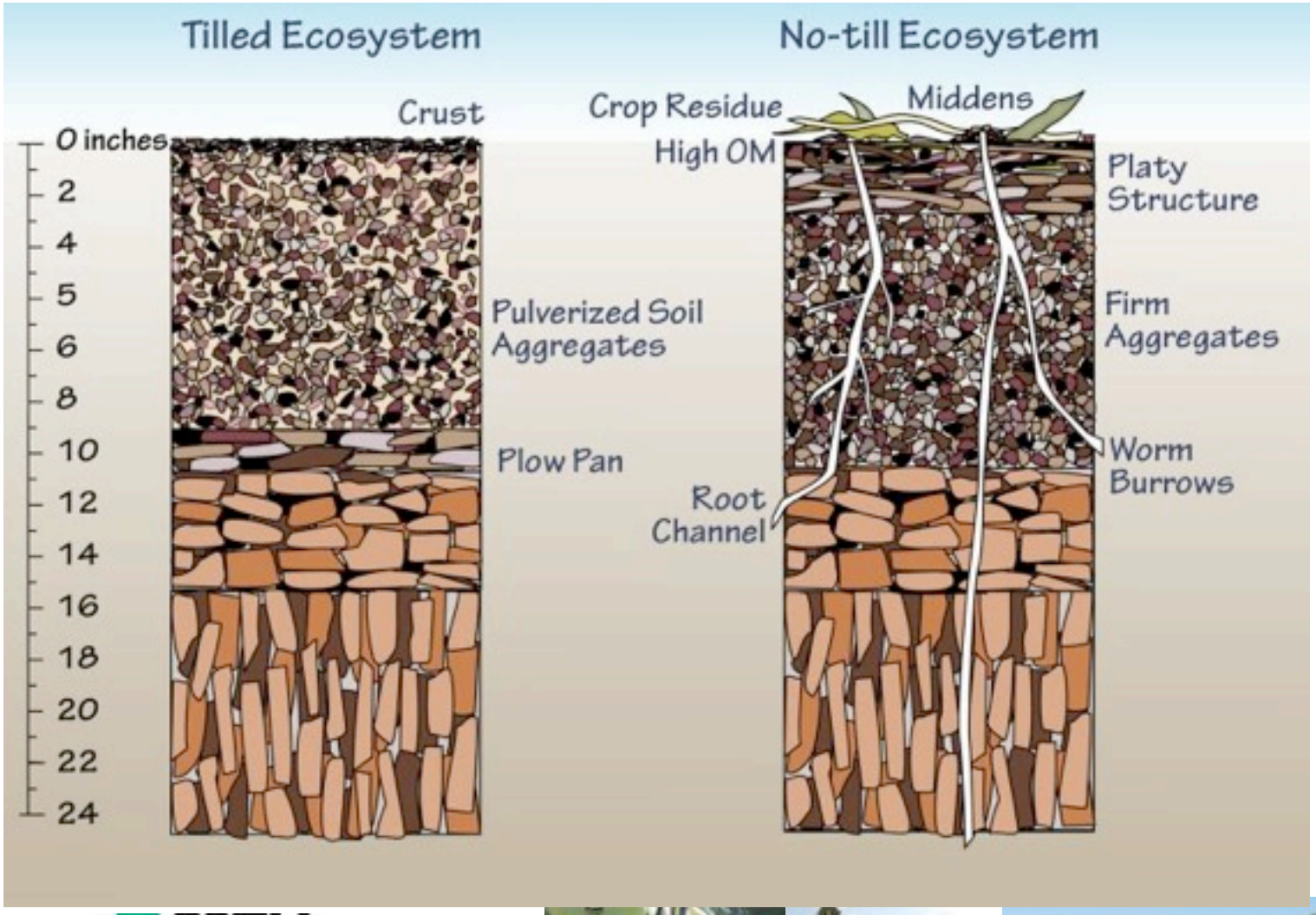
1994-1995 data from Long-Term Ecological Research in Row Crop Agriculture http://lter.kbs.msu.edu/

Permanent No-Till to Stimulate Microbial Activity

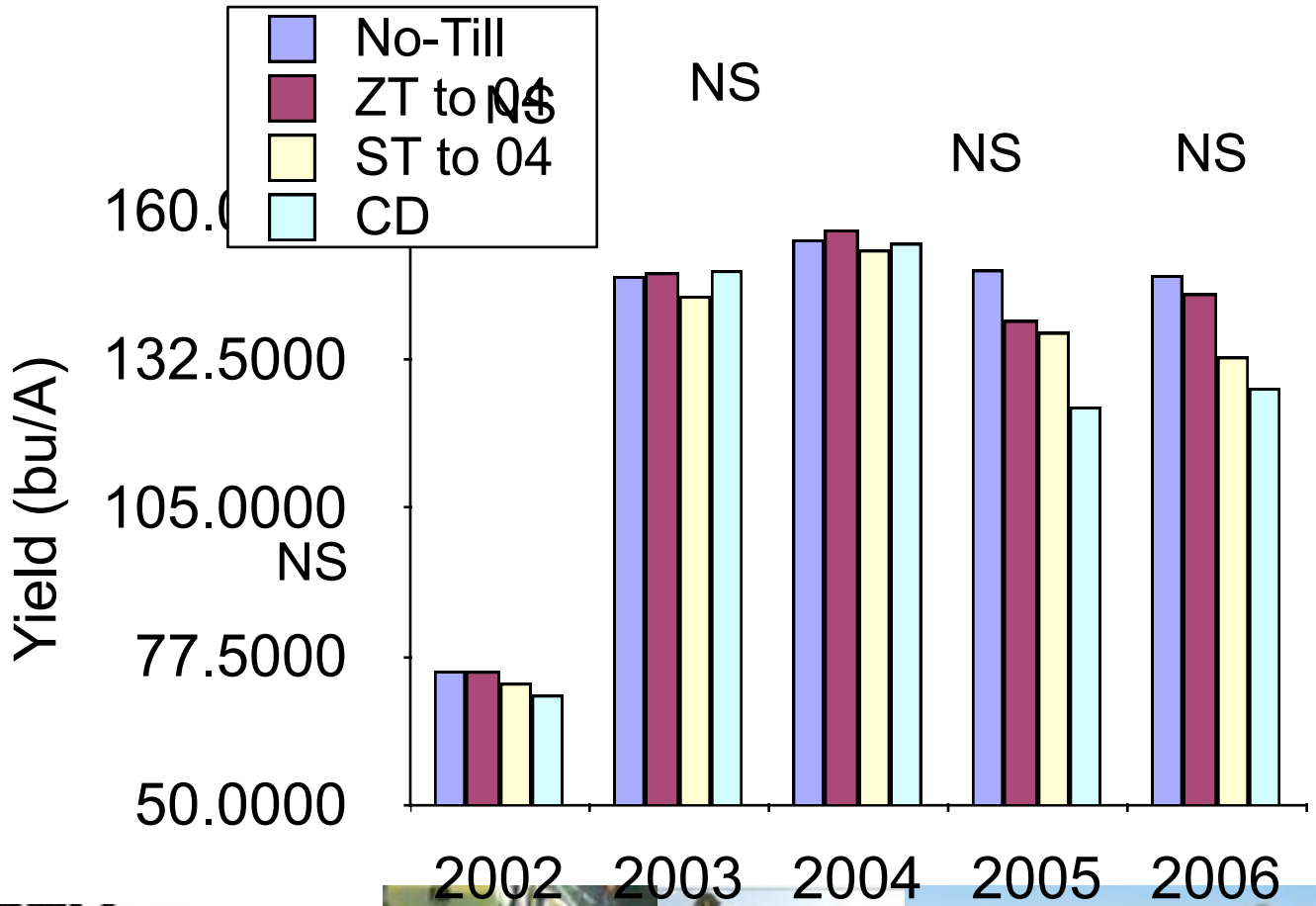


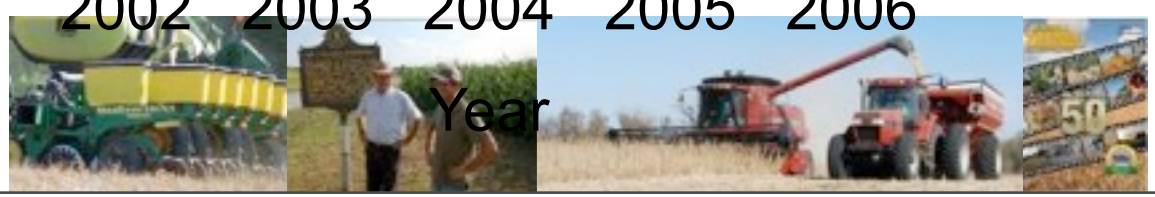
Andrade, D.S., Colizzi-Filho, A., and Giller, K.E. (2003) The soil microbial community and soil tillage. In: El Titi, A. (Ed.) Soil tillage in agroecosystems. CRC Press, Boca Raton, FL, pp. 51-81.

Profile Modification with Continuous No-Till

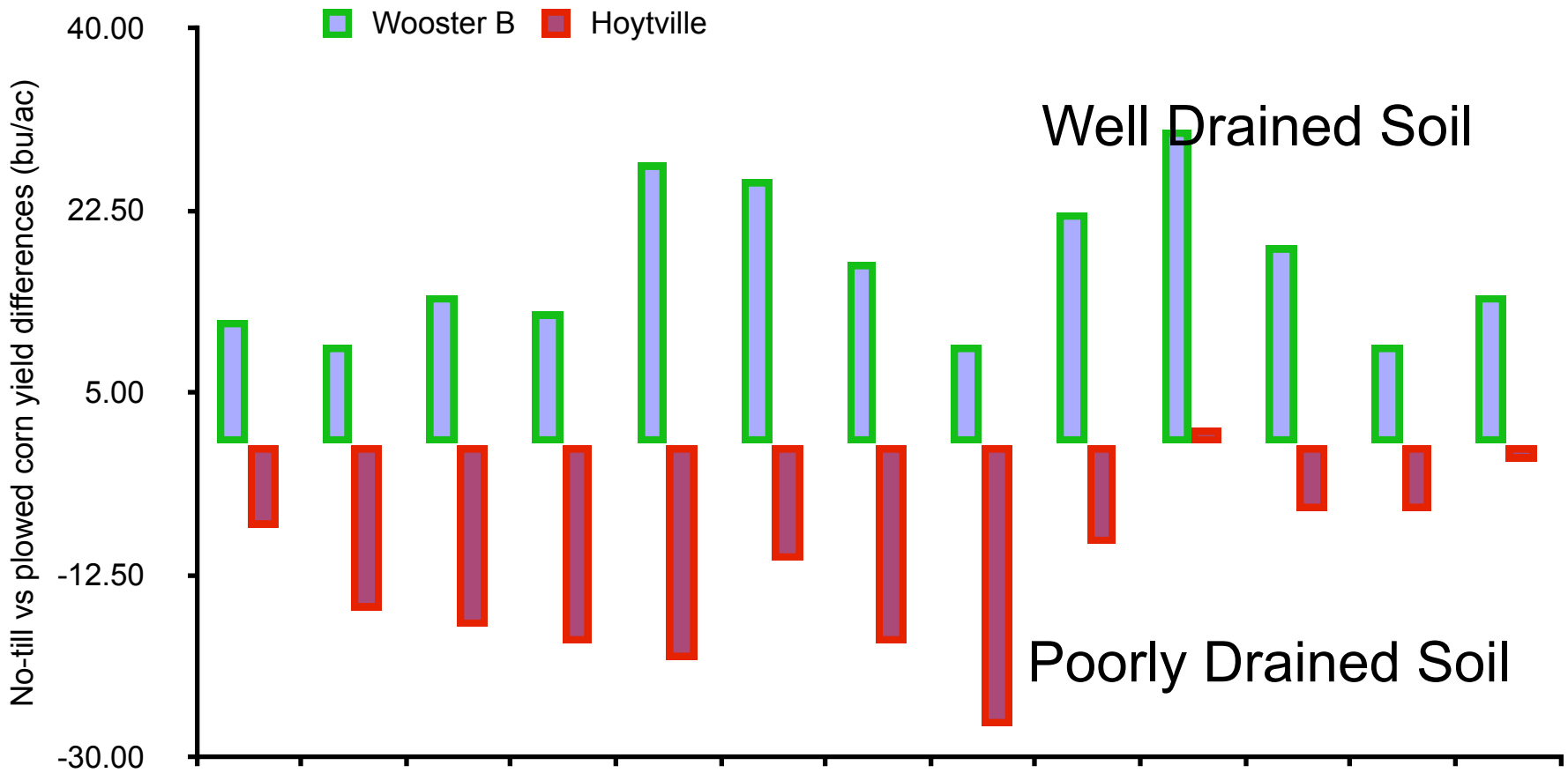


Are Corn Yields Reduced in Long-Term, Continuous No-Tillage?
Tillage effects on corn yields Landisville, southeast PA





Corn Yields in Continuous No-Till Improve on Poorly Drained Soil



Crop rotation to Improve No-Till Performance in Poorly Drained Soils

	No-Till	Conv.Till
Continuous Corn	112	125
Corn-Soybean	129	129
Corn/Soy/Meadow	127	133

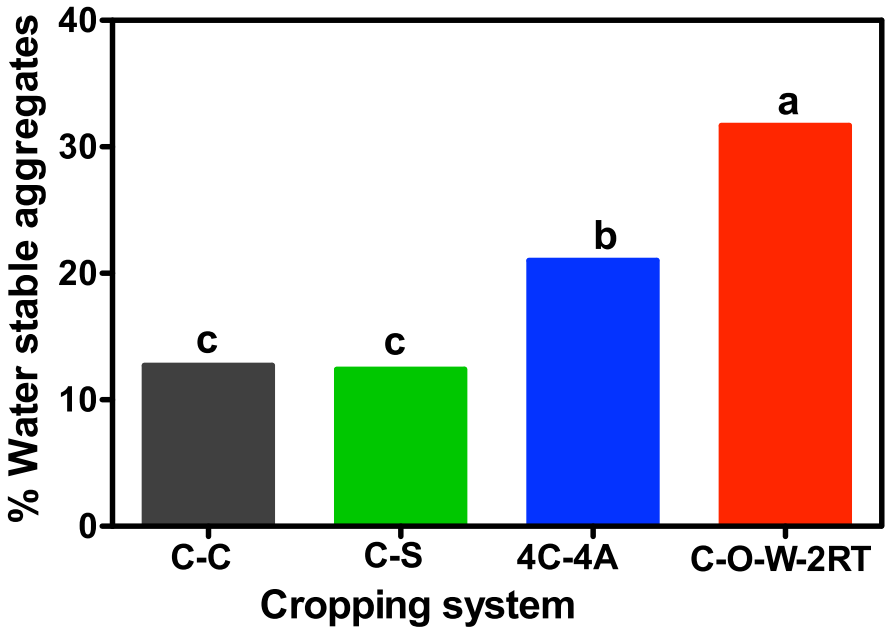
20-yr average corn yields (Bu/A) on a poorly drained Hoytville sicl, Ohio

Crop Rotations to help You Become a Continuous No-Tiller

- To reduce risk of weather and price fluctuations
- To reduce fallow periods
- To reduce need for fertilizer
- To reduce the build-up of pests – weeds, diseases
- To reduce reliance on agricultural chemicals
- To spread the workload
- To improve yields

Crop rotations to improve soil structure

Soil aggregate stability for four cropping systems under inorganic fertility of Hunter Rotation Experiment (1990)



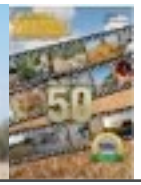
Grover, 2008. Long-term cropping systems effects on soil aggregate stability, corn grain yields, and yield stability. PhD thesis., The Pennsylvania

Crop Rotation Improves Disease Control

Disease	Major Crops Attacked[1]	Best Control Methods
Common root rot	wheat, barley, grasses	Rotation, seed trt.
Ergot	rye, wheat, grasses	Rotation, tillage
Bacterial blights	wheat, barley, grasses, rye	Rotation
Scab	wheat, barley, corn, rye	Rotation
Tan spot	wheat, durum	Rotation, fungicide
Net blotch	barley	Rotation, fungicide
Septoria (different species)	wheat, barley	Rotation, fungicide
Pasmo	flax	Rotation, variety
Wilt (flax)	flax	Rotation, variety
Rust (flax)	flax	Resistant Variety, rotation
Seedling blight	wheat, barley, corn, oats, rye	Seed treatment
Smut (corn)	corn	Rotation
Bacterial wilt	alfalfa	Variety resistance
Crown rot	alfalfa	Variety resistance
Verticillium wilt	potato, sunflower, safflower	Rotation, variety
Rust (sunflower)	sunflower	Variety, rotation
Sclerotinia (white mold)	sunflower, dry beans safflower,	Rotation 4 to 5 years
	soybean, potato, canola	
Phoma	sunflower	Rotation

www.ag.ndsu.edu/pubs/plantsci/crops/eb48-1.htm



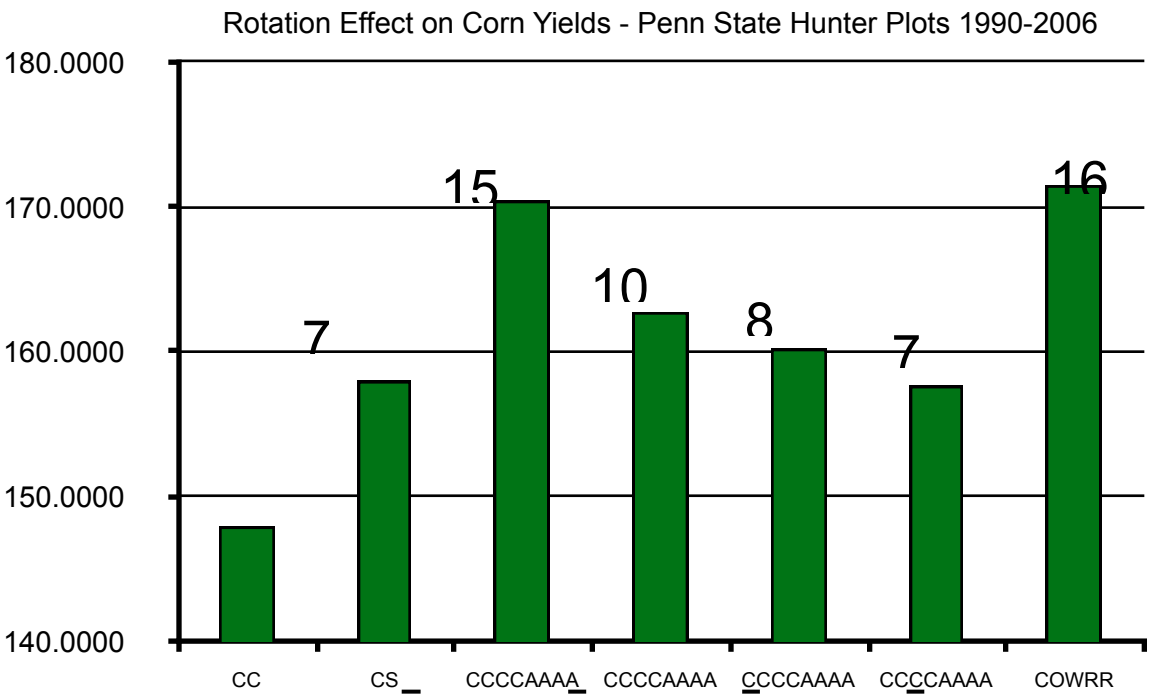
Crop Rotation for Weed Control

Varying patterns of:

- Resource competition
- Allelopathic interference
- Herbicide application timings
- Herbicide modes of action
- Cultural practices (e.g. mowing)

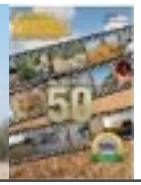
Adapted from Liebman and Dyck, 1993

Crop Rotation Improves Yield



C=Corn S=Soybean A=Alfalfa O=Oats W=Wheat R=Red clover/grass

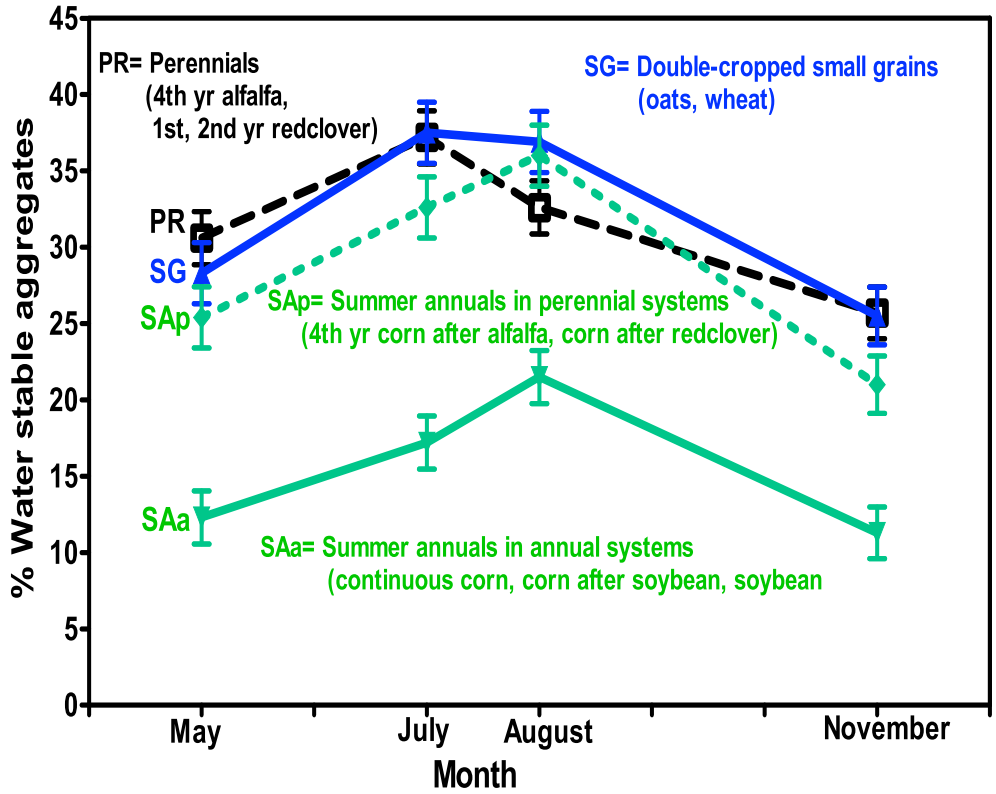


Cover Crops to Help You Become a Continuous No-Tiller

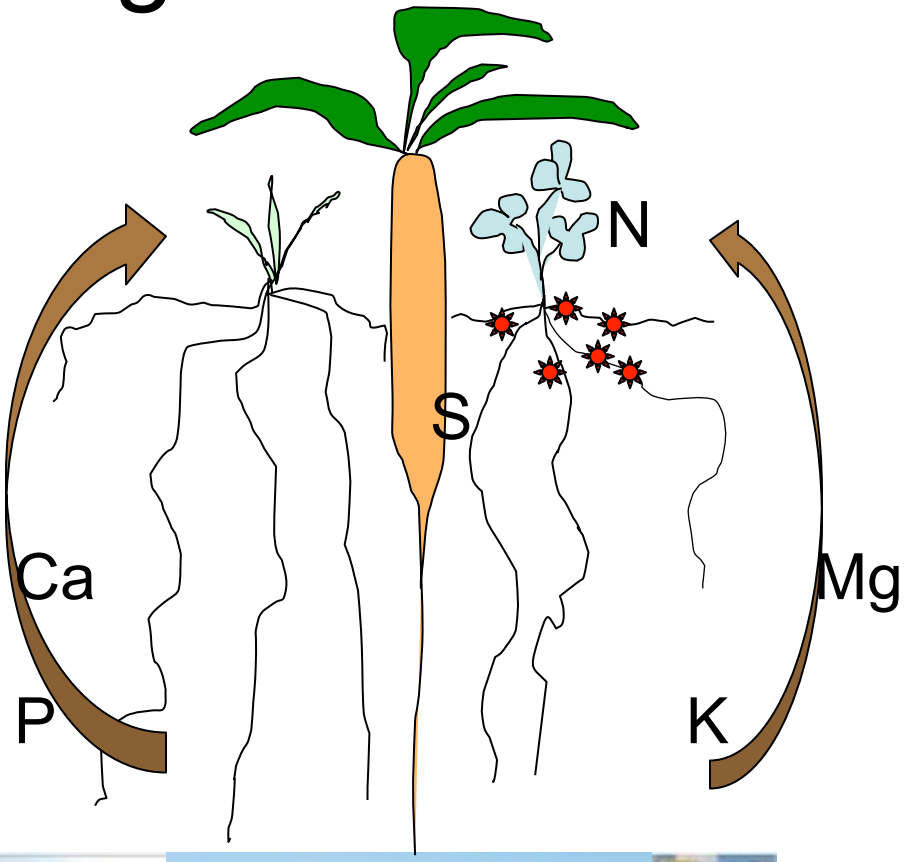
- Maintain and improve soil structure
- Absorb and retain (recycle) nutrients
- Fix atmospheric N
- Maintain and improve organic matter content
- Provide weed control
- Provide forage

Cover Crops to Improve Soil Structure

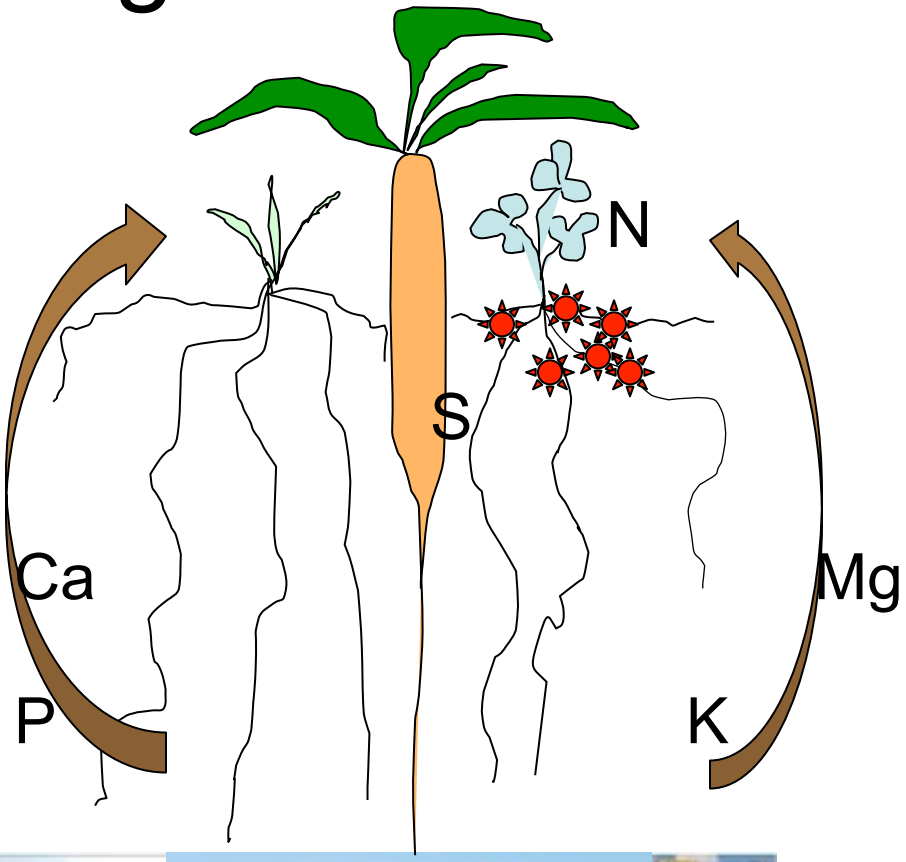


Grover, 2008. Long-term cropping systems effects on soil aggregate stability, corn grain yields, and yield stability. PhD thesis., The Pennsylvania State University

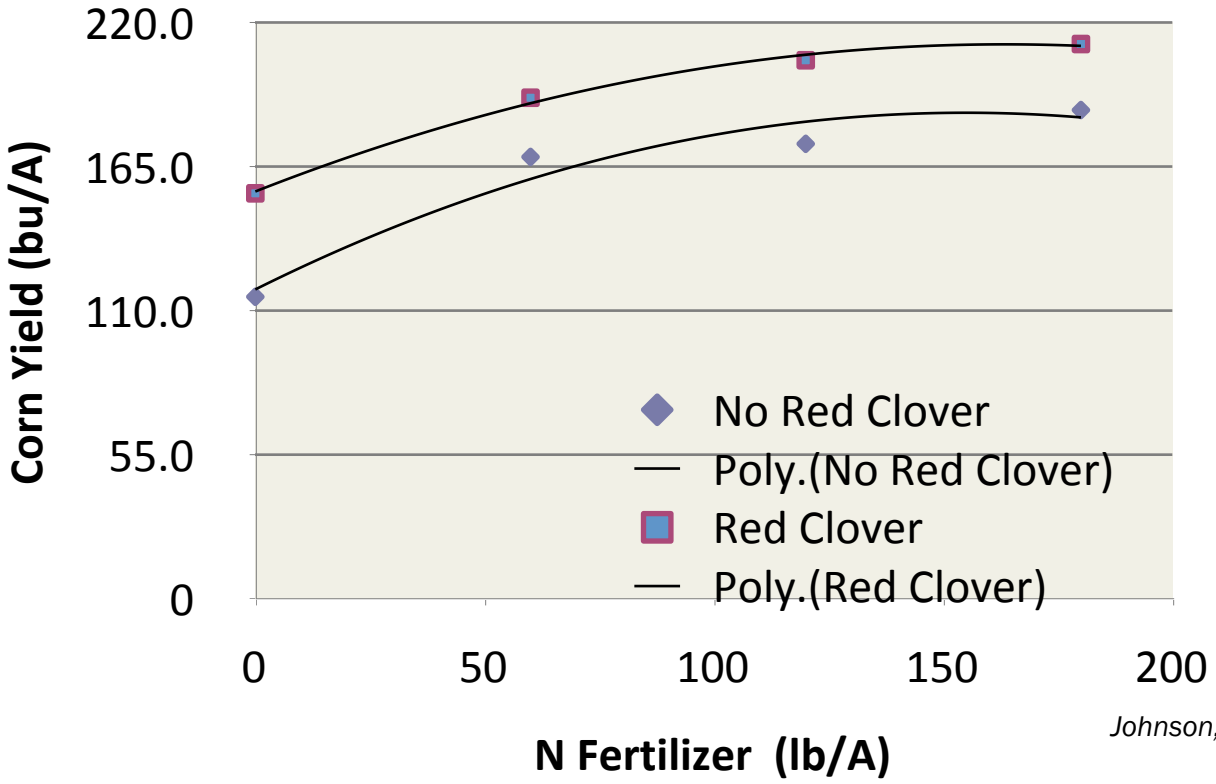
Cover Crops for Nutrient Fixation, Liberation and Recycling



Cover Crops for Nutrient Fixation, Liberation and Recycling



Clover Cover Crop Benefits



SE Pennsylvania, 2007

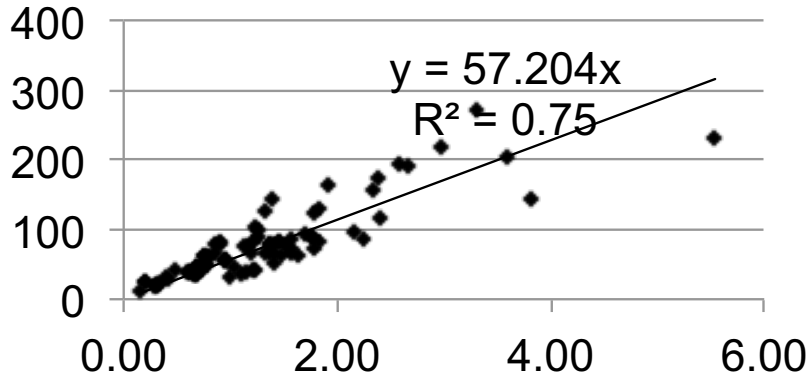
Note: ~30 bu/A higher yield with Red Clover regardless of N applied

Johnson, PSU

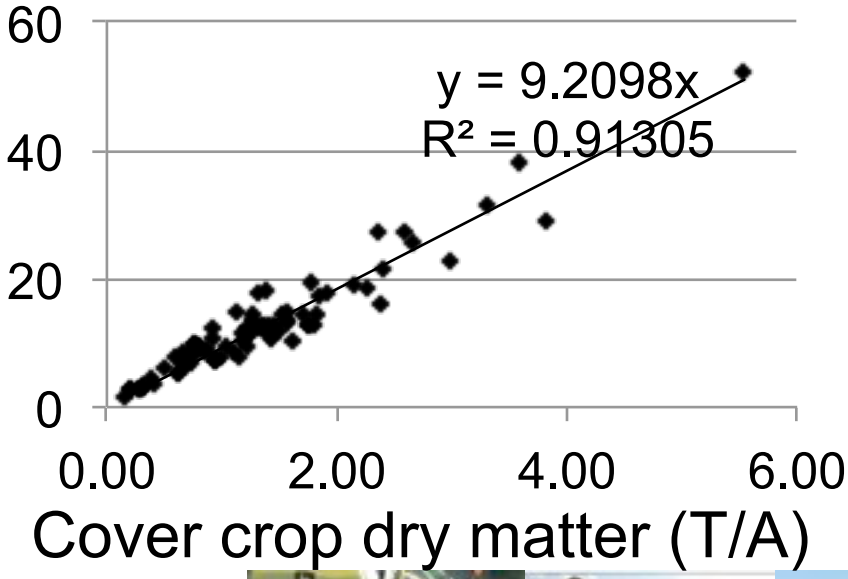
Clover frost seeded into wheat the previous year with no clover harvest, corn no-till in clover residue

Nutrient recycling with cover crops

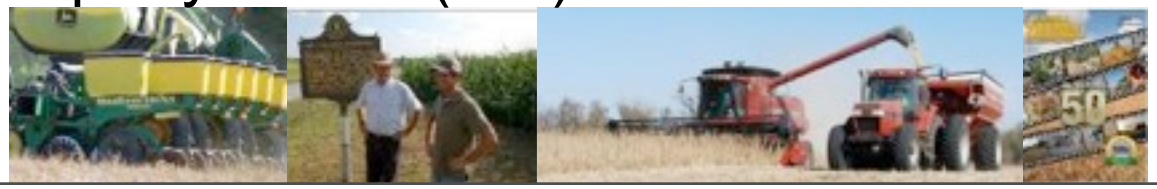
Rye cover crop N content (lbs/A) in spring



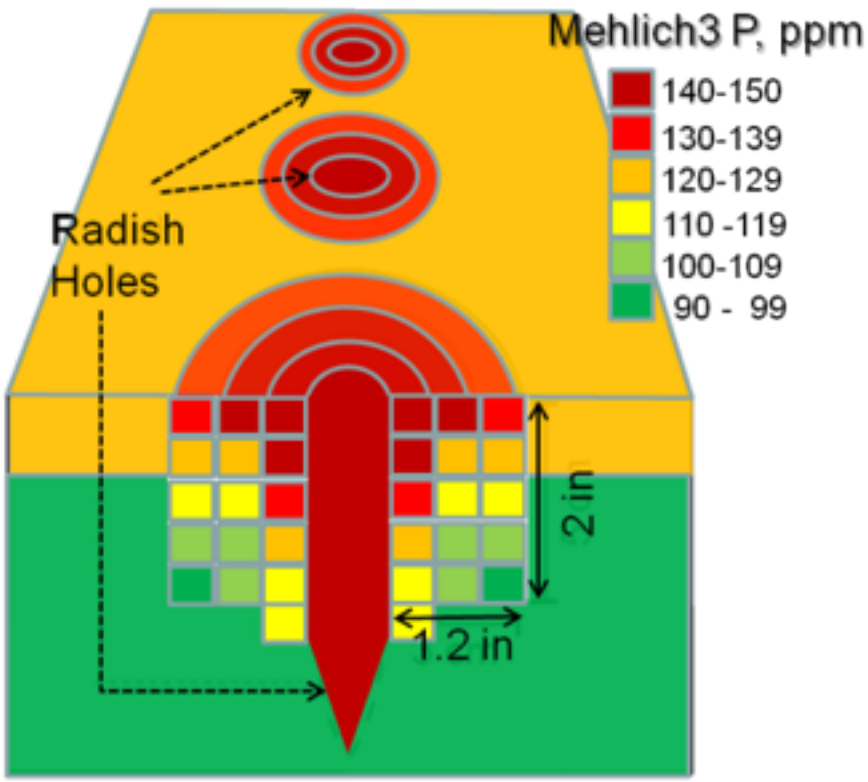
P content (lbs/A)



Courtesy Doug Beegle, On-farm research 2007-2009



Cover Crops for Biological P "Banding"



(White and Weil, 2011)

How to Help Yourself to Become a Continuous No-Tiller

1. Realize its importance
2. Realize its benefits
3. Move away from 'One-Crop Agriculture' by increasing *rotation diversity*
4. Implement the principle of continuous living cover by plugging the fallow holes
5. Move to greater profitability and sustainability

Let us be Husbandmen!