The Abdus Salam
International Centre
for Theoretical Physics

2444-16

College on Soil Physics - 30th Anniversary (1983-2013)

25 February - 1 March, 2013

Soil management to improve water use efficiency
Part 2

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Winter Rye in March

Courtesy Charlie White

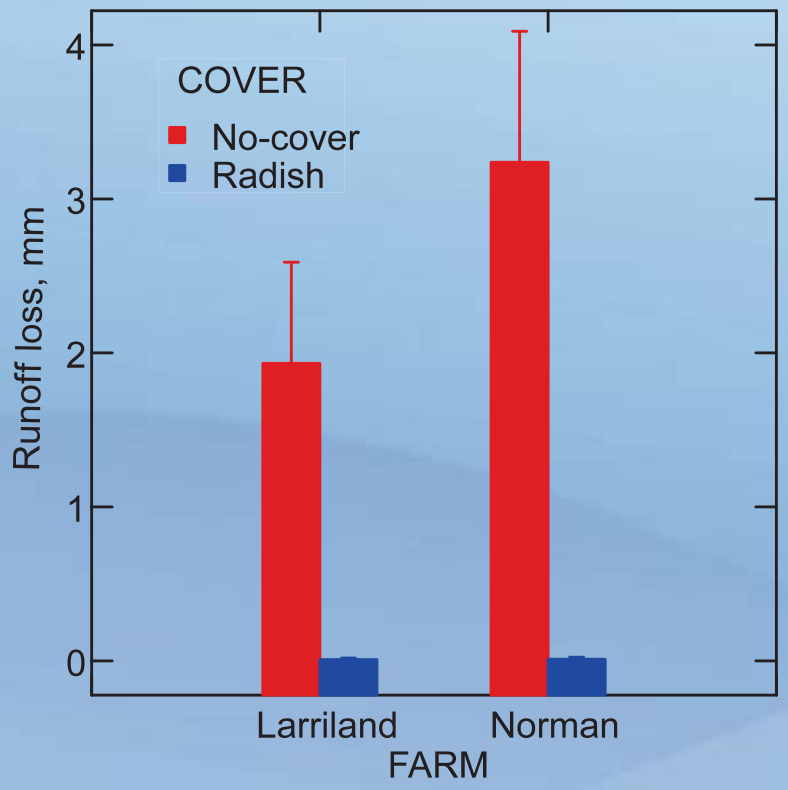
Forage radish in November, Maryland

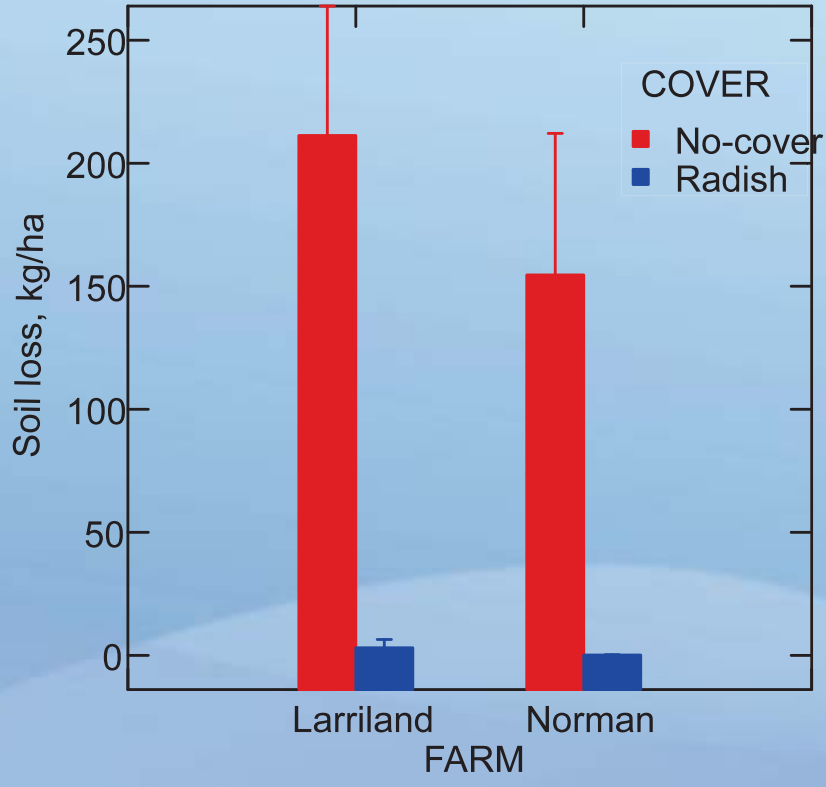
Courtesy Charlie White

Forage radish in May

Forage radish in March after -8 ºC frostkill in January/February

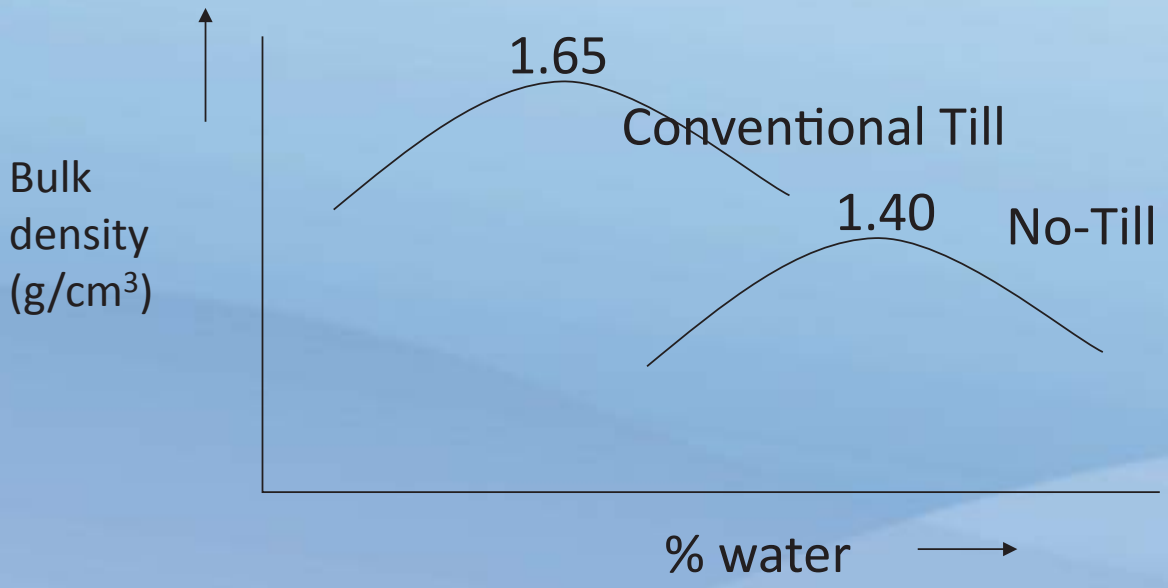
Radish Cover Crop Effect on Runoff and Erosion Losses





Courtesy Charlie White

Organic Matter Decreases Soil Compactability



Top 5 cm, proctor, Thomas et al., 1996

Soil Aggregation

With Plant Cover

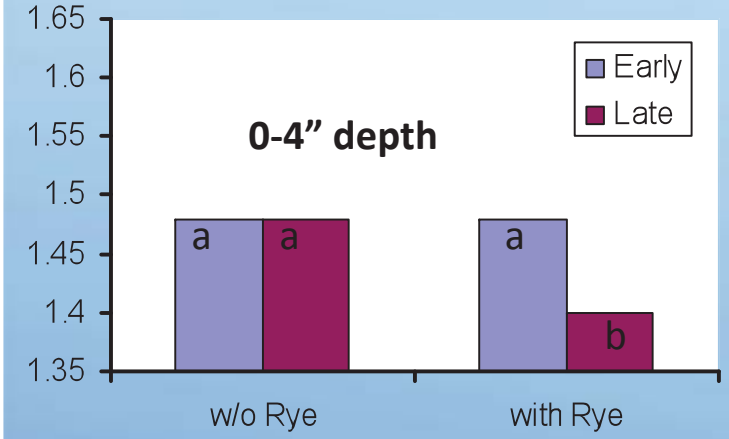
Cover crop treatment	Aggregate stability in surface 2.5 cm in March
No cover crop	60% a
Radish cover crop	73% b
Rye cover crop	85% c

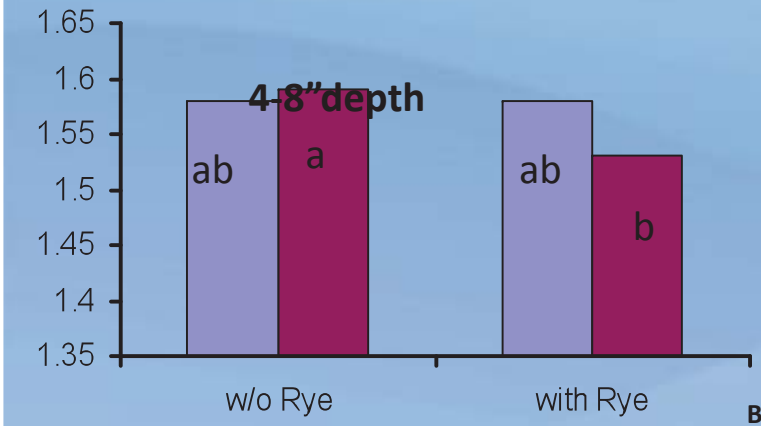
Courtesy Charlie White, means with different letters are significantly different (LSD p<0.05)

Without Plant Cover

Courtesy Charlie White

Cover Crop Effects on Soil Density in Next Crop

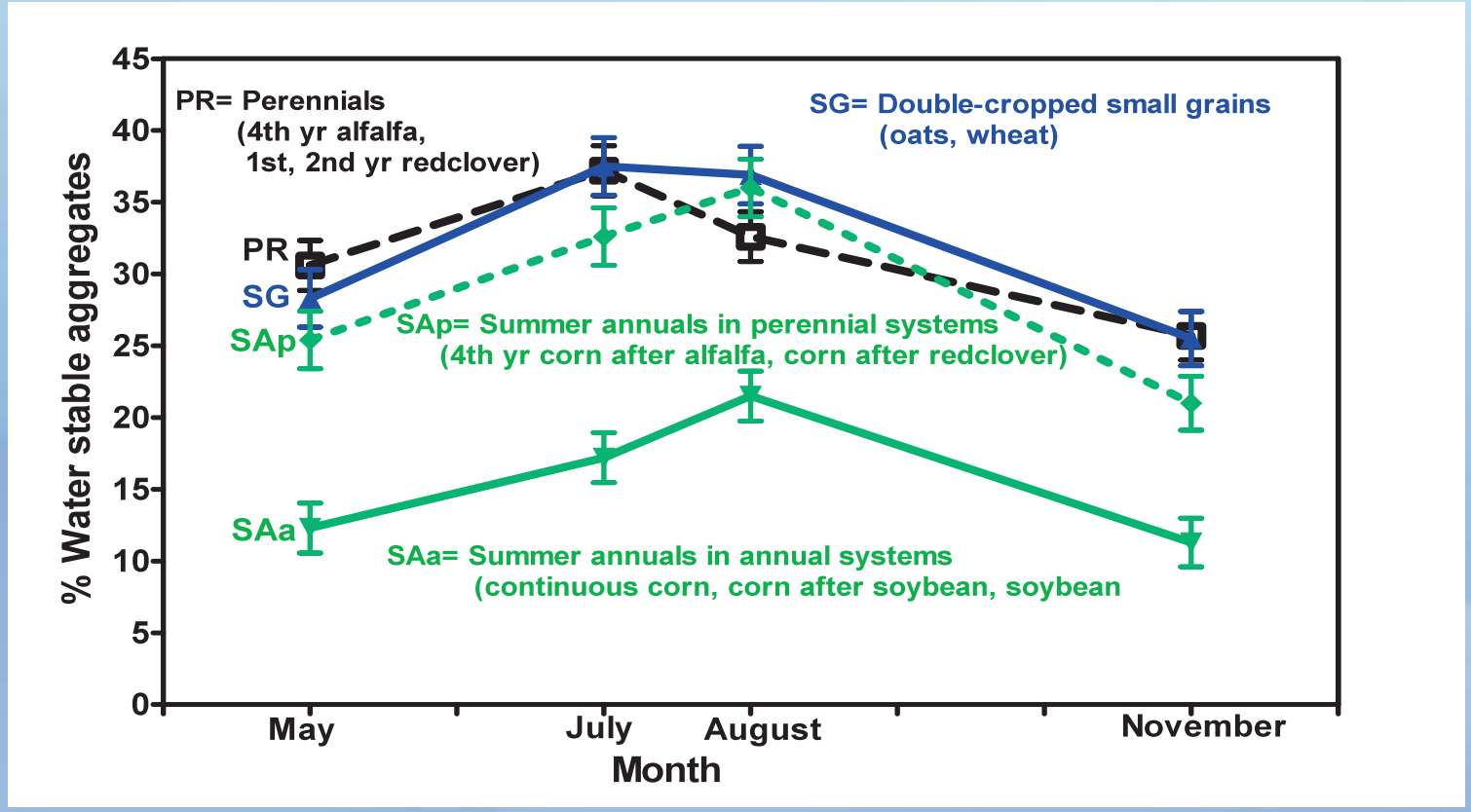




Both samples under manure spreader tracks on dairy farm operation

Rye effect on bulk density (g/cm^3) in following maize crop in summer

Crop Rotations

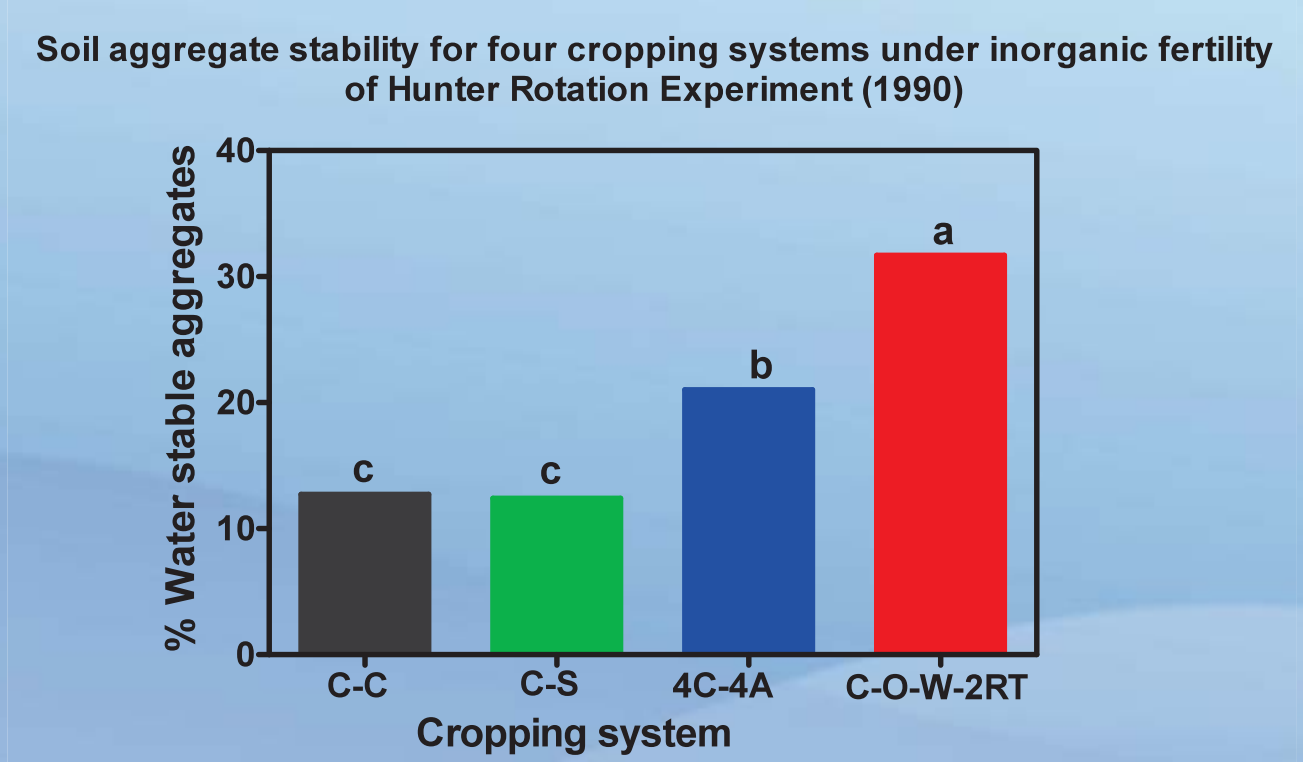


Continuous Living Root Occupation

Alfalfa roots – taproots penetrate subsoil

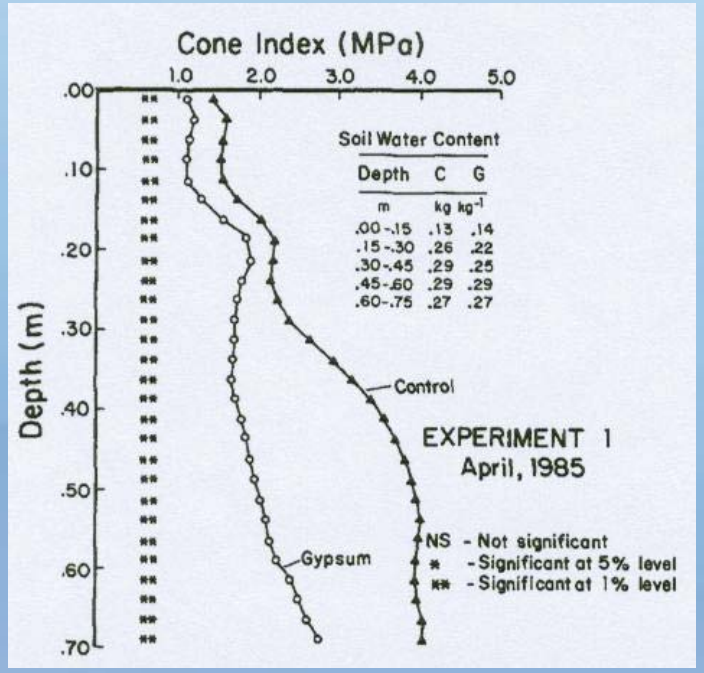
Annual Ryegrass established in standing corn @ N-sidedress

Crop Rotation Effects on Soil Structure



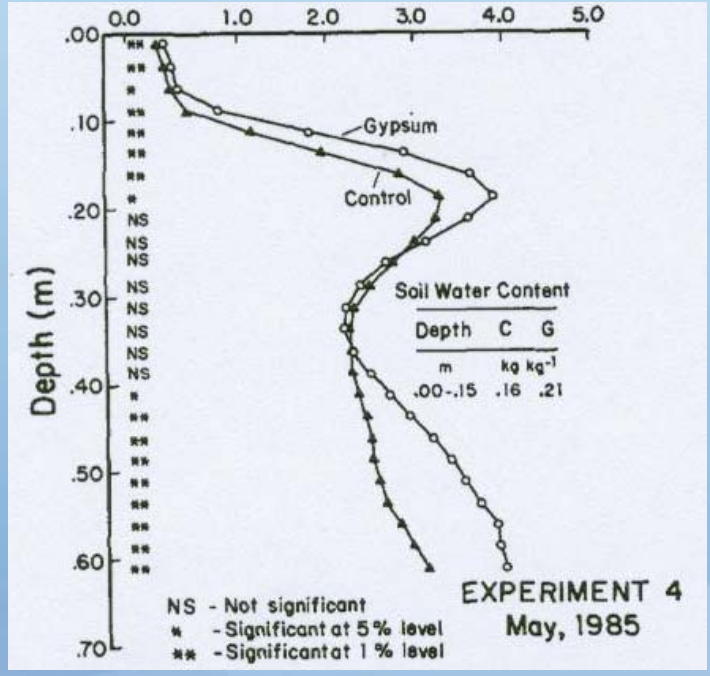
Grover, 2008. Long-term cropping systems effects on soil aggregate stability, corn grain yields, and yield stability. PhD thesis., The Pennsylvania State University

Improve Subsoil Structure Using Deep-Rooting Crops



4-yr old experiment
(soy-soy-corn silage-alfalfa- alfalfa)

ALFALFA ROOTS ABLE TO PENETRATE THE SUBSOIL – CAUSED PENETRATION RESISTANCE TO DECREASE



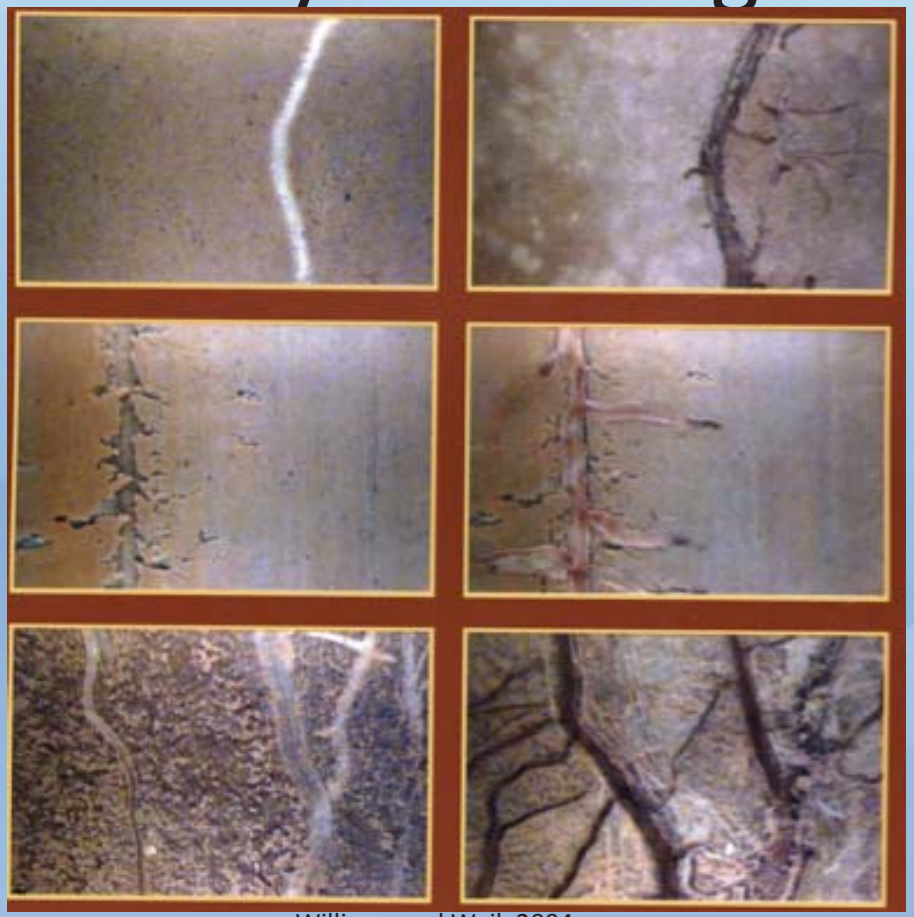
2-yr old experiment (fallow)

GYPSYM ALONE DIDN'T DECREASE PENETRATION RESISTANCE

Radcliffe et al., 1986

Root Channels Created by Cover Crop Used by Following Maize Crop

Canola roots penetrate plow pan in winter when soil is soft



Soybean roots follow root channels created by canola

Williams and Weil, 2004

Stimulating Biological Activity

Living vegetation to improve biological activity

Worm holes covered with organic matter go >1 m deep


Removed midden
Nightcrawler burrow
Fresh Cast

Deeper rooting with no-tillage!

	Tillage	Rooting depth (cm)	Lumbricus terrestris burrow depth (cm)	Middens (# m^{-2})
1992 Mandan ND	NT sunflower	193	0	0
	Tilled sunflower	143	0	0
2009 Oshkosh WI	NT corn	131	128	24
	Tilled corn	67	0	0

Deeper rooting in semi-arid ND was attributed to water conservation, while in humid WI it was attributed to activity of deep-burrowing earthworms. Kemper, Schneider and Sinclair. 2011. No-till can increase earthworm populations and rooting depths. J. Soil & Water Cons.66:13A-17A

Yield increase due to root depth increase

Heights, rooting depths, and yields of corn in tilled and no-till areas.

Area	Final height (cm)	Root depth (cm)	Grain yield (bu/ac)	Grain yield (t/ha)
Tilled #1	230	58	160	10
Tilled #2	232	69	164	10.3
No-till #1*	222	122	186	11.7
No-till #2	242	132	205	12.9

* Where water table was high and corn appeared to be nitrogen deficient until July 22nd.

Deeper rooting in humid WI it was attributed to activity of deep-burrowing earthworms. Kemper, Schneider and Sinclair. 2011. No-till can increase earthworm populations and rooting depths. J. Soil & Water Cons.66:13A-17A

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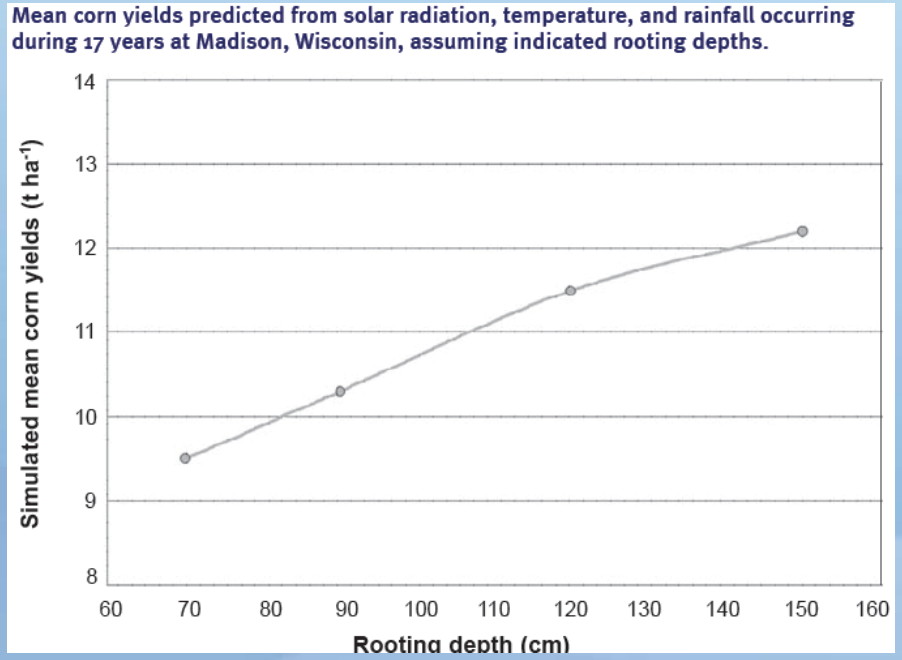

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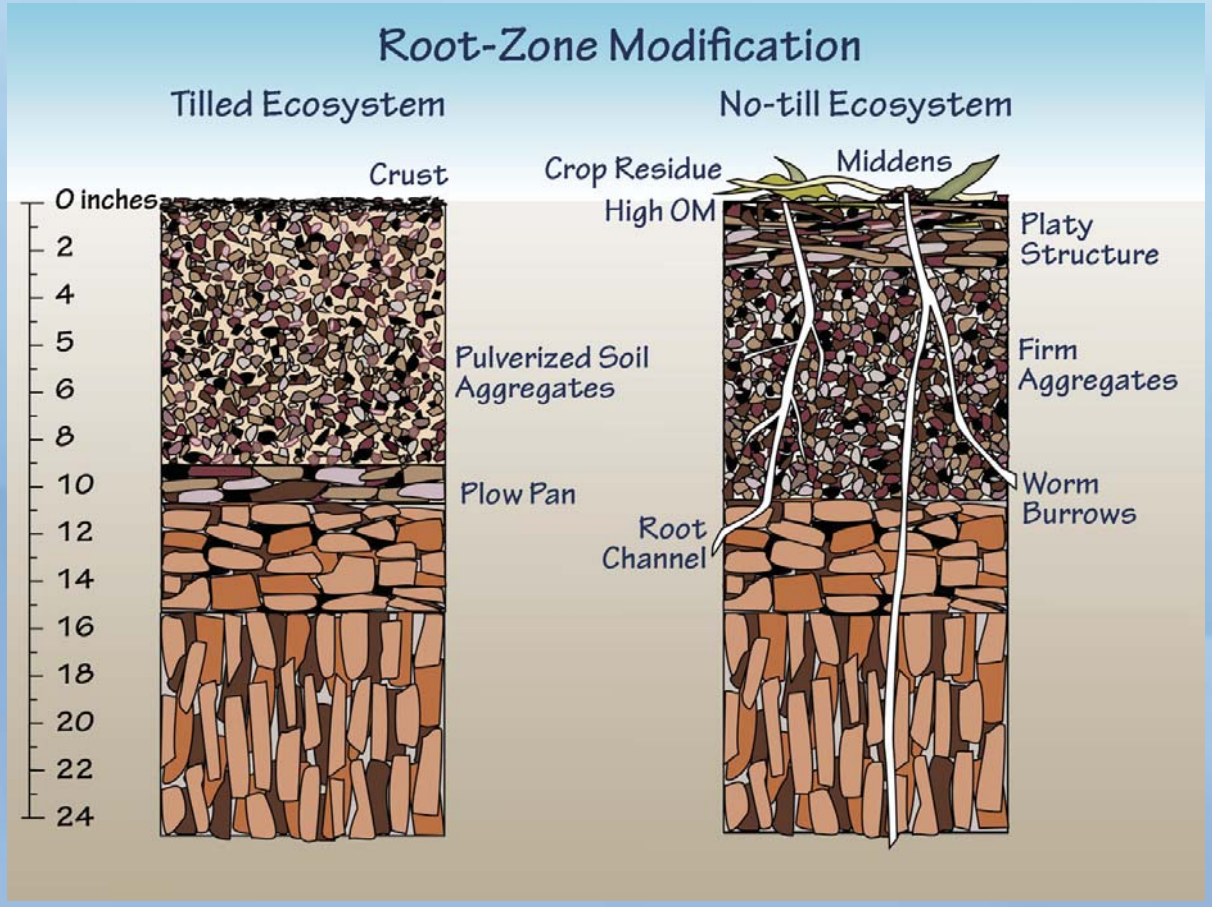
Soil Profile Modification



Conclusions

To improve water use efficiency:

1. Mulch cover maintenance for evaporation and runoff control
2. Need to evaluate entire cropping rotation – including fallow periods
3. We are experiencing a shift from thinking of physical and chemical solutions to WUE improvement to biological solutions, including permanent no-tillage, crop diversity, and cover crops to improve soil quality and WUE at the same time.