The Abdus Salam International Centre for Theoretical Physics

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

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Soil management to improve water use efficiency

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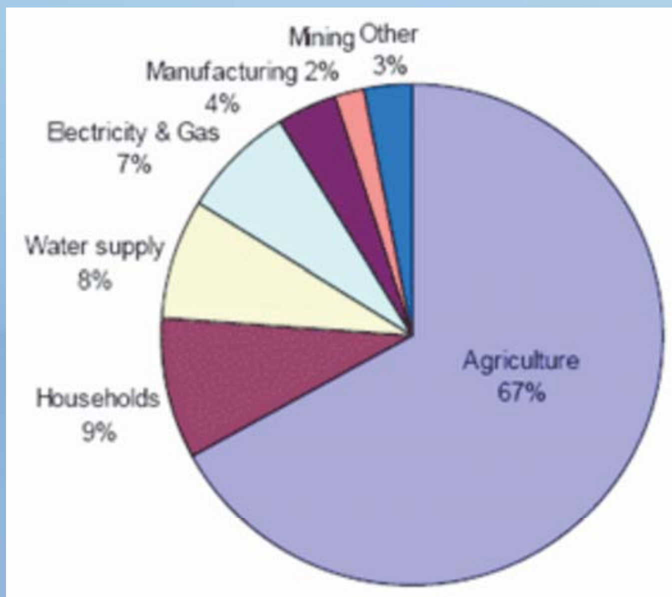
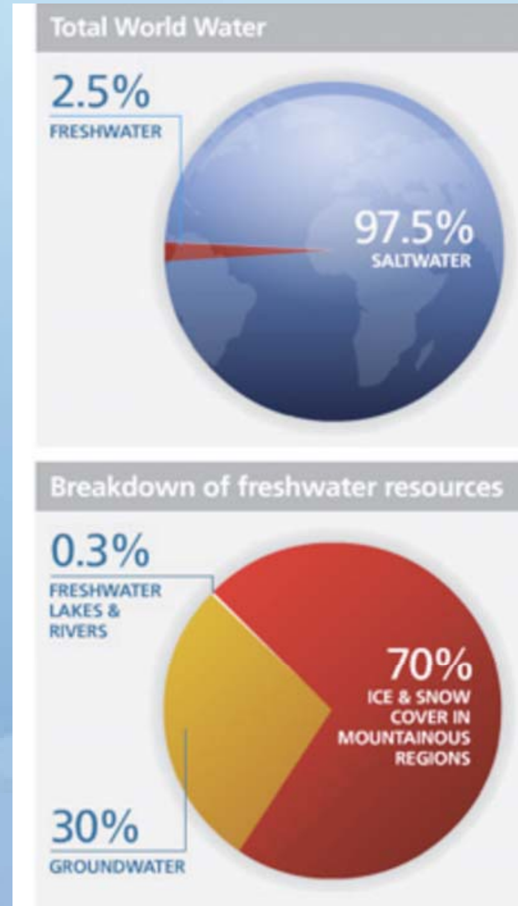
SOIL MANAGEMENT TO IMPROVE WATER USE EFFICIENCY

Penn State Extension

Fresh water is scarce and most of it is used in agriculture



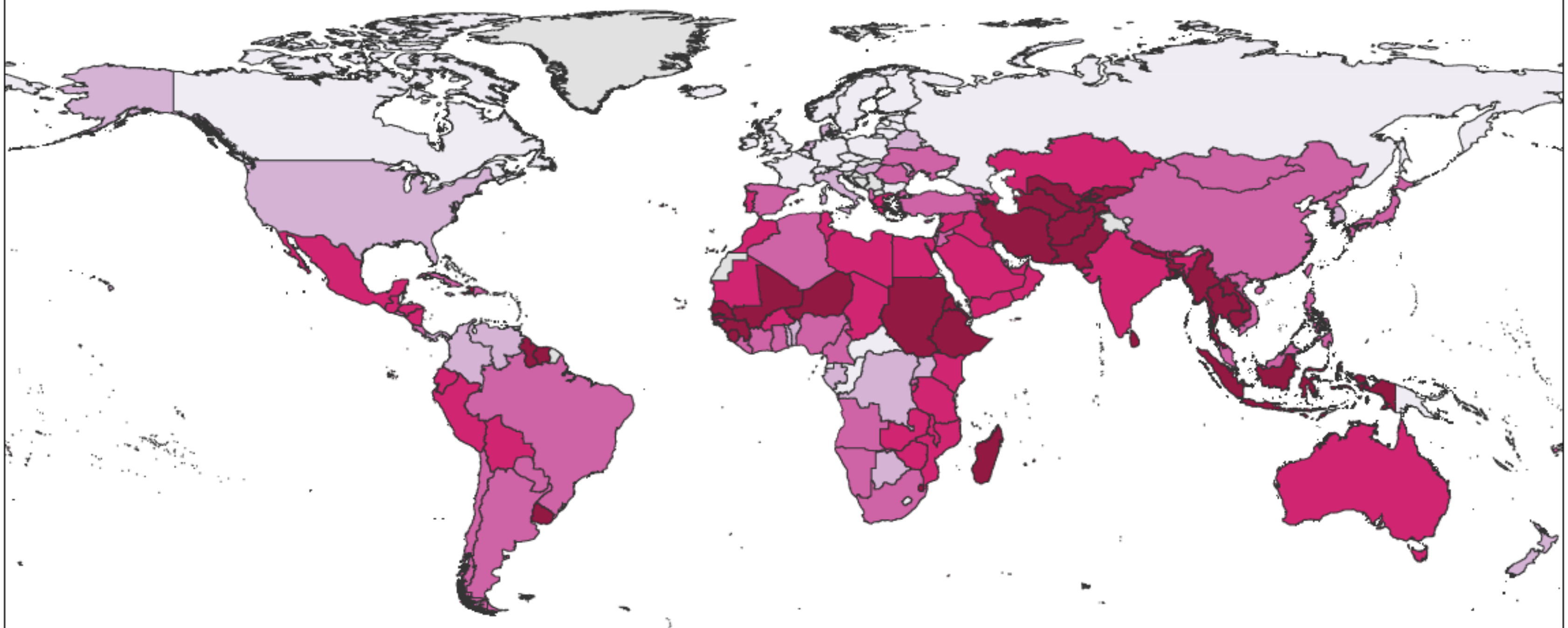
http://www.climate.org



http://www.unwater.org/statistics_res.html

Proportion of total water withdrawal withdrawn for agriculture

Agricultural water withdrawal as percentage of total water withdrawal for agricultural, domestic and industrial purposes (around 2001)



Legend

No Data | < 25 | 25 - 50 | 50 - 75 | 75 - 90 | > 90 %

FAO - AQUASTAT, 2008

Source: AQUASTAT
Projection: Plate Carrée

Disclaimer
The designations employed and the presentation of material in the map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

Penn State **Extension**

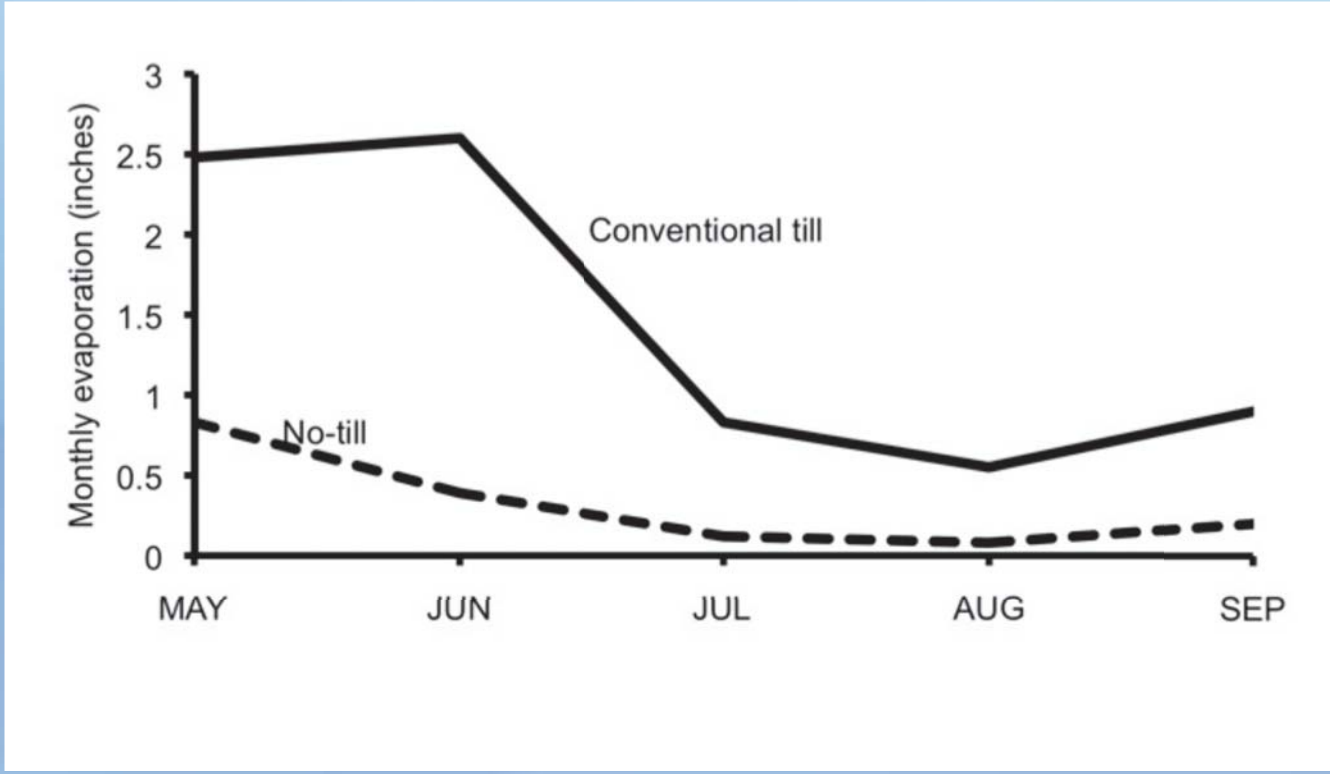
Evaporation control critical

Effect of evaporation control on sorghum yield, and water use efficiency

Treatment	Yield Kg ha^{-1}	Water used cm	WUE Kg $ha.cm^{-1}$
Conventional irrigation	5,800	46 b	126 b
100% plastic cover, no irrigation after planting	6,300	18 c	350 a
No cover, soil water maintained at 50% PAW	8,300	130 a	64 c
80% plastic cover on ridges between rows, irrigated at first signs of stress	7,200	51 b	141 b

Unger and Stewart,1983. Soil management for efficient water use: an overview. *In* H.M. Taylor, W.R. Jordan, T.R. Sinclair. Limitations to efficient water use in crop production. American Society of Agronomy, Madison, WI. P. 419-460

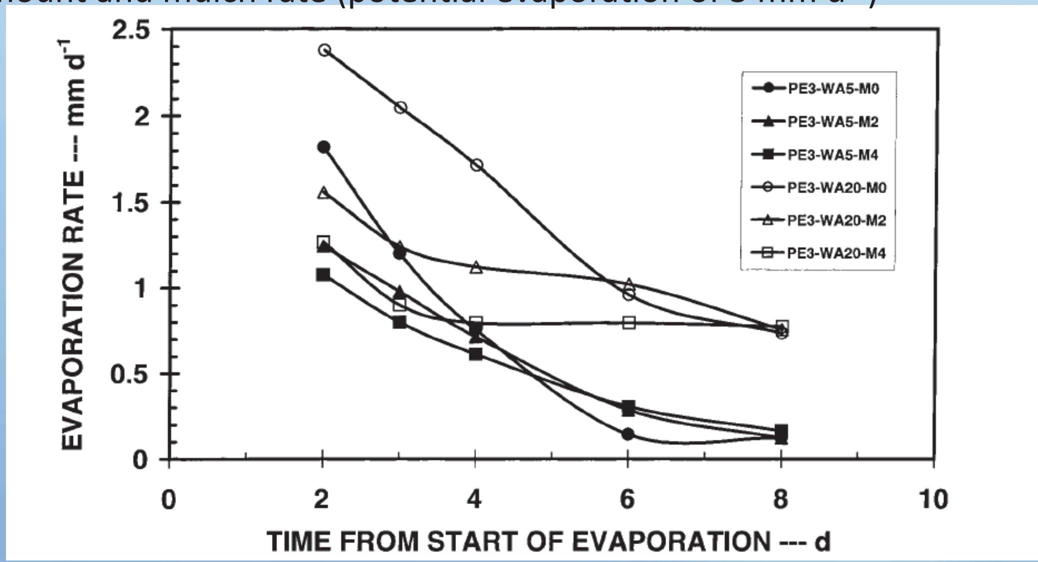
Tillage Effect on Evaporation



Adapted from Phillips and Phillips, 1984. No-Tillage Agriculture: Principles and Practices. Van Nostrand Reinhold Co, New York.

Mulch Rate Governs Evaporation

Soil water evaporation rate, as influenced by water water application amount and mulch rate (potential evaporation of 3 mm d^{-1})



WA5, WA20 = 5 mm or 20 mm/event
M0, M2 or M4 = 0, 2, 4 Mg ha^{-1} straw mulch

Ji and Unger. 2001. Soil Sci. Soc. J. 65:442-448

Fallow Periods Wasting Water

Water storage efficiencies of fallow periods in Great Plains using no-till summer fallow

Region	Cropping system	Water storage efficiency
Texas	Winter wheat – 14 mo fallow	10%
Eastern Colorado	Winter wheat- 14 mo fallow	22%
Western Kansas	Winter wheat- 14 mo fallow	25-30%
Northern Plains	Spring wheat – 21 month fallow	25%

Peterson, G.A. , Schlegel, A.J., Tanaka, D.L. and Jones, O.R. 1996. Precipitation use efficiency as affected by cropping and tillage systems. J. Prod. Ag. 9: 180-186.

Note: WSE averaged 25% with no-till vs 16% in tillage era

Precipitation storage efficiency and soil water storage during fallow period in spring-wheat fallow system

56% (80 mm)	23% (41 mm)	19% (9 mm)	MT, NT, '81-'85
60% (83 mm)	5% (10 mm)	19% (16 mm)	MT, MT, '56-'64
33% (60 mm)	17% (51 mm)	0% (0 mm)	ND, PT, '15-'85

Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	State, tillage, period

Analysis shows that most precipitation in summer and winter is wasted.

From Farahani, H.J., Peterson, G.A., and Westfall, D.G. 1998. Dryland cropping intensification: A fundamental solution to efficient use of precipitation. Advances in Agronomy 64:197-223

Precipitation storage efficiency and soil water storage during fallow period in winter-wheat fallow system

Jul–Dec (Jul, Aug, Sep, Oct, Nov, Dec)	Jan–Apr (Jan, Feb, Mar, Apr)	May–Aug (May, Jun, Jul, Aug)	State, tillage, period
46% (40 mm)	48% (38 mm)	27% (36 mm)	MT, NT, ‘81-’84
43% (37 mm)	52% (41 mm)	16% (21 mm)	MT, MT, ‘81-’84
18% (34mm)	92% (258 mm)	-11% (-18 mm)	NE, NT, ‘63-’66

Analysis shows that most precipitation in summer is wasted. Averaged over many trials, NT has doubled fallow-water storage from 10 to 20-30%, but still fallow is very inefficient.

From Farahani, H.J., Peterson, G.A., and Westfall, D.G. 1998. Dryland cropping intensification: A fundamental solution to efficient use of precipitation. Advances in Agronomy 64:197-223

Plant available water at crop planting as affected by intensification

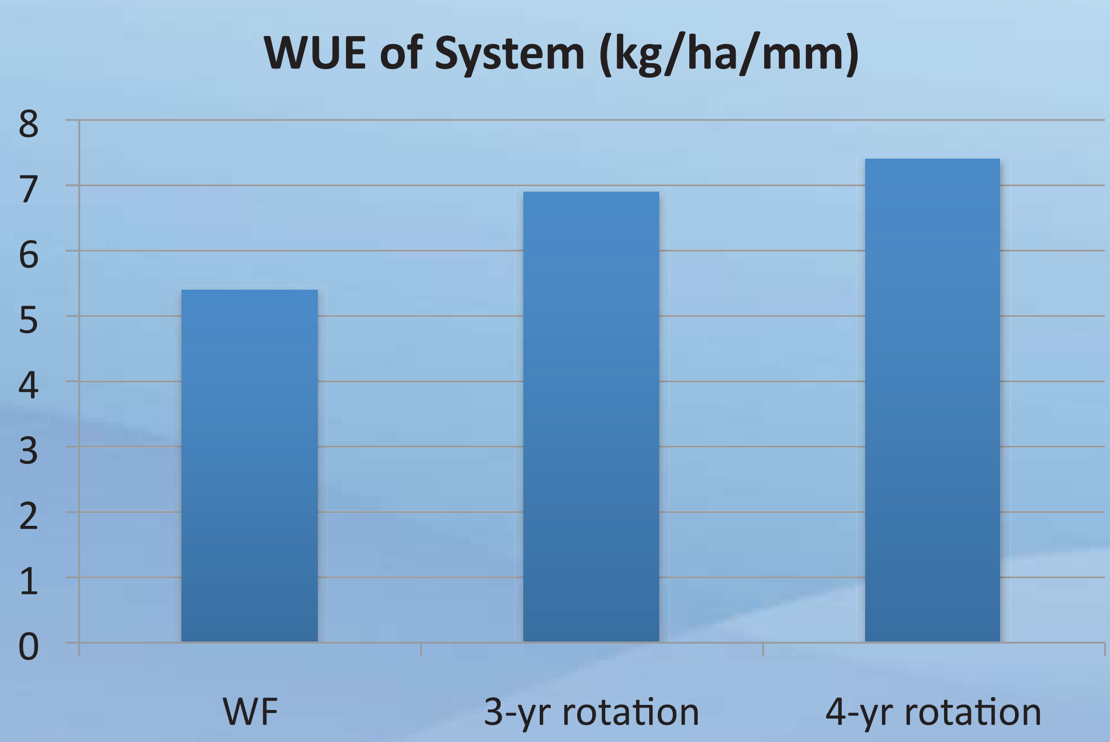
	PASW at wheat planting (mm)	PASW at 1st summer crop planting (mm)	PASW at 2nd summer crop planting (mm)
Wheat-fallow	220	-	-
Wheat-summer crop-fallow	213	226	-
Wheat-summer crop-summer crop-fallow	228	227	193

Average of 6 different studies in TX, KS and CO. PASW is total soil-water profile (avg depth 1.5 m) minus soil-water profile at 15-bar water content.
Summer crops were corn, millet or sorghum.

1. Soil water at wheat planting is not a function of intensity of cropping system as long as wheat planting is preceded by a long fallow.
2. Summer fallow water can efficiently be used to grow a summer crop.

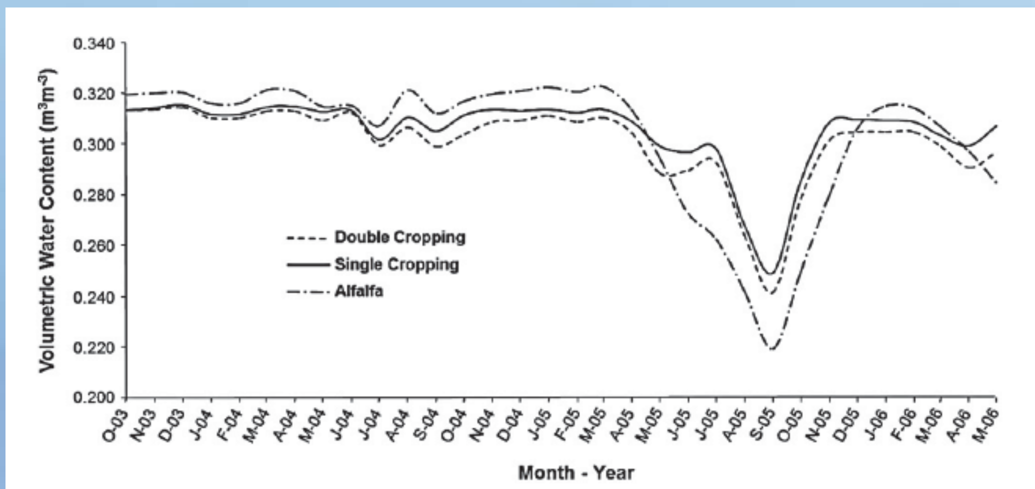
From Farahani, H.J., Peterson, G.A., and Westfall, D.G. 1998. Dryland cropping intensification: A fundamental solution to efficient use of precipitation. Advances in Agronomy 64:197-223

Effect of cropping intensification on water use efficiency in Great Plains



From Farahani, H.J., Peterson, G.A., and Westfall, D.G. 1998. Dryland cropping intensification: A fundamental solution to efficient use of precipitation. Advances in Agronomy 64:197-223

Double cropping in Pennsylvania – no impact on soil water content or main crop yields



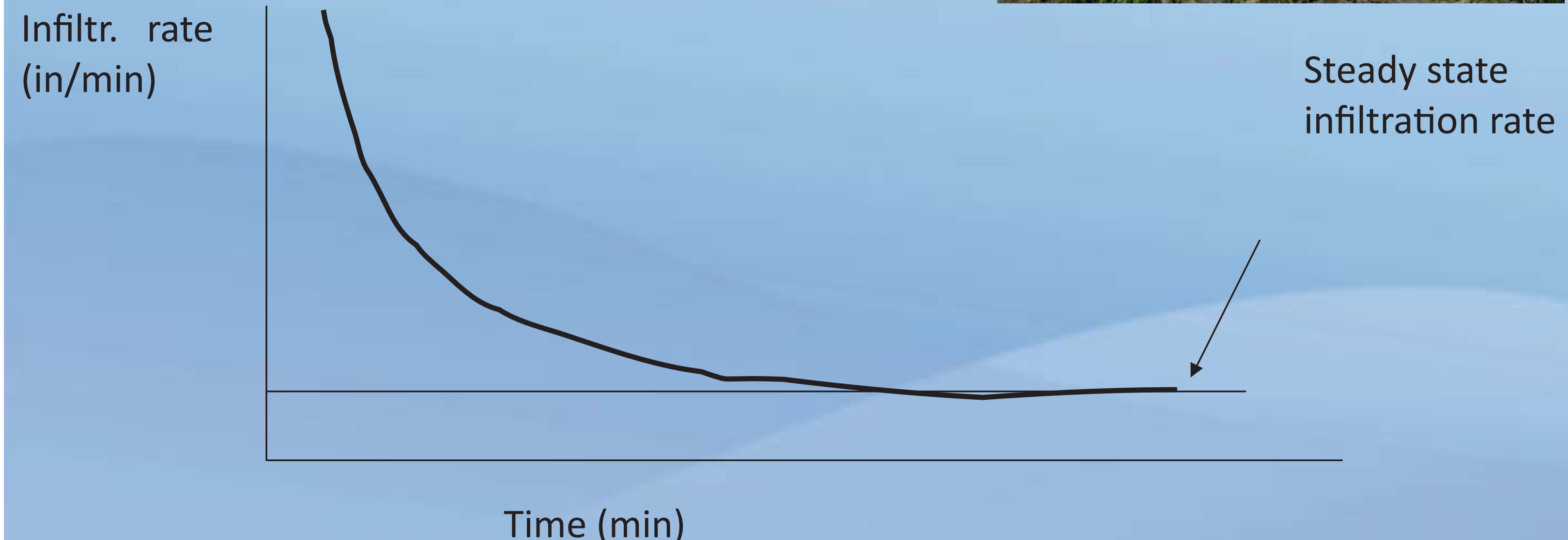
Fouli, Y. Duiker, S.W., Fritton, D.D., Hall, M.H., Watson, J.E., and Johnson, D.H. 2012. Double cropping effects o forage yields and the field water balance. Agr. Water Management 115:104-117

Runoff control critical

Runoff from 12.7 cm, 1-hr simulation storm from three Puerto Rico soils

Soil	Treatment	Runoff (cm)	Comments
Humatas clay 38% slope	Conventional till	8.2	Runoff governed by percolation
Typic Tropohumult	Mulch tillage	9.9	
	Grass strip	10.6	
Juncos silty clay 33% slope	Conventional till	11.6	Infiltrated water returned (interflow)
Vertic Eutropept	Mulch tillage	11.5	
	Grass strip	11.0	
Pandura sandy loam 27% slope	Conventional till	4.8	Runoff governed by intake rate
ShallowTypic Eutropept	Mulch tillage	2.9	
	Grass strip	3.2	
			Barnett et al., 1972

Infiltration Rate

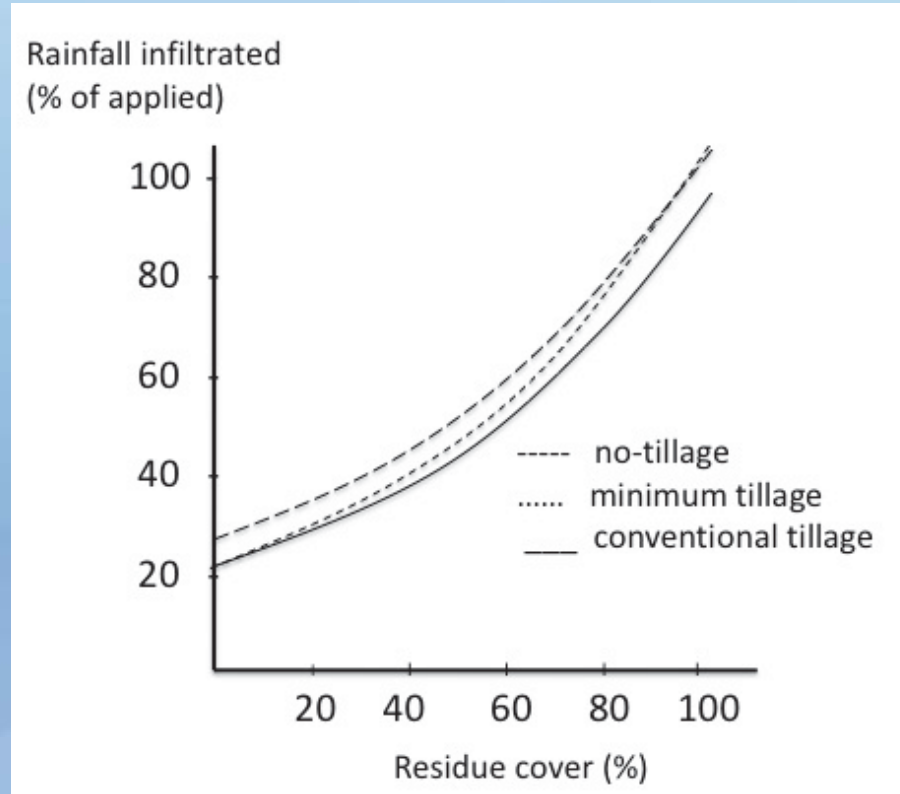


Infiltration Rate and Soil Texture

	Steady State Infiltration rate (in/hr)
Sand	>0.8
Silt	0.4-0.8
Loam	0.2-0.4
Clay	0.04-0.02

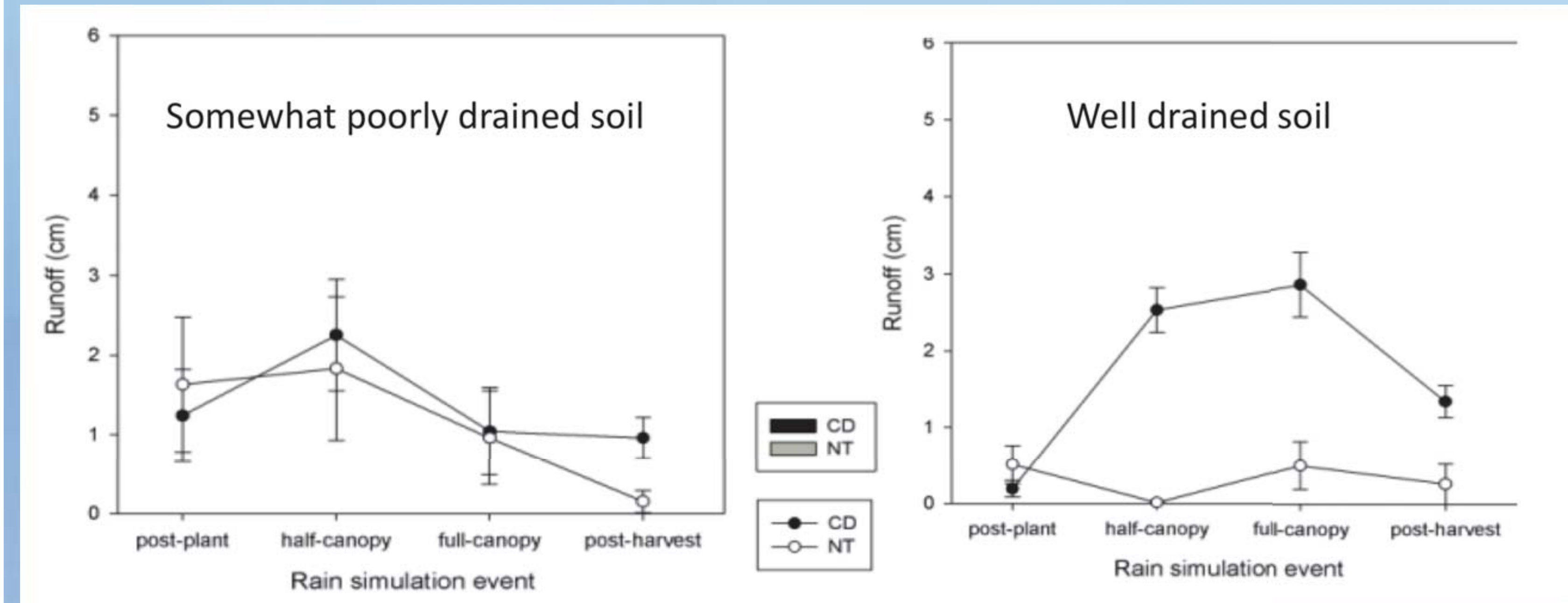
High Mulch Cover for Increased Infiltration

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.

Tillage/Residue Benefit for Infiltration Depends on Soil Drainage Type



Verbree, D.A., Duiker, S.W., and Kleinman, P.J.A. 2010. Runoff losses of sediment and phosphorus from no-til and cultivated soils receiving dairy manure. JEQ 39:1762-1770.

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

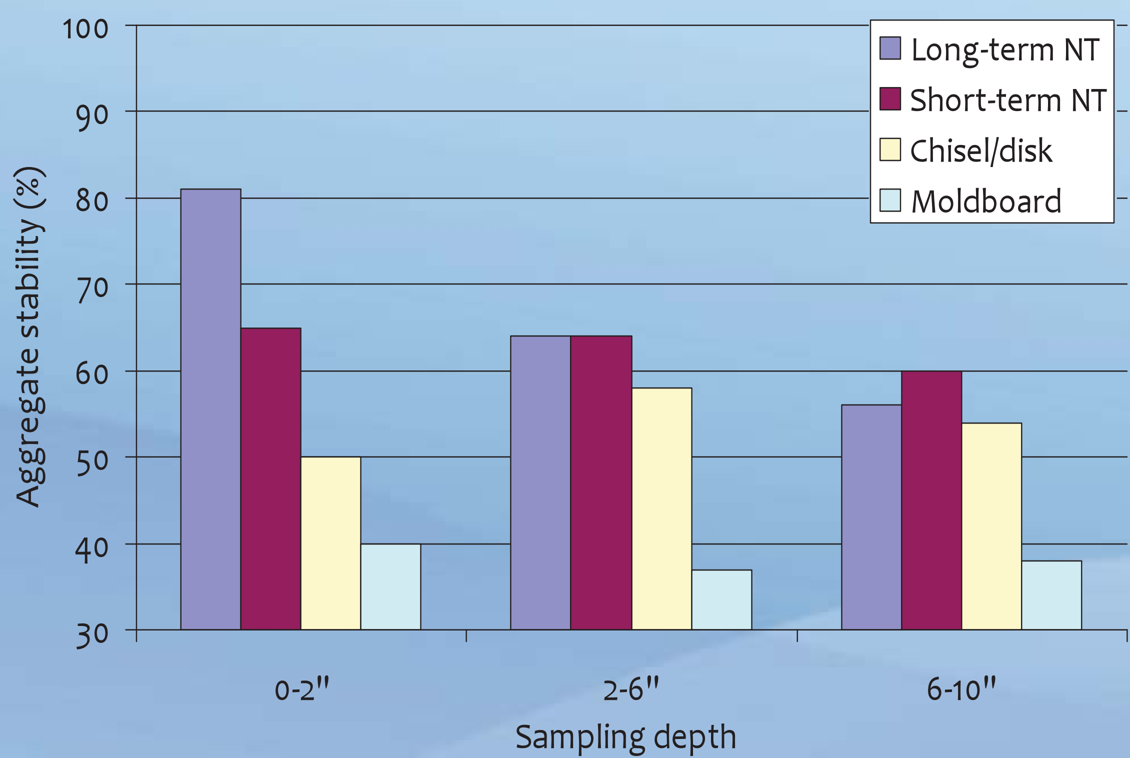
Runoff (")

	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

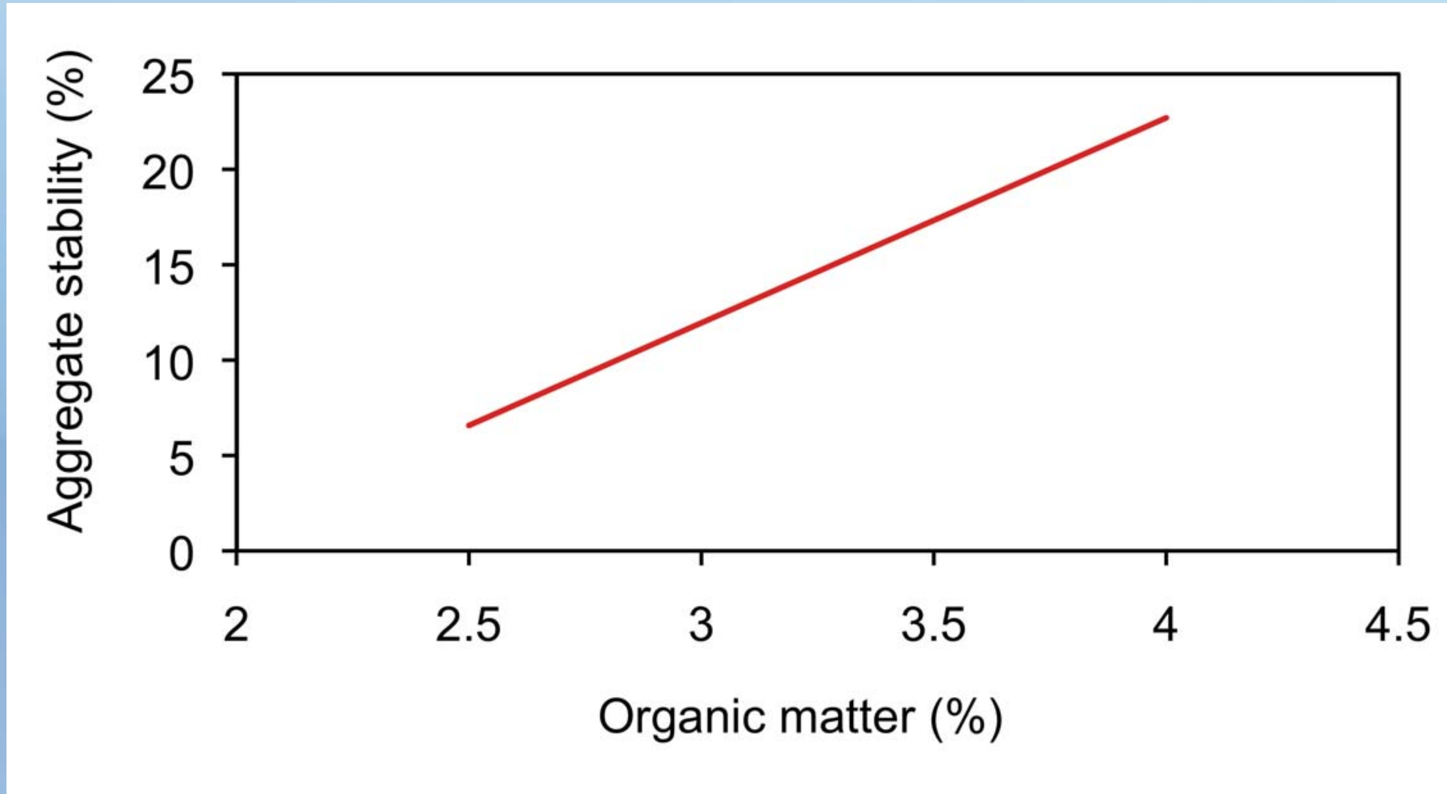
Coshocton, OH, no till was on 9% slope, conventional till on 6% slope. Average rainfall 42 inches

Permanent No-Till for Improved Surface Aggregation



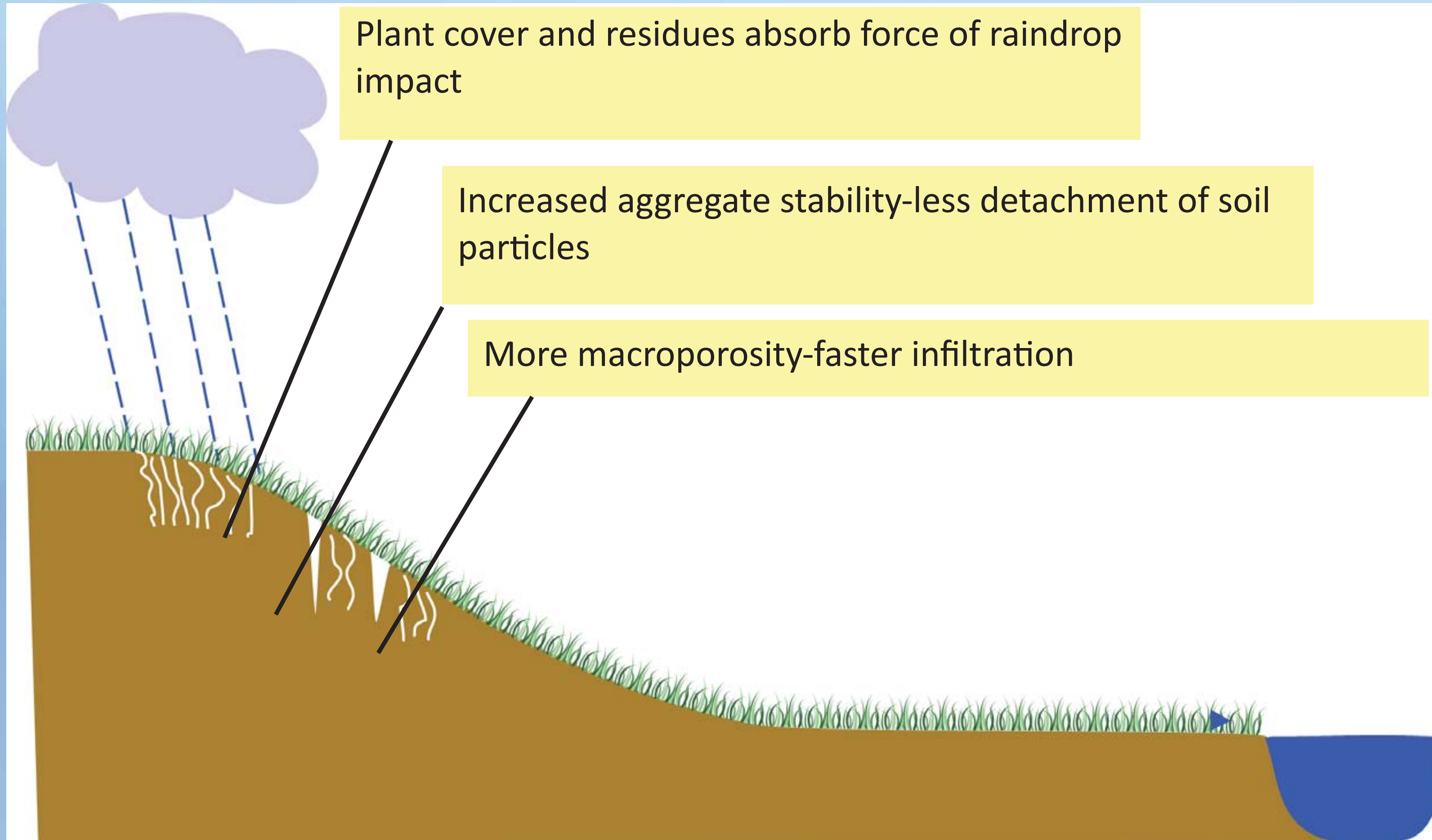
Data from long-term tillage study, Penn State University

Soil aggregation and organic matter



Tisdall and Oades, 1982

Runoff and Erosion Mitigation by Cover Crops



Courtesy Charlie White