Cropping Systems Research: Present and Future

CARC Research Roundup
7 December, 2017

Patrick Carr
Associate Professor & Superintendent
Montana State University
Central Ag Research Center

- Jed Eberly, Assistant Professor, Microbiology
- Simon Fordyce, Research Associate, Cropping Systems
- Sally Dahlhausen, Research Assistant III, Cropping Systems
- Sherry Bishop, Research Assistant III, Forages/Variety trials
- Heather Fryer, Research Assistant III, Economics, Web and Social Media
- Darryl Grove, Farm Manager
- Tim Bishop, Farm Mechanic
- Lorrie Linhart, Administrative Associate III

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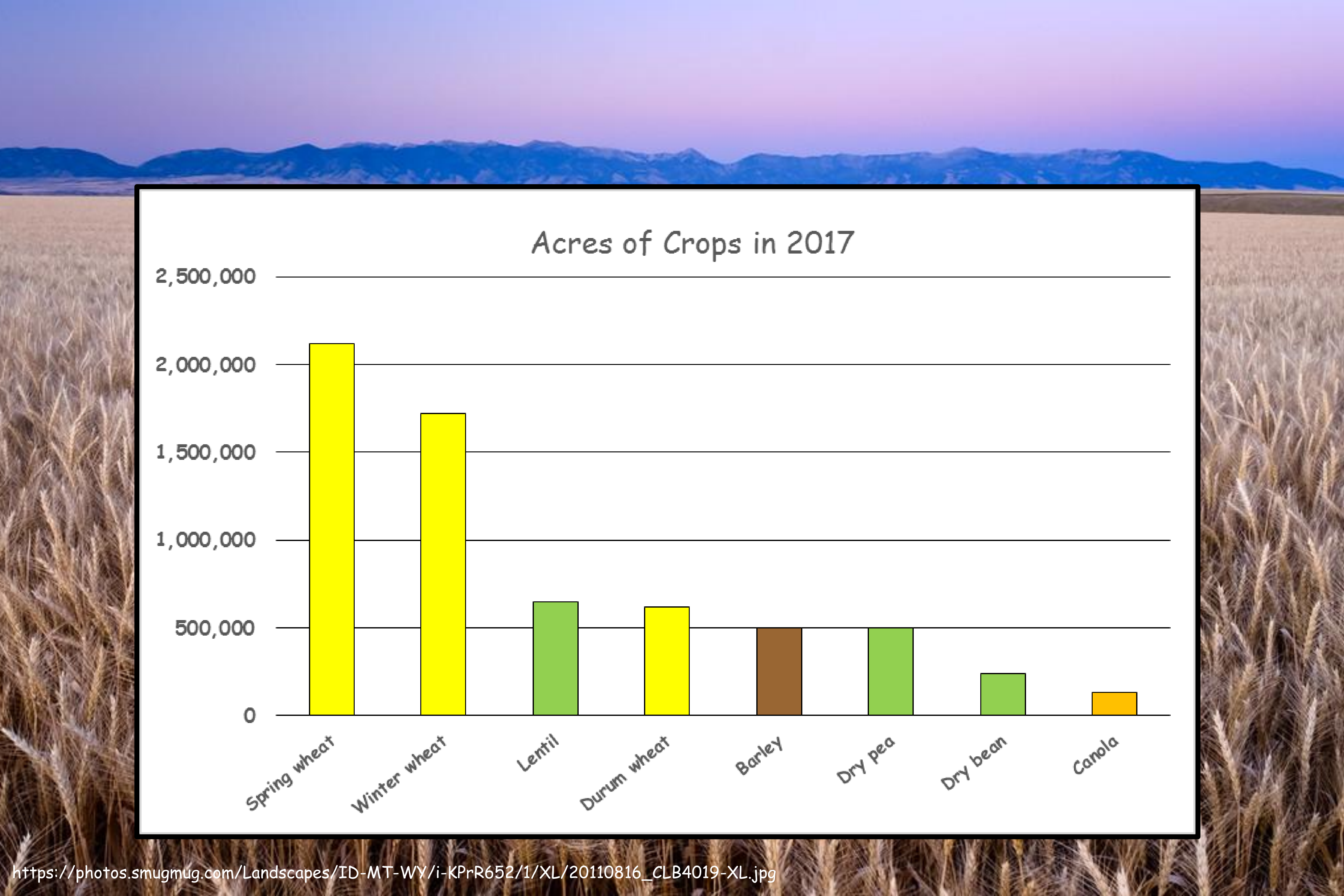
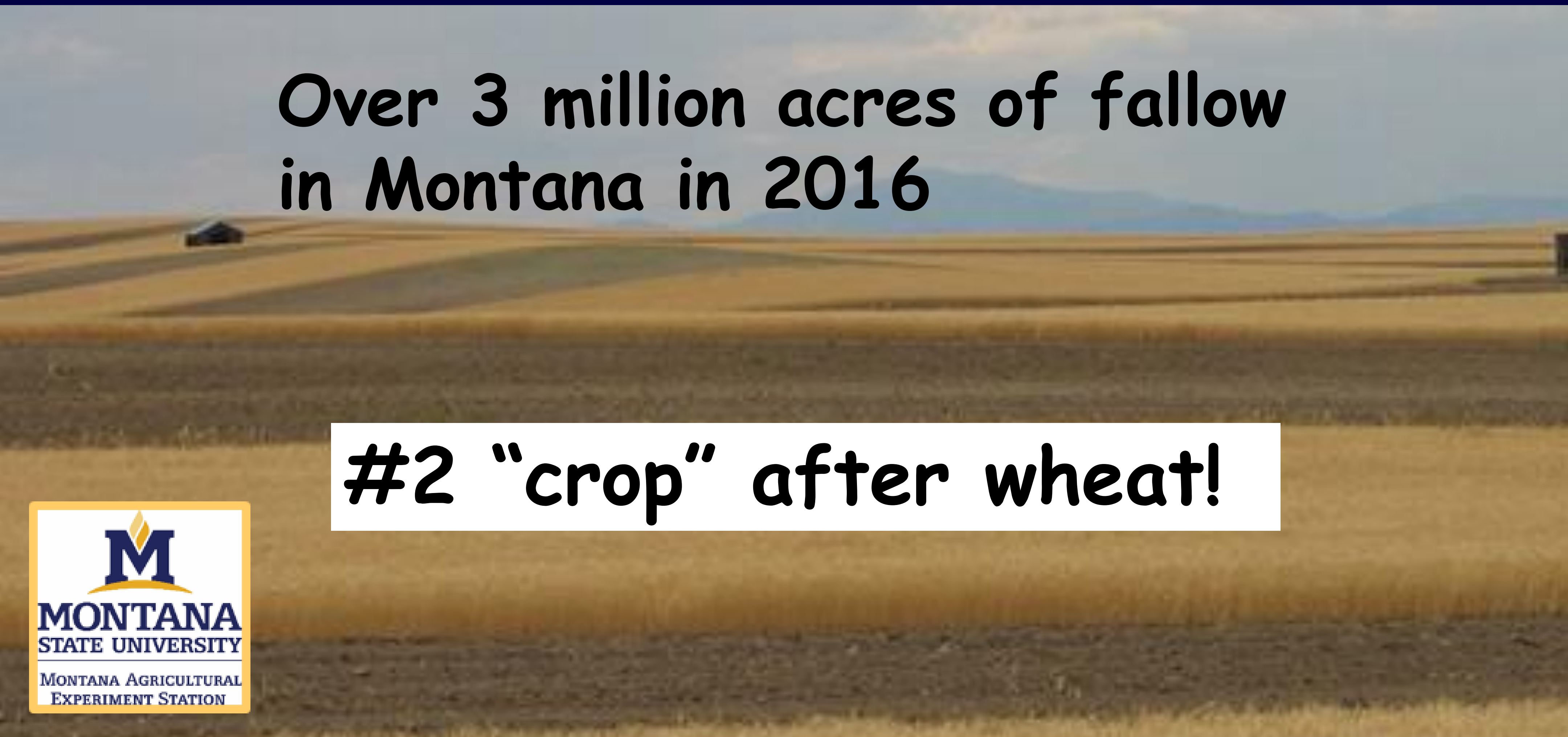

Acres of Crops in 2017
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Spring wheat
Winter wheat
Lentil
Durum wheat
Barley
Dry pea
Dry bean
Canola
https://photos.smugmug.com/Landscapes/ID-MT-WY/i-KPrR652/1/XL/20110816_CLB4019-XL.jpg

Wheat - Summer fallow

Over 3 million acres of fallow in Montana in 2016

#2 "crop" after wheat!



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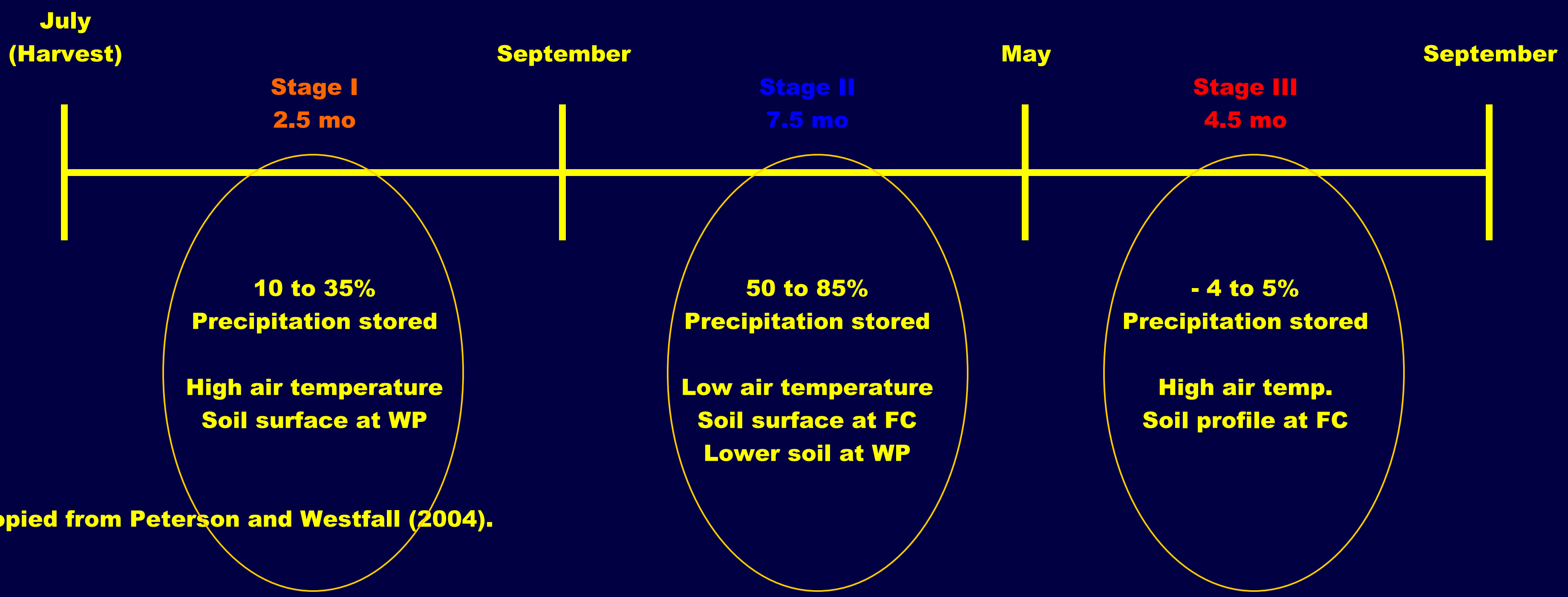
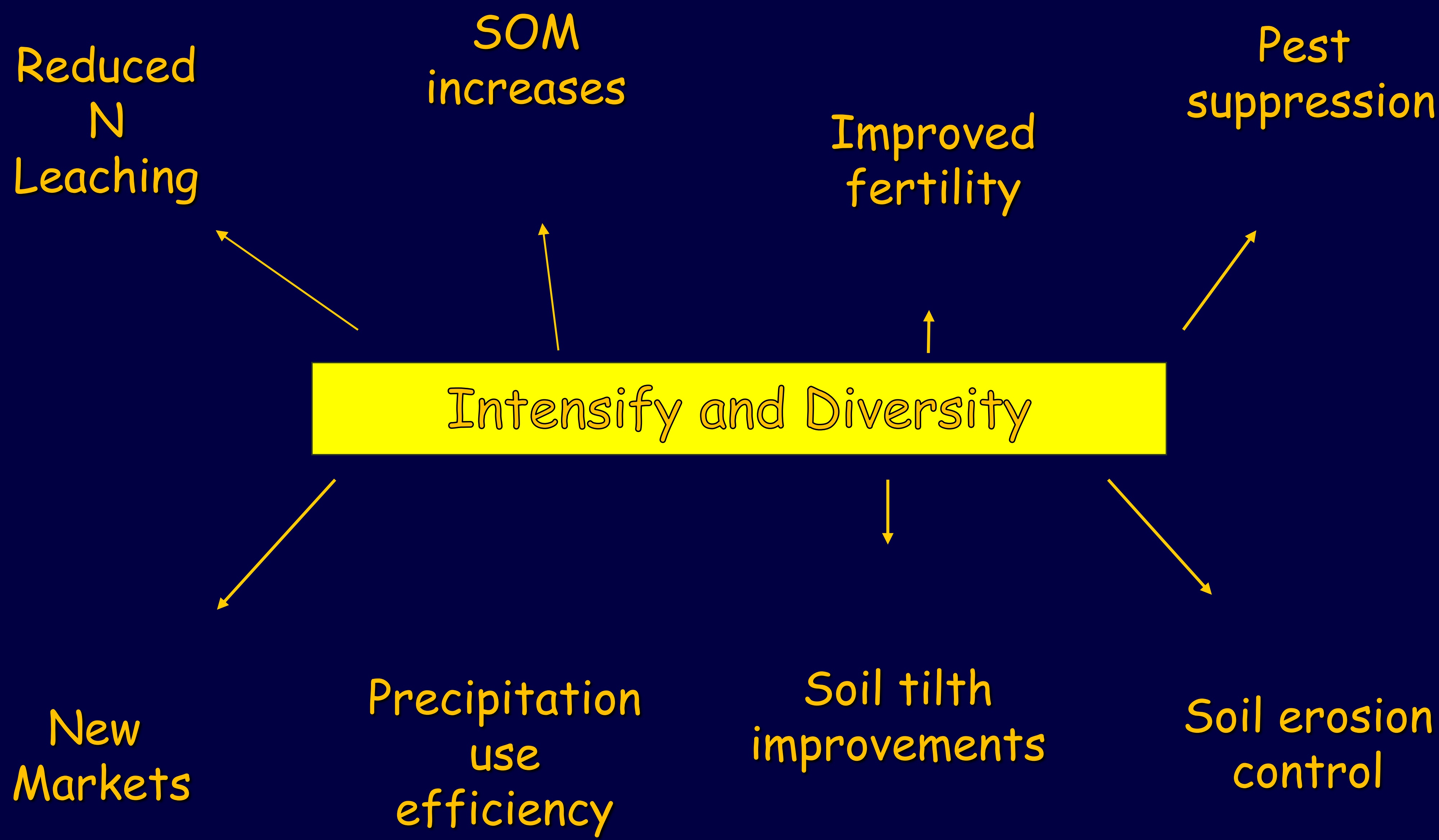
Montana Agricultural Experiment Station

Efficiency of water storage in a winter wheat-fallow system.



Copied from Peterson and Westfall (2004).


Reduced N Leaching
SOM increases
Improved fertility
Pest suppression
Intensify and Diversity
New Markets
Precipitation use efficiency
Soil tilth improvements
Soil erosion control

The Secret of NT's Success?

- Reduce evaporation
- Increase snow catch
- Improve infiltration

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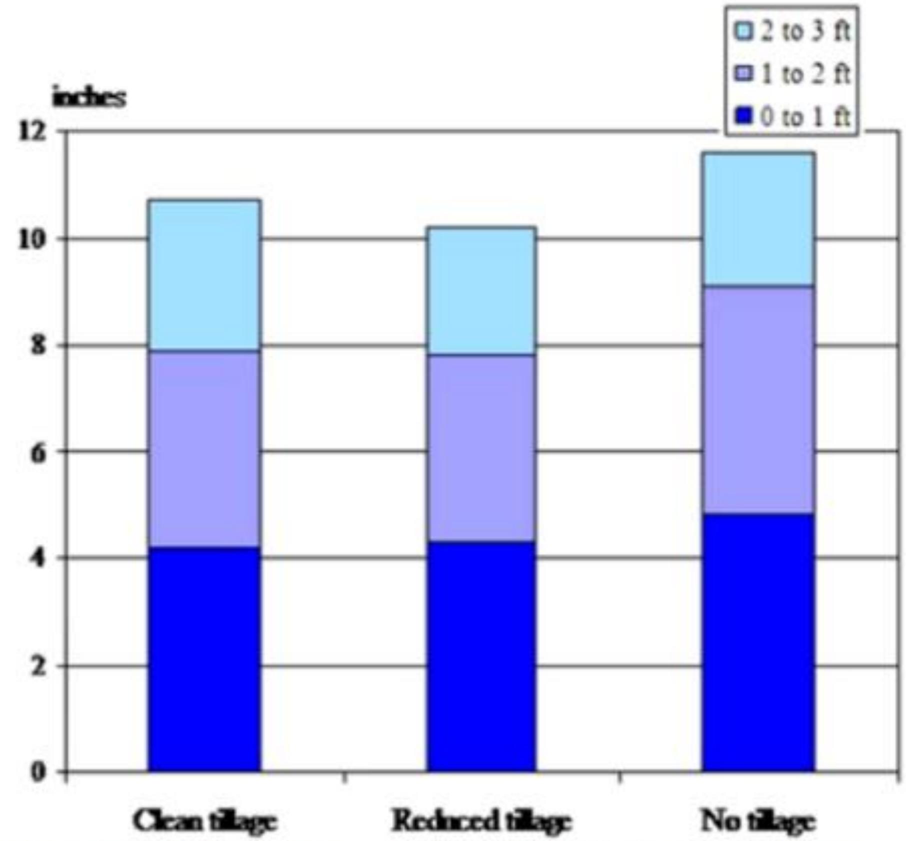

Fig. 1. Inches of stored water in the top 3 ft of soil under clean-till (Clean tillage), reduced-till (Reduced tillage), and no-till (No-tillage) management prior to seeding spring wheat following field pea and spring wheat in April during 2004 and 2005 at Dickinson, ND.

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Wheat yield following selected crops

	Bozeman		Denton		Dutton	
Crop	Grain yield	% Fallow	Grain yield	% Fallow	Grain yield	% Fallow
	- bu/ac -		- bu/ac -		- bu/ac -	
Fallow	54	--	37	--	21	--
Pea	50	93	33	89	6	29
Flax	55	102	33	89	5	24
Wheat	47	87	28	76	7	33
Chickpea	50	93	31	84	5	24
Sunflower	40	74	26	70	7	33
Millet	--	--	--	--	7	33

Miller, P.R., and J.A. Holmes. 2005. Cropping sequence effects of four broadleaf crops on four cereal crops in the northern Great Plains. Agron. J. 97:189-200.

http://www.bigskyseeds.net/wp-content/uploads/2014/09/Montech-4152-Yellow-Pea-seed-production-field.jpg

Annual Cropping VS. Wheat-Fallow

Crop and Rotation	1983	1984	1985	1986	1987	1988	1989	1990	8 year average	% of fallow
	- bu/A -									
Wheat Yields on:										
Fallow	47.1	34.5	36.7	57.8	20.7	9.4	20.1	36.9	32.9	100
Continuous recrop	38.5	27.2	20.6	36.1	9.3	0.0	5.7	10.6	18.5	56
No-till continuous	39.0	20.4	14.8	22.9	4.8	0.0	9.3	11.8	15.4	47
Sunflower stubble	46.1	21.4	16.9	39.5	6.5	0.0	9.0	15.6	19.4	59
Corn stubble	47.2	32.2	29.6	45.4	16.6	0.0	10.2	17.7	24.9	76
Barley Yields on:										
Sunflower stubble	64.8	36.3	31.5	43.6	26.8	0.0	9.0	21.8	29.2	
Corn Yields on Wheat stubble:										
Grain (bu/a)	72.6	72.4	56.5	57.2	82.4	11.2	0.0	21.9	46.8	
Silage (ton/a)	10.3	8.9	12.6	9.7	12.7	4.5	2.7	7.9	8.7	
Sunflower on:										
Wheat stubble(lb/a)	1784	1664	1224	2423	1182	0.0	0.0	0.0	1035	

E. Vasey, 1993, NDSU Ext. Serv. Bul. EB-59, Fargo, ND.

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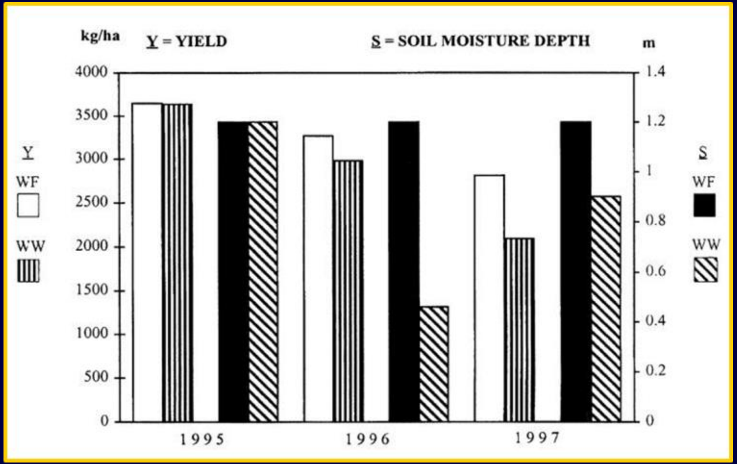
Technology Improvements

http://www.shelbourne.com/uploads/asset_image/2_450_e.jpg

Annual Cropping VS. Wheat-Fallow

Carr et al., 2001, Can. J. Plant Sci. 81:399-404



WW ≈ 90%

Crop and Rotation	1983	1984	1985	1986	1987	1988	1989	1990	8 year average	% of fallow
	----------	----------	----------	----------	bu/A	----------	----------	----------	----------	
Wheat Yields on:										
Fallow	47.1	34.5	36.7	57.8	20.7	9.4	20.1	36.9	32.9	100
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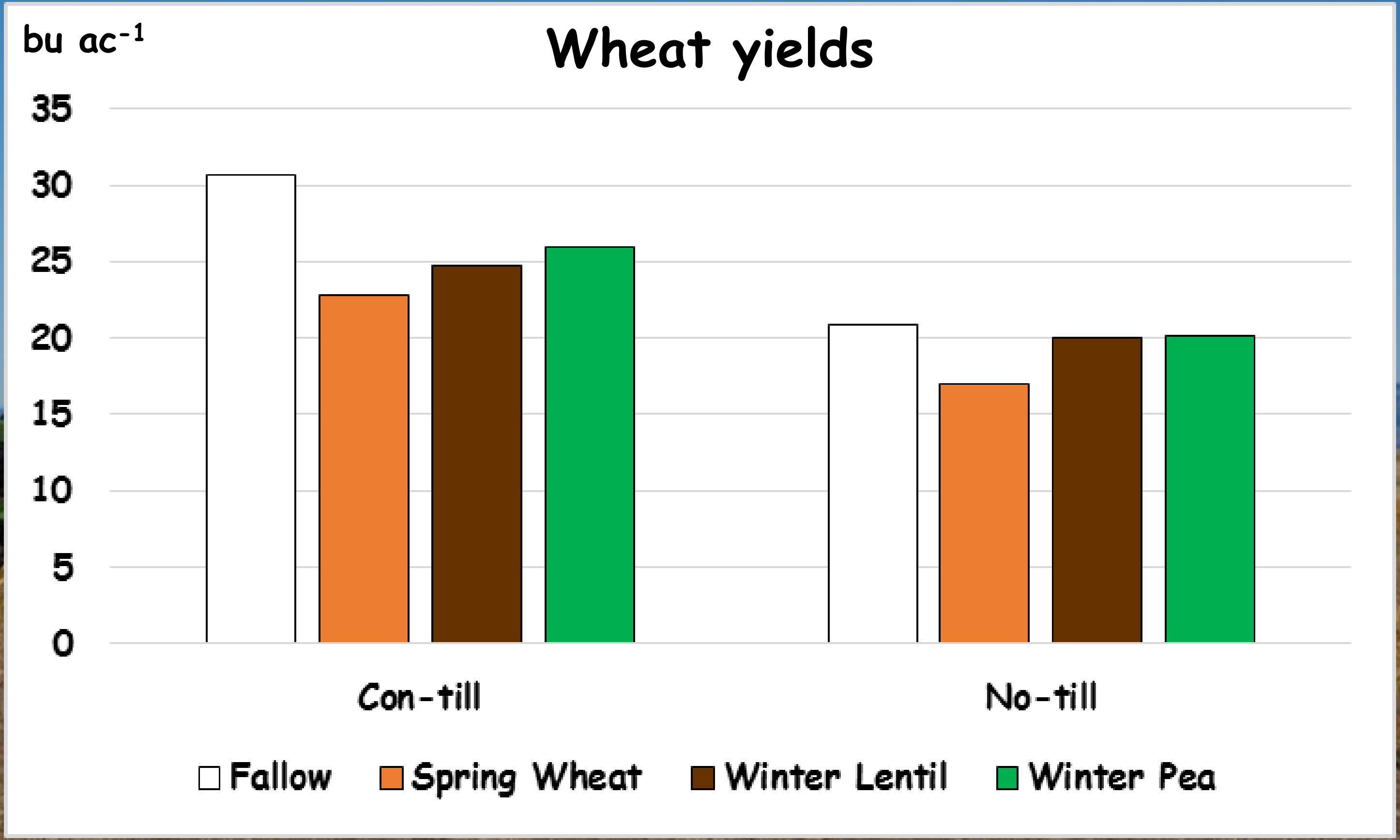
Rotation And Tillage Systems (RATS)



No-till adoption possible SOC capture and retention strategy

Post et al., 2012, Front. Ecol. Environ. 10:554-461.

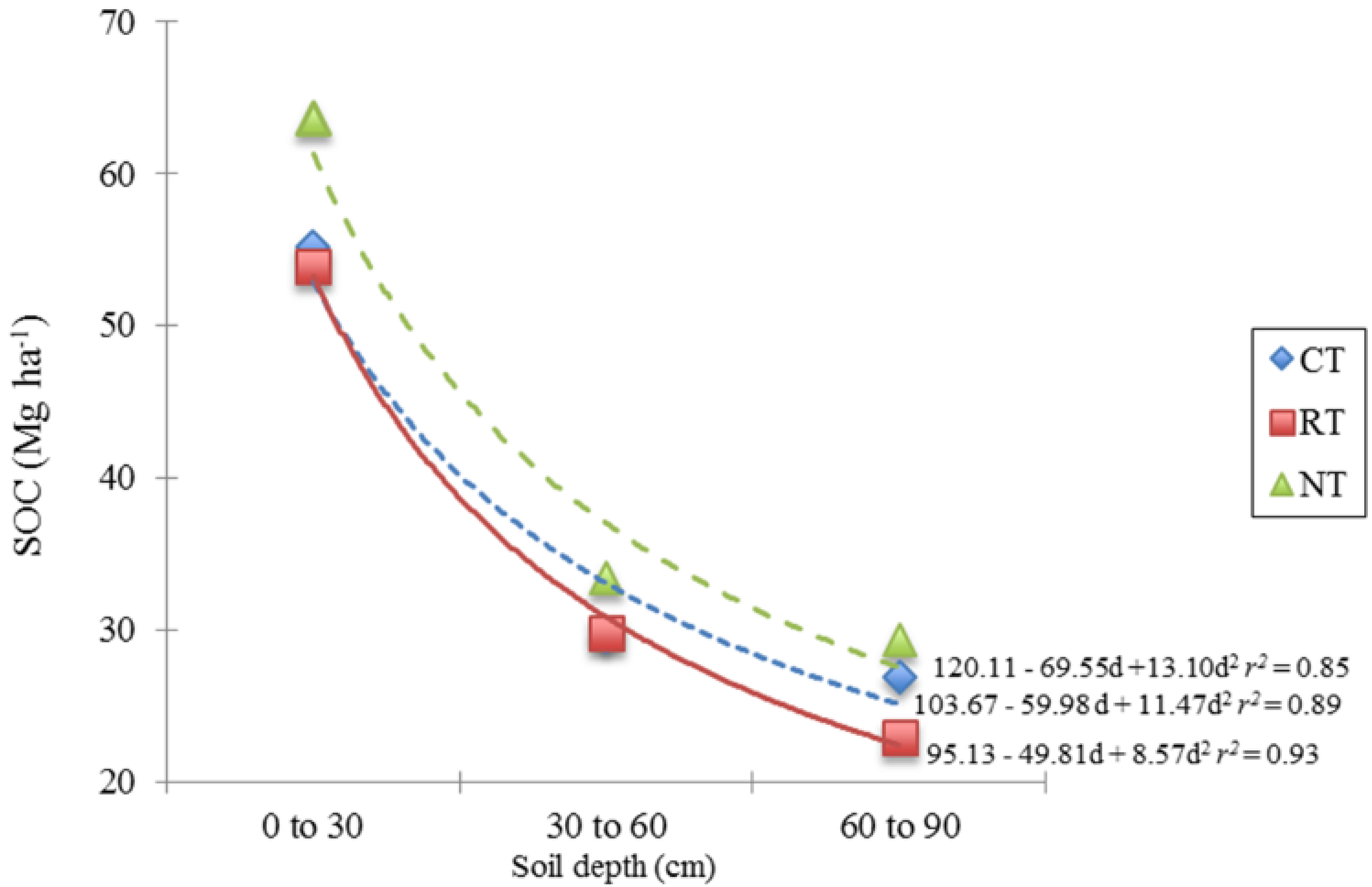


Figure 1. Soil organic carbon mass per unit area at 0- to 30-cm, 30-to 60-cm, and 60- to 90-cm depth increments in long-term clean-till (CT), reduced-till (RT), and no-till (NT) plots at Dickinson in southwestern North Dakota, USA.

NDSU
North Dakota State University
ND Agricultural Experiment Station

No till *can* result in cooler soil temperatures in the spring

Another NT plug …

"… AM hyphae, which over wintered in the field remained viable as inoculum in spring and that disturbance of these hyphae in spring reduced colonization and P uptake in the following crop."

Tillage or no-tillage: Impact on mycorrhizae

Zahangir Kabir

Department of Land, Air and Water Resources, 1150 Plant and Environmental Sciences Building, University of California, Davis, One Shields Ave., Davis, California 95616, USA (e-mail: kabir@ucdavis.edu). *Received 14 October 2003, accepted 9 September 2004.*

Kabir, Z. 2005. **Tillage or no-tillage: Impact on mycorrhizae.** Can. J. Plant Sci. **85**: 23–29. Arbuscular mycorrhizal (AM) fungi are ubiquitous in agricultural soils. These fungi play important roles in plant nutrition and soil conservation. The persistence of AM fungi in ecosystems depends on the formation and survival of propagules (e.g., spore, hyphae and colonized roots). While spores are considered to be resistant structure that may be view as "long-term" propagules when viable host plants are not present, hyphae are considered to be the main source of inocula when host plants are present and the soil is not disturbed. Tillage is an integral part of modern agriculture that can modify the physical, chemical and biological properties of a soil. Consequently, tillage practices may also affect AM fungi. The various tillage practices used in the management of soil for maximum crop production may negatively impact the survival of AM fungal propagules. In tilled soil, certain AM species may survive while others may disappear. Because AM fungi are more abundant in the topsoil, deep plowing may dilute their propagules in a greater volume of soil, thereby reducing the level of infection of a plant root. Tillage is particularly detrimental to AM hyphae if the soil is tilled in the fall and the hyphae are detached from the host plant. Under no-till (NT), AM fungi survive better, particularly when they are close to the host crop on which they developed. There is speculation that in NT systems, plants may follow old root channels and potentially encounter more AM fungal propagules than plants growing in soil that has been tilled. Management of AM fungi in NT soil is essential to maximizing benefits to crops. This review reports how tillage practices affect AM fungi species richness, survivability and infectivity, and how conservation tillage can increase AM fungi survival, consequently improving plant phosphorus uptake and soil aggregate stability.

Key words: Arbuscular mycorrhizal fungi, conservation tillage, conventional tillage, P uptake, soil aggregate stability, cover crops, crop yield

Kabir, Z. 2005. **Travail ou non-travail du sol : incidence sur les mycorhizes.** Can. J. Plant Sci. **85**: 23–29. Les mycorhizes à arbuscules (MA) sont des champignons omniprésents dans les sols agricoles. Ces champignons jouent un rôle important pour la nutrition des plantes et la conservation du sol. Leur persistance dans l'écosystème dépend de la formation et de la survie des propagules (les spores, les hyphes et les racines colonisées). Bien que les spores soient considérées comme des propagules « à long terme » à cause de leur résistance en l'absence de plantes hôtes, les hyphes demeurent la principale source d'inoculum quand il y a des plantes hôtes et que le sol n'est pas perturbé. Les labours font partie intégrante des pratiques agricoles modernes et peuvent modifier les propriétés physiques, chimiques et biologiques du sol. De telles pratiques affectent donc aussi les MA. Diverses pratiques employées pour parvenir à la production maximale d'une culture ont une incidence négative sur la survie des propagules des MA. Certaines espèces de champignons survivront dans le sol retourné alors que d'autres périront. Les MA étant plus abondants dans le sol de surface, un labour en profondeur diluera leurs propagules dans un plus grand volume, donc réduira le taux d'infection des racines de la plante hôte. Les labours sont particulièrement néfastes quand le travail s'effectue à l'automne et que les hyphes des MA se détachent de la plante hôte. Les MA survivent mieux avec le non-travail du sol, surtout quand ils se trouvent à proximité de la culture qui a servi à leur développement. On se demande si les plantes n'empruntent pas les anciens canaux radiculaires dans les champs non travaillés, si bien qu'elles trouvent plus de propagules de MA que celles poussant dans un sol travaillé. Une gestion des MA dans le sol non travaillé est essentielle si l'on veut que les cultures en profitent au maximum. La présente étude explique comment les pratiques en matière de travail du sol affectent la richesse des espèces de MA, leur capacité de survie et leur pouvoir infectieux et comment les pratiques de conservation accroissent la survie de ces cryptogames, donc améliorent l'absorption du phosphore par les plantes et la stabilité des agrégats du sol.

Mots clés: Mycorhizes à arbuscules, conservation du sol, travail du sol classique, absorption du P, stabilité des agrégats, cultures abris, rendement des cultures

Tillage, the mechanical manipulation of soil, is a common practice in modern agriculture. Tillage is performed to enhance decomposition of crop residues through physical breakdown and incorporation into soil. Tillage is also used to level soil, prepare seedbeds for planting, and incorporate fertilizers, manures and pesticides. Additionally, it can serve as a method of post-emergence weed control and as a management tool to disrupt or reduce the incidence of diseases and pests. While tillage is necessary in many situations, it may also lead to soil degradation and environmental pollution. There are two main types of tillage systems, conventional (CT) and conservation (at least 30% residue left on the soil surface; Conservation Technology Information Center 1995). The general category of conservation tillage includes specific practices such as no-till (NT), ridge-tillage, reduced tillage (RT), shallow tillage and strip tillage. Reduced tillage systems are characterized by a reduction in the intensity or number of tillage operations compared to CT (generally autumn plowing plus spring disking). In RT sys-

Abbreviations: **AM**, arbuscular mycorrhizal; **CT**, conventional tillage; **NT**, no-till; **RT**, reduced tillage

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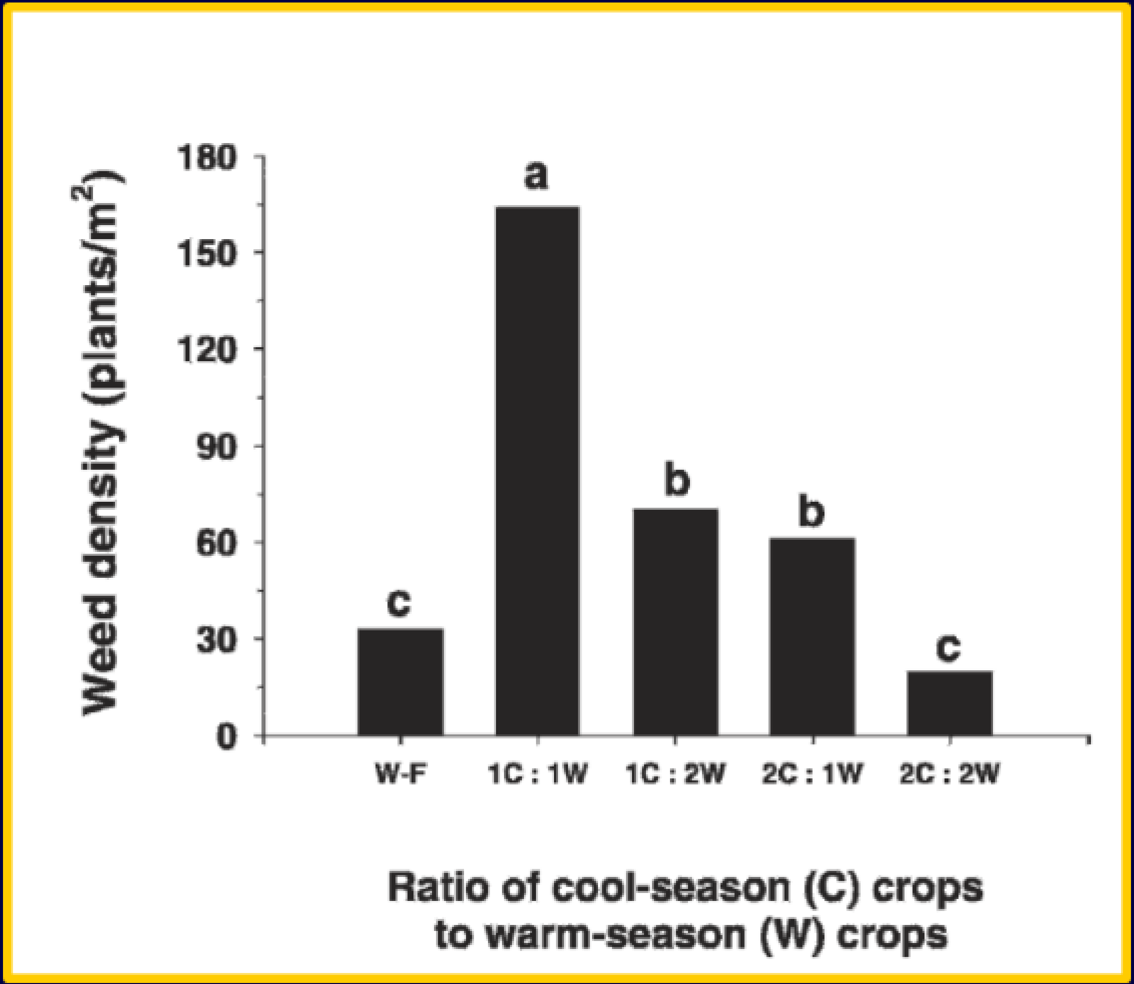
Impact of Rotation on Weeds



R.L. Anderson. 2008. Diversity and no-till: Keys for pest management in the U.S. Great Plains. Weed Sci. 56:141-145.

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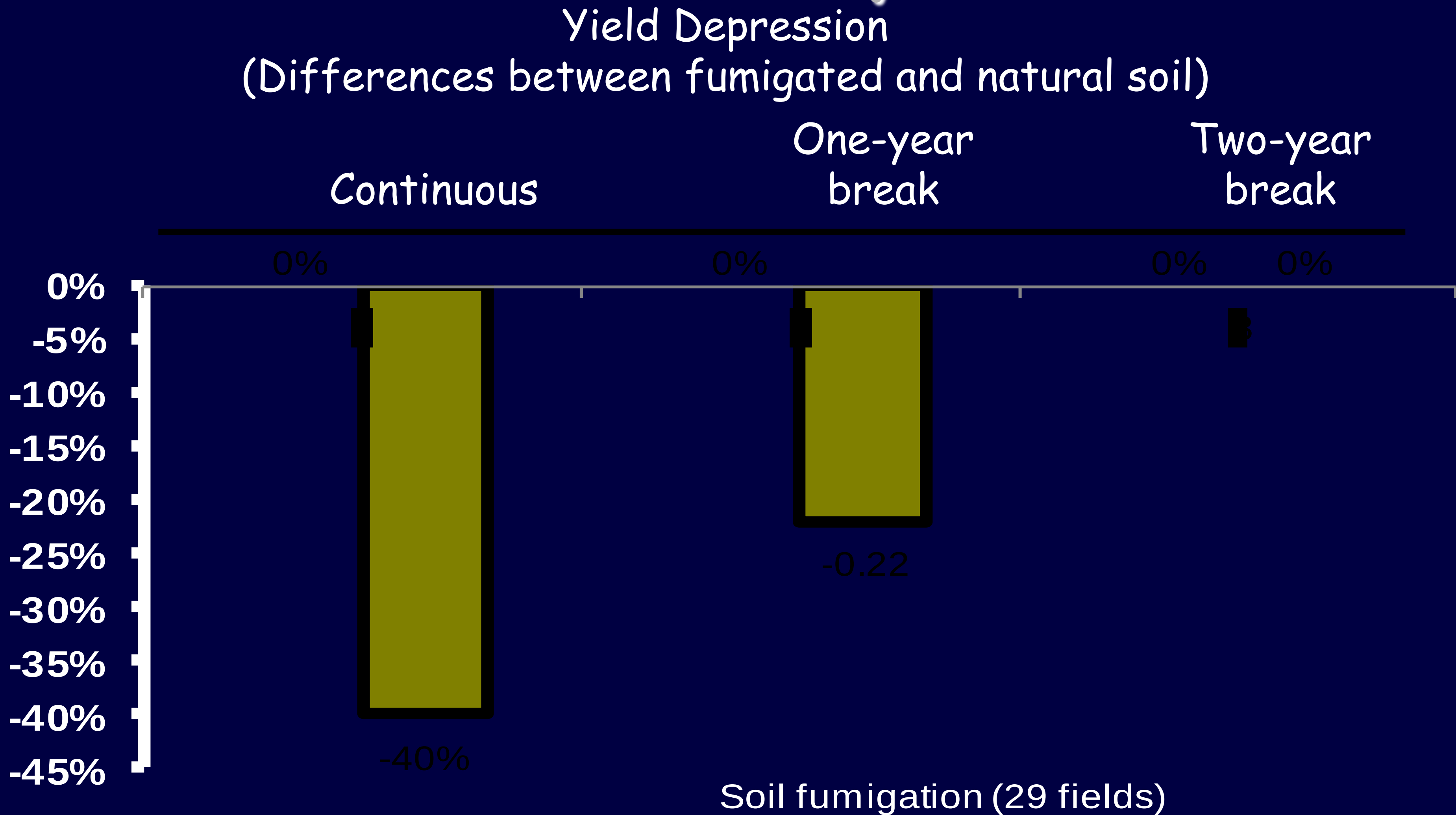
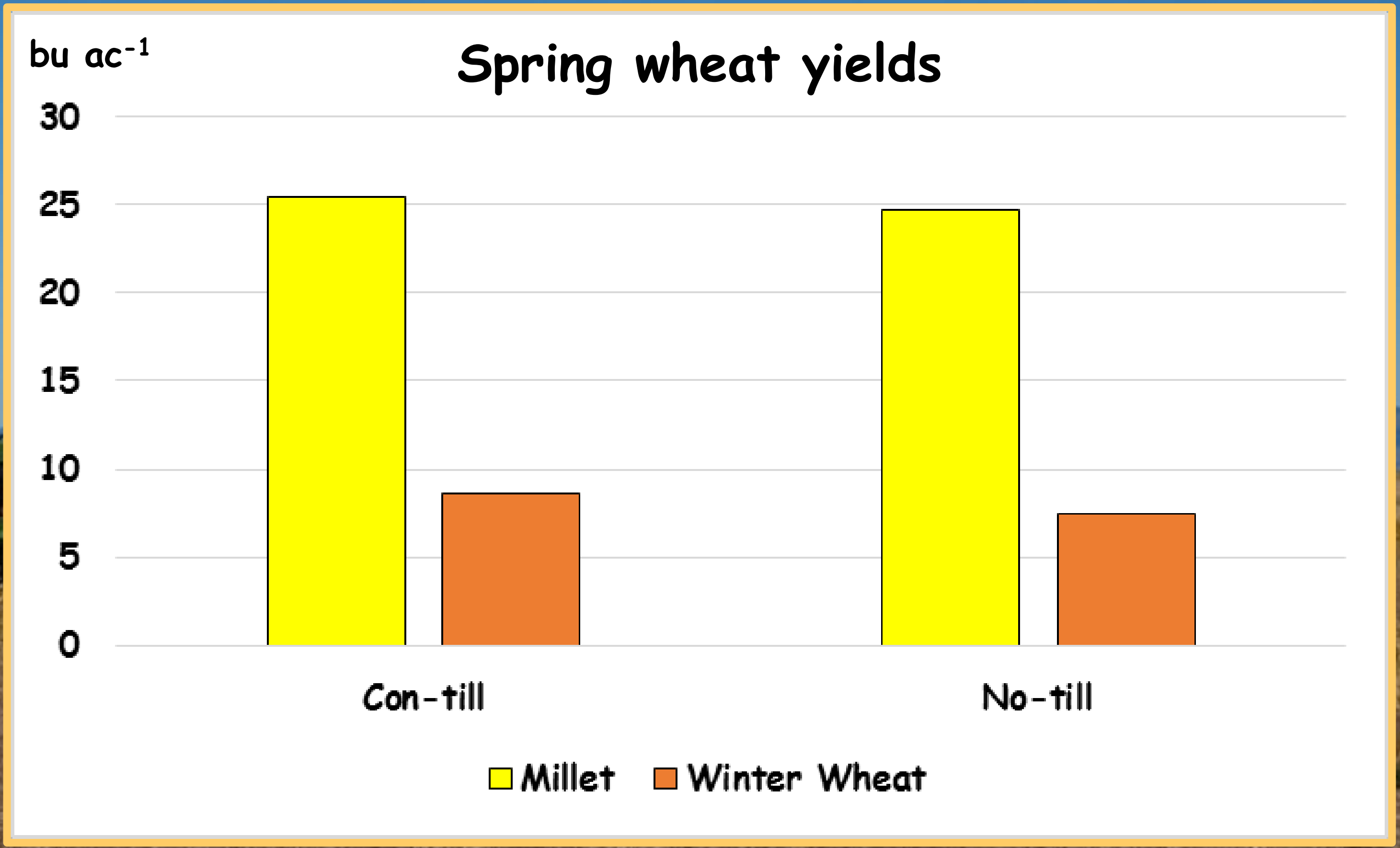
Wheat Rotations Summary



Ashley, R.O., et al 2000

Rotation And Tillage Systems (RATS)



Intensification/Diversification Challenges

- **Demands high level of management skill (more crops, more markets, more pests, more …)**

10%

70%

V.M. Davis et al. 2008. *Crop Management* doi:10.1094/CM-2008-0721-01-BR.

Impact of tillage on soil pH

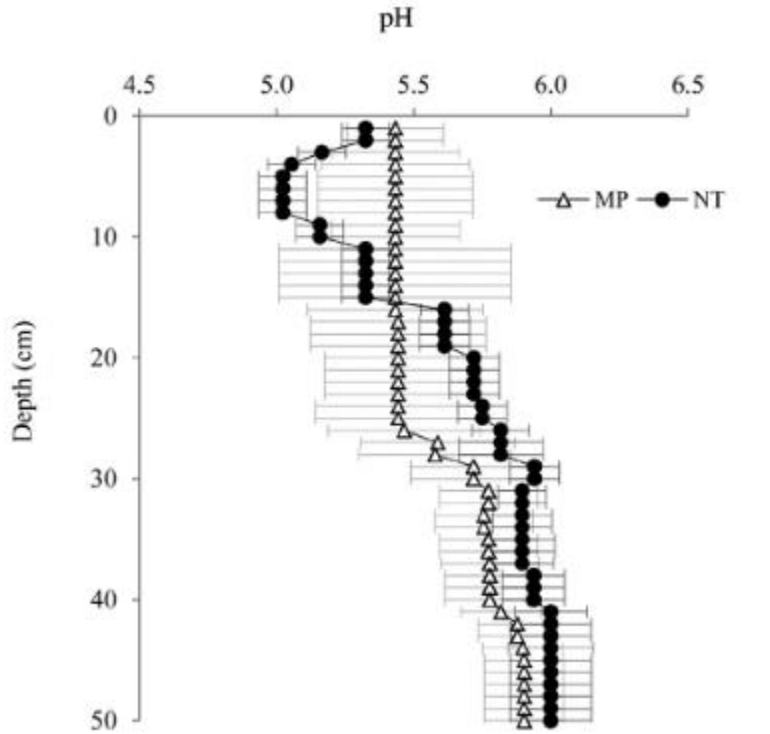


Fig. 5. Influence of tillage system on soil pH. Black circles: no-till (NT); open triangles: mouldboard ploughing (MP). Error bars indicate standard error.

I. Martinez et al. 2016. Soil & Tillage Research 163:141-151.

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Dryland Crop Choices

Cool-season cereals

Cool-season broadleaves

Warm-season cereals

Warm-season broadleaves

Forages

Cover crops

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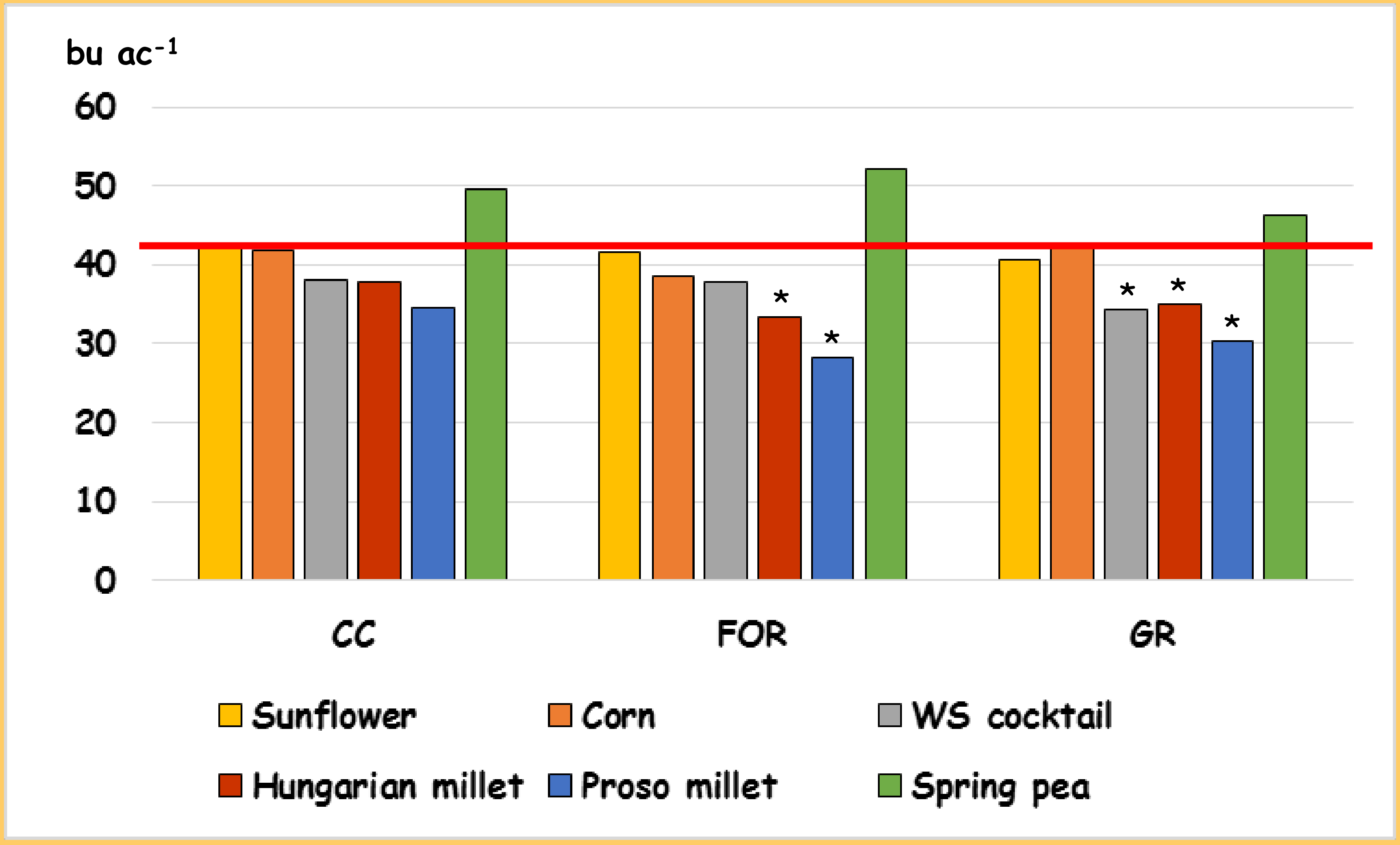
Winter wheat grain yield following five warm-season crops and spring pea grown for cover, forage, and grain at Moccasin, MT



Erosion protection

Enhanced profitability

Nutrient cycling

Weed suppression

Increased SOC

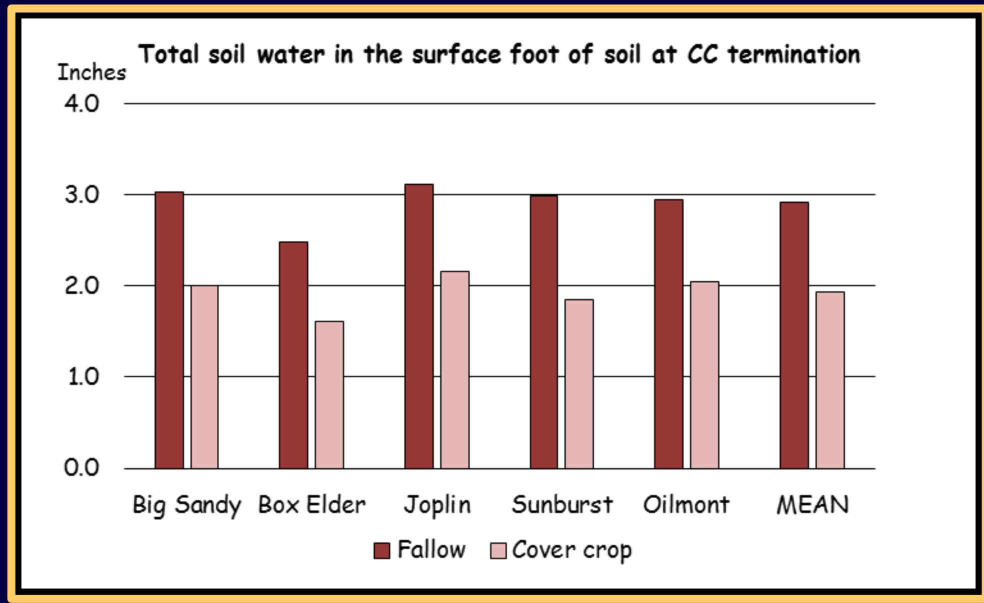
Nitrogen retention

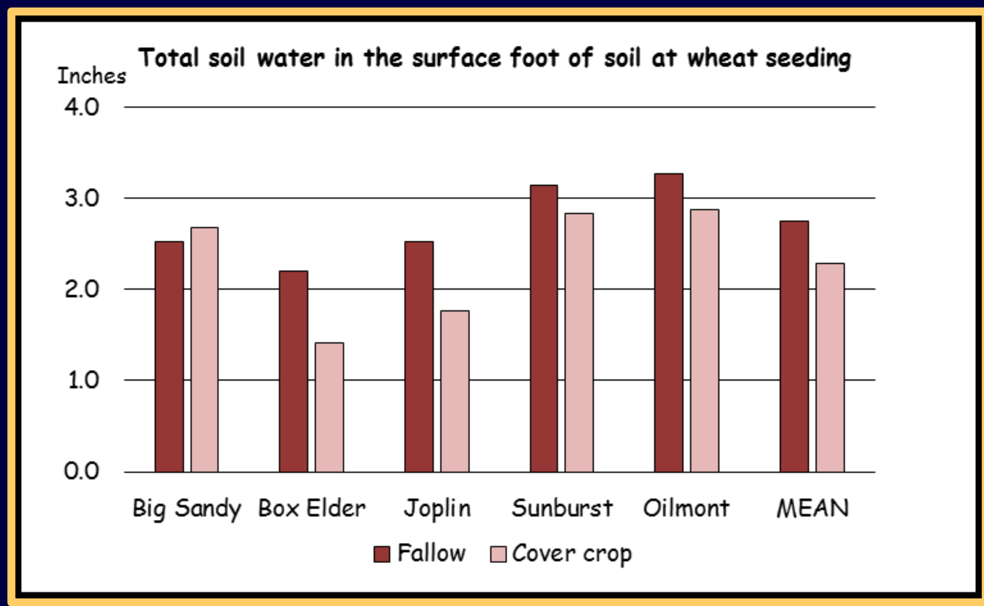
Disease regulation

Grazing opportunity

Nitrogen supply

http://organicgrowersschool.org/wp-content/uploads/2016/12/Gabe-Brown-in-Corn-Field.jpg





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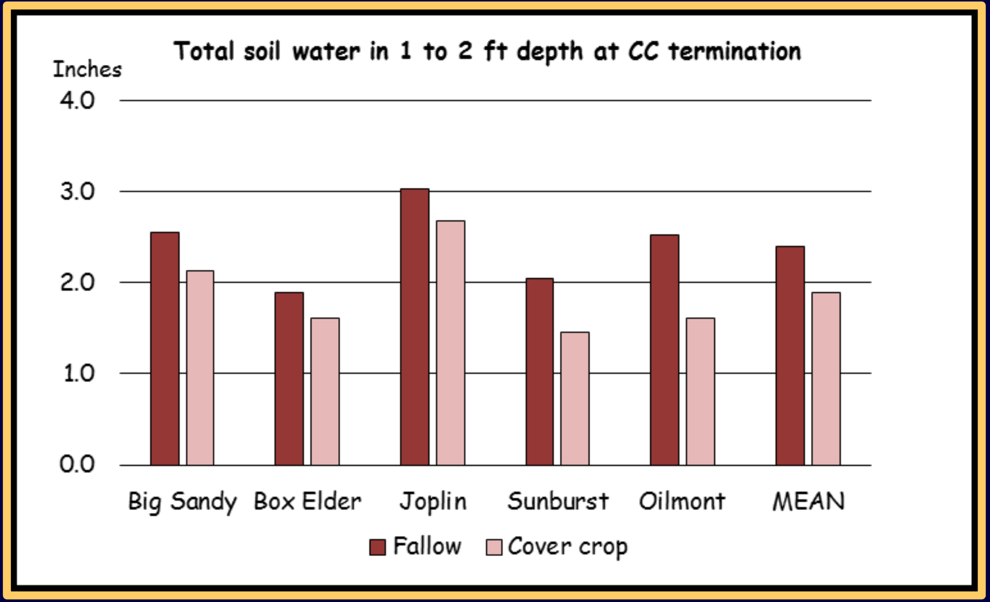
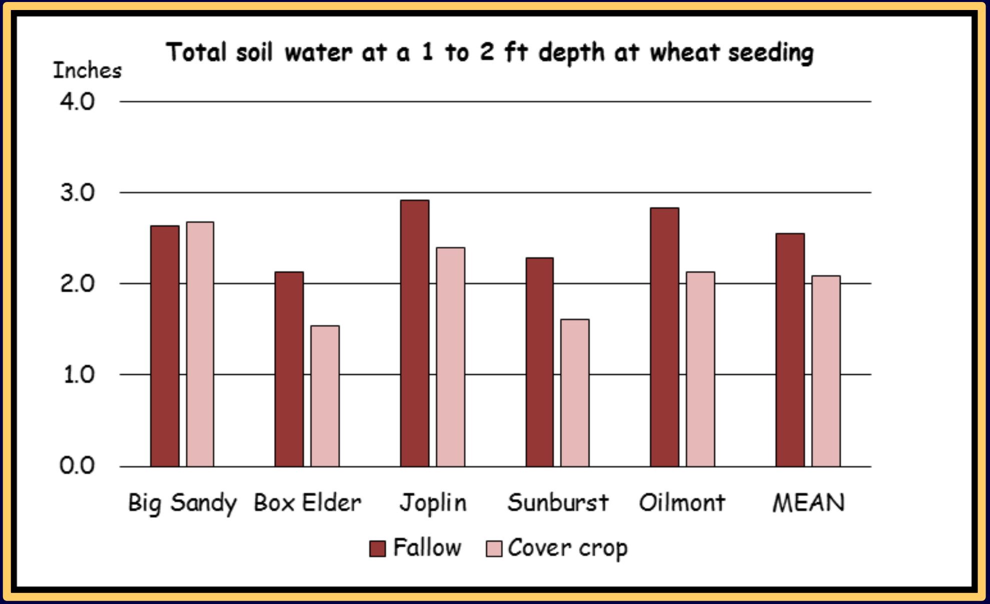
J.K. O'Dea, P.R. Miller, and C.A. Jones. 2013. *Journal of Soil & Water Conservation* 68:270-282.





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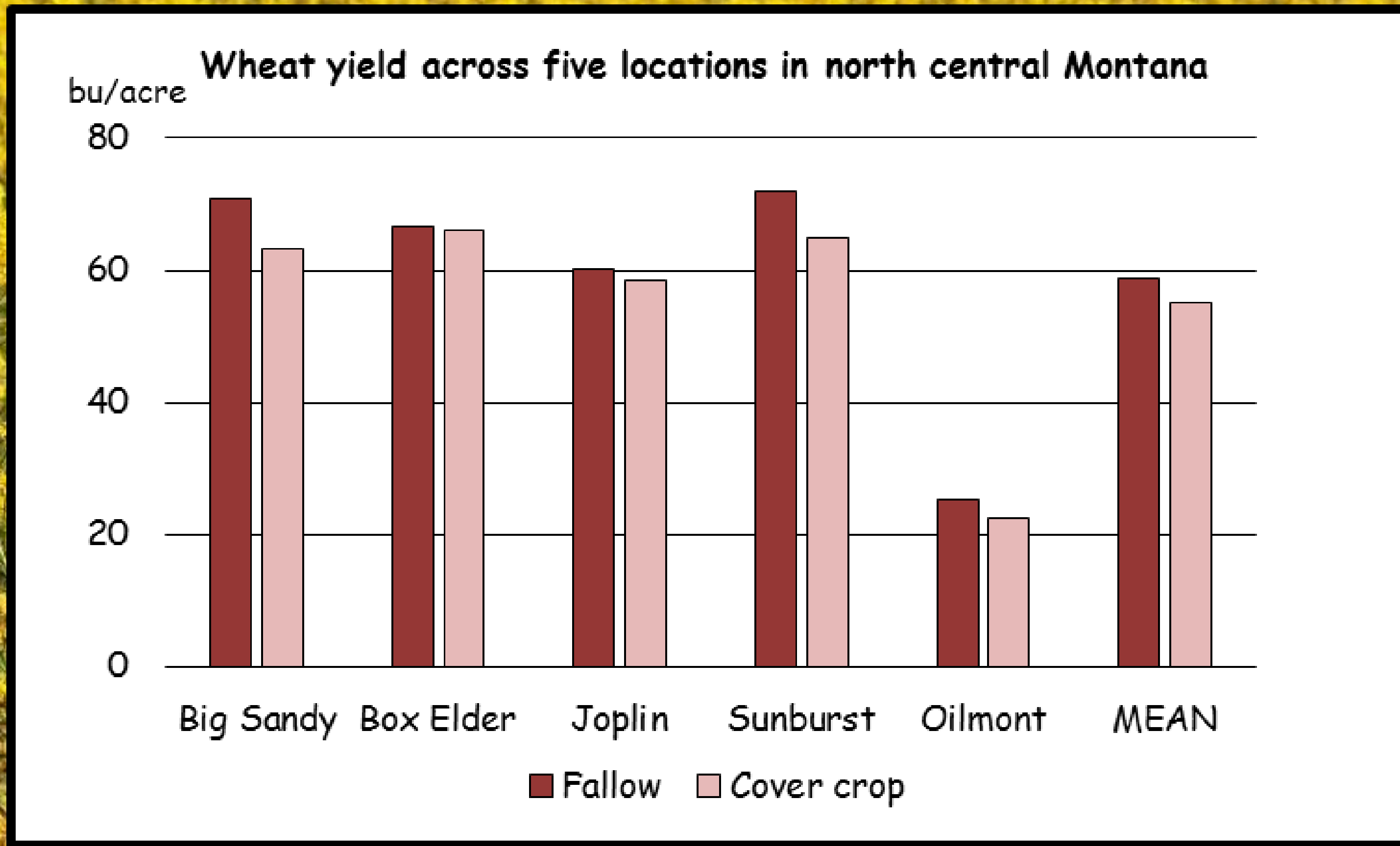

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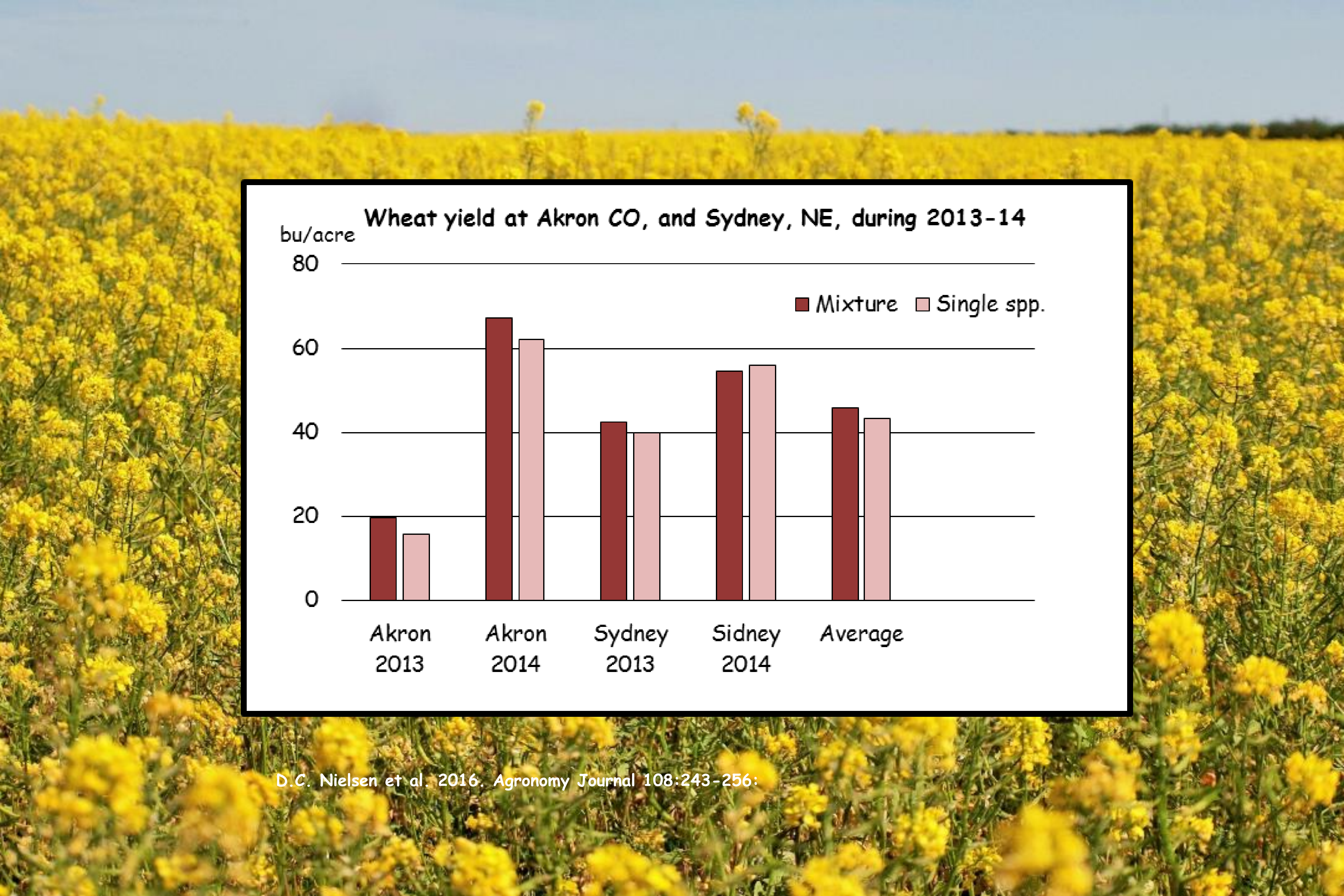
Wheat yield at Akron CO, and Sydney, NE, during 2013-14
bu/acre
80
60
40
20
0
Mixture
Single spp.
Akron 2013
Akron 2014
Sydney 2013
Sidney 2014
Average
D.C. Nielsen et al. 2016. Agronomy Journal 108:243-256:

What will research program look like in the future?


atlas

Optimistic people play a disproportionate role in shaping our lives… [They are] not average people [and] *got* to where they are by seeking challenges and taking risks.

Daniel Kahneman, psychologist

Patrick M. Carr

Superintendent

Associate Professor of Cropping Systems

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