Cropping Systems Research: Present and Future

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Associate Professor & Superintendent
Montana State University
Central Ag Research Center

CARC Research Roundup
7 December, 2017
• 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
Wheat - Summer fallow

Over 3 million acres of fallow in Montana in 2016

#2 "crop" after wheat!
Efficiency of water storage in a winter wheat-fallow system.

July (Harvest)
- Stage I
  - 2.5 mo
  - 10 to 35% Precipitation stored
  - High air temperature
  - Soil surface at WP

September
- Stage II
  - 7.5 mo
  - 50 to 85% Precipitation stored
  - Low air temperature
  - Soil surface at FC
  - Lower soil at WP

May
- Stage III
  - 4.5 mo
  - - 4 to 5% Precipitation stored
  - High air temp.
  - Soil profile at FC

September

Copied from Peterson and Westfall (2004).
Intensify and Diversity

- New Markets
- Reduced N Leaching
- Precipitation use efficiency
- SOM increases
- Improved fertility
- Soil tilth improvements
- Soil erosion control
- Pest suppression
The Secret of NT’s Success?

• Reduce evaporation
• Increase snow catch
• Improve infiltration
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.
**Wheat yield following selected crops**

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<tr>
<th>Crop</th>
<th>Bozeman Grain yield</th>
<th>% Fallow</th>
<th>Denton Grain yield</th>
<th>% Fallow</th>
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## Annual Cropping VS. Wheat-Fallow

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Technology Improvements
**Annual Cropping VS. Wheat-Fallow**


**Crop and Rotation**

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**Graph:**

- **Yield (kg/ha)**: 0 to 4000
- **Soil Moisture Depth (m)**: 0 to 1.4

**Legend:**

- WW = Wheat-Fallow
- WT = Wheat-Till

**Legend Notation:**

- WW = 90%
Rotation And Tillage Systems (RATS)

Wheat yields

bu ac⁻¹

- Con-till
  - Fallow
  - Spring Wheat
  - Winter Lentil
  - Winter Pea

- No-till
  - Fallow
  - Spring Wheat
  - Winter Lentil
  - Winter Pea
No-till adoption possible SOC capture and retention strategy

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.
No till can result in cooler soil temperatures in the spring.
Another NT plug ...

"... AM hyphae, which overwintered in the field remained viable 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

Zihefang Li, Belton

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

Lihe, Z. 1995. Tillage or no-tillage: Impact on mycorrhizae. Can. J. Plant Sci. 75:23–30. Arbuscular mycorrhizal (AM) fungi are ubiquitous, obligate biotrophs in almost all plants and major mycorrhizal symbionts. The presence of AM fungi is considered to depend on the formation and survival of propagules, i.e., spores, hyphae, and infected root tips. While spores are essential to the survival structure that may be seen as long-term propagules, spores root hyphae can remain viable but are not present. AM hyphae are considered to be the main source of inocula when plants are present and the soil is not disturbed. Tillage is a major cultural practice that can modify the physical, chemical and biological properties of the soil. Consequently, tillage greatly affects the survival of AM fungi. The various effects of tillage on the survival of AM fungi were not examined in the present study. This may negatively impact the survival of AM fungal propagules, limiting soil conserving AM fungi may survive while others may die. The disturbance of AM fungal propagules by tillage is of major importance in the present study. The survival of AM fungal propagules in soil may directly influence the level of initial colonization of P.

Tillage is particularly detrimental to AM fungi if the soil is wet and soil structure is disrupted. This study was conducted in the field to evaluate the effects of tillage on AM fungi in soil and the growth of P. The effects of tillage on AM fungal propagules in soil were evaluated at the seedling stage and at the harvest stage. The effects of tillage on AM fungal propagules in soil were evaluated at the seedling stage and at the harvest stage. The effects of tillage on AM fungal propagules in soil were evaluated at the seedling stage and at the harvest stage. The effects of tillage on AM fungal propagules in soil were evaluated at the seedling stage and at the harvest stage. The effects of tillage on AM fungal propagules in soil were evaluated at the seedling stage and at the harvest stage.

Key words: Arbuscular mycorrhizal fungi, conservation tillage, conventional tillage, P uptake, soil mycorrhizal diversity, root crops, soil fertility

Lihe, Z. 2005. Tillage and conservation in the soil. In: Biocontrol of soil-borne diseases, pp. 23–28. Z. Lihe, ed. EMARKS, University of California, Davis, CA, USA. The role of AM fungi in soil health and plant growth is highlighted. AM fungi are considered to be the main source of inocula when plants are present and the soil is not disturbed. Tillage is a major cultural practice that can modify the physical, chemical and biological properties of the soil. Consequently, tillage greatly affects the survival of AM fungi. This may negatively impact the survival of AM fungal propagules, limiting soil conserving AM fungi may survive while others may die. The disturbance of AM fungal propagules by tillage is of major importance in the present study. The survival of AM fungal propagules in soil may directly influence the level of initial colonization of P.

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Impact of Rotation on Weeds

Wheat Rotations
Summary
Yield Depression
(Differences between fumigated and natural soil)

Soil fumigation (29 fields)
Ashley, R.O., et al 2000
Rotation And Tillage Systems (RATS)

Spring wheat yields

bu ac\(^{-1}\)

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Intensification/Diversification Challenges

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

  10% 70%
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.

Dryland Crop Choices

- Cool-season cereals
- Cool-season broadleaves
- Warm-season cereals
- Warm-season broadleaves
- Forages
- Cover crops
Winter wheat grain yield following five warm-season crops and spring pea grown for cover, forage, and grain at Moccasin, MT.
Total soil water in the surface foot of soil at CC termination

Total soil water in the surface foot of soil at wheat seeding
Wheat yield at Akron CO, and Sydney, NE, during 2013-14

bu/acre

Akron 2013  Akron 2014  Sydney 2013  Sidney 2014  Average

Mixture  Single spp.
What will research program look like in the future?
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