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# Long-Term Organic and Tillage Study (LOTS) Results from a Cropping System in Transition from Conventional to Organic Management

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## Research Summary

Many producers are diversifying wheat-based systems to improve the economics of dryland crop production. The Long-Term Organic and Tillage Study (LOTS) began in 1999 with the objectives of identifying cropping systems that optimize economic returns and renewable energy use. A 6-yr rotation was included in which no synthetic fertilizers or pesticides are applied. This rotation included alfalfa (*Medicago sativa* L. subsp. *sativa* var. *sativa*), hard red spring (HRS) wheat (*Triticum aestivum* L. emend. Thell.), flax (*Linum usitatissimum* L.) , and yellow-flowered (YF) sweetclover (*Melilotus officinalis* Lam.) and was developed jointly by researchers and practicing organic agriculturists. A severe infestation of grass and broadleaf weeds developed in 1$^{st}$-yr alfalfa and flax plots in 2000. The organic rotation has been revised so that weed pressure can be reduced. The study is ongoing.

## Introduction

Dryland wheat-fallow monoculture no longer is viable economically in much of the Great Plains. Producers and researchers alike are exploring alternative cropping systems. Two independent agronomy boards have directed scientists at the Dickinson Research Extension Center (DREC) to study alternative cropping practices, including organic systems. In response to this directive, the Long-Term Organic and Tillage Study (LOTS) was established.

## Materials and Methods

Two 4-yr rotations and one 6-yr rotation were established in 30 ft x 100 ft plots in a replicated and randomized design at the Dickinson Research Extension Center in 1999. The rotations were developed jointly by scientists and commercial agriculturists in North Dakota. The 4-yr rotations include: (i) [1] hard red spring (HRS) wheat - [2] pea (*Pisum sativum* L. subsp. *sativum*) - [3] winter wheat [1] - [4] canola (*Brassica napus* L.); and (ii) [1] HRS wheat - [2] pea - [3] corn (*Zea mays* L.) - [4] buckwheat (*Fagopyrum esculentum* Moench.) The 6-yr rotation include: [1] HRS wheat - [2] alfalfa - [3] alfalfa - [4] flax - [5] HRS wheat + YF sweetclover - [6] YF sweetclover [plowdown]. Continuous HRS wheat also is included in the study.

The 2, 4-yr rotations and the continuous HRS wheat monoculture are managed without tillage, while tillage is used in the 6-yr rotation. Conventional fertilizer and pesticides are used in the 4-yr rotations and the HRS wheat monoculture, but not in the 6-yr rotation.

Soil nutrient and water content, crop and weed vegetative growth, grain production, and other data are being collected. Data will be analyzed using PROC MIXED from SAS once the contrasting cropping systems have achieved a new steady state, which will not occur for several more yr. Means of yields for crops from the various rotations and the continuous HRS wheat monoculture are reported for both 1999 and 2000.

**Results and Discussion**

Hard red spring wheat yield averaged 22.1 bu/acre across the various cropping systems in 2000 (Table 1), compared with 32.1 bu/acre in 1999 (Table 2). The presence of wheat streak mosaic virus in HRS wheat plots partially explains the low mean yields in 2000 compared with yields in 1999.

Average yields ranged from 17.7 bu/acre for HRS wheat grown after flax in the 6-yr rotation to 25.7 bu/acre in a 4-yr rotation in 2000 (Table 1). Average yield of the continuous HRS wheat monoculture was 24.1 bu/acre. These data suggest that yield of HRS wheat was depressed following flax. This depression may have resulted from severe weed infestations in flax compared with other crops in 1999, resulting in a lower yield of the HRS wheat crop which followed in 2000.

Weed biomass production appeared greater in HRS wheat plots in the 6-yr rotation than in the 4-yr rotations or the continuous HRS wheat monoculture. No herbicides are used to control weeds in the 6-yr rotation, while herbicides are used in the 4-yr rotations and the continuous HRS wheat monoculture. The first 2 yr of the LOTS suggest that yield depression can occur when weeds are not controlled with herbicides and weed management is not an important consideration when developing a crop rotation.

Yield of pea averaged 40.3 bu/acre across the 2 4-yr rotations in 2000 (Table 3). Pea yield averaged 23.4 bu/acre in 1999 (Table 4). Climatic conditions favored pea more in 2000 than in 1999. Pea yields in 1999 and 2000 suggest that pea is adapted to growing conditions in southwestern North Dakota. In addition, few pest problems occurred in pea plots in either yr.

Yield of canola averaged 22.4 bu/acre in 2000 and 23.4 bu/acre in 1999 (Tables 5 and 6). Hot dry conditions limited canola seed production in 2000, and residual herbicide carryover (Pursuit) damaged canola plants in some plots in 1999.

Yield of flax averaged only 4.5 bu/acre in 2000 (Table 5). Flax yield averaged 12.7 bu/acre in 1999 (Table 6). The low yield of flax in both yr probably resulted from weed infestations that developed in plots, particularly in 2000.

Birds destroyed sunflower plots before seed was harvested in 1 of the 4-yr rotations in 1999. As a result, buckwheat was sown in place of sunflower in 2000. Buckwheat produced an average seed yield of only 10.3 bu/acre across plots (Table 5), even though early-season vegetative growth suggested yield levels around 40 bu/acre would be produced.

Hot dry conditions occurred during most of the period when buckwheat was flowering. Low yields result when hot dry conditions coincide with flowering, making buckwheat a risky crop to grow in some yr at Dickinson.

Hail in August destroyed corn plots in 1999. Corn grain yields averaged 59.1 bu/acre across plots in 2000, making corn the most productive grain or seed crop on a lb/acre basis (Table 5). Previous research at Dickinson identified corn as a productive crop when grown for grain in southwestern North Dakota (Carr, 2000). Growers in southwestern North Dakota are cautioned, however, that growing corn for grain can be risky. Carr (2000) concluded that cold temperatures limit grain production of many cultivars about 30% of the time.

Corn silage yield averaged 2.2 t/acre of dry matter in 2000 (Table 7). Dry matter yields of alfalfa and YF sweetclover were < 1 t/acre. Weed infestations developed in sole-seeded alfalfa plots in 1999. Vegetative growth suggested that competition from weeds for nutrients and water stressed alfalfa plants, resulting in low forage yields in 2000. Heavy feeding by the sweetclover weevil explains the low forage yield of YF sweetclover in 2000.

A LOTS site visit by some members of the DREC Agronomy Organic Advisory Board was made during the growing season in 2000. Following the site visit, board members agreed with DREC scientists that the 6-yr rotation needed modification so that weed pressure could be reduced. A new 6-yr rotation was developed by members during a January board meeting and will be established in 2001. The 6-yr rotation is:

[1] oat/pea - [2] HRS wheat+alfalfa - [3] alfalfa - [4] alfalfa - [5] HRS wheat - [6] corn

where:

- the oat/pea intercrop is hayed,
- alfalfa is underseeded with HRS wheat when it first is established,
- 3$^{rd}$-yr alfalfa is plowed under and not hayed, and
- corn is grown for grain.

The short-term objective of the revised 6-yr rotation is to control weeds, not develop an organic system that will generate the highest net

economic returns. Comparisons of weed populations and HRS wheat performance in the 6-yr organic rotation, the conventional 4-yr rotations, and the continuous HRS wheat monoculture will be used to indicate if the short-term objective is achieved.

The revised 6-yr rotation incorporates both grain and forage crops and reflects diversified operations that include both crop and livestock enterprises, as is the case at the Dickinson Research Extension Center. Operations that include both crop and livestock enterprises are common in southwestern North Dakota.

**Acknowledgments**

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**Literature Cited**

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1 Dormant-seeded HRS Wheat or hard red w inter w heat.

| **Table 1.** 2000 LOTS, Wheat | | Dickinson, ND | |
|---|---|---|---|
| **Rotation** | **Yield** | **Kernel weight** | **Test weight** |
| | **bu/ac** | **kernels/lbs** | **lbs/bu** |
| **HRS wheat**-Alfalfa-Alfalfa -Flax-HRS wheat-Sweetclover | 18.1 | 12,958 | 63.0 |
| HRS wheat-Alfalfa-Alfalfa-Flax-**HRS wheat**-Sweetclover | 17.7 | 13,772 | 60.9 |
| **HRS wheat**-HRS wheat | 24.1 | 14,122 | 59.0 |
| **HRS wheat**-Pea-Hard red winter wheat-Canola | 25.1 | 14,158 | 58.1 |
| **HRS wheat**-Pea-Corn-Buckwheat | 25.7 | 13,962 | 59.4 |
| Mean | 22.1 | 13,795 | 60.1 |

| **Table 2.** 1999 LOTS, Wheat | | Dickinson, ND |
|---|---|---|
| **Rotation** | **Yield** | **Test weight** |
| | bu/ac | lbs/bu |
| **HRS wheat**-Alfalfa-Alfalfa-Flax-HRS wheat-Sweetclover | 26.3 | 61.6 |
| HRS wheat-Alfalfa-Alfalfa-Flax-**HRS wheat**-Sweetclover | 31.2 | 60.7 |
| **HRS wheat**-HRS wheat | 34.3 | 60.7 |
| **HRS wheat**-Pea-Hard red winter wheat-Canola | 33.6 | 61.7 |
| **HRS wheat**-Pea-Corn-Buckwheat | 34.9 | 62.0 |
| Mean | 32.1 | 61.3 |

| **Table 3.** 2000 LOTS, Pea | | Dickinson, ND |
|---|---|---|
| **Rotation** | **Yield** | |
| | - lbs/ac - | - bu/ac - |
| HRS wheat-**Pea**-HRWW-Canola | 2347.5 | 39.1 |
| HRS wheat-**Pea**-Corn-Buckwheat | 2485.5 | 41.4 |
| Mean | 2416.5 | 40.3 |

| **Table 4.** 1999 LOTS, Pea | | Dickinson, ND |
|---|---|---|
| **Rotation** | **Yield** | |
| | - lbs/ac - | - bu/ac - |
| HRS wheat-**Pea**-HRWW-Canola | 1488 | 24.8 |
| HRS wheat-**Pea**-Corn-Buckwheat | 1314 | 21.9 |
| Mean | 1401 | 23.4 |

| **Table 5.** 2000 LOTS, Other Crops | | | Dickinson, ND |
|---|---|---|---|
| **Rotation** | **-----Yield-----** | | **--Test weight--** |
| | **lbs/ac** | **bu/ac** | **lbs/bu** |
| HRS wheat-Pea-Corn-**Buckwheat** | 496 | 10.3 | 45.4 |
| HRS wheat-Pea-HRWW-**Canola** | 1122 | 22.4 | 46.8 |
| HRS wheat-Pea-**Corn**-Buckwheat | 3312 | 59.1 | 56.8 |
| HRS wheat-Alfalfa-Alfalfa-**Flax**-HRS wheat-Sweetclover | 251 | 4.5 | 51.8 |
| HRS wheat-Pea-**HRWW**-Canola | 1,402 | 23.4 | 53.2 |

| **Table 6.** 1999 LOTS, Other Crops | | | Dickinson, ND |
|---|---|---|---|
| **Rotation** | **-----Yield-----** | | **--Test weight--** |
| | lbs/ac | bu/ac | lbs/bu |
| HRS wheat-Pea-HRWW-**Canola** | 1170 | 23.4 | --- |
| HRS wheat-Alfalfa-Alfalfa-**Flax**-HRS wheat-Sweetclover | 709 | 12.7 | --- |

| **Table 7.** 2000 LOTS, Forages | | | Dickinson, ND |
|---|---|---|---|
| **Rotation** | **Moisture** | **Yield** | **Plant stand** |
| | **%** | **t/ac** | **plants/ac** |
| Alfalfa | 70 | 0.7 | --- |
| Corn | 73 | 2.2 | 23,174 |
| Yellow-flowered sweetclover | 70 | 0.5 | --- |