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

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Research Summary

Tillage is declining in western North Dakota, and the practice of growing wheat without the use of synthetic fertilizers and pesticides (i.e., organic farming) is increasing. The objective of the Long-Term Organic and Tillage Study (LOTS) is to identify alternative cropping systems that optimize economic returns and non-renewable energy use. The study began in 1999 and includes a 6-yr rotation in which no synthetic fertilizers or pesticides are used (organic). This rotation originally included flax (*Linum usitatissimum* L.), but in 2001 the flax phase was replaced with an intercrop of oat (*Avena sativa* L.) and pea (*Pisum sativum* L. subsp. *sativum*) because of recurring weed infestations when flax was grown. Other crops in the 6-yr rotation include alfalfa (*Medicago sativa* L. subsp. *sativa* var. *sativa*), corn (*Zea mays* L.), and hard red spring wheat (wheat; *Triticum aestivum* L. emend. Thell.). Gross economic returns have been equal or greater for wheat in the organic rotation compared with wheat in other production systems. Grain yield of wheat following the oat-pea phase in the organic rotation compared favorably with grain yield of wheat in other production systems in 2002. Grain yield of wheat following the alfalfa phase in the organic rotation was lower than grain yield of wheat in other production systems in 2002 but generally not in 2001. Grain protein sometimes was lower for wheat in both phases of the organic rotation compared with other production systems. Grain test weight generally compared favorably for wheat grown in the organic rotation compared with wheat grown in other production systems. This research is ongoing.

Introduction

Dryland wheat-fallow and continuous annual wheat monoculture is declining in much of the Great Plains because of economic and environmental inefficiencies. Conversely, "chemical-free" wheat- production systems (i.e., organic farming) are expanding in the region. The Long-Term Organic and Tillage Study (LOTS) was established in response to these two developments and recommendations of two advisory boards that assist in developing the research agenda in agronomy at the Dickinson Research Extension Center.

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 4-yr rotations include: (i) [1] wheat – [2] pea – [3] wheat – [4] canola; and (ii) [1] wheat – [2] pea – [3] corn – [4] buckwheat (*Fagopyrum esculentum* Moench.) The 6-yr rotation include: [1] wheat + alfalfa – [2] alfalfa – [3] alfalfa plowdown – [4] wheat – [5] corn – [6] flax (1999 and 2000) or oat + pea for hay (2001 and 2002). Continuous wheat also is included in the study.

The 2, 4-yr rotations and the continuous 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 wheat monoculture, but not in the 6-yr rotation which is referred to as the "organic" rotation.

Grain and seed production data are collected each year. Soil nutrient and water content, crop and vegetative growth, and other data are collected on an intermittent basis, as extramural funding in support of the study is obtained. Wheat performance across the various cropping systems and phases are compared using PROC GLM from SAS. Data will be analyzed using PROC MIXED once the contrasting cropping systems have achieved a new steady state, which will not occur for several more years.

Results and Discussion

Grain yield of wheat following the oat-pea phase in the organic rotation was equal to grain yield of wheat in other production systems in 2002 (Table 1). Grain yield of wheat following alfalfa in the organic rotation was lower than grain yield for wheat in other production systems and in other phases of the organic rotation in 2002, and lower than grain yield of wheat in the wheat-pea-corn-buckwheat rotation in 2001. These preliminary data indicate that wheat yield may be reduced in organic systems compared with

conventional systems in some environments, and that crop rotation may have a greater impact on wheat yield than management system (conventional vs. organic). Unfortunately, the ability to separate the impacts of crop rotation from those of management system on wheat yield is beyond the current design of this study.

Grain protein was lower when wheat followed alfalfa than when wheat followed the oat-pea hay crop in the organic rotation in 2002 (Table 1). Grain protein was lower for wheat following alfalfa in the organic rotation than for wheat in a continuous monoculture in 2001. Alfalfa seedlings grew poorly when seeded with wheat in this study, and thin alfalfa stands remained after the wheat grain was harvested. Extensive feeding by alfalfa webworm in 2001 and alfalfa weevil in 2002 further damaged alfalfa stands. The few alfalfa plants that remained probably contributed relatively low amounts of biologically fixed nitrogen to the subsequent wheat crop, but may have remained in sufficient numbers to deplete soil moisture prior to seeding wheat. These data indicate that grain protein depression may result in some environments when wheat follows alfalfa under organic management.

Differences in grain protein were not detected for wheat across production systems where synthetic fertilizers and pesticides were applied in 2002 (Table 1). Grain protein was lower in wheat following pea than following canola in 2001, although protein yield (yield multiplied by protein) was similar between treatments (data not provided). We are unable to explain the grain protein depression for wheat following pea compared with canola in 2001, particularly since grain protein was elevated following pea compared with canola in other research at Dickinson in that year (data not provided).

Consistent trends in grain test weight were not detected among cropping systems in either 2001 or 2002 (Table 1). Test weight averaged more than 60 lb/bu across rotations and management systems in 2002, and slightly more than 59 lb/bu in 2001.

Gross economic returns were equal or greater for wheat grown organically compared with wheat receiving synthetic fertilizer and pesticide applications (data not provided). The premium paid for wheat grown organically explains why gross economic returns were greater for wheat produced organically.

Yields for other crops grown in different crop rotations in the LOTS in 2002 were low because of weed infestations (i.e., corn grown organically) and/or drought. Corn yield averaged 19 bu/acre when grown organically and 47 bu/acre when grown using applications of synthetic fertilizer and pesticides. Forage yield for alfalfa and the oat-pea intercrop averaged 0.5 tons/acre and 1.5 tons/acre, respectively. Buckwheat seed yield averaged 966 lb/acre; canola yield averaged <100 lb/acre.

Table 1. Performance of hard red spring wheat for selected traits in different crop rotations.

	Yield			Protein			Test weight		
Rotation[1]	2001	2002	mean	2001	2002	mean	2001	2002	mean
	--------- bu/acre --------			---------- % ----------			--------- lb/bu ---------		
Organic -(1)	--[2]	32.6	17.3	--[2]	16.1	9.1	--[2]	59.0	30.5
Organic -(4)	45.4	21.1	33.3	13.9	15.0	14.5	59.4	62.1	60.8
Continuous	44.8	27.8	36.3	15.5	16.4	16.0	60.2	62.2	61.2
Cool (1)	46.5	33.3	39.9	14.9	16.3	15.6	60.1	59.3	59.7
Cool (3)	49.3	36.4	42.9	13.6	16.7	15.1	59.3	60.5	59.9
Cool/Warm	56.0	37.2	46.6	14.9	16.3	15.6	58.7	60.5	59.6
Trial Mean	47.9	31.4	39.6	14.4	16.1	15.3	59.3	60.6	60.0
C.V. %	10.9	14.6	--	5.4	4.2	--	2.1	2.9	--
LSD .05	6.9	6.0	--	1.0	0.9	--	NS	2.3	--

NS = No statistical difference at the $P < 0.05$ level.

[1] Organic = (1) wheat + alfalfa - (2) alfalfa - (3) alfalfa plowdown - (4) wheat - (5) corn - (6) oat + pea (hayed); Continuous = wheat grown continuously; Cool = (1) wheat - (2) field pea - (3) wheat - (4) canola; Cool/Warm = (1) wheat - (2) field pea - (3) corn - (4) buckwheat.

[2]Flax was replaced with an oat-pea intercrop in 2001 so wheat was grown after the oat-pea mixture for the first time in 2002.