The Effect of Previous Crop and Rotation on Hard Red Spring Wheat (HRSW) Production in each Four-Year Cycle for the Past Twenty Years

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Abstract

In 1987, a long-term cropping systems study was initiated at the NDSU Carrington Research Extension Center. The study investigates individual and combined effects of crop rotation, fertility treatments, and tillage systems on crop establishment, biomass production, grain yield, grain quality, and numerous soil parameters. Data was analyzed using SAS GLM procedures with significant differences expressed at the P<0.05 level. Analysis to assess the effect of previous crop and rotation on hard red spring wheat (HRSW) performance during Cycle 1 (1987-1990) indicated significantly higher HRSW yield and protein content when wheat was preceded by fallow (Rotation 1) versus either soybean (Rotation 2) or barley (Rotation 3). In Cycle 2 (1991-1994) and Cycle 3 (1995-1998) wheat preceded by fallow (Fallow 1) again resulted in yield and protein content compared to preceding crops of soybean (Rotation 2, Cycle 2), field pea (Rotation 2, Cycle 3) and soybean (Rotation 2, Cycle 2) and field pea (Rotation 2, Cycle 3) had significantly higher yield than millet (Rotation 3, Cycle 2) and rye (Rotation 3, Cycle 3). In Cycle 4 HRSW preceded by field pea (Rotation 2) resulted in significantly higher yield and protein content compared to a preceding crop of canola (Rotation 3). Wheat performance during the most recent timeline of this experiment Cycle 5 (2003-2006), indicates significantly higher grain yield and protein content from wheat after field pea (Rotation 2) as compared to preceding crops of soybean (Rotation 1) or either of two phases of Rotation 3 when wheat was preceded by both canola and HRSW. In the earlier years of this experiment, fallow was still considered a viable cropping sequence and this data reflects positive wheat performance. The past two crop cycles (1999-2006) show that wheat followed by legumes in rotation improved grain yield and grain quality.

Objectives

Investigate the effects of crop rotation/previous crop on hard red spring wheat (HRSW) yield and grain protein content.

Materials and Methods

This study was initiated in 1987 and is conducted at the North Dakota State University Carrington Research Extension Center near Carrington, North Dakota, on a Heimdal-Emrick loam soil. It consists of three, four-year crop rotations with three replicates. Each crop in each rotation occurs in every year. Within each crop (0.45 ha main plot) in a rotation, three tillage systems (0.15 ha sub-plots) are imposed and four N fertility treatments are imposed perpendicular to the tillage systems (0.0375 ha sub-sub-plots) (Fig. 1). The crop rotations for the all cycles are listed in Table 1. The tillage systems are conventional (T), minimum tillage (M), and no-till (N). The N fertility treatments are ammonium nitrate broadcast applied each spring to non-leguminous non-fallow plots at 0, 45, or 90 kg ha^{-1} or as manure (M) applied at 179 kg ha^{-1} of N the first spring of each four-year rotation to all. The crop rotations were designed to test varying crop types and water use intensities on crop yield, crop quality, diseases, insects, weeds, and soil nitrogen (N), phosphorous (P), organic matter (OM), and pH against the traditional crop rotation in the area. The crops are planted and harvested each year in a timely fashion as weather and time permit. Plots were soil sampled each fall after harvest.

Figure 1. Layout of the study

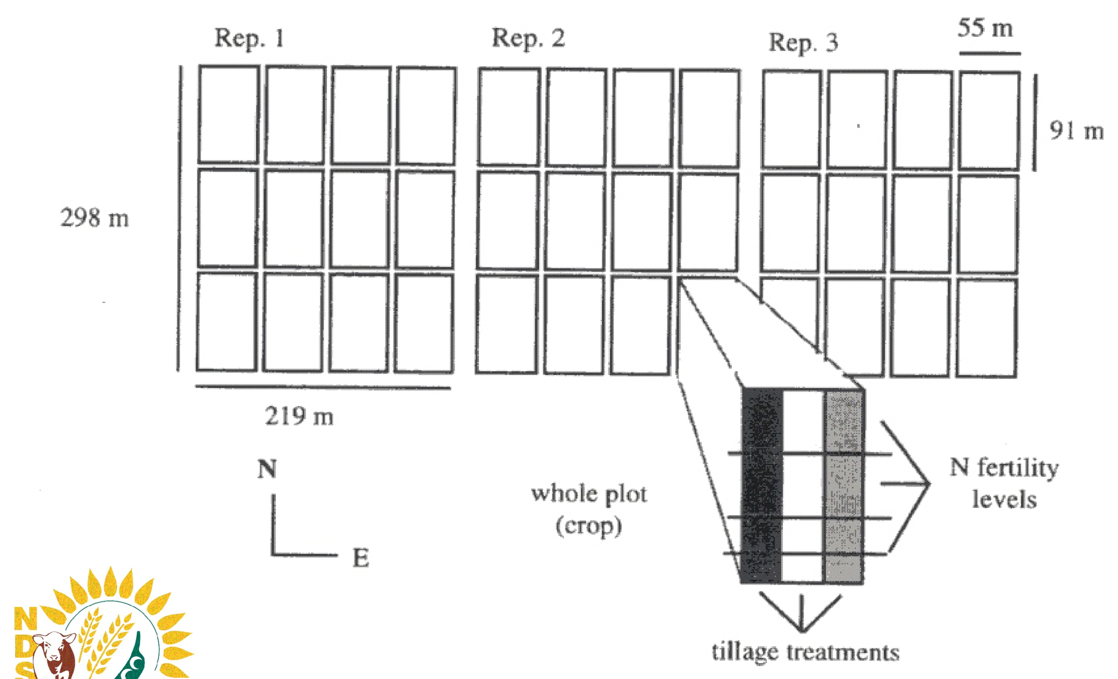


Table 1. CREC Cropping Systems Study Crop Rotations 1987-2006.

Years	Cycle	Rotation	Year 1	Year 2	Year 3	Year 4
1987-1990	Cycle 1	1	HRSW	Sunflower	Barley	Fallow
1991-1994	Cycle 2	1	HRSW	Sunflower	Barley	Fallow
1995-1998	Cycle 3	1	HRSW	Sunflower	Barley	Fallow
1999-2002	Cycle 4	1	HRSW	Sunflower	Barley	Fallow
2003-2006	Cycle 5	1	HRSW	Sunflower	Barley	Soybean
1987-1990	Cycle 1	2	HRSW	Alfalfa	Corn	Soybean
1991-1994	Cycle 2	2	HRSW	Sweetclover	Corn	Soybean
1995-1998	Cycle 3	2	HRSW	Soybean	Millet	Field Pea
1999-2002	Cycle 4	2	HRSW	Soybean	Durum	Field Pea
2003-2006	Cycle 5	2	HRSW	Soybean	Corn	Field Pea
1987-1990	Cycle 1	3	HRSW	Sunflower	Corn	Barley
1991-1994	Cycle 2	3	HRSW	Buckwheat	Sunflower	Millet
1995-1998	Cycle 3	3	HRSW	Buckwheat	Sweetclover	Rye
1999-2002	Cycle 4	3	HRSW	Corn	Soybean	Canola
2003-2006	Cycle 5	3	HRSW	HRSW	Soybean	Canola

Results

Years

As one would expect, year affected yield and protein across all cycles (Fig. 2 & 3).

Crop Rotation

In Cycle 1, where fallow preceded HRSW (Fallow 1), HRSW had a significantly higher yield than the other two rotations (Soybean 2 and Barley 3) that had a crop preceding HRSW (Fig. 2). However, protein content was significantly higher for Fallow 1 and Barley 3 than Soybean 2 (Fig. 3). This was in part due to no prior history of soybean production which resulted in very poor nodulation and N fixation. Also, fallow stimulates N mineralization and therefore provided more N to the following HRSW crop than the legume credit.

In Cycle 2, where fallow preceded HRSW (Fallow 1), HRSW had a significantly higher yield and protein content than Soybean 2 which in turn was significantly higher yield than Millet 3 (Fig. 2 & 3). This was again in part due to only one soybean crop four years prior which resulted in very poor nodulation and N fixation. Again, fallow stimulates N mineralization and therefore provided more N to the following HRSW crop than the legume credit.

In Cycle 3, where fallow preceded HRSW (Fallow 1), HRSW had a significantly higher yield than Field Pea 2 and Rye 3 (Fig. 2). Fallow 1 had significantly higher protein content than Field Pea 2 and Rye 3 (Fig. 3). This was in part due to no prior history of field pea production which resulted in very poor nodulation and N fixation. Again, fallow stimulates N mineralization and therefore provided more N to the following HRSW crop than the legume credit.

In Cycle 4, where field pea preceded HRSW (Field Pea 2), HRSW had a significantly higher yield than when canola preceded HRSW (Canola 3) (Fig. 2). However, there was no difference between Fallow 1 and Field Pea 2. Grain protein was significantly higher in Fallow 1 than Field Pea 2 which in turn was significantly higher than Canola 3 (Fig. 3). Therefore Fallow 1 provided more N to the following HRSW crop than the legume credit.

- In Cycle 5, where field pea preceded HRSW (Field Pea 2), HRSW had a significantly higher yield than both phases of Rotation 3 (Canola 3 and Wheat 3) (Fig. 2). Soybean 1 had significantly higher yield than HRSW 3 (Fig. 2). This shows the benefit of the additional N credit from the legumes and the benefits of dissimilar crops preceding wheat verses wheat on wheat. Field Pea 2 had significantly higher protein content than both phases of Rotation 3 (Canola 3 and Wheat 3) (Fig. 3). Soybean 1 had significantly higher protein content than Canola 3 (Fig. 3). This shows that Field Pea 2 has provided an additional N credit above the non-legume broadleaf crop. It also shows that Soybean 1 provided an additional N credit over Canola 3, another broadleaf crop but a heavy N user. However, the higher yield of the Soybean 1 verses the Wheat 3 attributed to the non-significantly different protein content.

Figure 2. Effect of Previous Crop on Grain Yield.

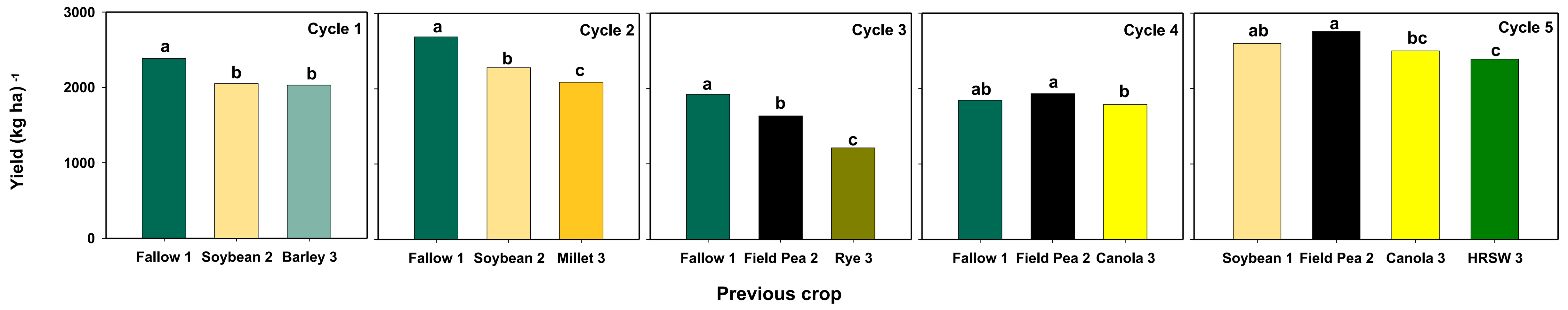
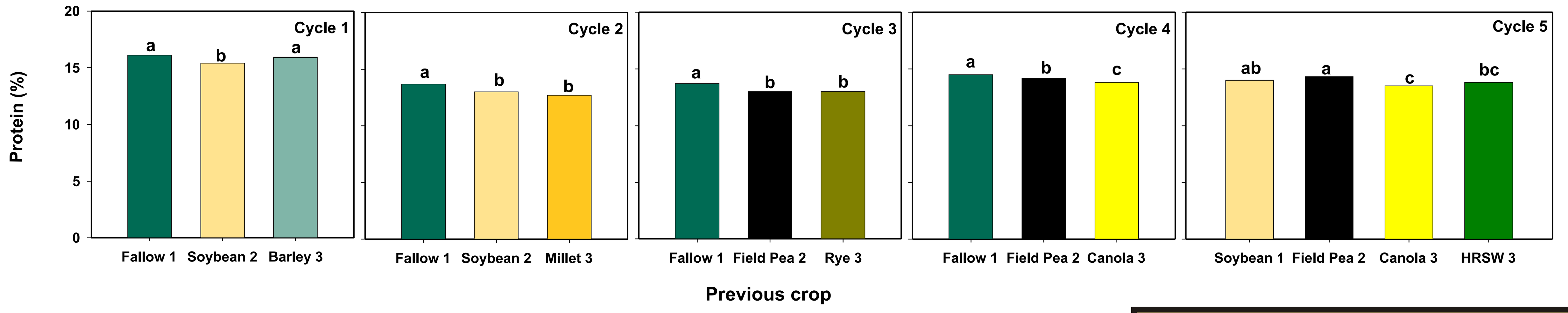


Figure 3. Effect of Previous Crop on Grain Protein.



No-till planting barley into sunflower stubble that followed HRSW.

An aerial view of the Cropping Systems Study looking south.

Conclusions

Field Pea was able to provide additional yield and protein content of HRSW verses the other crops preceding HRSW except the first time it was grown in the rotation.

Soybean was able to provide additional yield except the first time it was grown in the rotation verses the other crops preceding HRSW. However, it did not always significantly increase protein content of HRSW verses the other crops preceding HRSW.

Small grain such as millet, rye, and spring wheat, as the previous crop of spring wheat had negative impacts on both grain yield and protein content of spring wheat compared with legume crops such as soybean and field pea.

Fallow, which is no longer an accepted practice due to erosion and lack of revenue, was able to increase HRSW yield and protein content verses crops preceding HRSW due to N mineralization and potential moisture storage.

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