Winter Wheat – Chemical Fallow Can Replace Conventional Tillage Winter Wheat - Summer Fallow in North-Central Oregon

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Introduction

Wheat-fallow rotation (WW-SF) is predominant cropping system in North-Central Oregon (NCO) where rainfall is considered inadequate to produce a crop every year. Fallowing is used primarily to store winter precipitation, allow mineralization of nutrients (N, S), and control weeds and is economical where rainfall is less than 330 mm. WW-SF, however, depletes soil organic carbon (SOC), exacerbates soil erosion and it is not biologically sustainable. Despite these concerns, adoption of alternate systems such as direct seeding (DS, no-till) has been slow due to limited long-term research in NCO on viability of these alternate cropping systems. DS involves seeding and fertilizing in one pass using a no-till drill. No-till has been shown to increase residue cover, increase soil SOC, increase available soil moisture, reduce soil loss by wind and water erosion, and reduce soil water evaporation. The main objective of this experiment was to evaluate DS cropping systems and develop biologically and economically sustainable cropping systems that can replace WW-SF in NCO.

Materials and Methods

The experiment was conducted at the Columbia Basin Agricultural Research Center (CBARC) at Moro, Sherman County, OR. The site has an elevation of 575 m and receives 297 mm mean annual precipitation, nearly all of which occurs from late autumn (October) through spring (May). Mean daily air temperature is 30°F during January and 66°F during July and August. Soil is a moderately deep (mostly >1.5 m) Walla Walla silt loam (coarse-silty, mixed, superactive, mesic Typic Haploxeroll). The experiment was initiated in the 2003-04 crop-year and consist of 42 plots of 14.6 m × 107 m arranged as 14 treatments of eight crop rotations, randomized within three blocks.

In this long-term experiment (LTE), initiated in 2003-04 crop-year, WW-SF, was compared to DS systems that included annual winter wheat (WW-WW), annual spring wheat (SW-SW), annual spring barley (SB-SB), winter wheat-chemical fallow (WW-CF), winter wheat-winter pea rotation (WW-WP), and winter wheat-spring barley-chemical fallow rotation (WW-SB-CF).

Data on grain yield, diseases, weeds, microbial biomass, soil moisture, and crop residue cover were collected.

An economic analysis was conducted to determine the most profitable cropping system. Costs and revenues were calculated per rotational acre. For example, in a WW-SF (2-year) rotation, profit per rotational acre would be profit for 0.5 acre of wheat plus profit for 0.5 acre of fallow. The 2010 input prices, and average 2005-2010 crop prices were used: wheat \$205.95 Mg^{-1}, WP \$328.85 Mg^{-1}, SB \$167.41 Mg^{-1}.

Results and Discussion

Grain Yield

Based on the 7-yr average (2004/05 to 2010-11 crop-years, Table 1) there were no significant differences in wheat grain yield among the WW-SB-CF, WW-SF, and WW-CF rotations. These yields were significantly higher than grain yields from annual crops.

Table 1. Grain yield of winter wheat, spring wheat, spring barley, and winter peas under different cropping systems at CBARC, Moro, 2004-11.

Rotation	Grain yield (Mg/ha)								WUE (kg ha^{-1} mm^{-1})
Annual cropping	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2004-11	2004-11
Continuous Winter Wheat (WW-WW, DS)	0.67 b	1.27 b	2.03 b	1.28 a	1.75 a	0.95 c	3.89 b	1.72	6.7 b
Continuous Spring Wheat (SW-SW, DS)	0.62 b	2.56 ab	2.10 b	0.93 ab	1.13 a	2.58 b	2.24 c	1.79	10.4 a
Continuous Spring Barley (SB-SB, DS)	0.64 b	3.75 a	2.28 b	1.25 a	1.76 a	2.48 b	2.96 b	2.05	12.0 a
Two-year rotations									
Winter Wheat-Summer Fallow (CT)	3.81 a	4.06 a	4.38 a	2.46 a	2.29 a	4.47 a	5.70 a	3.91	10.5 a
Winter Wheat-Chemical Fallow (DS)	3.51 a	3.17 a	4.03 a	2.61 a	2.66 a	4.47 a	5.77 a	3.78	10.9 a
Winter wheat-Winter Pea (DS)	2.66 a	2.26 b	2.38 b	0.83 b	2.16 a	2.67 b	4.15 b	2.49	8.2 b
Three-year rotations									
Winter Wheat-SB-Chemical Fallow (DS)	4.08 a	3.91 a	4.34 a	2.69 a	2.53 a	4.93 a	4.86 a	3.98	11.8 a
WW-Spring Barley-Chemical fallow (DS)	0.72 b	3.32 a	2.08 b	0.50 b	1.67 a	2.69 b	2.91 b	1.89	11.5 a
Precipitation (mm)	201	429	282	213	231	348	382.52	297.18	

All plots are direct seeded (DS) except the conventional tillage (CT) winter wheat- summer fallow treatments

Means compared by a Tukey Test (0.05)

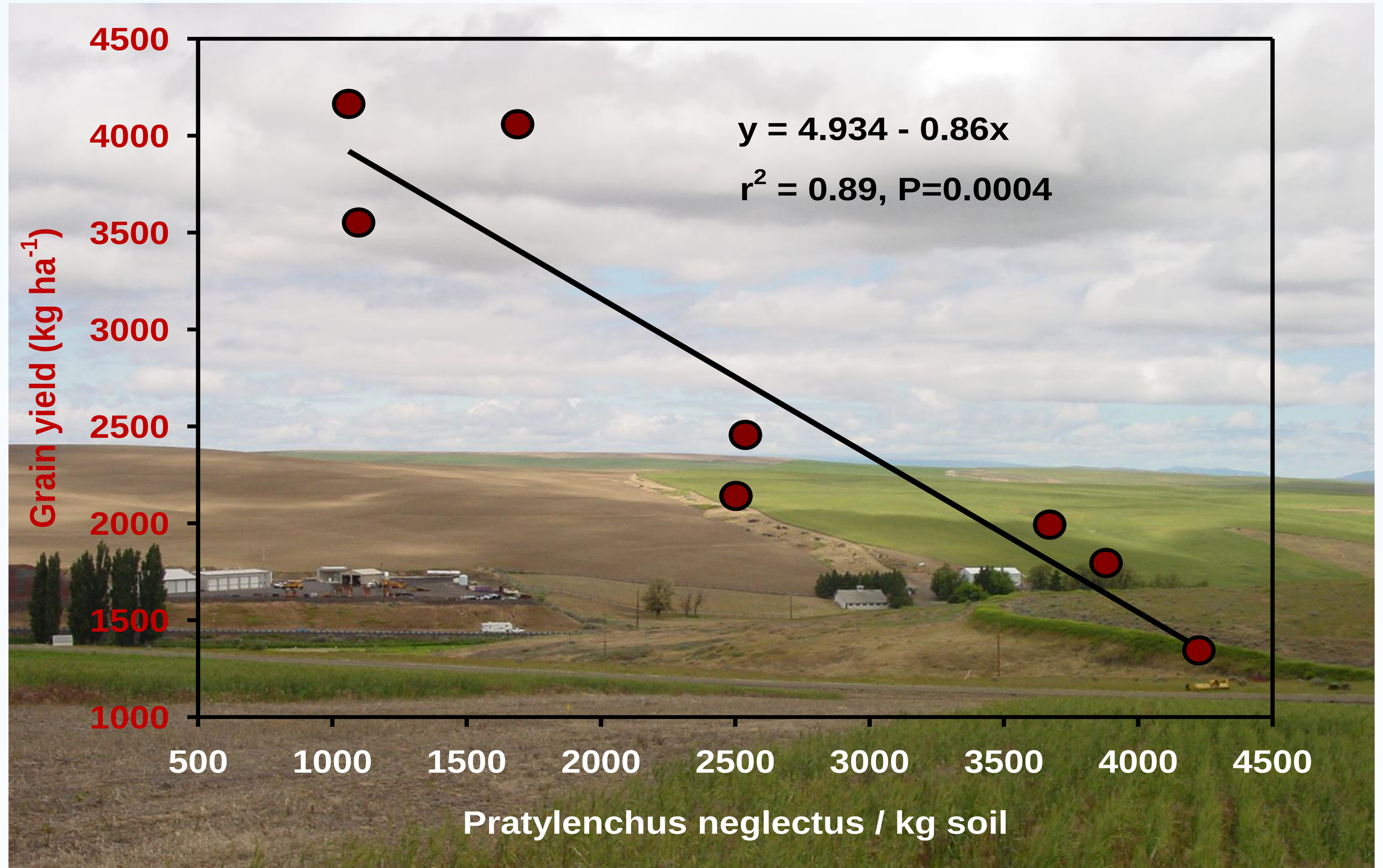

Figure 1. Relationship between root-lesion nematode populations and yields for winter wheat, spring wheat, and spring barley averaged over three years (crop years 2005-2007)

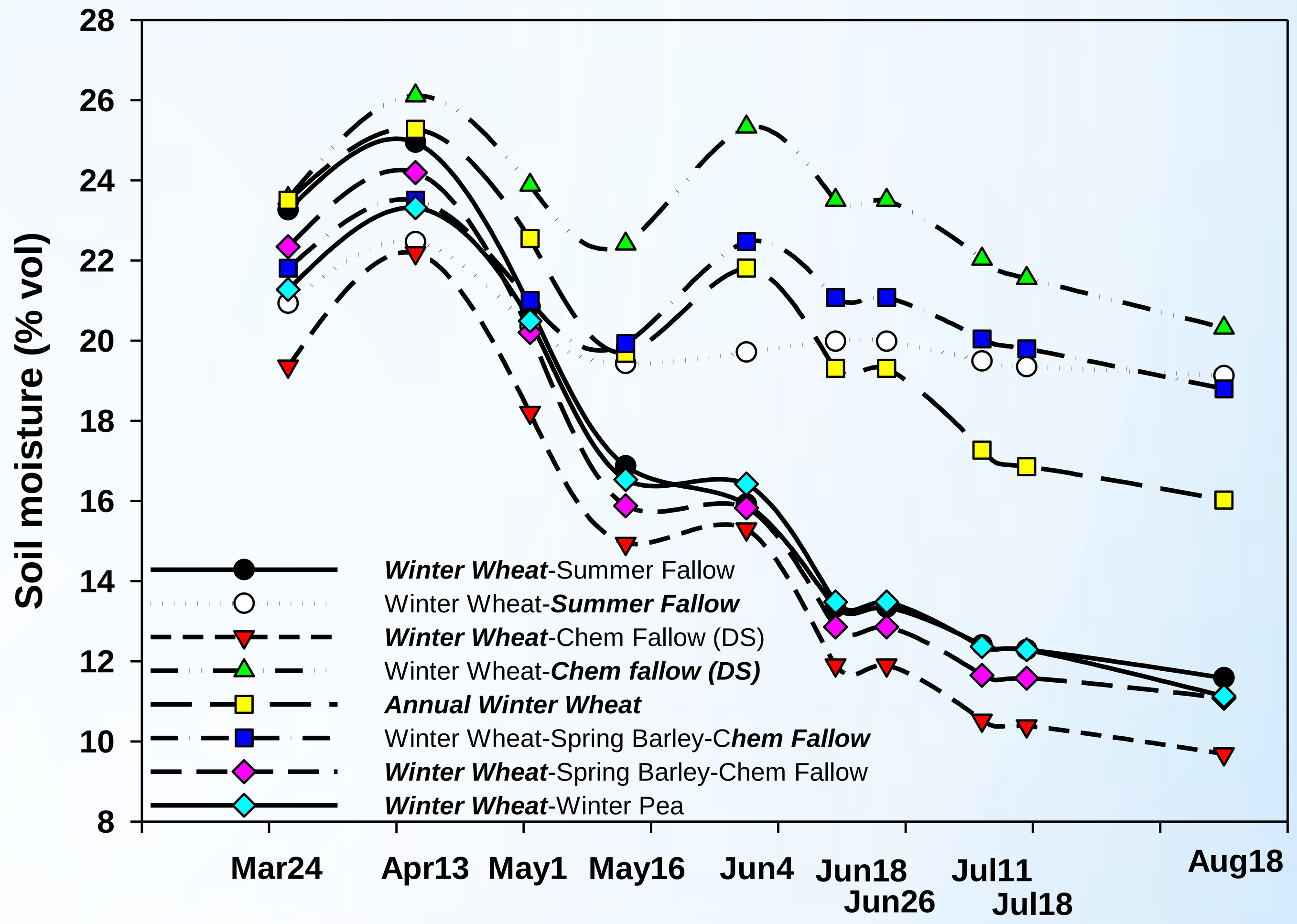

Figure 2. Average soil water content under all rotations in the 0 to 100-cm depth profile from March to August, 2006, at CBARC Moro. Data shown are for crop/treatment in boldface and italics of a rotation.

Table 2. Average profit by system, Moro, OR, 04/05-09/10

Cropping System	Av. GR (\$ rot-ha^{-1})	Av. Cost (\$ rot-ha^{-1})	Av. Profit (\$ rot-ha^{-1})	Av. Profit Rank	Av. GR Rank	Av. Yield Rank
Winter Wheat-Chemical Fallow (CF)	383.03	362.57	20.45	1	2	3
Winter Wheat-Summer Fallow	400.01	394.43	5.58	2	1	2
Winter Wheat-Spring Barley-CF	359.04	379.71	-20.67	3	3	1
Annual Spring Wheat	357.78	431.53	-73.75	4	4	5
Winter Wheat-Winter Pea	352.00	442.38	-90.38	5	5	4
Annual Spring Barley	305.40	426.96	-121.55	6	6	NA
Annual Winter Wheat	291.29	420.72	-129.43	7	7	6

Yields of annual spring barley in SB-SB and WW-SB-CF rotations were significantly higher than annual wheat yields in WW-WW and SW-SW but not from wheat yield in WW-WP. In general wheat yields were negatively correlated with high downy brome (*Bromus tectorum*) infestation (data not shown) and high incidences of root-lesion nematodes (*Pratylenchus neglectus*) (Fig. 1).

Water Use

Water use efficiency was highest in SB-SB and lowest in WW-WW (Table 1). Water uptake was reduced under WW-WW due to high incidences of root-lesion nematode infestation. Soil moisture in plots of WW-WW was higher than in other rotations beginning in May until harvest during the early years of the experiment (Fig 2, yellow symbols) indicating that the crop was not able to fully utilize available soil moisture.

Results and Discussion

Economic Analysis

Results of the economic analysis are shown in Table 2. All summer fallow rotations were more profitable and less risky (data not shown) than annual cropping in this region. WW-CF produced the highest returns followed by WW-SF and WW-SB-CF rotations. WW-CF also manages economic risk and smoothens seasonal machinery and labor demands.

Grain yield from annual cropping varied yearly with precipitation and annual cropping was more risky economically than summer fallow rotations. The lowest returns were observed in the annual winter wheat cropping system (WW-WW) (Table 2).

Summary and Conclusions

Based on these results, winter wheat – chemical fallow (WW-CF) represents a promising cropping system for both farmers' bottom line and the environment in Moro, Sherman County and perhaps in similar regions.

WW-CF also manages economic risk and smoothens seasonal machinery and labor demands.

If the current trends that show declining glyphosate/diesel price ratios continue, the advantage of WW-CF will be further strengthened.

Based on these results the directed seeded winter wheat-chemical fallow can replace the traditional winter wheat –conventional tillage fallow in this region. Added benefits of DS systems include increased surface residues that prevent soil erosion and increased soil organic carbon.

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