Long-term Experiments at CBARC-Moro and Center of Sustainability-Heppner, 2006-2007

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Abstract

This project is now in the fourth year and two more crop-years are required for all crop rotations to complete a full cycle. This report covers the 2006-2007 crop-year results and summaries from the past 3 years. *Columbia Basin Agricultural Research Center* (*CBARC) experiment (Moro)*: Under continuous annual cropping, spring barley, which had a reduced population of root-lesion nematodes, produced the highest yields while continuous winter wheat, which had high populations of root-lesion nematodes and high downy brome populations, produced the lowest yields. Winter wheat after chemical fallow in a 3-year rotation with spring barley also had low populations of root-lesion nematodes and produced the highest yields, although not significantly different from winter wheat following conventional tillage (CT) fallow. Yields from the 3-year rotation and winter wheat-CT fallow rotation were significantly higher than the yield of winter wheat following chemical fallow. Under annual cropping, continuous spring barley produced the highest yields followed by winter wheat after winter pea. An economic analysis was performed by subtracting the costs of all variable inputs (herbicides, seed and seeding, fertilizer, equipment costs), including fallow, from the grain value. The greatest annualized partial net return was achieved in the conventional fallow winter wheat rotation followed by continuous spring barley and then the three-year rotation. The standard deviation of partial net return was smallest for the 3-year rotation of winter wheat-spring barley-chemical fallow. *Center of Sustainability (Heppner)*: Continuous spring barley produced the highest grain yields followed by continuous winter wheat and winter wheat following fallow (conventional or chemical). The lowest yield was obtained from continuous spring wheat. Yields of continuous winter wheat were higher than continuous spring wheat yields.

Introduction

The conventional tillage (CT) winter wheat-summer fallow rotation reduces soil organic carbon, exacerbates soil erosion, and is not biologically sustainable (Rasmussen and Parton 1994). Despite these concerns, adoption of alternate cropping systems, such as intensive cropping and direct seeding, has been slow due to lack of long-term research on viability of alternate cropping systems in Oregon. Occasional crop failures occurred under long-term conventional intensive cropping studies conducted at the Sherman Experiment Station in the 1940's to the 1960's (Hall 1955, 1960, 1963). But with the advent of new varieties and agronomic practices such as direct seeding, long-term research is needed to evaluate benefits and risks of annual cropping, potential alternate crops, and alternative rotations. The main focus of this work is to establish and maintain long-term experiments that compare the conventional wheat-fallow system with alternate cropping systems with crop management practices such as direct-seeding that reduce wind and water erosion. Specific objectives include developing systems that increase residue cover; increase soil organic matter and biological activity; increase water infiltration and available soil moisture; reduce wind and water erosion; reduce soil water evaporation; reduce pests; sustain soil and crop productivity; evaluate the variable costs and crop value of the cropping systems under evaluation; and extend the results to growers. The research is targeted for Agronomic Zones 4 and 5 in north-central Oregon.

Methods and Materials

Columbia Basin Agricultural Research Center* (*CBARC*)*, Moro

The experiment was established on a 28-acre site at the Sherman Experiment Station near Moro in the fall of 2003. Results from this year, however, are of little value because this was the year when the treatments were first established. The rotations started in the 2004-2005 crop year and the experiment is now in its fourth year (2007-2008). The soil is a Walla Walla silt loam (coarse, silty, mixed, mesic Typic Haploxeroll) and more than 4 ft deep. The station receives an average of 11.5 inches of annual precipitation. Rainfall and soil at the station is representative of the average conditions in the target area.

Treatments

Crop rotations under evaluation are shown in Table 1. Each phase of each rotation appears every year. The treatments are replicated three times. There are 14 plots per replication and the minimum plot size is 48 by 350 ft, bringing the minimum total experimental area to 13.88 acres. Agronomic practices (planting date, planting rate, and fertilizer, herbicides, seed-treatment fungicide, and insecticide application) are based on the treatment in question. Direct seeding is conducted using the Fabro® drill purchased with assistance from the Sherman Station Endowment Fund.

Table 1. Cropping system treatments at the Sherman County Experiment Station, Moro, Oregon.

Rotation	2003				2004				2005				2006				2007			
	W[a]	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F
1A		S. wheat[b]		W. wheat				Conventional fallow				W. wheat				Conventional fallow				
1B		S. wheat		Conventional fallow				W. wheat				Conventional fallow				W. wheat				
2A		S. wheat		W. wheat				Chemical fallow				W. wheat				Chemical fallow				
2B		S. wheat		Chemical fallow				W. wheat				Chemical fallow				W. wheat				
3		S. wheat		W. wheat				W. wheat				W. wheat				W. wheat				
4		S. wheat				S. wheat				S. wheat				S. wheat				S. wheat		
5		S. wheat				S. barley				S. barley				S. barley				S. barley		
6A		S. wheat		W. wheat						S. barley		Chemical fallow				W. wheat				
6B		S. wheat				S. barley		Chemical fallow				W. wheat						S. barley		
6C		S. wheat		Chemical fallow				W. wheat						S. barley		Chemical fallow				
7A		S. wheat		W. wheat				W. peas				W. wheat				W. peas				
7B		S. wheat		W. peas				W. wheat				W. peas				W. wheat				
8		S. wheat																		
9		S. wheat																		

[a]W = winter; Sp = spring; Su = summer; F = fall.
[b]S. wheat = spring wheat, W. wheat = winter wheat, and S. barley = spring barley.

Field operations:

ORCF101 winter wheat, was seeded in rotation 1 on September 26, 2006, using the HZ drill at 18 seeds/ft^2. ORCF101 was seeded on September 27, 2006 for rotation 2, on October 17, 2006 for rotation 6, on November 6, 2006 for rotation 7, on November 9 for rotation 3, and on November 14, 2006 for rotation 8b (flex), using a Fabro drill at a rate of 20 seeds/ft^2 . Winter wheat for rotation 1 was seeded on October 10, 2005 using the HZ drill at 18 seeds/ft^2). Different fertilizer rates were applied to plots of different rotations to bring up the N levels to 80 lbs N/acre; fertilizer rates ranged from 30 to 70 lbs N/acre. Winter pea ('Spector') for rotation 7 was direct-seeded at the rate of 7 peas/ft^2 (85 lbs/acre) on November 10, 2006. Granular inoculant was applied with the seed at the rate of 57 g/1,000 ft. About 10 lbs N/acre were applied at seeding. 'Camas' spring barley was direct-seeded for rotations 5 and 6 at 22 seeds/ft^2 on April 7, 2007. 'Louise' spring wheat for rotations 4 and 8a (flex) was seeded at 22 seeds/ft^2 on April 4, 2007. Each phase of each rotation is present each year.

Data on plant stand, phenology, weeds, and diseases were collected. Herbicide application history is shown in Table 2. Weed plant counts were taken in March and May of each year. At maturity, plots were harvested using a commercial combine with an 18-ft header. The 18-ft swath was taken in the center of the 48-ft-wide plot. Grain was weighed using a weigh-wagon to determine yield per treatment.

Table 2. Herbicide applications in the 2006-2007 crop-year at Moro.

Treatment	Herbicide	Date
2,4,5,8,12	Clearmax + NIS + Sol. 32 (1.5 oz + 3.2 oz + 2.5 gal)	3/17/07
3,6,7,9,13	RT-3 + Quest + NIS (16 oz + 5 pts + 3.2 oz)	3/21/07
11	Assure ll + COC (12 oz + 19 oz) and Chiptox + Sencor (16 oz + 4 oz)	4/19/07
14	Clearmax + NIS + Sol. 32 (15 oz + 3.2 oz + 2.5 gal)	4/19/07
3,10	RT-3 + Quest + NIS (32 oz + 5 pts + 3.2 oz)	5/18/07
6,7,9,13	Harmony Extra + 2,4-D Amine + NIS(0.6 oz + 12 oz + 3.2oz)	5/18/07
3,10	RT-3 + Quest + NIS (40 oz + 5 pts + 3.2 oz)	8/7/07
3,10	RT-3 + Quest + NIS (40 oz + 5 pts + 3.2 oz)	8/17/07
3,10	RT-3 + Quest + NIS (48 oz + 5 pts + 3.2 oz)	9/17/07

Check the rates of NIS, etc. applied

Soil water measurements were taken throughout the growing season using a PR2® probe (Delta-T Devices Ltd. Cambridge, England). The probe senses the soil moisture content at 4-, 8-, 16-, 24-, and 40-inch depths by responding to dielectric properties of the soil. Readings were made on two access tubes in each plot. At each reading, two measurements were taken, each time with the probe rotated to a different direction.

Economic Analysis

A partial net economic analysis of the continuous cereal, wheat fallow, and winter wheat-spring barley-fallow rotations was performed by subtracting the variable input costs from the gross crop value. Variable input costs for herbicides, fertilizer, and seed were based on the invoices for the products. Tillage, herbicide and fertilizer application, and seeding costs were based on the Oregon State University Enterprise Budget for Wheat (Macnab 2003); these costs include labor, equipment repairs, depreciation, etc. The costs in these budgets were adjusted to reflect the increased fuel costs from 2004 to 2007. The costs of flailing and seeding using a direct-seed drill were estimated. Costs were broken into crop input (planting through harvest, about 10 months) and fallow phase (harvest through seeding, about 14 months). Crop value was determined by multiplying the crop yield by the crop price that was taken from tables prepared by Sandy Macnab, Sherman County Agricultural Extension Agent. The selling price was taken to be the average Portland price in October of the year the grain was harvested. The costs in the analysis do not include counter-cyclical payments, loan deficiency payments, crop insurance, or fixed costs such as cash rent or taxes. No statistical analysis was performed because of the limited data set (3 years) but we did calculate the standard deviation of the average as a measure of variability from year to year.

Center of Sustainability* (*COS*), *Heppner

The experiment is located at the William Jepsen farm near Heppner, Oregon. In the past 5 years COS has evaluated cropping systems that are similar to the cropping systems at Moro (Table 3). The COS site receives crop-year precipitation similar to Moro (11 inches), but it is shallower (2 ft deep) than the Moro site (more than 4 ft deep). This makes it possible to effectively determine the influence of soil depth on the alternate cropping systems. The cropping systems being evaluated at COS were modified in the 2003-2004 season to match most of the treatments at Moro. Data collection was the same as at Moro, but the experiment was not replicated. However, the experiment has very large plots that measure 80 by 900 ft and it may be possible to split the plots and add at least one replication. In the meantime, data will be analyzed using statistical methods for unreplicated studies (Perrett and Higgins 2006).

Table 3. Cropping and tillage systems under evaluation at the Center of Sustainability (COS) study at Bill Jepsen's farm near Heppner, Oregon.

Treatment/rotation	Description
1	Conventional winter wheat/conventional fallow
2	Winter wheat/chemical fallow-direct seeding
3	Continuous spring barley-direct seeding
4	Continuous spring wheat-direct seeding
5	Continuous spring dark northern spring wheat-direct seeding
6	Continuous winter wheat-direct seeding
7	Spring barley/mustard/spring wheat-direct seeding
8	Winter wheat/mustard/chemical fallow-direct seeding
9a	Flex crop
9b	Flex crop

Results and Discussion

CBARC, Moro

Soil Water Measurements

Soil moisture content measurements for all winter wheat treatments from March 3, 2006 to August 18, 2006 are shown in Figure 1. As expected, fallow treatments retained the highest amount of moisture throughout this period. The amount of water stored during fallow was higher under conventional tillage fallow (CT fallow) than under chemical fallow. However, the CT fallow lost more water (26 percent) than chemical fallow after winter wheat (21 percent) and chemical fallow after spring barley (23 percent) from March to September. Similar to the 2005-2006 crop-year, moisture content of plots under continuous winter wheat was higher than all cropped treatments beginning in May onwards, indicating that other factors were preventing the crop from utilizing available water.

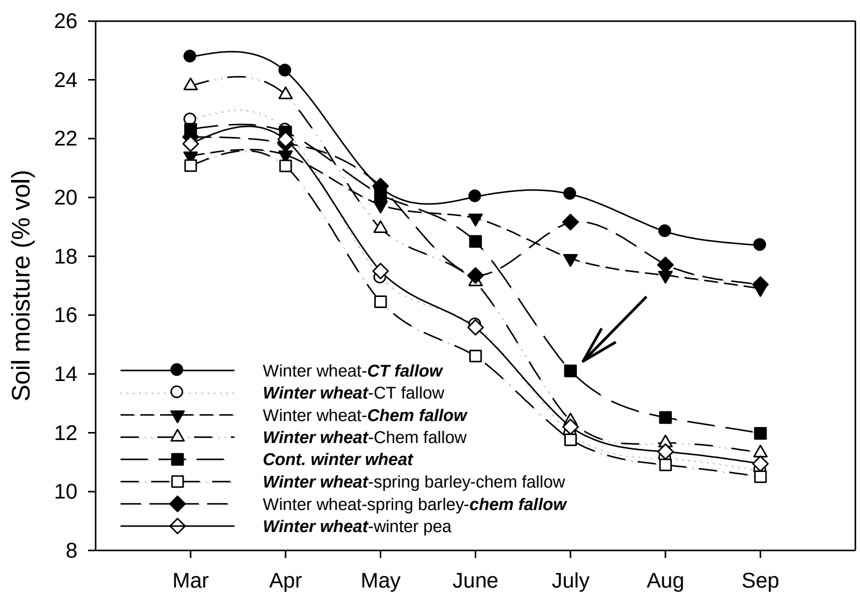

Figure 1. Average soil water content under all rotations in the 0- to 40-inch depth profile from March to September, 2007, at Columbia Basin Agricultural Research Center, Moro, Oregon. Data shown are in bold for crop/treatment and in italics for the rotation. Arrow shows data on continuous winter wheat.

Weeds

The weeds team evaluated downy brome (*Bromus tectorum*) and broadleaf weed control in the cropping systems under study. Table 2 shows herbicide application details for each treatment for 2007. Results showed that downy brome populations continue to increase in recrop direct-seeded winter wheat (Table 4). Downy brome populations in all other treatments were negligible (fewer than five plants/m^2). All broadleaf weed species population numbers were very low in all treatments.

Table 4. Downy brome populations in different cropping systems after herbicide treatment. (Moro, Oregon long-term experiment 2004-2007).

	Treatment	5/5/04	Downy brome 5/3/05	5/19/06[a]	5/17/07
			---------------no./m^2---------------		
1	WW – conven[b]	5	2	6	0
2	Fallow-conven	0	1	0	2
3	WW – DS	4	2	12	41
4	Fallow-chem	0	2	0	3
5	WW – DS	8	11	20	4
6	SW – DS	0	0	0	2
7	SB – DS	0	0	2	0
8	WW – DS	8	0	0	0
9	SB – DS	0	0	0	1
10	Fallow-chem	0	5	0	3
11	WW – DS	8	0	8	2
12	WP – DS	2	1	0	0
13[c]	SW	0	0	0	1
14[d]	SW	0	0	0	1
	LSD (0.05)	7	4	8	9

[a] Treatments no. 1, 3, 5, 9 and 11 did not receive a grass herbicide before 5/19/06.
[b]WW = winter wheat, DS = direct seeding, SW = spring wheat, SB = spring barley, WP = winter pea.
[c]Flex crop in 2004 was spring wheat, in 2005 it was spring barley, and in 2006 it was mustard.
[d] Treatment no. 14 was plowed up in 2006.

Diseases

Fungal diseases of fall-planted crops:

All three replicates of six winter wheat and one winter pea treatment were sampled on April 2, 2007. The incidence of lesions on subcrown internodes, caused by Fusarium crown rot, was highest (50-75 percent) where winter wheat was sown into the winter wheat-summer fallow rotations, both of which were planted early. Fusarium was much less prevalent or absent on all other direct-seeded plots, each of which was sown later when soil temperature was cooler. The severity indices for subcrown internode lesions were also highest for the early planted treatments. There was no statistical difference among treatments for the incidence and severity of Rhizoctonia root rot, Take-all, Fusarium crown rot, and Pythium root rot symptoms on seminal or coronal roots. Cotyledons of winter pea that was rotated with winter wheat had a moderate incidence (23 percent) of a blackening root rot. The cause was not determined but in previous years the blackening symptom was caused by *Thielaviopsis basicola*. A complex of *Rhizoctonia* and *Pythium* species caused lesions to occur on only 3 percent of tap roots and the severity of lesion development was low (rating of 1.2). As in previous years, vascular browning caused by Fusarium wilt was not detected.

Fungal diseases of spring-planted crops:

There were few or no disease symptoms on subcrown internodes of spring wheat and spring barley. Symptoms of infection by Fusarium and Rhizoctonia were present on seminal and coronal roots. Fusarium crown rot symptoms were more prevalent on seminal and coronal roots of spring barley compared to spring wheat. The incidence and severity of Rhizoctonia did not differ among the four rotations sampled. Take-all was essentially absent from these rotations.

Summary of root-lesion nematode densities over treatments and years:

Root-lesion nematodes (mixtures of *Pratylenchus neglectus* and *P. thornei*) were the primary plant-pathogenic species detected in soil samples collected on April 2, 2007. At that time the winter crops were well established and spring crops were just being planted. Other nematode genera occurring in a few plots were always at very low populations and had no pattern that could be associated with crop rotation or the physical location of the 42 plots in the experimental block. The other nematodes included root-knot (*Meloidogyne chitwoodi*, 1 plot), stunt (*Tylenchorhynchus* and/or *Geocenamus* spp., 3 plots), spiral (*Helicotylenchus* spp.,1 plot), pin (*Paratylenchus* spp., 1 plot), and ring (*Criconemoides* spp., 1 plot).

Root-lesion nematode populations differed significantly among treatments during 2007. Populations of root-lesion nematodes were generally low in annual spring barley and in two phases of the three 3-year rotation treatments. Populations in winter wheat-summer fallow rotations (chemical vs. conventional fallow) were significantly lower in the over-wintering in-crop phase than in the first 6 months of the fallow phase. Another component of our research includes soil sampling to a depth of 4 ft. Results from deep-core sampling indicate that the root-lesion nematode populations did not significantly decline during the fallow period but became more deeply positioned in the soil profile. The deep-lying populations would not have been detected by the shallow sampling used for nematode assessments in this long-term experiment.

Patterns in root-lesion nematode populations over rotational and management sequences have become apparent when rotations were analyzed over the most recent 3 or 4 years of the experiment. Rotations with consistently lowest populations include annual spring barley and 2 of the 3, 3-year rotations (6A and 6B) of winter wheat, spring barley, and chemical fallow. Annual winter wheat is generating the highest population of root-lesion nematodes. Since the inception of the experiment, rotations 1B and 2B have had consistently lower lesion nematode populations than treatments 1A and 2A. This pattern first appeared as the experiment became established and may have been maintained in response to the initial year (2004) of fallow in the 'B' series, compared to 2 years of consecutive winter wheat at the beginning of the 'A' series. However, it should also be noted that populations have been consistently high in treatment 6C with an initial sequence to treatment 2B.

Another way to examine the influence of crops and rotations is to evaluate the 3-year data set (crop years 2005-2007) for root-lesion nematode densities based on the previous crop or management system. That evaluation shows that populations were highest following crops of winter wheat, spring wheat, winter pea, and spring mustard, and lowest following spring barley or summer fallow, without a difference evident between chemical or conventional fallow. The earlier explanation of profile depth sampling indicates that the purported low populations following fallow may be an artifact of sampling method. However, that is not the case with spring barley, which is a relatively poor host for these nematode species and causes a significant reduction in populations throughout the soil profile. It appears that lesion nematode numbers are also being maintained at a high level by winter pea in the winter pea-winter wheat rotation. When nematode data for crop years 2005-2007 were evaluated in the same manner as presented for 3-year mean grain yields, a significant (P = 0.0008; R^2 = 0.8630) negative correlation is shown between yield and root-lesion nematode populations (Fig. 2).

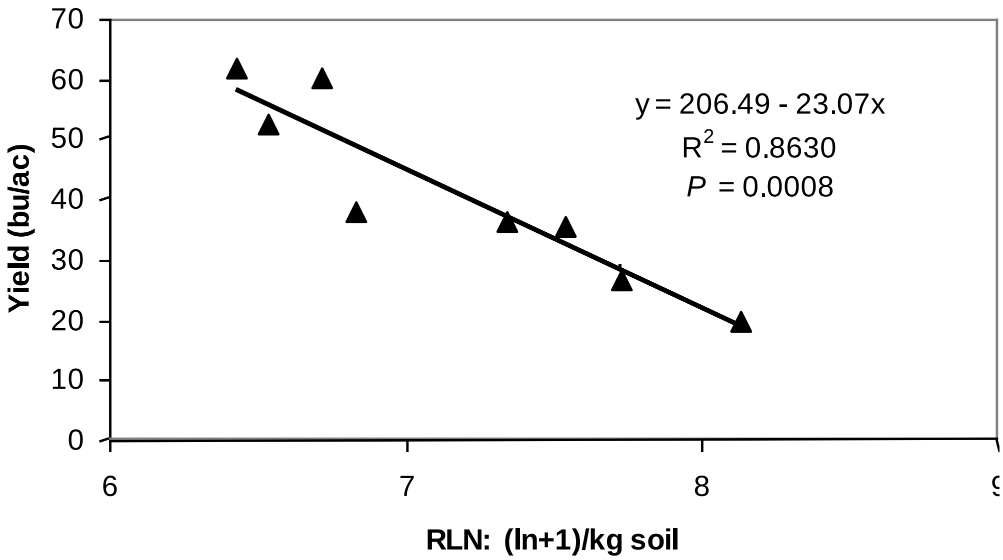

Figure 2. Relationship between root-lesion nematode populations (RLN; expressed as the log transformed number/kg of soil) and yields for winter wheat, spring wheat, and spring barley averaged over 3 years (crop years 2005-2007), Columbia Basin Agricultural Research Center, Moro, Oregon.

Grain Yield

The 2006-2007 crop-year was the fourth cropping season of this experiment. Treatments with 2-year rotations have completed a full cycle. Two more years are required to complete a full cycle for treatments with 3-year rotations. Grain yields of winter wheat, spring wheat, spring barley, and winter pea from the 2006-2007 crop year are shown in Table 5. This crop-year had the second lowest precipitation (11.06 inches) and this reduced the yields of annual crops compared to the previous year when precipitation was high (16.92 inches). Yields of winter wheat after fallow were not affected, and in fact were higher than in the 2005-2006 crop-year when precipitation was higher. Continuous spring barley produced the highest yield compared to winter and spring wheat under annual cropping. This was partly due to a low density of root-lesion nematodes in continuous spring barley compared to winter wheat, where the density was highest. However, continuous annual spring barley yields were not significantly different from yields produced by spring barley following winter wheat in the 3-year rotation (rotation 6). Highest yields were produced by winter wheat following either conventional or chemical fallow and continuous winter wheat produced the lowest yields. Results from the 2006-2007 crop-year indicate that soil moisture was not limiting, leading us to conclude that other factors influenced the yield of continuous winter wheat. Downy brome population was highest in this treatment (Table 2), indicating a problem with grassy weed control in this treatment. Furthermore, there were high incidences of root-lesion nematodes in this treatment that could have reduced yields.

Based on the 3-year average (2004-2005 to 2006-2007 crop-years) winter wheat following fallow in a 3-year rotation with spring barley produced the highest yields, although these yields were not significantly different from yields of wheat after conventional fallow. The high yield obtained from winter wheat in the 3-year rotation with spring barley could have been partly attributed to low levels of root-lesion nematodes. Yield from these two rotations was significantly higher than yield of winter wheat following chemical fallow. Under annual cropping, continuous spring barley produced the highest yields followed by winter wheat after winter pea. Continuous winter wheat produced the lowest yields over the 3 crop-years. The initial yields of the experiment (2003-2004 crop-year) were left out of the averages because this was a set-up year and all crops followed spring wheat.

We conducted an economic analysis of the first 3 years of the trials. The annual cost of tillage-based fallow was $22.65 less than the average cost of chemical fallow per acre. The variability (standard deviation) in fallow costs was much greater in the chemical fallow than in conventional fallow. There were usually as many herbicide applications each year in the chemical-fallow treatments as there were rod-weeding operations in the tillage-fallow treatments, except that five herbicide applications were made in the summer of 2007 to the chemical-fallow treatment. The chemical-fallow cost was greater in 2005-2006 because we applied Spartan® herbicide, which increased the cost by $20.88/acre. Use of a less expensive herbicide would have reduced overall chemical fallow costs and reduced the cost advantage of tillage fallow. Crop value was consistently greater in the tillage fallow because the yields were greater (Table 5); the average crop value was $44.69/acre greater in the tillage fallow and conventional seeding than in the chemical-fallow and direct-seeding treatments. The crop value in 2007 was more than double the crop value in 2005 and 2006 because wheat prices rose to record levels in the fall of 2007. The Portland wheat price in October 2007 was $9.25/bu compared to the 36-year average (1970-2006) of $3.69/bu. The annualized total 2-year partial net return (crop value – fallow cost) was $32.71/acre greater for tillage fallow and conventional seeding compared to chemical fallow and direct-seeding. and partial net return was as much as 69 percent of the average value because of the record price for wheat in 2007.

Table 5. Comparison of fallow costs, variable cost inputs, crop value, and partial net returns from winter wheat in conventional fallow and chemical fallow rotations at Moro, Oregon, 2004-2007.

Input	Year			Average	Std Dev
	2004-05	2005-06	2006-07		
Fallow phase	----------------------------	$/acre	----------------------------		
Chemical fallow	40.16	57.02	77.35	58.18	18.60
Tillage fallow	38.10	35.76	32.72	35.53	2.70
Difference	2.06	21.26	44.63	22.65	
Crop value					
Direct seeding	190.97	228.12	546.67	321.92	195.52
Conventional tillage	216.60	291.24	592.00	366.61	198.73
Difference	25.63	63.12	45.33	44.69	
Crop Input Costs					
Direct seeding	65.23	65.15	90.42	73.60	14.57
Conventional tillage	90.35	53.96	82.28	75.53	19.11
Difference	25.12	11.19	8.14	1.93	
Partial net return					
Direct seeding - chem fallow	125.74	162.97	456.25	248.32	181.03
Conventional tillage	126.25	237.28	509.72	291.08	197.31
Difference	0.51	74.31	53.47	42.76	
Annualized partial net return					
Direct seeding - chem fallow	42.79	52.98	189.45	95.07	81.89
Conventional tillage	44.08	100.76	238.50	127.78	99.98
Difference	1.29	47.78	49.05	32.71	

Continuous cropping using direct-seeding provides essentially continuous soil cover and offers the greatest potential to reduce erosion and halt the decline of soil organic matter of the cropping systems we are studying in these trials. Yields were low in 2005 for all cereal crops because the crop year precipitation was only 7.88 inches compared to the long-tem average of 11.9 inches. Annual input costs for continuous winter wheat averaged $69.25/acre (Table 6) compared to $56.84/acre for continuous spring wheat and $49.79/acre for continuous spring barley. The greater input cost for continuous winter wheat was primarily for additional herbicides compared to the continuous spring crops. Input costs for spring wheat were somewhat greater than for spring barley due to increased seed cost and slightly higher N rates. The annual partial net return for continuous winter wheat was $68.95/acre compared to $116.44/acre for continuous spring wheat and $124.41/acre for continuous spring barley.

Table 6. Comparison of variable cost inputs, crop value, and partial net returns from continuous winter wheat, spring wheat, and spring barley at Moro, Oregon, 2004-2007.

Input	Year			Average	Std Dev
Crop	2005	2006	2007		
	---------------------------- $/acre† ------------------------------				
Continuous winter wheat					
Input costs	80.79	59.84	67.13	69.25	10.63
Crop value	38.27	91.45	284.90	138.20	129.79
Partial net return	(42.52)	31.61	217.77	68.95	134.10
Continuous spring wheat					
Input costs	49.02	51.28	70.22	56.84	11.65
Crop value	36.46	187.37	296.00	173.28	130.34
Partial net return	(12.56)	136.09	225.78	116.44	120.48
Continuous spring barley					
Input costs	42.32	45.37	61.67	49.79	10.41
Crop value	28.70	244.80	249.10	174.20	126.03
Partial net return	(13.62)	199.43	187.43	124.41	119.69

† Parentheses indicate loss

A 3-year rotation consisting of winter wheat-spring barley-chemical fallow has 2 crops in 3 years and places the winter wheat immediately after the fallow to maximize the yield potential of the higher value cereal in the rotation. The use of 2 crops in 3 years with direct seeding provides continuous soil coverage to minimize erosion and the fallow phase provides an opportunity for improved weed control in addition to storing moisture for the winter wheat crop. Crop input and yield data from all 3 phases of the 3-year rotation are available (Table 7). The crop value varies for each cycle because the crop price varied during the 3 years of the crop cycle, as did the fallow costs because of increasing fuel and fertilizer costs. To assess the crop input costs and crop returns during the 3 years, we annualized the partial net return. The average partial net return was $119.57/acre with a standard deviation of only $28.41, the smallest standard deviation of any rotation we examined.

Table 7. Comparison of variable cost inputs, crop value, and partial net returns from the winter wheat-spring barley-chemical fallow treatment at Moro, Oregon, 2004-2007.

Crop	Cycle			Average	Std Dev
	1	2	3		
	---------------------------- $/acre†			------------------------------	
Fallow	56.81	42.12	53.76	50.90	7.75
Winter wheat					
Input costs	83.16	61.85	66.73	70.58	11.16
Crop value	601.25	282.79	228.15	370.73	201.50
Partial net return	518.09	220.94	161.42	300.15	191.07
Spring barley					
Input costs	42.32	63.83	69.95	58.70	14.51
Crop value	31.78	227.90	244.80	168.16	118.41
Partial net return	(10.54)	164.07	174.85	109.46	104.06
Annualized partial net return	150.25	114.30	94.17	119.57	28.41

† Parentheses indicate loss

The summary partial net returns for the cereal-based rotations in the study are shown in Table 8. Winter wheat tillage-fallow resulted in the largest average partial net return during the 3 years of the study, followed by continuous spring barley and the 3-year rotation. The standard deviations of the partial net returns of continuous cropping are much higher than those for 2- or 3-year rotations indicating that annual cropping is riskier than cropping systems with 2- or 3-year rotations. The 3-year rotation had the lowest standard deviation, indicating that the partial net return is most stable over time.

Table 8. Average annualized partial net returns from cereal-based rotations at Moro, Oregon, 2004-2007.

Rotation	Annual partial net return	Std Dev
	------------- $/acre	-------------
Conventional fallow-winter wheat	$127.78	$99.98
Chemical fallow-direct seed winter wheat	$95.07	$81.89
Continuous spring wheat	$116.44	$120.48
Continuous spring barley	$124.41	$119.69
Continuous winter wheat	$68.95	$134.10
Winter wheat-spring barley-chemical fallow	$119.57	$28.41

These results must be interpreted with caution; we have only 3 years of data and an additional 3 years of data will allow for a more accurate comparison of the rotations. This partial economic analysis does not include any counter-cyclical payments, loan deficiency payments, crop insurance, or fixed costs such as cash rent or taxes, nor does it include any Conservation Security Program payments. The addition of these costs and payments will change the net returns in these systems and may affect the overall ranking of the rotations. Finally, and perhaps most importantly, this analysis does not include any offsite or societal costs that may result from soil erosion, loss of soil organic matter, and other factors.

Center of Sustainability, Heppner

Grain Yield

Grain yields obtained in the 2006-2007 crop-year are shown in Table 9. Under continuous cropping, spring barley produced the highest yield followed by winter wheat. Dark northern spring wheat produced the lowest yield. Under 2-year rotations, winter wheat, following CT fallow produced higher yields than winter wheat after chemical fallow. Based on the 3-year average (2004-2005 to 2006-2007) annualized yields, continuous spring barley produced the highest yields followed by continuous winter wheat (Table 10). Continuous spring wheat produced the lowest yields. Winter wheat after either conventional fallow or chemical fallow produced much higher yields than continuous crops, but annualized yields were similar to yields from continuous winter wheat. The experiments will run for 2 more crop-years for all rotations to complete a full cycle.

Table 9. Grain yield of winter wheat, spring wheat, spring barley, and winter peas under different cropping systems at Columbia Basin Agricultural Research Center, Moro, Oregon.

Rotation†	**Grain yield (bu/acre)‡**				
Annual cropping	2003-04	2004-05	2005-06	2006-07	3-year average
Continuous *winter wheat*†	50.88ab	10.57c	18.41d	30.76ef	19.91e
Continuous *spring wheat*	39.39c	10.10c	37.71bc	32.01e	26.61d
Continuous *spring barley*	54.31a	11.61c	63.56a	39.31d	38.16c
2-year rotations					
Conventional fallow-*Winter wheat*	48.06b	57.99a	58.62a	63.95ab	60.19a
Chemfallow-*Winter wheat*	48.83ab	52.91ab	45.88b	59.18b	52.66b
Winter wheat-*winter pea*		9.13c	17.13d	9.49g	11.92f
Winter pea-*winter wheat*	48.53ab	40.52ab	32.76c	35.96de	36.41c
3-year rotations					
Chemfallow-*winter wheat*-spring barley	50.08ab	63.24a	56.93a	65.04a	61.74a
Winter wheat-*spring barley*-chemfallow	40.61c	12.76c	57.99a	35.81de	35.52c
Flex Crop					
Spring barley-*spring wheat*	36.95c	12.87c	-		
Spring wheat-*spring barley*	41.83c	13.83bc	-		
Spring wheat-*mustard*	-	-	13.61d		
Mustard-*spring wheat*-				29.00f	
Fallow (canola)-*winter wheat*				51.47c	
Precipitation (mm)	11.91	7.88	16.92	11.06	

†All plots are direct seeded except the conventional fallow treatments (rotation 1).

‡ Means with similar letters are not significantly different

Table 10. Grain yield (lbs/acre) of winter wheat, spring wheat, and spring barley under different cropping systems at the Center of Sustainability, Heppner, Oregon.

	Continuous cropping				2-year rotations		
Rotation	3	4	5	6	1	2	Precip (in)
Year	Cont. S barley	Cont. S wheat	Cont. DNS[a]	Cont. W wheat	W wheat after conv. fallow	W. wheat after chem. fallow	Sept-June
2004-05	42	16	23	25	68	71	9.4
2005-06	52	29	28	34	47	56	14.5
2006-07	47	29	25	33	62	56	12.26
Mean	**47**	**25**	**25**	**31**	**59**	**61**	**12.05**
Annual	**47**	**25**	**25**	**31**	**30**	**31**	

[a]DNS = dark northern spring wheat.

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