

STEEP PROGRESS REPORT-2007

RESEARCH PROJECT TITLE: Developing Profitable and Sustainable Cropping Systems for North-Central Oregon and South-Central Washington.

INVESTIGATORS:

Stephen Machado (PI), Dryland Cropping Systems Agronomist, OSU, CBARC, Pendleton
Steve Petrie (Co-PI), Soil Scientist, and Superintendent, OSU, CBARC, Pendleton
Dan Ball (Co-PI), Weed Scientist, OSU, CBARC, Pendleton
Richard Smiley (Co-PI), Plant Pathologist, OSU, CBARC, Pendleton
Don Wysocki (Co-PI), Extension Soil Scientist, OSU, CBARC, Pendleton

University Cooperators

Larry Pritchett, Faculty Research Assistant, OSU, CBARC, Pendleton
Erling Jacobsen, Sherman Station Manager, OSU, CBARC, Moro
Karl Rhinhart, Farm Manager, OSU, CBARC, Pendleton
Sandy Macnab, Extension Agent, OSU, Sherman County, Moro
Brain Tuck, Extension Agent, OSU, Sherman County, Moro
Dr. William Schillinger, Dryland Systems Agronomist, WSU, Lind

USDA-ARS Cooperators

Dr. Stephan Albrecht, Soil Microbiologist, USDA-ARS, CPCRC, Pendleton
Dr. Hero Gollany, Soil Scientist, USDA-ARS, CPCRC, Pendleton
Dr. John Williams, Hydrologist, USDA-ARS, CPCRC, Pendleton
Dr. Stewart Wuest, Soil Scientist, USDA-ARS, CPCRC, Pendleton

Grower Advisory Group and Cooperators

Ernie Moore, Producer, Chairman of the Sherman Station Liaison Committee, and Research and Production co-chair of the Oregon Wheat Growers League, Sherman County.
Chris Kaseberg, Producer, Member of the Sherman Station Liaison Committee, President of Sherman County Wheat League, Sherman County.
Tom McCoy, Producer, former President, Oregon Wheat Growers League, Sherman County.
Walter Powell, Producer, Gilliam County.
John Hilderbrand, Producer, Sherman County.
David Brewer, Producer, Wasco County.

INTERIM OR FINAL REPORT: Interim

PROJECT OBJECTIVES:

The overall focus of this project is to develop profitable and sustainable cropping systems for north-central Oregon and south-central Washington. The main objective is to establish a long-term experiment that will compare the effects of a conventional wheat-fallow system with potential alternative and intensive crop systems and crop management practices such as direct seeding. Specific objectives include determining systems that

- increase residue cover,
- increase soil OM,
- increase available soil moisture,

- reduce wind and water erosion,
- reduce soil water evaporation,
- sustain soil productivity.

Information to address these objectives will be, however, obtained only after long-term experimentation.

KEYWORDS: Long-term experiments (LTEs), intensive cropping systems, direct seeding

STATEMENT OF PROBLEM: The wheat/fallow rotation reduces soil organic carbon, exacerbates soil erosion, and it is not biologically sustainable. 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 in Oregon on viability of alternate cropping systems. Occasional crop failures occurred under long-term conventional intensive cropping studies conducted at the Sherman Experiment Station in the 1940s to the 1960s. But with the advent of new varieties and agronomic practices such as direct seeding, long-term research is needed to enhance benefits and reduce risks for annual cropping.

AGRONOMIC ZONE OF INTEREST: Research is targeted for Agronomic Zones 4 and 5 in north-central Oregon and south-central Washington. The investigations emphasize dryland production with increased cropping intensity under reduced tillage and direct seed cropping systems.

ABSTRACT OF RESEARCH FINDINGS: Under continuous annual cropping, spring barley, which had reduced root-lesion nematode incidences, produced the highest yields and winter wheat, with high root-lesion nematode incidences and high downy brome populations, produced the lowest yields. Winter wheat after chemical fallow in a 3-yr rotation with spring barley, also with low root-lesion nematodes incidences, produced the highest yields although this yield was not significantly different from winter wheat following conventional fallow. Based on the three year average (2004-05, 2005-06, and 2006-07 crop-years) winter wheat following fallow in a 3-yr 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-yr rotation with spring barley could have been partly attributed to low levels of root-lesion nematode incidences. 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 three crop-years.

MATERIALS AND METHODS

The experimental site was solid seeded to spring wheat in 2003 to homogenize the site. Experimental plots were then established in the fall of 2003. Each plot measures 48 x 350 ft. Plots were established after harvest in 2003 in an RCB arrangement, with 3 replications. Soil at the site was a Walla Walla silt loam. The following rotations (1-8) are being evaluated in this study:

1. Winter wheat-conventional fallow: Conventional tillage
2. Winter wheat-chemical fallow: Direct seeding
3. Continuous winter wheat: Direct seeding

4. Continuous spring wheat: Direct seeding
5. Continuous spring barley: Direct seeding
6. Winter wheat-spring barley-chemical fallow: Direct seeding
7. Winter wheat-winter pea: Direct seeding
8. Flex crop (a, b)

Winter wheat, variety ORCF 101, was seeded for rotation 1 on September 26, 2006 using the HZ drill at 18 seeds ft⁻². ORCF 101 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⁻¹. Fertilizer rates ranged from 30 to 70 lbs N acre⁻¹. Winter pea (Spector) for rotation 7 was direct-seeded at the rate of 7 peas ft⁻² (85 lbs acre⁻¹) on November 10, 2006. Granular inoculant was applied with the seed at the rate of 57 grams per 1000 ft. About 10 lbs N acre⁻¹ was applied at seeding. Spring barley (variety Camas) was seeded for rotation 5 and 6 was direct-seeded at 22 seeds ft⁻² on April 7, 2007. Spring wheat (variety Louise) for rotation 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 1. Weed plant counts were taken in March and May of each year (Tables 2 and 3). 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 1. Herbicide applications in the 2006-07 crop-year.

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

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. Data on soil moisture for this period is not yet available.

RESULTS AND INTERPRETATION

Weeds-Dan Ball, Sandy Frost, and Larry Bennett

The weeds team evaluated downy brome (*Bromus tectorum*) and broadleaf weed control in the cropping systems under study. Table 1 shows herbicide application details for each treatment for 2007. Results showed that downy brome populations continue to increase in re-crop direct-seeded winter wheat (Table 2). Downy brome populations in all other treatments were negligible (fewer than 5 plants/m²) (Table 2). All broadleaf weed species population numbers were very low in all treatments (Table 3).

Table 2. Downy brome populations in different cropping systems after herbicide treatment. (Moro LTE 2004, 2005, 2006, 2007)

	Tmt	Downy brome			
		5/5/04	5/3/05	5/19/06 ³	5/17/07
		-----#/m ² -----			
1	WW – conven	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 ¹	SW	0	0	0	1
14 ²	SW	0	0	0	1
LSD (0.05)		7	4	8	9

¹ Flex crop in 2004 was spring wheat, in 2005 it was spring barley, and in 2006 it was mustard.

² Treatment #14 was plowed up in 2006.

³ Treatments No. 1, 3, 5, 9 and 11 did not receive a grass herbicide before 5/19/06.

Table 3. Weed populations in different cropping systems after herbicide treatment. (Moro LTE 2004, 2005, 2006, 2007)

Trt	Knotweed				Prickly lettuce				Tumble mustard				Peas			Other broadleaf			
	5/05 /04	5/03 /05	5/19 /06	5/17 /07	5/05 /04	5/03 /05	5/19 /06	5/17 /07	5/05 /04	5/03 /05	5/19 /06	5/17 /07	5/03 /05	5/19 /06	5/17 /07	5/05 /04	5/03 /05	5/19 /06	5/17 /07
1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	16	1	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	1	0	1	0	1	0	2	0	0	0	0	0	0	0	0	1
7	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	2
8	12	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0
9	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10	0	0	0	1	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0
11	3	0	0	0	0	0	0	0	0	1	0	1	0	34	0	0	0	0	0
12	0	0	2	0	1	0	0	0	0	0	0	0	170	2	1	0	0	0	2
13 ¹	0	0	--	0	0	0	--	0	0	0	--	1	0	0	0	0	0	--	0
14	0	0	--	0	0	0	--	0	0	2	--	0	0	0	0	0	0	--	0
LS	NS	NS	NS	NS	0.4	NS	NS	NS	NS	1	NS	1	--	19	NS	NS	NS	NS	NS
D																			
(0.05)																			

¹ Flex crop in 2004 was spring wheat, in 2005 it was spring barley, and in 2006 it was mustard.

Diseases-Richard W. Smiley, Sandra A. Easley, and Jason G. Sheedy

Diseases on fall-planted plots were assessed by collecting plants on April 2, 2007. Diseases on spring-planted plots were assessed by collecting plants on May 25. Plant samples consisted of 20 to 40 plants plus intact roots collected over the length of each plot, washing soil from the roots, and scoring each root system for incidence (percent plants) and severity (qualitative rating scale) of diseases such as *Fusarium* foot rot, take-all, *Rhizoctonia* root rot, and *Pythium* root rot. We also examined plants for the presence or level of damage by other diseases and insect pests but none were observed on samples collected during 2007. Soil samples (about 20 cores per plot; 1-inch diameter by 12-inch depth) were collected on April 2 and sent to Western Laboratories (Parma, ID) for quantification of plant-parasitic nematode genera.

Fungal diseases of fall-planted crops

All three replicates of six winter wheat (rotation 1, 2, 3, 6, 7, 8) and one winter pea (11) treatment were sampled on April 2, 2007. The incidence of lesions on subcrown internodes, caused by *Fusarium* crown rot, was highest (50%-75%) where winter wheat was sown into the winter wheat-summer fallow rotations, both of which were planted early (Table 4). *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 (rotation 7) had a moderate incidence (23%) of a blackening root rot (Table 5). 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 a very low percentage (3%) 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:

All replicates of two spring wheat (rotations 4 and 8a) and two spring barley (rotation 5 and 6) were sampled on May 25, 2007. There were little or no disease symptoms on subcrown internodes (Table 6). 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 barley compared to 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 (Table 7). 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 six months of the fallow phase. Another component of our research includes soil sampling to a depth of four feet. 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 samplings used for nematode assessments on this long-term experiment.

Patterns in lesion nematode populations over rotational and management sequences have become apparent when rotations were analyzed over the most recent three or four years of the experiment (Table 7; 3- and 4-year means). Rotations with consistently lowest populations include annual spring barley and two of the three 3-year rotations (6A and 6B) of winter wheat, spring barley and chemical fallow. Annual winter wheat is generating the highest population of 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 two 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 a 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, 2006, and 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 between chemical or conventional fallow (Table 8). The earlier explanation of profile depth sampling indicates that the purported low populations following fallow may to 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 shown in Table 9, a highly significant ($P = 0.0008$; $R^2 = 0.8630$) negative correlation is shown between yield and root-lesion nematode population (Fig. 1).

Table 4. Fungal diseases of winter wheat in the long-term experiment at Moro on April 2, 2007.

2007 trtmt		2	4	5	8	12	14			
Rotation:		1B	2B	3	6A	7B	8B			
2007		Conv WW	Dir Seed WW	Dir Seed WW	Dir Seed WW	Dir Seed WW	Flex: Dir Seed WW			
2006:		Conv Fallow	Chem Fallow	Dir Seed WW	Chem Fallow	Dir Seed WP	Chem Fallow			
2005:		Conv WW	Dir Seed WW	Dir Seed WW	Dir Seed SB	Dir Seed WW	Flex: Dir Seed SB			
2004:		Conv Fallow	Chem Fallow	Dir Seed WW	Dir Seed WW	Dir Seed WP	Flex: Dir Seed SW	lsd _{0.05}	p>F	
<u>Parameter</u> ¹										
SCI	% plants	75.0	50.0	11.7	11.7	0	0	35.1	0.003**	
	severity	3.1	2.7	1.1	1.2	0	0	2.3	0.053*	
SR - RRR	% plants	8.3	3.3	1.7	10.0	10.0	0	ns	0.54	
	severity	0.8	0.5	0.7	1.1	0.3	0	ns	0.56	
SR - TA	% plants	10.0	5.0	1.7	0	8.3	0	ns	0.54	
	severity	0.5	0.7	0.3	0	0.7	0	ns	0.49	
SR - FCR	% plants	43.3	41.7	48.3	48.3	45.0	31.7	ns	0.60	
	severity	1.6	2.0	1.9	1.6	1.8	2.0	ns	0.81	
CR - RRR	% plants	38.3	38.3	15.0	30.0	23.3	25.0	ns	0.61	
	severity	1.0	1.2	1.1	1.4	1.1	1.0	ns	0.58	
CR - TA	% plants	0	0	0	0	0	0			
	severity	0	0	0	0	0	0			
CR - FCR	% plants	23.3	15.0	6.7	13.3	0	8.3	ns	0.52	
	severity	1.0	0.9	0.8	0.7	0	2.3	ns	0.28	
PRR	% plants	11.7	36.7	20.0	26.7	16.7	11.7	ns	0.28	

¹ SCI = lesions on sub-crown internodes, SR = seminal roots, CR = crown roots, RRR = Rhizoctonia root rot, TA = take-all, FCR = Fusarium crown rot, PRR = Pythium root rot, RLN = root-lesion nematode, “% plants” = percentage of plants exhibiting symptom described, “severity” = disease severity rating scale (0-4; 4=most severe).

Table 5. Fungal diseases of winter pea in the long-term experiment at Moro on April 2, 2007.

		Treatment 11
		Rotation 7A
<u>Parameter</u> ¹		
Black cotyledon	% plants	23.3
	severity	1.4
Rhizoctonia/Pythium complex:		
Root rot lesions on tap root	% plants	3.3
	severity	1.2
Vascular browning	% plants	0

¹ “% plants” = percentage of plants exhibiting symptom described, “severity” = disease severity rating scale (0-4; 4=most severe).

Table 6. Fungal diseases of spring cereals in the long-term experiment at Moro on May 25, 2007.

		2007	6	7	9	13			
		trmt:							
		Rotation:	4	5	6B	8A			
		2007:	SW	SB	SB	SW			
		2006:	SW	SB	WW	SM			
		2005:	SW	SB	CF	SW			
		2004:	SW	SB	SB	SB	lsd _{0.05}	p>F	
<u>Parameter</u> ¹									
SCI	% plants	1.7	0	0	0	0	ns	0.45	
	severity	0.3	0	0	0	0	ns	0.45	
IC	% plants	0	0	0	0	0	ns	--	
SR - RRR	% plants	20.0	18.3	16.7	28.3	28.3	ns	0.76	
	severity	1.0	1.3	1.2	1.3	1.3	ns	0.63	
SR - TA	% plants	0	0	0	0	0	ns	--	
	severity	0	0	0	0	0	ns	--	
SR - FCR	% plants	10.0	68.3	45.0	3.3	3.3	26.5	0.0029**	
	severity	0.7	1.7	1.4	0.3	0.3	0.7	0.0092**	
CR - RRR	% plants	15.0	8.3	8.3	10.0	10.0	ns	0.61	
	severity	1.0	0.7	0.7	0.7	0.7	ns	0.45	
CR - TA	% plants	0	0	0	3.3	3.3	ns	0.45	
	severity	0	0	0	0.3	0.3	ns	0.45	
CR - FCR	% plants	0	11.7	13.3	0	0	ns	0.07	
	severity	0	1.8	0.7	0	0	0.7	0.0024**	

¹ SCI = lesions on sub-crown internodes, IC = plants with visible infection (rotting) of crown tissue, SR = seminal roots, CR = crown roots, RRR = Rhizoctonia root rot, TA = take-all, FCR = Fusarium crown rot, RLN = root-lesion nematode, “% plants” = percentage of plants exhibiting symptom described, “severity” = disease severity rating scale (0-4; 4=most severe).

Table 7. Density of root-lesion nematodes (*Pratylenchus* spp./kg of soil) in the upper soil profile of the long-term experiment at Moro.

Rotation	Crop or management					Pratylenchus/kg of soil ¹					
	2007	2006	2005	2004	2003	3-yr mean 2005-2007	4-yr mean 2004-2007	2007	2006	2005	2004
1A	CoF ²	WW ³	CoF	WW ³	SW	2,467 ab	2,129 a	3,253 ab	938 abc	4,920 a	1,369 a
1B	WW ³	CoF	WW	CoF	SW	834 cde	769 bcd	684 cd	984 abc	861 a	604 a
2A	ChF	WW ³	ChF	WW ³	SW	1,417 abcd	1,814 ab	2,932 ab	1,082 abc	897 a	3,800 a
2B	WW ³	ChF	WW ³	ChF	SW	403 e	408 d	732 cd	203 d	413 a	422 a
3		annual WW ³			SW	3,392 a	2,175 a	4,464 a	3,126 a	2,796 a	573 a
4		annual SW			SW	2,261 abc	1,301 abc	3,617 ab	1,129 abc	2,832 a	247 a
5		annual SB			SW	922 bcde	694 cd	691 cd	470 bcd	2,409 a	297 a
6A	WW ^{3,4}	ChF	SB	WW ³	SW	853 cde	778 bcd	371 d	885 abcd	1,886 a	591 a
6B	SB	WW ³	ChF	SB	SW	639 de	656 cd	2,160 abc	342 cd	353 a	709 a
6C	ChF	SB	WW	ChF	SW	1,721 abcd	1,561 abc	1,668 abc	1,632 ab	1,873 a	1,166 a
7A	WP	WW ³	WP	WW ³	SW	2,119 abc	1,680 abc	5,401 a	1,187 abc	1,483 a	838 a
7B	WW ³	WP ³	WW	WP ³	SW	1,733 abcd	1,150 abc	2,268 abc	1,691 ab	1,356 a	335 a
8A	SW	SM	SW	SB	SW	1,419 abcd	1,217 abc	1,839 abc	670 bcd	2,322 a	767 a
8B	WW ³	SM	SB	SW	SW	1,360 abcd	1,036 abcd	1,100 bcd	1,542 ab	1,482 a	458 a
	p>F ⁵					0.005**	0.014*	0.005**	0.072*	0.762	0.313
	CV (%)					15.3	16.6	10.4	12.5	21.2	16.9

¹ Sampling was from the surface 6-inches in spring 2004 and on March 7, 2005, and from the surface 12-inches on April 4, 2006 and on April 2, 2007.

² CoF = conventional fallow, ChF = chemical fallow

³ Treatments that were planted during the fall and were therefore “in-crop” for five months prior to sampling. Sampling of all other plots was performed immediately after spring crops were planted; including samplings of summer fallow treatments. All except treatments 1 and 2 are direct seeded; e.g., no-till.

⁴ Winter wheat plots in rotation 6A were very dry and compact on April 2, 2007. It was impossible to collect manual core samples to the same depth as for other plots. Low numbers of RLN may be somewhat biased by the slightly shallower sampling depth in those three plots.

⁵ Data are from back-transformed means of the $\ln(x+1)$ transformation used for ANOVA.

Table 8. Density of root-lesion nematodes (*Pratylenchus* spp./kg of soil) during early spring following specific crops or management practices over a 3-year period in the long-term experiment at Moro.

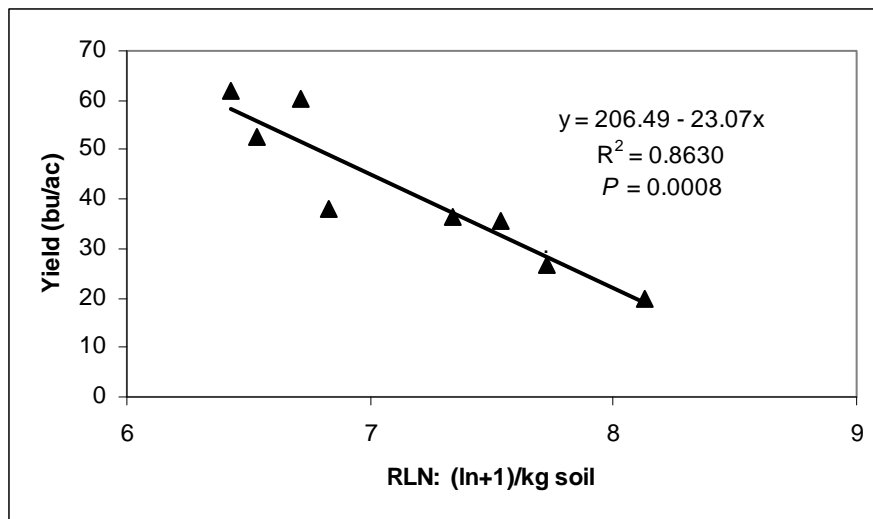
Previous crop or management	RLN ¹	n ²
Winter wheat	1,995 a	45
Mustard	1,839 ab	3
Spring wheat	1,629 ab	15
Winter pea	1,540 ab	9
Spring barley	992 b	21
Conventional fallow	821 b	9
Chem fallow	777 b	24
p>F ³	0.0292*	
CV (%)	16.0	

¹ Calculated as the back-transformed mean for samples from the surface 6-inches on March 7, 2005, and from the surface 12-inches on April 4, 2006 and on April 2, 2007.

² Number of plots for specific treatments over the 3-year history of the experiment; crop years 2005-2007.

³ Data are from back-transformed means of the ln (x+1) transformation used for ANOVA.

Figure 1. 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 three years (crop years 2005-2007) as shown for the ‘3-yr average’ in Table 9.



Grain yield of winter and spring crops under different cropping systems

Stephen Machado, Larry Pritchett, Erling Jacobsen

The 2006-07 crop-year was the fourth cropping season of this experiment. Treatments with two-year rotations have completed a full cycle. Two more years are required to complete a full cycle for treatments with three-year rotations. Grain yields of winter wheat, spring wheat, spring barley, and winter pea obtained in the 2006-07 crop year are shown in Table 9. 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 2005-06 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 low density of root-lesion nematodes in continuous spring 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 2006-07 crop-year indicate that soil moisture was not limiting leading us to the conclusion that other factors influenced the yield of continuous winter wheat. Downy brome population were highest in this treatment (Table 2) indicating a problem with grassy weed control in this treatment. Furthermore, there were high incidences of Fusarium crown rot lesions in this treatment that could have reduced yields.

Based on the three year average (2004-05, 2005-06, and 2006-07 crop-years) winter wheat following fallow in a 3-yr rotation with spring barley produced the highest yields although these yields were not significantly different from yields of wheat after conventional. The high yield obtained from winter wheat in the 3-yr rotation with spring barley could have been partly attributed to low levels of root-lesion nematode incidences. 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 three crop-years. The initial yields of the experiment (2003-04 crop-year) were left out of the averages this was a set-up year and all crops followed spring wheat.

Soil Chemical Properties-*Stephen Machado and Larry Pritchett*

At the beginning of the experiment, each plot was sampled to establish baseline soil information (see attached 2003-04 STEEP Report). Soils were analyzed for pH, NO₃-N, NH₄-N, P, SO₄-S, K, OM, and pH. The next detailed soil sampling will be conducted in 2009.

Water Infiltration and Earthworm Measurements-*Stewart Wuest, Tami Johlke, Bob Correa, and Amy Baker, all ARS Pendleton.*

Data on cylinder infiltration measurements on each plot were collected in April of 2004 to establish baseline readings (see 2004 STEEP report). The next infiltration rate measurements will be taken in 2009.

Table 9. Grain yield of winter wheat, spring wheat, spring barley, and winter peas under different cropping systems at CBARC, Moro, 2005.

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

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

INTERACTION WITH OTHER SCIENTISTS CONDUCTING RELATED ACTIVITIES:

Scientists from OSU and USDA-ARS Pendleton are collaborating in this project.

PUBLICATIONS AND PRESENTATIONS:

Machado, S., L. Pritchett, E. Jacobsen, S. Petrie, R. Smiley, D. Ball, D. Wysocki, S. Wuest, H. Gollany, and W. Jepsen. 2006. Long-term Experiments at CBARC-Moro and Center of Sustainability, Heppner, 2005. Oregon Agricultural Experiment Station Special Report 1068

Machado, S., L. Pritchett, E. Jacobsen, S. Petrie, R. Smiley, D. Ball, D. Wysocki, S. Wuest, H. Gollany, and W. Jepsen. 2007. Long-term Experiments at CBARC-Moro and Center of Sustainability, Heppner, 2005-2006. Oregon Agricultural Experiment Station Special Report 1074