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

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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 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, fallow

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: Precipitation during the 2007-08 crop-year was the second lowest (8.4 inches) in four years. Under continuous annual cropping, spring barley, with low root-lesion nematode (*Pratylenchus* spp) incidences, produced the highest yields although these yields were not significantly different from continuous wheat yields. Spring wheat produced the lowest yields for the first time in four years probably due a high incidence of root lesion nematodes. Although annual winter wheat was infested with root lesion nematodes, it produced yields comparable to annual spring barley. This is because the use of Clearfield technology reduced weed pressure that had contributed to yield reductions in this treatment during previous years. Direct seeded 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 directed seeded winter wheat following chemical fallow and winter wheat following conventional tillage fallow.

Based on the 4-yr average (2004/05 - 2007-08 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 tillage fallow. The high wheat yield obtained from the 3-yr rotation is partly attributed to low levels of root-lesion nematode incidences and low weed infestation. Yield from the 3-yr rotation was significantly higher than yield of winter wheat following chemical fallow. Yields from annual crops were strongly influenced by annual precipitation. Continuous spring barley produced the highest yield followed by winter wheat after winter pea. Continuous winter wheat produced the lowest yields over the four crop-years. This was probably due to a combination of high downy brome (*Bromus tectorum*) infestation which was observed in the first three-years and high incidences of root lesion nematodes but not due a shortage of water as was expected in annual cropping. Grain yields of all the crops were negatively associated with root-lesion nematode incidences.

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 is 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)

During the 2007-08 crop-year, Clearfield Technology was used in all treatments with winter wheat to control grassy weeds particularly downy brome (*Bromus tectorum*) whose population was high in annual winter wheat treatment. Winter wheat, variety ORCF 101, for rotation 1 was seeded at 18 seeds ft^{-2} on October 10, 2007 using the HZ drill. ORCF 101 for rotation 2 and 6 was seeded on November 2, 2007 and for rotation 3 and 7 on November 15, 2007. Spring pea for rotation 7 was direct-seeded at the rate of 7 peas ft^{-2} (120 lbs $acre^{-1}$) on February 26, 2008. Granular inoculant was applied with the seed at the rate of 57 grams per 1000 ft. Camelina for rotation 8A was seeded on April 4, 2008. Spring (yellow) pea for rotation 8B was seeded at 120 lbs $acre^{-1}$ on April 11, 2008. Spring barley (variety Haxby) for rotation 5 and 6 was direct-seeded at 20 seeds ft^{-2} on April 5, 2008. 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. Different fertilizer rates were applied to plots of different rotations to bring up the N levels to 80 lbs N $acre^{-1}$. Nitrogen rates ranged from 10 to 50 lbs $acre^{-1}$.

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 2007-08 crop-year.

Treatment	Herbicide	Date
12	RT-3 + Quest + NIS (24 oz + 5 pts + 32 oz)	2/22/08
2,4,6,7,8,9,13,14	RT-3 + Quest + NIS (24 oz + 5 pts + 32 oz)	3/19/08
1,3(partial)	Beyond + Turret + soln 32 (5 oz + .25% + 1.25%)	4/13/08
3,5,11	Beyond + Turret + soln 32 (5 oz + .25% + 1.25%)	4/24/08
10	Harmony X + 2,4-Da + NIS (0.6 oz + 16 oz + .25%)	4/29/08

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 and Larry Bennett*

The weeds team evaluated downy brome and broadleaf weed control in the cropping systems under study. Table 1 shows herbicide application details for each treatment for 2008. Results showed that downy brome populations were substantially reduced in re-crop direct-seeded winter wheat (Table 2). During this year Clearfield wheat (ORCF 101) was grown and sprayed with Beyond® herbicide. Downy brome infestations were present in plots in winter wheat (Table 2), despite planting of a CLEARFIELD variety and treatment with imazamox (Beyond) (Tables 1). Downy brome infestation levels were considered to be moderate. Using this technology, downy brome populations were reduced from 41 plants m^{-2} in 2007 to 6 plants m^{-2} in 2008 in continuous winter wheat (Trt 3). Prickly lettuce and prostrate knotweed densities were high in winter wheat grown in rotation with pea (treatment 11) (Table 3). This is likely due to poor, late-season control of these broadleaf weed species in the previous winter pea crop. Winter pea lacks effective broadleaf herbicide treatment options. Early-season weed counts did not indicate high levels of weed infestation from these species (Table 3). Rattail fescue was also evident in direct-seeded, continuous winter wheat. This is a weed problem seen in commercial, direct-seeded winter wheat.

Table 2. Downy brome populations in different cropping systems after herbicide treatment. (Moro 2004-08)

				Downy brome		
Trt		5/5/04	5/3/05	5/19/06[3]	5/17/07	5/10/08
				---------------#/m^2---------------		
1	WW – conven	5	2	6	0	14
2	Fallow-conven	0	1	0	2	0
3	WW – DS	4	2	12	41	6
4	Fallow-chem	0	2	0	3	0
5	WW – DS	8	11	20	4	2
6	SW – DS	0	0	0	2	0
7	SB – DS	0	0	2	0	0
8	WW – DS	8	0	0	0	0
9	SB – DS	0	0	0	1	0
10	Fallow-chem	0	5	0	3	4
11	WW – DS	8	0	8	2	3
12	WP – DS	2	1	0	0	0
13[1]	SW	0	0	0	1	0
14[2]	SW	0	0	0	1	0
	LSD (0.05)	7	4	8	9	4

[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 counts in Moro LTE plots in 2008

	Downy brome #/5m2		Mustard spp. #/5m2	#/5m2	Rattail fescue #/5m2		Prickly lettuce #/5m2		knotweed	
	3/5/08	5/9/08	3/5/08	5/9/08	3/5/08	5/9/08	3/5/08	5/9/08	3/5/08	5/9/08
Trt No.										
1	29	72	1	0	0	0	1	0	0	0
2	3	0	1	0	0	0	3	0	0	0
3	2	30	2	0	0	0	0	0	10	3
4	12	0	2	0	1	0	5	0	0	0
5	1	11	0	0	0	0	0	3	0	2
6	47	0	30	1	117	2	29	0	0	1
7	37	0	36	1	30	0	28	0	3	3
8	13	0	2	0	0	0	2	0	0	0
9	55	0	28	1	1	0	8	0	0	0
10	1	22	0	0	0	0	0	5	9	40
11	2	14	0	1	9	48	9	98	32	71
12	3	0	2	3	0	0	0	4	0	9
13	68	0	103	23	2	0	5	0	0	6
14	10	0	4	0	1	0	4	0	0	0
LSD (P=.05)	26	20	22	4	NS	22	15	29	16	NS

Diseases*-Richard W. Smiley, J.A. Gourlie and A.L. Thompson.* Three plots (replicates) of early-planted winter wheat (Rotation 1A) were sampled on April 14, 2008. All other plots planted to cereals and broadleaf crops were sampled on June 11. 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. Soil samples (about 20 cores per plot; 1-inch diameter and 12-inch depth) were collected on April 14 and sent to Western Laboratories (Parma, ID) for quantification of plant-parasitic nematode genera. Data on diseases are shown in Tables 4 to 7.

Fungal diseases of cereal crops:

The incidence of subcrown internode lesions on winter wheat, caused by Fusarium crown rot, was highest where winter wheat was sown into the 2-year rotations of winter wheat and either summer fallow or winter pea (Table 4). The incidence of subcrown internode lesions in winter wheat-summer fallow rotations was higher when the wheat was planted early into cultivated fallow compared to wheat planted later into chemical fallow. Fusarium also caused extensive lesion development on subcrown internodes of wheat and barley planted during the spring. There were no statistical differences among treatments for the incidence and severity of Rhizoctonia root rot and take-all.

Fungal diseases of broadleaf crops:

There were no statistical differences among disease ratings for the three broadleaf crops. High proportions of the cotyledons exhibited a black-colored root rot (Table 7) but the severity of disease was relatively low. Symptoms of infection by *Fusarium* and *Rhizoctonia* were present on most tap roots but disease severity was again low to moderate. Vascular browning, typical of Fusarium wilt, was present but also at a low level of severity. Nubbing or pruning of branch roots, typically caused by species of *Rhizoctonia*, *Pythium* and/or *Pratylenchus*, was prevalent but not severe. No attempt was made to associate disease symptoms with specific pathogens or pathogen complexes.

Root-lesion nematodes:

Pratylenchus neglectus was the primary plant-parasitic nematode species detected. Other nematode genera and species occurred in a few plots but were always at very low populations and there was no pattern of association with a crop rotation or crop management variable. When samples were collected during early spring the winter crops were well established and spring crops were recently planted.

Root-lesion nematode populations differed significantly among treatments during 2008 (Table 6). Populations of root-lesion nematodes were lowest in annual spring barley. Populations were highest in the winter wheat-winter pea rotation, and in annual spring and winter wheat. Populations in the winter wheat-summer fallow rotations were statistically equal in each phase (planted vs. fallow) of the rotation.

Patterns in lesion nematode populations over rotational and management sequences were apparent when rotations were analyzed over five years (Table 6). Rotations with 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 and the winter wheat-winter pea rotation are generating the highest populations of lesion nematodes. These patterns are also clear when the 5-year data set is examined by grouping data based on the previous crop or management (Table 7).

Populations are highest following crops of winter wheat, winter pea and spring mustard, and lowest following spring barley and chemical fallow. Root lesion nematode populations were negatively correlated with grain yield of all crops (Fig. 1.)

Table 4. Fungal diseases of wheat and barley roots in the long-term experiment at Moro.

	2008 trtmt	1	3	5	6	7	8	10	11		
	Rotation:	1A	2A	3	4	5	6A	6C	7A		
	2008	Conv WW	Dir Seed WW	Dir Seed WW	Dir Seed SW	Dir Seed SB	Dir Seed SB	Dir Seed WW	Dir Seed WW		
	2007	Conv Fallow	Chem Fallow	Dir Seed WW	Dir Seed SW	Dir Seed SB	Dir Seed WW	Chem Fallow	Dir Seed WP		
	2006:	Conv WW	Dir Seed WW	Dir Seed WW	Dir Seed SW	Dir Seed SB	Chem Fallow	Dir Seed SB	Dir Seed WW		
	2005:	Conv Fallow	Chem Fallow	Dir Seed WW	Dir Seed SW	Dir Seed SB	Dir Seed SB	Dir Seed WW	Dir Seed WP		
	2004:	Conv WW	Dir Seed WW	Dir Seed WW	Dir Seed SW	Dir Seed SB	Dir Seed WW	Chem Fallow	Dir Seed WW	lsd $_{0.05}$	p>F
Parameter[1]											
SCI	% plants	96	51	26	71	84	77	18	51	20.3	<0.0001
	severity	2.6	1.1	0.9	1.4	2.1	2.1	1.0	1.4	1.0	0.0256
Infected crowns	% plants	0	0	0	3	7	13	0	4	ns	0.6740
SR - RRR	% plants	0	10	9	11	10	2	7	0	ns	0.7774
	severity	0	0.3	0.3	0.7	0.3	0.3	0.3	0	ns	0.6586
SR - TA	% plants	23	27	8	37	48	44	28	31	ns	0.5741
	severity	1.9	1.0	0.7	1.3	1.9	1.6	0.9	1.1	ns	0.4922
SR - FCR	% plants	96	87	91	67	81	87	62	100	ns	0.5516
	severity	3.1	2.1	2.6	1.9	2.2	2.3	1.8	3.0	ns	0.4355
CR - RRR	% plants	2	10	10	8	5	10	10	12	ns	0.8105
	severity	0.3	0.8	1.0	0.7	0.7	0.7	0.7	1.2	ns	0.7401
CR - TA	% plants	38	10	7	17	38	17	28	10	ns	0.3948
	severity	1.3	0.4	0.3	1.3	0.9	0.4	1.2	1.3	ns	0.1445
CR - FCR	% plants	93	65	62	63	68	57	82	73	ns	0.1538
	severity	1.8	1.3	1.2	1.4	1.6	1.8	1.6	1.4	ns	0.4528
PRR or RLN?	% plants	8	3	5	0	0	5	2	3	ns	0.8430

[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. Diseases of broadleaf crop cotyledons and roots in the long-term experiment at Moro.

Treatment:		12	13	14
Rotation:		7B	8A	8B
Current crop:		Winter Pea	Spring Pea	Camelina
Previous crop:		Winter Wheat	Spring Wheat	Winter Wheat
Parameter[1]				
Black cotyledon	% plants	88.3	60.0	69.7
	severity	1.8	1.4	1.2
Root rot lesions on tap root (Rhizoctonia/Pythium complex)	% plants	100	87.5	81.7
	severity	1.9	1.2	1.3
Vascular browning (Fusarium wilt??)	% plants	43.3	35.0	38.7
	severity	1.0	1.0	1.0
Branch roots 'nubbed' off	% plants	65.0	52.5	49.3
	severity	1.4	1.1	1.0

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

Table 6. Density of root-lesion nematodes (*Pratylenchus neglectus*/kg of soil) in the upper soil profile of the long-term experiment at Moro.

Rotation	Crop or management						*P. neglectus*/kg of soil [1]					
	2008	*2007*	*2006*	*2005*	*2004*	*2003*	*5-yr mean 2004-2008*	*2008*	*2007*	*2006*	*2005*	*2004*
1A	WW [3]	CoF [2]	WW [3]	CoF	WW [3]	ChF	2,321 a	3,276 ab	3,253 ab	938 abc	4,920 a	1,369 a
1B	CoF	WW [3]	CoF	WW	CoF	ChF	969 ab	2,440 ab	684 cd	984 abc	861 a	604 a
2A	WW [3]	ChF	WW [3]	ChF	WW [3]	ChF	2,195 ab	4,706 ab	2,932 ab	1,082 abc	897 a	3,800 a
2B	ChF	WW [3]	ChF	WW [3]	ChF	ChF	633 b	3,663 ab	732 cd	203 d	413 a	422 a
3	annual WW [3]					ChF	2,653 a	5,877 a	4,464 a	3,126 a	2,796 a	573 a
4	annual SW					ChF	1,900 ab	8,641 a	3,617 ab	1,129 abc	2,832 a	247 a
5	annual SB					ChF	626 b	413 b	691 cd	470 bcd	2,409 a	297 a
6A	SB	WW [3, 4]	ChF	SB	WW [3]	ChF	806 ab	931 ab	371 d	885 abcd	1,886 a	591 a
6B	ChF	SB	WW [3]	ChF	SB	ChF	810 ab	1,886 ab	2,160 abc	342 cd	353 a	709 a
6C	WW [3]	ChF	SB	WW	ChF	ChF	1,481 ab	1,199 ab	1,668 abc	1,632 ab	1,873 a	1,166 a
7A	WW [3]	WP [3]	WW [3]	WP [3]	WW [3]	ChF	2,449 a	11,052 a	5,401 a	1,187 abc	1,483 a	838 a
7B	WP [3]	WW [3]	WP [3]	WW	WP [3]	ChF	1,665 ab	7,326 a	2,268 abc	1,691 ab	1,356 a	335 a
8A	SP	SW	SM	SW	SB	ChF	1,760 ab	7,708 a	1,839 abc	670 bcd	2,322 a	767 a
8B	camelina	WW [3]	SM	SB	SW	ChF	1,265 ab	2,803 ab	1,100 bcd	1,542 ab	1,482 a	458 a
p>F [5]							0.0002**	0.006**	0.005**	0.072	0.762	0.313
CV (%)							14.3	11.3	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, April 2, 2007, and April 14, 2008.
[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 7. Density of root-lesion nematodes (*Pratylenchus* spp./kg of soil) during early spring following specific crops or management practices over a 5-year period (2004-2008) in the long-term experiment at Moro.

Previous crop or management	RLN [1]	n [2]
Winter wheat	2,276 a	63
Mustard	1,839 a	3
Spring wheat	1,035 ab	65
Winter pea	2,520 a	12
Spring barley	967 b	27
Conventional fallow	1,160 ab	12
Chem fallow	971 b	30
p>F [3]	0.0020**	
CV (%)	17.1	

[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, April 2, 2007, and April 14, 2008.
[2] Number of plots for specific treatments over the 5-year history of the experiment; crop years 2004-2008.
[3] Data are from back-transformed means of the ln (x+1) transformation used for ANOVA.

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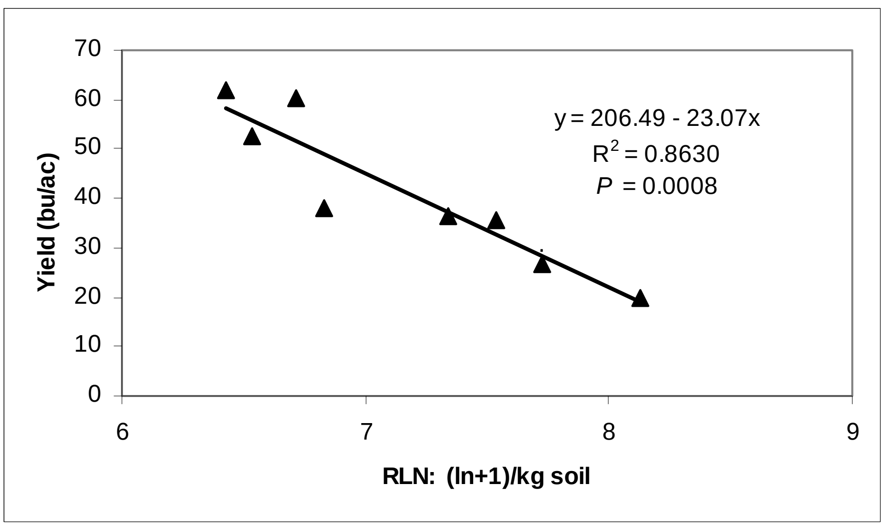

Fig 1. Relationship between root-lesion nematode populations (RLN; expressed as the log transformed number/kg of soil) and yields for winter wheat, spring wheat, and spring barley averaged over three years (crop years 2005-2007) as shown for the '3-yr average' in Table 8

Grain yield of winter and spring crops under different cropping systems*-Stephen Machado, Larry Pritchett, Erling Jacobsen.* The 2007-08 crop-year was the fifth cropping season of this experiment but fourth season in terms of meaningful results. The first year (2003-04) was a set up year. Treatments with two-year rotations have completed a full cycle. Two more years are required to complete a full cycle for three-year rotations treatment. Grain yields of winter wheat, spring wheat, spring barley, and winter pea obtained in the 2007-08 crop year are shown in Table

8. This crop-year had the second lowest precipitation (8.4 inches) which reduced yields of annual crops compared to years when precipitation was higher. Yields of winter wheat after either conventional or chemical fallow were also significantly reduced when compared to the 2006-07 because of low spring precipitation (Fig. 2). 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 spring 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 four-yr average (2004/05 - 2007-08 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 tillage fallow (Table 8). The high wheat yield obtained from the 3-yr rotation is partly attributed to low levels of root-lesion nematode incidences and low weed infestation. Yield from the 3-yr rotation was significantly higher than yield of winter wheat following chemical fallow. Yields from annual crops were strongly influenced by annual precipitation (Table 8). Continuous spring barley, with the lowest root lesion nematode incidences (Table 6), produced the highest yield followed by winter wheat after winter pea, with the lowest root lesion nematode incidences (Table 6). Continuous winter wheat produced the lowest yields over the four crop-years. This was probably due to a combination of high downy brome (*Bromus tectorum*) infestation which was observed in the first three-years and high incidences of root lesion nematodes but not due a shortage of water as was expected in annual cropping. Grain yields of all the crops were negatively associated with root-lesion nematode incidences (Fig 1.). Soil moisture in plots grown to annual winter wheat was higher than in other rotations beginning May until harvest (Fig 3 an 4, see arrow) indicating that the crop was not able to utilize available soil moisture. Crop rotation that involved spring barley had very low incidences of the root lesion nematode and consequently produced high yields.

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, NO_3-N, NH_4-N, P, SO_4-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 8. Grain yield of winter wheat, spring wheat, spring barley, and winter peas under different cropping systems at CBARC, Moro, 2005. The yield shown is for the crop in italics.

Rotation	Grain yield (bu/ac)				
Annual cropping	2004-05	2005-06	2006-07	2007-08	4-yr mean
Continuous *winter wheat*	10.6c	18.7d	30.76ef	20.2bc	20.2e
Continuous *spring wheat*	10.1c	37.9bc	32.01e	15.0c	23.9de
Continuous *spring barley*	11.6c	64.8a	39.31d	24.2b	34.9c
Two-year rotations					
Conventional fallow-*Winter wheat*	58.0a	59.5a	64.5ab	38.9a	55.2ab
Chemfallow-*Winter wheat*	52.9ab	46.5b	60.6b	41.4a	50.3b
Winter wheat-*winter pea*	9.1c	17.1d	9.5g	-	-
Winter pea-*winter wheat*	40.5ab	33.2c	36.4de	13.2cd	30.8c
Three-year rotations					
Chemfallow-*winter wheat*-spring barley	63.2a	57.9a	65.9a	42.6a	57.4a
Winter wheat-*spring barley*-chemfallow	12.8c	59.2a	35.7de	9.5d	29.3cd
Precipitation (mm)	7.9	16.9	11.1	8.4	

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

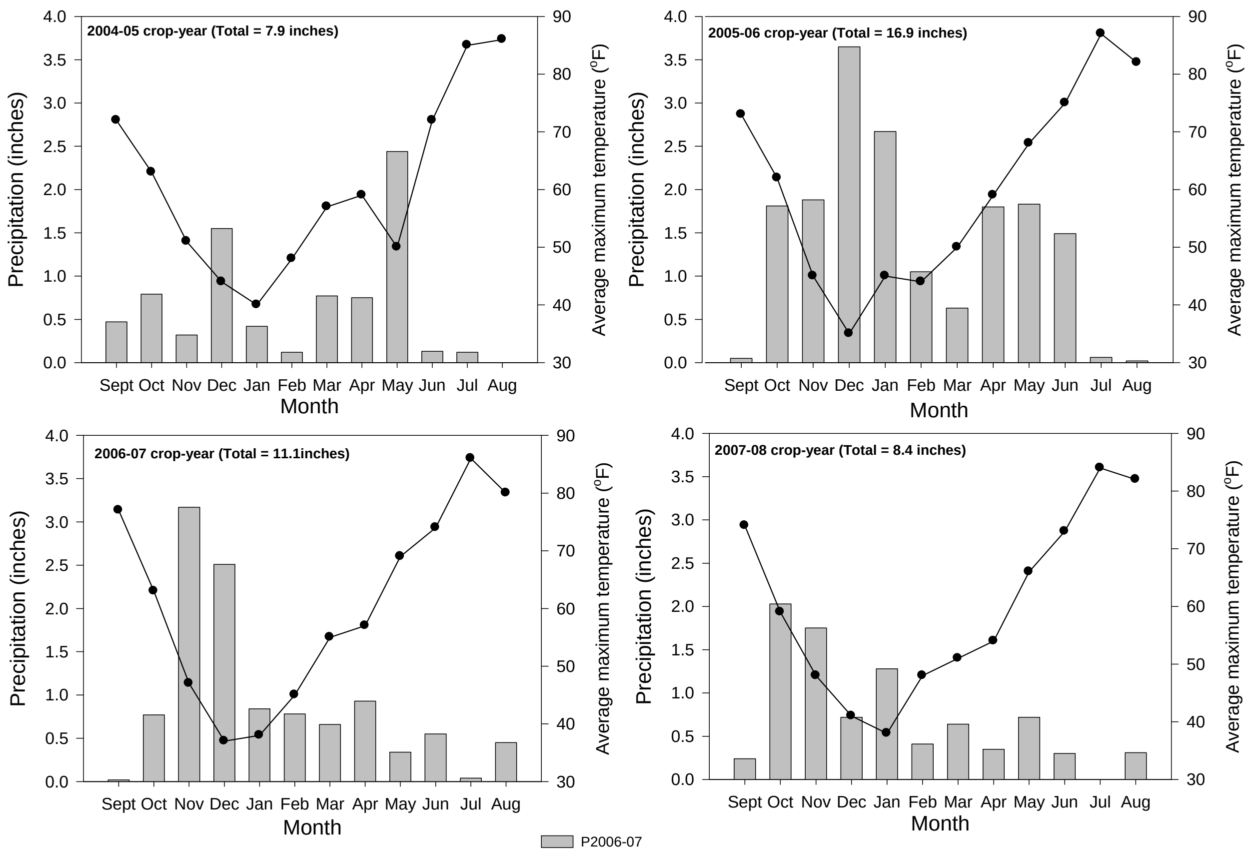

Fig. 2. Precipitation and average maximum temperatures at the OSU CBARC Moro long-term experiment site from 2004/05-2007/08 crop years

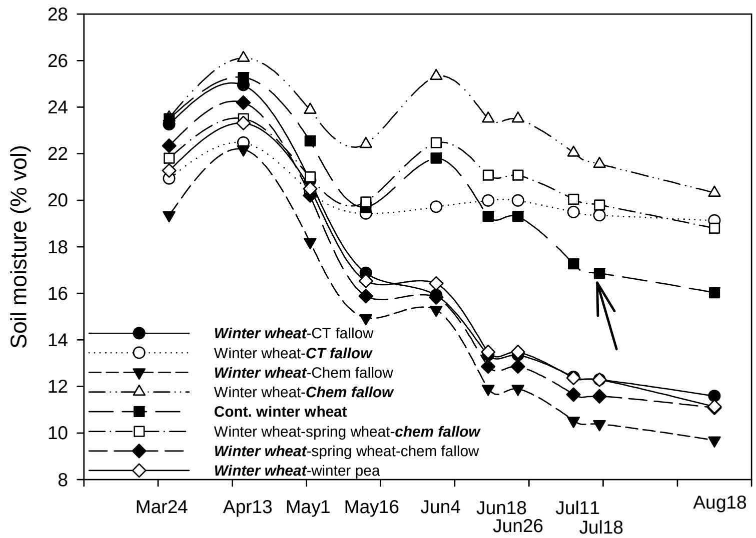

Fig. 3. Average soil water content under all rotations in the 0 to 40-inch depth profile from March to August, 2006, at CBARC Moro. Data shown is for crop/treatment in boldface and italics of a rotation. **Arrow shows data on continuous winter wheat**.

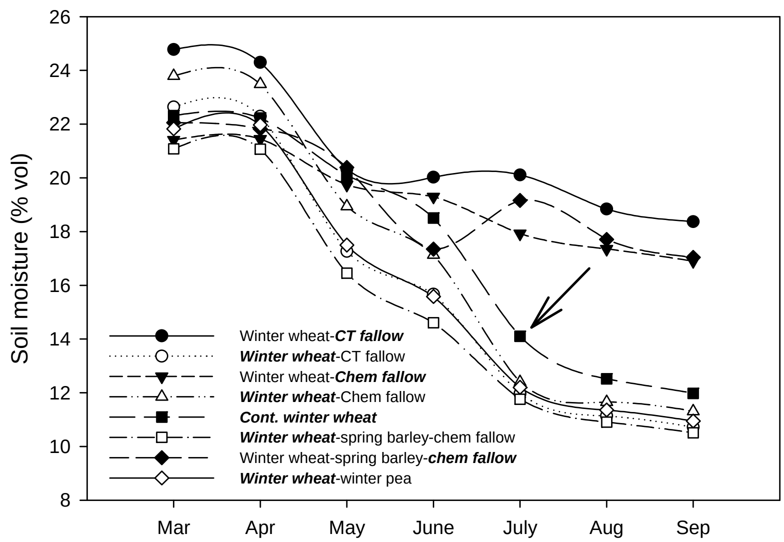

Fig. 4. Average soil water content under all rotations in the 0 to 40-inch depth profile from March to September, 2007, at CBARC Moro. Data shown is for crop/treatment in boldface and italics of a rotation. **Arrow shows data on continuous winter wheat**.

INTERACTION WITH OTHER SCIENTISTS CONDUCTING RELATED ACTIVITIES:

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

PUBLICATIONS

Smiley, R.W., and **S. Machado**. 2008. *Pratylenchus neglectus* reduces winter wheat yield and water extraction in dryland cropping systems.-accepted for publication in *Plant Pathology*

Machado, S., L. Pritchett, E. Jacobsen, S. Petrie, R. Smiley, D. Ball, D. Wysocki, S. Wuest, H. Gollany, and W. Jepsen. 2008. Long-term Experiments at CBARC-Moro and Center of Sustainability, Heppner, 2006-2007. Oregon Agricultural Experiment Station Special Report 1083

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

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

PRESENTATIONS

Machado, S., D. Ball, S. Petrie, L. Pritchett, and R. Smiley. 2008. Developing Profitable and Sustainable Cropping Systems for North-Central Oregon and South-Central Washington. Poster presented at the 2008 GSA, ASA, CSSA, SSSA Annual Meetings, Houston, TX.