# *Proposal for 2010-2011*
# *Northwest Columbia Plateau $PM_{10}$ Project*

**Objective 5:** **Identify Alternative Cropping Systems that Reduce Wind Erosion**

***Title:*** ***Developing Sustainable Intensive Cropping and Conservation Tillage Systems in North-Central Oregon and south-central Washington***

**Personnel:** Principal Investigator: **Stephen Machado, OSU.**

## Objectives

The ultimate objective of this project is to develop profitable and sustainable cropping systems for north-central Oregon and south-central Washington. Specific objectives include developing cropping systems that increase residue cover, reduce wind and water erosion, reduce soil water evaporation, increase soil available moisture, increase soil OM, and sustain soil productivity. Information to address these objectives, however, will be obtained after long-term experimentation. This proposal seeks to extend the on-going project consisting of long-term experiment at the Columbia Basin Agricultural Experiment Center (CBARC) at Moro, OR.

## Recent Accomplishments

The experiments are in their 6$^{th}$ year (2009-10) and some trends are beginning to show. The results are now being published.

The CBARC, Moro project seeks to develop cropping systems that reduce wind erosion and have the potential to sustain soil productivity compared to the traditional winter wheat-fallow system. Different conservation tillage systems involving direct seeding are under evaluation (Table 1).

**Table 1. Cropping and tillage treatments for the long-term experiment at the CBARC, Sherman Experiment Station, Moro.**

| Rotation | Description |
|---|---|
| 1 (WW TF) | Conventional winter wheat/conventional tillage fallow |
| 2 (WW CF) | Winter wheat/chemical fallow-direct seeding |
| 3 (WW WW) | Continuous winter wheat-direct seeding |
| 4 (SW SW) | Continuous spring wheat-direct seeding |
| 5 (SB SB) | Continuous spring barley-direct seeding |
| 6 (WW SB CF) | Winter wheat/spring barley/chemical fallow-direct seeding |
| 7 (WW WP) | Winter wheat/winter pea-DS |
| 8 (Flex) | Flex crop |

### *Grain yield*

Grain yields for the 2008-09 crop-year are shown in Table 2. Under continuous annual cropping, spring barley, with the lowest root-lesion nematode (*Pratylenchus* spp) incidences, produced the highest yield followed by annual winter wheat. Spring wheat produced the lowest yields for the second time in five years. Although annual winter wheat was the most infested by root lesion nematodes, its nematode density was not significantly different from that of annual spring wheat. Both annual spring barley and annual winter wheat used more soil water than spring wheat. Direct seeded winter wheat after chemical fallow produced the highest yield although this yield was not significantly higher than yield from winter wheat after chemical fallow in a 3-yr rotation with spring barley. Both rotations had low root-lesion nematodes incidences. For the first time, winter wheat after conventional tillage fallow produced significantly less yield than winter wheat after chemical fallow. This was probably due to low and sporadic stands that were further reduced by wide spread gopher damage in the wheat after conventional tillage fallow. In general, plant stand was lower for winter wheat after all the fallow treatments. Yield of winter wheat after winter pea cover crop was not significantly different from yield obtained from winter wheat after conventional tillage fallow.

Based on the 5-yr average (2004/05 to 2008-09 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 and wheat after chemical fallow. These results suggested that direct seeded systems, that tend to increase soil organic matter and maintain surface residues that prevent soil erosion, can replace the conventional tillage wheat fallow system that is prevalent in these low rainfall areas of North-Central Oregon and South-Central Washington. The high wheat yield obtained from the 3-yr rotation is partly attributed to low levels of root-lesion nematode (*Pratylenchus neglectus*) incidences and low weed infestation. 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 yield over the four crop-years although this yield was not significantly different from yield from annual spring wheat. The low average yield from annual winter wheat 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 is usually the case in annual cropping. Grain yields of all the crops were negatively associated with root-lesion nematode incidences.

**Table 2. 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 | 2008-09 | 2004-09 |
| Continuous *ww* | 10.6c | 18.7d | 30.76ef | 20.2bc | 26.7e | 21.5c |
| Continuous *sw* | 10.1c | 37.9bc | 32.01e | 15.0c | 17.0f | 22.5c |
| Continuous *sb* | 11.6c | 64.8a | 39.31d | 24.2b | 30.7cd | 34.1b |
| Two-year rotations | | | | | | |
| Conventional fallow-*ww* | 58.0a | 59.5a | 64.5ab | 38.9a | 34.1bc | 51.0a |
| CF-*ww* | 52.9ab | 46.5b | 60.6b | 41.4a | 39.5a | 48.2a |
| WW-*winter pea* | 9.1c | 17.1d | 9.5g | - | - | - |
| Winter pea-*ww* | 40.5ab | 33.2c | 36.4de | 13.2cd | 33.7c | 31.4b |
| Three-year rotations | | | | | | |
| CF-*ww*-sb | 63.2a | 57.9a | 65.9a | 42.6a | 37.8ab | 53.5a |
| WW-*SB*-cf | 12.8c | 59.2a | 35.7de | 9.5d | 29.0de | 29.2b |
| Precipitation (inch) | 7.9 | 16.9 | 11.1 | 8.4 | 9.1 | |

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

***Soil Aggregate Distribution***

After four years of alternative cropping system there is an indication of shift in aggregate size distribution due to cropping system (Fig 1 and 2). The majority of the aggregates were in the medium size range, between 0.125 and 1.00 mm. In 2009, most of the treatments had increases in the largest aggregate size (> 2mm) range, especially in the fallow phase of the treatments. Treatment 10 (winter wheat-spring barely-chemical fallow under direct seeding) in the fallow phase had the highest increase in the > 2mm aggregate size range perhaps due to intensification of cropping and less tillage under direct seeding with chemical fallow. The winter wheat-chemical fallow under direct seeding (treatment 3) had the greatest increase in macro-aggregate (> 0. 250 mm) in the range of > 0.5- to < 2-mm and smallest percentage of the aggregates in clay size (0.053 mm) fraction. The percentage of clay size fraction for most of the other treatments increased by more than 10%, especially for the winter wheat-fallow under conventional tillage treatments (treatment 1 & 2), and winter wheat-winter pea under direct seeding (Treatment 11 & 12) in both phases. Micro-aggregates (< 0.250 mm) increased in the continuous spring barley (treatment 7) and flex cropping system (treatment 13 and 14). An increase in macro-aggregates could decrease soil susceptibility to wind and water erosion while an increase in micro-aggregates could contribute wind and water soil erosion.

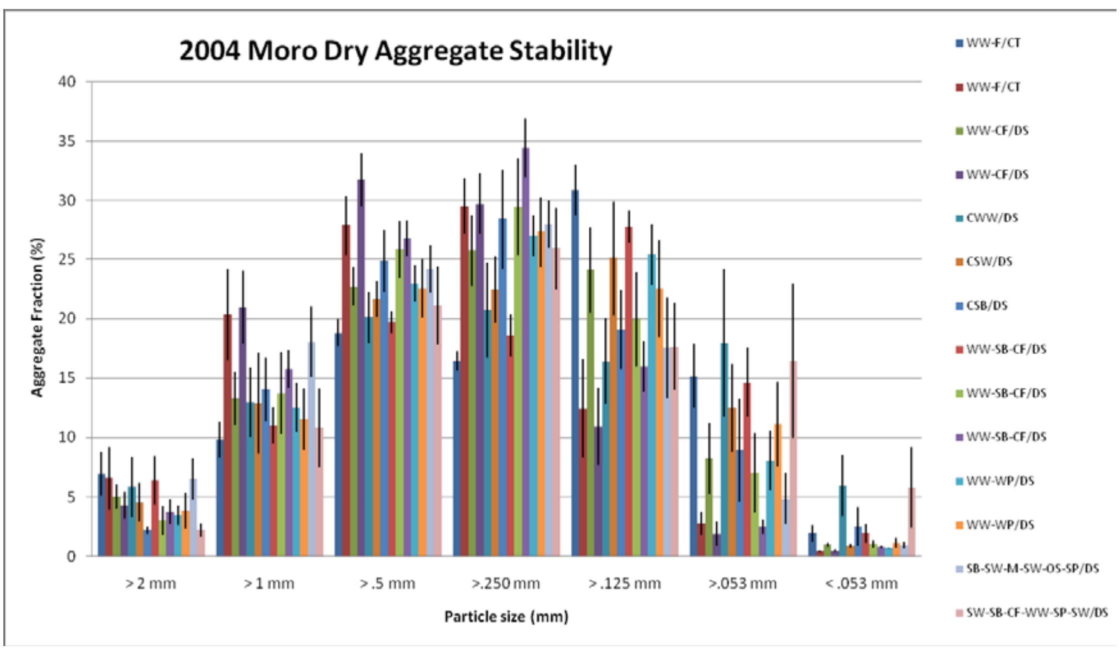


**Fig. 1. Mean and standard error of the mean aggregate size fraction for the cropping systems at Moro in 2004.**

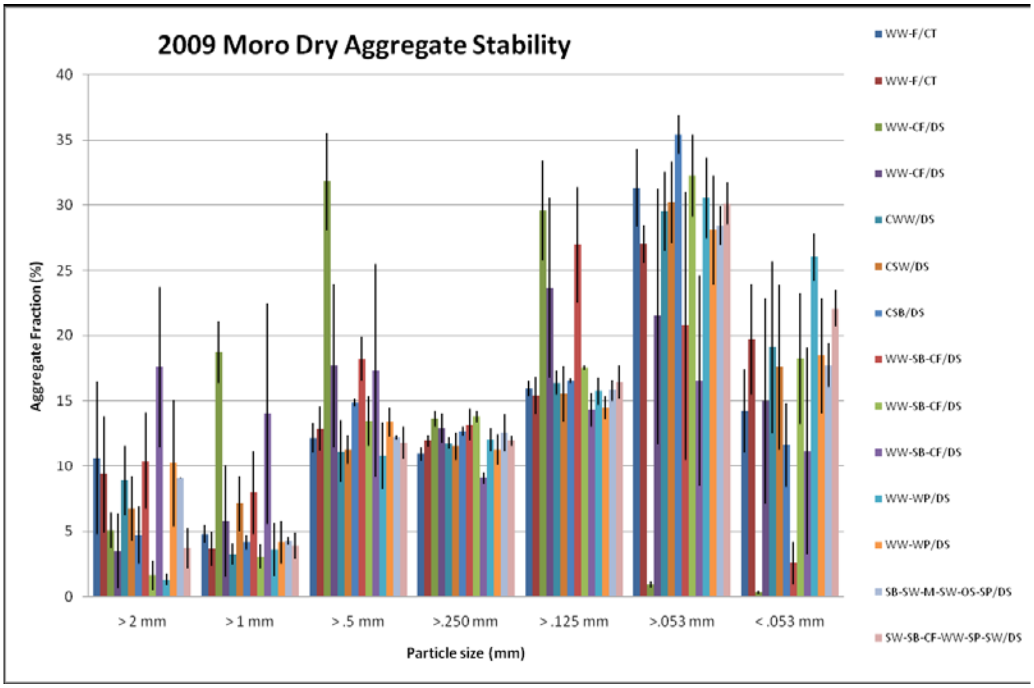


**Fig. 2. Mean and standard error of the mean aggregate size fraction for the cropping systems at Moro in 2009 (5 years later).**

***Residue production and erosion control potential***

Crop residue measurements (amount and percent ground cover) taken before seeding winter crops in 2008 and spring crops in 2009 are shown in Figure 3. Residue cover was lowest (below 40%) following winter peas, the traditional fallow and chemical fallow in the winter wheat-spring barley-chemical fallow rotation. Residue cover after chemical fallow and under continuous annual cropping of winter wheat, spring wheat, and spring barley was above 60%. The highest residue cover was obtained following winter wheat in the winter wheat-spring barley-chemical fallow rotation. The relationship between residue cover and residue weight is shown in Figure 4.

The project is now in the sixth year and all crop rotations will have completed at least two full crop cycles. To this end, continued funding of the experiments to completion is vital to generate information required to determine whether the systems under evaluation control soil erosion and sustain soil productivity. It is envisaged that the experiment will continue for another rotation cycle.

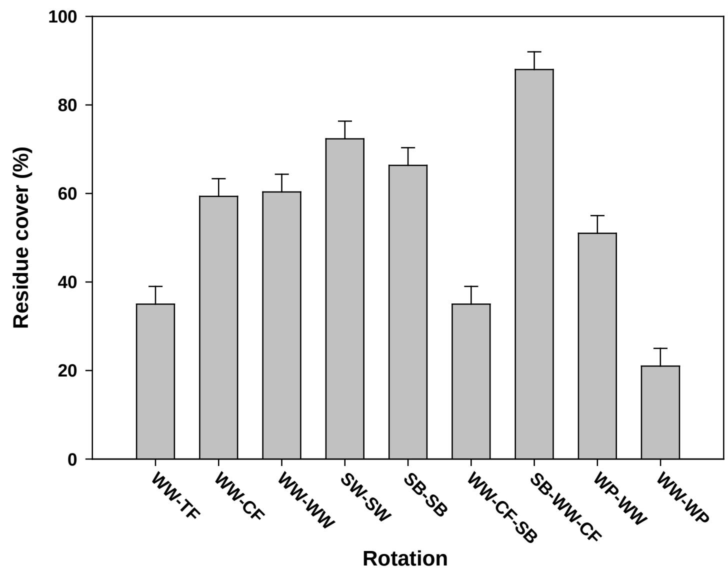


**Fig .3 Cropping system effects on percent residue cover after traditional summer fallow (TF), chemical fallow (CF), after seeding winter wheat (WW) and winter pea (WP) in the fall of 2008 and spring wheat (SW) and spring barley (SB) in the spring of 2009.**

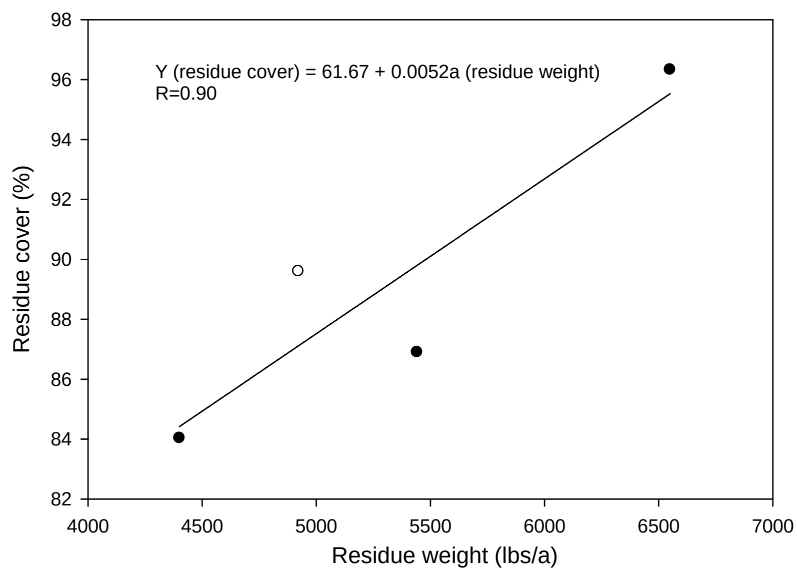


**Fig 4. Relationship between residue cover and weight. Data obtained in the spring of 2008 before seeding spring crops at OSU, CBARC Moro Long-term experiment, OR.**

***Microbial Community Composition***

The composition of the microbial community followed somewhat similar trends to those found for microbial biomass. The composition of the bacterial and fungal communities differed with depth, with communities being significantly different at each of the four depth intervals. The fungal community of the control soil was significantly different from each of the 14 management treatments; however, there were no differences in the fungal community among the 14 management treatments. The bacterial community of the control soil differed from a few of the management treatments, but like the fungal communities, bacterial communities did not differ among the 14 management treatments.

Differences in the microbial community, both in terms of biomass and composition, were found with soil depth. The size of the biomass decreased with depth, paralleling similar trends in soil organic matter. Other studies have also found that composition of bacterial and fungal communities changes with depth.

The managed soils tended to have less microbial biomass and different fungal, and to a lesser degree, bacterial communities when compared to the control (unmanaged) soil. After four years of management, no trends in the composition of bacterial or fungal communities were found, even when just the upper portion of the soil was examined.

**Planned Research**

To fulfill the overall objectives, the long-term experiment at CBARC, Moro will continue in 2009-10 crop year with the same treatments shown in Table 1. The following data will be collected.

***CBARC, Moro***

***Crop Productivity (Crop Growth, Grain Yield, and Yield Components)****-Stephen Machado, Larry Pritchett, Erling Jacobsen*

Basic data on the timing of agronomic practices, dates of plant emergence, plant populations, flowering, and maturity, biomass, grain yield will be collected every year. Plants will be considered emerged when >50% of the plot has emerged plants. Plants will be counted 10 to 14 days after emergence on at least 10-3 ft row lengths in the sampling areas. The plot will be considered to have flowered or matured when >50% of the plants have flowered or matured. Bundle samples from at least 10-3 ft quadrats will be collected from the harvest areas for the determination of crop residue biomass and harvest index. Yield components will be determined from plants in bundle samples. Plants in the quadrat are cut as close as possible to the ground and weighed for total biomass. The spikes are then cut off and counted; spikelets from 10% of the spikes are counted and grain from these spikelets threshed, weighed and counted. From these data, spikes $m^{-2}$, spikelets per spike, grains per spikelet, and kernel weight will be derived. The rest of the plot area will be harvested by a commercial size combine to obtain grain yield.

***Soil Erosion, Soil Physical Characteristics, Water Infiltration, Soil Available Moisture****, - Stephen Machado, Stewart Wuest (ARS), Hero Gollany (ARS), and John Williams (ARS)*

Soil moisture data will be measured by dielectric methods (2 access tubes/plot) to about 36 inches every year. Erosion will be measured by a rill meter (McCool et al., 1976) during 2008-11 phase with the help of either Dr. J Williams and Dr. B. Sharratt. The rill will be set up at least 4 locations in the plot and a digital photograph taken of the rill pins after seeding of fall crops or in January or February when the ground has settled. Another set of measurements will be taken on the same positions after the erosion season in May or June. The difference in the data will be used to estimate soil erosion. Data on earthworm populations, bulk density, water infiltration and aggregate stability were measured at the start of the experiments in 2003 and will be measured every 5 years thereafter. The next measurements of these variables will be conducted during 2008-11 phase. Water infiltration will be measured using a double ring infiltrometer.

***Soil Organic Matter, Soil Chemical Characteristics, Soil Productivity****-Stephen Machado, Steve Petrie, Larry Pritchett, Erling Jacobsen*
A representative soil sample will be collected at 12-inch intervals to 48 inches or to restricting layer using a Giddings® probe at 3 locations in each plot every year. In the first year (2003) and 5 years thereafter, samples will be analyzed for pH, OM, P, K, $NO_3$, $NH_4$, $SO_4$, Zn, Soluble salts, in the 0 to 12 inch samples, $NO_3$ and $SO_4$ in the 12 to 24 inch samples, and $NO_3$ in the 24 to 48 inch samples. In other years the soil will be analyzed for $NO_3$, $NH_4$, and SO4 in the first 12 inches and $NO_3$ in the 12 to 48 ft samples to determine fertilizer recommendations. Soil for SOM determination will be collected at 4-inch intervals in the top foot and at 12 inch intervals to a depth of 48 inches. The next comprehensive soil analysis will be conducted during the 2008-09 crop-year.

***Surface Crop Residue Cover****- Stephen Machado, Larry Pritchett, Erling Jacobsen*
Surface residue cover (%) in each plot will be estimated by taking digital photographs of surface residues in at least 10, one meter quadrats in each plot after harvest and at seeding. The images will be analyzed to determine percent surface cover using Sigma Scan Pro 5.0 (SPSS Inc.) software. The amount of total residues produced will be derived from bundle samples obtained at harvest.

***Diseases****-Dick Smiley, Jason Sheedy, and Sandra Easley*
Diseases will be monitored at least twice annually in each planted plot. All procedures are routinely performed in on-going disease-management research with wheat and rotational crops (Smiley et al., 1996). Plots will be sampled for disease assessments during early winter (late November or early December) and late spring (May), and whiteheads, if present, will be quantified during mid- to late-June. Winter and spring samples involves removing 20 to 40 plants per plot, washing soil from roots, and scoring each plant individually for presence and severity of diseases such as Fusarium foot rot, take-all, Rhizoctonia root rot, strawbreaker foot rot, or Cephalosporium stripe. If present, the incidence and/or damage by insect pests is also quantified.

***Weeds****-Dan Ball and Larry Bennett*
Evaluations will be made on changes in density and species composition of weed populations. Emphasis will be placed on downy brome and jointed goatgrass, two weeds of primary importance in this agronomic zone. Weed density and species composition estimates will be made twice during the growing season. One count will be made in late January before crop canopy closure by counting all weeds in 5 randomly placed 2.68 $ft^2$ quadrats per plot. A second count will be made in mid April after application of appropriate herbicide treatments. Weed counts will be made in three large 9.8 ft by 16.4 ft quadrats suspended above the crop canopy to assess mid-season weed populations after herbicide treatment.

***Profitability of Cropping Systems****-Doug Young, Steve Petrie, Stephen Machado, Larry Pritchett, Erling Jacobsen*
A proposal to conduct an economic analyses is under development. Dr. Doug Young has agreed to lead the evaluation. Inputs and outputs of each cropping system that have already been recorded will be used for economic analyses. A thorough profitability and economic risk analysis will be conducted.

*Sustainability-Stephen Machado, Steve Petrie, Dick Smiley, Dan Ball*
Data obtained from all the above activities will be used to assess the productivity and sustainability of the cropping systems under evaluation.

**Expected outcomes and anticipated impacts for research and extension:**
The two experiments are expected to generate data on cropping systems effects on soil erosion, soil quality, and soil productivity. Using this information, the sustainability and profitability of different cropping systems will be determined and necessary adjustments will be made to improve potential cropping systems. Information obtained from these experiments will go a long way to influence growers to adopt sustainable cropping practices that reduce wind erosion.

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