

ORVILLE VOGEL WHEAT RESEARCH FUND

Project #: 5250

Progress Report Year: 2008

Title: Dryland Wheat Agronomy Research in the Low-Precipitation Zone

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ACCOMPLISHMENTS / RESULTS / IMPACTS:

Overview: The WSU Dryland Research Station received 6.77 inches of precipitation during the 2008 crop year (Sept. 1 – Aug. 31), the least since the 1977 crop year. Long-term average annual precipitation for the Station is 9.50 inches. Growing season precipitation was only 0.20 inch for April, 0.10 inch for May, and 0.48 inch for June. The 2008 winter wheat yield (after summer fallow) at Lind was only 26 bu/acre. Recrop spring wheat averaged 5 bu/acre. Due to dry soil conditions, deep-furrow planting of winter wheat in summer fallow was the most difficult since 1994.

Project 1: Rotational Benefits of Winter Canola on the Subsequent Wheat Crop

Multiple-year experiments are being conducted in the low (Ritzville) and intermediate (Davenport) precipitation regions of eastern Washington to document the rotation benefits of winter canola (WC) in wheat-based cropping systems. Some growers have reported that wheat following winter canola has less disease and weed pressure and produces considerably higher grain yield compared to monoculture cereals in either a two-year winter wheat-summer fallow (WW-SF) rotation or three-year WW-spring wheat (SW)-spring barley rotation. Additionally, it has been observed that water runoff from frozen agricultural soils does not occur from winter canola stubble; presumably because the deep tap root provides open channels for water to penetrate through the frozen surface soil layer. Neither the boost in winter wheat grain yield or the soil physical, biological, or pathological factors, that may account for better water infiltration and increased wheat yield as affected by having winter canola in the crop rotation, have been documented.

Objectives: To determine the benefits of winter canola grown in (i) a 4-year WC-SF-WW-SF rotation compared to the traditional 2-year WW-SF rotation in the low-precipitation zone and, (ii) a 3-year WC-SW-SF rotation compared to a WW-SW-SF rotation in the intermediate precipitation zone on:

1. Grain yield of the subsequent winter wheat (low zone) or spring wheat (intermediate zone) crop.

2. Soil microbial changes after winter canola versus after winter wheat.
3. Plant diseases of the subsequent winter wheat (low zone) or spring wheat (intermediate zone) crop.
4. Soil water infiltration and frozen soil runoff after winter canola versus after winter wheat.
5. Economic assessment.

Results to Date: Like all high-quality crop rotation experiments, several years of field data from our multiple locations will be required to “tell the story” on the benefits of WC as a rotation crop. Winter canola is difficult to establish in tilled summer fallow because emerging seedlings are killed by the hot surface soil when air temperatures are 85⁰ F or greater. Thus, it is necessary to time the planting of WC with the expected air temperature 6-8 days after planting. We have had no problem establishing WC in the intermediate precipitation zone in chemical summer fallow where planting depth is shallow and soil water plentiful; however, our first planting of WC at Davenport in 2007 was completely destroyed by grasshoppers.

Winter canola tends to use more water in the lower (i.e., 3 to 6 feet) profile than does winter wheat (Fig. 1). There was a grain yield reduction of WW at Ritzville in 2008 that was correlated with the high water use by WC grown in 2006 (Fig. 2). Now that experiments have been established for several years, we will hereafter be able to measure rotation benefits at all sites every year.

Soil samples have been assessed for soil microbial differences following WC compared to WW but preliminary laboratory results are not yet available. Differences in disease pressure in wheat as affected by crop rotation have not yet been detected. Frozen soil infiltration measurements have not yet been made because surface soils have not frozen solidly during the past several winters.

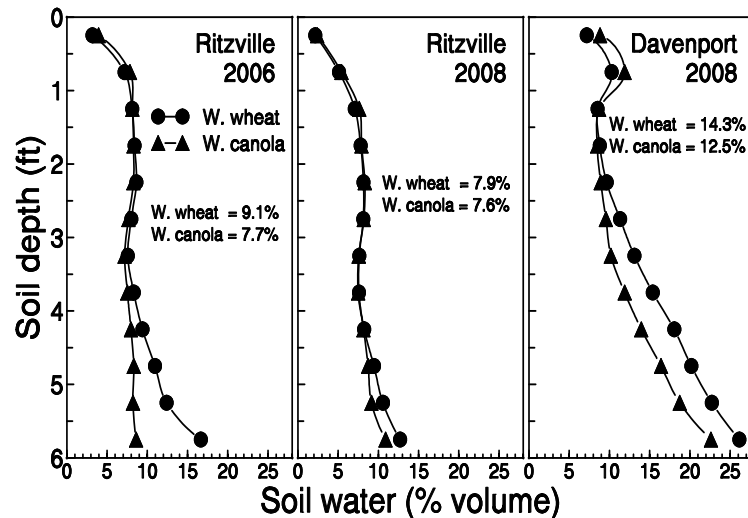


Fig. 1. Soil water in the six-foot soil profile just after the harvest of winter canola compared to after harvest of winter wheat. Winter canola used significantly more water than winter wheat at the Ritzville 2006 and Davenport 2008 studies. There were no differences in soil water between these two crops during a year of extreme drought at Ritzville in 2008.

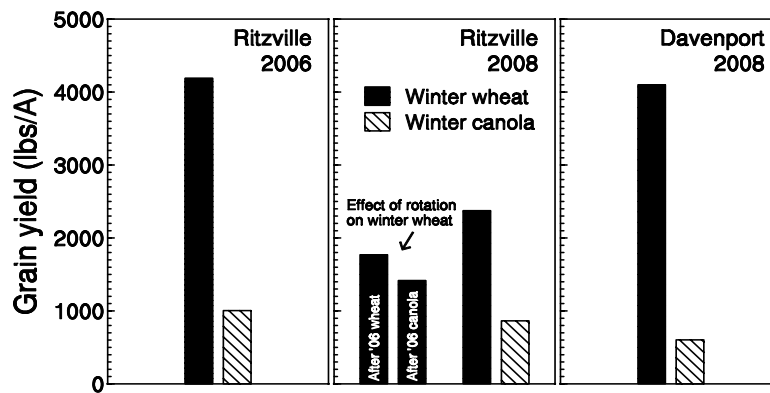


Fig. 2. Winter wheat produced more than four times the grain biomass compared to winter canola during three site years. Monoculture winter wheat after fallow produced 30 bu/a at Ritzville in 2008 compared to 24 bu/a when the previous crop was winter canola (with a year of fallow in between). The wheat grain yield reduction following winter canola is positively correlated with winter canola's greater soil water use in 2006 (see Fig. 1).

Project 2: Optimum Rodweeding Frequency to Maintain Seed-zone Moisture

A 4-year field study was initiated in 2006 at the WSU Dryland Research Station at Lind to evaluate the frequency of rodweeding operations on seed-zone moisture retention and several other agronomic and environmental factors. In mid April, primary spring tillage is conducted to a depth of 5 inches. Aqua nitrogen fertilizer is injected into the soil with the undercutter sweep implement during the one-pass primary tillage. Subsequent rodweeding operations are conducted at the 4-inch depth with a Calkins center-drive rodweeder. Treatments are:

1. No rodweeding (i.e., check). Weeds are controlled with a glyphosate herbicide with a sprayer as needed to maintain weed-free plots.
2. Rodweed only when required to control weeds (this will range from 1 to 3 rodweedings, depending on the year, but only one rodweeding was required in 2006).
3. Rodweed immediately after primary spring tillage, but thereafter only as required to control weeds (as per treatment no. 2, above).
4. Rodweed immediately after primary spring tillage and then at one-month intervals until late July-early August. This was a total of five rodweedings.

Results for 2006, 2007, and 2008 show that primary spring tillage alone (in this case mid April with a Haybuster undercutter sweep) was the only operation required to retain seed-zone moisture. Surface residue and surface clod mass are reduced with increased rodweedings (Fig. 3). The undercutter only treatment maintained a highly crusted surface that provided excellent control for wind erosion throughout the fallow cycle during all three years.

There was a much higher quantity of subsurface clods in the reduced rodweeding treatments compared to the 5x treatment (data not shown) but, as previously documented by Schillinger and Papendick (SSSAJ 1997), subsurface clods do not appear to reduce seed-zone water content in tilled summer fallow. In all three years, the 5x rodweeding treatment reduced surface residue compared to treatments that received none or only one rodweeding (Fig 3).

The best stands in 2008 were achieved in the 5x rodweeding treatment (data not shown), presumably because it had the fewest soil clods to impede coleoptile/first leaf movement towards

the soil surface. There had been no differences in plant stand establishment among treatments in previous years.

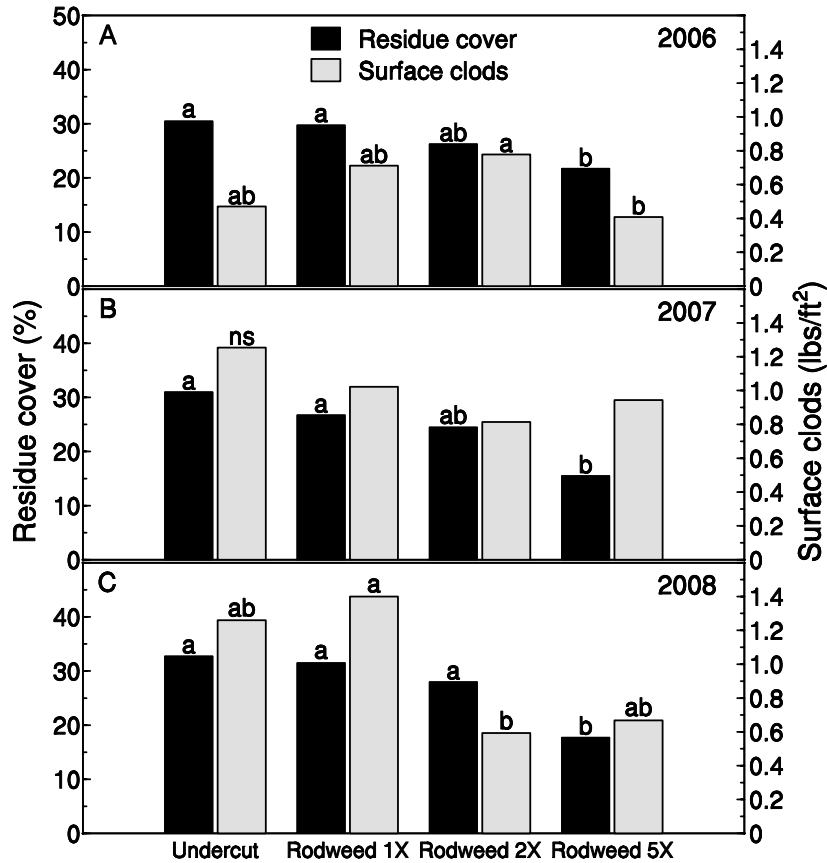


Fig. 3. Residue cover and surface clod mass in summer fallow just prior to planting winter wheat in late August in 2006, 2007, and 2008 at Lind with three rodweeding frequency and timing treatments plus the undercutter only check. Within residue cover and surface clod mass means followed by the same letter are not significantly different at $P < 0.05$.

Winter wheat grain yields as affected by rodweeding frequency are shown in Fig. 4. Grain yield in the 5x rodweeding treatment was reduced by about 5 bu/a compared to the other treatments in 2007. The reason for this reduction is not known since there were no differences in seed-zone water content, 6-ft soil profile water content, or plant stand establishment in either the 2007 and 2008 crop years. There were no differences in grain yield among treatments in 2008 (Fig. 4).

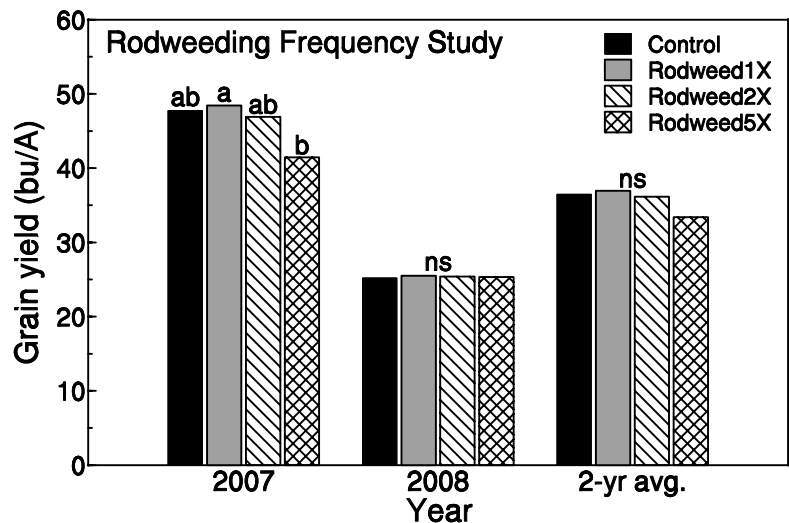


Fig. 4. Winter wheat grain yield as affected by frequency of rodweeding.

Project 3: Long-Term Dryland Cropping Systems Research at Lind: Years 2002 to 2008.

We completed a 6-year no-till and minimum-till cropping systems research experiment at the WSU Lind Dryland Research Station in 2008. A committee of farmers and scientists designed the study. The following cropping systems were in place from 2002 to 2008: (i) continuous annual soft white spring wheat, (ii) continuous annual hard red spring wheat, (iii) continuous annual hard white spring wheat, (iv) winter wheat - summer fallow (tillage), (v) winter wheat - spring wheat - spring wheat, (vi) winter wheat - spring wheat - chemical summer fallow, and (vii) winter wheat - spring wheat - summer fallow (tillage). Average annual precipitation during the 6-year study was 8.42 inches, - well below the 88-year average of 9.50 inches of annual precipitation.

The experimental design was a randomized complete block with four replications, thus a total of 56 plots. Individual plots were 225 ft long. Each phase of all treatments appeared every year. Grain harvest was with a plot combine equipped with chaff spreader. The entire experiment area was then "blanket harvested" with a commercial-scale combine to uniformly spread straw and chaff. Tillage (in treatments iv and vii above) was with a wide-blade undercutter sweep, both to control Russian thistle after harvest (if needed) and for primary spring tillage (aqua N is applied with the undercutter in the spring), followed by two rodweedings (i.e., minimum tillage). All other treatments are planted and fertilized in one pass into undisturbed standing stubble from the previous crop with a hoe-type no-till drill.

Results show that winter wheat (WW) grown after tilled summer fallow in a 2-year rotation (36 bu/a) and WW after tilled summer fallow in the 3-year rotation (35 bu/a) had significantly greater grain yield than any of the other treatments (Table 1). Planting WW into chemical fallow treatment resulted in an average 36% reduction in grain yield compared to winter wheat planted in late August into tilled fallow. However, in August 2004 and August 2007, 0.5 inch or more rainfall occurred that was sufficient for the moisture line to meet in chemical summer fallow. We planted WW in late August into chemical fallow during these years and the subsequent grain yield was statistically not different than WW after tilled fallow (Table 1). Grain yield for recrop WW (i.e., no fallow) as well as recrop spring wheat in all rotations averaged 3 bu/a or less (Table 1).

Slightly higher SW grain yields were obtained in the 3-year rotations that included summer fallow, even though the summer fallow preceded WW, not SW (Table 1). There were no differences in grain yield among continuous annual soft white, hard white, and hard red spring wheat in 2008 or the 6-year average (Table 1). The greatest water use efficiency was achieved in the 2-year WW-SF rotation, even though it takes two years of precipitation to produce only one crop. Although the economic analysis has not yet been conducted, it is clearly evident that SW is not economically viable during drought years. Farmers are advised to consider planting SW if they have five inches or more plant-available moisture by early March; it is likely better to make conservation-till summer fallow and plant winter wheat in late August.

In addition to grain yield, other measurements obtained each year in this study are soil water status, weed dynamics, plant pathology, soil quality attributes, and the effects of added surface residue on soil water retention in chemical summer fallow. A refereed journal article and a *Wheat Life* article will be published from this study in the near future.

Table 1. Wheat grain yield, water use efficiency, and crop-year precipitation during a six-year cropping systems experiment at Lind.

Rotation	Year						6-yr avg.	Avg. WUE — bu/in. —
	2003	2004	2005	2006	2007	2008		
	Grain yield (bu/A)							
Two-year rotation								
Winter wheat (after tilled SF)	29.4	41.1	34.2	41.4	42.9	24.5	35.6	2.08
Three-year rotation I								
Winter wheat (after tilled SF)	29.9	40.7	30.0	42.9	37.0	29.0	34.9	2.04
Spring wheat	10.8	12.5	6.8	31.2	9.3	7.7	13.1	1.46
Three-year rotation II								
Winter wheat (after chemical SF)	24.1	15.5	23.9	33.4	14.7	26.6	23.0	1.40
Spring wheat	11.1	11.7	9.5	30.2	9.3	8.4	13.4	1.51
Three-year rotation III								
Winter wheat	16.3	11.3	7.7	27.3	10.4	4.1	12.8	1.44
Spring wheat	10.3	8.9	3.3	24.5	7.4	3.0	9.5	1.03
Spring wheat	9.9	8.7	6.3	25.7	11.9	6.7	11.5	1.29
Continuous annual spring wheat								
Hard white spring wheat	14.6	12.4	4.3	26.5	8.9	4.4	11.9	1.31
Soft white spring wheat	8.5	7.7	5.5	26.1	11.7	5.9	10.9	1.18
Hard red spring wheat	11.7	10.5	4.7	26.6	10.7	5.5	11.6	1.28
LSD (0.05)	9.3	7.9	5.5	10.9	6.5	6.7	3.9	0.37
	Crop-year precipitation (in.)							
	7.87	8.08	6.85	11.90	9.02	6.77	8.42	

Project 4: Seed Priming Winter Wheat for Emergence and Yield

We are conducting research on priming winter wheat seed because insufficient stand establishment of winter wheat is a major problem in the low-precipitation (< 12 inch annual) dryland summer fallow region of the inland Pacific Northwest. This problem was readily apparent in the drought year of 2008. Low seed zone soil water potential, deep planting depths with 5 inches or more soil covering the seed, and soil crusting caused by rain before seedling emergence frequently impede winter wheat stands.

A multiple-year field study was initiated at Lind in early September 2004 to determine seed priming effects on winter wheat emergence and grain yield. Two wheat varieties were used based on their strong (either Edwin or Buchanan) and moderate (Eltan) emergence capabilities. The three early phases of germination are: i) imbibition, ii) lag phase, and iii) protrusion of the radicle through the testa. Priming is a procedure that partially hydrates seed to initiate the germination process. The experiment has four treatments: Edwin (or Buchanan) and Eltan seed both primed and not primed (i.e., check). Primed seed is soaked in water for 12 hours, and then spread on a concrete platform for 15 minutes. Within the subsequent 3-hr time period, seed from all four treatments is planted into summer fallow with 5 inches of soil cover in 200-ft-long plots with a John Deere HZ deep furrow drill. Yield components (i.e., heads per unit area, number of kernels per head, and kernel weight) are obtained from all treatments in July. Plots are then harvested with a plot combine.

Our experience with seed priming has been mixed. Prior to this year, we felt that priming is of benefit to emergence under dry seed-zone moisture conditions, but may be detrimental to emergence under relatively wet seed-zone conditions (see previous Vogel progress reports). Seed priming also appeared to benefit the semidwarf variety (Eltan) more than the standard-height varieties Edwin and Buchanan. However, in 2008 (dry planting conditions), the checks of both Buchanan and Eltan emerged better than when primed (Fig. 5). To date, with four years of yield data, there has been little to no difference in winter wheat grain yield as affected by priming (Fig. 6).

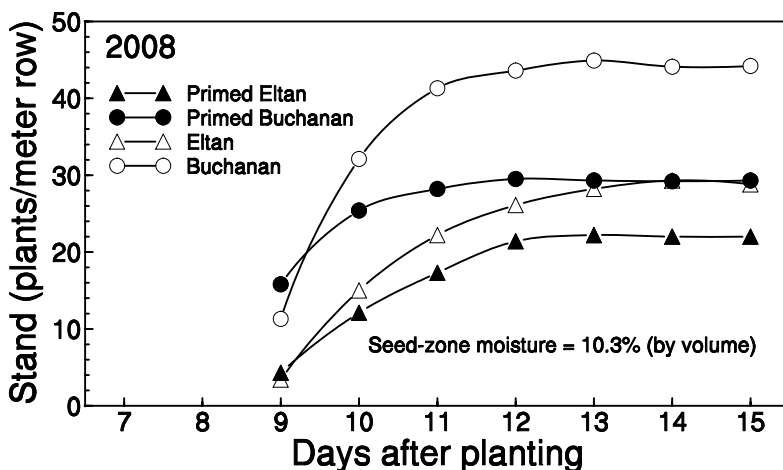


Fig. 5. Seedling emergence of Buchanan and Eltan as affected by priming seed in water for 12 hours prior to planting versus checks in late August 2008. The trial was planted with a John Deere HZ deep-furrow drill and the seed was covered with 5 inches of soil. Although seed priming has tended to benefit emergence of winter wheat seedlings in previous dry years, the checks for both Buchanan and Eltan did better than their primed counterparts in 2008.

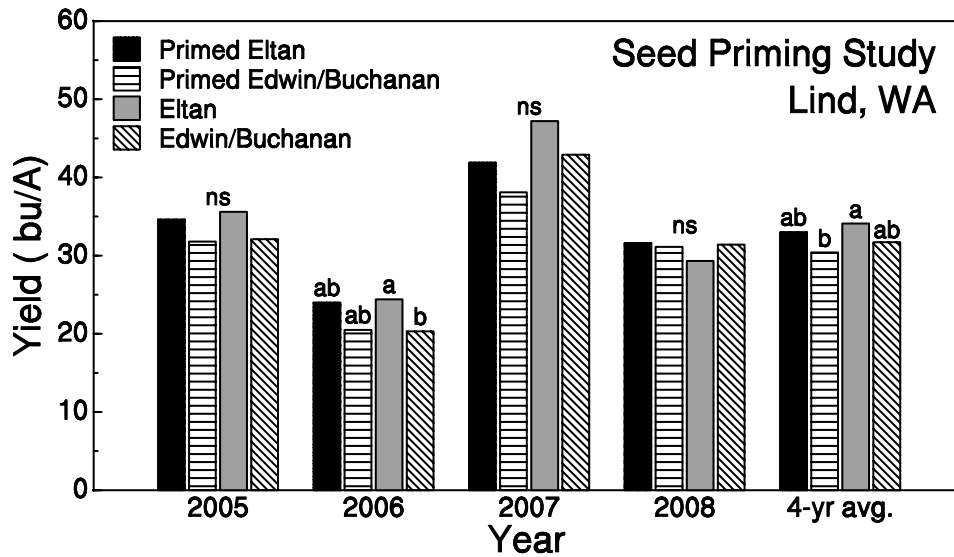


Fig. 6. To date, seed priming has had little to no effect on winter wheat grain yield. Within-year means followed by the same letter are not significantly different at $P < 0.05$. ns = not significant.

To gain a better understanding of emergence of semidwarf and standard-height winter wheat varieties, we are conducting a series of pot experiments under controlled laboratory conditions. Primed and non-primed seed is planted under several different seed-zone moisture conditions. Our first run of pot experiments in 2008 showed that priming benefits Eltan emergence from both low and high soil water potential (Fig. 7).

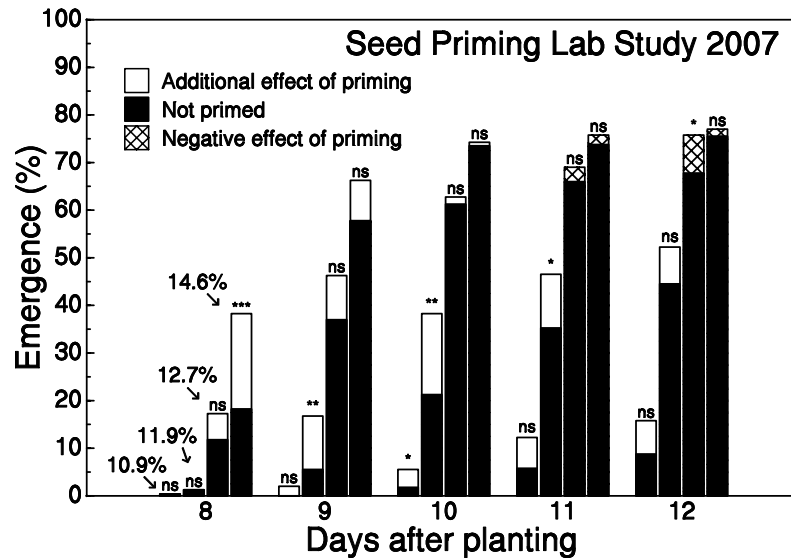


Fig. 7. Pot studies in the laboratory show that priming Eltan winter wheat seed enhances seedling emergence at both low and high soil water potentials, but can have slight negative effects beginning 11 days after planting with the higher water potentials.

Publications from Vogel Project 5250 in 2008

Scientific Journal Articles

- Schillinger, W.F., S.E. Schofstoll, and J.R. Alldredge. 2008. Available water and wheat grain yield relations in a Mediterranean climate. *Field Crops Research* 109:45-49.
- Wuest, S.B., and W.F. Schillinger. 2008. Small-increment electric soil sampler. *Soil Science Society of America Journal* 72:1554-1556.
- Schillinger, W.F., and R.I. Papendick. 2008. Then and now: 125 years of dryland wheat farming in the Inland Pacific Northwest. *Agronomy Journal* 100(Suppl.):S166-S182.
- Schillinger, W.F., T.A. Smith, and H.L. Schafer. 2008. Chaff and straw spreader for a plot combine. *Agronomy Journal* 100:398-399.
- Flury, M., J.B. Mathison, J.Q. Wu, W.F. Schillinger, and C.O. Stockle. 2009. Water vapor diffusion through wheat straw residue. *Soil Science Society of America Journal* (in press).

Extension Bulletins

- Schillinger, W.F., H.L. Schafer, S.E. Schofstoll, and B.E. Sauer. 2008. Ecology and control of Russian thistle after spring wheat harvest. *Washington Agric. Exp. Station. Bull. XB1046E*.

Abstracts from Professional Meetings

- Lutcher, L., W.F. Schillinger, N. Christensen, S. Wuest, and D. Wysocki. 2008. Phosphorus fertilization of late-seeded winter wheat in a chemical fallow system [CD-ROM]. Soil Science Society of America annual meeting, 5-9 Oct., Houston, TX. *ASA, CSSA, and SSSA Abstracts*.
- Schillinger, W.F., D.L. Young, and B.S. Sharratt. 2008. The undercutter method of dryland wheat farming to control wind erosion in the western United States [CD-ROM]. European Society of Soil Science 'EUROSOIL' Congress, 25-29 Aug., Vienna, Austria.

Washington State University Field Day Abstracts

- Schafer, H., W. Schillinger, B. Rude, and D. Wysocki. 2008. Pacific Northwest undercutter project. *In 2008 Field Day Abstracts: Highlights of Research Progress*. Dept. of Crop and Soil Sciences Tech. Report 08-1, WSU, Pullman, WA.
- Schillinger, W.F., A.C. Kennedy, T.C. Paulitz, D.L. Young, and T.A. Smith. 2008. Winter canola as a rotation crop in the low and intermediate precipitation zones. *In 2008 Field Day Abstracts: Highlights of Research Progress*. Dept. of Crop and Soil Sciences Tech. Report 08-1, WSU, Pullman, WA.
- Lutcher, L.K., W.F. Schillinger, S.B. Wuest, D.J. Wysocki, and N.W. Christensen. 2008. Phosphorus fertilization of late-seeded winter wheat in a chemical fallow system. *In 2008 Field Day Abstracts: Highlights of Research Progress*. Dept. of Crop and Soil Sciences Tech. Report 08-1, WSU, Pullman, WA.
- Wuest, S.B., and W.F. Schillinger. 2008. An improved method for soil sampling at small increments. *In 2008 Field Day Abstracts: Highlights of Research Progress*. Dept. of Crop and Soil Sciences Tech. Report 08-1, WSU, Pullman, WA.

Wheat Life Articles

- Schillinger, W.F., and R.I. Papendick. 2008 - 2009. Then and now: 125 years of dryland wheat farming in the Inland Pacific Northwest. Four-part series published in *Wheat Life* from November 2008 to February 2009.