Northwest Columbia Plateau PM_{10} Project

Objective 5: ***Wind Erosion and PM_{10} Emission Control Methods***

Title: ***Dryland Cropping Systems Research to Control Blowing Dust***

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Project 1: Long-Term Dryland Cropping Systems Research at the Ron Jirava Farm
We are currently in the 15th year of direct-seed and conservation-till intensive cropping experiment on 20 acres on the Ron Jirava farm near Ritzville, WA. Annual precipitation has been lower than the long-term average during 8 of the past 10 years (the 2006 and 2010 crop years were the exceptions). These drought conditions have not favored the economics of intensive (i.e., no fallow) cropping. Rhizoctonia bare patch first appeared in 1999 but has declined to near zero levels in the past three years. This is the first documentation of natural suppression of Rhizoctonia bare patch in long-term no-till in the United States. Soil organic matter in no-till treatments in the 0-to 2-inch layer has increased to that of the native undisturbed soil during the course of this experiment. Phase IV of the experiment began during the 2010 crop years. This new phase of the experiment will run for six years from 2010 to 2015.

Overview
A long-term alternative cropping systems project using direct seed and conservation tillage practices was initiated in 1997 on the Ron Jirava farm near Ritzville, WA. The soil at the experiment site is a Ritzville silt loam. The soil is more than 6 feet deep with no rocks or restrictive layers and slope is less than 1%. Thirty-year average annual precipitation for the site is 11.5 inches. The field where the experiment is conducted was in an intensive tillage-based WW-SF rotation for more than 100 years before the onset of the experiment.

In Phase I (1997-2000) of the experiment, cropping systems treatments were: (i) a 4-year safflower (SAF)-yellow mustard (YM)-soft white spring wheat (SW)-SW crop rotation, (ii) a 2-year SW-spring barley (SB) rotation and, (iii) continuous annual SW. Experimental design was a randomized complete block with four replications. Each crop in all rotations occurred each year in 60- by 500-ft plots, making a total of 28 plots. The 4-year rotation was designed primarily to test the effects of back-to-back broadleaf crops on the epidemiology of soil fungal diseases that plague monoculture wheat.

In Phase II (2001-2004) of the experiment, existing plots were split along the long axis (i.e., from 60-by 500-ft to 30-by 500-ft for a total of 56 plots) to introduce the following cropping systems: (i) a 4-year WW-WW-SW-SW rotation, (ii) a 4-year WW-SB-YM-SW rotation, (iii) a 2-year SW-SB rotation (retained from Phase I), (iv) a 2-year hard white spring wheat (HW)-SB rotation, (v) continuous annual SW (retained from Phase I) and, (vi) continuous annual HW.

For Phase III (2005-2009), treatments are: (i) a 4-year WW-SB-SW-chemical fallow (CF) rotation, (ii) a 4-year WW-SB-SW-tilled summer fallow (undercutter method) rotation, (iii) a 2-year SW-SB rotation, (iv) a 2-year SW-SB rotation, (v) continuous annual SW, and (vi) continuous annual HW.

An advisory group meeting was held in October 2009 to determine crop rotations for the next six years of the study (i.e., Phase IV, 2010-2015). The Phase IV crop rotations are (i) a 3-year CF-triticale-SW rotation, (ii) a TF-WW-SAF rotation, (iii) a 3-year TF-WW-SW rotation, (iv) a 2-year WW-TF rotation, (v) a 2-year SW-SB rotation, and (vi) continuous SW. Note that the continuous annual SW and the 2-year SW-SB rotations have been in place since 1997. In addition to the above, a small-scale 3-year TF-winter pea-SW rotation study was initiated in 2010 on land adjacent to the long-term study. All four phases of the experiment were designed in consultation with an advisory group of regional dryland wheat farmers.

The 20-acre Jirava site has been carefully managed through the years to maintain the integrity of the experiment. We know the exact history of each of the 56 plots. We feel that, with current technology, the Jirava site perhaps represents the lower precipitation boundary where intensive cropping may be an economically viable alternative to WW-SF. Therefore, knowledge and success stories generated from the Jirava experiment should be applicable throughout the 11-to 14-inch annual precipitation zone.

Growing Conditions and Grain Yields in 2010

Crop-year (September 1 – August 31) precipitation for 2010 at the Jirava site was 12.30 inches. Winter triticale that was planted late on chemical fallow produced 2.25 tons/acre. We were very pleased with this high yield of winter triticale because winter wheat from late October – early November planting dates has not been competitive with early-planted winter wheat in the region. Early-planted winter wheat on tilled fallow produced 78 bushels/acre. Spring wheat grain yield (in the various rotations) ranged from 39 to 44 bushels/acre. Spring barley grown in a 2-year rotation with spring wheat produced 1.23 tons/acre. Adequate stands of safflower were achieved and the crop appeared to do well, except that the flowering period was very short (i.e., less than one week). Safflower grain yield was a disappointing 125 lbs/acre.

Seed-zone water conditions were excellent in early September 2010. For the first time ever, we were able to plant early (winter triticale) into carryover soil moisture in chemical fallow and achieved excellent stands. We also achieved excellent stands of winter wheat and winter peas planted into tilled fallow.

Natural Suppression of Rhizoctonia Bare Patch with Long-Term No-Till

Rhizoctonia bare patch caused by *Rhizoctonia solani* AG-8 is a major fungal root disease in no-till cropping systems. In a 14-year experiment, Rhizoctonia first appeared in year 3 in all no-till plots and reached peak levels by year 2004 (Fig. 1). Rhizoctonia infected all crops grown with long-term no-till, including winter wheat, spring wheat, spring barley, yellow mustard, and safflower. The area of bare patches has been measured in mid-June every year in all plots with a backpack-mounted GPS unit. The area of bare patches began to decline in year 9 and reached near zero levels by years 2008, 2009 and 2010 (Fig. 1). Natural suppression of Rhizoctonia has been document only one time previously, - from a long-term continuous no-till wheat experiment in Australia. This is the second documentation of natural suppression of Rhizoctonia bare patch and the first in the world documenting suppression with diversified cropping. We plan to write and submit a journal article on this phenomenon in 2011.

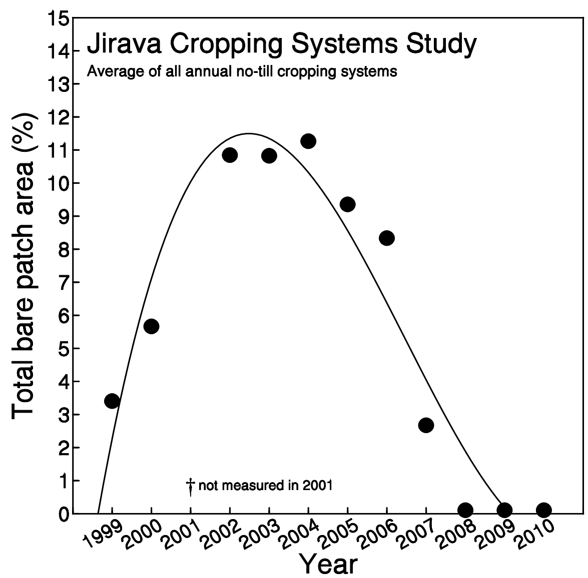

Fig. 1. Total bare patch area in no-till crops grown in a long-term dryland cropping systems experiment on the Ron Jirava farm near Ritzville, WA. Data are the average from all no-till plots including winter wheat, spring wheat, spring barley, and yellow mustard.

Rotation Benefits of Spring Barley on Subsequent Wheat Grain Yield

Crop rotation treatments evaluated over the 14 years include a 2-year soft white spring wheat (SW) – spring barley (SB) rotation versus continuous annual SW. The SW and SB varieties used are Alpowa and Baronesse, respectively. These crops have always been planted no-till. Long-term average annual precipitation at the site is 11.4 inches, but only an annual average of 10.30 inches has occurred since the inception of the study. There has been high year-to-year variability in grain yields for both SW and SB.

One consistent pattern has occurred. Spring wheat grain yields following SB are generally greater than monoculture SW (Fig. 2). This SW grain yield boost following SB is not significantly different every year, but there are statistical differences when averaged over the 14 years (Fig. 2). The 14-year average grain yield of SW after SB is 31.4 bu/acre compared to 29.6 bu/acre for monoculture SW. We have intensively measured soil water dynamics in this experiment and can say with certainty that the SW yield differences are not due to water. More likely, the yield increase is due to less Rhizoctonia bare patch disease pressure when SB is included in the rotation.

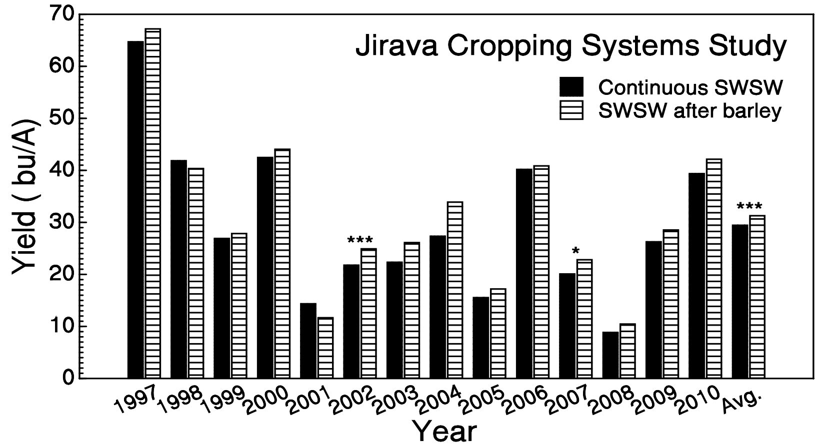

Fig. 2. Grain yield of continuous annual soft white spring wheat versus soft white spring wheat grown in a 2-year rotation with spring barley in a long-term dryland no-till cropping systems experiment near Ritzville, WA. * and * indicate significant statistical differences at the 0.05 and 0.001 probability levels, respectively**.

Grain yields of winter wheat grown after tilled summer fallow (WW-SF) were compared to those of continuous annual no-till spring wheat (SW) near Ritzville, WA during the past 14 years. Grain yields of WW-SF were relatively stable and averaged 52.7 bu/acre over the 14 years compared to 29.6 bu/acre for continuous annual SW (Fig. 3). Profitability of cropping systems fluctuates widely due to many factors such as cost of diesel, herbicides, and other inputs. However, as a general rule of thumb, recrop SW needs to yield 65% of that of WW-SF to be equally profitable. Using this measure, SW was equally as profitable as WW-SF in 5 of 14 years at Ritzville (Fig. 3). A model has been developed to help farmers decide when it may be desirable to plant spring cereals (in lieu of summer fallow) based on measured over-winter soil water storage and expected spring rainfall.

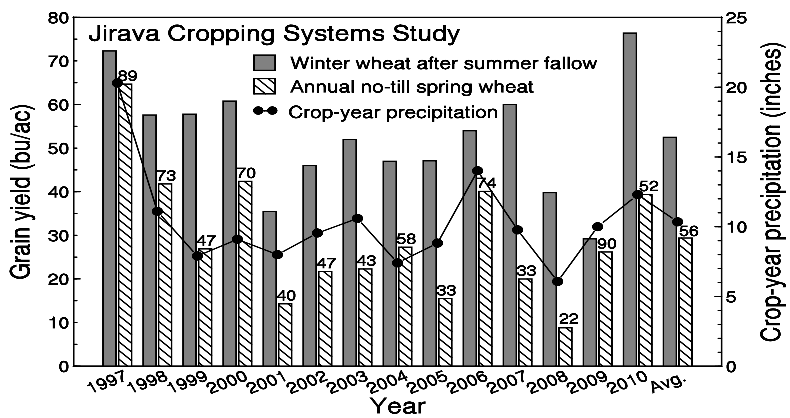

Fig. 3. Grain yield of soft white winter wheat after tilled summer fallow versus continuous annual no-till soft white spring wheat near Ritzville, WA. Numbers above the spring wheat bars indicate the percentage of spring wheat grain yield that was achieved compared to the grain yield in the winter wheat-summer fallow system. Units of measurement for crop-year precipitation are shown on the right axis.

Project 2: Rainfall Impacts on Winter Wheat Seedling Emergence

Abstract of Research Findings

Farmers in the low-precipitation (<300 mm annual precipitation) region of the Pacific Northwest USA (PNW) practice a 2-yr tillage-based winter wheat (*Triticum aestivum* L.) – summer fallow (WW-SF) rotation. Winter wheat (WW) is planted deep into moisture in late August or early September and seedlings emerge through 10 to 16 cm of dry soil cover. Rain showers that occur after planting create fragile soil crusts that the emerging first leaf often cannot penetrate. A rainfall simulator was used to conduct a 5-factor factorial laboratory experiment to evaluate emergence of WW planted deep in pots. Factors were: (i) rainfall intensity and duration (1.25 mm/hr for 3 hr, and 2.50 mm/hr for 2 hr); (ii) timing of rainfall after planting (1, 3, and 5 d after planting + controls); (iii) cultivar (standard-height vs. semi-dwarf); (iv) residue on the soil surface (0, 840, and 1680 kg/ha); and v) air temperature (21^0 and 30^0C). The high-intensity rain caused a 2.3-fold reduction in emergence compared to the low-intensity rain. Emergence improved proportionally with increasing quantities of surface residue. The standard-height cultivar had four times greater emergence than the semi-dwarf. Air temperature and timing of rainfall had no significant effect on WW emergence. Results show that planting a WW cultivar with long coleoptile and first leaf as well as maintaining high quantities of surface residue to intercept rain drops will enhance WW stand establishment after rain showers to benefit both farmers and the environment.

Study Methods

A laboratory experiment was conducted to determine impacts of rainfall on emergence of WW from deep planting depths. There were five factors:

i) Rainfall intensity and duration: 1.25 mm/hr for 3 hr and 2.50 mm/hr for 2 hr.
ii) Timing of rainfall: 1, 3, and 5 days after planting + controls (i.e., no rain).
iii) Winter wheat cultivar: Eltan (semi-dwarf) and Buchanan (standard-height).
iv) Surface residue: 0, 840, and 1680 kg/ha.
v) Air temperature: 21^0C (no sunlamp) and 30^0C (with sunlamp).

Experimental design was a split-plot factorial with one whole-plot factor (air temperature) and four subplot factors (rainfall intensity, timing of rainfall, cultivar, and surface residue) in a completely randomized layout. A total of 84 pots were required for each run of the study. These were: 2 rainfall intensities x 2 cultivars x 3 rainfall timings x 3 surface residues x 2 air temperatures + 12 controls (the controls were 3 surface residues x 2 cultivars x 2 air temperatures). Three separate runs were conducted, with each run serving as a replicate. Tukey's HSD test was used for comparisons between treatment means. Means were considered significantly different at $P<0.05$.

A. Preparing Pot Experiments

Soil used in the experiment was Shano silt loam with < 1% organic matter. Shano silt loam soil, and its close relative the Ritzville silt loam, are the major soil types of the 1.22 million hectare low-precipitation WW-SF region of east-central Washington. Soil textural size distribution of soils used in this study was 10% clay, 51% silt, and 39% fine sand. Shano soils lack structure and are highly susceptible to wind erosion when pulverized by excessive tillage and when residue cover is lacking. These soils contain significant quantities of fine particulates <10 *u*m in diameter (PM_{10}) that are readily suspended and transported long distances during windstorms.

Dry soil was collected from the surface 10 cm of tilled summer fallow at the Washington State University (WSU) Dryland Research Station in early September and sifted through a 6-mm-mesh screen to remove clods and residue. Water content of the soil (≈ 3% water by mass) was determined using the oven-drying method. A measured mass of dry soil was placed in a slowly-revolving portable cement mixer and a pressurized backpack sprayer was then used to uniformly mist a known quantity of water into the mixer to achieve the desired soil water content of 11% by mass. One thousand g of wetted soil was placed at the bottom of each 15-cm-diameter x 18-cm-tall pot and tamped to a depth of 5 cm to a bulk density of 1.25 g/cm^3 to achieve a volumetric soil water content of 13.7%. The 13.7% volumetric soil water content is considered slightly greater than what is normally experienced in field conditions, but was deemed necessary because trial and error indicated that soil drying in pots occurred at a much faster rate than under field conditions (data not shown). A hand-held patterned dimpling devise was then used to create 25 uniformly-spaced 6-mm-deep indentations in the moist soil in which 25 seeds were placed. A mixture of 50 g wetted soil and 50 g field dry soil (• 1.10 g/cm^3 bulk density) was then placed over the surface to cover the seeds. The remaining pot depth of 13 cm was loosely filled with field-dry soil to a bulk density of • 0.90 g/cm^3 and then leveled at the lip of the pot. These methods mimicked the soil conditions of deep-furrow planting of WW into tilled summer fallow.

Two WW cultivars were used on the basis of their strong (Buchanan) and moderate (Eltan) emergence capabilities. Buchanan is a standard-height, hard-red, common cultivar with long coleoptile, whereas Eltan is a semi-dwarf, soft-white, common cultivar with medium-length coleoptile. Buchanan is renowned for its excellent emergence ability from deep planting depths. Due to its high grain yield potential, Eltan has been the most widely-planted cultivar in the WW-SF region of east-central Washington for the past 20 years.

Standing stubble from WW grown at the WSU Dryland Research Station was allowed to weather in the field for 13 mo before being clipped into 5-cm-long segments. The dry residue segments were spread uniformly on the surface soil of pots at rates corresponding to 0, 840, and 1680 kg/ha. All 84 pots in each run were prepared as described above within a 10-hr time period.

B. Rainfall Simulation

A Palouse Rainfall Simulator was used to simulate the low-intensity, small-drop-size rains typical in the PNW. The simulator was equipped with two independent rotating heads with two different nozzles. Model 2.8w and 4.3w wide-angle, full jet nozzles were fitted on the heads to deliver rainfall at 1.25 and 2.50 mm/hr, respectively. The nozzles sprayed vertically downward at 100 kPa pressure with each head covering a 2.0-m-diameter area. Heads were located 2.5 m above the surface to generate drop size and drop velocity similar to naturally-occurring, low-intensity rainfall common in the PNW. Median raindrop size diameter was 1.20 and 1.39 mm for the 1.25 and 2.50 mm/hr delivery rates, respectively. The uniformity and intensity of rain distribution from both heads was verified by placing 10-cm-diameter containers in a 30-cm grid under the entire catchment area. For both heads, there was < 5% variability in uniformity of rain across the distribution area.

Selected pots were gently lifted from the laboratory bench and placed on a concrete floor under the two heads of the rainfall simulator on 1, 3, and 5 days after planting. The control pots received no rain.

C. Seedling Emergence

Immediately after each of the three rainfall simulations, half the pots were kept on a laboratory bench at constant 21^0C air temperature with the remainder placed in 90 x 90 cm-wide, 40-cm tall cardboard boxes under a sunlamp. Air temperature within the boxes was kept at 30^0C for 9-hr during each 24-hr period to simulate daytime field temperatures in early September.

Attempts were made to measure soil penetration resistance with two different instruments in pots six days after planting. Both the Gilson Geotester dial penetrometer and the Soiltest CL-700 pocket penetrometer were not sensitive enough to obtain viable readings in the extremely fragile crusts that formed on these soils.

The number of emerged seedlings in each pot was counted beginning 7 days after planting. Emerged seedlings were thereafter counted at 24-hr intervals until 14 days after planting when no further emergence occurred.

Results

Rainfall intensity, cultivar, and surface residue had highly significant ($P<0.001$) impacts on seedling emergence. Timing of rainfall and air temperature (heat) had no overall statistically significant effect on emergence. Among the five factors, the only interactions that occurred were timing of rainfall x cultivar and heat x cultivar. These interactions are explained by the fact that: (i) Timing of rainfall had no effect on the semi-dwarf cultivar Eltan, whereas emergence was lowest in the one day after planting rainfall treatment for the standard-height cultivar Buchannan and; (ii) heat from the sunlamp had no effect on Eltan but reduced emergence in Buchanan (Fig. 1).

Final emergence as influenced by individual factors is shown in Fig. 4. Combined for the two cultivars, the high-intensity rain reduced emergence to 16% compared to 36% for the low-intensity rain. Emergence in the control pots averaged 86%. The standard-height cultivar Buchanan had a four-fold increase in emerged seedlings compared to the semi-dwarf cultivar Eltan. Surface residue benefited emergence, most likely by intercepting rain drops. Conservation tillage management systems to retain maximum quantities of surface residue during fallow have been developed, and these methods are successfully practiced by many dryland farmers. Timing of rainfall had no significant effect on final emergence, but the general trend indicated that earlier rain is more detrimental for emergence than later rain, presumably because crust strength increased somewhat with time. Treatments subjected to 30^0C air temperature under the sunlamp for 9/hr/d showed emergence reduced by 30% compared to those held at constant 21^0C, but these differences were not significantly different. This lack of statistical difference in WW emergence due to air temperature likely occurred because air temperature was the whole-plot factor in a split-plot design. The split-plot design provides increased precision for subunit comparisons (i.e., rainfall intensity, timing of rainfall, cultivar, and surface residue) but at the cost of lower precision for the whole-plot comparison, since the overall precision of the experiment will not be changed.

All possible two-way interactions of the five factors were tested for seedling emergence from 7 to 14 days after planting. Emergence was always greatest for the low intensity rainfall treatments at all surface residue levels, and the presence of residue consistently benefited emergence. The timing of rain had no overall effect on emergence but the two intensities of rain were significantly different from each other. Similarly, the effect of rainfall intensity outweighed that of air temperature. Rainfall intensity caused emergence differences for both cultivars, but Buchanan had better emergence under both rainfall intensities compared to Eltan.

There was a general trend that the greater the surface residue, the better the emergence. This was the case with the relationships for residue x timing of rainfall, residue x air temperature, and especially for residue x cultivar. Buchanan emergence was significantly greater than for Eltan with all residue levels, once more strongly indicating that the longer coleoptile and first leaf of standard-height cultivars significantly improve seedling emergence compared to semi-dwarf cultivars.

Air temperature appeared to be a slightly more important indicator of emergence than timing of rainfall. As previously discussed, the only statistically significant two-way interactions that occurred were timing x cultivar and air temperature x cultivar. All three-way, four-way, and five-way interactions were not statistically significant.

Conclusion

Fragile soil crusts formed on silt loam soils after low intensity rainfall impede emergence of WW planted deep into summer fallow in eastern Washington. Crusts formed in this study were almost imperceptible and, although soil penetration resistance could not be measured with the available penetrometers, rainfall after planting had a marked negative impact on WW seedling emergence. Of the five factors evaluated, only cultivar selection and quantity of surface residue can be controlled by the farmer. Data conclusively show that when rainfall occurs after planting and before emergence: (i) the standard-height cultivar had an overall four-fold increase in seedling emergence compared to the semi-dwarf cultivar, and (ii) greater surface residue led to improved seedling emergence. These results bolster work currently in progress to enhance WW seedling emergence from deep planting depths through plant breeding and other research and extension efforts to promote the adoption of conservation-tillage summer fallow.

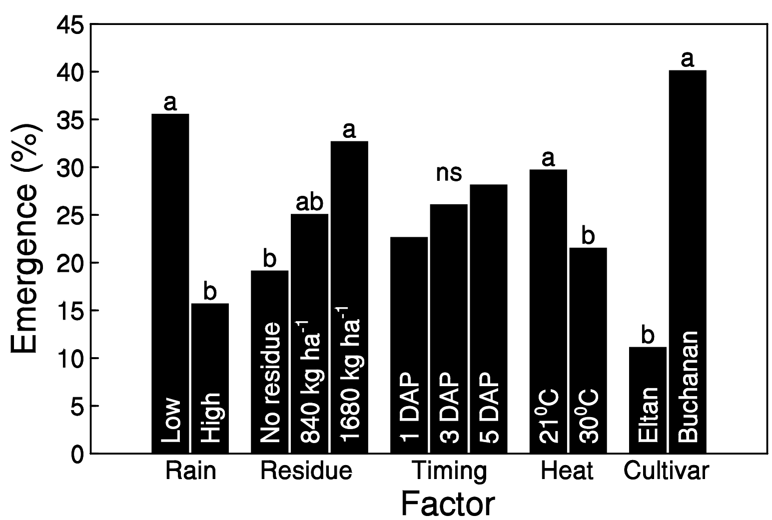

Fig 4. Percent emergence of Eltan and Buchanan winter wheat cultivars planted deep into pots as affected by rainfall intensity and duration, residue cover, timing of rainfall, and heat. Data are the average from three runs. Data are combined for the two cultivars. DAP = days after planting.

Blowing dust from excessively tilled summer-fallowed fields in the Horse Heaven Hills is a major air quality concern in the Tri-cities, WA. The two major goals for this study are to: (i) determine, based on measured soil moisture in early April, the likelihood of having adequate seed-zone moisture for successful late-August planting into tilled summer fallow and; (ii) provide the research-based information needed for USDA-NRCS to implement farm programs to entice wheat farmers to change from tillage-based fallow to no-till fallow in the Horse Heaven Hills. Beginning in March 2006, replicated on-farm experiments were established on the David Pearson and Mike Nichols farms. The Pearson farm is located in the central Horse Heavens on deep Ritzville silt loam soil. Average annual precipitation at the Pearson site averages 8.0 inches. The Nichols farm is located in the western Horse Heavens on deep Warden silt loam soil and annual precipitation averages 6.0 inches. Wheat farmers Pearson and Nichols manage all aspects of field operations for the experiments. The experimental design at both sites is a randomized complete block with four replications. Individual plots are 200 ft long and 60 ft wide. Total plot area at each site is 9.5 acres. Tillage treatments are (i) traditional tillage summer fallow, (ii) conservation tillage summer fallow, and (iii) chemical summer fallow.

With five years of fallow data, seed-zone water content in late August was too dry for planting into tilled fallow at the Nichols site in four out of five years. Conversely, at the Pearson site seed zone-water content in tilled fallow was adequate in all but one of the five years. No-till fallow was too dry for late-August planting at both sites in all years. Due to extreme dryness in the western Horse Heavens, we feel that no-till summer fallow can be practiced most years since seed-zone water for late-August planting is not available with tilled fallow during many years. With four years of grain yield data, we've measured a slight, but statistically significant, grain yield reduction with no-till fallow even on years when the tilled and no-till fallow were planted by "dusting in" on the same date in mid to late October (Fig. 5). We do not yet know the reason(s) for these grain yield differences as there were no significant differences in the total 6-foot profile water between tilled and no-till fallow methods. We (Singh, Flury, and Schillinger) plan to submit a manuscript to Soil & Tillage Research on this project in 2011.

Project 4. Evaporation from high residue no-till versus tilled fallow in a dry summer climate

Farmers in the low-precipitation (< 300 mm annual) region of the Inland Pacific Northwest of the United States practice summer fallow to produce winter wheat (*Triticum aestivum* L.) in a 2-yr rotation. No-till fallow (NTF) is ideal for wind erosion control but is not widely practiced because of seed-zone soil drying during the summer, whereas adequate seed-zone water for germination and emergence of deep-sown winter wheat can generally be retained with tilled fallow (TF). Successful establishment of winter wheat from late August – early September planting is critical for optimum grain yield potential. A 6-yr field study was conducted at Lind, WA to determine if accumulations of surface residue under long-term NTF might eventually be enough to substitute for TF in conserving seed-zone water over summer. Averaged over the six years, residue rates of 1500, 6000, and 10,500 kg ha^{-1} (1x, 4x, and 7x rates, respectively) on NTF produced incrementally greater seed-zone water but were not capable of conserving as much as TF (Fig. 6). Total root zone (0 to 180 cm) over-summer water loss was greatest in the 1x NTF whereas there were no significant differences in the 4x and 7x NTF versus TF. Average precipitation storage efficiency ranged from 33% for 1x NTF to 40% for TF (Table 1).

We conclude that for the low-precipitation winter wheat-summer fallow region of the Inland Pacific Northwest: (i) Cumulative water loss during the summer from NTF generally exceeds that of TF; (ii) there is more extensive and deeper over-summer drying of the seed-zone layer with NTF than with TF; (iii) increased quantities of surface residue in NTF slow the rate of evaporative loss from late-summer rains, and (iv) large quantities of surface residue from April through August will marginally enhance total-profile and seed-zone water in NTF, but will not retain adequate seed-zone water for early establishment of winter wheat except sometimes during years of exceptionally high precipitation or when substantial rain occurs in mid-to-late August.

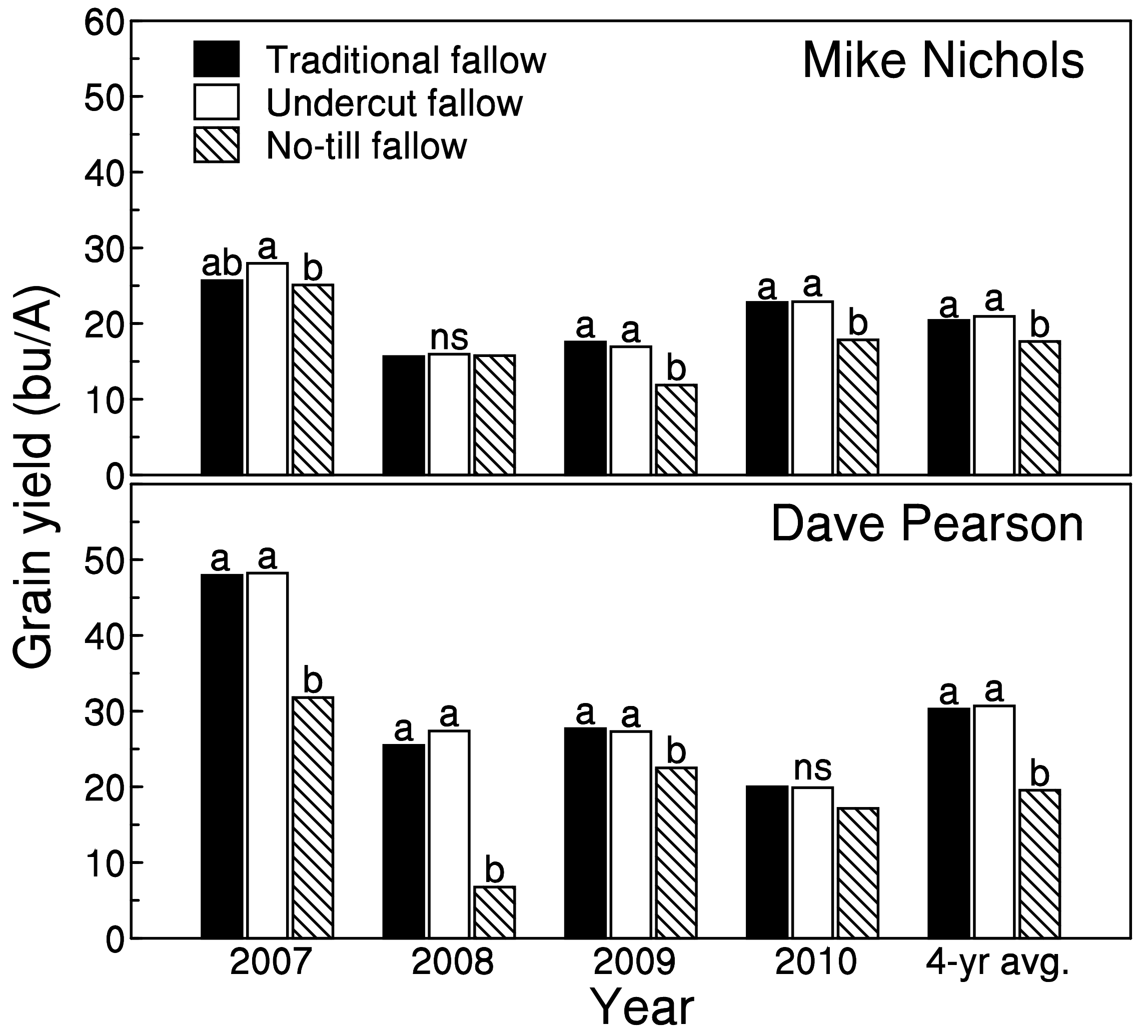

Fig. 5. Winter wheat grain yield at the Nichols (western HHH) and Pearson (central HHH) sites for four years where traditional, undercutter, and no-till methods were used during the preceding fallow period.

Table 1. Soil water content at the beginning (after harvest), early spring, and end of fallow (before planting) and associated gain or loss of water and precipitation storage efficiency (PSE = gain in soil water / precipitation) in tilled versus no-till summer fallow (at 1x residue rate) averaged over six years at Lind, WA. The top portion of the table shows water in the surface 90 cm of soil and the bottom portion of the table shows water content

	Timing in fallow period					
	Beginning (early Aug.)	Spring (mid Mar.)	Over-winter gain	End (late Aug.)	April - Aug. water loss	
	Soil water content (mm)					PSE (%)
			Top 90 cm of soil profile			
Treatment						
No-till fallow	57	145	88	104	41	20
Tilled fallow	49	138	89	104	33	25
P > F	0.04	0.01	ns	ns	0.02	ns
			Entire 180 cm soil profile			
Treatment						
No-till fallow	145	258	113	218	40	33
Tilled fallow	132	248	116	219	29	40
P > F	ns	ns	ns	ns	ns	ns

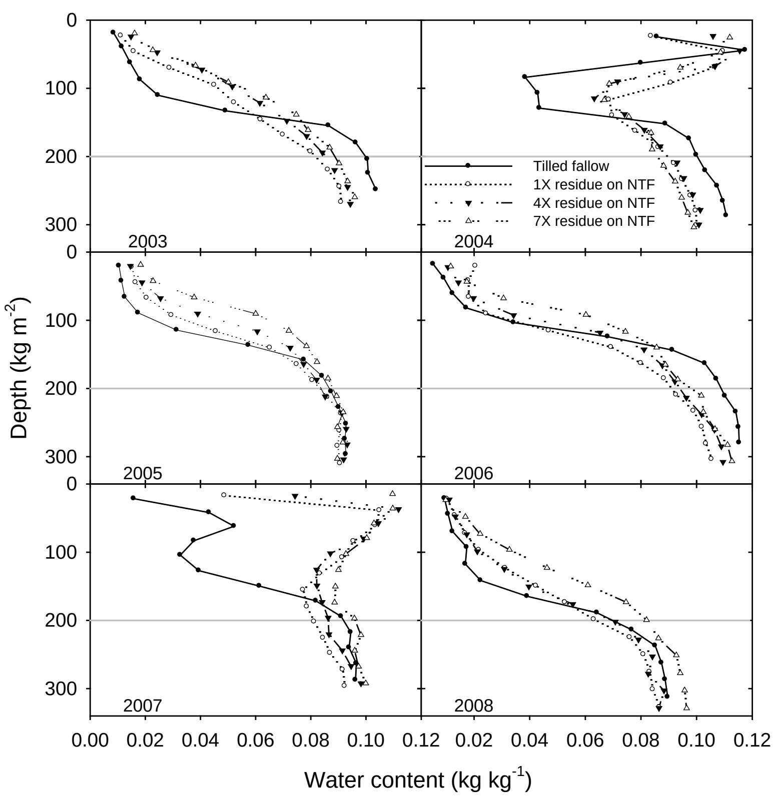

Fig. 6. Seed-zone water content profiles measured in late August from 2003 to 2008 at Lind, WA. Samples were taken in 2-cm increments from 0- to 26-cm depth (22 cm in 2003) and are plotted on a dry soil mass per area basis in both tilled fallow and in no-till fallow (NTF) with three surface residue rates. The horizontal guideline marks 200 kg m^{-2} used for equivalent-mass treatment comparisons.

Project 6: Develop and Test New Deep-Furrow Drill Prototypes for Conservation Tillage Wheat-Fallow

Winter wheat-summer fallow is the dominant cropping system on three million cropland acres in east-central Washington where annual precipitation is less than 12 inches. Wheat growers in this region use either John Deere HZ or International 150 deep-furrow drills for planting. These drills were developed 45 years ago and have not been manufactured for decades. Existing drills are wearing out and need to be replaced. Conservation tillage methods have been developed that allow growers to preserve ample residue during fallow, but existing deep-furrow drills cannot pass through heavy residue. Farmers are therefore reluctant to retain heavy residue during fallow when they know it will likely plug their drills, cause a major inconvenience, and slow them down during planting, - their most time-sensitive and critical farming operation of the entire year.

Two major meetings were held during the winter of 2009-2010 in Ritzville, WA to discuss the need for new deep-furrow drills and to set the stage for building some "conservation-friendly" deep-furrow drill prototypes. More than 100 wheat growers, agricultural industry personnel, and scientists participated in both these meetings. There was a general consensus at the meetings on features that should be developed in deep-furrow drill prototypes. The desired features are: (i) a taller packer wheel than on existing drills to pass through high residue and deep tillage mulches without pushing soil or plugging, (ii) a wide packer wheel to create a better defined furrow with less soil covering the seed compared to existing drills, and (iii) a coulter in front of each boot and packer assembly that can be raised or lowered to cut surface residue if needed.

The objectives of the project are to build and evaluate the effectiveness of deep-furrow drill prototypes to plant winter wheat into very high surface residue in tilled summer fallow.

Prototypes are expected to:

1. Easily pass through and retain 30 percent or more surface residue after seeding.
2. Place seed as deep and as accurately and achieve as good or better stands as existing John Deere HZ and International 150 drills.
3. Work successfully in the toughest of planting conditions (for example, deep tillage mulches with marginal seed-zone moisture such as in the Horse Heaven Hills).

Two prototype deep-furrow drills are being built at the WSU Dryland Research Station at Lind with funding from CP_3. Both drills have 36-inch-diameter packer wheel assemblies. The drills will be equipped with both 4-inch wide and 6-inch wide packer halves (Photo 1). One prototype drill will have staggered shovel-type openers ahead of the packer wheels (Photo 2) whereas the other prototype will have the openers between the split-packer halves (thus making 4 distinct prototype variations). In addition we will configure each of the two Lind prototypes at 16, 19, and 21-inch row spacing. Funding is being sought (from a funding source other than CP_3) to extensively evaluate the drill prototypes in large-scale replicated field experiments in a grower's field beginning in late August 2011.

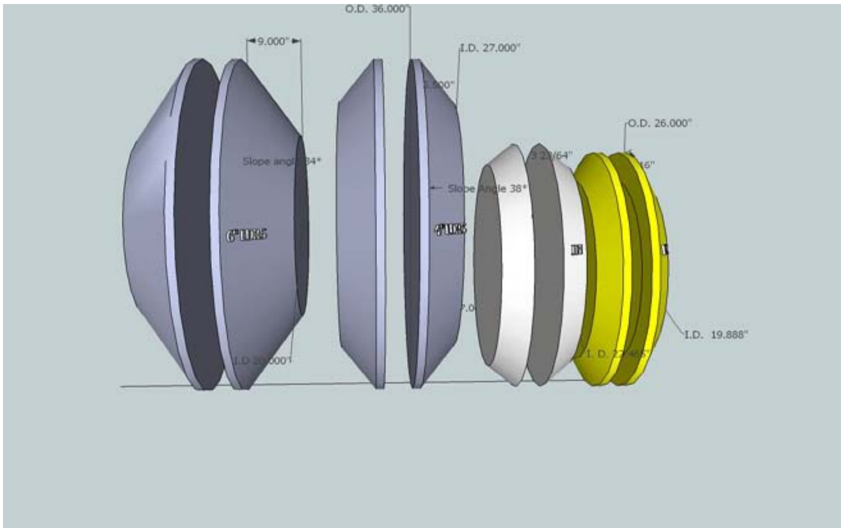

Photo 1. Two new drill packer wheel assemblies under development at the WSU Dryland Research Station near Lind compared to existing technology. From left: 36-inch-tall with 6-inch-wide packer halves; 36-inch-tall with 4-inch-wide packer halves; 27-inch-tall International 150 packer assembly and; 26-inch-tall John Deere HZ packer assembly.

Photo 2. One of the WSU Lind Station prototype deep-furrow drills with staggered shovel-type openers and 36-inch-tall packer wheels.

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