

STEEP FINAL REPORT

RESEARCH PROJECT TITLE: Long-Term Alternative Crop Rotations Using No-Till in Low-Rainfall Dryland Areas: Years 4 through 6.

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FINAL REPORT

OBJECTIVES: The objective of the study is to determine the long-term feasibility of diverse, cereal-based, no-till cropping systems for low-rainfall dryland areas of the inland Pacific Northwest. Specific objectives are to evaluate and compare several long-term no-till annual cropping systems on: (i) root disease, soil moisture dynamics, and grain yield of wheat, (ii) weed species shifts and weed ecology, (iii) physical and biological properties of the surface soil, and (iv) the agronomic and economic of potential as a replacement for the traditional winter wheat-summer fallow system.

KEY WORDS: No-till, low-rainfall, alternative rotations, dryland

STATEMENT OF PROBLEM: Farming in the dryland areas of the Pacific Northwest (less than 12 inch annual) has been mostly an intensive tillage-based wheat-fallow system since the land was broken out of native grassland and sage in the 1880s. Tillage is well known to accelerate the loss of soil organic matter by increasing biological oxidation and often by increasing soil erosion. The loss is exacerbated with fallow because oxidation of carbon exceeds carbon input from crop residues during the 2-year cycle. Because of the decline in organic matter and associated soil quality, most tillage-based farming systems in dryland environments are not sustainable in the long-term. Options for maintaining and improving soil quality in the drylands are to simultaneously increase the cropping intensity and reduce or eliminate tillage.

ZONE OF INTEREST: The low-rainfall (6-to 12-inch annual) dryland area of east-central Washington and north-central Oregon. This zone encompasses 3.5 million cropland acres.

ABSTRACT OF RESEARCH FINDINGS: We have completed six years of an ongoing cropping systems research project at the Ron Jirava farm near Ritzville, Washington. Annual precipitation was less than the long-term average in five of the six years. Annually cropped no-till soft white spring wheat (SWSW) averaged 35 bu/a with net returns of \$8.52 acre/yr which was

statistically equivalent to the traditional winter wheat - summer fallow system. This is the first economic "good news" for annual cropping in the low-precipitation zone. Spring planted barley, safflower, and yellow mustard showed negative net returns. Rhizoctonia root rot 'bare patch' disease first appeared in 1999 and is an ever-increasing problem. Phase II of the project, which began in the 2001 crop year, includes two 4-yr rotations that contain recrop soft white winter wheat. Similar to spring-planted crops, recrop winter wheat failed during extreme drought in 2001. In 2002, recrop winter wheat yields were the same as for spring wheat. Downy brome, which had not been present for five and six years with continuous spring crops, heavily infested winter wheat in both 2001 and 2002. The scientists are highly appreciative of funding received from STEEP. Numerous reports and journal articles have already been published on this project and more are in the pipeline. The long-term cropping systems research project at the Jirava farm will continue for the foreseeable future.

RESULTS AND INTERPRETATION:

Description of the Experiment

A six-year dryland cropping systems study was conducted from 1997 to 2002 on 20 acres near Ritzville, Washington. Average annual precipitation at the site is 11.5 inches. The crops in phase I (1997-2000) of the experiment were yellow mustard, safflower, soft white spring wheat (SWSW), and spring barley (SB). Cropping systems were a 4-yr safflower-yellow mustard-SWSW-SB rotation, a 2-yr SWSW-SB rotation, and continuous SWSW (Table 1). The soil is a uniform Ritzville silt loam with a depth of more than 6 feet, no restrictive layers or rocks, and slope less than 1%. The field where the experiment was established had been planted to spring wheat in 1996 following decades of traditional winter wheat-summer fallow. The experimental design was a randomized complete block with four replications. Each crop in all rotations occurred each year in 60 X 500 ft plots, making a total of 28 plots.

Beginning with the 2001 crop year, the experiment was expanded to include two 4-yr rotations as well as two 2-yr and two continuous rotations using soft white and hard white spring wheat and spring barley (Table 1). Both 4-yr rotations contain soft white winter wheat. Expansion of the project in phase II was possible because the original plots were long and wide. For phase II we split each plot to create 30 ft x 500 ft strips (total = 56 plots). We were able to create the additional treatments and still have four replicates; thus the statistical precision of the experiment was maintained.

During the first 3 years (1997, 1998, and 1999), all plots were planted and fertilized in one-pass with the grower's Flexi-Coil 6000TM air-delivery no-till drill equipped with Barton IITM dual-disk openers on 7.5-inch spacing. Beginning in 2000, all plots are planted and fertilized in one-pass using a custom-built no-till drill equipped with Cross-slotTM notched-coulter openers on 8-inch spacing. Both openers are low-disturbance and place fertilizer beneath and slightly to one side of the seed. All plots were harvested with a commercial-size combine, and grain yield determined on site by auguring grain into a weigh wagon.

Measurements conducted annually include: soil water to a depth of six feet in early spring and at time of harvest, disease assessment which includes GPS mapping of rhizoctonia bare patches, grain yield, populations and dry matter of all weed species, and economic analysis. A surface residue load study was also conducted during three years. Results from the Jirava cropping system project

have been reported extensively in previous STEEP reports, conferences, field tours, and scientific journals.

Table 1. Previous (1997-2000) and current (2001-2004) crop rotations in the long-term cropping systems study at the Ron Jirava farm in Adams County, Washington. All phases of each rotation are planted every year in 500-ft-long plots, each replicated four times.

Years 1997 through 2000	Years 2001 through 2004
_____Four-Year Rotations_____	
1. Safflower-YM-SWSW-SWSW	1. SWWW-SWWW-SWSW-SWSW
	2. SWWW-SB-YM-SWSW
_____Two-Year Rotations_____	
2. SWSW-SB	3. SWWW-SB
	4. HWSW-SB
_____Continuous Spring Wheat_____	
3. Continuous SWSW	5. Continuous SWSW
	6. Continuous HWSW

Abbreviations: HWSW, hard white spring wheat; SB, spring barley; SWSW, soft white spring wheat; SWWW, soft white winter wheat; YM, yellow mustard.

Crop Yields

Annual crop year (Sept. 1 - Aug. 31) precipitation during the first six years of the study (1996-2002) ranged 7.86" to 20.11" and averaged 10.95" (Table 2). Grain yields for 1997-2000 (Phase I) are shown in Table 3. Grain yield for the first two years of Phase II are presented in Table 4.

Weeds

Weed dynamics in the various cropping systems have been measured each year. Major weeds of spring-planted crops are Russian thistle, mares tail, prickly lettuce, and tansy and tumble mustard. Population and dry biomass of these weeds just before grain harvest have been reported in previous STEEP reports and are not repeated here. Broadleaf weed infestation of yellow mustard is a major problem as there are no labeled broadleaf weed herbicides for this crop. Although there was essentially no downy brome in the cropping systems plots from 1996 to 2000, there were major infestations of downy brome in recrop winter wheat in both 2001 and 2002. Obviously, we still have much to learn about seed longevity and physiology of downy brome.

Table 2. Crop year (1 Sept. - 31 Aug.) precipitation at the Jirava cropping system site near Ritzville, WA, during six crop seasons. Long-term average annual precipitation at the site is 11.50 inches.

Crop Year	Precipitation (in.)
1996-1997	20.11
1997-1998	11.10
1998-1999	7.86
1999-2000	9.08
2000-2001	8.00
2001-2002	9.55
6-year-average	10.95

Table 3. Crop yields at the Ron Jirava farm in Adams county, Washington during Phase I from 1997 to 2000.

Rotation	Units	1997	1998	1999	2000
1. Four year					
Safflower	lb/a	1420	720	1040	600
Y. mustard	lb/a	1430	340	110	490
1 st yr wheat	bu/a	---	41	27	40
2 nd yr wheat	bu/a	---	---	25	38
2. Two year					
Wheat	bu/a	---	40	28	44
Barley	ton/a	2.30	1.13	0.76	1.30
3. Cont. wheat					
	bu/a	64	41	27	43

Economic Analysis

The economic feasibility of alternative no-till spring cereal and oilseed rotations at the Jirava site was assessed for the 1997 to 2001 crop years by WSU graduate student Louis Juergens under direction of professor Doug Young. Net returns from traditional winter wheat - summer fallow on ten neighboring farms during this period averaged \$11.80 acre/year. The most profitable no-till spring cropping rotation, continuous soft white spring wheat (SW) averaged statistically equivalent net returns of \$8.52 acre/year. Spring barley (-\$1.28 acre/year), safflower and yellow mustard (-\$9.43) had average annual negative net returns.

All no-till spring crop rotations had higher annual income variability than winter wheat - summer fallow. Two other multi-year studies in the Horse Heave Hills of Benton county (Schillinger PI) and

at Ralston in Adams county (F. Young PI) showed that continuous no-till hard red spring wheat lagged winter wheat - summer fallow and had negative net returns of -\$40/acre/yr. Targeted agricultural policies such as "green payments" for no-till spring cropping in areas vulnerable to wind erosion could help tip the scale toward adoption of these soil conserving cropping systems. Subsidized crop insurance for farmers adopting these spring cropping systems could also reduce their economic risk. Our low yields of SW in 2001 present an unacceptable risk for most growers even if long run average prospects are positive. Further policy and research efforts to reduce the riskiness of continuous spring wheat rotations in low rainfall areas should be considered.

Rhizoctonia Root Rot

Rhizoctonia 'bare patch' disease at the Jirava site continued to spread in the 2002 crop year. There is evidence from Australia that Rhizoctonia severity decreases with time. We have not seen a decline in Rhizoctonia at the Jirava site as evidenced by the highest level of infestation to date in the 2002 crop year (data not shown). The bare patches first appeared in 1999 (the third year of the study) and have become progressively larger and/or more numerous every year since. All Rhizoctonia patches in the entire 20-acre experiment have been mapped with a GPS unit for the past four years (data not shown). Many of the patches are large (100 square ft) and have been at the 'acute level' for four years. A meeting among scientists and farmers will be held in February 2003 to discuss research ideas on what can be done to beat this disease in no-till systems.

Insect Ecology with Broadleaf Crops

Insect populations in spring-planted wheat, barley, yellow mustard, and safflower were measured during two years at the Jirava cropping system research site. Sweep net and plant beating methods were used to collect insects at 10-day intervals during the crop growing season. Herbivorous insects collected were members of six orders: aphids/leafhoppers, grasshoppers, thrips, true bugs, beetles, and moths; all of which are considered pests of one or more of the crops in this study. The percentage of each order of insects differed within crops. Aphid/leafhoppers averaged 83% of the total insect population in wheat and barley, whereas in safflower and yellow mustard it was 49% and 39%, respectively. The other five orders were present at significantly higher levels in safflower and yellow mustard compared to wheat and barley. Results suggest that diversified insect fauna will develop if the acreage of non-cereal alternative crops increases in the inland PNW dryland cropping region.

Table 4. Crop yields at the Ron Jirava farm during Phase II of the long-term experiment. Phase II began in the 2001 crop year.

Rotation	Units	2001 ^w	2002	6-yr-avg. ^y
1. Four year I				
Winter wheat	bu/a	7 cde	21 b	
Winter wheat	bu/a	9 bc ^x	21 b	
Spring wheat	bu/a	8 bcde ^x	23 ab	
Spring wheat	bu/a	10 bc	23 ab	

2. Four year II				
Winter wheat	bu/a	5 e	16 c	
Spring barley	ton/a	0.16 ^x	0.65	
Yellow mustard	lb/a	350	---	^z
Spring wheat	bu/a	12 ab	21 b	
3. Two year I				
Spring wheat	bu/a	12 ab	25 a	35
Spring barley	Ton/a	0.35	0.75	1.10
4. Two year II				
HW spring wheat	bu/a	10 bc	22 ab	
Spring barley	bu/a	0.27	0.78	
5. Cont. spring wheat				
Soft white spring	bu/a	14 a	22 ab	35
Hard white spring	bu/a	6 cde	21 b	

w: Within-column wheat yields followed by the same letter are not significantly different $P < 0.05$.
x: Followed spring wheat, not winter wheat, during the first year (2001) of the 4-yr rotation.
y: Continuous spring wheat and the SW-SB rotation have been ongoing since 1997.
z: Yellow mustard was planted twice and killed twice by cold in 2002. There was no harvest.

INTERACTION WITH OTHER SCIENTISTS CONDUCTING RELATED ACTIVITY:

In addition to the co-investigators of this project, the PI is cooperating with: Doug Young, WSU Pullman, on economic evaluation of spring wheat vs. winter wheat-fallow in the Horse Heaven Hills; Ann Kennedy, USDA-ARS Pullman, on soil microbiology of dryland and irrigated cropping systems at Lind; Tim Paulitz, USDA-ARS Pullman on diseases in irrigated cropping systems at Lind; Roger Veseth, WSU/UI Moscow, on cropping systems technology transfer; Don Wysocki, OSU Pendleton, on irrigated cropping systems research at Lind; Frank Young, USDA-ARS, on the Ralston project; Richard Smiley, OSU Pendleton, on evaluation of Australian wheat lines; Stewart Wuest and John Williams, USDA-ARS Pendleton, on reducing water erosion on frozen agricultural soils; and Stephen Machado and Steve Petrie, OSU Pendleton, on cropping systems research at Moro, OR.

PUBLICATIONS AND PRESENTATION (2002 only)

Refereed Journal Articles

Cook, R.J., W.F. Schillinger, and N.W. Christensen. 2002. Rhizoctonia root rot and wheat take-all in diverse direct-seed spring cropping systems. *Canadian Journal of Plant Pathology* 24:349-358.

Stubbs, T.L., A.C. Kennedy, and W.F. Schillinger. 2002. Soil ecosystem changes during the transition to no-till cropping. *Journal of Crop Production* (in press).

Juergens, L.A., D.L. Young, W.F. Schillinger, and H.R. Hinman. Economics of alternative no-till spring crop rotations in Washington's wheat-fallow region. *Agronomy Journal* (submitted).
Gillespie, R.L., and W.F. Schillinger. Insects of diverse dryland spring crops in the inland Pacific Northwest USA. *Canadian Entomologist* (submitted).

Published Abstracts

Kennedy, A.C., T.L. Stubbs, and W.F. Schillinger. 2002. Soil quality changes with the transition to no-till dryland cereal systems. [CD-ROM]. Soil Science Society of America annual meeting 11-14 Nov., Indianapolis, IN. *ASA, CSSA, and SSSA Abstracts*.

Experiment Station Research and Extension Reports

- Cook, R.J., W. Schillinger, N. Christensen, R. Jirava, and H. Schafer. 2002. Occurrence of rhizoctonia "bare patch" disease in diverse direct-seed spring cropping systems in a low-precipitation zone. *Pacific Northwest Conservation Tillage Handbook Series* no. 19, 4:1-7.
- Schillinger, B., R. Jirava, H. Schafer, J. Cook, D. Young, A. Kennedy, and S. Schofstoll. 2002. Long-term direct seed alternative cropping systems research at the Ron Jirava farm: Year 5. pp. 92-94. In: *2002 Field Day Proceedings: Highlights of Research Progress*. Department of Crop and Soil Science Technical Report 02-1, Washington State University, Pullman, WA.
- Juergens, L., D. Young, and W. Schillinger. 2002. Winter wheat after fallow yield survey results for Ritzville growers, Adams county, WA. pp. 141-142. In: *2002 Field Day Proceedings: Highlights of Research Progress*. Department of Crop and Soil Science Technical Report 02-1, Washington State University, Pullman, WA.
- Juergens, L., D. Young, R. Jirava, and W. Schillinger. 2002. Economics of alternative no-till spring crops at Jirava farm, Ritzville, WA. pp. 132-133. In: *2002 Field Day Proceedings: Highlights of Research Progress*. Department of Crop and Soil Science Technical Report 02-1, Washington State University, Pullman, WA.
- Juergens, L., D. Young, and W. Schillinger. 2002. Economics of no-till annual spring cropping systems project, Ritzville, WA. pp. 134-135. In: *2002 Field Day Proceedings: Highlights of Research Progress*. Department of Crop and Soil Science Technical Report 02-1, Washington State University, Pullman, WA.

Popular Publications

Cook, J., B. Schillinger, N. Christensen, R. Jirava, and H. Schafer. 2002. Rhizoctonia "bare patch" disease in diverse direct-seed spring cropping systems in a low-precipitation zone. *Wheat Life* Vol. 45 10:4-13.

Field Days and Presentations

This project was shown and discussed by Schillinger, Cook, and D. Young to 45 people participating in the PNW Direct Seed Association "Quality of Life" tour on June 26, 2002. A presentation on this project were made to 70 people at the annual meeting of the Columbia Plateau Wind Erosion/Air Quality Project on December 6, 2002.