RESEARCH PROJECT TITLE: New Technologies and Strategies for Managing Weeds in Conservation Cropping Systems for Dry Land Wheat

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INTERIM OR FINAL REPORT: Interim report for objectives I, II, III, and IV. The final report for objective IIa was presented last year.

PROJECT OBJECTIVES:

Objective I: Determine the impact of farming practices and systems on soil, air, and water quality. Assess the impacts of conservation practices on soil, water, and air quality and use this information to develop tools for improved conservation planning and resource management.

Objective II: Develop new technologies and increase efficiency of inputs that improve profitability of conservation farming systems. Develop profitable and environmentally sound conservation practices for pest and plant nutrient management. Identify crop plants and plant characteristics that enhance conservation farming systems for specific agronomic zones. Develop profitable conservation tillage and cropping systems for lands most vulnerable to resource degradation.

Objective IIa: Determine effectiveness of different herbicides for control of volunteer herbicide-resistant crops (HRC); Roundup Ready? spring wheat and canola, Clearfield? ?wheat and canola, and Liberty Link? ?canola.

Objective III: Assess the profitability of conservation tillage and cropping systems for lands most vulnerable to resource degradation. Estimate profitability, risk, and other economic impacts of conservation farming systems.

Objective IV: Accelerate grower evaluation and adaptation of profitable conservation systems.

KEY WORDS: Herbicide-resistant crops (HRC), Roundup (glyphosate), diffusion of technology, social influence, survey.

STATEMENT OF PROBLEM: Weeds often pose the single greatest threat to successful adoption of direct-seed, conservation cropping systems. With current herbicide technology, weeds such as jointed goatgrass, feral rye, and downy brome are difficult or impossible to selectively control in winter wheat. In spring crops, especially broadleaf crops, Russian thistle is the major threat. Herbicide-resistant crop development is progressing rapidly and providing an opportunity to selectively control these and other weeds in direct-seed cropping system. However, there is little or no information on how to safely and effectively incorporate them into Pacific Northwest (PNW) direct-seed dry land winter wheat cropping systems. Important, unanswered questions include which HRC crops should or should not be used in a particular cropping system, and if used, how often. Many of the herbicides used on HRC are currently used or are closely related to herbicides used in PNW wheat production. Thus, how best to control volunteer herbicide resistant crops in these situations also requires study. Traditionally, growers have relied on Roundup to control volunteer crops and weeds in no-till cropping systems. This poses a problem for control of volunteer HRC such as Roundup Ready wheat and canola.

ZONE OF INTEREST: winter wheat-fallow and annual crop in low, intermediate and high rainfall.

ABSTRACT OF RESEARCH FINDINGS: For the second consecutive year, rainfall has been below the long-term average of 11.5 inches. Rainfall was 4 and 3 inches less than average for the 2000-2001 and 2001-2002 growing seasons respectively. This spring was also very cold and a late-spring/early-summer frost injured the spring cereals. Winter wheat following traditional fallow produced 45% less rain compared to the long-term average winter wheat yield. Considering two consecutive low-moisture years, spring cereal yield was "acceptable". In infiltration measurements, water infiltrated at a higher rate in no-till spring cereal stubble compared to winter wheat stubble in the wheat fallow system. In carbon sequestration studies, disturbance (tillage) did not accelerate turnover of C in the soil. In May 2002, a self-administered questionnaire was sent to growers in attendance of field tours featuring the Ralston Project. Respondents were asked questions to measure their interest in the project and its usefulness to them, to document the trial and/or adoption of any experimental elements, the transfer of information gained from field tours, and to assess their opinions about the project's collaborators, funding sources, and experimental design. The survey ended with a 63% response rate. Preliminary data highlights include an appreciation for project's collaboration and unique research design. Respondents' concerns include project funding, recent drought conditions that have hindered experimentation efforts with spring crops, conversion costs, and current economics of alternative crops.

RESULTS AND INTERPRETATION:

Objective I: Crop rotations to be examined in Phase II selected for the main core site include three rotations compared to the traditional tillage winter wheat fallow system. These rotations include a) no-till hard red spring wheat; b) no-till hard red spring wheat/spring barley; and c) no-till facultative spring wheat/no-till spring canola. Hard red spring wheat entailed using a variety (Tara) that has host-plant resistance to Hessian fly, a major pest of no-till spring wheat. Hard red spring wheat plots were split in half and compared grain production and quality of normal inputs with reduced inputs. Phase II cropping systems include: a) three-year crop rotation of no-till winter wheat, spring triticale, spring wheat; b) no-till hard white spring wheat, no-till spring canola; and c) no-till spring oats, spring mustard, spring canola.

This past growing season was again very dry with only 8.5" of rain from October 1, 2001 to July 31, 2002. Over 55% of the total rainfall fell before January 1, 2002. Winter wheat stand was non-uniform because of uneven moisture depths in the summer fallow. Some of the wheat emerged in late winter /early spring causing an uneven date of maturity. "Edwin" winter wheat produced 30 bu/A (0% moisture) with 13% protein. Facultative "Alpowa" spring wheat produced 17 bu/A at 14.3% protein. No-till, hard red spring wheat with recommended inputs (fertilizer) yielded 14.2 bu/A. In contrast, no-till hard red spring wheat with less nitrogen applied yielded 12.8 bu/A. Both hard red spring wheat treatments made > 16% protein. When hard red spring wheat was grown after barley, yield was reduced to 11.7 bu/A, while protein was maintained at >16%. In the 3-year rotation of no-till late planted (November) winter wheat/spring triticale/spring wheat, yields were 19, 10, and 17 bu/A respectively. "Macon" hard white spring wheat produced 13 bu/A and spring oats produced 17 bu/A on 3 years of annual no-till cropping. For the third consecutive year, no-till spring broadleaf crops failed to produce a harvestable product. The spring canola was even replanted and failed to produce a stand. Planting conditions were too dry.

The project was requested again, by WSU administrators and the Washington Wheat Commission, to abandon Roundup? Ready? spring wheat experiments. Because of the turmoil and discontent surrounding the use of Roundup? Ready? spring wheat on growers fields, the separate long-term study evaluating a HRC rotation of Roundup? Ready? spring wheat and Liberty? Link? canola was changed. In lieu of this system, the use of Roundup? Ready? canola had been inserted into the main plot trials. However, for the second consecutive year canola (all varieties) did not establish at Ralston.

***Objective II*:** Other information presented in this report (objective) include carbon sequestration and soil water relations. Water infiltration rate was measured in continuous no-till DNS stubble and winter wheat stubble (winter wheat-fallow rotation) at Ralston in fall 2001 and spring 2002. A 30-inch-diameter cylinder single-ring infiltrometer was driven 3 inches into the soil. The edge of the cylinder was beveled to reduce soil disturbance when the cylinder was driven into the soil. The area inside the cylinder was then flooded with water to a depth of 3 inches and the rate at which water moved into the ground was measured for 90 minutes. Constant depth of water in the infiltrometer was maintained.

Figure 1 shows that infiltration rate became essentially constant (i.e., steady state) after about 30 minutes. The no-till DNS stubble had a steady state infiltration rate of 0.04 inches per minute compared to about 0.02 inches per minute in the winter wheat stubble. The higher ponded water infiltration rate in no-till compared to the tillage-based system could be especially important after heavy precipitation events where first-stage evaporative drying would be minimized in the no-till system.

Water infiltration rate will be measured again in late winter 2003. We will also obtain soil penetrometer resistance and bulk density measurements at that time. Intensive measurement of soil water storage using neutron attenuation and gravimetric techniques has been ongoing at Ralston since 1996 and been reported previously.

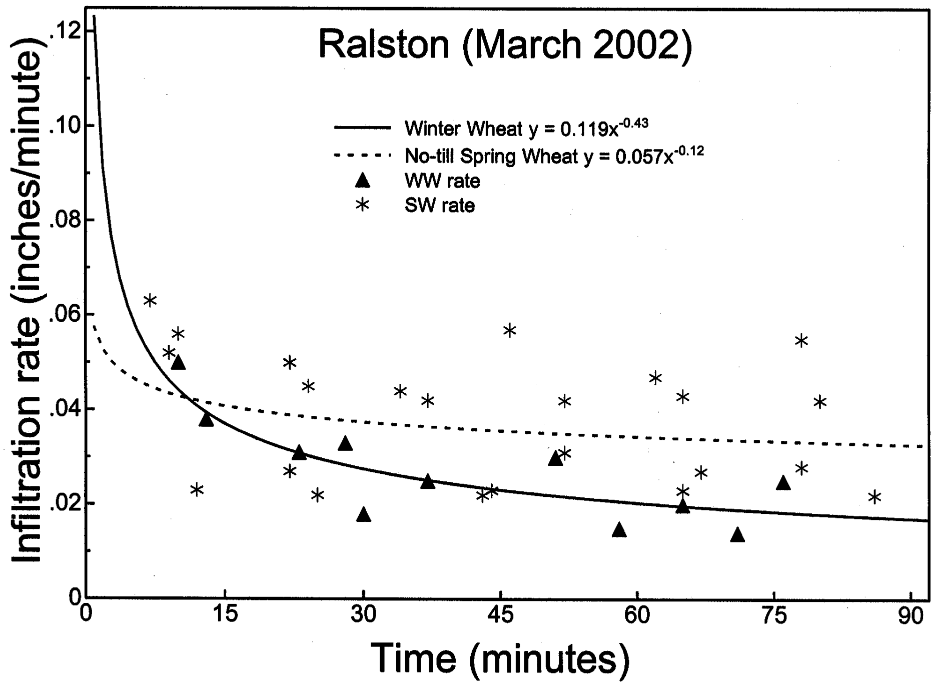

Figure 1. Water infiltration rate in continuous no-till DNS stubble and winter wheat stubble (winter wheat-fallow rotation).

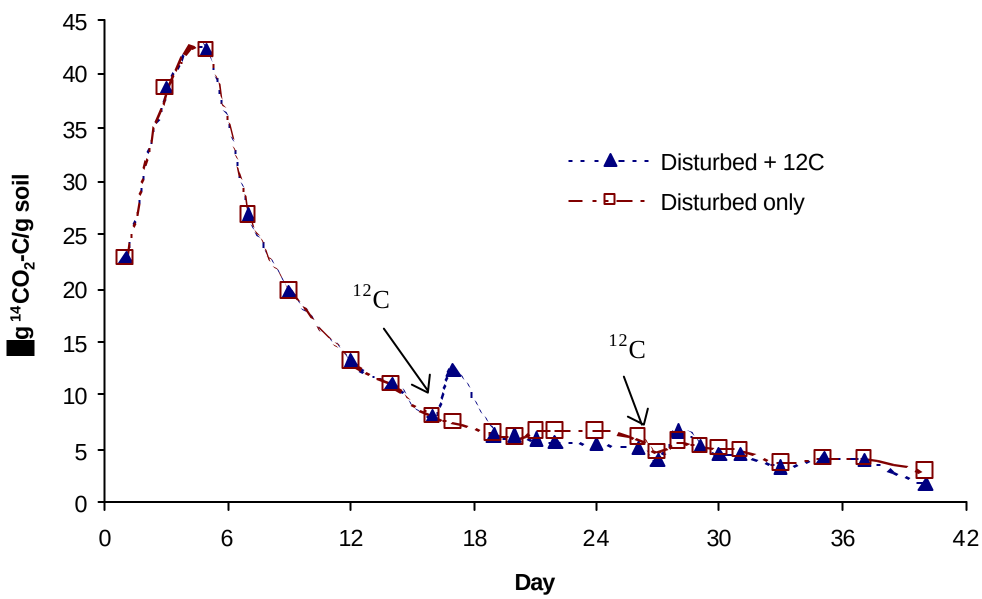

Figure 2. The effect of disturbance and adding non-labeled wheat straw on the decomposition of ^{14}C labeled soil organic matter.

In order to better understand what effect NT and continuous cropping has on residue C dynamics, the combined effects of disturbance and addition of non-labeled wheat straw (D + ^{12}C) on the mineralization of residual ^{14}C organic matter were compared to the singular effect of disturbance only (DO) using soils from the winter wheat- fallow and continuous hard red spring wheat rotations.

The results were similar for both rotations. Disturbance only did not accelerate turnover of residual ^{14}C in the soil (Figure 2). Instead what was observed in these samples was a natural turnover of ^{14}C every 12 days (approx.) most likely due to death of bacterial cells. On the other hand, addition of ^{12}C at the time of disturbance resulted in a flush of $^{14}CO_2$ not seen in the disturbed only samples (Figure 2). The enhanced turnover of ^{14}C in the microbial biomass of the D + ^{12}C samples was triggered by the sudden availability of easily decomposable ^{12}C compounds from the added straw. Subsequent metabolism of these compounds results in a flushing of endogenous ^{14}C reserves from the microbial biomass. From this we conclude that pulsed additions of residue stimulate microbial biomass C turnover and that this needs to be considered when evaluating a soils ability to sequester C.

***Objective III*:** These experimental trials were initiated in August 1995 on a farm near Ralston in an 11.5-inch annual rainfall zone. The main trials at the site evaluated four tillage/crop rotation systems: a) conventional/minimum tillage SWWW/fallow; b) no-till soft white spring wheat (SWSW)/chemical fallow; c) continuous no-till HRSW; and d) no-till HRSW/no-till spring barley (SB). The SWSW/fallow rotation was eliminated in 2002. Above average precipitation in 1996-98 favored both spring and winter grain yields, but yields for both spring and winter grains were reduced by dry conditions in 1999-2002 (Table 1). The 2001 drought, with crop year precipitation of only 7.2 inches at Ralston, reduced all yields, but continuous no-till spring grains were especially hard hit. In 2001, continuous HRSW, HRSW after SB, and SB after HRSW suffered yield losses 67, 79, and 84 percent, respectively, compared to their 1996-2000 averages. Precipitation from July 2001-July 2002 was only 9.2 inches, but the slight increase over 2001 boosted spring grain yields slightly in 2002. However, SWWW after fallow yielded slightly less in 2002 (Table 1).

Table 2 shows that the 2001 and 2002 droughts caused experiment-duration average yields to trend downward for all crops. Not surprisingly, the index of yield variability (C.V.) has trended steadily upward reaching 30% for SWWW after fallow and 44-54% for the spring crops for 1996-2002.

Standard enterprise budgeting was used to compute average net returns over total costs for all rotations. Total costs include all variable costs such as fertilizer, fuel, seed, pesticides utilized in the experiment and a market wage for the operator's labor. Common farm machinery costs for the area were assumed. The analysis also sums fixed costs including a return on land, machinery, and an allowance for overhead. Under such total cost budgeting a "fair or normal profit" would be zero. Anything less than zero implies the farmer is receiving less than market returns for his labor, land, and other resources. The net returns in this section also include an estimated $29/yr for government payments. In fact, government payments on farms in the area will vary above and below this figure depending on farm-specific historical grain yields and acres. No allowance was made for crop insurance because of highly variable insurance participation and coverage levels. The analysis uses long run average prices of $3.44/bu for SWWW, $4.18/bu plus protein adjustments for HRSW, and $104.21/mt for SB. These prices are below relatively high 2002 prices and above previous low prices. All costs and revenues are reported on a rotational acre basis; for example, SWWW/fallow costs and revenues are computed for one half acre of winter wheat and one half acre of fallow. This provides a consistent unit of measurement for all rotations.

Higher production costs for spring cropping systems are still incurred in a drought year, but yields and revenue are drastically reduced. Consequently, it is not surprising that net returns for these crops plummet. Losses per acre for continuous HRSW more than quadrupled in 2001 to -$114.07 compared to -$25.55 for the earlier five-year average (Table 3). Losses retreated only to -$103.55 in 2002. Slightly lower losses were realized with the HRSW/SB rotation. While SWWW/fallow averaged $16.29 “above normal” profit/acre during 1996-2000, it averaged only $3.81 over 1996-2002 (Table 3). Nonetheless, it is noteworthy that during this seven year-period, with several dry years, SWWW/fallow earned modest above-market returns to all resources when government payments are considered. However, without the assumed $29/acre government payments, SWWW/fallow would have missed making normal returns by $25/acre over 1996-2002. Of course, net returns for actual farmers could differ markedly due to different cost structures or yields from those observed in the experiment.

These results show that spring cropping was relatively more vulnerable to down side risk in drought years. The 1996-2000 average disadvantage of $42/acre for continuous HRSW versus SWWW/fallow grew to a $53/acre average shortfall over 1996-2002. Of course, sustained higher grain prices, such as those observed during 2002, could raise net returns for all rotations. However, a normal price rise will not alter the rankings markedly given the substantial separation in yields and profitability between wheat/fallow and spring crop rotations in these results.

Table 1. Annual Crop Yields by Rotation, Ralston

Crop/Rotation	1996	1997	1998	1999	2000	2001	2002
SWWW (bu/ac) swww/fallow	78	64	73	58	73	37	33
HRSW (bu/ac) cont. hrsw	40	55	39	32	34	13	16
HRSW (bu/ac) hrsw/sb	43	56	42	37	39	9	13
SB (met. tons/ac) hrsw/sb	0.89	1.52	1.49	0.90	1.02	0.19	0.42

NOTE: Wheat and barley yields reflect 10 and 7.5 percent moisture and chaff levels.

Table 2. Average and Coefficient of Variation (Percent) of Crop Yields by Rotation and Period, Ralston

Crop/Rotation	Avg. 96-00	Avg. 96-01	Avg. 96-02	C.V. 96-00	C.V. 96-01	C.V. 96-02
SWWW (bu/ac) swww/fallow	69	64	59	12	23	30
HRSW (bu/ac) cont. hrsw	40	35	33	23	38	44
HRSW (bu/ac) hrsw/sb	43	38	34	17	41	50
SB (metric tons/ac) hrsw/sb	1.16	1.00	.92	27	49	54

NOTES: Wheat and barley yields reflect 10 and 7.5 percent moisture and chaff levels.
% Coefficient of Variation (CV) = (Standard Deviation/Average) 100

Table 3. Net returns over total costs ($/rot. ac) by rotation for averages of 1996-2000, 1996-2002 and for 2001 and 2002 drought years.

Rotation	1996-2000	2001	2002	1996-2002
SWWW/ fallow	16.29	-24.16	-30.55	3.81
Cont. HRSW				
actual protein	-25.55	-114.07	-103.55	-49.36
HRSW/SB				
actual protein	-13.73	-108.59	-89.40	-38.11

NOTE: Net returns for all periods include estimated government payments of $29/ac/yr.

Phase II Rotations. Phase II of the Ralston project includes four new rotations of (a) facultative spring wheat/herbicide resistant canola (no-till), (b) late SWWW/spring triticale/SWSW (no-till), (c) spring oats/spring canola (1-pass tillage), and (d) HRSW/mustard (no-till). These crops have been harvested only in 2001 and 2002 providing insufficient data to permit any reliable economic analysis at the current time. As might be expected with drought conditions during 2001 and 2002, yields of most of the new crops have been very low. Mustard and canola have experienced crop failures in both years; spring wheat, triticale, and oats have yielded poorly; and late planted SWWW yielded only 7 and 19 bu/ac (0 moisture basis) in 2001 and 2002. Yields of these new rotations would have to improve substantially to be economically competitive with the 7-year results of the min-till SWWW/fallow system described above.

Summary and Conclusions. No-till continuous spring grain rotations are clearly an environmental success. Research has shown that these systems can reduce predicted dust emissions by 94% during severe wind events compared to conventional wheat-fallow. But seven years experimental results at Ralston have shown that the continuous no-till spring grain systems tested have not been economically competitive with a minimum tillage winter wheat/fallow system. The 1996-2000 average disadvantage of $42/acre/year for continuous HRSW versus SWWW/fallow grew to a $53/acre/year average disadvantage over 1996-2002. Furthermore, the spring cropping systems exhibited significantly more economic risk in dry years. Of course, more yield enhancing research and public support for these soil and air quality conserving spring cropping systems, possibly using different wheat classes, might make them more competitive. Researchers should also investigate other soil conserving systems. Minimum tillage SWWW-fallow systems tested at Lind and at Ralston employed substantially less tillage during the fallow operation than was typical on most area farms. These “minimum tillage” SWWW-fallow systems, which are predicted to cut dust emissions in severe events by 54 percent relative to conventional systems, might provide a cost effective intermediate cropping system for the region.

Results from farmer surveys and Cooperative Extension farmer panels have indicated that farmers may be able to trim the cost of production for HRSW. If possible, this would improve their competitiveness with winter wheat-fallow.

Other research has shown significant public valuation for higher levels of air quality, which are provided by soil conserving cropping systems. Public cost sharing for soil conserving no-till annual spring cropping would assist innovative growers adopts these systems profitably. However, Congress has not been inclined recently to substitute “green payments” in a major way for commodity-based payments.

Objective IV: In May 2002, a survey was conducted to find if and how the research design of the 'Ralston Project' had an influence on dry land farmers in attendance at any field tour during 1996-2000 that featured the project. The survey will also be used to find out what information and which technologies were being transferred into the region's dry land farming community. Respondents were selected from registration logs obtained from WSU Co-operative Extension in Lind, WA. Participation eligibility was limited to dry land growers identified as the primary, production decision-maker(s) for their associated farming operation(s).

Respondents were mailed an 8-page questionnaire consisting of 32 open-ended, partially close-ended, close-ended, and ordered choice questions. Questions were designed to measure growers' interest in the project and its usefulness to them, to document the trial and/or adoption of any experimental elements, the transfer of information gained from field tours, and assess their opinions about project’s collaborators, funding sources, and experimental design.

The survey was administered through the U.S. Postal service using a five-part mailing strategy. Mailing 1 – a single page cover letter explaining the purpose for the survey and need for participation, was sent May 21. Mailing 2 – cover letter, questionnaire, and stamped, return envelope, was sent on May 23. Mailing 3, a reminder postcard, was sent June 3. Mailing 4 - new, personalized cover letter, replacement questionnaire, and stamped, return envelope, was sent June 24. Response rate after Mailing 4 was 51%. This response rate was lower than expected and due in part, to the time of year at which the survey occurred. The final mailing was therefore, sent at the conclusion of attendee's harvest and fall planting activities. A revised, personalized, cover letter, questionnaire, and stamped, return envelope were mailed on September 11. Priority Mail packaging was used to increase visibility and perceived importance of the survey packet to non-respondents. The overall response rate was increased to 63% thus, indicating the importance of this extra effort.

Responses from the questionnaires have been coded and entered into a database. Data sets are currently being organized for statistical analysis. Highlighted responses include a large amount of interest and experimentation with no-till and reduced-till, continuous spring cropping (especially spring wheat), fertilizing and seeding operations, and chemical spray operations (e.g. for greenbridge control). Respondents have expressed a general appreciation for the collaborative efforts of researcher and growers and the project's experimental design - project duration, the use of large-scale plots, commercial-size equipment, and cropping systems as treatments. Respondents' general concerns include future funding to sustain project, drought conditions that have hindered efforts to experiment with spring crops, refining operations for conversion to spring cropping, and poor economics of spring cereals compared to winter wheat. Conclusion of this study and the presentation of its results are scheduled for mid-January 2003.

INTERACTION WITH OTHER SCIENTISTS CONDUCTING RELATED RESEARCH:
Dan Ball, OSU Weed Scientist, Pendleton, OR and Joe Yenish, WSU Extension Weed Scientist, Pullman, WA have also conducted studies to evaluate the effectiveness of different herbicides for control of volunteer Roundup? Ready? spring wheat in no-till cropping systems.

PUBLICATIONS, REPORTS, AND PRESENTATIONS:
Field Day, June 2002. Over 100 attendees including growers, commodity commissioners, agricultural consultants, scientists, and agency/university administrators. Presentations included plant pathology, weed management, nutrient management, carbon sequestration, crop varieties, and water relations.

Publications

Young, D.L., W.F. Schillinger, and F.L. Young. "How the 2001 drought affected the economic risk of continuous no-till hard red spring wheat in Adams and Benton Counties Experiments" In J. Burns and R. Veseth (Editors) *2002 Field Day Proceedings: Highlights of Research Progress*. Tech. Report 02-1, 136-140. Dept. Crop and Soil Sciences, Wash. State U., Pullman, 2002.

Young, D.L., T.J. Kwon, E.G. Smith, and F.L. Young. "Evaluating a precision agriculture herbicide decision model for winter wheat." Selected paper presented at AAEA Meetings, Long Beach, California, July 28-31,2002. Posted on AGECONSEARCH Internet site.

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