Title: Dryland and Irrigated Cropping Systems Research with Winter Canola, Camelina, and Safflower

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Collaborating Scientists: Timothy Paulitz, USDA-ARS; Brenton Sharratt, USDA-ARS; Ann Kennedy, USDA-ARS; William Pan, WSU.

Funding term and duration: This progress report covers research and extension activities conducted in 2013.

Graduate students: Megan Reese (funded and advised by Dr. Pan) is conducting her MS research project on soil water use of winter canola planted into no-till fallow on several planting dates from a new project initiated by Schillinger in 2013 near Ritzville.

Cooperating Growers: Ron Jirava, Ritzville; Jeff Schibel, Odessa; Bruce Sauer, Lind; Hal Johnson, Davenport.

Technical Support: John Jacobsen, WSU agricultural research technician III; Steve Schofstoll, WSU technical assistant III; Cindy Warriner, WSU technical assistant II.

Background: This progress report covers the 2013 results of five oilseed-related research and extension projects conducted in east-central Washington. These projects are three ongoing dryland cropping systems studies (Lind, Ritzville, and Davenport), a new dryland winter canola planting date experiment that was initiated in 2013 near Ritzville, and a residue management study for irrigated canola production near Odessa. The oilseed crops are camelina (low precipitation zone) winter canola (both low and intermediate precipitation zone as well as irrigated) and safflower (low precipitation zone).

Acronyms used: C, camelina; NTF, no-till summer fallow; SAF, safflower; SW, spring wheat; TSF, tilled summer fallow; WC, winter canola; WW, winter wheat.

OBJECTIVES:

Winter Canola (Three studies)
Study 1. Determine the optimum planting date to achieve the best plant stands of winter canola (WC) sown into no-till summer fallow in the low-precipitation zone and measure the effects of planting date on soil water dynamics and seed yield.
Study 2. Determine the benefits of WC grown in a 3-year dryland WC-spring wheat (SW)-no-till fallow (NTF) rotation compared to the traditional winter wheat (WW)-SW-NTF rotation in the intermediate precipitation zone on soil water dynamics, grain yield of the subsequent SW crop, and soil microbial changes.

Study 3. For irrigated winter canola production, conduct field and laboratory research to better understand the physiological mechanism(s) governing winter canola health when planted soon after the harvest of winter wheat, and (ii) to learn how to effectively and profitably produce WC without burning or excessive tillage of wheat stubble. Our hypothesis is that fresh wheat stubble is not phytotoxic to WC and that WC can be successfully produced in a direct-seed system after wheat harvest as a viable alternative to field burning plus heavy tillage.

Camelina Study 4. Determine the long-term suitability of camelina in the typical winter wheat-summer fallow cropping zone of eastern Washington. This would allow farmers to plant crops in two out of three years (i.e., increase cropping intensity) instead of only once every other year as currently practiced.

Safflower Study 5. Evaluate safflower production potential when grown in a WW-safflower (SAF)-tilled summer fallow (TSF) rotation compared to several cereal-only rotations.

METHODS
Study 1. This study was initiated in 2013. Winter canola (cv. Flagstaff) was planted into no-till summer fallow on seven planting dates at the Ron Jirava farm near Ritzville, WA. Planting dates were June 10, June 26, July 8, July 22, August 5, August 12, and August 19. The experimental design is a randomized complete block with four replications of each planting date. Canola was seeded at a rate of 5 lbs/acre with a John Deere HZ drill. Individual plots are 8 ft x 100 ft in dimension. Soil water content was measured in each plot at approximate one-week intervals by graduate student Megan Reese. In late October, 50 lbs N and 20 lbs S per acre in liquid Solution 32 formulation was stream jetted on the experiment just prior to a major rain event. Seed yield of WC in the various planting dates will be determined by harvesting with a plot combine.

Study 2. This study was initiated in August 2007 on deep, productive soils at the Hal Johnson farm east of Davenport, WA. Annual precipitation at the site averages 18 inches. We are comparing a WC-SW-NTF rotation with the more traditional WW-SW-NTF system. All crops are direct seeded with a Kile hoe-opener drill. The experimental design is a randomized complete block with six replications. Individual plot size is 16 ft x 100 ft. Fertilizer application rate is based on soil test results. In addition to WC, WW, and SW grain yield (determined using a plot combine), we are measuring soil water content in all plots (i) just after harvest in August, (ii) in early April, and (iii) in NTF in August. Ponded water infiltration is measured using 2-ft-diameter
infiltration rings in standing WC and WW stubble from the previous harvest during some winters when soils are partially or completely frozen. Plant diseases and microbial attributes are assessed by Tim Paulitz and Ann Kennedy, respectively.

Study 3. This experiment was initiated in 2012. Four winter wheat stubble management treatments were established in August and September 2012 at the Jeff Schibel farm SW of Odessa, WA. The experiment is embedded in a circle of irrigated winter canola belonging to Mr. Schibel. Irrigated WW stubble in the plot area was burned in treatments I and III (below) on August 20 and irrigation water immediately applied to promote germination of volunteer wheat. Glyphosate was applied to the entire plot at a rate of 24 oz/acre on September 4. Land was prepared as required by protocols for each treatment (i.e., straw chopping, disking, moldboard plowing; see list of treatments below) on September 4-6. Winter canola was planted and fertilized in one pass on September 7 using a Kile no-till hoe drill. Assure II herbicide for grass weed control was applied on October 6.

All field equipment used in establishment of the experiment was transported to the site from the WSU Dryland Research Station. Treatments established at the Schibel site in 2012 were: (i) stubble burned + disked, (ii) stubble chopped + moldboard plowed, (iii) stubble burned, then direct seeded and, (iv) direct seeding into standing and undisturbed stubble. Experimental design is a randomized complete block with four replications of each treatment for a total of 16 plots. Individual treatment plot widths range from 8-to 10-ft depending on the tillage implement (if any) used. All plots are 100 ft long. Application of irrigation water, which totals about 15 inches for the crop year, is managed by Mr. Schibel. Winter canola was harvested with a plot combine on July 30, 2013.

A new (fifth) treatment was added to the experiment in 2013. In the new treatment we broadcast WC into the standing (i.e., not yet harvested) wheat crop. Five inches of irrigation water is then applied to germinate the WC. Volunteer wheat is controlled with an application of Assure II grass herbicide in October.

Study 4. We are currently in year six of a 9-year-long cropping systems experiment to evaluate camelina (C) produced in a 3-year WW-C-TSF rotation compared to the 2-year WW-TSF rotation practiced throughout the low-precipitation zone. The experiment is located at the WSU Dryland Research Station near Lind. Experimental design is a randomized complete block with four replicates. There are 20 plots, each 250 ft x 30 ft in size. Camelina is direct drilled + fertilized into standing WW stubble during late February or early March. Winter wheat is planted into TSF in late August. Soil water content to a depth of six feet is measured in all 20 plots after C and WW harvest in July and again in March, and from the eight TSF plots in late August just before planting WW. Weed species in C and WW are identified, counted, and collected just before grain harvest within a 6 ft x 6 ft sample frame randomly placed in each plot. Above ground dry biomass of each weed species is determined after placing samples in a low-humidity greenhouse for 30 days. Surface residue remaining after planting WW into TF is measured in both rotations using the line-point method.
Study 5. Since 2010, the production potential for safflower (SAF) is being determined at the long-term dryland cropping systems experiment on the Ron Jirava farm located west of Ritzville, WA. Safflower is grown in a 3-year WW-SAF-TSF rotation and is compared to WW-SW-TSF and WW-TSF rotations. Each phase of all rotations is present each year and there are four replicates. Size of individual plots is 30 ft x 500 ft. Soil water is measured in all plots after grain harvest, in mid-April, and from TSF in early September. Treflan, a soil-residual herbicide, is applied in March or April to be rain incorporated into plots that will be sown to SAF. Safflower is direct sown at a rate of 40 lbs/acre + fertilized into standing and undisturbed WW stubble in late April or early May. Grain yield is determined with a commercial-sized combine and a weigh wagon.

RESULTS, DISCUSSION, AND IMPACT

Winter Canola

Study 1: Winter canola planting date. More than two inches of rain fell at the Jirava Ritzville site in June 2013. Air temperatures remained fairly cool following the first (June 10) WW planting and perfect plant stand establishment was achieved (Photo 1). Following the June 26 planting, WC emerged during several days of 100+ degree F air temperatures. Newly-emerged cotyledon leaves (i.e., seed leaves) showed no stress and full and successful stands were achieved (Photo 2, Photo 1). The key for the June 26 planting was having excellent seed-zone moisture that allowed emergence and adequate water for evapotranspiration needs of newly-emerged WC seedlings. To the PI’s knowledge, this is the first documentation of successful emergence and stand establishment of dryland WC under such extreme heat conditions.

**Photo 1.** Dryland winter canola (WC) planted on June 10 (right) and June 26 (left) in the WC planting date experiment near Ritzville, WA. Winter canola was direct seeded into no-till summer fallow with a John Deere HZ drill with 16-inch row spacing. Photo was taken on July 29, 2013.

**Photo 2.** Newly emerged winter canola (WC) seedlings from the June 26, 2013 planting into no-till summer fallow near Ritzville, WA. The seedlings emerged and survived 100+ degree F air temperatures that occurred for several days following planting. Heavy rains just before planting allowed WC seedlings to survive the extreme heat. Photo was taken on July 2.
The WC planting on July 8 failed to emerge due to a crusting rain that fell soon after planting. Excellent emergence was achieved from the July 22 planting date, but cotyledon leaves were burned off due to high air temperatures and all plants died. In this case, the seed zone was not wet enough to sustain the evapotranspiration requirements of the newly-emerged seedlings.

Successful WC stands were achieved from the August 5 planting following a 0.88-inch rain that occurred on August 2. A partial stand was achieved from the WC planting on August 12. The final WC planting on August 19 failed to emerge as seed was placed about two inches deep with marginal seed zone moisture.

Soil water use for the three successful stands (planted on June 10, June 26, and August 5) compared to the check (i.e., unplanted no-till fallow) are shown in Figure 1. Soil water measurements were obtained on September 16. June-planted WC had used more than three inches more soil water than the successful August 5 planting. Also, the August 5 planting had used only 1.1 inches more soil water compared to the baseline unplanted no-till fallow (Figure 1). Winter canola stands in the experiment on October 17 are shown in Photo 3.

![Figure 1. Water content in the six-foot soil profile measured on September 16, 2013 as affected by winter canola planted on three different dates near Ritzville, WA. Values in parenthesis after each planting date represent water (inches) remaining in the profile. Baseline refers to fallow left unplanted. Winter canola was planted into no-till summer fallow.](image)

**Photo 3.** Overview of the dryland winter canola planting date experiment near Ritzville, WA. Photo was taken on October 17, 2013.

**Study 2: Winter canola rotation benefit.** Outstanding yields of WC and WW were again achieved in 2013 in this experiment located on the Hal Johnson farm east of Davenport. Winter canola seed yield averaged 3687 lbs/acre and WW 105 bushels/acre. Thus, even though the
price of WC was lower than that received by farmers in 2012, WC competed quite favorably with WW for gross economic returns in 2013 also. Planting WC into no-till fallow during the first week of August is a good fit at this location as WC seed yields have improved markedly during the last three crop years compared to the first three years of this study (Figure 2). Seed-zone moisture in no-till fallow is always adequate at this site and stand establishment has not been a problem.

Figure 2. Six years of yield and soil water data from the winter canola rotation benefit study at the Hal Johnson farm east of Davenport, WA. Top: Winter wheat and winter canola grain yields and water remaining in the six-foot soil profile following harvest of these crops from 2008 to 2013 and the 6-year average. Bottom: Soil water in the six-foot soil profile in April prior to planting spring wheat and spring wheat grain yields as affected by previous crop (either WW or WC) from 2009 to 2013 and the 5-year average. Within-year soil water values with different letters indicate significant differences at the 5% probability level. Letters above spring wheat grain yield bars indicate significant differences at the 5% probability level. ns = no significant differences.

In the 2013 crop year, spring wheat grain yield following WC was 77 bu/acre compared to 84 bu/acre following WW, despite the fact that there was 0.6 inches more water in the WC stubble versus WW stubble at time of SW planting in April (Figure 2). A similar trend occurred in the 2012 crop year where spring wheat grain yield was 41 versus 57 bu/acre follow WC and WW, respectively and where WC stubble in the spring (prior to planting SW) had 1.4 inches more water than WW stubble. We feel the reason for these yield differences is volunteer WC in the SW crop. Although glyphosate herbicide is applied prior to planting SW and a broadleaf herbicide is applied in the growing SW crop, volunteer WC was present in SW in both 2012 and 2013. The broadleaf herbicide extremely stunted, but did not completely kill, the volunteer
WC. There were essentially no other weeds in the SW. The 5-year average SW grain yield from this experiment is 58 and 63 bu/acre following WC and WW, respectively, with no statistically significant differences. We feel a major take-home lesson learned these last two years is for farmers to make sure to completely control WC volunteer.

**Study 3: Irrigated winter canola.** Four winter wheat stubble management treatments were established in late August – early September 2012 just prior to planting winter canola. The experiment was embedded in a circle of irrigated winter canola. The treatments were: (i)

![Photo 4](image4.jpg)

**Photo 4.** Direct seeding irrigated winter canola into newly-harvested winter wheat stubble. A no-till hoe-opener drill with 12-inch row spacing and openers staggered on three ranks was used to plant all residue management treatments in the experiment.

![Photo 5](image5.jpg)

**Photo 5.** Cooperator Jeff Schibel demonstrates the shorter height of irrigated winter canola (WC) direct seeded into standing and undisturbed winter wheat (WW) stubble compared to a treatment where the WW stubble had been burned and the soil then heavily tilled prior to WC planting. Photo was taken on May 16, 2013. Winter canola plants in all residue management treatments were the same height by the end of May.

Stubble burned + disked; (ii) stubble burned, then direct seeded; (iii) stubble chopped + moldboard plowed; and (iv) direct seeding into standing and undisturbed stubble (Photo 4 and Photo 5). Fertilizer rate was 120 lbs N, 40 lbs P, and 40 lbs S per acre applied in the fall with an additional 50 lbs of N topdressed in the spring. Application of irrigation water, which totals 15 inches for the crop year, is managed by Mr. Schibel as part of his normal irrigation schedule for the winter canola circle.
A twilight tour at the experiment site was held on May 30, 2013 with 40 people attending. A follow on press article about the tour was published in the *Odessa Record* weekly newspaper.

No root or foliar diseases were detected in any of the treatments in the 2013 crop year or in the fall of the 2014 crop year. Winter canola seed yields in 2013 ranged from 3014 to 3276 lbs/acre with no statistical differences (P=0.40) among treatments (Photo 4, Figure 3).

![Bar chart showing seed yields](chart.png)

**Figure 3.** Irrigated winter canola seed yields in 2013 at the Jeff Schibel farm near Odessa, WA with four different methods of managing newly-harvested winter wheat stubble just to planting winter canola. Seed yields ranged from 3014 to 3276 lbs/acre with no statistically significant (P = 0.40) differences among the residue management treatments.

A new (fifth) treatment was added to the experiment beginning in the 2014 crop year where winter canola seed is broadcast into the standing wheat crop (i.e., before wheat harvest) (Photo 6). Winter canola stands in all five treatments for the 2014 crop year are excellent. At the time of this progress report was written (January 2014), there is some concern that the low air temperatures likely damaged WC in the region. The low temperature at the Schibel farm was -3 degrees F. We are encouraged by the results of the experiment to date, but the two remaining years of research need to be conducted before we can provide conclusive results.

**Photo 6.** A new (fifth) residue management treatment was added to the irrigated winter canola experiment for the 2014 crop year. Winter canola seed was broadcast into the standing winter wheat crop before wheat harvest. Following wheat harvest, five inches of irrigation water was applied resulting in a thick stand of canola. Volunteer wheat was controlled with an application of Assure II grass weed herbicide.

A new (fifth) treatment was added to the experiment beginning in the 2014 crop year where winter canola seed is broadcast into the standing wheat crop (i.e., before wheat harvest) (Photo 6). Winter canola stands in all five treatments for the 2014 crop year are excellent. At the time of this progress report was written (January 2014), there is some concern that the low air temperatures likely damaged WC in the region. The low temperature at the Schibel farm was -3 degrees F. We are encouraged by the results of the experiment to date, but the two remaining years of research need to be conducted before we can provide conclusive results.

**Study 4: Camelina Cropping Systems Experiment at Lind:** The 2013 crop year was not a good year for camelina (C) in most locations in eastern Washington. The 2012-2013 winter was much drier than normal. Camelina (cv. Calena) was direct seeded into standing WW stubble at a rate of 5 lbs/acre with a hoe-type no-till drill on March 4, 2013. Plant stand establishment was spotty and unacceptable because of the dry surface soil conditions and lack of rain after planting. Camelina was replanted on April 8 after a rain storm. Plant stand establishment was excellent from this planting, but all plants were killed by subfreezing temperatures while still in
the cotyledon leaf stage. By that time (April 24), it was too late for replanting, thus the camelina plots were left fallow. The PI has been conducting research on camelina at Lind for seven years and 2013 was the first year when good or excellent camelina stands were not achieved.

Camelina yields since 2009 in this experiment are shown in Figure 4. The 5-year average yield (not counting 2013) is 489 lbs/acre. Winter wheat grain yields have generally been slightly, but not significantly, higher in the 2-year WW-TSF rotation compared to the 3-year WW-C-TSF rotation (Figure 4). The 5-year average WW grain yield is 34 bu/acre with WW-C-TSF and 36 bu/acre with WW-TSF.

Averaged over the five years, water content in TSF at the time of WW planting in late August is 0.6 inches greater (P < 0.001) in the 2-year compared to the 3-year rotation (Table 1). There are no differences in soil water content after the time of harvest of WW and camelina nor are there differences in over-winter water gain on WW versus camelina stubble (Table 1). The differences in water loss between the two fallow rotations occur during the summer (P < 0.001, Table 1). The average of 0.6 inches more water in the 2-year rotation would account for the two bu/acre average WW grain yield increase in the 2-year rotation. Why is greater water loss occurring during the summer in the 3-year rotation when both fallow systems are treated the same (i.e., plots are always undercut, rodweeded, and planted to WW at the same time)? The reason is likely that greater surface residue in the 2-year rotation provides better shading.

**Figure 4.** Camelina and winter wheat yields in the long-term camelina cropping systems study at the WSU Dryland Research Station near Lind, WA. The two cropping systems are winter wheat-camelina-tilled summer fallow and winter wheat-tilled summer fallow. ns = no significant difference at the 5% probability level.
The PI completed a consultancy assignment in 2013 for a British company that is interested in camelina for what they term “unique oil characteristics”. The British company is interested in what it will take to encourage Inland Pacific Northwest farmers to produce camelina on 100,000 or more acres per year. A summary of the PI’s recommendations (Schilling, 2013) was published in the 2013 WSU Field Day Abstracts.

Study 5: Safflower cropping systems. Since 2010, safflower (SAF) has been included in the long-term cropping systems on the Ron Jirava farm near Ritzville where it is grown in a 3-year WW-SAFTSF rotation. Planting of SAF was delayed until April 24 in 2013 (i.e., until soil temperature warmed) and excellent plant stands were achieved (Photo 7). Safflower was harvested on September 26 and seed yield was a disappointing 550 lbs/acre. Safflower seed yields through the years have ranged from 125 to 1130 lbs/acre and crop-year precipitation appears to have

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**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 the 6-ft soil profile in summer fallow in a 2-year winter wheat-summer fallow rotation versus a 3-year winter wheat-camelina-summer fallow rotation. The top portion of the table shows water content during the 2012-2013 fallow cycle and the bottom portion of the table shows fallow water content for the 5-year average. ns = no significant differences.

<table>
<thead>
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<th>Timing in fallow period</th>
<th>Soil water content (inches)</th>
<th>PSE (%)</th>
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<tr>
<td></td>
<td>Beginning (late Aug.)</td>
<td>Spring (mid Mar.)</td>
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<tr>
<td>Fallow treatment</td>
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<tr>
<td>After winter wheat (2-yr rotation)</td>
<td>6.8</td>
<td>11.7</td>
</tr>
<tr>
<td>After camelina (3-yr rotation)</td>
<td>6.9</td>
<td>11.6</td>
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<tr>
<td>P-value</td>
<td>ns</td>
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**B. 5-year average**

<table>
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<th>Fallow treatment</th>
<th>Soil water content (inches)</th>
<th>PSE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>After winter wheat (2-yr rotation)</td>
<td>6.3</td>
<td>9.8</td>
</tr>
<tr>
<td>After camelina (3-yr rotation)</td>
<td>6.0</td>
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<tr>
<td>P-value</td>
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little to do with this wide range (Figure 5). Soil water use by SAF is greater than any other crop grown in the Jirava cropping systems experiment (data not shown).

Photo 7. Excellent plant stands of safflower were achieved in 2013. Planting was delayed until April 24 to allow soil warming. Stands of safflower are shown on June 17 and July 2 above.

Figure 5. Safflower seed yields and crop-year precipitation at the Jirava long-term cropping systems study near Ritzville, WA. Safflower is grown in a 3-year winter wheat-safflower-tilled summer rotation.

Figure 6. Winter wheat grain yield in three cropping systems at the Jirava cropping systems study near Ritzville. Although the safflower rotation has been in place since 2010, the rotation effects on winter wheat yield could not be reported until beginning in 2012.

Winter wheat grain yields in the WW-SAF-TSF rotation are compared to those in the WW-SW-TSF and WW-TSF rotations. WW grain yield in 2013 was 64, 81, and 63 bu/acre in the WW-SAF-TSF, WW-SW-TSF, and WW-TSF rotations, respectively (Figure 6).
Affiliated Projects and Funding: Schillinger and Paulitz are Co-PIs on a 3-year grant from the Washington Department of Ecology for a project titled “Management of fresh wheat residue for irrigated winter canola production”. Schillinger has received $12,500 annually from the REACCH Project for the past several years for support of the large-scale (i.e., 20 acre) Jirava cropping systems experiment that is now in its 18th year.

Oilseed-related publications in 2013 (and in press for 2014)

Referred Journal Articles

Extension Bulletins

Conference Proceedings Papers

Abstracts from Professional Meetings

Washington State University Field Day Abstracts
Research Progress. Dept. of Crop and Soil Sciences Tech. Report 13-1, WSU, Pullman, WA.


Field Tours
A twilight tour of the irrigated winter canola residue management experiment at the Jeff Schibel farm near Odessa (40 attended) was held on May 30, 2013.

A field tour of the Jirava cropping systems experiment (which includes the safflower crop rotation study) was presented to 35 farmers and scientists on June 5, 2013.

Proposed Future Research/Extension
New winter canola cropping systems study. In addition to continuation the five ongoing oilseeds-related experiments, the PI proposes to initiate in 2014 a new winter canola cropping systems research project on the Ron Jirava farm near Ritzville. The new cropping system to be tested is a 4-year winter canola-NTF-winter triticale-NTF rotation. The WC planting will likely take place in June due to the high likelihood of successful WC stand establishment when air temperatures are still relatively cool and the surface soil still retains adequate moisture. The ongoing WC planting date experiment at this site will help to further define the optimum planting date. Winter triticale will be included in the rotation because research by Schillinger et al. (2012) has shown that late planted (mid-October or later) winter triticale produces equivalent grain biomass as early planted (early September) winter wheat. This is of crucial importance because with NTF there is rarely adequate seed-zone moisture for early establishment of WW. If farmers have to wait until the onset of fall rains, which typically begin
no earlier than mid-October or later, their WW grain yields will be reduced by an average of 39% compared to early-planted WW (Higginbotham et al., 2013). The grain yield difference between early versus late planted winter triticale is much less than for WW (Schillinger et al., 2012). Thus, with the use of NTF, the proposed 4-year rotation of WC-NTF-winter triticale-NTF represents a promising possibility for a stable, sustainable, profitable, and ecologically-friendly crop rotation for the low-precipitation zone.

The new project will cover more than four acres. The 4-year WC-NTF-winter triticale-NT rotation will be compared to the 2-year WW-TSF rotation. Experimental design will be a randomized complete block with four replications. All segments of both rotations will be present every year (total of 24 plots). Individual plot size will be 30 ft x 250 ft and commercial-size equipment will be used.

References