COVER CROPPING AND COMPANION CROPPING FOR THE INLAND NORTHWEST: AN INITIAL FEASIBILITY STUDY

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Abstract

Dryland grain farmers in Spokane and Lincoln Counties, Washington, want to improve soil health on their land without compromising income from proven, regional cash crops. This project was an initial feasibility study for cover- and companion-crop mixes in a dryland cropping zone that depends heavily on winter precipitation. To maximize benefit to the reader, the experimental process is outlined, including mistakes and lessons learned. In this study, spring seeding of cover crops in place of fallowing the ground resulted in excessive loss of soil moisture. This in turn raised the risk of crop germination failure in the subsequent fall. Growing companion crops together with a cash crop shows potential for attaining the growers’ desired goal. However, not all obstacles have been identified, and more research should be conducted to optimize recommendations.

Introduction

Dryland grain farmers in Lincoln and Spokane Counties, Washington, want to improve soil quality on their farms. In 2011, farmers who attended a Washington State University (WSU) Extension workshop were inspired and intrigued by the success of Midwest farmers in using cover-crop cocktails for this purpose. A group of innovative growers developed the goal of learning how to include a cover crop or companion crop in their rotation to raise soil organic matter levels, break disease cycles, suppress weeds, penetrate soil compaction layers, and improve soil fertility by fixing atmospheric nitrogen. In addition, they wanted to make this system work with the winter precipitation (Mediterranean climate) of their area.

Cover crops were commonly grown in eastern Washington prior to the advent of synthetic fertilizers in the 1940s. One of the farmers in the Spokane-Lincoln group had childhood memories of growing yellow sweet clover (YSC) on their farm as a green manure. Widespread use of this species ended when insect damage to YSC made it impractical to grow (G. Dobbins, personal communication). Cover crops—A crop grown to feed/benefit the soil. No harvested material leaves the field: it is terminated with a selective herbicide or killed by frost, usually prior to seed set. If then incorporated by tillage, it is also known as green manure.

Companion crop (also known as “intercrop”)—A cover crop grown together with a harvested cash crop. It may be terminated with a selective herbicide or killed by frost.

Cover crop cocktail—A mixture of several species grown together as a cover crop. It may include warm and cool season species. Types may also include grasses (for biomass), legumes (for atmospheric nitrogen fixation), and broadleaf crops with a tap root to penetrate compaction layers.

Compilation of local research into cover crops indicates variable results. Walter Goldstein reported that crimson clover showed promise as a cover crop species (Goldstein 1986). In one on-farm project, Lincoln County farmers found that black medic clover was not sufficiently competitive as a companion crop (J. Jahn and C. Carstens, personal communication). In testing a wide array of cover crops at Pullman, WA, United States Department of Agriculture (USDA) researchers concluded that no single cover crop species proved profitable (D. Huggins, personal communication).

None of this research, however, looked at multi-species cover crops. The advantage of using a cover crop cocktail is twofold. Different species provide different soil benefits, and if one species in the mix fails to grow, others will take its place (Clark 2007). The Spokane-Lincoln County farmer group recognized that successful developments in midwestern states, which have a summer rainfall pattern, would not necessarily translate directly to eastern Washington where most of the annual precipitation occurs in the winter months. For example, an organic farmer from Big Sandy, Montana has developed a system for growing all the nutrients needed for his soil in the form of cover crops and companion crops, including YSC (Figure 1), on his 4,000-acre dryland farm. Although his total annual precipitation (13 to 14 inches) is similar to Davenport, WA, the wettest month on his
farm is typically June. This rainfall pattern enables him to grow warm season species that do not thrive in eastern Washington (R. Quinn, personal communication).

Figure 1. Bob Quinn of Big Sandy, MT, in a field of yellow sweet clover (YSC) that was planted as a companion crop with barley, then overwintered and was incorporated at flowering in July the following year. (Photo by Diana Roberts, WSU Extension.)

The model used for this feasibility study was to have farmer-collaborators choose which cash and cover crops to try, then grow a demonstration block on their farms. Extension professionals repeated these tests in randomized, replicated strips (each 18 ft wide by 200 ft long) on the WSU Wilke Research Farm at Davenport, WA.

The project began in Spring 2011. The Wilke Farm and most of the farmer-collaborators used direct seeding/no-till farming. However, these cover crop methods should benefit any type of farming system.

Research Objectives

The farmer-collaborators chose to experiment with cover crop cocktails and companion crops in order to determine what would grow in our environment and benefit other crops in the rotation. Their goal was to develop specific plant mixtures for local dryland grain rotations where the cover/companion crops benefit soil organic matter, soil pH, total nitrogen levels, and moisture retention, without negatively affecting the yield of cash crops.

In all the following trials, standard soil tests were taken early each spring (and in the fall, where specified) to track changes in soil moisture (%), soil pH, organic matter (%), and nutrients—focusing on total nitrate levels (lb).

Cover Crops

Cool Season Cover Crop (Wilke Cover Crop Trial A)

The farmer-collaborators started the project in 2011 by growing a nine-way mix cover crop cocktail: oats and peas (for biomass); peas, crimson clover, and hairy vetch (nitrogen-fixing legumes); mustard, safflower, sunflower, and purple top turnip (for deep tap roots to penetrate hardpan); and, safflower, sunflower and a sorghum-sudangrass hybrid that were warm season species. Plots on the Wilke Farm mirrored these and also included Phacelia tanacetifolia, a flowering species that attracts native pollinators (Figure 2). Details of the trial at the Wilke Farm, and subsequent crops located in the same strips, are included in Table 1.

The intent was to establish long term plots to measure the impact of cover/companion crops over several years. Companion plantings were made in these plots in the fall of 2015, so information for the intervening seasons (2013 and 2014) are also included in Table 1.

The cover crop plots were seeded in the place of no-till fallow, using a no-till disk drill. A fallow check plot was also included. There were four replications of each treatment. The crop was seeded on May 18, 2011, and grew well but did not canopy sufficiently to prevent transpiration from the soil. It was terminated a little over two months later on July 22. This date was chosen because the crops were flowering; termination then meant none of the species had set seed and would become weeds in subsequent seasons (Figure 3).
Table 1. Cover and companion crop production details (Trial A) from 2011 through 2016.

<table>
<thead>
<tr>
<th>Year: 2011–2016</th>
<th>Location: Block 3 Wilke Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatments</td>
</tr>
<tr>
<td>2011: 4 reps</td>
<td></td>
</tr>
<tr>
<td>3 = No-till fallow</td>
<td>1 = 9-way Cover Crop Cocktail</td>
</tr>
<tr>
<td>May 18–July 22</td>
<td>May 18–July 22</td>
</tr>
<tr>
<td>Fert: 8-10-0-7 starter Seed 80 lb/acre inoculant. Roller crimper did not work</td>
<td>Fert: 8-10-0-7 starter Seed 80 lb/acre inoculant. Roller crimper did not work</td>
</tr>
<tr>
<td>2012: 4 reps</td>
<td></td>
</tr>
<tr>
<td>Winter wheat–Xerpha</td>
<td>Winter wheat–Xerpha</td>
</tr>
<tr>
<td>55 bu/acre</td>
<td>0 bu/acre (herbicide damage)</td>
</tr>
<tr>
<td>Sept 16–Aug 28</td>
<td>Oct 10–Aug 28</td>
</tr>
<tr>
<td>Fert: 60-15-0-19 Seed 5 lb/acre hoe drill</td>
<td>Fert: 60-15-0-19 Seed 80 lb/acre</td>
</tr>
<tr>
<td>2013: 4 reps</td>
<td></td>
</tr>
<tr>
<td>Spring canola–RR 4551–harvested together in error.</td>
<td></td>
</tr>
<tr>
<td>April 17–Aug 22</td>
<td></td>
</tr>
<tr>
<td>Fert: 60-15-1-9 Seed 5 lb/acre hoe drill</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>Diva spring wheat seeded 4/29/2014 at 75 lb/acre. Anhydrous below seed at 43 lb N/acre. Liquid ammonium thiosulfate 11-37 and NACHURS at rate of 7-12-1-9 with the seed. Liquid Boron with the seed at 10.5 oz/acre.</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>No-till fallow</td>
<td>No-till fallow</td>
</tr>
<tr>
<td>2016: 4 Reps</td>
<td></td>
</tr>
</tbody>
</table>

An attempt was made to terminate the cover crop using a roller-crimper mounted on the rear of a tractor to crush the stems of the plants (Figure 4) and prevent further moisture loss (compared with mowing). However, the oat stems were so resilient that by the next day they were standing vertical again and pulled all the other species upright with them. So the crop was sprayed out with glyphosate (Figure 5).

In the following fall and spring (2012 crop season), the exact same plots were seeded to winter or spring wheat (Table 1). Seeding winter wheat was delayed following the cover crop, versus fallow, because the cover crop had removed much moisture from the soil. The disparity in wheat development and size resulted in herbicide damage to the later-seeded winter wheat.
Figure 3. Cool season nine-way cover crop June 15 (left photo), 2011, a month after seeding. July 15 (center photo and right photo), which was one week prior to termination. (Photos by Diana Roberts, WSU Extension.)

when the two seedings were sprayed together the following spring. Plots of winter wheat following cover crop were not worth harvesting (thus, zero bu/acre); winter wheat following fallow yielded 55 bu/acre. Spring wheat following cover crop only yielded the county average for spring wheat following winter wheat (44 bu/acre) so did not appear to benefit from the previous cover crop (Figure 6).

Figure 4. Roller crimper operating in a nine-way cover crop cocktail on a project collaborator’s farm. (Photo by Diana Roberts, WSU Extension.)

Figure 5. Nine-way cover crop mix on the Wilke Farm being sprayed out with glyphosate. (Photo by Diana Roberts, WSU Extension.)

Figure 6. Winter and spring wheat (2012 season) following 2011 nine-way cover crop cocktail. Yellowish plots are winter wheat following no-till fallow (55 bu/acre, average), green plots are spring wheat following cover crop (44 bu/acre average), and sparse plots are winter wheat seeded late after cover crop and damaged by herbicide (zero bu/acre, average). (Photo by Diana Roberts, WSU Extension.)

Extensive soil samples were taken from each trial, each sample comprised of soil cores collected from five random points within a plot, and there were four replications of each plot. All soil samples were collected in early spring (April) other than the additional samples collected in the fall of 2011.

For this cool season cover crop Trial A:

- Treatment 1 = winter wheat after cover crop
- Treatment 2 = spring wheat after cover crop
- Treatment 3 = winter wheat after no-till fallow

Figure 7 (a–c) shows how Treatments 1 and 2 (cover crop) removed moisture from the soil at all depths measured (Fall 2011). This validated the yield results obtained in 2012 (Figure 6). Treatment 1 then had
Figure 7. Soil moisture (%) in the 0–6 inch (a), 6–12 inch (b), and 12–24 inch (c) depths of the soil profile during and following a cool season cover crop mixture that was grown in the spring of 2011. All soil samples were collected early in the spring (April), other than samples collected in the fall of 2011, after the cover crop was harvested.
slightly higher moisture at all depths shown in the spring of 2013, possibly due to the winter wheat crop failure in 2012 from herbicide damage. In 2014, the cover crop plots (Treatments 1 and 2) had more moisture than the former fallow plots in the top six inches.

**In this study, spring seeding of cover crops in place of fallowing the ground resulted in excessive loss of soil moisture. This, in turn, raised the risk of crop germination failure in the subsequent fall.**

In addition to soil moisture, other soil tests measured organic matter (%), and soil pH. Charts are not presented, as there were no appreciable differences between treatments for these factors.

In 2013, the long-term plots were all seeded to spring canola and harvested together. In 2014, the plots were all seeded to spring wheat. The intention was to seed a companion crop in the fall of 2014, but this was not possible due to unseasonably dry conditions. In the fall of 2015, these plots were seeded to winter pea with a companion crop mix (Table 1).

**Warm Season Cover Crop (Wilke Cover Crop Trial B)**

In 2012, the farmers chose a five-way cover crop mix to test, because project advisor, J. Clapperton (March 2012, personal communication) recommended that a less diverse mix was more likely to be successful in the region’s dry climate. The mix included two warm season species, proso millet and buckwheat. Faba bean and crimson clover were cool season legumes, and flax was a cool season, deep-rooted crop. The five-way cover crop was direct seeded on May 17, 2012, and sprayed out on July 31. Treatments and crop details of successive seasons are shown in Table 2.

The intent was to establish long-term plots to measure the impact of cover/companion crops over several years. Companion plantings were made in these plots in the fall of 2015, so information for the intervening seasons (2014) are also included in Table 2.

Subsequent to completion of this project, and due to buckwheat being a severe allergen in Japan, the Washington Grain Commission and the USDA-Natural Resources Conservation Service “recommend buckwheat should not be planted in rotation with or adjacent to commodity wheat production that will be planted to wheat within two calendar years after planting buckwheat in the states of Colorado, Kansas, Minnesota, Montana, Nebraska, North Dakota, Oregon, South Dakota, Washington, and Wyoming” (Pavek 2016). Consequently, we do not recommend using buckwheat as a cover or companion species in wheat systems.

The summer of 2012 was the closest to a “summer rainfall season” that the area has had in the past 20 years—with rainfall events around the region occurring into July. The five-way cover crop mix grew well and canopied better at the Wilke Farm than the nine-way mixture grown the previous year (Figure 8). Details for subsequent years are in Table 2.

In 2013, the plots were seeded to winter and spring wheat (Table 2). The winter wheat following cover crop yielded 52 bu/acre versus 61 bu/acre for winter wheat seeded on fallow ground. Spring wheat after cover crop yielded 39 bu/acre, which is slightly less than the county average for spring wheat grown after winter wheat These yields indicate the cover crop did not benefit the subsequent cash crop.
Figure 8. Warm season five-way cover crop grown in the spring of 2012. Seeding was May 17, and the crop was sprayed out July 31. July 9 (left photo) and July 24 (right photo). (Photos by Diana Roberts, WSU Extension.)

Table 2. Cover and companion crop production details (Trial B) from 2012 through 2016.

<table>
<thead>
<tr>
<th>Wilke B Cover/Companion Crop Trial</th>
<th>Treatments</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year: 2012–2016</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Location:</strong> Miscellaneous Block Wilke Farm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Treatments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012: 4 reps</td>
<td>No-till fallow</td>
<td>5-Way Cover Crop Cocktail (Warm Season)</td>
</tr>
<tr>
<td></td>
<td>May 17–July 31</td>
<td>May 17–July 31</td>
</tr>
<tr>
<td></td>
<td>Fert: 8-10-0-7 starter Seed 45 lb/acre inoculant</td>
<td>Fert: 8-10-0-7 starter Seed 45 lb/acre inoculant</td>
</tr>
<tr>
<td>2013: 4 reps</td>
<td>Winter wheat–Xerpha</td>
<td>Winter wheat–Xerpha</td>
</tr>
<tr>
<td></td>
<td>61 bu/acre</td>
<td>52 bu/acre</td>
</tr>
<tr>
<td></td>
<td>Sep 14–Sep 3</td>
<td>Oct 10–Sep 3</td>
</tr>
<tr>
<td></td>
<td>Fert: 88-10-0-7: Seed 80 lb/acre</td>
<td>Fert: 88-10-0-7: Seed 80 lb/acre</td>
</tr>
<tr>
<td>2014</td>
<td>Dayn hard white spring wheat seeded by Kevin Klein on 4/29/14 at 75 lb/acre. Anhydrous below seed at 67 lb N/acre. Liquid ammonium thiosulfate 11-37 and NACHURS at 7-12-1-9 with the seed. Liquid boron with the seed at 10.5 oz/acre. Harvested August 26, 2014.</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>No-till fallow</td>
<td>No-till fallow</td>
</tr>
</tbody>
</table>
Companion Crops

Spring Barley with Yellow Sweet Clover

After 2011, the farmer-collaborators decided to focus their testing on companion crops rather than cover crops. Their preference was for companion crops that fit with local rainfall patterns and did not negatively affect establishment or yield of cash crops.

As stated earlier, prior to the development of synthetic fertilizers, farmers in this area grew YSC, a biennial legume, to provide nitrogen for their soil. This plant fell out of use due to insect infestations but has since naturalized in the region and grows in ditches and waste areas. This precedence, as well as its use by Bob Quinn at Big Sandy, MT (Figure 1), influenced farmer-collaborators to select YSC for testing.

On May 9, 2012, YSC was broadcast in plots on the Wilke Farm with a hand-held fertilizer spreader, then the field was cross-seeded with spring barley using a direct seed drill (Figure 9). Details are in Table 3.

The barley grew and was harvested, as normal, on August 28 but showed symptoms of nitrogen deficiency (Figure 10) as no fertilizer had been applied. The intention was for YSC to provide nitrogen to the barley. This assumption was proven incorrect; legumes generally release the bulk of their nitrogen to the subsequent crop rather than the current season’s crop. As the field was weed-free at the beginning of the season, no in-crop herbicide was applied. The YSC did not grow very tall as it was shaded by the barley (Figure 10).

Figure 9. Seeding yellow sweet clover as a companion crop with spring barley on the Wilke Farm. Hand seeding yellow sweet clover into standing stubble with a rotary spreader (left photo). (Photo by Aaron Esser, WSU Extension.) Cross-seeding barley on top of the sweet clover the same day (right photo). (Photo by Diana Roberts, WSU Extension.)
Table 3. Companion (yellow sweet clover) crop details 2012–2016.

<table>
<thead>
<tr>
<th>Year</th>
<th>Location: Block</th>
<th>Barley Crop Details</th>
<th>Companion Crop Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Miscellaneous Block</td>
<td>Spring barley—Lenatah. Companion crop yellow sweet clover—Madrid. Barley May 9–Aug 28 yielded 1 ton/acre. Fertilizer: Zero. YSC Seed 10–15 lb/acre Broadcast Cost $3.00–$3.60 per lb. No inoculant. YSC germinated and grew under the barley and into the fall. It was slow to emerge the following spring, and plot was weedy due to low stand. (In 2012 the ground was very clean and no herbicide needed in the crop.)</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Block 5</td>
<td>Spring barley—Lenatah. Companion crop yellow sweet clover—Madrid. Barley April 25–Aug 24. Yielded 1.6 ton/acre. Fert: 6-10-0-7. Seed 70 lb/acre. May 25, 2013 YSC was broadcast seeded 20 lb/acre. No inoculant. Due to low germination, it was reseeded with a disc drill on May 30 at 10 lb/acre. No inoculant. The whole trial was sprayed out in the spring of 2014 due to low survival of the YSC.</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>Block 2</td>
<td>Spring barley. Companion crop yellow sweet clover—Madrid. YSC was drilled in after the barley emerged. Starter fertilizer was used. Inoculant was applied. It was a drought year and the YSC did not survive, so the plot was sprayed out before winter.</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Block 2</td>
<td>Spring barley. Companion crop yellow sweet clover—Madrid. Barley seeded 4/21/15. 70 lb/acre barley seed, Fertilizer 72-10-0 lb with the seed. YSC seeded with a drill after barley emerged. Inoculant applied. 5/8/15 seeded clover at 14 lb/acre at 60 degrees (the barley is seeded at 90 degrees). 4 rows were seeded at about 1 inch and 3 rows seeded at about 1 ¼ inch. Barley harvested 8/3/15, yielded 1120 lb for the whole plot. The only YSC visible after harvest was where there were skips in the barley. It had come up well, but appeared to be desiccating when about 2 inches tall due to hot weather and lack of moisture.</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Northside</td>
<td>Spring barley. Companion crop yellow sweet clover—Madrid. Barley seeded April 22, 2016. Fertilizer applied. YSC drilled in over the barley the same day, April 22, 2016. Rate 5 lb/acre. Inoculant used. Seeded at about 37 degrees off barley rows. Late spring rain assisted germination and as of June 23, 2016, YSC was growing well under the barley canopy. Trial was discontinued as the project funding ended.</td>
<td></td>
</tr>
</tbody>
</table>
The YSC is biennial, so it went dormant in fall and winter, then started growing again the following spring (2013) but took a long time to show signs of life. Green tips finally appeared at the end of April, and the YSC started to grow vigorously at the end of May (Figure 11).

The Rhizobia nodules (*Rhizobium* spp.), which are responsible for fixing atmospheric nitrogen in a form usable by plants, slough off the roots of legume crops at flowering. So nitrogen fixation terminates when the plant enters the flowering stage.

In order to determine the most efficient time to terminate the YSC, the cover crop was sprayed out at two treatment stages: bolting and flowering (Figure 12). There was a big difference in plant size between these stages, which may present challenges in terminating the crop at a later stage and then seeding into the residue.

The seed for every legume crop should be inoculated with species-appropriate *Rhizobium*, unless that crop has been grown frequently in the same field.
Both winter and spring wheat were planted following YSC. However, the experiment was inconclusive; the YSC had an extremely low level (essentially zero) of Rhizobia nodules. Because YSC is naturalized in the region and is often found growing in harsh, dry roadsides and ditches, the assumption was that seed inoculation with Rhizobium before planting was not necessary. That assumption was proven false; species-appropriate Rhizobium inoculation is necessary. This step may only be omitted if that crop species has been grown frequently in the same field. A simple bioassay will determine the necessity for inoculation in a specific field.

Farmers may conduct a bioassay to determine the presence of an adequate Rhizobium population in a specific field. Put soil collected from the field in several plant pots, about 6 inches in diameter. Obtain a sample of the crop seed in question. Inoculate half of it with the appropriate Rhizobium. Plant the inoculated and non-inoculated seed in several separate pots and grow under optimal conditions until the plants are at least 6 inches tall. Empty the soil and plants out of the pots—do NOT pull out the plants as that will rip the Rhizobium nodules off the roots. Instead, gently tease the soil away from the roots and compare the numbers of nodules on inoculated versus non-inoculated plants. Inoculation will be necessary—unless there are numerous, active nodules on the roots of the non-inoculated test plants (Figure 13). Active nodules are pink on the inside, inactive or defunct nodules are gray on the inside.
Obviously, seeding a companion crop by hand is impractical in a farm situation. Experiments were devised to seed YSC mechanically from 2014 through 2016. After 2012, all seeding was performed with a no-till grain drill. Details are given in Table 3. We learned the hard way that inoculant must be applied with YSC (and every legume) to ensure nodulation. However, broadcasting the YSC seed and drilling the barley over the top buried too much YSC seed. Seeding the YSC after barley establishment (to enable an herbicide application) meant the YSC was too shaded or too short of moisture to establish. In dry summers (2014 and 2015) the YSC emerged but desiccated under the barley.

In 2016, YSC seeded the same day after the barley, at a slight angle, and at a rate of 5 lb/acre, germinated well and was able to benefit from early June rains (Figure 14). However, the YSC desiccated due to hot, dry weather later in the season.

While Wilke Farm trials were not successful after 2012 in establishing YSC as a companion crop with barley, several farmer-collaborators were successful in growing the YSC throughout the season (E. Warner, personal communication). They note that YSC may be slow to emerge in the spring of its second year.

**Winter Canola with Companion Crop Mixture**

In early August 2013, over one inch of rain was recorded at the Wilke Farm. Taking advantage of this moisture, a companion crop mixture was seeded with winter canola, following the lead of a farmer-collaborator (C. Gross, personal communication). Details are found in Table 4.

A three-way companion crop mix was chosen: buckwheat (makes phosphate available), tillage radish (penetrates hardpan), and peas (fix atmospheric nitrogen). These species were chosen because they grow in the fall, and then should die out over the winter, thus not depressing the cash crop yield. Roundup Ready canola was used so that any surviving companion crop could be sprayed out with glyphosate in the spring.

In order to prevent the spread of the black leg fungus, any cruciferous crops or seed mixes containing such species grown in Washington State, are subject to WAC 16-301-490 to -580. These regulations state that the seed grown be

- Laboratory tested and certified as free of black leg.
- Tagged for sale indicating the seeds have met the test requirement.

Cruciferous crops (cabbage family) include canola, mustard, tillage radish, and turnip. Further information is available through the Washington State Department of Agriculture.

With good moisture, the crops grew extremely well in the fall, though the peas emerged at a low density (Figure 15).

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**Figure 14.** Yellow sweet clover growing as a companion crop with spring barley, June 3, 2015. (Photo by Diana Roberts, WSU Extension.)

| Wilke E Companion Crop Trial |  
|-------------------------------|---|
| **Year:** 2013–2014 |  
| **Location:** Block 4 Wilke Farm |  
| **Treatments** |  
| **2014 Plans** | Spring canola | Winter canola–RR Camas | Winter canola–RR Camas  
| | | | Terminated spring 2014 as winter canola did not overwinter well.  

The buckwheat was in full flower by mid-September (six weeks after seeding) and froze out after a hard frost in mid-October (Figure 16).

The tillage radish continued to grow well into November and reached 3–4 pounds in weight. Unfortunately, the tillage radish also choked out much of the winter canola (Figure 17).

The tillage radish did penetrate deep into the soil. Kinks in the large tap root (Figure 18) show where it had to penetrate hard pan layers, which exist even in ground that has been under no-till production for many years (that is, since 1997 at the Wilke Farm).

Over the winter, the tillage radish froze out. It then resembled bathroom loofahs sticking out of the ground. These large roots left holes into which moisture could percolate (Figure 19).

Figure 15. Companion crop of buckwheat, tillage radish, and spring peas with winter canola on August 21, 2013. (Photo by Diana Roberts, WSU Extension.)
The winter canola also froze out, so the trial was terminated in the spring of 2014. In addition, the companion crop had been seeded at full rates of each component, which turned out to be too high and choked out the canola. (Table 4).

Companion crops seeded at the full, standard rate for solo crops may out-compete the cash crop. Further research is needed to determine appropriate seeding rates for companion crop mixes.

Following are soil test results from this trial (Figure 20). The most interesting sample in the soil moisture data was the 6- to 12-inch zone that had more moisture in the spring in plots that had a fall-planted crop (Figure 7). It is possible that the decaying tap roots of canola and tillage radish did allow moisture penetration and storage over winter.
The total nitrate levels (Figure 21) indicated that the canola plus companion crop was capable of mining nitrogen from the soil. Starter fertilizer was applied to plots that were seeded with a crop.

**Winter Pea with Companion Crop Mixture**

In September 2015, the Wilke Farm received more than one inch of rain, enabling seeding of fall companion crops. Oats, buckwheat, and winter pea (Table 1) were seeded in the long term plots established in 2011. Care was taken not to use high rates of the companion crop to avoid choking out the cash crop (Table 1). Both fall and spring soil samples were taken.

The pea crop plus companion crop grew well in the fall (Figure 22).

While a Rhizobium inoculant was applied, nodulation on the peas was disappointing (Figure 23). This may be due to the use of starter fertilizer, or low pH—which is an increasing phenomenon across the region. A pH below 7.1 was detrimental to nodulation on alfalfa Rhizobia (Perez-Galdona and Kahn 1994), and soil acidity on the Wilke Farm was typically around a pH of five in the top six inches of the soil profile and a pH of six in the next six inches.
The buckwheat and oats froze out over the winter as intended, and the winter peas were grown to harvest. Soil tests taken in the spring of 2016 did not show any meaningful differences between treatments, which were (1) winter pea plus companion crop and (2) no-till fallow (Table 1).

With the development of better adapted, higher-yielding cultivars, winter legume crops are being grown more commonly in the Pacific Northwest. Companion crops seeded in the fall along with the legume cash crop have the potential to compete with fall weeds and provide biomass to reduce winter soil erosion. Buckwheat is not recommended due to contamination issues in subsequent wheat crops (Pavek 2016), but spring oats would fit the desired profile. As oats should freeze during the winter, no herbicide would be needed to take them out. Optimal seeding rates for the oats still need to be researched. Nodulation issues with winter peas also need to be resolved.

**Winter Wheat with Companion Crop Mixture**

In September 2015, the Wilke Farm received more than one inch of rain, enabling seeding of fall companion crops. Tillage radish, faba bean, and buckwheat were planted with winter wheat (Table 2) in the long term plots established in 2012. Both fall and spring soil samples were taken.

The crops grew well in the fall (Figure 24).

Nodulation on the faba beans (Figure 25) was disappointing. This may be due to the use of starter fertilizer, or low pH—as described above for winter peas. Due to later rainfall in 2015, the crop that year was seeded five weeks later (September 11) than the 2013 companion crop (August 6), so the tillage radish was much smaller going into winter. Kinks in the tap roots still showed evidence of hardpan penetration.
Growing a companion crop with winter wheat has the potential to benefit the soil—though only feasible when timely rain facilitates early fall seeding. A variety of species may be considered. It is best if the companion crop freezes out over winter rather than being sprayed out in the spring.

Summary

We learned a lot from this project, especially through trial and error. Following is a summary of our experiences and lessons learned. It should be noted that all results are preliminary, subject to confirmation, and do not constitute a recommendation by WSU Extension.

- Spring seeded cover crops grown in place of fallow are likely to be high risk in the inland PNW environment. Ground fallowed over the summer provides water for germinating the following fall-seeded crop. The cover crop will likely reduce soil moisture and make it challenging for the subsequent fall-seeded crop to germinate.
- Companion crops may be more feasible than cover crops in this region—because they could provide soil health benefits without detracting from the cash crop.
- Cover/companion crops will not work every year—it is important to be flexible and opportunistic in taking advantage of soil moisture conditions (grain price, seed price, etc.) existing at the optimal seeding time.
- Nitrogen fixed from the atmosphere by legumes grown as a companion crop may
benefit subsequent crops only, rather than the current cash crop.

- Companion or cover crops are best limited to three to five species in the dry PNW climate. Seed for the cover crop grown in 2011 and 2012, and YSC seeded at 10 lb/acre cost $30 per acre, which would be tough to justify on a farm scale.
- Starter fertilizer may be helpful for establishing companion/cover crops. However, it may also exacerbate existing acidic (low pH) conditions in the seed zone that may reduce Rhizobium nodulation of legume species. Further research is needed for this factor.
- Using species-appropriate inoculant is important for all legumes, unless a bioassay indicates there is adequate inoculum already in the soil.
- Companion crops must be seeded at a rate that will not out-compete the cash crop.

**Areas Needing Additional Study**

Much additional work on companion crops is needed before we can make recommendations to growers. This includes identifying a variety of companion mixes that work well with existing cash crops, calculating economics of companion crops, and establishing soil health benefits such as water retention, organic matter content, hardpan resolution, nitrogen fixation, and nutrient availability. Also, figuring out how to fertilize companion and cash crops, what seeding rates are effective, and how to seed them cost effectively on a commercial scale will require further consideration.

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