

Progress Report: Organic Cropping Research for the Northwest

Title: Cover crops for weed management in organic and transition systems.

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Abstract:

Cover crops are a locally grown source of organic matter and nitrogen and a weed management tool. Despite these benefits, many organic farmers have not been able to work cover crops into their management systems.

We are evaluating different cover cropping systems, to help organic farmers determine how to best use cover crops on their farm. Relay planting is a system where farmers plant cover crops into standing cash crops, allowing early establishment of the cover crop. We have compared several types of legume cover crops relay-planted into corn (a tall crop) and beans (a short but leafy crop) to see if the cover crops can survive in the shade of the cash crops, produce good ground cover in the winter, and supply nitrogen-rich organic matter in the spring. Hairy vetch and red clover are promising relay cover crops, and we are now gathering long term information on how they affect weed and nutrient management.

We are comparing different blends of rye (nitrogen poor) and hairy vetch (nitrogen rich) as fall planted cover crops to determine how the blends affect weed management and nutrient availability for the next crop. Hairy vetch-rye blends have not effected weed pressure compared with pure rye, while they have provided substantial plant-available nitrogen. Planting date had a large effect on cover crop biomass, while harvest date had a large affect on biomass and quality. Based on two years' data, blends ranging from 50 to 75% vetch in the seed mix and planted by early October will yield significant biomass and nitrogen benefits to farmers.

Finally, we are assessing cover crops as a tool in low-input transition to organic production. Sudangrass was the most promising low-input summer cover, but our low-input system was not satisfactory for organic transition.

Objectives:

1. Evaluate the effect of rye-hairy vetch blends and planting date on cover crop establishment, weed pressure, and nitrogen availability to the following crop.
2. Evaluate the effects of relay cover crop types and seeding method on weed pressure and nutrient management in the cover crop and following cash crop.
3. Assess the effectiveness of buckwheat, sudangrass, and red clover on weed competition and soil building when managed under low-input conditions in western Washington.

Procedures and Progress Toward Objectives:

Fall cover crop blends.

One of the purposes of growing legume cover crops is to provide N for the following crop, and reduce reliance on outside sources of N. Legumes are often slow to establish in the fall, and leave fields with incomplete ground cover and more prone to erosion and weed growth. Legumes are often grown in a blend with a grass or cereal crop to overcome these problems, but local research has shown that the N benefits of blends are lost unless the legume makes up at least 40% of the mixture. In our IFAFS research we noted that rye tends to dominate the biomass of a 50:50 (seed weight basis) rye-hairy vetch blend, and we are investigating other seeding ratios to determine if we can improve N contributions by mixed cover crops without losing too many benefits of ground cover and weed suppression.

Procedure:

Blends of cereal rye and hairy vetch were drilled into a silt loam soil in the following ratios in mid September and early October each year.

- 100% rye
- 50% rye, 50% vetch (weight ratio)
- 38% rye, 62% vetch
- 25% rye, 75% vetch
- 100% vetch

The experimental design is a split-split plot with 4 replicates, with crop as the main plot, planting date as the first split and harvest date as the second split. Main plots measure 36 x 20 feet and are planted with a grain drill. Dates of planting, harvest, field measurements, and other field activities are summarized in Table A.

We estimated cover crop stand on three dates during the winter as percent of soil covered by the cover crop (excluding weeds). Two observers each evaluated 3 representative 0.25 m² quadrats per plot. A portion of each plot (30 to 60 ft²; 2.8 to 5.6 m²) was harvested for biomass and N concentration on two dates in the spring. Two subsamples were collected from representative 0.25 m² quadrats in each plot, and proportions of rye, vetch and weeds determined. After incorporation of the cover crops, soil samples were collected to a depth of 30 cm (composites of 9 cores/plot) and analyzed for nitrate-N. The experiment was planted to sudangrass in June of each year as a summer cover. In 2006, 80 lb/acre (88 kg/ha) organic N (Biogro fish-based fertilizer) was applied to the 100% rye plots only. No supplemental N was applied in 2005.

Progress toward objective:

Planting date had the greatest effect on cover crop stand throughout the winter, as expected, while rye-vetch proportions had inconsistent effects both years. (Figure 1).

In 2006 planting date and vetch-rye planting ratios had only small effects on the proportion of weeds in the cover crop at harvest (Fig A, Table X). The proportion of weeds was slightly, but significantly lower in the early plant, late harvest cover crop, and weeds were slightly higher in the pure vetch compared with rye and blends. These results contrast with 2005, where both planting and harvest dates had a large effect on the proportion of weeds in the crop at harvest (Fig A, Table X). The proportion of vetch in the cover crop increased with vetch-rye ratio both years.

Planting date and harvest date had large effects on cover crop biomass in 2006, overwhelming any effects from cover crop blends (Fig. B, Table Y). Planting in mid-September and harvesting in late April yielded 4X as much dry matter as planting in early October and harvesting in late March. In 2005, harvest date and proportion of vetch had the largest effects on biomass. Plant nitrogen concentration increased vetch proportion both years (Fig. C). Plant N was significantly higher in the early harvest samples in 2006, averaging 1% greater than in the later harvest (Fig B). In 2005 planting and harvest date effects declined as the proportion of vetch increased in the blends.

C:N ratio effects were similar both years, with harvest date and vetch proportion having the largest effects. C:N of all treatments was less than 20, with the exception of the late-harvested rye stands.

Biomass N reflects the contrasting trends of increasing biomass with early planting and late harvest, but decreasing N concentration with late harvest. The late harvested cover crops had higher total biomass N, despite lower tissue N concentrations and wider C:N ratios than the earlier harvest. The proportion of vetch had only a small effect on biomass N either year.

Soil nitrate-N was measured in the in early June before planting sudangrass (Fig. M). The vetch-rye blends averaged 16 mg/kg more NO₃-N (approximately 50 lb/acre) than the rye treatment, while the pure vetch treatment averaged 22 mg/kg more NO₃-N (approximately 65 lb/acre) than the rye treatment. There was no significant difference between years, and these results are averaged over both years. The early planted treatments averaged 8 mg/kg more NO₃-N (approximately 25 lb/acre) than the late planted treatments.

Increased nitrogen availability is also reflected in the yield and N uptake of sudangrass biomass, harvested in late July. All of the vetch-rye blends had equal or greater yield and N uptake than the rye treatment, which received 80 lb/acre of organic N at planting in the form of Biogro, a fish-based fertilizer. Our previous research has shown that about 50 lb of Biogro N would be available for uptake between the time of sudangrass planting and biomass harvest (35 days). Both yield and N uptake increased with increasing vetch proportion, although differences among the three blends were small.

Relay Cover Crop Experiment

Relay planting or interseeding of legume cover crops is designed to overcome some of the drawbacks of legumes, such as slow establishment in the fall, poor winter ground cover, and poor weed suppression, while improving N accumulation. Relay-cropping presents its own challenges, however, including shading by the cash crop, competition with the cash crop, weed management, and effects on winter hardiness. We are determining which cash crops, cover crops, and conditions are most amenable to successful relay cropping of legumes.

Procedure:

This experiment was begun in 2003 using funding from the Department of Ecology, and continued in 2004 and 2005 using CSANR funding. Legume cover crops are interseeded into snap bean (Jade) and sweet corn (Blaze) approximately 30 days after planting the cash crop.

Following cash crop harvest, the residue is mowed and the cover crop must grow through the residue. Specific treatments have changed each year as we have narrowed the focus of our experiment based on previous years' results. Treatments each year and key management dates are shown in Tables 1 and 2. Measurements include cash crop fresh yield, cover crop stand at intervals during the winter and spring, cover crop biomass at the time of incorporation, and soil inorganic N three weeks after cover crop incorporation.

In 2005 we moved the location of the experiment to increase the size of the plots and alleys. New plot sizes are 30 ft by 15 ft with 20 ft alleys between each plot along the direction of planting. Each experiment has five treatments (Table 2) and three replicates.

Progress toward objective:

Summary of 2003-04 experiment. The hairy vetch and woolypod vetch were well established by late October. Red clover had a fair stand, but common vetch and crimson clover performed poorly and were dropped from the trial. Some winter damage occurred to the vetch in January during a week-long period of snow cover and cold temperatures, but the vetch recovered by spring. Cover crops were harvested in early April 2004 and biomass was similar in the corn and bean experiments. Hairy vetch had the greatest biomass (2170 lb/acre dry weight) followed by woolypod vetch (1760 lb/acre) and red clover (720 lb/acre). Hairy vetch significantly increased early season inorganic N over the control treatment, but red clover did not. Later incorporation would likely have substantially increased biomass and N.

2004-05 experiment. Establishment of the cover crops was much poorer than the previous year. Heavy crop residue from the corn, followed by early rains that compacted the crop residue reduced the fall stand of the interseeded cover crops. Cover crops partially recovered during the fall, and by January ground cover averaged 40-50% for hairy vetch and 30-35% for red clover in both corn and bean plots. Cold night temperatures (10 consecutive nights between 20 and 25 F) and lack of insulation by snow in February reduced ground cover to 10 to 20% for hairy vetch by early March, while red clover ground cover was not affected. This illustrates one of the potential problems with interseeded hairy vetch – reduced winter hardiness when planted in mid-summer. Red clover had the greatest biomass at incorporation (12 May), averaging 1980 lb/acre dry matter (mean of corn and bean experiments), while average hairy vetch yields were only 900 lb/acre. The post-harvest rye vetch (planted 4 October) yielded nearly 6000 lb/acre of dry matter. Soil samples for early season available N have not yet been analyzed.

2005-06 experiment. The design was modified to make a direct comparison of interseeded vs. post-harvest plantings of hairy vetch and red clover. Fall stand of the interseeded hairy vetch and red clover was much improved over the poor stands 2004-05, and similar to 2003-04. Stand ratings over the winter showed trends similar to those observed in previous years: better initial stands with hairy vetch compared to red clover, better initial stands following beans than corn, a decline in the hairy vetch stand during the winter, particularly following beans, and a recovery in the spring (Table D). Post-harvest plantings of hairy vetch and red clover (done on October 4) had weak stands and never caught up to the interseeded plantings. Biomass yield at harvest was equal to or greater than observed the previous years (Table E). Soil nitrate-N at 2 weeks after cover crop incorporation was low in all plots, although greatest for interseeded hairy vetch (Table E). The trend was similar in mid July, with only interseeded hairy vetch approaching an

adequate level for a pre-sidedress nitrate test. No differences in weed pressure were observed during the 2006 cash crop season. Neither were differences in cash crop yield observed, although this may have been the result of high yield variability across the plots.

2006-07 experiment. Fall growth of red clover and hairy vetch was similar to the previous year, with some damage to hairy vetch during cold (20F) nights at the end of October. Fall seeded legumes were not planted until late October, and emergence to date has been poor.

Low-input cover crop strategies for organic transition.

Procedure:

In the summer of 2004 we planted buckwheat (2 planting dates), sudangrass, and red clover in 18 foot wide strips in weedy fallow ground. Treatments were replicated 6 times. No nutrients were added and only the north half of the plots received irrigation water. Buckwheat was tilled at flowering, and the sudangrass and red clover were mowed at intervals during the summer. Weed density was measured in November 2004. No cover was grown in 2005, and the entire plot area was planted to a rye-vetch mix (50:50) on 5 October 2005. In 2006 cover treatments included buckwheat, red clover, sudangrass, and weedy fallow, established on June 16. Measurements included weed density (measured July 20-21) and biomass at harvest (August 4). The experiment was irrigated only once, on July 26.

Progress toward objective:

Weed biomass data collected from non-irrigated plots in November 2004 showed that sudangrass and red clover had reduced weed biomass and diversity, despite no inputs aside from mowing (Table 3). In 2006 cover crops did not produce more biomass than the weedy check, but buckwheat and sudangrass did reduce weed proportions in the ground cover (Table F). The red clover cover was not successful in 2006. Based on the results of this project, we have incorporated sudangrass as a low-input summer cover on temporarily fallow ground. However, low-input summer cover crops do not appear to be a good alternative for organic transition at the level of management that we provided.

Outputs:

- Winter cover crops field day. WSU Puyallup, February 23, 2006
- Small farms field day. WSU Puyallup, July 10, 2006. Organic farming systems, including interseeded cover crops.
- Congressional fact finding tour. August 8, 2006. Staff from US Congressional and Senate offices. Tour of organic research plots, including cover crops
- Web site <http://www.puyallup.wsu.edu/soilmgmt/SusAg.htm>. We update this site every winter
- Cover crops section in soils classes in Living on the Land and Cultivating Success series

Impact:

Cover crop blends. Our research to date has shown that increasing proportion of vetch increases biomass N, soil nitrate-N and crop response, without a large effect on weed density. Biomass tends to decline with increasing vetch proportion, while total N uptake is variable. Early planting increases biomass yield without having a large effect on nitrogen, while late harvest increases yield but decreases N concentration. Late (early October) planting still yields

significant biomass and nitrogen benefits. Over the range of blends tested (not including the pure vetch and pure rye controls, we found that planting date and harvest date had a larger effect on biomass and N than the proportion of rye and vetch in the mix. Blends ranging from 50 to 75% vetch in the seed mix and planted by early October will yield biomass and nitrogen benefits to farmers. After collecting one more year of data, we will publish results as research and extension articles and seek on-farm partners for demonstrations.

Interseeded cover crops. Both hairy vetch and red clover have promise as interseeded cover crops in vegetable production. This research and other research that we have done shows that these cover crops work with a variety of vegetables, except those that cast the heaviest shade, such as winter squash. Interseeded hairy vetch established quicker ground cover than red clover, but was more subject to winter damage. One farmer cooperator has developed his own interseeded cover cropping system, and we plan a farmer-oriented publication after the final year's data collection that discusses both systems. We will also work with farmer cooperators to do on-farm demonstrations.

Low-input summer cover. We concluded that the systems we used were too low input for successful transition, but that sudangrass does have niche as cover for summer fallow, because it is drought tolerant and can be managed with mowing.

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State: Washington

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Table 1. Fall cover crop blends. Dates of sampling and field activities.

	2004-05	2005-06	2006-07
Early Planting	15 Sept	20 Sept	14 Sept
Late Planting	4 Oct	4 Oct	6 Oct
Stand evaluation 1	22 Nov	21 Nov	20 Nov
Stand evaluation 2	25 Jan	30 Jan	
Stand evaluation 3	2 Mar	3 Mar	
Early Harvest	12 Apr	27 Mar	
Late Harvest	6 May	24 Apr	
Field chopped	9 May	25 Apr	
Residue incorporated	27 May	26 Apr	
Soil sampled for NO ₃ -N	7 June	8 June	
Sudangrass planted	14 June	16 June	
Mid-season sudan yield		21 July	
Sudan incorporated	2 Sept	10 Aug	

Table 2. Rye, hairy vetch, and weeds as proportion of cover crop stand at harvest. Cover crop blends experiment 2005 and 2006. (not available)

Table 3. Effect of cover crop blends on cover crop biomass, N concentration, C:N, and N uptake averaged over planting and harvest dates. Means within a year and column followed by different letters are significantly different (P<.05). (not available)

Table 4. Cash crop and cover crop planting dates and cash crop mowing dates in interseeded cover crop experiment.

Cash crop	Year	Cash crop planting date	Cover crop planting date	Cash crop mowing date	Days from cash crop planting to cover crop planting
Snap bean	2003-04	29 May	26 June	19 Aug	30
	2004-05	15 June	21 July	31 Aug	35
	2005-06	3 June	30 June	18 Aug	27
	2006-07	7 June	3 July	22 Aug	26
Sweet Corn	2003-04	17 June	17 July	25 Sep	30
	2004-05	15 June	21 July	7 Sep	35
	2005-06	3 June	30 June	13 Sep	27
	2006-07	7 June	3 July	29 Sep	26

Table 5. Treatments in interseeded cover crop experiment, 2003-2006.

Year	Treatments
2003-04	Hairy vetch, woolypod vetch, common vetch, red clover, crimson clover, check
2004-05	Hairy vetch broadcast and drilled, woolypod vetch drilled, red clover broadcast, post-harvest rye- hairy vetch, check
2005-06	Hairy vetch drilled, red clover broadcast, post-harvest hairy vetch, post harvest red clover, check
2006-07	Hairy vetch drilled, red clover drilled, post-harvest hairy vetch, post harvest red clover, check

Target planting rates are 50 lb/acre for vetch and 30 lb/acre for red clover

Table 6. Cover crop stand evaluations, interseeded cover crop experiment. Winter 2005-06. (not available)

Table 7. Interseeded cover crop experiment following 2005 bean harvest. Cover crop yield at incorporation, spring and mid-season soil nitrate (not available)

Table 8. Interseeded cover crop experiment following 2005 corn harvest. Cover crop yield at incorporation, spring and mid-season soil nitrate (not available)

Table 9. Low-input cover crop experiment. Cover crop and weed status, 22 November, 2004.

Cover crop	Cover crop biomass g/m ² dry wt.	Weed biomass	Major weed species Number/whole plot
Control	0	152	6.4
Early buckwheat	0	152	6.7
Red clover	164	24	2.1
Sudangrass	96	38	3.8

Table 10. Dryland cover crop experiment. Cover crop biomass and weed ground cover, summer 2006. (not available)