Organic Cover Crop Research at WSU Puyallup

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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 adopted cover crops. We are evaluating different cover cropping systems, to help organic farmers determine how to best use cover crops. Relay planting is a system where farmers plant cover crops into standing cash crops, allowing early establishment of the cover crop. We 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 gathering long term information on how they affect N management. We compared 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 affected weed pressure compared with pure rye, while they have provided significant plant-available nitrogen. Planting date had a large effect on cover crop biomass, while harvest date had a large affect on biomass and quality. A 50:50 rye-hairy vetch blend planted by early October will yield significant biomass and N benefits to farmers. Our new research is focused on quantifying N benefits.

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.

New Objectives for 2007:

3. Assess nitrogen contribution of fall-planted rye, vetch, and rye-vetch blend cover crops in an organic vegetable production system and their effects on nutrient management.
4. Compare nitrogen contribution of summer-interseeded hairy vetch with a fall-planted rye-hairy vetch blend in on organic vegetable production system

Procedures and Progress Toward Objectives:

Fall cover crop blends.

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

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

	2004-05	2005-06	2006-07	2007-08
Early Planting	15 Sept	20 Sept	14 Sept	18 Sept
Late Planting	4 Oct	4 Oct	6 Oct	4 Oct
Stand evaluation 1	22 Nov	21 Nov	20 Nov	21 Nov
Stand evaluation 2	25 Jan	30 Jan	23 Jan	31 Dec & 8 Feb
Stand evaluation 3	2 Mar	3 Mar	2 Mar	29 Feb
Early Harvest	12 Apr	27 Mar	29 Mar	
Late Harvest	6 May	24 Apr	27 Apr	
Field chopped	9 May	25 Apr	30 Apr	
Residue incorporated	27 May	26 Apr	30 Apr	
Soil sampled for NO_3-N	7 June	8 June	25 June	
Sudangrass planted	14 June	16 June	29 June	
Mid-season sudan yield		21 July	14 Aug	
Sudan incorporated	2 Sept	10 Aug	27 Aug	

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 1.

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 m^2 quadrats per plot. A portion of each plot (30 to 60 ft^2) was harvested for biomass and N concentration on two dates in the spring. Two subsamples were collected from representative 0.25 m^2 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 and analyzed for nitrate-N. The experiment was planted to sudangrass in June of each year as a summer cover. In 2006 and 2007, 80 lb/acre (88 kg/ha) organic N (fish-based sources) was applied to the 100% rye plots only. No supplemental N was applied in 2005.

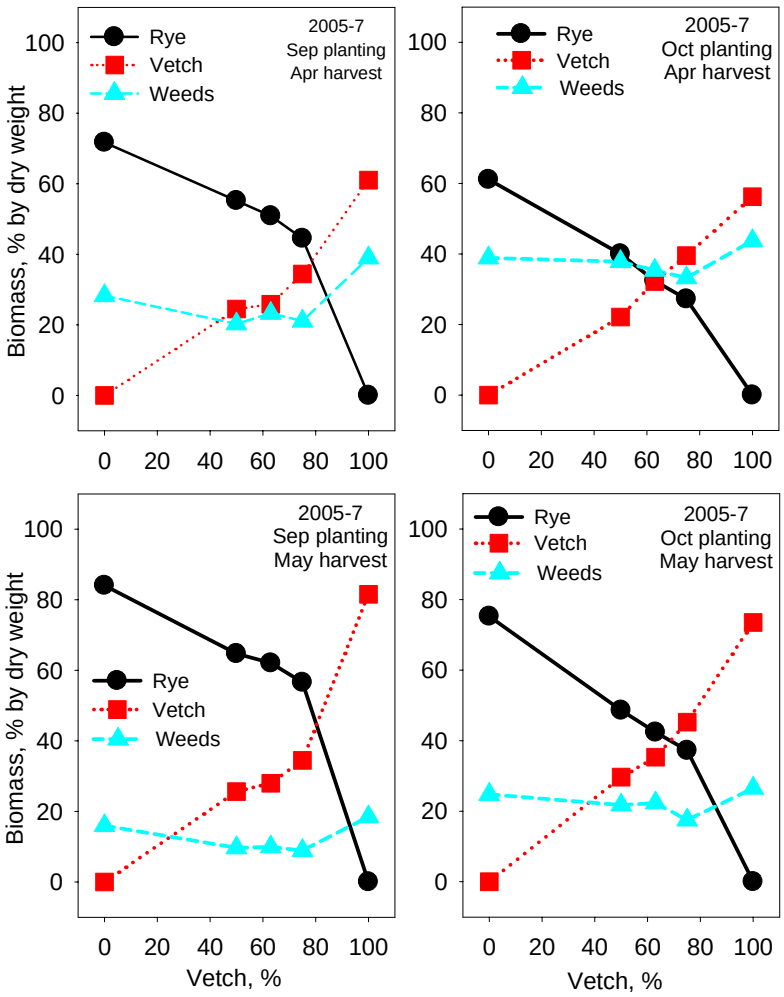

Figure 1. Rye, hairy vetch and weeds as portion of cover crop stand for early and late plantings and harvest dates. Cover crop blends experiment.

Progress toward objective:

Plant and soil C and N analysis and statistical analysis of 2007 data are still in progress. Cover crop yields were lower in 2007 compared with the previous years, a likely result of colder and wetter weather during the 2006-07 fall and winter compared with the previous two years.

Effect of planting and harvest date and rye-vetch planting ratios on proportions of rye, vetch, and weeds in above-ground dry matter averaged over three years are shown in Fig. 1. Planting ratio and planting date had little effect on weediness, while harvest date had the greatest effect. The proportion of weeds was lower in the late-harvested plots, because of the rapid growth of the rye and vetch in the spring. Despite apparent weak initial growth of rye each fall, rye biomass tended to exceed vetch in the spring.

Planting date and harvest date had large effects on cover crop biomass, overwhelming any effects from cover crop blends (Mean of 2005-07 shown in Fig. 2a). Planting in mid-September and harvesting in late April yielded 2-4X as much dry matter as planting in early October and harvesting in late March. Proportion of vetch and harvest date

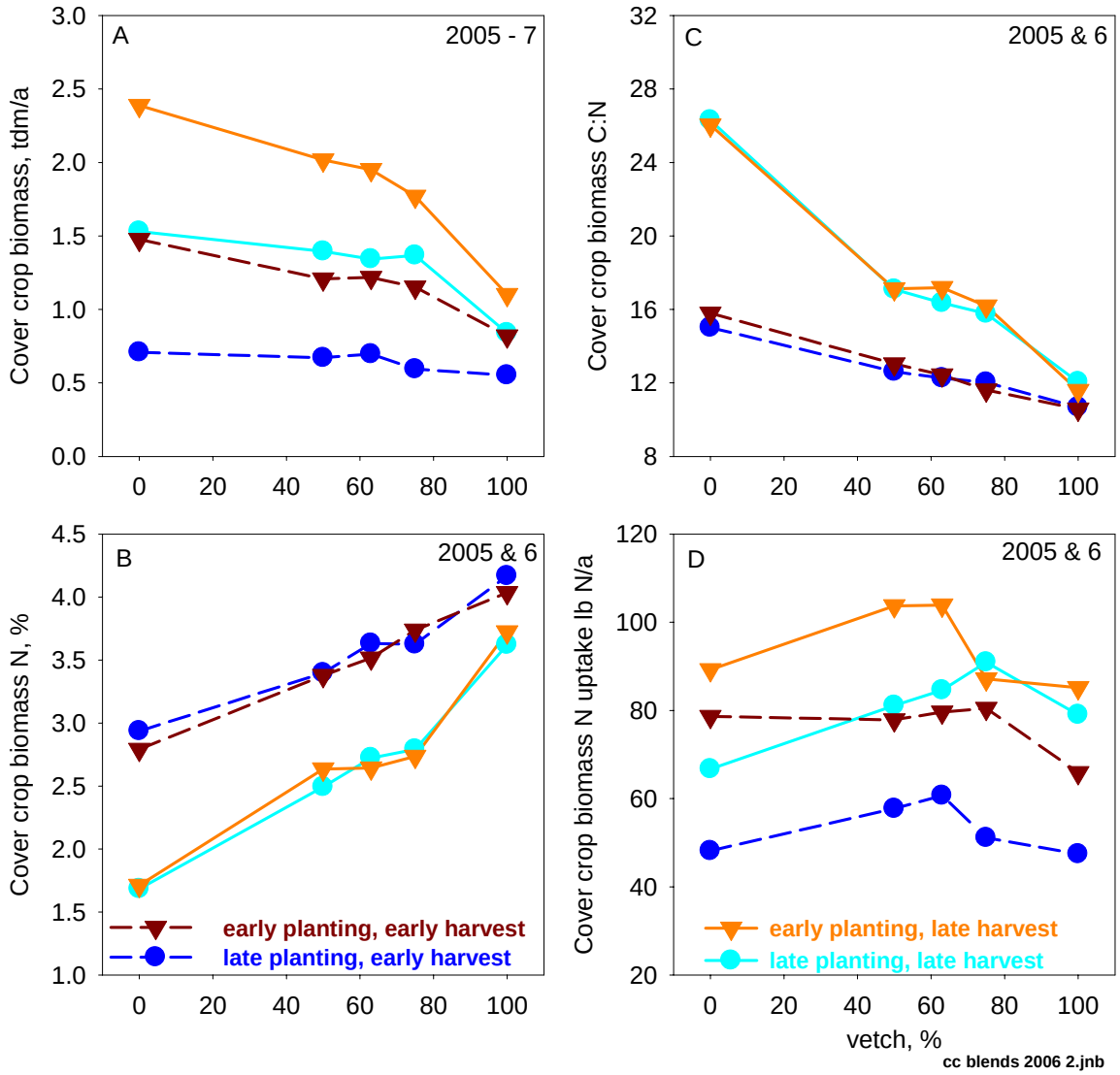

Figure 2. Cover crop biomass (A), N concentration (B), C:N (C), and N uptake (D) for different blends plantings and harvest dates.

had large effects on biomass %N and C:N ratio, while planting date had no effect (Figs 2b and c). Plant N was significantly higher in the early harvest samples, averaging 1% greater than in the later harvest. Rye-vetch blends averaged 0.7% greater N than the pure rye.

C:N of all treatments was less than 20, with the exception of the late-harvested rye stands. Biomass N reflects 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 (Fig. 2d). The proportion of vetch had only a small effect on biomass N.

Soil nitrate-N was measured in June before planting sudangrass (Fig. 3). Soil nitrate was lowest in 2007 (averaging 28 mg/kg for the blend treatments), reflecting the lower cover crop yields. Soil nitrate testing in June (pre-sidedress nitrate test or PSNT) has been correlated with corn response to additional N fertilization in manured systems. While the PSNT has not been calibrated for cover crop systems, it is interesting to compare soil nitrate from this study with PSNT recommendations. Nitrate levels measured following all rye-vetch blends and pure vetch were greater than 25 mg/kg all years, which is considered a sufficiency level of N for corn. Our new objectives in this study (see below) will evaluate N contribution from cover crop blends based on planting and harvest dates, and cover crop biomass and quality, and will provide a preliminary assessment of the PSNT in Northwest cover crop systems under organic production.

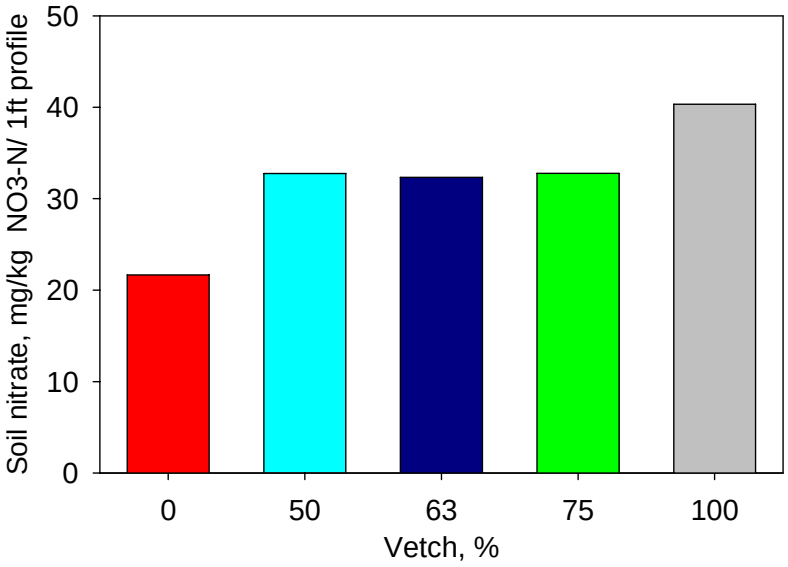

Figure 3. Soil nitrate-N in June before planting sudangrass. Mean of data from 2005-2007.

Yield (2006 and 2007) and N uptake (2006) of biomass of the subsequent sudangrass crop indicate a significant N contribution from the cover crop blends (Fig. 4). 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 50-60 lb of Biogro N would be available for uptake between the time of sudangrass planting and biomass harvest. The greater sudangrass yield in 2007 resulted from a longer interval from planting to harvest (47 days in 2007 vs. 35 days in 2006).

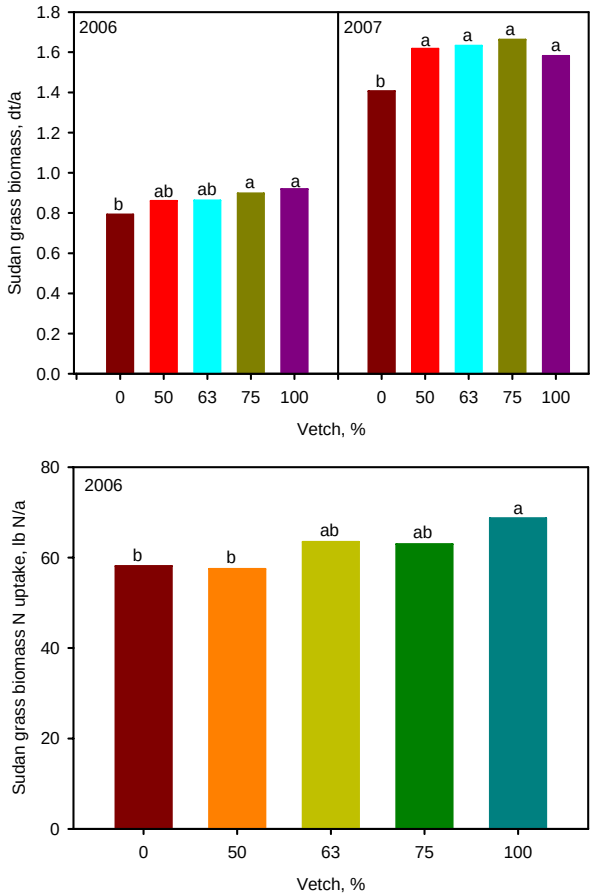

Figure 4. Sudan grass biomass yield and nitrogen uptake following incorporation of rye-vetch blends. Pure rye (0% vetch) treatment received 80 lb N/a organic N. Other treatments received no supplemental N.

Relay Cover Crop Experiment

Procedure:

Legume cover crops were 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. Treatments each year and key management dates are shown in Tables 2 and 3. Measurements include cash crop fresh yield, cover crop stand intervals during the winter, cover crop biomass at incorporation, and soil inorganic N three weeks after cover crop incorporation and at sidedress time.

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.

Table 2. 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 3. 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

2004-05 experiment. Establishment of the cover crops was poorer than the previous year. Heavy, wet residue from the corn reduced the fall stand of the interseeded cover crops. Cover crops partially recovered during the fall, but the hairy vetch stand declined again during the winter. 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 averaging 1980 lb/acre dry matter, compared with only 900 lb/acre for hairy vetch.

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, and a recovery in the spring. 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 averaged 2800 lb/acre dry wt for hairy vetch and 1900 lb/acre for red clover. Cover crop increased mid-season soil nitrate, but only interseeded hairy vetch (26 mg/kg) approached an adequate level for a PSNT. No differences in weed pressure or cash crop yield were observed during the 2006 cash crop season.

2006-07 experiment. Fall and winter stands of relay planted hairy vetch and red clover were similar to those observed in 2005-06. Biomass was much lower than the previous year, however, averaging only 940 lb/acre for hairy vetch and less than 500 lb/acre (stand not harvested) for red clover. The red clover was inadvertently drilled instead of broadcast, which reduced stand and yield. Fall seeded legumes were not planted until late October, and produced too little biomass to harvest. The reason for the reduced biomass in the relay plantings was not clear. Some winter damage of the hairy vetch occurred, but it was not more severe than in previous years. Samples were collected for soil nitrate in late June, but analyses are not complete.

Cover crop N experiments

We established two experiments in 2007 focused on N contribution from cover crops: 1) comparing post-harvest rye, vetch, and a 50:50 blend over two planting and harvest dates and 2) comparing interseeded hairy vetch with a post-harvest rye-vetch blend. Cover crop biomass, C:N, and quality will be measured in the spring, and soils will be tested for nitrate N early and mid-season and post-harvest. We will overlay a range of N rates (using relatively fast-release organic N) on the plots and develop N uptake curves and estimate available N supplied by the cover crops. The stands in the interseeded cover crop experiment are good going into the winter, while rye stands are weak in the post-harvest experiment.

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. Our next phase of research will help quantify the N contribution of cover crop blends under organic management.

Interseeded cover crops. Both hairy vetch and red clover have promise as interseeded cover crops in vegetable production. We have had mixed results with stands of interseeded cover crops, and their most promising niches appear to be with late planted row crops such as spinach, and with sweet corn varieties that do not cast heavy shade. One farmer cooperator has developed his own interseeded cover cropping system. Our next phase of research will focus on the nitrogen contribution of interseeded cover crops, and continued evaluation of the viability of interseeded cover crops in organic systems.