Pullman Plant Materials Center

National Soil Health Study Progress Report – Year 2

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Introduction

The Pullman PMC is one of seven PMCs participating in a national Plant Materials Program study to evaluate the effects of cover crops on soil health. A summary of first-year findings can be accessed here. We planted the second year of the study in October 2013, and have continued to collect cover crop percent cover and biomass data; measure soil bulk density, soil moisture, and soil temperature; collect soil nutrient and biological indicator samples; and assess commodity crop yield. The cycle will repeat for a third year and end in 2015. Information gathered in this study will help us determine the adaptability of the cover crop species to the Palouse region and their effects on soil health, as well as their effect on commodity crop performance.

Summary of Key Points

- Year 2 of the study was established during a fall with excellent moisture; 2.17 cumulative inches of rain had been received at the time of cover crop planting on Oct 6, 2013.
- Cover crops did not begin to accumulate significant biomass until the last week of April 2014.
- May 2014 had periods of unusually high temperatures and little precipitation.
- There was no barley yield this year due to the soil being hard and dry at the time of planting, low soil nitrate and a late planting date.
- Weeds increased in all plots from 3% to 7% cover in Year 1 to 28% to 46% in Year 2.
- From Year 1 to Year 2, soil bulk density increased, soil carbon decreased and Haney's Soil Health Indicator Values increased. Some of these effects may be related to the conversion to no-till.
- The species and protocols used in this study appear to not be ideal for our region. We plan to make changes and continue experimenting with cover crops after the national study completion in Fall 2015.

Materials and Methods

For a description of the study experimental design and materials and methods, please see the Year 1 Progress Report. During the 2013-2014 crop year, the Pullman PMC received 13.69 inches of precipitation, far below the average of 20 inches. Pullman had 5900 growing degree days (GDD, base temperature 32F), which is higher than the 2010-2014 average of 5695 GDD. We seeded the plots with a John Deere double disk drill on October 6, 2013. Planting conditions were good, since we received 2.17 inches of precipitation during the preceding month. We terminated the cover crops on May 15 with an application of glyphosate, and planted barley, our commodity crop, on May 20 with a Truax no-till range drill (with depth bands removed). The soil was hard and dry at the time of planting due to unusually high temperatures during the month of May and a late planting date.

Results and Discussion

Cover Crop Percent Cover and Height

The cover crops grew slowly from the time of emergence in mid-October through late April. Rates of cover crop growth increased during the first week of May, when we experienced unusually high temperatures. At the time of cover crop termination on May 15, cover crops had 34% to 59% cover, with higher percent cover in plots with 40 and 60 seeds per square foot and 4 and 6 species. Vetch cover in these plots was 15% to 20%. Cover crops had lower percent cover than last year, when they had 85% to 95% cover at the time of termination. There were more weeds in the study area this year; weed cover ranged from 28% to 46%, compared to 3% to 7% last year. Both years, weed cover was highest in the plots with the lowest seeding rate. Cover crop plant height at the time of termination ranged from 7 to 8 inches, compared to 12 to 18 inches last year.

Figure 1. Cover crop plot (4 species mix at 60 seeds/sq ft seeding rate) on March 24, 2014 (left) and May 5, 2014 (right).

Mix Compositions

Red clover and oat plants established in the fall but did not survive the winter. A small number of rapeseed and radish plants survived the winter and were counted in our percent cover measurements (Figure 2) however their biomass was negligible (Table 1). Triticale was the dominant species in all cover crop plots, with an average of 58% cover in the 2 species plots and 45% and 42% cover in the 4 and 6 species plots, respectively. The percent cover of each mix at the time of termination is diagramed in Figure 2.

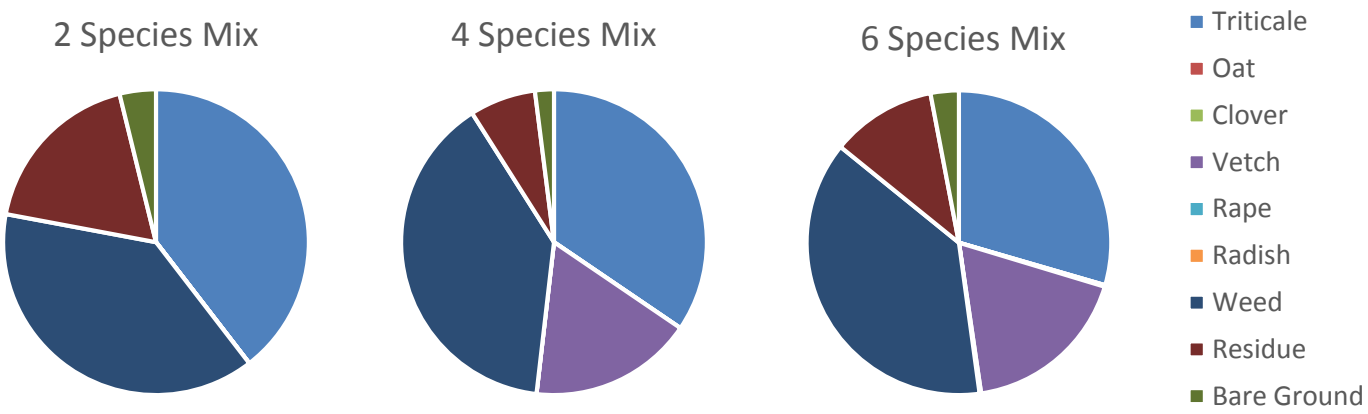

Figure 2. Average percent cover of cover crop mixes at the time of termination.

Cover Crop Biomass and Percent Nitrogen

Cover crop plots planted with 2 species had less biomass than plots planted with 4 and 6 species, which is the opposite of last year, when the 2 species plots had the most biomass. Volunteer vetch plants in the 4 and 6 species plots may be the cause of this change. The legume component in these plots was more than double than last year. Biomass percent nitrogen was lowest in the 2 species mix (2.2%) and slightly higher in the 4 and 6 species mixes (2.5% and 2.6% respectively). Weed composition was 2 to 14 times higher than in Year 1.

Table 1. Comparisons of average aboveground biomass dry matter, N content, and percent composition of three cover crops mixes and three seeding rates.

		N in Dry	Cover Crop Biomass Composition			
	Dry Matter	Matter	Grasses	Legumes	Brassicas	Weeds
Treatment	--t/ac--	----------	----------	%----------	----------	----------
2 Species	0.71 b[1/]	2.2 b	58 a	0	0	42 a
4 Species	0.95 a	2.5 a	45 ab	23 a	0	32 ab
6 Species	0.94 a	2.6 a	42 b	21 a	8	29 b
20 seeds/ft^2	0.86 a	2.6 a	43 a	17 a	0	40 a
40 seeds/ft^2	0.85 a	2.4 a	49 a	14 a	1	36 ab
60 seeds/ft^2	0.90 a	2.4 a	54 a	13 a	6	27 b
Control[2/]	.	.	.	.	.	.

1/ Means within the same column followed by the same letter are not significantly different with Tukey HSD means comparisons at α = 0.05. 2/ Control plots were not harvested this year.

Soil Temperature, Moisture and Nitrate Nitrogen

Cover crops had no effect on soil temperature at the time of commodity crop planting; all plots including the control had a soil temperature around 65°F (Table 2). The differences in soil moisture among cover crop plots were also very minor. All cover crop plots had more moisture than in the control, likely because we did not spray the control plots before weed growth increased. Soil nitrate nitrogen at the time of commodity crop planting was highest in the plots with 2 species and the lowest seeding rate, but all plots had very little soil

nitrate, including the plots with a vetch component. It is possible the nitrogen is being tied up in organic matter as we transition to no-till.

Table 2. Total cover crop biomass at time of termination; and soil temperature, moisture and nitrate-nitrogen at the time of commodity crop planting.

Cover Crop Mix	Cover Crop Seeding Rate (seeds/ft^2)	Total Biomass (DM t/ac)	Soil Temp (°F)	Soil Moisture (%VWC)	Soil Nitrate (NO_3-N lb/ac)
2 Species	20	0.80	68.0	22.25	3.3
2 Species	40	0.68	63.3	19.31	2.2
2 Species	60	0.66	63.4	20.80	1.7
4 Species	20	0.92	65.6	22.14	1.3
4 Species	40	0.97	66.9	22.15	2.0
4 Species	60	0.96	65.0	19.74	1.7
6 Species	20	0.87	64.6	17.14	1.0
6 Species	40	0.89	64.6	19.70	0.8
6 Species	60	1.08	66.1	21.95	1.2
Control	0	.	65.8	18.88	1.1

Commodity Crop Yield

There was no barley yield this year. The barley established poorly due to the soil surface being hard and dry following the cover crop. The barley plants that did establish were only 1 ft tall in September, produced few seed heads and did not mature.

Soil Bulk Density

Soil bulk density is often used as an indicator of soil health. Soils with high organic matter and good structure tend to have low bulk density, and compacted soils with poor structure tend to have high bulk density (USDA-NRCS, 2014). One of the goals of conservation tillage practices is often to reduce soil bulk density. Some studies have found, however, soil bulk density is not a reliable measurement for determining change in soil function (Logsdon and Karlen, 2004). In the Inland Northwest, research scientists and farmers have discovered soil bulk density actually increases over the long-term with the conversion to no-till, while at the same time, infiltration rates increase 5 to 10 fold (Dennis Roe, personal communication, 2014). This can be explained by the change in water movement with conversion to no-till, from capillary action to preferential flow through earthworm casings and root channels. In our Soil Health Study, we found bulk density has increased at both the 0-2" and 2-6" depths from Year 1 to Year 2 in all plots, including the control. In the 0-2" depth, it increased from 1.1 to 1.4, and in the 2-6" depth, it increased from 1.4 to 1.6, with only slight variations in treatments (data not represented).

Soil Health

Another measurement often used to assess soil health is the amount of carbon in the soil. Soil organic carbon (SOC) in the top 6" of soil in our study significantly declined in all plots from an average of 362 ppm to 219 ppm from the time of cover crop planting to the time of cover crop termination in Year 1, with no difference in trend among treatments. In Year 2, SOC continued to decline, but not as dramatically (Figure 3). Similar to the increase in soil bulk density, this trend is consistent with experiences farmers have had with conversion to no-till in our region. Soil carbon often declines temporarily, since residue is no longer being incorporated into the soil, and there is a lag time for conversion of soil microbial communities from residue feeders to root feeders (Dennis Roe, personal communication, 2014). We may be able to increase soil carbon in our soils by incorporating more legumes into mixtures and/or fertilizing the commodity crop to increase plant production in the future.

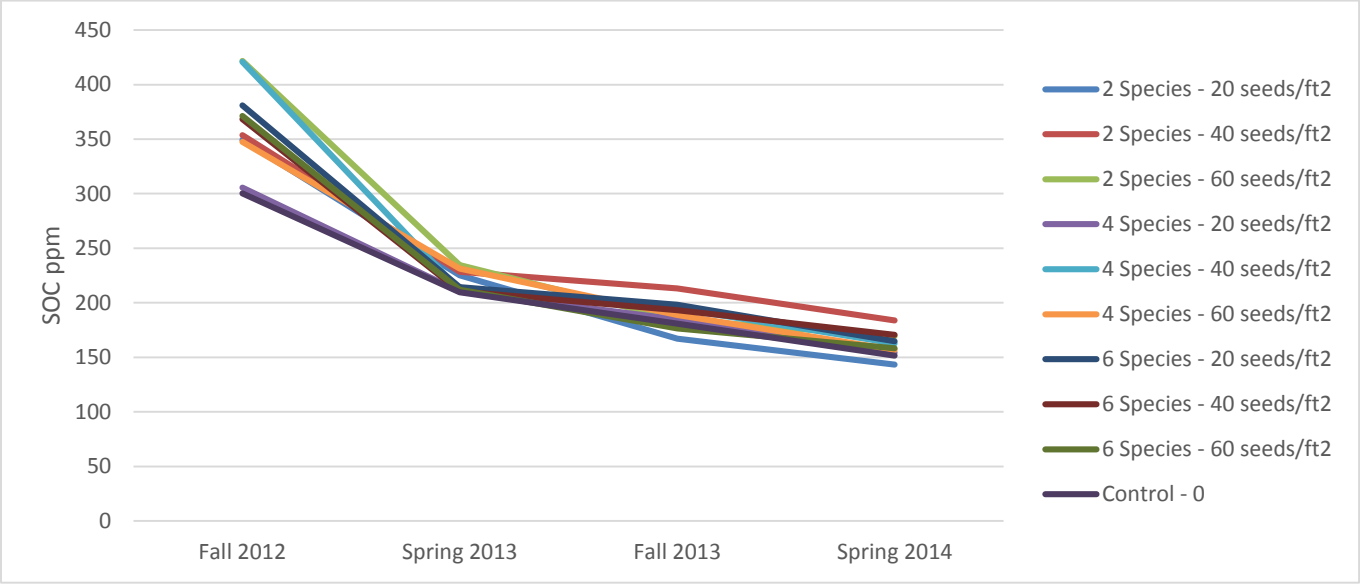

Figure 3. Change in soil organic carbon Fall 2012 to Spring 2014 in cover crop plots seeded with 2, 4 and 6 species mixes at 20, 40 and 60 seeds/ft^2.

Dr. Rick Haney (USDA-ARS, Temple, TX) has developed a tool to assess soil health which combines five measurements of soil biological properties into one Soil Health Indicator Value. Values can range on a scale of 0 to 50, and should increase over time if the soil is being sustainably managed. Our soil health indicator values declined slightly from the time of cover crop planting in Year 1 to time of cover crop planting in Year 2, and increased during cover crop growth in Year 2 (Figure 4). The soil health value of the control also increased during this time period.

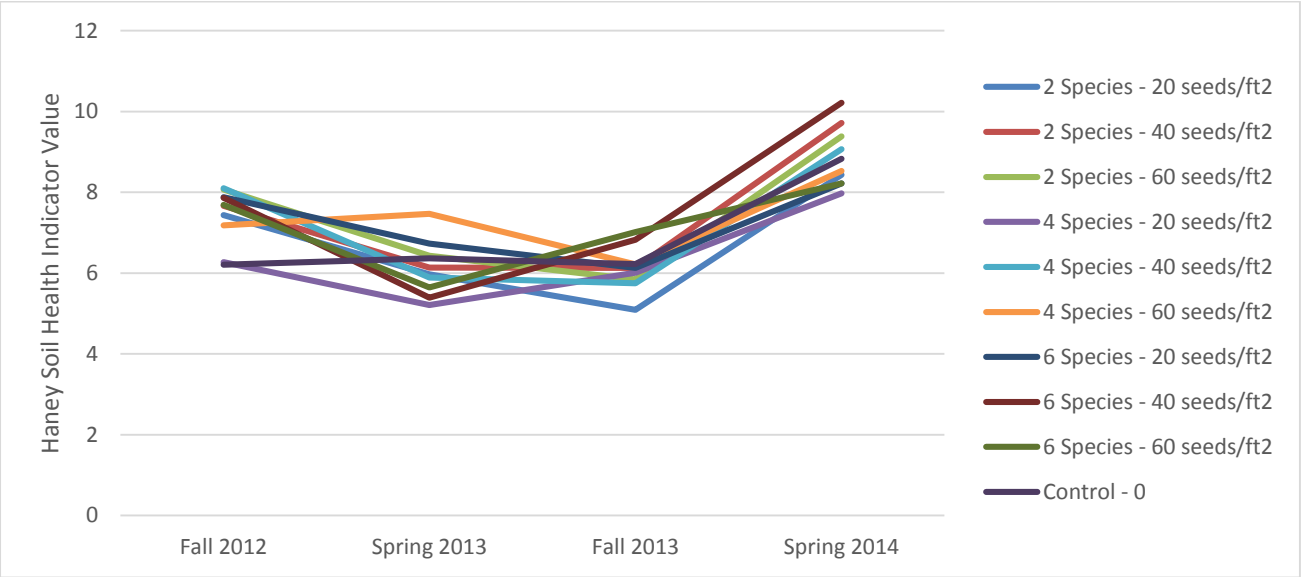

Figure 4. Change in Haney Soil Health Indicator Values Fall 2012 to Spring 2014 in cover crop plots seeded with 2, 4 and 6 species mixes at 20, 40 and 60 seeds/ft^2.

Conclusions

The rain we received in Fall 2013 did not improve cover crop stand success over the previous year because of the late planting date. Cover crops grew very little during the winter months and accrued most of their biomass during the first two weeks of May, when we had unusually high temperatures. Cover crop percent cover was lower and weed percent cover was higher in Year 2 than in Year 1. Biomass was lower in Year 2 in all plots except in the plots with 4 and 6 species, possibly because of re-seeding vetch plants. From Year 1 to Year 2 soil bulk density increased and soil carbon decreased, which may be a result of converting to no-till. These trends are similar to those experienced by growers in our region who have reduced their tillage. The cover crop species and protocols used in this study may not be ideal for our region, and we plan to make changes after the completion of the national study in Fall 2015. We will continue to monitor the results from this study and determine changes in soil health over time.

References

Logsdon, S.D. and D.L. Karlen. 2004. Bulk density as a soil quality indicator during conversion to no-tillage. Soil and Tillage Research 78:143-149.

USDA-NRCS. 2014. Soil Bulk Density/Moisture Aeration. Soil Quality Kit – Guides for Educators [Online] Available at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053260.pdf. USDA Natural Resources Conservation Service, Washington, DC.