# Effects of Mixed Species Cover Crop on Soil Health

USDA-NRCS California Plant Materials Center

Annual Progress report prepared by Shirley Fowler and Margaret Smither-Kopperl

# **Introduction**

Soil health is critical as a natural resource for crop production. The Lockeford Plant Materials Center (CAPMC) is participating in a national Plant Materials Program Study, with six other PMCs around the US, to evaluate the effects of cover crops on soil health. The CAPMC is the only PMC situated in California and with a Mediterranean climate. The first year of the study was planted in fall of 2012. The CAPMC is evaluating three different seeding rates and mixes of six plant species to observe their impact on soil health. Cover crops planted each fall and sweet corn is planted each summer as an example of a commodity crop. At multiple times during the life of the cover crop, the CAPMC will collect above-ground data to determine the consequences of treatments on plant cover, species composition, and total biomass. Analysis on soil properties, fertility, and biological activity are taken at cover crop planting and termination. This report is a preliminary analysis of data from the first year study and conclusions are subject to change with further data from the next two years.

Information gathered in this study will help us determine the effectiveness of these cover crop species to the Central Valley of California and their effects on soil health, as well as their effect on commodity crop performance.

## **Summary of Preliminary Results**

- % Cover averaged over seeding rates after 60 days was 95% for the 6-component mix, 90% for the 4-component mix and 85% for the 2-component mix.
- % Cover averaged over diversity after 60 days increased with seeding rate, at 60 days it was 95% for 60 seeds/ft<sup>2</sup>, 90% with 40 seeds/ft<sup>2</sup> and 85% with 20 seeds/ft<sup>2</sup>.
- Above ground biomass in the 4- and 6-component mixes was almost double the 2-component mix at cover crop termination.
- Weed suppression occurred. Weed biomass was higher with the 20 seeds/ft<sup>2</sup> seeding rate, especially in the 2-component mix. Weed biomass was lowest (below 10% cover) in plots containing tillage radish at seeding rates of 40 and 60 seeds/ft<sup>2</sup>.
- Canola was not competitive as it was not found within the 6-component mix.
- Total nitrogen and the soil health index were not significantly different between treatments, but had decreased after the sweet corn harvest prior to planting the cover crop for the second year.
- Below ground radish biomass was not significantly different between the 4- and 6-component mixes; dry matter averaged 1.05 ton/acre and 0.8 ton/acre respectively.
- Corn yields were significantly higher in the 4- and 6-component mix, compared to the control and 2- component mix.
- Tillage radish was the variable associated with increased corn yield.

#### **Methods and Materials**

Cover crop mixes were planted October 18-19, 2012 onto a cultivated clean seed bed in a field of Vina fine sandy loam. No irrigation was applied as 4 inches of rainfall fell in the two months following planting in 2012, ensuring good germination and early growth. The experimental design was a randomized complete block with four blocks and 2 factors; cover crop diversity and seeding rate. There were three seeding mixes representing increasing diversity with combinations of rye, crimson clover, radish, hairy vetch, canola, and oats. (Table 1). The second factor was seeding rates of 20, 40 and 60 seeds per ft<sup>2</sup>. In addition to these 9 treatments there was a control plot in each block.

Mix	Grasses	Legumes	Brassicas
2-component	50% cereal rye	50% crimson clover	
4-component	45% cereal rye	22.5% crimson clover	10% tillage radish
		22.5% hairy vetch	
6-component	22.5% cereal rye	22.5% crimson clover	5% tillage radish
	22.5% oats	22.5% hairy vetch	5% canola

#### Table 1. Planting mixes for soil health study.

The cover crop was terminated on March 27 using the roller crimper. Biomass samples using designated protocols were taken prior to rolling the plots. Soil temperatures and moisture levels were recorded at cover crop termination. This time was chosen as the tillage radish seeds were close to maturity. However the grasses, rye and oats were still leafy and immature and were not killed by the roller-crimper. A spray of glyphosate was applied to all plots to kill the cereals and weeds and the ground was left fallow prior to planting.

Sweet corn (cultivar Bodacious) was planted on May 13, 2013 using a modified Truax range drill, to give an approximate 32 in row spacing. Irrigation was applied using sprinkler irrigation prior to seeding and after planting until the corn plants were approximately 2 feet tall. After this time irrigation was applied using the buried drip lines set-up prior to planting in fall of 2012. Sweet corn was harvested on July 26, 2013. The corn was mowed prior to planting in cover crops again in fall of 2013 for the second year of the study.

#### **Results and Discussion**

## Above Ground Growth from Cover Crop Planting

After planting the seeds germinated and grew rapidly to provide cover over the soil, by 30 days cover was between 40 and 50% for all plots (Figure 1). After 60 days, cover was 85% for the 2-component mix, 90% for the 4-component mix, and 95% for the 6-component mix. Seeding rate also affected % cover at 60 days it was 85% with 20 seeds/ft<sup>2</sup>, 90% for 40 seeds/ft<sup>2</sup>, and 95% for 60 seeds/ft<sup>2</sup>. The canopy cover closed at about 90 days for all treatments.



*Figure 1. Effect of three cover crop mixes with 2, 4 and 6 species and three seeding rates on % cover during 2012 and 2013 season.* 

Soil moisture at cover crop termination was similar in all plots at 20 - 21 % volumetric water content as measured using the HydroSense II. Soil temperatures also were similar between treatments at cover crop termination at 45 - 47 °F. These temperatures were too cold to plant sweetcorn so planting was delayed until May.

Cover crop termination was carried out when the radish was approaching maturity, although the grains were still immature. Dry matter from above ground biomass was lowest in the control plots and the 2-component mix (Table 1, Figure 2a). The highest biomass values were in the 4- and 6-component mixes, which were almost double the two component mix.

The effect of seeding rates averaged across diversity treatments, indicated that the 20 and 40 seeds/ft<sup>2</sup> seeding rate had higher biomass than the 60 seeds/ft<sup>2</sup> seeding rate (Figure 2b). Presumably the higher seeding rate caused competition between plants reducing total biomass. As these plots were terminated prior to maturity of the grain crops, results could have changed significantly if termination had been delayed.

Cover crop	Seeding rate	Dry matter	Grass (rye	Legumes	Brassicas	Weeds %
diversity	(seeds/ft <sup>-</sup> )	(lb/acre)	and oats) %	(clover and	(tillage	
				vetch) %	radish) %	
2-component	20	927 с	39 ab	22 a	-	40 b
	40	1127 bc	55 a	22 a	-	24 bc
	60	908 c	54 a	26 a	-	20 bc
4-component	20	2241 a	28 b	22 a	35 a	15 c
	40	2191 a	29 b	22 a	40 a	9 c
	60	1467 abc	28 b	25 a	39 a	9 c
6-component	20	2107 a	36 b	19 a	30 a	14 c
	40	1939 ab	40 ab	22 a	29 a	9 c
	60	1405 abc	28 b	25 a	38 a	8 C
Control	0	510 c	=	-	-	99 a

Table 2. Above ground biomass of cover crops at termination and % composition of three cover crops mixes and three seeding rates. Values within the same column followed by the same letter are not significantly different in Tukey HSD means comparisons at  $\alpha = 0.05$ .



# Figure 2. Effect of three cover crop mixes with 2, 4 and 6 species and three seeding rates on above ground biomass at cover crop termination on March 27, 2013 (Dry matter Ib/acre)

A comparison of the plant composition across treatments finds that the proportion of legumes, crimson clover and hairy vetch, varied between 19 and 26% (Table 2, Figure 3). Rye made up a higher proportion of the 2-component mix than the 4-component mix, which was similar to the 6-component mix. Oats and rye were not separated in the 6-component mix. Canola planted in the six component mix was not competitive, only one canola plant was noted in the entire trial at termination. Tillage radish germinated rapidly, the seedlings were very vigorous and continued to dominate their plots until cover crop termination (Figure 3). Weeds comprised less than 10% of total biomass in the 4- and 6- component cover crop plots at the 40 and 60 seeds/ft<sup>2</sup> seeding rates, significantly lower than other treaments. The most serious weed problem in our plots during 2013 – 2014 was cheeseweed *Malva* spp. a perennial weed that grows through the year in the Central Valley.



Figure 3. Botanical Composition of Above Ground Biomass at Cover Crop Termination.

Measured at cover crop termination, the botanical composition of above ground biomass for; weeds, tillage radish, legumes, combined crimson clover and vetch, and grass, combined rye and oats. Treatments were rye (r), crimson clover (c), hairy vetch (v), tillage radish (t), oats (o), and brassica, canola (b), at 20, 40 and 60 seeds/ft2. The canola plants were not competitive, none were found in the plots.

#### **Below Ground Biomass and Soil Health**

As documented above, tillage radish germinated rapidly and grew strongly from the fall to spring and effectively suppressed weeds. Below ground biomass of harvested radish roots were not significantly different between treatments (Table 3) although the proportion of seeds planted were 10% in the 4-component mix and 5% in the 6-component mix. The highest weights were in the 4-component mix planted at 20 and 40 seeds/ft<sup>2</sup>. The average water content of the harvested roots across treatments was highly variable from 7.5 – 39%, although the average was 16.9%. Radish roots provide a moisture reservoir within the soil following cover crop termination. Based on data presented here, assuming a 1 ton/acre presence of radish roots at 10% moisture, then the amount of water present in radish roots would be 9 ton/acre and as I ton is equivalent to 239.65 gal, this is equivalent to 2157 galls/acre. This is probably insignificant from the perspective of providing moisture to the commodity crop, but the drying radish roots would provide a pathway to enable infiltration of water from the initial sprinkler irrigation within the soil profile.

Cover crop diversity	Seeding rate (seeds/ft <sup>2</sup> )	Radish DM (lb/acre)	Total Nitrogen* (lb/acre)		Soil Health Calculation <sup>#</sup>	
			2012	2013	2012	2013
2-component	20		194	171	12.7	9.6
	40		245	119	12.5	8.9
	60		206	122	11.9	8.8
4-component	20	2220	209	157	11.4	8.9
	40	2386	234	186	15.1	9.0
	60	1790	269	193	10.4	8.9
6-component	20	1717	259	140	12.7	10.3
	40	1450	225	188	14.6	10.2
	60	1632	202	210	13.8	9.5
Control	0		211	129	13.5	10.5

Table 3. Below ground biomass of tillage radish at termination and values for total water ex	<i>ctractable</i>
nitrogen and the Soil Health Calculation.	

\*Total water extractable nitrogen.

<sup>#</sup>Soil Health Calculation from tool developed by Dr. Rick Haney USDA-ARS calculated from one day CO<sup>2</sup> release divided by the organic C:N ratio plus weighted organic C and N additions.

Soil analysis was provided by Dr. Rick Haney (USDA-ARS, Temple, TX). Data is presented here for total water extractable nitrogen and a Soil Health Indicator Value. The Soil Health Calculation was developed as a tool to assess soil health, and combines five measurements of soil biological properties into one. Values are on a scale of 0 to 50, and should increase over time if the soil is being sustainably managed. In this case there were no significant differences between treatments, and the values for both following the corn crop and prior to planting the second years cover crop were lower than the previous year.

#### **Commodity Crop - Sweet Corn**

Yields were significantly higher in the 4- and 6- component mixes, the highest yielding treatment was the 4-species mix seeded at 20 seeds/ft<sup>2</sup>, with 194 bushels/acre (5.4 tons/acre) (Figure 4). This yield is below the average sweet corn yield for San Joaquin County of 8 tons/acre, but was achieved without the

addition of fertilizer, a less than optimal irrigation set up, and use of a modified range drill as a planter. There were large differences between blocks due to some problems with installation of the subsurface drip irrigation. As there were no significant differnces in fertility between treatments it appears that the increased yields in sweet corn is associated with the radish as a component of the mix. It seems probable that this is linked to increased moisture in the soil and improved water infiltration at depth.

Figure 4. Average sweet corn yield (bushels/acre) following one season of cover cropping with three cover crop mixes (2- 4- and 60 component mix) and 3 seeding rates (20, 40, 60 seeds/ft<sup>2</sup>) at Lockeford PMC in 2013.



Means with the same letter above the bar are not significantly different in LSD comparison at  $\alpha$ =0.05.

The Mediterranean climate of California poses particular challenges to the increased use of cover crops. This first years study indicates that use of a cover crop can improve yields in a commodity crop, although soil health improvements are not documented so far. The target of keeping a live root in the soil is hard to maintain under the summer droughts of California and with these two crops there were periods in spring and fall with no crop and so no live root in the soil. As we continue with the study we anticipate seeing improvements in soil health.

#### **References**

Clark, A., editor. 2007. Managing cover crops profitably, 3rd ed. National SARE Outreach Handbook Series Book 9. National Agric. Laboratory, Beltsville, MD. <u>http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition</u>.