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Warm-Season Legume Cover Cropping in the Delta – Preliminary Findings

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Introduction:

An on-farm trial in the Sacramento-San Joaquin Delta region of California was established to evaluate warm-season, annual legume cover cropping between winter small grains crops compared with a standard dry fallow. Cover cropping is a management practice identified in the Healthy Soils Program of the California Department of Food and Agriculture as having the potential to improve soil health, sequester carbon, and reduce greenhouse gas emissions. The trial will take place from 2018 to 2020 and will assess soil health properties, greenhouse gas emissions, and grain yield in replicated plots within a commercial field. Cover cropping is not a typical practice in the annual crop rotations of the region, and summer cover cropping is particularly rare. The Sacramento-San Joaquin River Delta is a unique agricultural region with unique environmental challenges. Some soils in the region are subsided due to oxidation of organic matter, and some soils suffer from salinity, having limited ability to leach salts due to low permeability soils and shallow groundwater. Because surface waterways provide water for irrigation, summer cover cropping with a legume has the potential to improve soil tilth at a time of year when the soil would have otherwise been fallowed and dry with no soil cover.

Methods:

The experiment is approximately 4.5 acres and compares two treatments: an irrigated cover crop (CC) to a dry, fallow soil (No CC) in between small grain crops. Plot size is approximately 0.75 acres, with three replicates in a randomized complete block design. The soil type across the trial is a Valdez silt loam. Baseline soil samples were collected on July 2, 2018 following wheat harvest but prior to tillage. Soil was sampled from 0-6, 6-12, 12-24, and 24-36 inch depths. Ten subsamples were aggregated by depth across the entire experimental design. Soil properties tested to date include bulk density, salinity (EC), pH, total nitrogen (N), and total carbon (C).
A cover crop of cowpea (*Vigna unguiculata* cv. 'Red Ripper') was inoculated with Rhizobium and planted. The cover crop was drill-seeded at 7-in row spacing with a planting density of approximately 51 lb/ac (2018) and 56 lb/ac (2019). In the first year, planting occurred on July 30, 2018, after a pre-irrigation using flood/furrow irrigation. In the second year, planting occurred on July 15, 2019 into dry soil, and the crop was irrigated up using solid set sprinklers. Irrigation is only applied to the cover crop plots. In 2018, a second irrigation was applied approximately one month after planting by flood/furrow irrigation. In 2019, the crop was sprinkler irrigated periodically during the season. We evaluated cowpea stand by counting the number of plants in six replicate 11 ft^2 (1 m^2) quadrats in each of the three cover crop plots.

End-of-season soil and cover crop biomass sampling occurred on October 23, 2018, prior to cover crop termination. Ten soil subsamples from 0-6 and 6-12 inches were aggregated by depth for each plot. For biomass, six replicate 11 ft^2 (1 m^2) quadrats were sampled from each of the three cover crop plots. In 2019, soil samples were collected following triticale harvest but prior to tillage from 0-6, 6-12, 12-24, and 24-36 inch increments and tested for pH and EC only. Soil and biomass properties were analyzed by the following methods: pH from the soil saturated paste, salinity (i.e. electrical conductivity) from the saturated paste extract, and total N and C by combustion method. Triticale forage yield was assessed in July 2019, which was the first cash crop to follow the cover cropping treatments. Yield was assessed by sampling two 11 ft^2 quadrats per plot. End-of-season soil

and cover crop biomass sampling will occur in mid-September 2019. Greenhouse gas (GHG) samples have been collected at approximately 3-week intervals and/or around tillage and irrigation events.

Results:

Among the soil properties, we have observed essentially no change in bulk density, total C, and total N (Table 1) from the baseline condition. We are monitoring salinity and pH semi-annually because we have observed these properties to improve in the cover-cropped plots. After one cover cropping season, salinity increased in both treatments, but it increased more in the dry fallowed plots, averaging 1.22 dS/m from 0 to 30 cm, compared to 0.64 dS/m in the cover crop (CC) treatment. Rainfall during the 2018-19 winter season leached salts in both treatments, but the CC treatment started the 2019 cover cropping season with a lower average rootzone salinity (0-36 in) of 0.78 dS/m, compared to 1.13 dS/m in the dry fallow (No CC) treatment. Soil at this site is acidic, which is typical for the region, but pH was observably higher in the CC treatments.

We made changes to our planting and irrigation scheme in the 2019 season, which appears to have improved overall stand (Table 2). There has been a lot of competition from volunteer wheat/triticale and weeds, but we decided in both years not to manage these with tillage or herbicides. Both add biomass to the soil (Table 3), which is an objective of the Healthy Soils Program. Competition, however, likely impedes cowpea growth and nitrogen fixation, and future study should investigate how these soil properties are affected by single-species and mixed cover crop stands. At the end of the first cover cropping season, biomass largely favored the volunteer wheat (Table 3). Of the total C added to the soil from biomass, the wheat contributed 42-71%, compared to 15-24% from the cowpea, across the three plots. Of the total N added from biomass, the wheat contributed 68-87%, and the cowpea contributed 9-15%. The triticale forage crop yielded 5.4 tons per acre for the CC plots and 6.3 tons per acre for the No CC plots. (The overall field averaged approximately 5.5 tons per acre.)

Table 1. Soil properties at three samplings from plots with a summer 2018 cover crop (CC) versus dry fallow (no CC).

Season*	Depth (in)	Bulk Density (g/cm^3)		Soil Moisture (% by vol.)		Salinity (EC_e)		pH		Total C* (%)		Total N* (%)	
Baseline	0-6	1.01		0.13		0.47		5.39		3.47		0.27	
Baseline	6-12	0.97		0.17		0.62		5.32		3.06		0.25	
Baseline	12-24	1.06		0.22		1.29		5.70		2.01		0.17	
Baseline	24-36	1.02		0.26		2.44		5.90		1.06		0.10	
		No CC	CC	No CC	CC	No CC	CC	No CC	CC	No CC	CC	No CC	CC
Fall 2018	0-6	0.96	0.90	0.08	0.23	1.05	0.60	5.32	5.49	3.39	3.42	0.27	0.27
Fall 2018	6-12	0.92	1.06	0.13	0.26	1.39	0.67	5.29	5.47	2.97	2.89	0.23	0.23
Spring 2019	0-6	0.96	0.92	0.21	0.21	0.50	0.40	5.4	5.8				
Spring 2019	6-12	1.01	0.97	0.23	0.25	0.72	0.40	5.2	5.6				
Spring 2019	12-24	1.09	1.07	0.23	0.29	0.92	0.69	5.8	5.9				
Spring 2019	24-36	1.08	1.08	0.29	0.40	2.38	1.61	6.0	6.1				

* No data for depths 12-24 and 24-36 inches in Fall 2018. No Total C and N data for Spring 2019.

Table 2. Cowpea stand counts at two weeks after planting.

Year	Block	Stand Count Range (plants/m^2)	Stand Count Average (plants/ac)
2018	1	17-40	111582
2018	2	16-43	124301
2018	3	26-43	139911
2019	1	19-79	190787
2019	2	16-73	189631
2019	3	16-72	167661

Table 3. Cover crop biomass, biomass C, and biomass N in fall 2018.

	Cowpea			Wheat			Weeds		
Block	Total Biomass (lb/ac)	Biomass C (lb/ac)	Biomass N (lb/ac)	Total Biomass (lb/ac)	Biomass C (lb/ac)	Biomass N (lb/ac)	Total Biomass (lb/ac)	Biomass C (lb/ac)	Biomass N (lb/ac)
1	831	340	8	2381	1017	74	163	70	3
2	591	234	6	1570	666	34	1583	674	10
3	564	226	6	1416	608	30	1224	531	5

Summary:

- Cover cropping, particularly in the warm-season, is not a typical management practice in the annual crop rotations of the Sacramento-San Joaquin River Delta region.
- After the first year of a three-year study, cover cropping had no observed effect on bulk density, Total N, and Total C. We observed better salinity and pH conditions in the cover-cropped plots.
- Cowpea stand establishment and volunteer grain and weed competition have been the biggest challenges to growing a summer cover crop at this site, and the cover crop was not observed to improve cash crop yield in the following season.
- We will continue to monitor soil and cover crop properties in 2019 and 2020, and additionally, we will reach conclusions about GHG (CH_4, N_2O) emissions.

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