Effect of two seasons of cover crop on soil health in almond orchards along a precipitation-gradient

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Introduction

Healthy soils provide critical ecosystem services for agriculture: biological processes for nutrient cycling, retention of mineralized nutrients as well as water conductivity and storage. Cover cropping has been demonstrated to have a large impact on soil health in arid, irrigated agricultural systems of the Central Valley (Mitchell *et al.*, 2017). Cover crop species mixes and functional trait selection have gained increasing attention, as a way to capture specific plant-to-soil effects and associated soil health improvements (Cortois *et al.*, 2016). Although short-term studies in the 1990s showed that cover cropping is compatible with almond production, this practice was never widely implemented due to remaining concerns over resource competition and operational challenges. This project addresses the increasing demand for soil-building resources and the adaptability of this practice for almond orchards in California.

Research Questions

1) **To what extent does the selection and use of cover crops enhance the provision of multiple ecosystem services such as soil health and C and N cycling in conventional almond orchards?**
2) **Does location along a precipitation gradient affect cover crop services?**

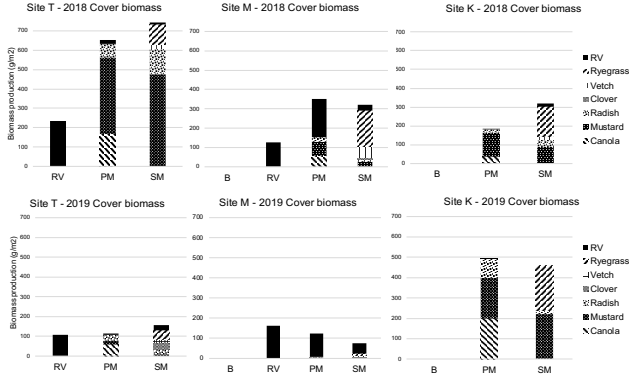
Methodology

- Design: Randomized Complete Block Design (RCBD) with four replicates
- Field trials were established in conventional, commercial orchards in Tehama county (site T), Merced county (site M) and Kern county (site K).
- Cover crops (CC) were seeded with either soil mix (SM) (density 56 kg/ha) or a pollinator mix (PM) (density 9 kg/ha). The 2 cover crop mixes were compared to resident vegetation and/or bare soil (B) as controls.
- Covers were seeded from Oct 30-Nov 6 in 2017 and from Nov 1-Dec 21 in 2018.
- Covers were terminated from March 30-April 10 in 2017 and from April 5-12 in 2018 (latest termination).
- Soil samples were collected at baseline, post cover crop termination in Nov 2018, during the cover establishment in Feb 2019, and post termination in May 2019.
- Soil carbon (SOC) and nitrogen (TN) measurements are reported on a per-weight basis.

Cover vegetation biomass (g/m^2) x 3 sites – 2018-2019

- Despite similar seeding rates and identical seed mixes, cover biomass production and species composition were site and season-dependent.
- Biomass production in the seeded CC compared to RV varied with up to 2 x more biomass in the CC in 2018, whereas there were little differences observed in 2019.
- CC provided better groundcover (%) in 2018 whereas RV provided better cover in 2019.
- In 2019, the SM and PM contributed 7.8 and 8.1 g N/m^2 to the system, respectively.

Figure 1. Cover vegetation biomass (g/m^2) per site and per season

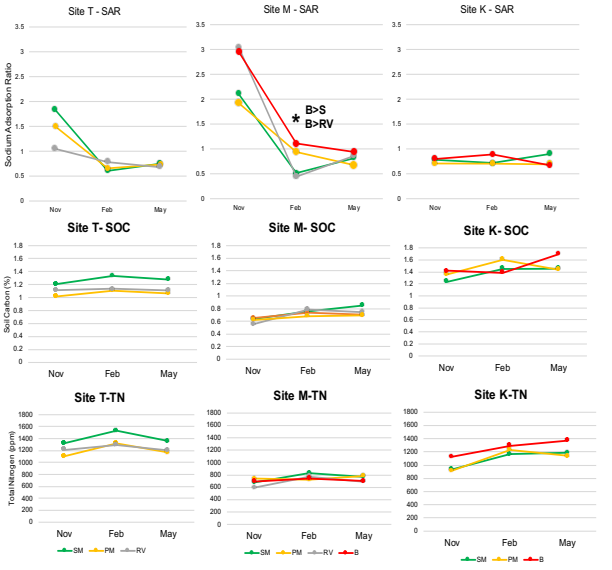


B = bare plots; RV = Resident vegetation; PM = Pollinator mix; SM = Soil mix

Soil health shifts – 2 seasons of cover crop

- Results of SAR measurements from the 2018-19 winter cover crop season indicated a decrease in sodicity under vegetative covers (RV, PM and SM) with significant differences (P<0.05) with B>SM and B> RV at site M.
- Similarly, we observed season-dependent trends of increased TN and SOC (P>0.05) in the top 15-cm of the soil with up to 14% increases in both TN and SOC during the cover crop.
- However, these factors (SAR, TN and SOC) returned to near identical conditions across treatments following termination of the vegetative cover.
- Biological indicators showed significant (P<0.05) and site-dependent effects of the seeded cover: higher enzyme activity of C processors (BG and CB) was observed in the PM at site M and higher food web enrichment index was measured in the SM at sites T and M (not pictured).

Figure 2. Sodium Adsorption ratio (SAR), soil organic carbon (SOC) and total soil nitrogen (TN) per site



B = bare plots; RV = Resident vegetation; PM = Pollinator mix; SM = Soil mix

Conclusions

1. **Significant soil improvements were found in all vegetative covers (resident vegetation and cover crop mixes), despite considerable differences in biomass production.**
2. **Cover cropping can significantly enhance soil enzyme activity, thereby supporting soil nutrient cycling functions.**
3. **Most soil quality improvements from cover cropping (i.e. SAR) occurred during the cover establishment.**
4. **Further continuation of the practice (>2 seasons) is necessary to observe substantial soil health enhancements.**

Growers' Survey

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