Evaluating Cover Crops to Mitigate Chlorosis In Concord Grapevines: Soil Microbial Community Response and Feedbacks

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Introduction

In central Washington **more than 50% of the Concord vineyards are affected by chlorosis**. Classical chlorosis symptoms include yellowing of leaves and decreased vine vigor, reduction in root biomass and shoot elongation, altered vine uniformity, productivity, and eventual vine death. Often, chlorosis may be associated with a suite of nutrient deficiencies, edaphic, and environmental factors, but a **specific cause is yet to be determined**. Soil or foliar application of Fe-chelates may reduce chlorosis symptoms, but a longer-term remedy is required.

To maximize Fe availability, many plants and microbes in soil exude metal-chelating molecules, called siderophores, which chelate Fe into bioavailable forms. Therefore, our primary objective was to enhance soil health by utilizing cover crops which stimulate microbial activity and increase nutrient availability. To this end, **we hypothesized:**

- Input of organic matter and actively growing root systems of Strategy II plants (in cover crops) will increase nutrient bioavailability and microbial activity.
- Beneficial microbial activity in the grapevine rhizosphere (including siderophore production) will be associated with decreased chlorosis severity.

Our ultimate goal, is for a long-term, management based solution to grapevine chlorosis.

Methods

The Concord vineyard in our study is located near Sunnyside, WA. The grower currently uses a wheat-based cover cropping (CC) system, but many in the region maintain bare ground or resident vegetation between vine rows.

4 CCs **(Barley, Rye, Wheat, and a Wheat/Vetch mix)** and a **Grower Control** were planted in a completely randomized block Design with 6 replicates of each CC.

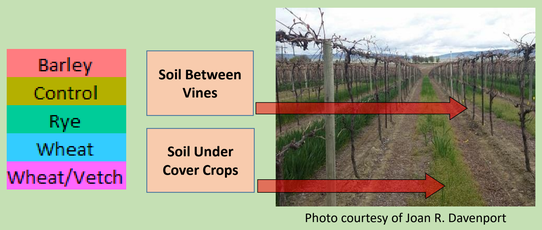


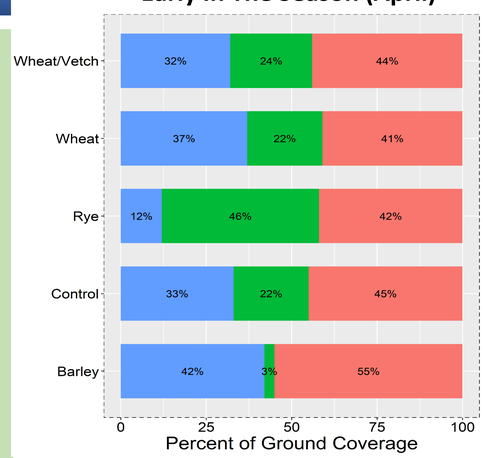
Photo courtesy of Joan R. Davenport

Vines were visually assessed for Chlorosis Severity, and leaf and soil samples were collected at **2** different physiological stages of vine development (Bloom and Veraison) in 2017 and analyzed for the following:

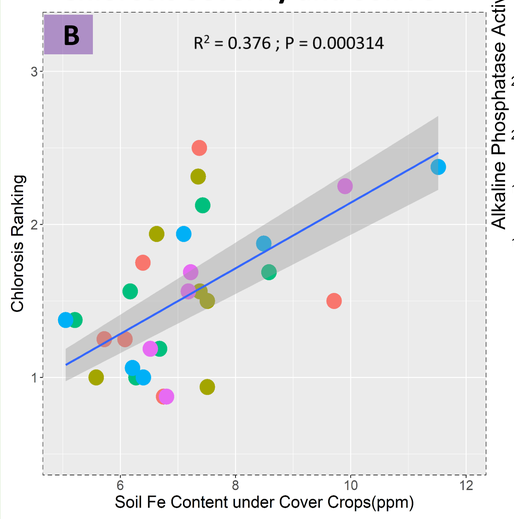
- **Siderophore Production:** a 96-well format of the traditional CAS (Chrome Azurol S) assay, with 12 technical replicates of each soil sample, measured on day 5, at 420 nm, via spectrophotometric absorbance.
- **Alkaline Phosphatase (AP):** enzyme activities were measured according to the modified methods of Schinner et. al, (1996) via spectrometric absorbance.
- **Polyphenol (PPO):** enzyme activities were determined by spectrophotometric absorbance and fluorescence (Jackson et. at, 2013).
- **Soil Fe Content:** was measured by diethylenetriaminepentaacetic acid (DTPA) method at bloom.
- **Statistical Analyses**: Regression and correlation, were performed at the α= 0.05 significance level in R, Version 3.4.2.

A

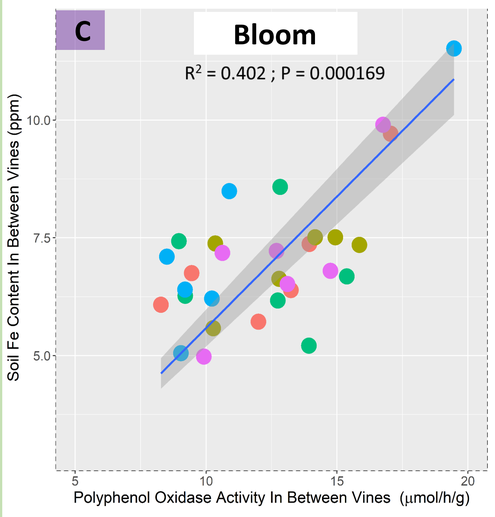
Stand Establishment



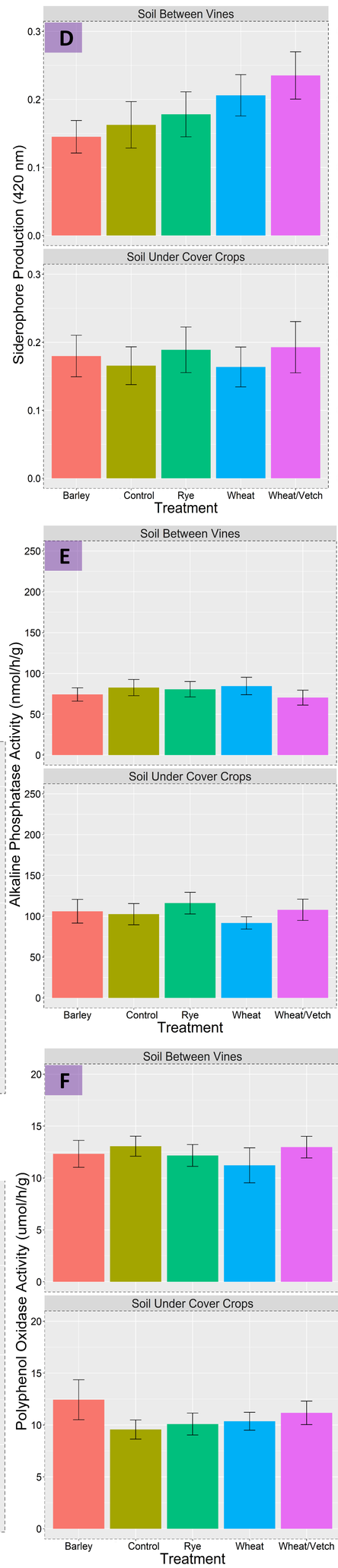
Chlorosis Severity and Soil Fe



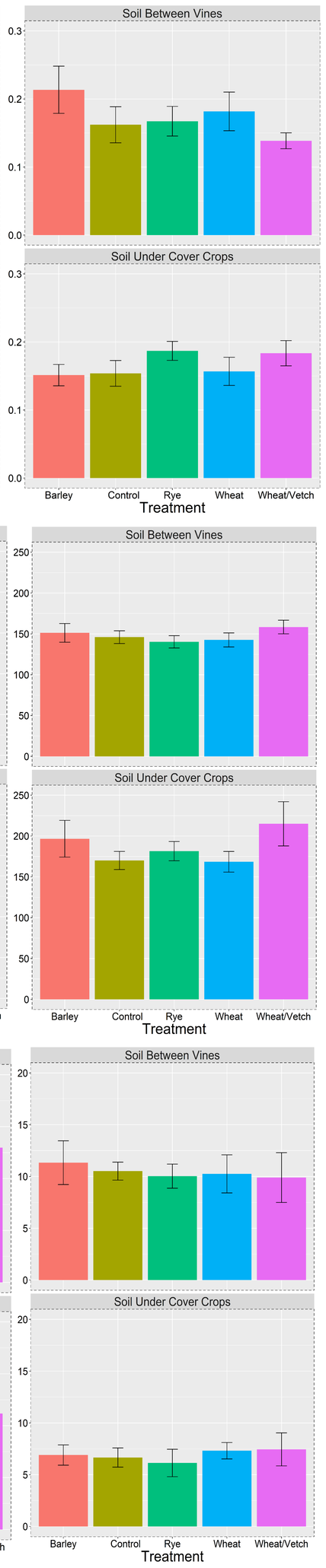
Soil Fe and Microbial PPO



Microbial Activity at Bloom



Microbial Activity at Veraison



Results And Discussion

Based on the means and standard errors, there likely is a significant relationship between microbial activities and cover crop treatments. Further statistical analyses are ongoing.

Due to the application of irrigation system, moisture content of our study site fluctuated; the soil pH was consistent from 8.4 to 8.9.

Figure A. At both sampling times**, Rye was the most successful cover crop**, at 46% stand establishment and only 12% weeds early in the season, and 37% cover with 27% weeds later in the season. But all treatments experienced significant bare-ground (42-55%) and weedy species competition (32-42% ground cover). Though the stand establishment of Barley was higher in May than earlier in the season, **Barley clearly did not establish well** with regard to other treatments.

Figure B. Chlorosis severity is positively correlated with total soil Fe under the cover crops, while no such relationship was seen for soil Fe between vines with chlorosis severity (Data not shown).

Figure C. PPO activity was positively correlated with total soil Fe at bloom. PPO is involved in decomposing recalcitrant soil organic matter, which could contribute to a release of humified organic Fe-compounds in soil and potentially increasing overall soil Fe content.

Figures D,E,&F. Wheat/Vetch cover crop mix exhibited the highest level of siderophore production, and microbial extracellular enzyme activity levels compared to other cover crops. It is possible this mix of Strategy I and II plants stimulated microbial activity and produced "rhizosphere priming" in a way the other cover crops did not.

Preliminary analyses suggest that while **Rye might be most successful at establishment**, the **Wheat/Vetch mix likely stimulates microbial activity and soil health** through production of more siderophores and extra-cellular enzymes (PPO and AP).

On-Going Work

- Terminal Restriction Fragment Length Polymorphism (T-RFLP) analysis is underway to determine differences in **bacterial and fungal community composition** associated with cover crop treatments.
- Soil metals and micronutrients, including Na, Ca, Mg, Zn, Cu, and Al will be determined on soil extracts by ICP-MS, as well as plant tissue nutrient content, to attain a more **holistic view of chlorotic and healthy plants**.
- Meta-genomic sequencing of microbial communities associated with the highest levels of siderophore production under each the cover crop will be completed to **determine specific members of the soil community responsible for Fe bioavailability.**

Acknowledgement

We would like to gratefully acknowledge the help of the Davenport Lab for orchestrating the study and collecting samples. Also, Kalyani Muhunthan, Ricky Lewis, and the Sullivan Lab for help in every aspect of experimental design and optimization, as well as the Concord Grape Research Council and the CSANR BIOAg program for fiscal support.

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