I. Cover Page, Final Report, Shrestha, 2020 UC SAREP

A. Date: June 30, 2022
B. Project title: Cover cropping impacts on vineyard water demands and weed population dynamics
C. Principal Investigator: Dr. Anil Shrestha, California State University, Fresno
D. Collaborator: Dr. Lauren Hale, USDA-ARS, Parlier CA
E. Location of Project: Parlier, CA, Fresno County
F. Proposal Category: Applied Research
G. Priority Area: Supporting Farmers and Ranchers
H. Commodities: Table grapes, vineyards
I. Grant Amount: $6,952

II. Objectives

Objective: *Integrate weed surveys into assessments of cover crops impact on water availability for table grape vines.* To optimize regenerative agriculture strategies for semi-arid climates, it is critical to approximate how practices such as cover crops impact water and weed population dynamics. We aim to expand on ongoing soil health assessments in two ways; (i) through research, by assessing weed density, weed species compositional changes, and weed seed banks to better assay vineyard weed pressure in response to the cover crop treatments and (ii) through outreach, by expanding our field days to encompass weed specialist expertise and to extension programs hosted by California State University, Fresno.

III. Summary

Cover crops are promoted as means to enhance soil health and climate resilient cropping systems. Yet, water resource limitations have been a notable concern for growers considering adoption of cover crops as a soil building practice in semi-arid areas. This project was an expansion of an on-going study wherein soil health benefits of cover crops are being evaluated in a table grape vineyard in Eastern San Joaquin Valley. Preliminary evidence suggested water savings associated with native plant species utilized as winter cover crops, but the mechanisms underlying this trend are not understood. Cover crop-induced variation in weed populations were assayed, as this may be a critical factor impacting the water dynamics in this vineyard. Weed surveys revealed that cover crop weed suppression was seasonally dependent and was only detected in one spring season. While a cover crop treatment composed of an introduced plant species had negative impacts on weed pressure at one point, a native plant cover crop treatment was consistently neutral or beneficial with respect to weed management. The native cover crop treatment also demonstrated neutral to positive benefits on soil water infiltration and retention compared to the bare alley and introduced cover crop treatments.

IV. Specific Results

A table grape research demonstration project established in 2020 incorporated two cover crop treatments, one using native plant species (Tansy Phacelia dominant) and a second using introduced plant species (Merced Ryegrass dominant), which were both compared to a no-cover, standard management control. Both cover crops and weeds may exacerbate vineyard water demands by enhancing soil water loss through transpiration. But the cool-season cover crops seeded at this field site have peak growth in late winter/ early spring and are mowed/ mulched during the summer months, when the late-developing grape variety, Autumn King, is hitting maximal water demands. We assessed if the cover crops suppressed weeds via winter/spring competition and summer mulching, and/or by reducing the soil weed seed bank and thereby enhancing soil water available for grapevines. Native and introduced cover crops had divergent impacts on weed suppression, which helps fill a substantial knowledge gap on integrated weed management attributes of native vs. introduced plant species.

Weed surveys

Fresno State graduate student Margaret Fernando quantified weed species frequencies and weed density during the spring, summer, and fall of 2021. Weed surveys were conducted in the alleys, where cover crops were seeded and in the vine rows, which did not receive cover crop seeds, but may be impacted by shade or mulch from cover crops. An additional estimate of weed % cover was collected for alleys in Spring 2022. Alleys were dominated by common knotweed (*Polygonum arenastrum*) whereas vine rows had higher portions of cereal grass, horseweed, and carpetweed (*Mollugo verticillata*) (Figure 1A and 1B). In the alleys the weed species were negligibly impacted by the cover treatments, but under vines, the cover treatments tended to have lower portions of horseweed (*Erigeron canadensis*) and higher portions of cereal grass (Figure 1A and 1B). The percentage of ground area covered by weeds was not significantly impacted by the cover treatments in Fall 2020 or Spring 2021 (Figure 1 C and D). But in the Summer of 2021, the introduced cover crop treatment had a higher percent weed cover in the vine rows and in the Summer of 2022, both cover crop treatments resulted in lower weed densities than the bare

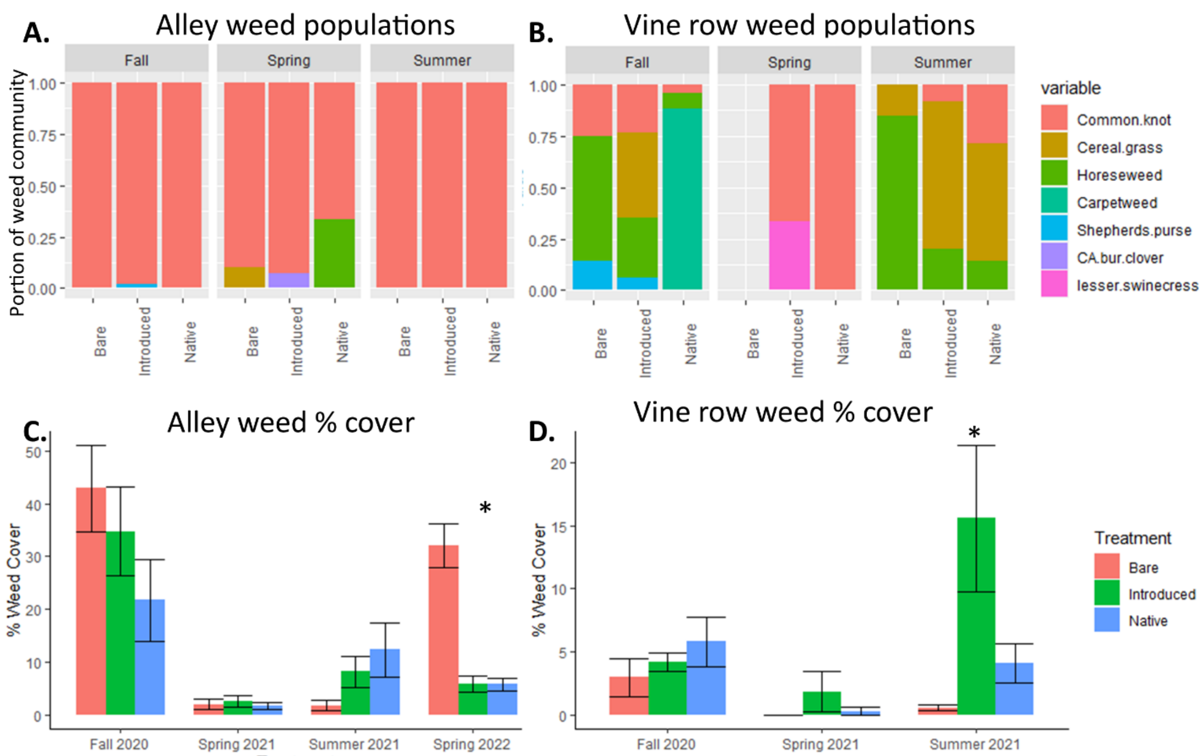

Figure 1. The portion of the total weed community attributed to weed plant species or groups from weed surveys conducted in vineyard alleys (A) or within vine rows (B). The total percent ground cover from weeds is indicative of weed density/ pressure and was quantified in vineyard alleys (C) or vine rows (D).

treatment (Figure 1 C and D).

Weed Seed Bank

In November 2021 the weed seed bank was collected from alleys and in vine row soils for all treatment and control subplots using soil from two depths (0-5 cm and 5-20 cm). Soil cores for each subplot/ depth were aggregated, placed on plastic trays in a greenhouse and watered as necessary. Seedlings emerging from soils were identified and counted each month from

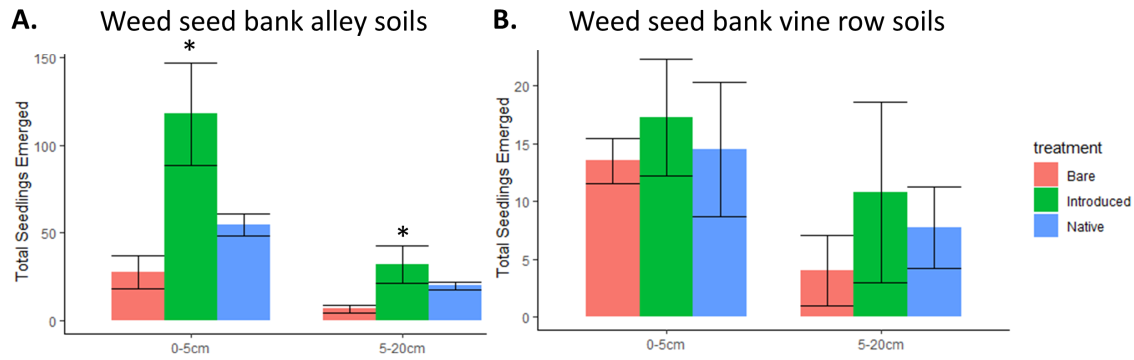

Figure 2. Counts for total seedlings emerged from alley (A) and vine row (B) soils from 0- 5 cm and 5-20 cm depths. Counts were conducted from November 2021- April 2022.

November 2021- April 2022. Total seedlings emerged from alley soils of introduced cover crop plots were highest (3-way ANOVA, $P < 0.05$, Figure 2A), suggesting higher weed pressure in those plots compared to alleys with native cover crop or no cover/bare ground and the possibility of greater weed populations in this area in the future. However, vine row soils did not have significant differences in the weed seed bank based on treatment (Figure 2B). Weed seedlings that emerged included common chickweed (*Stellaria media*) (84%), common knotweed (10%), henbit (*Lamium amplexicaule*) (2%), lesser swinecress (*Coronopus didymus*) (1%), annual sowthistle (*Sonchus oleraceus*) (1%) and less than 1% of mayweed (*Anthemis cotula*), redmaid (*Calandrinia ciliata*), annual bluegrass (*Poa annua*), mouse-eared chickweed (*Cerastium fontanum*), and oxalis (*Oxalis corniculata*). The majority of these species are winter annual weeds in the Central Valley.

Soil Infiltration, Bulk Density, Moisture Retention, and Aggregate Stability

The SAREP sponsored student, Margaret Fernando installed double ring infiltrometers in vine rows and alleys of treatment and control plots to quantify soil water infiltration. The steady state infiltration rate was not significantly impacted by treatment but was significantly different in vine rows and in alleys. Soil bulk density cores were collected for the 0-5 cm soil layers. There were not significant differences in surface soil bulk density based on treatment (ANOVA, $p > 0 .05$). Soil moisture retention, based on the soil water content at field capacity and at permanent wilting point, was significantly different based on depth, but not on treatment (2-way ANOVA, $p < 0 .05$). Water stable aggregates from soils collected from 0-20 cm of all subplots were quantified for aggregates in three size fractions (i) > 2 mm, (i) 0.2 mm > and < 2mm, and (iii) soil that was not contained in stable aggregates. Aggregate

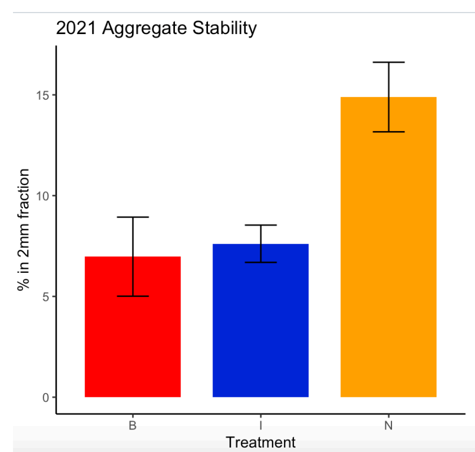

Figure 3. Soils in vine rows adjacent to alleys where native cover crops were planted (N) have greater aggregate stability than those adjacent to bare ground (B) or introduced cover crops (I).

stability was determined using a wet-sieving method and revealed that the native cover crop treatment contained a significantly higher portion of soil in stable aggregates > 2 mm (Figure 3).

Key Findings

1. Vine row soils adjacent to a native cover treatment (Tansy Phacelia dominant) maintained higher volumetric soil moisture contents when irrigation water was supplied at similar rates compared to berms adjacent to introduced plant species (Merced Ryegrass dominant) or those maintained with bare alleys. This soil enhancement corresponded to higher vine row soil microbial biomass and greater vine vigor in the native treatment subplots.
2. Soil properties that correspond to soil water retention (infiltration, bulk density, and plant available water) did not differ significantly based on cover crop treatment, with the exception of water stable soil aggregates, which were enhanced in the native cover cropped plots.
3. Cover crop impacts on weed pressure varied depending on season, dominant cover crop plant species, and area of concern (e.g., alleys or vine rows). Notably, the introduced plant species (Merced Rye) had increased weed pressure in vine rows during one summer and a larger weed seed bank in alleys. But, in the following spring, both cover crop treatments showed reduced weed ground cover compared to the bare ground, untreated plots. Also, both cover crop treatments reduced incidence of horseweed in vine rows during 2 of the 3 seasons sampled. Thus, weed management via cover crops should take into consideration problematic weeds in a cropping system, seasonal demands for weed control, and cover crop plant species.
4. Weed populations are dynamic and require multi-timepoint assessments to monitor treatment impacts on weed pest pressure. Also, many soil properties (e.g., changes to bulk density) take many years to develop. The integration of these assessments into our vineyard monitoring provides a needed, comprehensive picture of soil water dynamics impacted by a native and introduced cover crops in table grape vineyards, common perennial cropping systems in the San Joaquin Valley.

V. Dissemination of Findings

Project supported graduate student, Margaret Fernando, shared project data during several research presentations at professional scientific society meetings:

- Lightning talk, "Impacts of Native and Introduced Cover Crops in a Table Grape Vineyard in the San Joaquin Valley", California Plant and Soil Conference, Fresno, CA January 2021
- Student Oral Presentation Competition, "Impacts of Native and Introduced Cover Crops in a Table Grape Vineyard in the San Joaquin Valley", California Weed Science Society Conference, Sacramento, CA, January 2022. 3rd place winner for student oral presentation
- Virtual oral presentation, , "Impacts of Native and Introduced Cover Crops in a Table Grape Vineyard in the San Joaquin Valley", Annual Central California Research Symposium. April 2022, Oral presentation winner for Fresno State college of science and mathematics

- Student Oral Presentation Competition, “Impacts of native and introduced cover crops on soil health in a tablegrape vineyard of San Joaquin Valley”, American Society of Viticulture and Enology, San Diego, CA, 22 June 2022 (to be presented).

SAREP supported student’s research results were also shared during in-person and virtual field days co-hosted by Dr. Lauren Hale;

- Webinar, “Vineyard water dynamics with cover crops”, 69 attendees, co-hosted with UCANR April 2021 https://youtu.be/pXvDmuv-8X0. This is also available with Spanish language translation.
- Virtual field day, “Cover Crops in the San Joaquin Valley”, 95 attendees, co-hosted with UCANR May 2021 https://youtu.be/tGd_9cL1jZw
- Webinar, “The Benefits of Cover Crops in California: Above and Belowground Impacts” 103 attendees, co-hosted with Xerces Society, Nov. 2021 https://youtu.be/vYAK8gP-v6c
- UCCE Vineyard Soil Health and Cover Crop Day held in-person in Fresno, CA. Dr. Hale provided a talk titled “Vineyard soil health under cover crops” in March 2022.

This project was also highlighted in the UCANR Green Blog, https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=50723

VI. Benefits/Impacts on Agriculture and/or Food Systems

When cover crops are adopted with the goal of weed control growers should consider the following:

- Overall, the utility of cover crops for weed control may be realized after several seasons of winter cover crops, rather than initially after the cover crops are established.
- There is seasonality to the reduction in weed pressure by cover crops. So, winter cover crops may be more effective in weed control during spring months.
- Proportionally horseweed was present in lower quantities beneath vines that were adjacent to cover crops. In recent years, horseweed is becoming prevalent in the San Joaquin Valley, producing up to 800k seeds per plant (Shrestha et al., 2010a; Shrestha et al., 2010b), so control of this weed in young vineyards may be a high priority for some growers.
- Cover crop plant species exhibited divergent impacts on weed suppression and in some seasons the introduced cover crop, Merced Rye, enhanced weed pressure.
- Our Tansy Phacelia cover crop offered improved weed suppression and soil conditioning compared to Merced Ryegrass. The broad leaf and dense growth of Phacelia were likely qualities that are optimal for weed suppression potential. This plant also has a higher portion of nitrogen in its residues, which often facilitates faster decomposition and may be a reason for its early impacts on soil carbon, microbes, and aggregate stability. Potentially allelochemical compounds or root exudates unique to the plant also played roles to attribute it these benefits.

VII. Impact on Target Audience

A. Number of adults reached: Virtual webinar, 104 adults; Fresno County field day, 44 adults
B. Number of youth reached: N/A
C. Number of businesses reached (e.g. farms or food businesses): Of the webinar attendees 26 were farmers and/or ranchers. Eighteen businesses or farms were denoted in our field day sign-in sheet, along with three governmental or non-profit organizations (RCD, UCCE, and CDFA).
D. We did not collect gender, ethnic, nor racial demographics during any of our events.

VIII. Literature Cited

Shrestha, A., Fidelibus, M.W., Alcorta, M. and Hanson, B.D. (2010a). Growth, phenology, and intra-specific competition between glyphosate-resistant and glyphosate-susceptible horseweed (*Conyza canadensis*) in the San Joaquin Valley of California. Weed Sci., 58: 147–153.

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