



California Pistachio Research Board 2026 Research Grant Cover Page

This form is to be filled out and included with research proposals submitted to the CPRB.

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Project Title: Evaluating Ground Cover Options and Integrative Crop-Livestock in Californian Pistachio Systems

Total amount requested for the project: \$ \$94,327

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Mailing Address for Payments: UC Davis Sponsored Programs Lockbox, P.O. Box 743739, Los Angeles, CA 90074-3739.

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Project Duration: : New : Continuing / : Year _____ of _____.

(Continuing) Previous Year(s) Project #: _____
Title: _____

Collaborating Commodities:**Amount requested from collaboration: \$ _____****Project Objectives:**

This project will compare volunteer vegetative ground cover with a cover crop mixture and compare the implications of grazing on soil cover selections on key outcomes, across two pistachio orchards. Specific objectives are to compare how volunteer vegetation and cover crop mixes, grazed and un-grazed influenced: 1) changes in nutrient cycling functions supporting N, C and K availability 2) evaluate water use differences related to infiltration, soil moisture and tree stress responses 3) evaluate tree health and productivity changes by surveying insect damage and yield and nut quality 3) assess economic feasibility. Results will be disseminated through a grower centered field day and extension outlets.

Brief Description of research project:

Research on grazing sheep in almond orchards, and the use of cover crops, have shown potential for agronomic and ecological benefits, such as increasing soil fertility, optimizing soil N cycling, reducing pests and disease, and supporting profitability. However, while these practices may help build more resilient systems, agronomic benefits and tradeoffs are still largely unknown for the pistachio industry, and management and economic concerns limit implementation.

Quantifying whether cover crops grown between orchard rows can contribute to orchard nutrient needs is an important question. Further research is needed to understand how seeded cover crops are more beneficial to growers compared to volunteer vegetation; related to how they contribute to nutrient provisions in the soil, water use, and how grazing and non-grazing treatments may change these outcomes, and if there are any agronomic tradeoffs with productivity. Furthermore, until further economic analyses are done, economic benefits and tradeoffs of these practices will remain uncertain. The goal of this study is to better understand how cover crops and volunteer vegetation, grazed and un-grazed influence nutrient cycling, water use, tree health and productivity, as well as provide economic cost of production breakdowns for these practices.

There is a need to evaluate these conservation practices at the regional level to interpret findings meaningfully to producers. Growers in Southern San Joaquin Valley experience significantly lower rainfall compared to Northern San Joaquin counties, which may have different implications on ground cover management. Differences in precipitation and temperature can have a significant impact on the growth potential of cover crops and ground cover which may impact outcomes.

We will implement two experiments, using a replicated block design. The experiments will be composed of five treatment plots, replicated three to four times at each site: no cover, resident vegetation and planted cover crops with grazed and un-grazed (mowed) treatments. Tree surveys will collect information on tree damage, pest and disease scouting, and yield and nut quality. Soil moisture probes will be installed to evaluate soil moisture at depth between ground covered treatments and bare ground.

Evaluating Ground Cover Options and Integrative Crop-Livestock in Californian Pistachio Systems

Principal Investigator(s) and Cooperator(s) (Contact information on cover page)

PI: Sara Rosenberg-Regenerative Agriculture Advisor, UC Cooperative Extension

Co-PI: Phoebe Gordon- Orchard Systems Advisor, UC Cooperative Extension, Madera County

Co-PI: Amelie Gaudin -Professor, Endowed Chair in Agroecology, University of California Davis

Co-PI: Elizabeth Fichtner – Orchards System Advisor, UC Cooperative Extension, Tulare County

Objectives of proposed research

Across two sites, evaluate: 1) Changes in nutrient cycling supporting N, C and K 2) Evaluate water use differences related to infiltration, soil moisture, applied water and tree stress responses 3) Evaluate tree health and productivity changes by evaluating insect damage and yield and nut quality 4) Assess economic feasibility.

Key words

Sheep grazing, soil health, cover crops, resident vegetation, nutrient management

Justification of proposed research

Research on grazing sheep in almond orchards, and the use of cover crops, have shown potential for agronomic and ecological benefits, such as increasing soil fertility, optimizing soil N cycling, reducing pests and disease, and supporting profitability^{1,2}. Grazing and cover cropping could be more feasible in Pistachios than in Almonds or Walnuts due to off ground harvest which limits food safety concerns and allows growers to maintain residue longer. However, while these practices may help build more resilient systems, agronomic benefits and tradeoffs are still largely unknown for the pistachio industry, and management and economic concerns limit implementation.

A participatory needs assessment implemented between 2024-2025 by the UCCE Regenerative Agriculture Advisor, determined research questions that were of importance to producers³. Out of 28 interviews and 13 site visits, three pistachio growers were interviewed, and five pistachio fields were visited. Field visits and interviews revealed some orchard producers had tried cover cropping but switched to volunteer vegetation due to management challenges. This includes problems with increased gopher populations, challenges with cover crop germination and termination due to erratic rainfall, and challenges with ground cover affecting subsurface irrigation performance. During organized listening sessions, growers requested more information on economic considerations, and quantifiable data on how different ground cover management options affect nutrient needs³.

Quantifying whether cover crops grown between orchard rows can contribute to orchard nutrient needs is an important question. Our current understanding is that trees will not take up nutrients in dry soil. Since pistachios are micro irrigated, the space where cover crops are grown are dry by the time pistachios demand most of the nitrogen, roughly April through August. However this varies by region and year due to differences in climate and precipitation amounts. Furthermore, multiple ecological mechanisms may support nutrient flow and transformation, increasing accessibility for tree uptake. Cover cropping has been shown to affect microbial shifts such as increased fungal and bacterial communities specializing in mineralization⁴, which contributes to a change in how nutrients cycle through the soil profile and may also affect how nutrients are taken up by tree roots. Added grazing events can further affect how vegetation biomass cycles nutrients, increasing readily available nutrients through urine, manure and trampling effects⁵.

Wauters et al., 2024⁶ found that during the growth period, seeded cover crops increased microbial biomass nitrogen compared to volunteer vegetation, and after termination, seeded cover crops supported more complex nematode food webs which can affect key soil ecosystem functions regulating nutrient

cycling. However research sites were not expanded into the San Joaquin Valley, and grazing effects on these nutrients have not been explored. While grazing can have a profound impact on nutrient cycling optimization⁵, these effects may function differently based on climatic region, ground cover species, biomass and the nuances of each production system. Further research is needed to understand if, and when, seeded cover crops are more beneficial to growers compared to volunteer vegetation, their potential provisions for tree nutrient needs, and determine how grazing and non-grazing treatments may affect these outcomes.

Furthermore, growers have concerns about water use and how it may affect SGMA regulations. California orchards are entering a period when incremental gains in irrigation efficiency and increased water storage and recharge capacity matter more than ever. In California, organic matter amendments, and use of ground cover and cover crops can increase soil water content through increased soil moisture, increased infiltration, and reduce tree water stress under certain soil conditions⁷. Information is lacking at the regional level, related to how different ground cover and management impact water use dynamics related to soil water storage and tree stress response.

It is important that research on conservation-based practices related to soil health be evaluated with a regionally relevant and cropping system specific lens. Currently most Pistachio acreage in California is in Southern San Joaquin Valley (SSJV) with Kern County holding 170,000 acres, Fresno 150,000 acres and Kings County 50,000 acres. Madera has 51,000 acres and Merced has about 30,000 acres of pistachio⁸. Northern San Joaquin Valley (NSJV) acreage is expanding with less profitable crops coming out of production combined with heightened water resource limitations, increased salinity challenges, and reduced chilling hours in SSJV^{9, 10}. At the same time, these regions receive different rainfall amounts as well as have temperature differences, which can impact ground cover growth outcomes. Merced and Madera counties in the north receive more rainfall than Kings and Kern counties in the south. The Northern San Joaquin Valley (Merced/Madera) generally receives around 11–13 inches annually, while the Southern San Joaquin Valley (Kings/Kern) is more arid, receiving closer to 5–10 inches¹¹. To provide sound and regionally relevant evidence for the pistachio industry, it is necessary to conduct this study across both SSJV and NSSV, with support and collaboration from multiple county based UCCE farm advisors.

Without evaluating the economic considerations of conservation-based management practices, quantifying agronomic and ecological benefits will have a limited impact on supporting grower decision making. Growers lack exposure to applications of these practices and are skeptical of agronomic and economic benefits³. Anecdotal evidence, recorded in the Regenerative Agriculture Needs assessment, suggests that growers who have been integrating regenerative practices, including vegetative cover, cover crops, and/or grazing, are experiencing a substantial decrease in reliance on fertilizers, pesticides, miticides and fungicides. At the same time, other growers report not seeing a direct effect from cover crops and grazing and others feel the counter costs of contract grazing and cover crop seed are not cost effective³. Until further economic analyses are done, economic benefits and tradeoffs of these practices will remain uncertain in Pistachio systems¹³.

The goal of this study is to better understand how cover crops and resident vegetation, grazed and ungrazed influence nutrient cycling, water use, tree health and productivity, as well as provide partial economic cost of production breakdowns to assess how practices may impact profitability. Furthermore, by evaluating this research across two sites, we will be able to interpret results based on regionally relevant data and analyze how climatic differences may play a role in ground cover selection and management outcomes. We have two sites selected for the experiment. One site situated in SSJV, and one in West Madera. To capture evidence for changes on soil function that may not respond in a year one timeframe, we are expecting to apply for this grant again for at least three years. The results will be a beginning point for understanding how to integrate regenerative practices for pistachio trees in the SJV.

Time frame	Event	Description
May- June 2026	Baseline soil analysis, baseline infiltration, and bulk density, to get late spring soil health data	Baseline soil samples will provide a baseline on soil organic and inorganic nutrients, and soil health indicators before any treatments.
June – October 2026	Economic analysis framework development	Surveys development will cover information on management data and associated costs. Analysis will be led by PI S. Rosenberg
July 2026	Leaf sampling to get baseline tree nutrition from 2026 year	The leaf analysis will be used as a comparison before treatments and N omission plots are implemented.
Fall 2026 October - November	Trial set up at both sites	Teams will be deployed to each site to set up the field trials including marking plots, marking where moisture probes will be and discussing management needs with farm managers
Fall 2026 October- November	Plant cover crops	Mixture will be drill seeded.
Fall 2026 October- November	Insert soil moisture probes and water flow meters	Soil moisture probes will evaluate changes down to 1 meter depth with one probe per plot (excluding grazed plots).
Spring 2027 February- End of March	Biomass sampling	Biomass samples will be collected at the cover crop flowering stage, or before the grazing event occurs. Dry weight will be taken, and plant biomass will be sent in for nutrient analysis.
Spring 2027 (TBD by contract grazer and grower)	Terminate cover crops by grazing	Grazing events will occur before any orchard spray applications during onset of bloom.
Winter- Spring 2027 March - May	Terminate Cover Crop by Mowing	We will terminate by mowing the cover crop down. Mowing time will be considered based on spray application needs during bloom (i.e. if vegetation biomass is hindering entrance.
Spring 2027 March-May	Infiltration and bulk density sampling and soil sampling	Infiltration and bulk density tests will be taken at 3-6 locations in each plot.
Spring – Summer 2027	Twice a month SWP reading will be taken. In April, leaf sampling for tree nutritional status will also be done	A pressure bomb will be used to track any tree stress responses. Leaf samples from multiple trees in each plot will be aggregated and sent to local lab for nutritional profile. The leaf analysis will monitor any tree nutrition changes.
Spring and Summer 2027	Bug damage scouting and nut damage assessment	Assessments will cover stink bugs and small plant bugs.
Summer 2027	Foliar disease assessments	Alternaria will be monitored using disease severity indices
Summer 2027 July	Tree leaf sampling analysis and late season soil analysis	The leaf analysis will monitor any tree nutrition changes. Late season soil analysis may also be conducted to compare with spring samples.

Summer 2027 August – September	Yields from each plot	Yield quality and quantity comparisons: before harvest, collecting nuts across the orchards, and hulling and cracking them to take quality data. Yields collected at each block separately for comparison.
June – October 2027	Economic Analysis. Surveys with growers and grazers will collect cost of production data	Surveys implementation will collect information on management data and associated costs. Analysis will be led by PI S. Rosenberg

Projected results or results (if year 2+)

This research will be foundational in providing regionally relevant data on how grazing and cover cropping may impact nutritional outcomes, water use and economic feasibility of pistachio orchards. Furthermore, this research will inform how ground cover management and selection options can be adapted to pistachio management systems. We hypothesize that planted cover crop species will accumulate more biomass and species diversity than resident vegetation corresponding to improved soil health outcomes. Specifically we expect to see changes in the form of increased Nitrogen and Potassium accrual over the course of three years with potential nitrogen benefits after year one. We expect that cover crop mixtures and grazing will also reduce compaction and increase infiltration. Furthermore, we hypothesize that grazing will lead to faster nutrient cycling benefits compared to non-grazing.

We suspect that soil moisture may be less at the thirist 1-2 feet of the soil profile in the resident vegetation and cover crop plots compared to bare soil, however improved infiltration in the soil will increase deeper soil moisture profiles. We suspect great variability in cover crop growth based on annual rain events which will affect all outcomes, and resident vegetation may be more stable with growth response. We suspect that economic benefits are unlikely to be experienced in the short term (1-3 years), but, using grower survey and data, and trial outcomes, expect mid-term systemic changes resulting in lower inputs, leading to higher profit outcomes.

Evidence on benefits and tradeoffs among the use of cover crops versus volunteer vegetation will allow growers to make informed decisions based on their sustainability goals and cropping system needs, about how to manage ground cover, and what type of ground cover to use, increasing pathways for transitioning into more sustainable systems. Finally, calculating nitrogen demand using integrated methods is difficult, this research will illuminate potential N credits which may provide suggestions for input reductions for growers interested in pursuing these practices. Regional differences will highlight ground cover feasibility variability by providing quantifiable evidence for differences in biomass accumulation, sand oil functionality and tree health response differences that could be impacted by climatic differences.

Potential economic value to the pistachio industry (i.e. ROI)

There is an increasing need for producers to enhance sustainability while maintaining profitability. California pistachio acreage has seen significant growth, estimated to be 488,000 acres in 2024. Integrative crop livestock systems, and cover cropping is gaining popularity by both consumers and producers, but barriers such as adapting management needs remain issues. The direct potential value to the pistachio industry is cost savings in inputs for pistachio growers due to an increase in soil health function related to nutrient management, water infiltration and pest management. Based on the UCANR 2020 Cost of production study, for SJV pistachio orchards, growers spend an average of \$195 on herbicide costs, \$178 on insecticide costs, and \$1,186 on fertilizer costs in respect to nitrogen and potassium¹⁶. This research will evaluate potential savings opportunities for growers. The economic analysis will provide information on potential economic outcomes for these selected practices, helping

growers decide if they should spend money on cover crop seeds, grazing or not, for the potential benefits being measured in this study. If growers decide to let the resident winter vegetation or cover crops grow, they can save on preemergent herbicides as well as possibly post emergent herbicides through using grazing to manage biomass growth. Furthermore, while there aren't many organic pistachio growers, weed control is extremely expensive and difficult in organic systems. Grazing could be a way to control weeds/cover crops during the winter and spring. The economic analysis can provide insight into these scenarios. From a SGMA perspective, if ground covers show direct increase in improved infiltration and soil water storage (soil moisture), this information could be used to support SGMA policy with increasing incentives for ground cover use through MLRP and other state funding opportunities¹⁵.

Education and Outreach plans

We will hold one field-day event over the course of the project at one of the chosen sites. These days will allow researchers to present on the research activities and provide a platform for growers and contract grazers to discuss their experience. As we aim to request funding for a second and third year, the second-year field day will be hosted to provide results of year one. We will also showcase research outcomes via growing the valley newsletter, Regenerative Ag newsletter as well as UCCE social media outlets, Farmer Ag Network¹⁶ newsletter, as well as a scientific publication and extension article, for example in west coast nuts.

References

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Budget (includes: salary, benefits, equipment, supplies, travel, other)

The total request for this proposal is \$94,327

Materials

- Cover Crop Seed - **\$600** - Based on 2025 cost for cover crop mixture at a seeding rate of 80-100lbs per acre for 8 acres - increasing amount in case we need to reseed, or price goes up.
- Sampling bags and shipping coolers - **\$625**- These will be necessary for all in field soil and leaf sampling purposes. Since we are sampling microbial analysis, shipping soil samples in coolers will be necessary. \$57/ cooler * 4 coolers + \$25/box *16 count.
- Field day food and beverages-**\$900**-For an expected 60 ind. (15\$ per person) to cover coffee and light breakfast, beverages.
- Field day materials: folders, printing fees- **\$200**
- Infiltration rings -**\$1,296**- \$325 ea *4
- Soil water flow meters - **\$2,000**- \$500 ea *4
- Data Logger – **\$2,625**- \$875 ea*3

Labor and Salary

- Livestock contractor -**\$3,000**-This fee is negotiated with contract grazers. They need to cover travel and labor costs, usually charged by acre. Since this is a small trial, we are doubling their transportation and acreage fee to account for the opportunity cost of grazing at a large farm with more acreage.
- SRA –Step 2 -**\$30,745**-Calculated at 50% time. This research project will require at least 2 personnel in each site for data collection and processing. The PI and SRA will fill these roles, with help from Co- PIs. The Salary is based on the UCANR 2025 Salary chart.
- SRA step 2 benefits -**\$17,156** -Based on UCANR Salary charts
- SRA step 2 -**\$6,149** – calculated at 12% time. For Pheobe workers time to supplement trial implementation, and some data collection as needed
- SRA step 2 benefits -**\$3,431** – based on UCANR salary charts
- Farm contract fees for any needed services outside of normal management operation for collaborating grower – **\$3,000**

Other

- Soil and plant analysis-**\$15,000**-All samples will be sent to Ward Laboratory which also provides a 35% discount to UC affiliates.
- Shipping costs over night- **\$600**-Estimated overnight shipping costs for soil and plant analysis.
- Publication cost – **\$3,000**
- Travel/Gas – **\$4000**