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Connecting Soil Health and Water in California

Joanna Ory, PhD, Timothy Bowles, PhD, Alastair Iles, PhD

BERKELEY FOOD INSTITUTE

Overview

California farmers are often concerned with water, what it costs, and its short supply. With recent droughts — made more intense by climate change — farmers have relied more on groundwater as surface water allocations decline. More reliance on groundwater has caused rapid depletion in many regions and prompted state regulators to make groundwater use more sustainable. California farmers face tough choices about how to adapt to a future with less water.

During previous droughts, farmers have abandoned crops in their fields, removed orchards due to lack of water supply, or found it financially beneficial to sell their water rather than grow crops. In other instances, farmers might be paid not to plant crops to save water, due to temporary water shut-offs.[1] Irrigation management and careful crop selection will play important roles in helping farmers avoid these choices. Investing in healthy soil practices will also be an essential strategy for making the best use of rainfall and stewarding irrigation inputs wisely.

Healthy soil practices like cover cropping, planting hedgerows, and reducing tillage provide on-farm water benefits, which are outlined in Table 1.

Table 1. Practices that enhance soil health and water resources.

PRACTICES FOR SOIL HEALTH	POTENTIAL WATER BENEFITS
Cover cropping, allowing native plants to grow between rows and on field borders.	In between cash crop plantings, a cover crop can be grown for the purpose of improving the soil. Planting a cover crop ensures that the soil is covered and living roots are in the soil to reduce runoff and increase water infiltration.
No-till, reduced tillage, reduced tractor passes, reduced chemical inputs.	Reduced soil disturbance can increase water infiltration and avoid compacted soil.
Planting hedgerows and perennials.	Living roots are in the soil to reduce runoff and increase water infiltration. Runoff into natural waterways is reduced.

Healthier soils with good structure, healthy roots, and high organic matter can hold more water, which can help prevent runoff and erosion. Some soil health practices reduce evaporation, which is effectively wasted water (Mitchell et al., 2022). When a heavier rain happens, healthier soils may even allow for better percolation that helps recharge groundwater by preventing runoff. These practices make better use of

This BFI brief is based on interviews by researchers at the Center for Diversified Farming Systems with 45 nut and leafy greens farmers in the Central Coast and the Central Valley between 2019 and 2021, as well as a 2018 California statewide survey with 140 agricultural extension personnel, with the goal of providing recommendations towards improved soil health in California. Funding for this project came from the Berkeley Food Institute, the US Department of Agriculture (USDA AFRI Grant # 2019-67019-29537), Patagonia, Inc., Annie's Organic, Inc., and the National Science Foundation) NSF Coupled Natural Humans Systems Grant #1824871).

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Berkeley Food Institute
50 University Hall, Berkeley, CA 94720-3102 (510) 529-1533 food.berkeley.edu foodinstitute@berkeley.edu

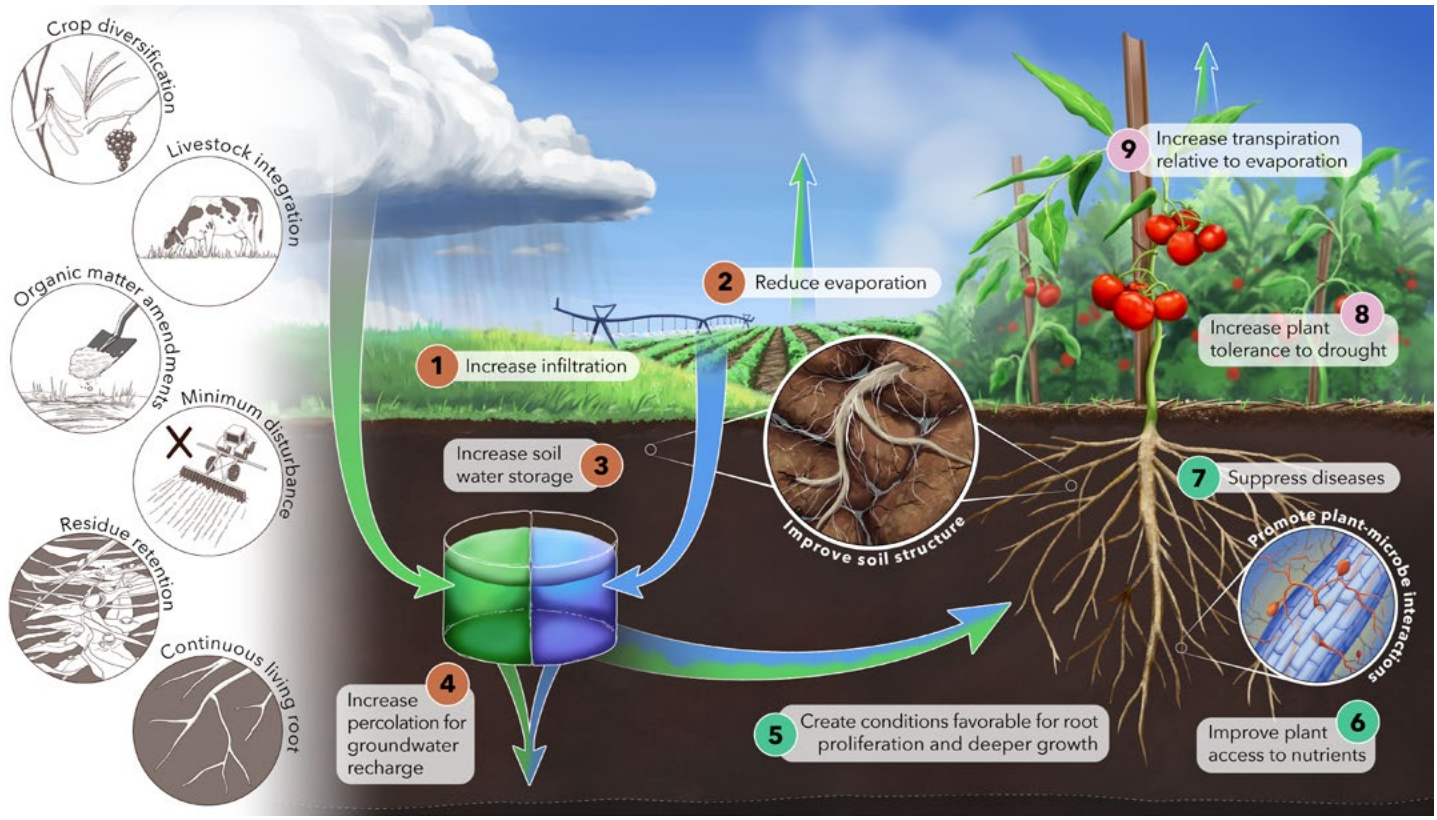
rain water and could allow farmers to reduce irrigation, especially early in the growing season (Libohova et al., 2018; Cohen and Estrada, 2021). Healthier soils can also support beneficial plant-microbe interactions and allow roots to grow more widely and deeply. These all allow crops to better deal with water stress while maintaining productivity (Acevedo et al., 2022 forthcoming).

Building healthy soils complements efficient irrigation management practices. A study from UC researchers demonstrated that allowing crops to utilize water stored in the soil, including its deeper levels, before irrigating could save up to 30 cubic kilometers of irrigation water (by reducing evaporation) and increase use of rainwater by 7 cubic kilometers over the course of 13 years (Devine and O'Geen, 2019). This amount of water would fill the state's largest reservoir, Shasta Lake, 6.6 times. All of these aspects, and more, are crucial to helping growers become more resilient in the face of intensifying climate change.

Saving water motivates healthy soil practices

Growers in water scarce regions are increasingly worried about drought. An orchardist in the Central Valley explains in an interview: *"We're losing our ability to ensure our trees against extreme drought. Because of this, we will feel it more when we have droughts. We have survived the drought because of buffer water. The last year of the drought would have been the breaking year because there was no more water. If you have less than you had, you are going to feel the changes a lot more."*

Referring to the 2017 drought, another orchardist in Stanislaus County lamented, *"One of our biggest challenges was probably during the drought because we had little to zero water available. We had to use the groundwater, which I totally do not like using. Groundwater is our emergency backup, and we had to use it during those years and we ended up with salt problems."*



Hydrologic processes (orange circles) and plant-soil-microbe interactions below (green circles) and aboveground (pink circles) affect blue and green water use in irrigated systems. Blue water is surface or groundwater. Green water is water left in soil after precipitation and drainage. Soil health management practices are represented in circles on the left side. Blue arrows indicate blue water flows, and green arrows indicate green water flows. Arrows with both colors represent mixed blue and green water components. Arrow size does not represent the flow magnitude. Original artwork by Elena Harley (www.elabarts.com) for Acevedo et al., 2022 forthcoming.

Photo Credit: Joanna Ory

Such farmer feelings have likely intensified. In 2021, California experienced extreme or severe drought conditions throughout the majority of the state. While heavy rain and snow during Fall 2021 improved the situation, the driest January-March on record for much of north and central California means that 2022 will continue to be extremely dry.[2]

While some growers can be powerfully motivated by the prospect of healthier soil, linking its benefits to water can bring more growers to the table. In this context, understanding the relationship between healthy soils and water saving benefits is important for farmer adoption. An orchardist in the San Joaquin Valley noted the challenges farmers face in navigating short-term vs. longer-term decisions on water. He described how a neighboring almond grower removed all native vegetation from the inter-row spaces to save water in the short term. *"It's a bad idea to take out vegetation because of drought. One farmer sprayed herbicide to take the vegetation out during the drought. The next year, still in drought, he had major problems with infiltration because you need the roots to create the pore space for the water to get in."*

Recent UC research also shows how enhanced soil health from whole orchard recycling[3] increased irrigation efficiency and improved soil and tree water status for almonds when less water was available (Jahanzad et al., 2020).

"The single most important motivator [for farmers] I have seen [is] available water holding capacity and a healthy soil's ability to absorb water, especially runoff during storms."

Other growers have recognized the benefit of healthy soil practices in tackling water issues. Referring to cover cropping, which involves planting non-crop plants like clover so that the soil is covered when not in production, a farmer in the Central Valley said, *"We want cover crops on the areas where there are infiltration problems. For example, you would put cover crops with mustard seed and put it in the ground to reduce compaction and standing water."* Similarly, in our statewide survey, we found that several UC Cooperative Extension staff members associated greater soil health with water retention. One technical assistance provider said, *"The single most important motivator [for farmers] I have seen [is] available water holding capacity and a healthy soil's ability to absorb water, especially runoff during storms."*

The perception of water scarcity limits soil health practices

Even though the water saving benefits of healthy soil practices are attractive to some growers, the physical and economic burden of drought is too high for some

to even consider alternatives. Some driving factors include limited water availability due to drought, declining Sierra snowpacks, saltwater intrusion, and groundwater depletion. Some farmers may view certain soil health practices, like cover cropping, as competing for the water needed for crop production. This is a common tension in the Central Valley nut industry. Many orchardists interviewed for this study reported they either could not plant cover crops due to a lack of water, or did so at the perceived cost of reducing their production. However, recent UC research suggests that cover crops in the San Joaquin Valley might actually not require much water if grown during the winter, when evaporation is much lower (DeVincentis et al., 2022).

"If I was to put a lot of compost on an orchard that had drip irrigation, most likely what would happen is I would sweep that up during the harvest process...it wouldn't be where the tree could utilize it."

In some instances, certain water saving measures can conflict with healthy soil practices. Although highly desirable for its water-saving precision, growers told us drip irrigation is often incompatible with healthy soil practices, like cover cropping or composting. With drip irrigation set in place, especially for orchards, it is difficult to provide water to a cover crop because drips cannot easily be moved to the center between the rows. Related to composting, one almond grower in the Central Valley explained this barrier: *"If I was to put a lot of compost on an orchard that had drip irrigation, most likely what would happen is I would sweep that up during the harvest process...it wouldn't be where the tree could utilize it."* It's important to understand how to best implement water-saving irrigation management practices that are in sync with soil health practices.

At the state level, there are policies that have the important goal of water conservation but have the unintended consequence of making farming more challenging. The Sustainable Groundwater Management Act (SB 1319/AB 1739), passed in 2014, was intended to control the unsustainable pumping of groundwater, which largely occurred in the San Joaquin Valley. SGMA has already reduced, and will continue to reduce, water availability for farmers who rely on groundwater wells (Shapiro, 2019). One Central Valley almond farmer stated, *"SGMA is a huge threat. Without additional surface water, we're screwed. The fallback has been to tap more groundwater, but that's not sustainable in the long run, whether it's regulated out or not. You can't just keep pumping it. It's going to go away."* When farmers are dealing with cut-backs and higher water costs, any intervention, whether or not it's related to soil health, creates fear and is viewed as a challenge.

"...Growing cover crops even during a drought is part of our commitment. We water it with our wells, and we water at nighttime. So some people probably look at us and say, 'Wow, that's kind of crazy. You're wasting water on a cover crop.' But we're looking for next year. And we're constantly reaching out for the following couple of years."

Photo Credit: Joanna Ory

Despite these difficulties, some growers still plant cover crops because they know it will repay them with healthier soils for the longer term. One lettuce grower in the Central Coast shared that *"...growing cover crops even during a drought is part of our commitment. We water it with our wells, and we water at nighttime. So some people probably look at us and say, 'Wow, that's kind of crazy. You're wasting water on a cover crop.' But we're looking for next year. And we're constantly reaching out for the following couple of years."*

Linking California programs for soil and water

Existing California programs offer some support for linking soil health and water, but this connection can be strengthened. Funds from the California Healthy Soils Program (HSP) can be used toward different soil management practices, like cover cropping, which has demonstrated benefits towards water retention. But, more information is needed to understand when, where, how, and to what extent specific soil health practices help with efficient use of water. More insight is needed into how these practices enable farmers to make the best use of rainfall and steward irrigation inputs wisely.

One of only two long-term agricultural studies that exist in the state is threatened. The Century Experiment has had a long-term goal of optimizing irrigation efficiency and understanding its impact on soil health, but this goal may be in jeopardy as campus priorities change. At the UC West Side Research and Extension Center in Five Points, California, farmers in the San Joaquin Valley have more than 20 years of evidence bolstering the positive impact of healthy soil practices on crop production, water use and the environment.[4] It is critical that the state prioritize rigorous long-term research that creates actionable information for growers and regulators.

In addition to the HSP, the State Water Efficiency and Enhancement Program (SWEEP) offers grants to California farmers to reduce water use and install renewable energy systems.[5] SWEEP's goals of carbon emission reduction overlap with greenhouse gas reduction goals of the HSP.[6] Further, California farmers must adhere to the Irrigated Lands Regulatory Program (ILRP), which seeks

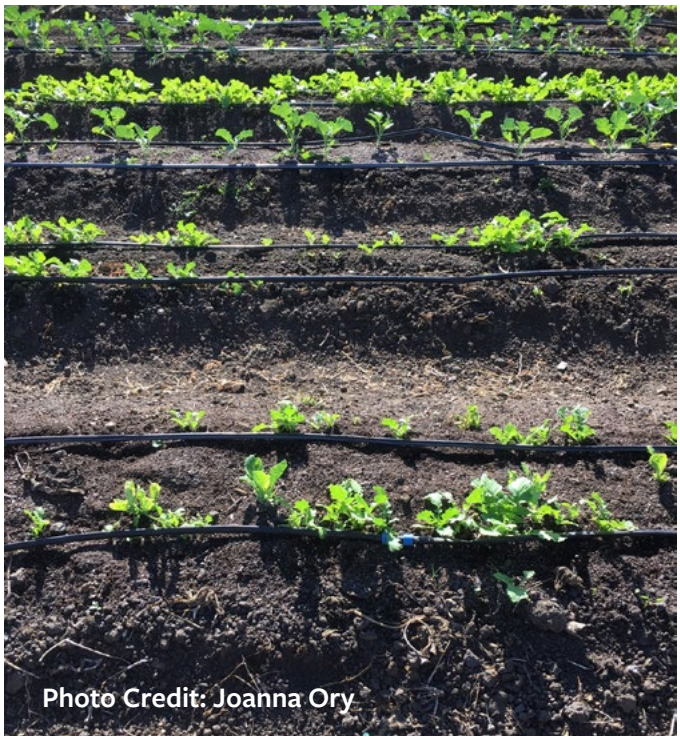


Photo Credit: Joanna Ory

to improve water quality by reducing agricultural runoff of pesticides, fertilizers, and other contaminants.[7] The goals of each program create an opportunity for healthy soils and efficient water use to be prioritized by farmers across all of California. But these programs are not yet fully coordinated to achieve this outcome.

Actions to better link soil health and water

California continues to face drought and ever drier conditions caused by climate change (Swain et al., 2018). The water benefits that come from adopting healthy soil practices are beneficial to growers and the environment — and deserve deeper exploration by researchers, growers, and policy-makers. Better water management must be prioritized while also improving coordination between state funded programs that have overlapping priorities. With adequate knowledge and support, growers have greater willingness and capacity to adopt healthy soil and water saving practices.

Policy-makers have an important window of opportunity now to move growers toward adopting these beneficial practices. The following recommendations can help.

Recommendations

1 Provide CDFA funding for long term trials that study the impact of using soil health building practices on water. In addition, the University of California should provide a stable, funded infrastructure for research and monitoring of connections between soil health and water resources in California, including long term field trials.

Additional research is needed on water and soil health in the state's diverse regions with vastly differing soil, water, and climate conditions. Increasing the funding available for HSP research and setting aside a portion for long-term demonstration projects that show linkages between soil health and water outcomes, which can take some years to develop. Both will inform ongoing soil health-water policy-making and provide tangible evidence to growers. This could be done through creating a third programmatic component to the Healthy Soils Program dedicated to long-term experiments (10+ years) in multiple locations that focus on evaluating soil health practices. The University of California could help support this by creating new experimental sites.

2 Evaluate how the Healthy Soils Program has supported growers to adopt and continue healthy soils practices, especially with regard to water benefits, with the aim of using this data to guide further scaling up of these practices statewide.

As the HSP continues to expand in participation, it is generating a significant pool of potential data through more than 1,550 farmers and demonstration projects it has funded so far. Comprehensive analysis of this data can inform deeper understanding of the motivations and experiences of grantees, whether growers continue and expand use of practices, the barriers that may discourage them from doing so, and the perceived and substantiated impacts of specific practices (including around water use and benefits). In particular, targeted evaluation can focus on identifying whether and how practices can work in concert with irrigation management to reduce pressure on water resources and enable farmers to make the best use of rainfall. Ongoing evaluation will help identify program successes and challenges, and contribute to future program design efforts.

3 Create stronger synergy between the HSP and the Sustainable Groundwater Management Act (SGMA) to ensure that soil health and groundwater management are prioritized together.

Increase research and modeling to give Groundwater Sustainability Agencies and farmers better tools and information to assess net water impacts of healthy soils practices (especially cover crops); and reward farmers for healthy soils practices that have a net benefit to groundwater sustainability (e.g. similar to the Recharge Net Metering program in the Pajaro Valley[8]).

4 Create stronger synergy between the HSP and the Irrigated Lands Regulatory Program (ILRP) to ensure that soil health and water quality are prioritized together.

Allow farmers statewide to receive nitrogen credits to meet regulatory requirements and to enjoy reduced reporting requirements from water quality enforcement programs when they are implementing soil health practices, like cover cropping. One example is the local implementation of the ILRP with the Central Coast Water Regional Water Quality Control Board. In 2021, the board rolled out the Ag Order 4.0, which incentivizes cover crop usage in winter months through nitrogen credits.

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