Final Report for the
Subtropical Soil Health Initiative

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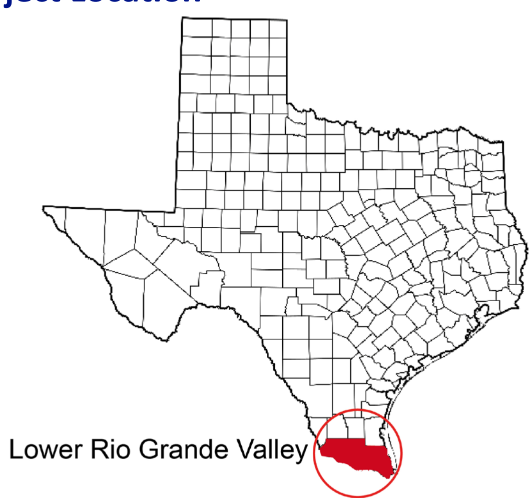
- Hilltop Gardens, Lyford Texas
- PPC Farms, Mission, Texas
- Texas AgriScience, Lyford, Texas

Project Location



NATIONAL CENTER FOR APPROPRIATE TECHNOLOGY

The University of Texas Rio Grande Valley

NRCS Natural Resources Conservation Service

Project Summary

From 2017 to 2022, a team led by the National Center for Appropriate Technology and the University of Texas Rio Grande Valley studied and promoted the use of cover crops, reduced tillage, organic farming, and other ecological soil health management methods in the subtropical Lower Rio Grande Valley (LRGV) of Texas. These methods are extremely uncommon in this region, and they are badly needed. Crop fields are often left bare during the summer months, exposing soil to intense heat and high winds that cause dust storms and topsoil loss. In this hot, humid area where it rarely freezes, insect and weed pressure are also intense.

We tested over 40 cover crop species and mixtures for weed suppression and effects on soil moisture, crop yields, and soil health—as indicated by compaction, organic matter, soil respiration, and other soil properties. We studied planting techniques, seeding rates, timing, and termination methods on both dryland grain farms and irrigated vegetable farms. Our field trials included nine unusual warm season cover crops not described in NRCS technical manuals for Texas.

Based on these studies, we developed regionally appropriate recommendations, disseminated our findings, and provided technical assistance, making a special effort to reach farms with Hispanic operators. We created 16 publications, 10 videos, and 4 podcasts, and gave 29 workshops or field days and 19 conference presentations—in both English and Spanish.

Our project raised awareness and interest among producers while answering many questions about the use of cover crops in subtropical areas. Cover crops proved their value for weed suppression and (to a lesser extent) soil health improvement, and we found many varieties that grew well in hot and humid conditions. We identified two major challenges: First, cover crops are hard to terminate in subtropical areas, where freezing temperatures are rare. Second, cover crops can reduce soil moisture levels, creating risks for dryland producers who depend on properly timed rainfall for seed germination and crop growth.

These results underscore the need for further research and the importance of cost-sharing programs like the NRCS EQIP program to reduce financial risks, especially for dryland growers who are learning to use cover crops.

Background

With a year-round growing season and rich alluvial soils, the Lower Rio Grande Valley is the leading vegetable-producing region in Texas and a nationally important farming region, known especially for its winter vegetables and world-famous citrus industry. It is home to 3,800 Hispanic farmers, the highest concentration in the United States, and hundreds of thousands of acres of cotton, sorghum, corn, and other row crops.

In this semiarid subtropical region, fields are commonly left bare during the summer months, exposing soil to intense heat and high winds for many months each year. It's not unusual to see winds stirring up large dust clouds and blowing away topsoil. Cover crops and no-till farming methods are badly needed to shade, cool, and armor the soil surface but very few producers use them or have seen them. Besides being unfamiliar with cover crops, many growers are concerned that cover crops will "steal soil moisture" from their cash crops.

Those growers who do explore the idea of using cover crops find that their options are limited. For example, out of 32 annual legumes and forbs currently listed by Texas NRCS for use as warm season cover crops, only 13 are recommended for the LRGV. While cover crops are a proven conservation method, most research on them has taken place in temperate parts of the United States, leaving unanswered questions about the suitability, performance, and profitability of cover crops in subtropical regions.

Besides their importance for conservation, cover crops are also essential for the growth of organic farming in South Texas. USDA National Organic Program regulations (section 20.203) state that *"The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials."* Certified organic growers face special challenges because they are required to use only organic or untreated cover crop seeds, and these are often unavailable. Also, cover crop termination can generally not be done with herbicides since most herbicides are not allowed by organic regulations.

Objectives

Our project objectives were to:

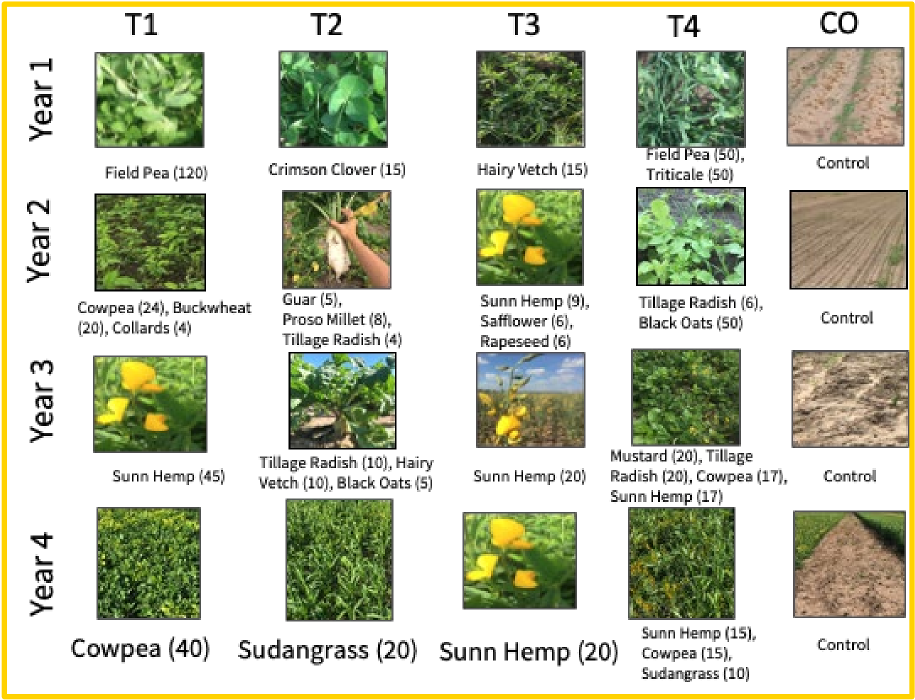
1. Determine the impact and practicality of as many cover crop treatments as possible, including at least five warm season cover crops not currently listed in NRCS technical manuals.
2. Demonstrate other soil health management methods that are uncommon in the Rio Grande Valley, such as cover crops in vegetable production, reduced tillage for vegetables and row crops, organic farming methods, and on-farm propagation of cover crop seeds.
3. Facilitate transfer of knowledge concerning these fundamental soil health practices to Hispanic growers through field days, videos, publications, and workshops in English and Spanish.

Methods

Over a four-year period, we conducted controlled studies and on-farm demonstrations, showcasing a wide variety of ecological farming practices. Most demonstrations took place on certified organic and transitioning vegetable and row crop farms, focusing on the effectiveness, practicality, and profitability of cover crops, reduced tillage, and related methods. Our project was guided by the idea of participatory research, where producers and researchers are peers and co-learners. Many of our research questions came from producers.

We did frequent soil sampling and testing for nutrients, organic matter, bulk density, and other soil health indicators. We measured biological activity in soil using a LI-Cor Soil CO_2 Flux System and sent soil samples to the Texas Plant & Soil Lab and USDA-ARS Grassland Soil and Water Research Laboratory. We measured biomass production and weed suppression by cover crops and paid special attention to the effects of cover crops on soil moisture, using an Extech MO750 soil moisture meter for periodic sampling in the top six inches of the soil profile. We installed weather stations in our test plots and measured soil moisture and temperature in dryland sorghum fields after cover cropping, at sorghum seeding, and at sorghum germination using TEROS 11 moisture sensors inserted 10 cm below the soil surface (as shown at right).

We tested over 40 cover crop species, singly and in mixtures. See Appendix, Figure 1 for a list. The figure below shows treatments in our 25 study plots at Hilltop Gardens. (Numbers in parentheses are planting rates in pounds per acre.)



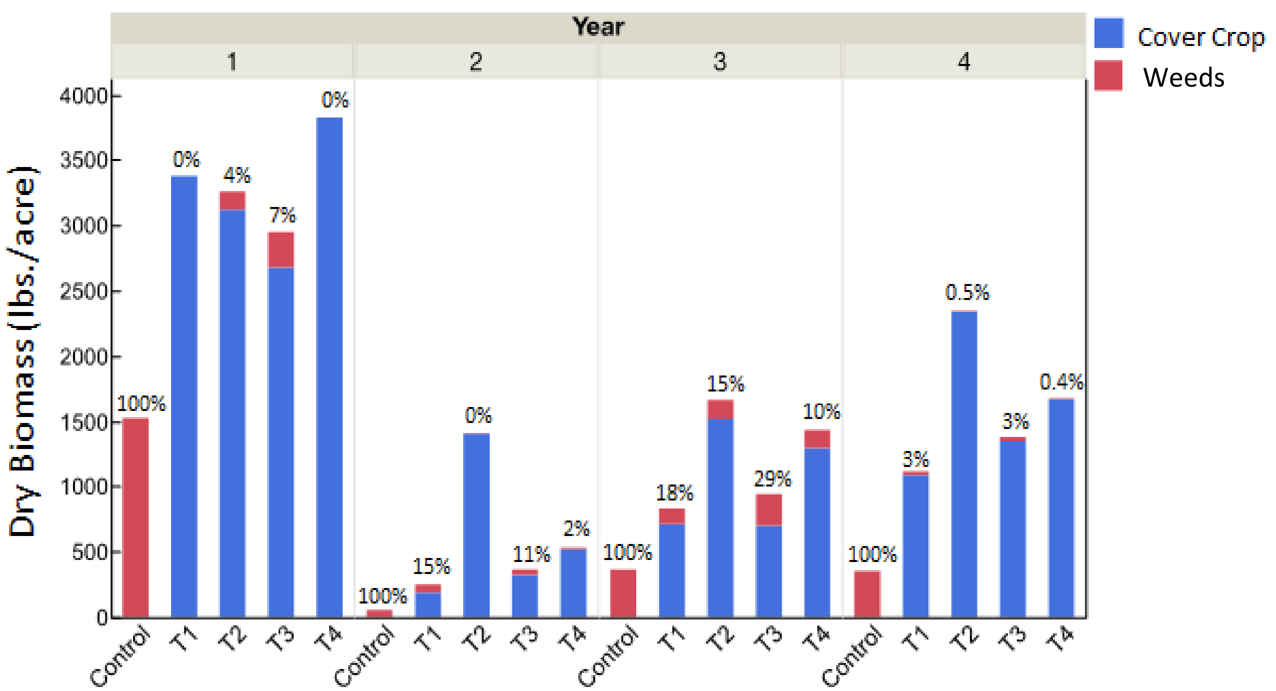
Results

Objective 1: Determine the impact and practicality of as many cover crop treatments as possible.

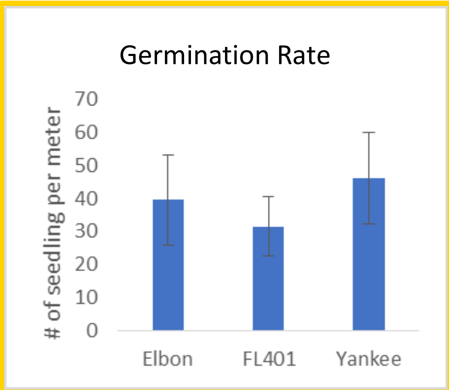
Impact of cover crops on weed suppression

The cover crop treatments above were very effective at suppressing weeds. See the chart below and Appendix, Figures 2 and 3.

Average biomass in cover cropped plots and control plots at Hilltop Gardens



In another trial in 2020, three different cereal rye varieties all germinated did an impressive job of suppressing weeds, despite extremely dry conditions.



Sunn hemp field in bloom, showing near-total weed suppression.

Impact of cover crops on soil organic matter

Throughout our project, we analyzed both active and total organic matter levels in our study plots. We took soil samples at three different times in the growing season: before or just after planting cover crops, when cover crops were about to be terminated, and after cover crops had been terminated and were slightly decomposed. We sent samples to Texas Plant and Soil Lab for analysis of active organic matter, and we analyzed total organic matter levels ourselves in the lab at UTRGV, using the loss-on-ignition method.

As shown in the Appendix, Figure 3, the results of all this sampling and testing were inconsistent and do not support any confident conclusion about how cover crops influenced organic matter. For example, samples taken in the early season each year showed a dramatic average increase in total organic matter of 29% from Year 1 to Year 4 (from 1.92% OM to 2.48% OM), compared to a much smaller average increase of just 11% in our control plots (from 2.05% to 2.28%). However, samples taken at the same time (early season) showed a dramatic average *decrease* in *active* organic matter of 27% from Year to Year 4 (from 1.02% to 0.74%). This compared to a similar decrease of 26% in the control plots (from 0.98% to 0.72%).

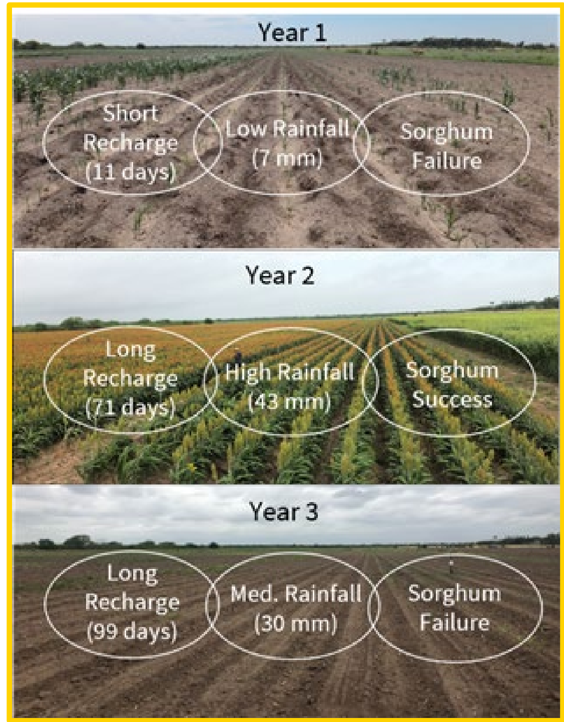
Even more surprising, soil samples taken after cover crops had been terminated in Year 4 showed an average decrease in total organic matter of 51% compared to samples taken two years earlier (from 2.09% to 1.02%). We saw an even higher average decrease of 59% in the control plots (from 2.06% to 0.85%).

We suspect that sampling errors in Year 4 caused some of these surprising results. But even if we throw out Year 4 data, the Year 1-3 results don't show a strong and consistent trend.

Impact of cover crops on soil moisture

Many farmers in the LRGV are concerned that cover crops will deplete soil moisture, harming their cash crops. As shown in the Appendix, Figures 4 and 5, our research generally validated these concerns. In all four years of our project, plots with cover crops had significantly lower soil moisture and lower germination rates than control plots. Soil moisture deficits increased with higher cover crop biomass production and higher seeding rates.

In South Texas, sorghum is planted in late spring and harvested in the summer, creating an opportunity to plant cover crops in the fall and terminate them in late winter. Sorghum germination is then heavily dependent on rainfall wetting soils during the "recharge period" in late winter and early spring: the period after cover crop termination and before sorghum planting.



The need to recharge soil moisture after cover crop termination creates risk since rainfall is unpredictable. Years 1, 3, and 4 of our project saw limited rainfall during the recharge period (as shown in the Appendix, Figure 6), poor sorghum germination in cover cropped plots, and better germination in control plots. The photographs on the right show the dramatic differences in sorghum germination caused by rainfall amounts during the recharge period.

These results show that cover crops can create risk in dryland cropping systems requiring properly timed rainfall for adequate soil moisture. This certainly includes the Lower Rio Grande Valley, a semiarid region that experiences frequent droughts. Of course, these risks must be balanced against clear benefits that cover crops provide, such as controlling weeds, reducing soil erosion, and saving plants from damaging winds.

Farms with access to irrigation, or those practicing reduced tillage, have less reason to be concerned about potential soil moisture losses caused by cover crops. High crops values per acre, as in many fruits and vegetables, also make it more feasible to invest money and time in soil health improvements that increase yields or quality.

But especially in the first few years, when they are on a steep learning curve (finding the best crops, planting dates, seeding rates, equipment, and so on), the expense of cover crops may be hard to justify for dryland farmers, whose profit margins are often extremely low. These results also reinforce the importance for NRCS, when communicating with dryland farmers, of maintaining a realistic focus on grower priorities: crop yields, economics, and profitability.

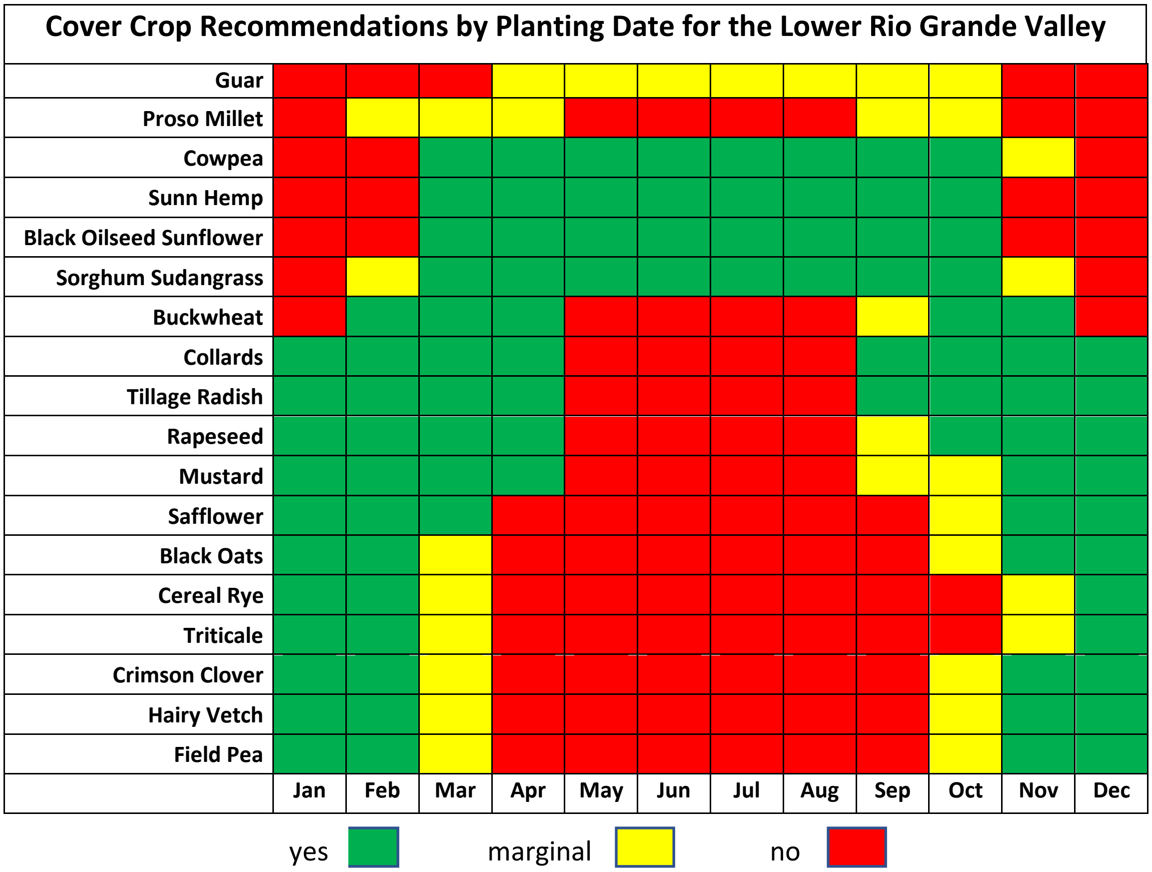
Impact of cover crops on other indicators of soil health and crop yields

In our trials, cover cropped plots generally showed greater soil respiration than control plots, especially in the late part of the cover crop growing season, indicating more microbial activity. (See Appendix, Figure 7.) Cover cropped plots also showed greater average reductions in soil bulk density than control plots, indicating reduced compaction and improving aggregate stability. (See Appendix, Figure 8.)

We tried to study the effects of various cover crop treatments on sorghum yield, but these experiments were not very successful. As shown in the Appendix, Figure 3, drought conditions and poor germination prevented us from collecting sorghum yield data in Years 1, 3, or 4. Data from Year 2 were inconclusive. Average sorghum seed yield (measured in pounds per acre) came out higher than the control plots in two of our treatments (T1 and T3) but came out lower than yields the control plots in the two other treatments (T2 and T4).

Cover crop recommendations

The figure below summarizes our recommendations for 18 cover crops by planting date. Crops rated “yes” germinated and grew well when planted in the indicated month, generated large amounts of biomass, were effective at suppressing weeds, and did not cause large reductions in soil moisture.



Unusual cover crops

We ran trials of nine warm season cover crops not currently described in NRCS Texas technical manuals: pigeon pea (*Cajanus cajan*), partridge pea (*Cassia/Chamaecrista*), wild blue vine (*Centrosema mole/pubescens*), butterfly pea (*Clitoria terneata*), carpon (*Desmodium uncinatum*), velvet bean *(Mucuna pruriens*), scarlet runner bean (*Phaseolus coccineus*), Brazilian lucerne (*Stylosanthes guayanensis*), and perennial peanut (*Arachis*).

Of these, the most promising were pigeon pea and partridge pea. Pigeon peas did a good job of suppressing weeds and grew to an average height of six feet tall despite weather extremes that included intense heat, drought, and flooding. A dense planting of partridge peas also germinated nicely and grew well. We saw promising but tentative results for butterfly pea and velvet bean. Clitoria (butterfly pea) had mediocre germination because of hot, dry conditions during its establishment phase. Initially, velvet beans did well, producing strong, robust vines. However, droughty conditions eventually caused them to fail before setting fruit. Results were mixed or inconclusive for the other four varieties tested: carpon, scarlet runner bean, Brazilian lucerne, and perennial peanut. Some of our scarlet runner bean accessions did poorly or showed nitrogen stress while others performed well. The centrosema accessions (wild blue vine) did not perform well at all. Only a few grew and they were not healthy.

Pigeon peas flourished despite heat and drought.

Termination methods

Terminating cover crops poses a real challenge for producers in subtropical areas because there is rarely a killing freeze. The growers in our project often resorted to disking, which can cause a loss of organic matter and damage to soil microbial communities. Roller crimping and flail mowing are promising ways of terminating cover crops without disking. We tried both methods with generally disappointing results. Quite a few sunn hemp plants and mustard-type cover crops survived roller crimping even when disc ripping was added. The farmer was not satisfied with the results and re-disked the field before planting.

Roller crimper

Other research results

A few other research results are briefly summarized below:

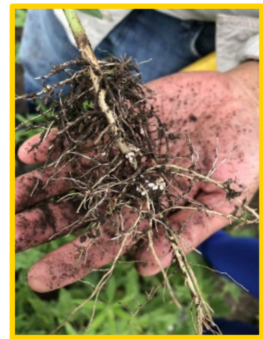
- We compared two varieties of cowpea, Iron & Clay and Red Ripper, finding that Iron & Clay cowpeas grew better, produced more biomass, and were more aggressive against weeds than Red Ripper in our trial plots.
- Crimson clover did not grow especially well but showed surprising effectiveness at controlling germination of pigweed, a major weed problem in the Lower Rio Grande Valley. This observation merits further investigation under controlled conditions.
- We also noted apparent allelopathic effects of sorghum-sudangrass on pigweed and silverleaf nightshade. Vegetable fields that had been covered with sorghum-sudangrass did not need to be weeded until six weeks later than similar fields nearby.
- We looked for potential impacts of mycorrhizae on aloe vera yield and polysaccharide content: an indicator of aloe vera quality. Applying arbuscular mycorrhizal fungus (AMF) to aloe vera did not lead to a statistically significant increase in yield or polysaccharide content.
- At the request of a participating farm, we tried incorporating grain sorghum into cover crop mixtures, as a cost reducing measure. Six mixtures included varying ratios of cowpea, grain sorghum, black oilseed sunflower, and sesame. The experiment was largely unsuccessful since mixtures with grain sorghum had poor weed suppression compared to those with sorghum-sudangrass.
- Graduate student Matt Kutugata made a pilot effort to use drones to monitor crops and other vegetation. He learned to use a drone to photograph and map vegetation patterns, noting many challenges related to aligning images with accurate drone position and cloud cover affecting image quality.
- Graduate student Stephanie Kasper studied nodulation failures in legume cover crops, finding that drought-related stress was the most likely cause. Subtropical and tropical legume species (sunn hemp and cowpea) also seemed to show higher nodulation rates than temperate legumes (clover, vetch, and pea).
- Graduate student Habraham Lopez found plant-parasitic nematodes in all cover crops he checked. Numbers increased at one farm but were unchanged at another farm when cover crops were introduced. The effects of cover crops on plant-parasitic nematodes merit further study.
- Graduate student Jasleen Kaur found that sorghum-sudangrass plants inoculated with arbuscular mycorrhizal fungi (AMF) had significantly higher germination, plant growth, and beneficial insect populations, and lower numbers of plant-feeding herbivores, compared to plants without AMF.

Objective 2. Demonstrate other soil health management methods that are uncommon in the LRGV.

We began a demonstration of no-till farming and vegetable variety trials under organic production at PPC Farms. This study showed promise—especially an experiment using clover as a living mulch under broccoli—but could not be completed because the farm ceased operations and ended its involvement in our project.

We completed a study of the commercial viability of growing and marketing sunn hemp seed at Texas AgriScience, LLC. We compared local seed grown at nearby Anaqua Farms to seed purchased commercially. While the sunn hemp grew well, seed production from both varieties was far below the levels needed for profitable commercial seed production. Under ideal conditions, sunn hemp has been known to produce up to 6,000 pounds per acre. By contrast, we collected only 75-100 pounds of seed per acre.

Most of our work was done on certified organic farms, which are rare in the Lower Rio Grande Valley. An important outcome of the project was exposing area growers to organic certification and farming methods. We also offered a field day at Anaqua Farms showcasing strip tilling.



Checking for nodulation in a field of cowpeas at Hilltop Gardens.

Objective 3. Facilitate transfer of knowledge concerning these fundamental soil health practices to Hispanic growers.

We created 16 publications, 10 videos, and 4 podcasts and gave 29 workshops or field days and 19 conference presentations. We also provided one-on-one technical assistance to dozens of growers.

Challenges

Drought conditions in Years 1, 3, and 4 limited the growth of cover crops and caused sorghum failure in our research plots. From the spring of 2020 onward, the COVID-19 public health emergency caused many travel restrictions, delays, and disruptions to our field activities. We worked around these problems and followed CDC guidelines to keep our workers and farm participants safe.

Outputs

Project Website

Subtropical Soil Health Initiative: attra.ncat.org/subtropical-soil-health-initiative
Includes most project outputs and materials along with other useful resources for growers in subtropical areas.

Publications (all at attra.ncat.org/subtropical-soil-health-initiative)

Duncan, Justin. Cover Crop Options for Hot and Humid Areas. National Center for Appropriate Technology, ATTRA Publication IP535. April 2017.

- Spanish translation: Cultivos de Cobertura para Climas Calidos y Humedo. National Center for Appropriate Technology, ATTRA Publication SP535. April 2017.

Duncan, Justin. Butterfly Pea: a Cover Crop for Hot and Humid Areas (tip sheet). National Center for Appropriate Technology, ATTRA Publication IP626. March 2022.

- Spanish translation: Guisante de mariposa: Un cultivo de cobertura para áreas cálidas y húmedas. National Center for Appropriate Technology, ATTRA Publication SP626. March 2022.

Duncan, Justin. Patridge Pea: a Cover Crop for Hot and Humid Areas (tip sheet). National Center for Appropriate Technology, ATTRA Publication IP624. March 2022.

- Spanish translation: Guisante Chamaecrista: un cultivo de cobertura para zonas cálidas y húmedas. National Center for Appropriate Technology, ATTRA Publication SP624. March 2022.

Duncan, Justin. Pigeon Pea (*Cajanus Cajan*): a Cover Crop for Hot and Humid Areas (tip sheet). National Center for Appropriate Technology, ATTRA Publication IP621. March 2022.

- Spanish translation: Gandul (*Cajanus cajan*): un cultivo de cobertura para áreas cálidas y húmedas National Center for Appropriate Technology, ATTRA Publication SP621. March 2022.

Duncan, Justin. Scarlet Runner Bean: a Cover Crop for Hot and Humid Areas (tip sheet). National Center for Appropriate Technology, ATTRA Publication IP625. March 2022.

- Spanish translation: Frijol escarlata: un cultivo de cobertura para áreas cálidas y húmedas. National Center for Appropriate Technology, ATTRA Publication SP625. March 2022.

Duncan, Justin. Velvet Bean (*Mucuna pruriens var utilis*): a Cover Crop for Hot and Humid Areas (tip sheet). National Center for Appropriate Technology, ATTRA Publication IP623. March 2022.

- Spanish translation: Frijol terciopelo (*Mucuna pruriens var utilis*): un cultivo de cobertura para áreas cálidas y húmedas. National Center for Appropriate Technology, ATTRA Publication SP623. March 2022.

S. Kasper, F. Mohsin, L. Richards, A. Racelis. Cover Crops May Exacerbate Moisture Limitations on South Texas Dryland Farms. Journal of Soil and Water Conservation, April 2022. doi.org/10.2489/jswc.2022.00088

Kasper, Stephanie. A Guide to Troubleshooting Nodulation Failure in Leguminous Cover Crops. https://www.utrgv.edu/agroecology/research/subtropical-soil-health/nodulation-guide/index.htm

Kasper, Stephanie, Bradley Christoffersen, Pushpa Soti, and Alexis Racelis. 2019. Abiotic and Biotic Limitations to Nodulation by Leguminous Cover Crops in South Texas. Agriculture 9 (10): 209. doi.org/10.3390/agriculture9100209.

Schahczenski, Jeff. Recursos Federales de Conservación de Tierras de Trabajo para la Agricultura y la Ganadería Sostenibles. National Center for Appropriate Technology. ATTRA Publication SP294.

Videos (all at attra.ncat.org/subtropical-soil-health-initiative)

Iron & Clay Cowpea & Cover Crop Inoculation. Also a Spanish version: Inoculación de Caupi de Hierro y Arcilla.

Sunn Hemp (*Crotalaria juncea*). Also a Spanish version: Cáñamo Sunn.

Pigeon Pea. Also a Spanish version: Gandules.

Sorghum-Sudangrass Cover Crop for Soil Health. Also a Spanish version: Sorgo-Sudán.

Cover Crops for Hot and Humid Areas

Leguminous Cover Crops in South Texas

Conference Presentations (posters at attra.ncat.org/subtropical-soil-health-initiative*)*

Dec. 7, 2017. Duncan. Cover Crops & Soil Health. Texas Hispanic Farmer & Rancher Conference. McAllen, TX. 25 attendees. Also a poster presentation: Kasper, Lopez, Richards, Soti, Racelis. Impacts of Winter Cover Crops on Soil Respiration in the Rio Grande Valley. 25 attendees.

Feb. 2, 2018. Morris & Racelis. Subtropical Soil Health Initiative. Texas Organic Farmers & Gardeners Association Conference. Georgetown, TX. 100 attendees. Also a poster presentation by Richards, Mohsin, Kasper, Racelis: Effect of Cover Crops on Soil Respiration and Organic Matter in South TX. 50 attendees.

June 23, 2018. Duncan. Farmscaping. Grow South Texas Conference. Corpus Christi, TX. 10 attendees.

Dec. 7, 2018. Morris & Racelis. Subtropical Soil Health Initiative. Texas Organic Farmers & Gardeners Association Conference, 20 attendees.

April 15, 2019. Mitchell. Cover Crops for Hot & Humid Areas. Grow South Texas Conference. Corpus Christi, TX. 30 attendees.

Jan. 27, 2020. Morris & Racelis. Sustainable Agriculture in Texas. National Sustainable Agriculture Coalition Winter Meeting. McAllen, TX. 75 attendees. Also a poster presentation by Kasper, Richards, Faustro: Moisture management is key for cover crop success in South TX. 50 attendees.

Aug. 28, 2020. Morris. Introducing Cover Crops to the Rio Grande Valley of Texas (poster). Soil & Water Conservation Society Conference (virtual). 60 attendees. Also a poster presentation by Kasper, Mohsin, Richards, Racelis: Cover Crops May Exacerbate Moisture Limitations on South TX Dryland Farms. 60 attendees.

Jan. 5, 2021. Mitchell & Kasper. Soil Health with Cover Crops. Texas Hispanic Farmer & Rancher Conference (virtual). 100 attendees.

Jan. 6, 2021. Morris. Regenerating the Rio Grande Valley. Texas Hispanic Farmer & Rancher Conference (virtual). 100 attendees.

Jan. 12, 2021. Duncan. Cover Crops for Hot and Humid Regions. Texas Hispanic Farmer & Rancher Conference (virtual). 100 attendees.

Jan. 13, 2021. Racelis. Texas Hispanic Farmer & Rancher Conference (virtual). 100 attendees.

July 27, 2021. Morris & Racelis. Cover Cropping as a Double-Edged Sword. Soil & Water Conservation Society International Conference (virtual). Talk and poster presentation. 200 attendees.

Aug. 10, 2021. Duncan. Cover Crops for Hot and Humid Areas. Southern Family Farm and Food System Conference. San Marcos, TX. 150 attendees. Also a poster presentation by Richards, Kasper, Racelis: Subtropical Soil Health Initiative: a 3-Year Participatory Research Program. 50 attendees.

Jan. 12, 2022. Duncan. Cover Crops for Hot and Humid Areas. TX Hispanic Farmer & Rancher Conference (virtual). 100 attendees.

Sorghum-sudangrass over six feet tall.

Workshops, Trainings, and Field Days

Sept. 6, 2018. Duncan, Racelis, Richards. Pigeon Pea Field Day. PPC Farms, Mission, TX. 30 attendees.

Nov. 15, 2018. Morris, Racelis, Richards, Kasper. Cover Crop Field Day. PPC Farms, Mission, TX. 30 attendees.

Jan. 29-30, 2019. Racelis, Richards, Kasper. High Tunnel Workshop/Field Day at UTRGV. 30 attendees.

June 6, 2019. Morris, Racelis, Richards, Kasper. Cover Crop Field Day. Hilltop Gardens, Lyford, TX. 33 attendees.

July 11, 2019. Racelis, Richards. Vegetable Farming with Cover Crops. PPC Farms, Mission, TX. 29 attendees.

Feb. 25, 2020. Kasper. Cover Cropping in South TX. Beginning Farmer workshop. Edinburg, TX. 12 attendees.

Feb. 28, 2020. Morris, Racelis, Richards. Field Day. Hilltop Gardens, Lyford, TX. 30 attendees.

April 22, 2021. Duncan. Organic Tomato, Pepper, Eggplant Production. HOPE. Harlingen, TX. 12 attendees.

April 24, 2021. Duncan. Summer Production. Gardopia Gardens, San Antonio, TX. 22 attendees.

May 16, 2021. Duncan. Tomato Production Class. Harlingen, TX. 117 attendees.

June 28, July 12, and July 29, 2021. Maggiani. Organic Training for NRCS Staff (virtual). 150 attendees.

Podcasts (all at attra.ncat.org/category/podcasts/)

Inoculating Legume Cover Crops. attra.ncat.org/episode-205-inoculating-legume-cover-crops/

Do Cover Crops Steal Water? Part 1. attra.ncat.org/episode-222-do-cover-crops-steal-water/

Do Cover Crops Steal Water? Part 2. attra.ncat.org/episode-223-do-cover-crops-steal-water-part-2/

Using Drones in Agriculture. attra.ncat.org/episode-213-using-drones-in-agriculture/

Press Releases & News Stories

In July 2020, the NRCS CIG communications team featured our project in their Investing in the Future campaign. www.usda.gov/media/blog/2020/07/28/where-soil-health-meets-public-health-cover-crops-lower-rio-grande-valley

Reports about the project were included in NCAT press releases and Weekly Harvest newsletter, which reaches over 20,000 readers nationally.

Impact

The project succeeded in introducing cover crops, reduced tillage, organic farming, and other ecological soil health management methods to an underserved community of farmers in the Lower Rio Grande Valley of Texas. Hundreds of local producers saw these methods demonstrated or learned about them from their peers. At least anecdotally, area farmers seemed to become more receptive to these ideas, more interested in trying them, and more aware of NRCS conservation programs.

Our project also had a positive impact on the sustainable agriculture program at the University of Texas Rio Grande Valley, a large Hispanic-serving university. Dozens of students were exposed to sustainable agriculture and organic farming through real-world research on farms. Many of these students pursued undergraduate or graduate degrees in the university's Agroecology and Resilient Food Systems program, and several are now employed in agriculture-related fields.

Next Steps

The University of Texas Rio Grande Valley and NCAT are continuing to do related work with several grant-funded projects. These include a 2019 award to UTRGV from the NRCS Dynamic Soil Properties for Soil Health program and a 2020 award to UTRGV from the NRCS CIG On-Farm Conservation Innovation Trials program for a project focused on "long-term regional implementation and evaluation of cover crops and improved/reduced tillage practices in degraded, subtropical soils on arid, water-limited farms."

There is no question that cover crops, reduced tillage, and other soil health improvement strategies can work in subtropical areas. However, our knowledge about how to use these methods is still, in many ways, in its infancy. Some knowledge gaps are beginning to be filled by organizations like the Southern Cover Crops Council (southerncovercrops.org), yet many questions remain. To mention just a few topics, further research is needed on optimal timing, seeding rates, and cover crop mixtures; the use of native species as cover crops; termination methods; allelopathic effects on weeds; impacts on insect populations; effects on water infiltration and retention in soils; and the challenge of maintaining and increasing organic matter levels in a hot and humid environment. The economics and return on investment from cover cropping and reduced tillage also need more study, especially on dryland farms growing agronomic crops that have a relatively low value per acre.

Acknowledgments

This project was funded by the Conservation Innovation Grants program at USDA's Natural Resources Conservation Service, agreement #69-3A75-17-281. Many partners, advisors, and volunteers helped make this a successful project, and we're grateful to all of them. Special thanks to graduate students Stephanie Kasper, Matt Kutugata, Habraham Lopez, and Lindsey Richards, who reliably carried out much of the field work for this project with volunteer help from dozens of UTRGV undergraduate students. All photos in this report are by Lindsey Richards.

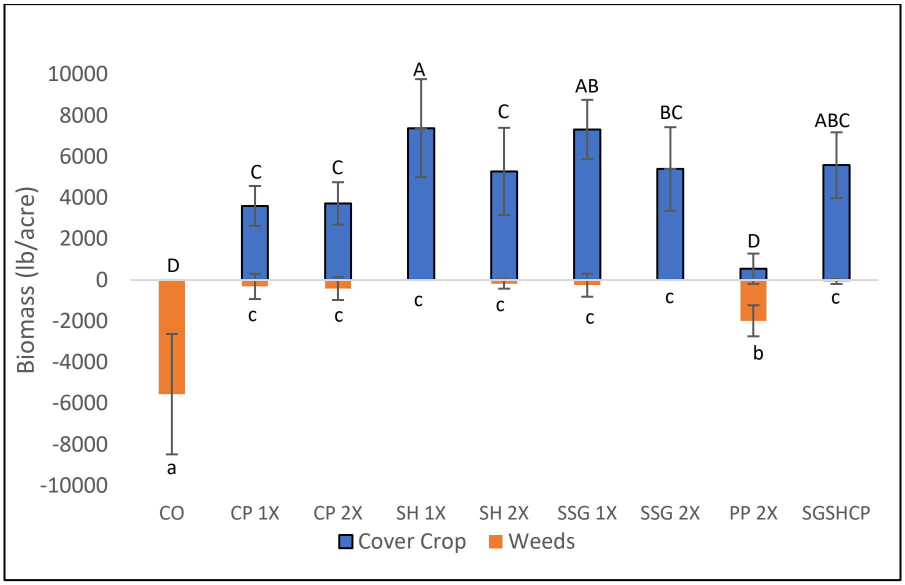
Appendix

Figure 1. Cover crops tested

Black Oats (*Avena strigose*)
Brazilian lucerne (*Stylosanthes guayanensis*) [1]
Buckwheat (*Fagopyrum esculentum*)
Butterfly Pea (*Clitoria ternatea*) [1]
Carpon (*Desmodium uncinatum*) [1]
Cassia spp. [1]
Cereal Rye: FL 401, Elbon, Yankee
Chinese Bushclover (*Lespedeza cuneata*)
Collards
Cowpea: Iron & Clay, Red Ripper
Clover, Crimson (*Trifolium incarnatum*)
Field Pea
Flax
Forage pea (Austrian Winter Pea)
Guar
Hairy Vetch
Hyacinth Bean (*Lablab purpurea*)
Sweet Alyssum (*Lobularia martima*) [2]
Mexican Hat Plant (*Ratibida columnifera*) [2]
Millet: Brown Top, Proso
Mung Bean (*Vigna radiata*)
Mustard: Brown, Yellow, Florida Broadleaf
Okra
Partridge Pea (*Chamaecrista rotundifolia & fasciculata*) [1]
Perennial Peanut (*Arachis glabrata*)
Pigeon Pea (*Cajanus cajan*) [1]
Pink Pappusgrass (*Pappophorum bicolor*) [2]
Rapeseed
Runner Bean (*Phaseolus coccineus*) [1]
Safflower
Sesame
Sorghum, Grain
Sorghum-Sudangrass (*Sorghum bicolor*)
Squash
Sunflower, Black Oilseed
Sunn Hemp: Tropic (*Crotalaria juncea)*
Sweet Clover (*Melilotus alba*)
Sweet Potato
Tillage Radish (*Raphanus sativus*)
Triticale
Velvet Bean (*Mucuna pruriens*) [1]
Wild Blue Vine (*Centrosema molle/pubescens*) [1]
Wild Tantan (*Desmanthus virgatus*) [2]

[1] Not listed in NRCS technical manuals for Texas
[2] Native to the Rio Grande Valley

Figure 2. Biomass from various cover crop treatments at PPC Farms, summer 2019



Mean values from May 2019 trials, using Fisher Least Significant Difference method and 95% confidence. Values sharing a letter (A, B, C, D, or E) are not significantly different.

KEY: CO = control; CP 1X = cowpea @ 40#/acre (2X = 60#/acre); SH 1X = sunn hemp @ 30#/acre (2X = 40#/acre); SSG 1X = sorghum-sudangrass @ 20#/acre (2X = 40#/acre); PP 2X = pigeon pea @ 60#/acre; SGSHCP = mixture of sorghum-sudangrass, sunn hemp, & cowpea @ 30#/acre

Figure 3. Changes in biomass, sorghum yield, and organic matter at Hilltop Gardens.

		Average Biomass (kg/ha)					Average Yield	Average Organic Matter (%)				
							Sorghum Seed Weight	Active OM %			Total OM %	
		Above	Below	Above	Below		(lbs./acre)	Early	Late	Post	Early	Post
Control	Year 1	-	-	1706.7	0	1706.7	-	0.978	0.946	0.938	2.052	-
	Year 2	-	-	19.5	4.5	24	4245.19	-	-	-	-	2.056
	Year 3	-	-	394.2	27.1	421.3	-	1.062	0.886	-	2.287	-
	Year 4	-	-	368.1	30	398.1	-	0.728	-	0.988	2.28	0.851
	Total	**-**	**-**	**2488.5**	**61.6**	**2550.1**	**4245.19**					
T1	Year 1	3787.1	42.4	0	0	3829.5	-	1.006	1.062	1.03	1.886	-
	Year 2	1457.6	113.2	1245.2	1.1	2817.1	4560.13	-	-	-	-	2.122
	Year 3	733.3	76.8	143.7	11.5	965.3	-	1.106	0.984	-	2.084	-
	Year 4	1128.1	89.2	23.8	6.8	1247.9	-	0.718	-	1.132	2.594	0.97
	Total	**7106.1**	**321.6**	**1412.7**	**19.4**	**8859.8**	**4560.13**					
T2	Year 1	3446.2	56.4	151.4	0	3654	-	1.094	1.026	0.974	1.894	-
	Year 2	4770.5	949.8	55.2	0	5775.5	4144.29	-	-	-	-	2.094
	Year 3	1134.8	717.4	151.4	13.3	2016.9	-	1.166	1.086	-	2.026	-
	Year 4	2029.2	591.2	6.4	0	2626.8	-	0.762	-	1.194	2.46	1.082
	Total	**11380.7**	**2314.8**	**364.4**	**13.3**	**14073.2**	**4144.29**					
T3	Year 1	2935.8	67.9	303.3	0	3307	-	0.992	0.95	0.956	1.986	-
	Year 2	2027.4	71.8	322.1	23.9	2445.2	4455.44	-	-	-	-	2.108
	Year 3	485.9	69.6	218.9	22.9	797.3	-	1.094	1.006	-	1.96	-
	Year 4	1381.1	130.8	34.6	2.3	1548.8	-	0.748	-	1.064	2.561	0.909
	Total	**6830.2**	**340.1**	**878.9**	**49.1**	**8098.3**	**4455.44**					
T4	Year 1	3685.8	601.9	0	0	4287.7	-	1.006	0.962	0.984	1.916	-
	Year 2	3218.2	368.4	70.2	7.8	3664.6	4164.71	-	-	-	-	2.052
	Year 3	1151.3	300.6	133.7	13.3	1598.9	-	1.212	1.064	-	2.372	-
	Year 4	1581.2	290.1	7.7	0	1879	-	0.746	-	1.054	2.308	1.108
	Total	**9636.5**	**1561**	**211.6**	**21.1**	**11430.2**	**4164.71**					

Mean values from 20 cover crop plots and 5 control plots. Layout shown below (not to scale). **Early** = just before planting cover crops; **Late** = cover crops about to be terminated; **Post** = after cover crops had been terminated and were slightly decomposed.

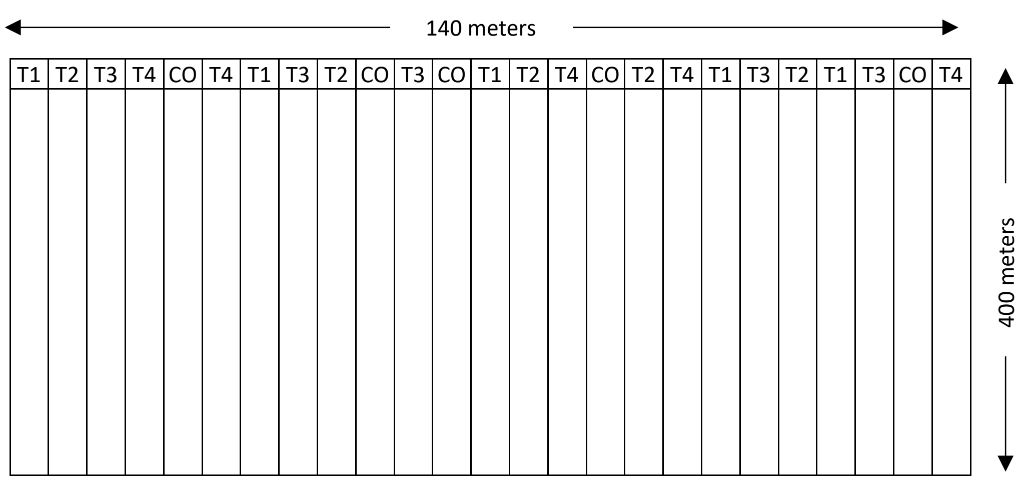
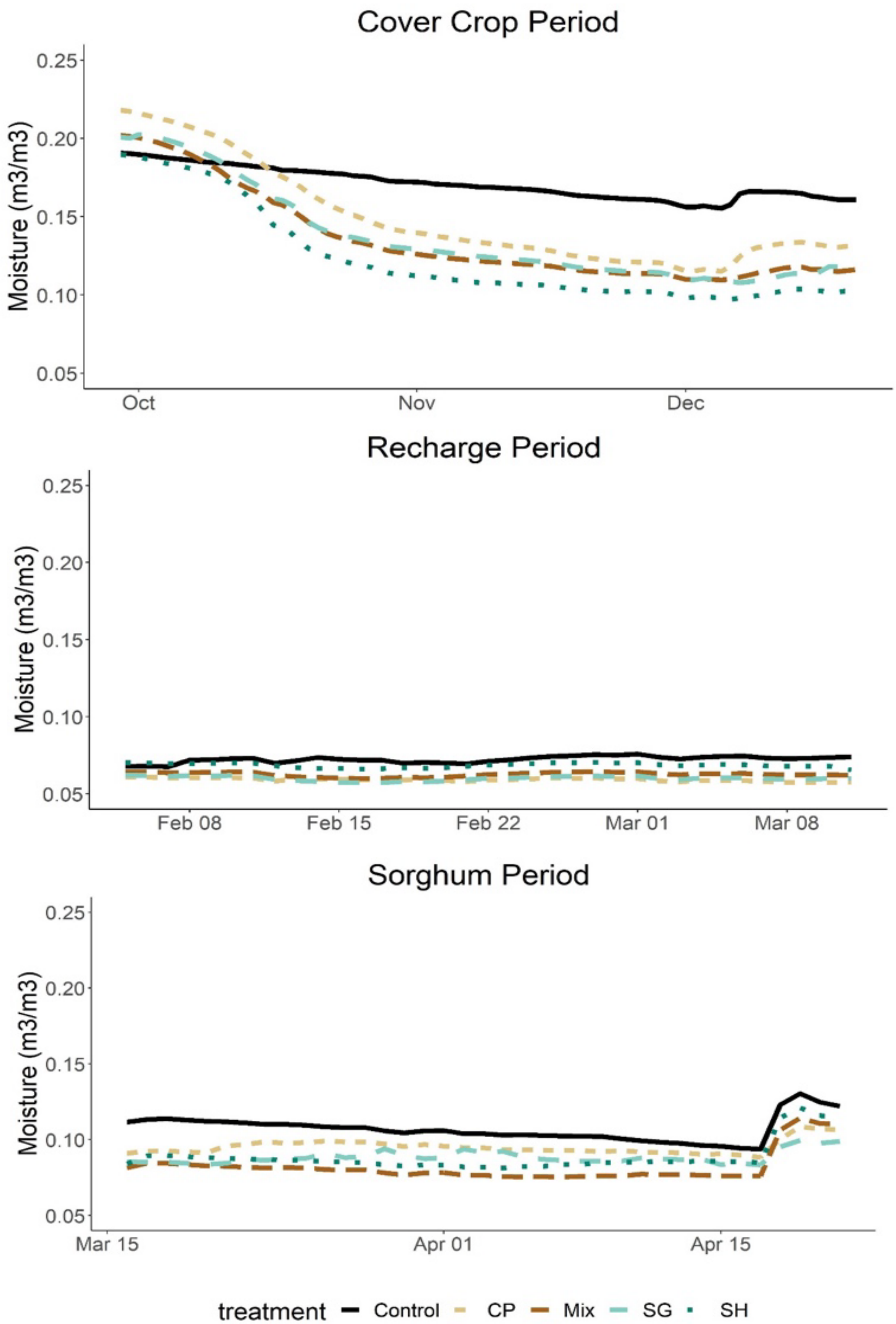
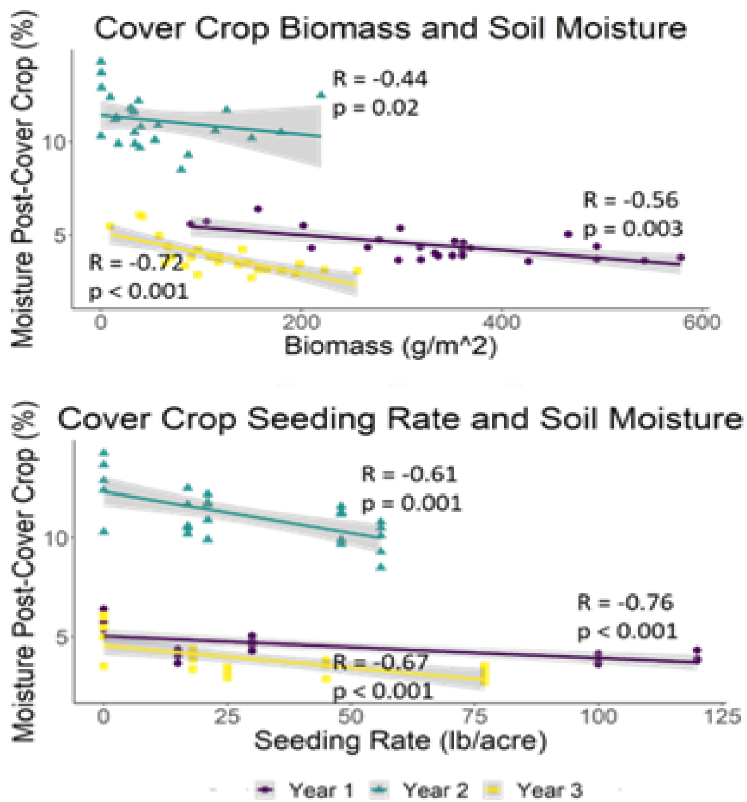


Figure 4. Soil moisture in cover crop treatments and control plots in 2020-2021



Soils dried out while cover crops were growing (October-December 2020) and did not regain much moisture during the "recharge period," leaving soils extremely dry when sorghum was planted and causing poor germination.

Figure 5. Average soil moisture in all cover cropped plots at Hilltop Gardens



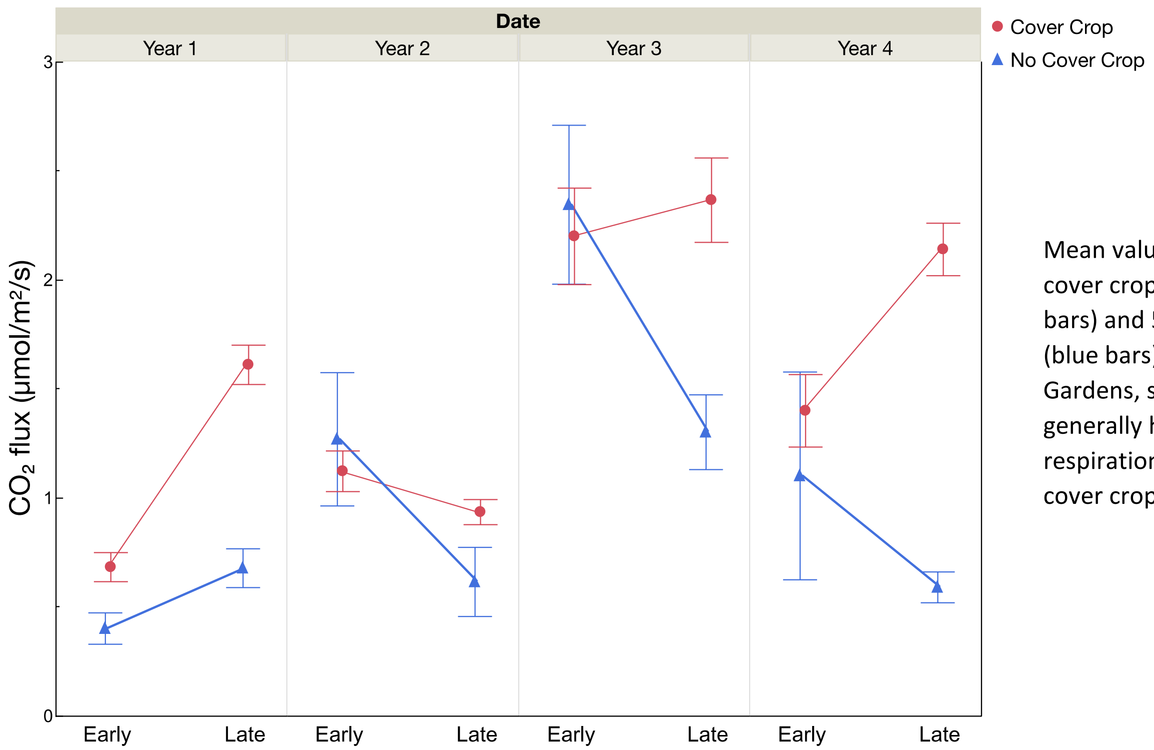
Greater cover crop biomass and higher seeding rates both correlated with drier soils.

Figure 6. Planting calendar and rainfall at Hilltop Gardens

Crop year	Season	Start Date	End Date	Days	Rainfall (mm)
Year 1 2017-2018	Cover crop	11/17/2017	2/24/2018	100	24.40
	Recharge*	2/25/2018	3/7/2018	11	7.30
	Sorghum	3/8/2018	6/12/2018	97	56.60
	Fallow	6/13/2018	9/24/2018	115	332.10
				Total	420.40
Year 2 2018-2019	Cover crop	9/25/2018	12/17/2018	84	146.10
	Recharge*	12/18/2018	2/26/2019	71	43.30
	Sorghum	2/27/2019	9/3/2019	189	169.12
	Fallow	9/4/2019	9/17/2019	34	32.60
				Total	391.12
Year 3 2019-2020	Cover crop	9/18/2019	12/30/2019	104	112.60
	Recharge*	12/31/2019	4/7/2020	99	29.70
	Sorghum	4/8/2020	6/8/2020	62	86.36
	Fallow	6/9/2020	9/25/2020	109	673.35
				Total	902.01
Year 4 2020-2021	Cover Crop	9/25/2020	1/27/2021	125	37.85
	Recharge*	1/28/2021	3/11/2021	43	8.89
	Sorghum	3/12/2021	6/10/21	91	281.69
				Total	328.43

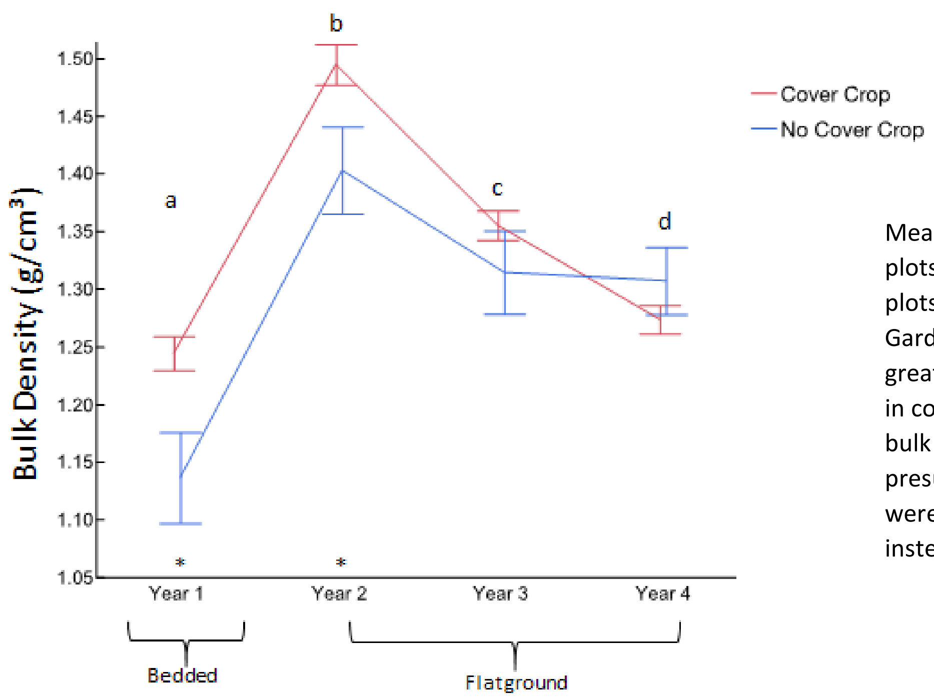
*Recharge is the time between cover crop termination and cash crop planting.

Figure 7. Soil respiration in during early and late stages of cover crop season



Mean values from 20 cover crop plots (red bars) and 5 control plots (blue bars) at Hilltop Gardens, showing generally higher respiration rates in cover cropped plots.

Figure 8. Average changes in bulk density in cover crop and control plots



Mean values from 20 cover crop plots (red bars) and 5 control plots (blue bars) at Hilltop Gardens, showing generally greater decreases in bulk density in cover cropped plots. Average bulk density increased in Year 2, presumably because cover crops were planted on flat ground instead of raised beds.