Final Report for the
Subtropical Soil Health Initiative

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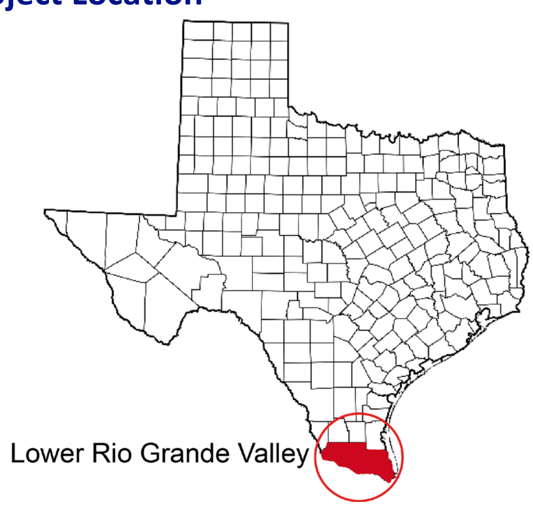
Farm Partners

- Anaqua Farms, Lyford, Texas
- 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 2013 to 2017, 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 of Texas. Although these methods are extremely uncommon in this region, 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, carbon-nitrogen ratios, 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 several unusual crops that were not described in NRCS technical manuals for Texas.

Based on these studies, we developed regionally appropriate recommendations, disseminated our findings, and provided technical assistance and training to area farms, which include about 3,800 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. In our field trials, cover crops proved their value for weed suppression and 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 (kill) 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 (LRGV) 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 the 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.


Pigeon peas flourished despite heat and drought.

Besides their importance for conservation, cover crops are also essential for the growth of organic farming in South Texas. In organic production, cover crops are not just desirable but mandatory. 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 are required to use only organic or untreated cover crop seeds, and these are often unavailable. Termination also poses special challenges since most herbicides are not allowed by organic regulations.

Objectives

Our project objectives were to:

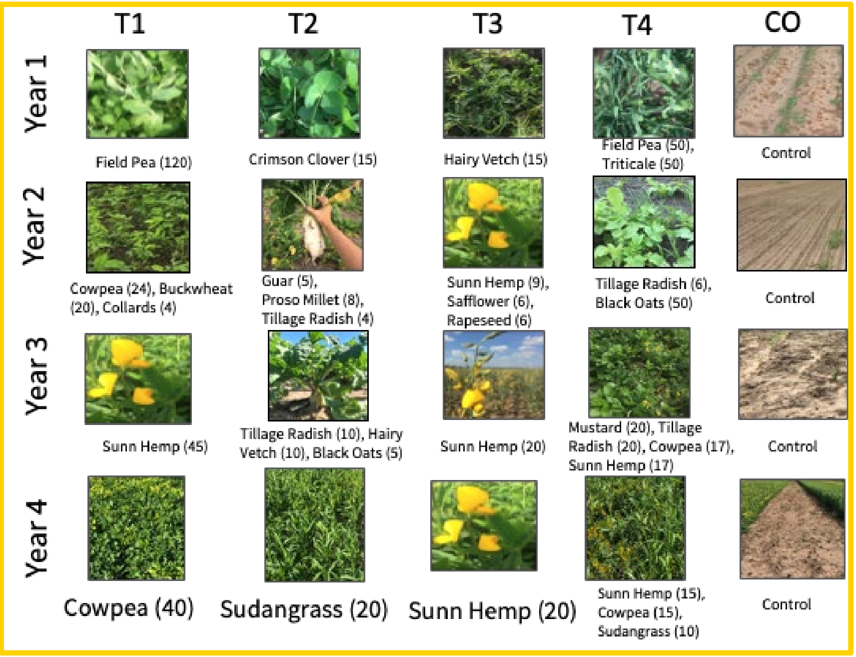
1. Determine the impact and practicality of as many cover crop treatments as possible, including at least five warm season cover crops not currently listed in NRCS technical manuals.
2. Demonstrate other soil health management methods that are uncommon in the Rio Grande Valley, such as cover crops in 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 the course of four growing seasons, 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 research questions came from producers.

We did frequent soil sampling and testing for nutrients, organic matter, bulk density, aggregate stability, and other soil health indicators. We measured biological activity in soil using a LI-Cor Soil CO2 Flux System and sent soil samples to the USDA-ARS Grassland Soil and Water Research Laboratory for Haney Testing. We measured biomass production and weed suppression by cover crops and paid special attention to the effects of cover crops on soil moisture. We installed weather stations near 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.

We tested over 40 cover crop species and mixtures. The figure on the right shows the treatments in our main study plot at Hilltop Gardens.



Results

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

Most cover crops did a good job of weed suppression. For example, our 2019 trials showed excellent weed suppression by sunn hemp, sorghum-sudangrass, and cowpea, all of which produced 4,000 to 8,000 pounds of biomass per acre. Despite poor growing conditions in 2020, black oats and three different cereal rye varieties all did an impressive job of suppressing weeds.

Cover crops also proved their value for soil improvement. At Hilltop Gardens, we saw an average 29% increase in organic matter between 2017 and 2020 in cover-cropped plots, compared to an average increase of 11% in control plots. Cover-cropped plots showed greater soil respiration than control plots, indicating more microbial activity. Bulk density also declined more in cover-cropped plots than in the control plots, a sign of better aggregate stability and improved pore structure.

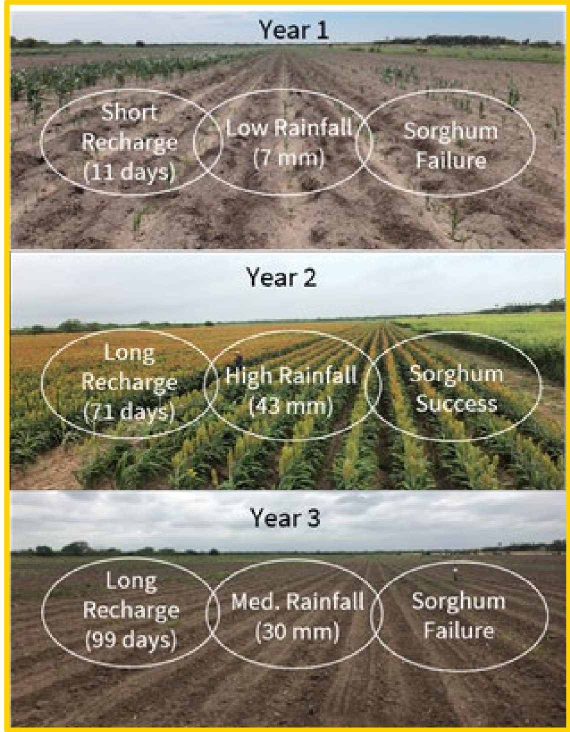
The table below summarizes our findings about the effectiveness and practicality of individual cover crops. We also tested many combinations (cover crop “cocktails”) not shown in this table.

Planting Date	Winners	Losers
Early Fall (Aug/Sept)	Sunn hemp Sorghum-Sudangrass Cowpea (Iron and Clay) Tillage Radish Collards Buckwheat	Guar Proso Millet Safflower Rapeseed Mustard Sorghum Sesame Okra Squash
Late Fall (Nov)	Vetch Field Peas Triticale Black Oats Cereal Rye Mustard	Crimson Clover Sunn Hemp
Spring	Sunn Hemp Cowpea Sorghum-Sudangrass Mustard Buckwheat Pigeon Pea Partridge Pea	Guar Mucuna

Sorghum-sudangrass over six feet tall: a field trial “winner.”

Do cover crops "steal" soil moisture from cash crops?

Many farmers are concerned that cover crops will deplete soil moisture, harming their cash crops. Our research generally validated these concerns while suggesting ways of managing them. In dryland sorghum fields, soil moisture showed significant deficits in plots with cover crops in all four years. Compared to control plots, cover-cropped plots also had lower sorghum germination.



In South Texas, sorghum is planted in late spring or early 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 risks since rainfall is unpredictable. Years 1, 3, and 4 of our project saw limited rainfall during the recharge period, poor sorghum germination in cover-cropped plots, and somewhat better germination in control plots. The photographs to the right show the dramatic differences in sorghum germination caused by rainfall amounts during the recharge period.

Cover crops can clearly create risk in dryland cropping systems that require properly timed rainfall for adequate soil moisture. This certainly includes the Lower Rio Grande Valley, a semiarid region that experiences frequent droughts. Especially in the first few years, 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.

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

Of course, the risk of reduced soil moisture 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.

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 two clearest winners 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.

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 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

This was a wide-ranging project with many small or focused experiments and studies. A few research results are briefly summarized below:

- Graduate student Stephanie Kasper studied nodulation failures in legume cover crops, finding that drought-related stress was the most likely causes. Subtropical and tropical legume species (sunn hemp and cowpea) also seemed show higher nodulation rates than temperate legumes (clover, vetch, and pea).
- 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.
- We made a pilot effort to use drones to monitor crops and other vegetation. Graduate student Matt Kutugata was successful in learning 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.
- 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, saving the farm a substantial amount of money on weeding crews.
- 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.
- We looked for potential impacts of mycorrhizae on aloe vera yield and polysaccharide content: an indicator of aloe vera quality. Results were negative or inconclusive. Applying arbuscular mycorrhizal fungus to aloe vera did not lead to a statistically significant increase in yield or polysaccharide content.
- We found evidence confirming the idea that bedded soil holds more water than flat (unbedded) soil. Across several cover crop treatments, bedded soil held consistently more moisture than flat (unbedded) soil.
- 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 as mixtures with grain sorghum generally had poor weed suppression compared to those with sorghum-sudangrass.

Objective 2. Demonstrate other soil health management methods that are uncommon in the Lower Rio Grande Valley.

We began a demonstration of no-till farming and vegetable variety trials under organic production at PPC Farms. This study showed promise—especially in 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.

A field day at Anaqua Farms showcased strip tilling and we began a study of infiltration rates in strip-tilled fields.

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 Farm 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.

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.

As described under Outputs below, training and education were high priorities in this project. 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

Severe drought conditions in Year 1 and Year 3 limited the growth of cover crops and caused sorghum failure in our research plots. From the spring of 2000 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 International Conference (virtual). 60 attendees. Also a second 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.

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. 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, one of the largest Hispanic-serving universities in the country. 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; 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 Andy Cruz, Joseph Kim, Lois Kim, Anwar Garza, Marcelino Garza, Jacob Pekar, John Reilly, and Hunter Wilde for sharing their expertise and generously allowing us to use their farmland, equipment, and facilities. We're also grateful 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.