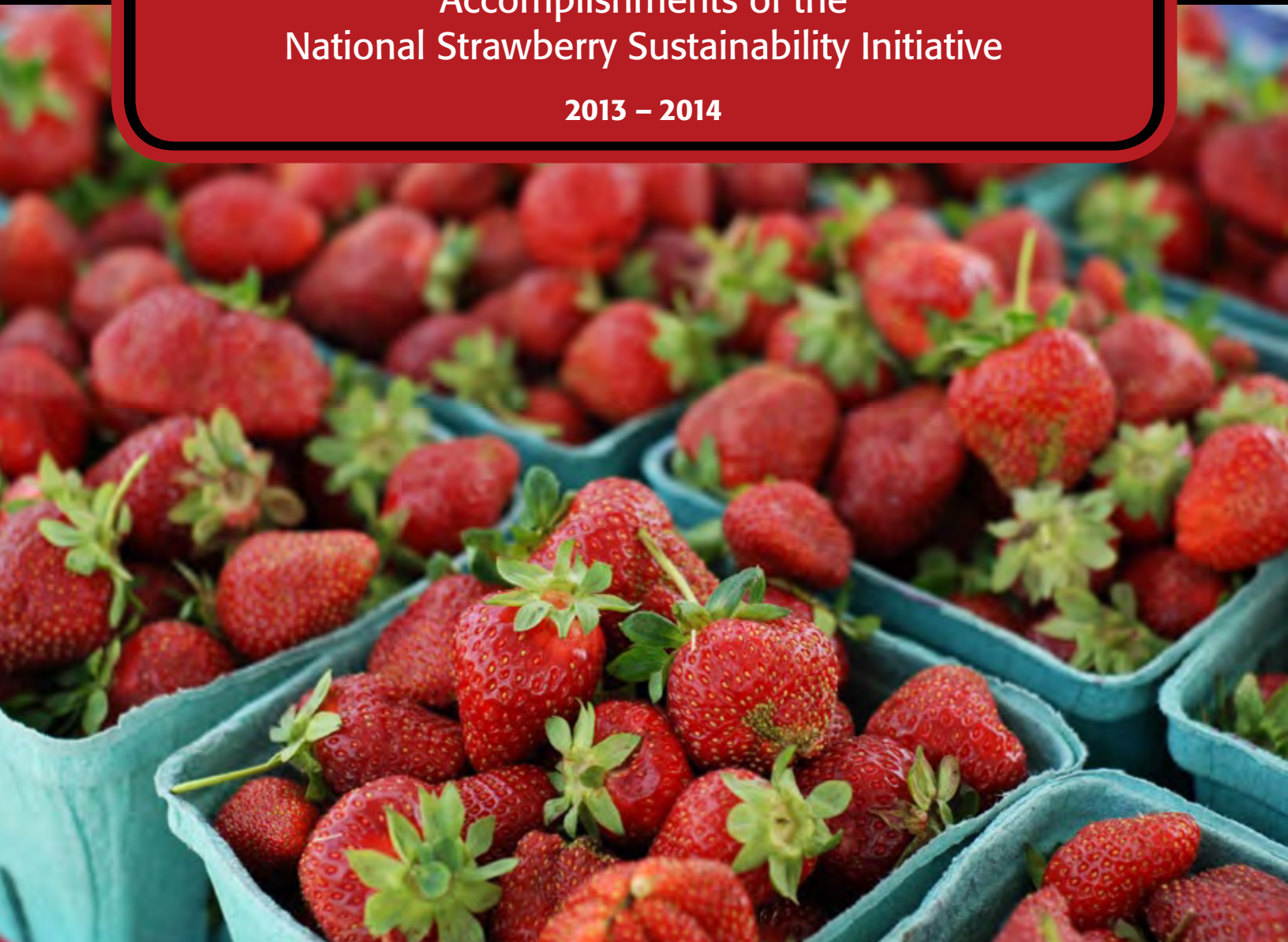


# Moving the Needle

Accomplishments of the  
National Strawberry Sustainability Initiative

2013 – 2014





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Accomplishments of the National Strawberry Sustainability Initiative  
2013 – 2014

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# Introduction to the National Strawberry Sustainability Initiative

## Strawberry Production in the U.S.

The production and consumption of strawberries is experiencing significant growth. World production has increased six percent in the past two decades. Strawberries rank as the fifth most popularly consumed fresh fruit in the U.S. after bananas, oranges, apples and grapes (USDA-AgMRC, 2012). The Rabobank Food and Agribusiness Research and Advisory group (2012) predicts that the sale of fresh berries in the U.S. will expand seven percent per annum over the next three years.

The United States is the world's largest strawberry producer, contributing approximately 27 percent of the global supply. The majority of this production is in California and Florida, representing 89 percent and nine percent of national production, respectively. Production in the U.S. has more than doubled in the past two decades, with the vast majority of this growth occurring in California. At the same time, there has been a decline in production for the 12 other states with commercial strawberry industries. Despite the enormity of the nation's strawberry industry, the U.S. is actually a net importer of strawberries, with 11 percent of the annual crop exported and a 15 percent equivalent of the annual crop imported from Mexico. Because the U.S. is a net importer of strawberries and domestic demand is expected to continue to increase, there is potential to expand production into other regions of the country without detracting from the profits of California and Florida strawberry growers.

The U.S. strawberry production system faces several specific challenges, including the loss of methyl bromide as a soil fumigant, limited availability of labor, and product losses as berries move through the lengthy supply chain from farms to consumers. The hypothesis of the National Strawberry Sustainability Initiative (NSSI) is that the sustainability of the national strawberry industry can be optimized by expanding production into states and regions outside of the primary production centers, thereby increasing local production while complementing the existing industry. Sustainability would be increased by reducing travel distance and time (thus reducing spoilage), using new technologies to extend the range of harvest dates, and implementing new pest management technologies. Although there has been significant research in many of these areas, the specific goal of this project is to support programs that implement the advancement of proven science and technology in production systems in a variety of regions.

## 2013 NSSI Awards

- Sustainable off-season production of high quality hydroponic strawberry in desert southwest, Chieri Kubota, University of Arizona
- Revitalizing strawberry production in Arkansas and the surrounding region via extended season production systems, Elena Garcia, University of Arkansas Cooperative Extension
- A YouTube-based video channel demonstrating hydroponic troughs as year-round sustainable strawberry production systems, Michael Evans, University of Arkansas
- Establishing and expanding sustainable strawberry production in Eastern Arkansas and surrounding areas, Leonard Githinji, University of Arkansas at Pine Bluff
- Development and adoption of annual, plasticulture strawberry production in the Great Plains, Cary Rivard, Kansas State University
- Development of a comprehensive, engaging e-learning tool for strawberry farmers, Emily Hoover, University of Minnesota
- Winter production of Nebraska strawberries: an idea whose time has come, Ellen Paparozzi, University of Nebraska-Lincoln
- Sustainable strawberry production for Mississippi and surrounding markets, William Evans, Mississippi State University Truck Crops Branch
- Revitalization of Texas strawberry industry through identification of production constraints and introduction of new technologies, Russell Wallace, Texas A&M AgriLife Research & Extension Center
- Sustainable strawberry production in the absence of soil fumigation, Thomas Gordon, University of California, Davis

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## 2013 NSSI Awards

*Continued from page 7*

- Optimizing fumigation rate, application depth, and plastic mulch use for strawberry production in raised-bed systems, Ruijun Qin, University of California, Davis
- Organic open-field and high tunnel strawberry cropping systems for long-term viability of the southeastern industry, Carlene Chase, University of Florida
- Strawberry diagnostics: a problem solving tool, Brian Whipker, North Carolina State University
- Placement of additional drip lines to enhance soil fumigation and irrigation efficiency and minimize environmental impacts, Oleg Daugovish, University of California Cooperative Extension
- Sustainable soil management practices for strawberries: evaluation of individual and integrated approaches, Michelle Schroeder-Moreno, North Carolina State University
- Developing the logistics for producing human pathogens-free organic strawberries in the state of Tennessee, Suping Zhou, Tennessee State University
- Reducing strawberry waste and losses in the postharvest supply chain via intelligent distribution management, Jeffrey Brecht, University of Florida
- Improved variety selection and sustainability of strawberries for the eastern United States, Peter Nitzsche, Rutgers Cooperative Extension
- Strawberry grower education and adoption of research innovations: technology transfer of production recommendations, Penny Perkins-Veazie, North Carolina State University
- Creating life cycle inventory datasets to support meaningful and constructive strawberry production sustainability metrics, Ganti Murthy, Oregon State University

## Program Goals of NSSI

There appears to be a gap between scientific research and the development of alternative strawberry production systems including new production areas in the U.S. The goal of the NSSI is to move science and technology for sustainable strawberry production out of laboratories and experiment stations and onto the farms of strawberry growers. The solution was to increase sustainable strawberry production in the U.S. through multiple approaches, ultimately creating positive economic, environmental, social and rural community impacts. Addressing the challenges that face the strawberry industry may result in increased opportunities for innovative production techniques and increased consumer access to nutritious, safe and affordable berries. The project priorities of the grants program were to 1) increase local strawberry production, supply and availability within the U.S.; 2) reduce chemical and energy inputs; 3) conserve and preserve water resources; 4) improve soil quality and health; 5) reduce food safety risk on fresh berries; 6) reduce crop losses and spoilage; 7) improve yield and economic return to producers; and 8) develop appropriate metrics for strawberry production sustainability. The program aimed to move sustainable production forward through new technology, demonstration, outreach, extension and education, resulting in increased sustainable production and supply of strawberries to American consumers.

## Implementation of the Grants Program

The University of Arkansas System Division of Agriculture Center for Agricultural and Rural Sustainability (CARS) received a gift from the Walmart Foundation to direct and manage the NSSI grants program and facilitate outcome communications to the broader audience of producers, marketers and consumers. CARS developed a targeted Request for Proposal seeking specific deliverables aimed at improving the sustainability of the U.S. strawberry industry. Requests were directed to agricultural programs in the U.S. Land Grant System, which offers agricultural research and extension programs through higher education institutions in all 50 states and U.S. territories. The system provides tremendous network capacity and the expertise needed to develop partnerships with industry stakeholders such as grower groups, distributors and marketers.

In May 2013, 20 projects were selected for funding based on peer-reviewed evaluations. Projects focused on a wide range of priorities, including improved soil management, decreased use of water and chemical inputs, expansion of production regions, season extension with high and low tunnels, on-farm testing of new cultivars, and implementation of diagnostic tools for growers. All of the projects were conducted in a 12-month time frame from July 2013 to June 2014. Project leaders submitted quarterly reports, created project videos, contributed to a program blog and shared information about their research with growers at workshops and field days. Project outputs and outcomes were shared through various media outlets including the program [website](#), [blog](#), [Facebook](#), [Twitter](#), [SmugMug](#), [Slideshare](#) and [YouTube](#) sites.

# Summary of Accomplishments

**T**he National Strawberry Sustainability Initiative (NSSI) was launched to improve and optimize the sustainability of the national strawberry production and distribution system and to address present challenges. The NSSI was unique in its broad-based approach to improve crop sustainability at a national level, and in its conception as a private-public partnership between the Walmart Foundation and the University of Arkansas System Division of Agriculture Center for Agricultural and Rural Sustainability (CARS).

Success of the NSSI was achieved through the focused effort of 20 project teams in 13 states with strong industry partnerships and interstate collaboration. This program brought together horticulturists, crop scientists, entomologists, plant pathologists, engineers, economists and marketing specialists. The program demonstrated collaboration among academics, research scientists, extension educators and growers across the country.

The 20 NSSI projects demonstrated innovative and appropriate technologies for sustainable and organic strawberry production, new production systems for local and regional markets, technologies and techniques for improved water conservation, the introduction of new cultivars for alternative locations and markets, the reduction of production inputs through use of environmentally sound practices, rapid testing for potential food safety hazards, utilization of intelligent distribution management to reduce product loss, and the development of metrics to measure system sustainability. These projects have demonstrated that there is opportunity to reintroduce strawberries as a local and regional crop by utilizing new production technology, complementing the current production system and satisfying consumer demand.



Through the projects and partnerships, nearly 100 workshops, demonstrations and field days were conducted, more than 60 presentations were given to technical and scientific groups and approximately 56 videos were produced. Workshop information reached approximately 5,000 growers and industry representatives and more than 1,500 extension agents and consultants. The project generated free digital diagnostic tools for strawberry growers and electronic strawberry production budgets

to guide grower decision-making. Informational strawberry production handbooks were written for the cold climates of the northern U.S. and for the state of Texas. The potential for producing strawberries out of season in many regions of the country was demonstrated with use of greenhouse hydroponic systems and high tunnel technologies. The activities and achievements of the NSSI were presented to broad audiences through conventional print, radio and television outlets. The extensive use of social media such as Facebook, Twitter and

YouTube encouraged audience engagement with the NSSI program and kept the public informed of activities and program achievements in real time. Through the various media channels and outlets, more than 300,000 consumers, growers, advisors, educators, scientists and students were informed and touched by the NSSI project.

Because of the work of the NSSI, the needle for sustainable strawberry production has begun to move. Science has been made available. Sustainability has been demonstrated. Strawberry growers now have the information and tools to reduce environmental impacts and build economically viable businesses, ultimately leading to a system that provides consumers with a greater supply of affordable, high-quality, nutritious strawberries.



# Project Priority I

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## Increase the production season and regional diversity of U.S. strawberry production

- **Sustainable off-season production of high quality hydroponic strawberry in desert southwest** – Chieri Kubota, University of Arizona
- **Revitalizing strawberry production in Arkansas and the surrounding region via extended season production systems** – Elena Garcia, University of Arkansas CES
- **A YouTube-based video channel demonstrating hydroponic troughs as year-round sustainable strawberry production systems** – Michael Evans, University of Arkansas
- **Establishing and expanding sustainable strawberry production in Eastern Arkansas and surrounding areas** – Leonard Githinji, University of Arkansas at Pine Bluff
- **Development and adoption of annual, plasticulture strawberry production in the Great Plains** – Cary Rivard, Kansas State
- **Development of a comprehensive, engaging e-learning tool for strawberry farmers** – Emily Hoover, University of Minnesota
- **Winter production of Nebraska strawberries: an idea whose time has come** – Ellen Paparozzi, University of Nebraska-Lincoln
- **Sustainable strawberry production for Mississippi and surrounding markets** – William Evans, Mississippi State University Truck Crops
- **Revitalization of Texas strawberry industry through identification of production constraints and introduction of new technologies** – Russell Wallace, Texas A&M AgriLife Extension



Chieri Kubota's strawberry greenhouse at the University of Arizona's Controlled Environment Agriculture Center.

## Sustainable off-season production of high quality hydroponic strawberry in the desert southwest

### Project Leaders

- Chieri Kubota, University of Arizona, Controlled Environment Agriculture Center
- Mark Kroggel, University of Arizona, Controlled Environment Agriculture Center

### Project Collaborators

- Ian Justus, Driscoll's Strawberry Associate, Inc.
- Seiji Matsuda, AGC Green-Tech, Japan
- Kelly Young, University of Arizona College of Ag and Life Sciences Cooperative Extension



### Project Summary

The goal of this project was to establish sustainable off-season hydroponic strawberry production in the desert Southwest. There is a strong greenhouse industry in the Southwest that primarily focuses on year-round tomato production, but strawberries are an untapped market that offers the potential for greenhouse growers to diversify and remain competitive. Objectives of the project were to 1) develop effective hydroponic production methods while quantifying cost of production; 2) develop a system for starting strawberry plugs from seed; and 3) communicate resulting information to stakeholders. Two different hydroponic systems were compared for Arizona winter greenhouse strawberry production: a Japanese Styrofoam trough system and a Dutch bucket system. In each of the systems Kubota's group examined the performance of two day-neutral cultivars, 'Albion' and 'Portola.' Commercial viability was determined through an economic analysis. The team also developed a one-of-a-kind hydroponic strawberry information website and reached out to stakeholders through workshops and one-on-one communication.

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Chieri Kubota discusses greenhouse hydroponic strawberry production at a workshop held at the Controlled Environment Agriculture Center in Tuscon.



## Project Outputs and Impacts

Winter strawberry production was successfully demonstrated using two different raised trough systems and achieved a record-high yield of greenhouse strawberries (2.0 to 2.6 lb/ft<sup>2</sup>). This project concluded that the system is profitable, with production costs of \$3.31/ft<sup>2</sup> and benchmark yields at 1.4 lb/ft<sup>2</sup>. Between the two cultivars grown, 'Portola' was the higher producer (at 1.6 kg per plant compared to 1.2 kg per plant from 'Albion'). Out of the systems tested, Styrofoam troughs showed advantages during midwinter to early spring when air temperatures were cooler. Another discovery was that an under-bench misting system proved an effective strategy for preventing tip burn of the strawberry leaves by increasing nighttime humidity. The project hosted two one-day workshops in Tucson, which attracted 60 attendees from seven Western states and Mexico. The findings from the project have been shared at three grower conferences, two outreach events, and have been



Project leaders Chieri Kubota and Mark Kroggel in the strawberry greenhouse at the Controlled Environment Agriculture Center.

made available on the [Hydroponic Strawberry Information Website](#) and Project [Blog](#). Since the launch of this project, two commercial greenhouse operations in Canada have announced that they will start producing and marketing hydroponic strawberries, demonstrating the relevance and potential of this production system.

## Websites

- [Hydroponic Strawberry Information Website](#)
- [Hydroponic Strawberry Project Blog](#)
- [Project photos](#)

## Presentation

- [Off-Season Hydroponic Strawberry Production](#)

## Videos

- [“Strawberry Sunrise in Arizona”](#) (full version)
- [“Strawberry Sunrise in Arizona”](#) (short version)



[“Strawberry Sunrise in Arizona”](#) (full version – video)



NSSI project leaders from across the US view Garcia's strawberry plots in Fayetteville during the NSSI Project Meeting in May, 2014.

## Revitalizing strawberry production in Arkansas and the surrounding region via extended season production systems

### Project Leader

- Elena Garcia, University of Arkansas Cooperative Extension Service

### Project Collaborators

- Donn Johnson, University of Arkansas, Department of Entomology
- Kristen Gibson, University of Arkansas, Department of Food Science
- Michael Evans, University of Arkansas, Department of Horticulture
- Hector German Rodriguez, University of Arkansas, Department of Agricultural Economics and Agribusiness
- Randy Chlapecka, University of Arkansas Cooperative Extension Service

### Project Summary

This project focused on a multidisciplinary approach to revitalize strawberry production in Arkansas and the region. Outreach activities were a large component of the project. These included workshops, in-depth schools, and field days open to the public. Activities focused on season extension technologies, innovative production methods, new cultivar trials, sustainable pest and fertilization management strategies, food safety, and a tool to assist growers with financial decisions. Strawberry demonstration sites

with high tunnel and field production were maintained at the Arkansas Agriculture Research and Extension Center in Fayetteville and the Fruit Research Station in Clarksville. Integrated pest management techniques were demonstrated for strawberries, using predatory species, exclusion netting, and other best management practices. Research



Elena Garcia presents information on strawberry production to interested growers and extension agents at a strawberry workshop in Fayetteville.





[Planting Strawberry Plugs in High Tunnels](#) (video)

was conducted on nutrient management for off-season high tunnel strawberry production and the correlation between nitrogen fertilization and mite populations was explored. A strawberry budget tool was developed by the team economists to serve as a decision-making tool for current and potential strawberry growers.

## Project Outputs and Impacts

With the objective of expanding and extending strawberry production in Arkansas and the surrounding region, this project conducted several outreach activities that demonstrated alternative production systems, modern cultivar evaluations, and innovative production methods. The Organic High Tunnel Strawberry Workshop in Clarksville attracted 18 people, who learned about strawberry cultivars, land preparation, high tunnels, insect management, diseases, fertilization and food safety. The High Tunnel Strawberry Production Workshop in Fayetteville was attended by 29 people and was followed by an open house tour of the strawberry research site. The growers interested in learning more attended a full-day, in-depth school, which covered topics of land preparation, cultivar selection, disease and insect management, greenhouse production, and food safety, in addition to offering hands-on demonstrations. All of the presentations given at the in-depth school have been made available on the project's [YouTube channel](#), where there is also a collection of instructional videos for new strawberry growers. The strawberry budget tool developed through this project is the first interactive budget to focus on strawberry production for the state of Arkansas and has been made available as a [free download](#) with a companion user guide.

Strawberries grown on plastic mulch  
in Garcia's research high tunnel.

## Publication

- [Interactive Sustainable Strawberry Budget](#) and [user-guide](#)

## Presentation

- [Revitalizing Strawberry Production in Arkansas and the Surrounding Region via Extended Season Production Systems](#)

## Websites

- [YouTube channel](#)
- [Project photos](#)

## Videos

### Arkansas Strawberry Production Video Series:

- [Video 1 — Receiving Your Plants](#)
- [Video 2 — Forming Beds and Laying Plastic](#)
- [Video 3 — Planting Strawberry Plugs in High Tunnels](#)
- [Video 4 — Fertilization and Irrigation for High Tunnels](#)
- [Video 5 — Fertilization and Irrigation for Strawberry Fields](#)
- [Winter Burn](#)

### Arkansas Strawberry Production Lecture Series:

- [Strawberry Virus Epidemics and Importance of Clean Plant Material](#)
- [Strawberry Diseases: Biology and Integrated Management](#)
- [Site Selection, Preparation and Soil Nutrition in Strawberry Production](#)
- [Direct Marketing Strategies](#)
- [The Strawberry Plant](#)
- [Interactive Tool to Assess Costs, Revenues and Risks](#)
- [Food Safety Aspects of Strawberry Production](#)
- [Strawberry Insect Pest Management](#)
- [Strawberry Fumigation & Methyl Bromide Alternatives](#)
- [Cover Crops in Strawberry Production](#)





Mike Evans explains a hydroponic system called "nutrient film technique" for greenhouse strawberry production.

## A YouTube-based video channel demonstrating hydroponic troughs as year-round sustainable strawberry production systems

### Project Leader

- Michael Evans, University of Arkansas, Department of Horticulture

### Project Collaborators

- Elena Garcia, University of Arkansas Cooperative Extension Service
- Donn Johnson, University of Arkansas, Department of Entomology
- Craig Rothrock, University of Arkansas, Department of Plant Pathology
- Chris Higgins, Hort Americas

### Project Summary

The use of hydroponic trough systems in high tunnels and polyethylene greenhouses provides growers with a means of sustainably growing strawberries year-round. However, the vast majority of strawberry production is in ground or field situations and most growers do not have the detailed knowledge or experience using hydroponic trough systems to be able to take advantage of the benefits they provide. The focus of this project was to demonstrate these systems and to use video to teach commercial growers how to build, maintain and operate hydroponic trough systems

placed in high tunnels and greenhouses to sustainably produce strawberries. Demonstration hydroponic and soilless strawberry production systems were assembled in greenhouses at the University of Arkansas for public viewing and a series of instructional YouTube videos were created to provide growers with free access to information on hydroponic strawberry production. By using hydroponic systems to produce strawberries, growers are able



Young strawberry plants grow in NFT troughs in a greenhouse at the Arkansas Agricultural Research and Extension Center in Fayetteville.





[Video 1. Introduction](#)

to more efficiently manage water and fertilizer, eliminate disease and weed pressure, reduce pesticide inputs, extend the harvest season and increase production per unit area.

## Project Outputs and Impacts

Demonstration hydroponic strawberry facilities were assembled at the University of Arkansas to use for education and training. In addition, 12 instructional videos were produced for the project [YouTube channel](#), which featured the University of Arizona hydroponic strawberry greenhouse and Arizona project leader, Mark Kroggel. By the conclusion of this project there were more than 1,800 views of the videos on the YouTube channel, with 60 subscribers and numerous requests from growers for more information. Two field days were held at the University of Arkansas where a total of 30 people came to the greenhouses and toured the hydroponic and soilless strawberry production system. Dr. Evans presented on the project at the Cultivate'14 AmericanHort meetings in Columbus, Ohio, in June 2014, where a total of 52 growers attended the presentation. In addition to the strong interest from growers, seven greenhouse companies have indicated that they will branch into hydroponic strawberries or expand their current production. This project has shown that the interest in these hydroponic strawberry production systems far exceeds the amount of information currently available to growers in the U.S., and has begun to bridge that gap by providing research-based information in an easily accessible video format.

## Websites

- [“Sustainable Hydroponic and Soilless Strawberry Production Systems” YouTube channel](#)
- [Project photos](#)

## Presentation

- [Video Channel Demonstrating Hydroponic Troughs as Year-round Sustainable Strawberry Production Systems](#)

## Videos

- [Video 1. Introduction](#)
- [Video 2. Arizona Gutter System for Greenhouse Strawberry Production](#)
- [Video 3. Arizona Greenhouse Strawberry Bucket System](#)
- [Video 4. Arizona Fertilizer Injector Board](#)
- [Video 5. Arizona System for Controlling Fertilizer Delivery](#)
- [Video 6. Arizona Emitters Used to Deliver Fertilizer Solution](#)
- [Video 7. Arizona Fertilizer A and B Stock Formulations](#)
- [Video 8. Arizona Pollination of Strawberries in Greenhouses](#)
- [Video 9. Arizona Strawberry Harvesting Guidelines](#)
- [Video 10. Arizona Strawberry Cultivar Selection](#)
- [Video 11. Arizona Pest and Disease Control in Greenhouse Strawberries](#)
- [Video 12. Arizona Mark Kroggel's Accumulated Wisdom on Growing Greenhouse Strawberries](#)



Leonard Githinji explains high tunnel strawberry production during a strawberry workshop held at UAPB.

## Establishing and expanding sustainable strawberry production in eastern Arkansas and surrounding areas

### Project Leader

- Leonard Githinji, University of Arkansas at Pine Bluff

### Project Collaborators

- Jim Goodson, Mid-America Strawberry Association
- Robert Cole, East Arkansas Enterprise Community

### Project Summary

Despite the increasing demand for strawberries in Arkansas, production has been shrinking with acreage dropping steadily since the 1970s. The goal of this project was to establish and expand sustainable strawberry production in eastern Arkansas and the surrounding area. In order to achieve this goal, extensive outreach and education, including hands-on exercises and demonstrations of sustainable strawberry production, was conducted across the eastern counties of Arkansas, covering the Delta region. Project activities included strawberry workshops where principles

of sustainable strawberry production were taught and participants were given hands-on experiential learning at three demonstration sites. High tunnels, low tunnels and plasticulture production were modeled at each site, in addition to cover crop and compost use. Objectives of the project included 1) demonstration of season extension technologies; 2) demonstration of sustainable methods of soil improvement and disease management; 3) demonstration of integrated pest management strategies; 4) training about water and energy conservation; and 5) training about good agricultural practices and good handling practices to reduce food safety risks for fresh strawberries.

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Leonard Githinji discusses plasticulture production of strawberries during a workshop at the UAPB Agriculture Demonstration Outreach Center in Mariana, Ark.







Workshop participants learn about using high tunnels for strawberry season extension during a workshop at UAPB.



Leonard Githinji discusses the use of low tunnels for strawberry production at the UAPB research farm.

## Project Outputs and Impacts

Three strawberry sites were established, in Jefferson, Lee and Lonoke counties, to provide hands-on training and demonstration of sustainable strawberry production practices, season extension, sustainable soil management and water conservation practices. A total of 882 participants were reached through project activities, including 25 cooperative extension agents trained on sustainable strawberry production. Three season extension workshops were held, demonstrating the use of high tunnels, row covers and plastic mulch technologies. Two soil management workshops were conducted, demonstrating soil solarization,

anaerobic soil disinfestation and the use of cover crops to improve soil quality and replace the use of chemical fumigants. An integrated pest management workshop was held to teach growers methods of sustainable pest and disease management and the use of beneficial insects. Two workshops were conducted about good agricultural practices and good handling practices to reduce contamination of fresh strawberries with human pathogens. Due to the work of this project, five new strawberry growers came into production, adding six acres of strawberry fields to Arkansas.



[UAPB Sustainable Strawberry Project Video](#)

## Website

- [Project photos](#)

## Presentation

- [UAPB Sustainable Strawberry Project Presentation](#)

## Video

- [UAPB Sustainable Strawberry Project Video](#)





Strawberries are harvested in the high tunnel trial at the Olathe Horticulture Research and Extension Center.

# Development and adoption of annual plasticulture strawberry production in the Great Plains

## Project Leader

- Cary Rivard, Kansas State University, Department of Horticulture, Forestry and Recreation Resources

## Project Collaborators

- Frank and Melanie Gieringer, Gieringer's Orchard
- Jerry and Jane Wohletz, Wohletz Farm Fresh

## Project Summary

Local production of strawberries in the Great Plains is limited due to poor performance of “traditional” perennial production systems. The annual plasticulture system has been widely adopted with great success in the southeastern U.S. and shows potential in Kansas, but colder winter temperatures create challenges for adoption in the Great Plains. This project investigated the proper application timing and thickness of row cover to best protect strawberries from winter injury, in addition to disseminating information on this annual production system to Great Plains growers. The project also investigated a spring-planted production system using day-neutral strawberries grown in high tunnels for an extended harvest season. Objectives of the project were to 1) verify the utility of annual plasticulture strawberry production for the Great Plains; 2) determine the

optimum application timing and thickness of row covers for open-field annual strawberry plasticulture systems; 3) identify the relationship between winter injury and crop performance and determine how row covers affect the soil and canopy microclimate; 4) investigate the utility of spring-planted annual strawberry production in high tunnels and identify varieties that perform optimally in the Great Plains; 5) determine how evaporative cooling affects crop performance and disease incidence in high tunnel strawberries; and 6) disseminate crop production information to growers.

## Project Outputs and Impacts

This project increased awareness and knowledge of the annual plasticulture strawberry production system among Great Plains growers through publications, dissemination of research findings, twilight farm tours and presentations at grower conferences. Eight commercial growers, most of whom plan to continue growing strawberries, received one-on-one consulting from the project team to assist with their first strawberry plantings. Two on-farm research trials that investigated the timing and thickness of row cover for winter protection of strawberries in an annual production system were successfully conducted. This research generated concrete recommendations used to inform more than



550 growers and 40 extension agents with best practices for winter strawberry protection in the Great Plains. The project also investigated spring-planted annual strawberries in high tunnels, which was shown to be a very productive system that could offer high tunnel growers in the Great Plains the opportunity to diversify away from tomatoes for crop rotation. In order to further disseminate information and research findings, videos outlining strawberry production for the Great Plains were created for distribution through the KSU Research & Extension Channel.

## Website

- [Project photos](#)

## Presentations

- [Development and Adoption of Annual Strawberry Production in the Great Plains](#)
- [Managing winter injury for annual strawberry production systems in the Great Plains](#) (Poster)



Marlin Bates, County Extension Agent, discusses annual strawberry production during a Grower Twilight Tour held at Jerry and Jane Wohletz's farm near Lawrence, Kan.



Kelly Gude harvests strawberries from the the on-farm research trial at Gieringer's Orchard in Johnson County, Kan.





A strawberry field using season-extending low tunnels, plasticulture, and straw mulch at the University of Minnesota in St. Paul.

## Development of a comprehensive, engaging e-learning tool for strawberry farmers

### Project Leader

- Emily Hoover, University of Minnesota, Department of Horticultural Science

### Project Collaborators

- Ron Branch, Berry Ridge Farm
- Arne Kildegaard, University of Minnesota, Center for Small Towns
- Roger Boleman, University of Minnesota, Instructional and Media Technologies
- Marilyn Johnson, Minnesota Fruit and Vegetable Growers Association
- Brenda Hartkopf, Minnesota Grown Promotion Group Inc.
- Helene Murray, Minnesota Institute for Sustainable Agriculture
- Bill Jacobson, Pine Tree Apple Orchard
- Mary Jo and Luverne Forbord, Prairie Horizons Farm
- Tony Nemmers, Sodexo
- Kathryn Draeger, University of Minnesota, Regional Sustainable Development Partnerships
- Jerry Untiedt, Untiedt's Vegetable Farm
- Steve Poppe, University of Minnesota, West Central Research and Outreach Center

### Project Summary

The objective of this project was to design, produce and disseminate a comprehensive e-learning tool to teach sustainable methods and technologies for growing, marketing and extending the season for strawberries. Strawberry farming requires multiple skills related to production and marketing. New farmers need to learn these skills, while established farmers constantly work on improvement to respond to changing circumstances and new information about sustainable farming. This e-learning tool was created to 1) educate farmers on the use of low tunnels to extend the strawberry season; 2) increase accessibility of information on June-bearing cultivar production; and 3) introduce innovative marketing techniques and resources to ensure locally grown strawberries reach as many consumers as possible. The results of this project will serve to educate existing and new strawberry farmers in Minnesota and the Upper Midwest about science-based methods to produce and market high-quality strawberries during a longer season with low environmental impact. Armed with this knowledge, farmers will be empowered to make lasting changes on their land and in their businesses, leading to increased strawberry production, higher fruit quality and a diversified local market. The result will be higher profits for farmers and a sustainable strawberry industry in the Upper Midwest region.



Portola day-neutral strawberries picked from the research plots at the University of Minnesota in St. Paul.

## Project Outputs and Impacts

The primary output of this project was a comprehensive strawberry e-learning tool, titled [Cold Climate Strawberry Farming](#). It is a complete guide on how to market, grow and sell strawberries in cold climates, comprising 28 videos, 104 images, 9 slideshows, 6 other interactive features and 7 worksheets. Upon its release to the public, the e-learning tool was disseminated to more than 100 Minnesota farmers and to many more farmers across the country. A [YouTube trailer](#) was also created to promote the resource. One highlight of the e-learning tool is a social media feature allowing users to see notes others have made about what has or hasn't worked on their farms and to highlight passages and bookmark pages. The project group also created a larger social media community on [Facebook](#) and [Twitter](#), where users can ask questions, connect with other farmers and provide feedback. Through targeted focus groups, 70 farmers read a chapter of the e-learning tool and provided feedback before it was released. This was the first time many of these farmers used electronic devices to learn about farming; many reported feeling more comfortable with online marketing after reading about the topic in the e-learning tool. The project group held four presentations on low tunnel production, which reached 300 participants and helped promote the e-learning tool. In addition, two papers will be published in peer-reviewed journals about the process of developing the e-learning tool so that other educators can learn from this project's success.



Strawberry grower Bill Jacobson at Pine Tree Farms conducts a video interview for the e-learning tool.

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## Publications

- [Cold Climate Strawberry Farming e-learning tool](#)

## Websites

- [Project blog](#)
- [Project photos](#)
- [Facebook page](#)
- [Twitter feed](#)

## Video

- [Cold Climate Strawberry Farming Trailer](#)



[Cold Climate Strawberry Farming Trailer](#) (video)





Researchers at UNL establish a winter strawberry trial at Pekarek's Produce Farm.

## Winter production of Nebraska strawberries: an idea whose time has come

### Project Leader

- Ellen Paparozzi, University of Nebraska-Lincoln, Department of Agronomy and Horticulture

### Project Collaborator

- Ryan Pekarek, Pekarek's Produce

### Project Summary

Many Nebraska farmers must work off the farm during the winter to bring in additional income. If winter strawberry production is shown to be profitable, it would provide an opportunity for Nebraska farmers to continue to work on-farm through the winter months. The project team developed and compared a commercial strawberry production system on a grower's farm with a scientifically monitored and ongoing prototype production system at the University of Nebraska-Lincoln. Project objectives were to 1) establish a heated high tunnel production system typical to what specialty crop growers use, tracking all associated costs with construction, production and marketing; 2) test the feasibility of a commercial production timeline for growing strawberries in a heated high tunnel on a production farm, and compare yield data to the university production system in a double-polyethylene greenhouse; and 3) determine gross profit and return on investment for strawberry production and develop a budget for future winter strawberry production under Nebraska conditions. For each experiment, five cultivars were grown on water-conserving capillary mats using automated irrigation and fertilization methods. Dormant crowns were received in early September and planted in a soilless mix. Harvested strawberries were weighed and graded for the fresh market.



A high tunnel is constructed and outfitted for winter strawberry production at Pekarek's Produce Farm.



## Project Outputs and Impacts

The plants were grown in a soilless mix in 6-inch pots utilizing a capillary mat system at both sites and in two different structures — a heated high tunnel and a double-polyethylene greenhouse. High tunnel costs were tracked and a budget was created for high tunnel construction. The cost (\$26,277) was within the proposed estimate. The total cost to build and equip the high tunnel was approximately \$29,000, with the owner and family helping out with labor. The cost to start the crop was \$1.56 per plant, which included labor plus production costs (bees, fertilizer, heat, etc.). Three construction-related videos were filmed and posted on YouTube, and an extension circular was published to aid growers and farmers with constructing a heated high tunnel. Toward the end of the project, a Strawberry Open House was hosted at the grower's farm where produce growers, extension agents, farmers, FFA students and others were invited to visit the heated high tunnel. In total, 98 farmers, 187 extension agents and 283 consumers were reached by this project.



Ryan Pekarek, owner of Pekarek's Produce Farm near Dwight, Nebraska, harvests the first marketable strawberries from his heated high tunnel in October.

## Websites

- [Winter Production of Nebraska Strawberries](#)
- [Controlled Environment Agriculture: Greenhouses, Strawberries and More](#)
- [Project photos](#)

## Publications

- [Constructing a Block and Fence Growing Bench for use with a Capillary Mat Irrigation System for Greenhouse Plant Production](#) (PDF)
- [The Challenges of Growing Strawberries in the Greenhouse](#) (PDF)

## Videos

- [Nebraska Winter Strawberries: Heated High Tunnel Construction](#)
- [Nebraska Winter Strawberries: Capillary Mat Construction](#)
- [Nebraska Winter Strawberries: Bench Construction](#)



[Nebraska Winter Strawberries, Video 1: Heated High Tunnel Construction](#)



Barclay Poling of NC State discusses strawberry production at the Mississippi Strawberry Short Course in Choctaw, Miss.

## Sustainable strawberry production for Mississippi and surrounding markets

### Project Leaders

- William Evans, Mississippi State University, Truck Crops Branch

### Project Collaborators

- Gilbert Thompson, Mississippi Band of Choctaw Indians, Dept. Natural Resources
- James Keller, Peaceful Valley Farm
- Juan Carlos Diaz-Perez, University of Georgia, Coastal Plain Experiment Station

### Project Summary

The objectives of the project were to 1) determine if commercial quality strawberries can be produced for the wholesale market under Mississippi growing conditions using modern production techniques; and 2) develop a core group of growers and educators to support the development of a strawberry production industry in Mississippi. Four cultivar trials were implemented: a replicated organic trial in north Mississippi, a conventional production trial on the lands of the Mississippi Band of Choctaw Indians, an observational trial at Mississippi State Truck Crops Branch, and a training trial for 4-H students in Jackson.

The trials generated valuable yield data and demonstrated several key elements of crop management. Fruit from the organic trial was processed to study postharvest quality traits. This data will help growers determine which cultivars ship and store best when grown under Mississippi conditions. The project team also organized a strawberry short course, led several tours, and hosted individual meetings.



Strawberries ripen in the cultivar trial at Choctaw.



Early season growth of organic strawberry trial at Tupelo, Mississippi, where eight different cultivars were grown.

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Farm staff plant strawberry plugs at the cultivar trial in Choctaw.

## Project Outputs and Impacts

The organic trial at Native Son Farm in North Mississippi revealed significant differences in yield among cultivars, but demonstrated that a well-managed plot of organic strawberries can yield well under state growing conditions. Analysis of post-harvest fruit quality data is underway at the University of Georgia. The project team worked with members of the Mississippi Band of Choctaw Indians on plasticulture techniques to improve crop performance. This is the first use of plastic mulch for an annual crop on the tribal lands. The relationships forged will continue as Choctaw farmers collaborate with a follow-up strawberry study in 2015. The project team introduced 30 high school students in Jackson to strawberry production through a project with the Dr. George Washington Carver Future Scientists 4-H Club and also met with students at the Choctaw reservation. The Strawberry Production Short Course reached 30 people with measurable results in knowledge gained. The project team provided tweets and web content about strawberry production that will remain accessible beyond the project dates. In total, the project reached 20 farmers, 30 extension agents, 50 students, 50 researchers, 20 administrators and 200 consumers. Eight acres of strawberries in the state are under new or improved production management because of this project.

## Websites

- [Project photos](#)



Russ Wallace discusses the benefits of high tunnels for strawberry production at the High Tunnel Strawberry Field Day in Lubbock.

## Revitalization of Texas strawberry industry through identification of production constraints and introduction of new technologies

### Project Leader

- Russell Wallace, Texas A&M AgriLife Research & Extension Center

### Project Collaborators

- Prairie View A&M University – Justin Duncan,
- Texas A&M AgriLife Extension – Monte Nesbitt, Mengmeng Gu, Juan Anciso, Joe Masabni, Pat Porter, Larry Stein, Marco Palma, Barbara Storz, Angel Fattorini, Helen White
- Texas A&M AgriLife Research – Genhua Niu and Daniel Leskovar

### Project Summary

Texas population growth is expected to increase by 6.5 million people in the next seven years, which represents a tremendous income opportunity for small- to medium-sized farmers, especially those considering expansion into horticultural crops such as strawberries. The Texas Strawberry Project addressed this opportunity with objectives to 1) organize and designate strawberry production centers in Texas based on climate and soil delineations and proximity to urban centers; 2) create strawberry

extension and research teams assigned to address specific geographically based needs of the strawberry industry; 3) identify current and potential strawberry growers to serve as survey participants for assessing the needs of producers and industry in Texas; 4) develop production models and research and demonstration trials for each region based on survey results; 5) organize a Strawberry High Tunnel Conference for project collaborators and growers and organize regional Strawberry Field Days for current and potential growers; and 6) organize the collective “best fit” production efforts from each of the strawberry centers into a concise, easy-to-understand guide book.

### Project Outputs and Impacts

The Texas Strawberry Project reached more than 99,000 people by active promotion through newspaper articles, television and radio interviews, magazine articles, and social media. The project also was very active in promoting sustainable strawberry production through a series of field days, meetings, and a High Tunnel Strawberry Conference. In the course of a year the project hosted 22 field days and demonstration trials, which reached more than 300 growers and 50 extension agents with information about how to evaluate irrigation, pH and salinity, select strawberry





[“The Texas Strawberry Project”](#) (video)

plant varieties, construct high and low tunnels, install drip irrigation and plastic mulch, and other topics. A two-day consumer taste and preference survey also was held to evaluate several strawberry varieties. In addition, a 41-page [Production Guide for Texas-Grown Strawberries](#) and an 11-minute video documentary, “[The Texas Strawberry Project](#),” were published. Due to the work of this project team, there are now five new acres of strawberry production in the state and 15 acres that have implemented more sustainable production practices.



Russ Wallace of Texas A&M-Lubbock with Peter Ampim and Billy Lawton of Texas A&M Prairie View visiting collaborating strawberry farms.

Strawberry cooperators Cline at the Food Bank Farm.

## Publications

- [Production Guide for Texas-Grown Strawberries](#)
- R.W. Wallace and C.J. Webb 2013. [Strawberries Grown Under Protected Cultivation on the Texas High Plains](#). J Am Pom Soc. (APS) 67:7-10

## Presentation

- [Revitalization of the Texas Strawberry Industry](#)

## Websites

- [Project Facebook page](#)
- [Project photos](#)

## Video

- [The Texas Strawberry Project](#)





# Project Priority 2

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Reduce the chemical inputs for soil sterilization, fertilization, weed control, and pest management

- **Sustainable strawberry production in the absence of soil fumigation**  
— Thomas Gordon, University of California at Davis
- **Optimizing fumigation rate, application depth, and plastic mulch use for strawberry production in raised-bed systems**  
— Ruijun Qin, University of California
- **Organic open-field and high tunnel strawberry cropping systems for long-term viability of the southeastern industry**  
— Carlene Chase, University of Florida
- **Strawberry diagnostics: a problem solving tool**  
— Brian Whipker, North Carolina State University



Four compost treatments are applied with the help of the University of California farm advisor and his assistant.

## Sustainable strawberry production in the absence of soil fumigation

### Project Leader

- Thomas Gordon, University of California, Davis
- Margaret Lloyd, Graduate Student, University of California, Davis

### Project Collaborators

- Jenny Broome, Driscoll's Strawberry Associates
- Scott Scholer, Lassen Canyon Nursery
- Jack Chambers, Sonoma Worm Farm
- Jim Cochrane, Swanton Berry Farm

### Project Summary

California produces more than 80 percent of fresh strawberries in the United States. Pre-plant soil fumigation using methyl bromide has been critical to this success. However, international regulations require growers to phase out methyl bromide. Consequently, non-chemical alternatives are necessary. Previous work shows promise for managing pathogens responsible for black root rot through compost amendments. Black root rot is not a problem in fumigated soil, and therefore, little was known about the susceptibility of the day-neutral cultivars that dominate the California industry. Therefore, both day-neutral and

short-day strawberry germplasm were evaluated in compost. The objectives of this project were to 1) evaluate the performance of two strawberry cultivars with and without compost amendments in the central coast, north coast and central valley of California; 2) evaluate four types of composts for effect on root health, suppression of black root rot, and effect on microbial communities; 3) develop recommendations for compost application and cultivar



The farm stand of one grower where a field trial is located.





Crowns used for planting showed a wide range of size and development, which was assessed before planting. Root health was also measured at the end of the study.

selection to induce disease suppressive soils based on geographic region; 4) evaluate flavor differences between cultivars based on geographic region and compost amendments; and 5) extend information to growers and other stakeholders through field days and publications.

## Project Outputs and Impacts

The four types of composts used in this study — yard trimmings, manure, vermicompost, and mushroom compost — significantly increased microbial activity and led to greater root development in the field. Over time, the effects of microbial populations of each type of compost on field soil were similar no matter the origin of the native soil. The use of vermicompost led to significantly more root development than the other composts in both field and potted trials. Detailed nutrient and microbial activity profiles for pure compost and compost-amended field soil were



Field assistant Peter Henry collecting plant diameter data in January. Plants were small, with 3-6 leaves, but treatment differences were noticeable.

generated and published. Additionally, significant differences were observed in the growth habits of the two types of strawberry germplasms. By April, the short-day cultivar ('Chandler') had much more vigorous and rapid growth than the day-neutral cultivar ('Albion') at all sites, which was largely attributed to root health. Information generated from this project has been shared through the [project website](#) and at professional meetings, reaching more than 130 growers, researchers and industry professionals.



[Pivotal Times: The California Strawberry and Research on Compost for Strawberry Health](#) (video)

## Publications

- [Research Summary](#)
- [Project poster](#)

## Presentation

- [Evaluation of Compost on Strawberry Root Health and Plant Growth](#)

## Websites

- [Gordon Lab website](#)
- [Project photos](#)

## Video

- [Pivotal Times: The California Strawberry and Research on Compost for Strawberry Health](#)





## Optimizing fumigation rate, application depth, and plastic mulch use for strawberry production in raised-bed systems

### Project Leader

- Ruijun Qin, University of California-Davis, USDA-ARS, Water Management Research

### Project Collaborators

- Oleg Daugovish, University of California, Ventura County Cooperative Extension
- Suduan Gao, U. S. Department of Agriculture, ARS, Pacific West Area

### Project Summary and Objectives

Soil fumigation is an important practice used on commercial strawberry farms to control soil-borne pathogens and nematodes that decrease plant productivity. More than 55 percent of California strawberry fields are treated with fumigants applied directly through drip irrigation lines buried near the surface of the beds prior to planting. In

the face of international pressure to phase out the most commonly used fumigant, methyl bromide, growers find themselves pressed to maximize the efficiency of allowable fumigants. In this project, Qin's team looked at the tarps used to restrict fumigants in the soil and the drip lines used to distribute those chemicals. Their objectives were to 1) compare the impact of drip-line placement on fumigant distribution and emissions in soil; 2) demonstrate that the use of totally impermeable film (TIF) tarp in drip fumigation can improve fumigant efficacy compared to standard polyethylene (PE) tarp; 3) evaluate the performance of recycled plastics film (RPF) on fumigant distribution in soil and fumigant emissions; 4) evaluate pest control efficacy under standard PE, TIF and RPF tarp from two different injection depths and application rates; and 5) monitor strawberry plant growth, root development and yield from different fumigation treatments in growers' fields. The study was conducted at DJ Ranch of Solimar Farms in Camarillo, Calif.

## Project Outcomes and Impacts

Results showed that TIF reduced fumigant emission effectively. Half-rate fumigant concentration under TIF was similar to or higher than fumigant concentration applied at full rate under PE. These findings suggest that using TIF may help growers reduce fumigant input while achieving comparable pest control results. Fumigant emissions were reduced even further when applied deeper in the soil (7 inches), as opposed to the shallow application (2 inches) typically practiced. Various outreach methods were used to extend the research findings to growers, regulators and extension specialists. Findings from this study were shared with more than 800 participants at workshops, field days and conferences, including the 2013 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, the 2014 California Plant and Soil Conference, the Water Management in Strawberry field day and educational meeting and the Organic Strawberry Workshop at Tennessee State University. This project demonstrated that strawberry growers safely can reduce their chemical inputs by adopting lower fumigant rates under TIF for effective pest control.



Ruijun Qin takes photos of strawberry beds to measure the effectiveness of various fumigation treatments.

## Presentations

- [Sustainable Strawberry Project Presentation](#)
- [Plant & Soil Conference Poster Feb 2014](#)
- [Optimizing Drip Fumigation through Deep Application and Totally Impermeable Film Covering for Strawberry Production](#)
- [Organic Strawberry Workshop Presentation](#) (Video)

## Website

- [Project photos](#)

## Video

- [California Strawberry Production](#)



[California Strawberry Production](#) (video)





Participants of the Growers' Assessment Event in Citra, Fla. write down observations of strawberry cultivars.

## Organic open-field and high tunnel strawberry cropping systems for long-term viability of the southeastern industry

### Project Leaders

- Carlene Chase, University of Florida, Horticultural Sciences Department
- Xin Zhao, University of Florida, Horticultural Sciences Department
- Oscar E. Liburd, University of Florida, Department of Entomology and Nematology
- Zhifeng Gao, University of Florida, Food and Resource Economics Department
- Marilyn E. Swisher, University of Florida, Department of Family, Youth and Community Sciences



### Project Collaborators

- Sambhav Sambhav, Driscoll Strawberry Associates, Inc.
- Marty Mesh, Florida Certified Organic Growers and Consumers, Inc.
- Sanjun Gu, North Carolina A&T State University

### Project Summary

The goal of this project was to determine the efficacy and suitability of cover crops in organic strawberry production to suppress weeds and nematodes and to improve soil quality and health. Eight strawberry cultivars were evaluated in four cover crop treatments. Cultivars were evaluated by plant growth parameters, fruit yield components and fruit quality attributes throughout the season. Sensory tests and an online survey were used to gather public opinion of these cultivars. Strawberries were grown in both open field and high tunnel systems. Organic pest management strategies using predatory species and trapping methods were developed to replace chemical pesticides. Trap and lure

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Weeds are counted and identified to quantify the effectiveness of cover crops in weed suppression.





[Organic Strawberry Cropping Systems for the Southeast](#) (video)

monitoring systems were used in the strawberry fields to target low populations of spotted-wing drosophila. Organic pest management tactics in the high tunnels included the use of the predatory mite *Neoseiulus californicus* for control of the two-spotted spider mite and cyclamen mite. Information gathered by this project was disseminated to the public through field days, workshops and seminars.

## Project Outputs and Impacts

The project team found that growers have options when it comes to rotating cover crops with an organic strawberry crop. Sunn hemp resulted in the tallest cover crops and the greatest amount of above ground biomass. However, hairy indigo and American joint vetch performed just as well at suppressing weeds. More than 200 growers were reached through trainings at five workshops and four field days, and 10 new acres of organic strawberries were put into production by farmers involved with the project. A spotted wing drosophila (SWD) symposium was organized at the Florida Entomological Society meeting with a discussion about monitoring and attractiveness of baits for assessing SWD populations in strawberries. The cover crops and strawberry varieties that had the best resistance to two-spotted spider mite were selected and advanced to a Phase II study. A national industry magazine, "[Growing Produce](#)," used the project press release for a feature article in their electronic magazine, reaching more than 14,000 readers. More than 2,700 consumers were reached through

the sensory test and online survey. Those results revealed that consumers are willing to pay more for sustainably produced strawberries than those that are conventionally grown. This information is valuable to growers who are considering the switch to sustainable farming methods in order to improve profitability.

## Publication

- [Weed Science Society of America 2014 Meeting Abstract](#)

## Presentation

- [Organic Open-Field and High Tunnel Strawberry Cropping Systems Presentation](#)

## Website

- [Project photos](#)

## Videos

- [Organic Strawberry Cropping Systems for the Southeast](#)
- [Cover Crops for Organic Strawberry Production](#)
- [Pest Management for Sustainable Strawberries](#)
- [Cultivar Assessment for Organic Strawberry Production](#)



Xin Zhao photographs strawberries for appearance quality and morphology characteristics.



## Strawberry diagnostics: a problem solving tool

### Project Leader

- Brian Whipker, North Carolina State University, Department of Horticultural Science

### Project Collaborators

- Barbara Shew, North Carolina State University, Department of Plant Pathology
- Hannah Burrack, North Carolina State University, Department of Entomology
- Jeremy Pattison, North Carolina State University, Plants for Human Health Institute
- Frank Louws, North Carolina State University, Department of Plant Pathology
- Rhonda Conlon, North Carolina State University, Cooperative Extension Information Technology

### Project Summary

The goal of this project was to create an online diagnostic key to enable growers to identify problems associated with strawberry production. Strawberry growers are often faced with unknown plant disorders during the production season. A comprehensive,

problem-solving identification tool will aid in rapid identification of arthropod, disease, physiological, and nutritional disorders and allow growers to select the most appropriate management strategy. The single objective of this project was to create an online diagnostic tool for strawberry growers to identify production problems, reduce chemical inputs, minimize crop loss, and improve profitability. This will enable growers to check off symptoms that appear on their crop in order to come up with a problem diagnosis. While there had been prior studies completed which investigate nutritional disorders, none of those images are available on the web. This has hin-

dered past efforts of growers to be able to identify nutritional disorders unless they owned a paper guide. This project overcomes that limitation by providing funding to induce those disorders and obtain problem photographs. With the inclusion of newly created nutritional disorder information, it enables the key to become holistic in its approach to problem diagnosis for strawberries.



Botrytis gray mold symptoms on a ripe strawberry in the field.

### Project Outputs and Impacts

This project developed the first interactive, attribute-driven diagnostic tool for strawberry disorders. The [Strawberry](#)





The Strawberry Diagnostic Key allows users to easily determine an observed disorder by checking off visible symptoms.

and uploaded onto the [NSSI YouTube channel](#).

## Websites

- [Strawberry Diagnostic Key](#)
- [Diagnostic Videos on YouTube](#)
- [NCSU Strawberry Growers Information website](#)

## Videos

- [Nitrogen vs Phosphorous Deficiency](#)
- [Iron Deficiency](#)
- [Potassium Deficiency](#)
- [Boron Toxicity](#)
- [Nitrogen vs Sulfur Deficiency](#)
- [Iron vs Sulfur Deficiency](#)
- [Sulfur Deficiency](#)
- [Leaf Tissue Testing](#)
- [Anthracnose crown rot — initial infection](#)
- [Anthracnose crown rot — advanced symptoms](#)
- [Anthracnose fruit rot \(\*Colletotrichum acutatum\*\)](#)
- [Black root rot field diagnosis](#)
- [Inducing sporulation of fungi](#)
- [Applying Predatory Mites](#)

[Diagnostic Key](#) is free to the public on the North Carolina Cooperative Extension's online [Strawberry Grower's Information](#) portal. It uniquely includes all disorders, including those caused by insects, disease, nutrition or physiological factors. The key is viewable from a desktop, laptop, tablet, or smart phone. Users simply check the boxes next to the symptoms they observe in their crop, and the key deduces the most likely causes, providing fact sheets for more information. In total, there are 77 fact sheets, including 22 for arthropods, 19 for diseases, 14 for nutritional disorders, and 19 for physiological disorders. In addition, nine videos about strawberry problem diagnostics have been recorded



[Strawberry Diagnostics: Anthracnose crown rot — initial infection](#) (video)

# Project Priority 3

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Conserve and preserve water resources used in the production system

- **Placement of additional drip lines to enhance soil fumigation and irrigation efficiency and minimize environmental impacts**  
— Oleg Daugovich, University of California Cooperative Extension





The strawberry irrigation trial in Ventura County, Calif. investigated the water savings from doubling the number of drip lines used for strawberry irrigation.

## Placement of additional drip lines to enhance soil fumigation and irrigation efficiency and minimize environmental impacts

### Project Leader

- Oleg Daugovish, University of California, Ventura County Cooperative Extension

### Project Collaborator

- Dan Legard, California Strawberry Commission

### Project Summary

The current multi-year drought in California and other western states has necessitated an urgent need for water conservation by the region's strawberry farmers. Those same growers are faced with pressure to adopt new pesticide strategies as international regulations phase out the use of methyl bromide, the standard practice for controlling soil-borne pathogens and nematodes. Some of the new alternative fumigants being implemented can be applied via the same drip lines used for irrigation. Studies in Southern California and Florida reveal that optimizing the number and placement of drip lines can significantly improve fumigation efficacy, establish plants without sprinkler irrigation (which can spread disease), and



A flow meter measures the water input for strawberry irrigation.

eliminate runoff and the associated environmental pollution. Expanding on this concept, the research group looked at fumigation efficacy and strawberry establishment in relation to the number of drip lines placed in three locations in the largest strawberry production regions in California. Research findings and information was then disseminated to growers.

### Project Outputs and Impacts

Research from this project showed that doubling the number of drip lines instead of using traditional overhead sprinklers during strawberry plant

establishment saves 20 to 67 percent of water needed and minimizes runoff. It was also discovered that the standard drip tape practice leads to inadequate distribution of generally effective fumigants and water, which allows for the survival of damaging soil-borne pathogens in some parts of the beds; this can lead to infection and eventual widespread plant collapse. A field-ready system designed to easily integrate with current production was created along with an accompanying brochure, [Best Management Practice for Water Quality](#), with more than 200 copies



[Doubling the Number of Irrigation Drip Tapes in Strawberry Beds](#) (video)

distributed. Collaboration with the California Strawberry Commission (CSC) and the Farm Bureau resulted in field days that showcased the project and awarded attendees water education credit hours. Daugovish discussed the progress of the project and received grower feedback from 28 attendees at a focus meeting hosted by the CSC. Ninety-six attendees learned about the project at the 2013 Fumigants and Alternatives meeting in Ventura, Calif. All of these outreach activities were supported by the CSC and included translation into Spanish. A video was produced to display key points of the project. Overall, 600 farmers (including industry leaders) and half a million consumers were reached by this project.

## Websites

- [Ventura County Extension Strawberry page](#)

## Presentations

- [Placement of Additional Drip Lines to Enhance Soil Fumigation and Irrigation Efficiency and Minimize Environmental Impacts](#)
- [Strawberry Establishment Period: More Drip, Less Sprinkler](#) (PDF)

## Publication

- [Best Management Practices to Protect Water Quality: A Guide for California Strawberry Growers](#)

## Video

- [Doubling the Number of Irrigation Drip Tapes in Strawberry Beds](#)



Strawberry roots are washed to determine the biomass of new roots under different irrigation regimes for plant establishment.



# Project Priority 4

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Improve soil quality and health in the production system for succeeding crops

- **Sustainable soil management practices for strawberries: evaluation of individual and integrated approaches**
  - Michelle Schroeder-Moreno, North Carolina State University



Inoculated strawberry plugs grow in the greenhouse on NCSU's campus before being planted in the field.

# Sustainable soil management practices for strawberries: evaluation of individual and integrated approaches

## Project Leaders

- Michelle Schroeder-Moreno, North Carolina State University, Department of Crop Science
- Amanda L. McWhirt, Graduate Student, North Carolina State University

## Project Collaborators

- Debby Wechsler, North Carolina Strawberry Association
- Gina E. Fernandez, North Carolina State University, Department of Horticultural Science
- Yasmin Judith Cardoza, North Carolina State University, Department of Entomology
- Hannah J. Burrack, North Carolina State University, Department of Entomology

## Project Summary

Soil-borne pathogens, weeds, and nematodes can reduce strawberry yields, especially when strawberries are replanted on the same site year after year without rotation. These challenges are intensified in the Southeastern U.S. where warmer temperatures and poorer soils result in increased pest pressure. Research on sustainable and biologically-based approaches to soil and pest management practices is currently lacking for both conventional and

organic strawberry growers, especially in the SE region. The purpose of this project was to examine the individual and integrated effects of sustainable soil and pest management practices of composts, summer cover crops, and beneficial soil inoculants (vermicomposts and arbuscular mycorrhizal fungi) on parameters that indicate successful production. These concerns were approached with objectives to 1) examine the effects of the sustainable soil and pest management practices on strawberry yields, growth,



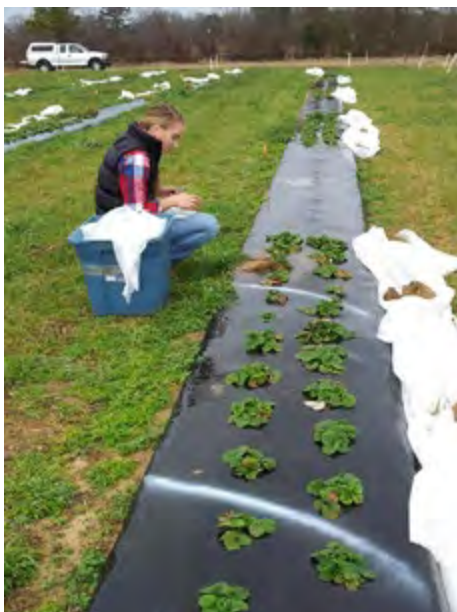
Cover crops (cow pea and pearl millet) are mowed down with a flail mower before being tilled in to prepare the field for strawberry beds.



nutrient uptake, fruit quality, above-ground arthropod pests, soil quality and economic indicators; and 2) promote the transfer of this technical and educational knowledge to farmers, extension agents, researchers and students.

## Project Outputs and Impacts

The research group monitored strawberry plant growth, soil nutrients, diseases, pollinator visits, and mycorrhizal colonization of roots. At the end of harvest soil samples were taken for soil nutrient analysis, aggregate stability and mycorrhizal fungal diversity. Total and marketable fruit yields for each treatment were also measured. The team was able to generate more activity than originally proposed. Five extra magazine and online articles on this research were generated in addition to a North Carolina Strawberry Association newsletter. A short [informational video](#) on plug production with beneficial inoculants (mycorrhizas and vermicompost) was produced and currently has 558 views on YouTube. Weekly



Sarah Wiebke, a student worker on the project, collects strawberry biomass samples from the research plots in January.

strawberry harvests from the field project were donated to the North Carolina Expanded Food and Nutrition Education Program (EFNEP) that reached low-income individuals, families and children in the community. It is estimated that about 150,000 consumers were reached through the News & Observer Newspaper article, social media, and the video on YouTube. An [online webinar](#) on the use and implementation of sustainable soil and pest management practices was attended live by 20 people from around the country. The recording remained available to the public, and has since been viewed 238 times.

## Websites

- [Schroeder-Moreno Mycorrhiza Lab](#)
- [Project Facebook page](#)
- [Project photos](#)

## Videos

- [The Use of Beneficial Soil Inoculants for Strawberry Tip Production](#)
- [Recorded Webinar: Incorporating Sustainable Practices into Plasticulture Strawberry Production](#)



[The Use of Beneficial Soil Inoculants for Strawberry Tip Production](#) (video)

# Project Priority 5

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Reduce the risk of human health pathogens spread on fresh berries

- **Developing the logistics for producing human pathogens-free organic strawberries in the state of Tennessee**
  - Suping Zhou, Tennessee State University





Research associate Christine Moore conducts a strawberry taste test comparing locally-grown and store-bought strawberries at the Portland Strawberry Festival in Portland, Tenn.

## Developing the logistics for producing human pathogen-free organic strawberries in the state of Tennessee

### Project Leaders

- Suping Zhou, Tennessee State University, Department of Agricultural and Environmental Sciences

### Project Collaborators

- Theodore Thannhauser, USDA-ARS, Plant, Soil and Nutrition Research Unit

### Project Summary

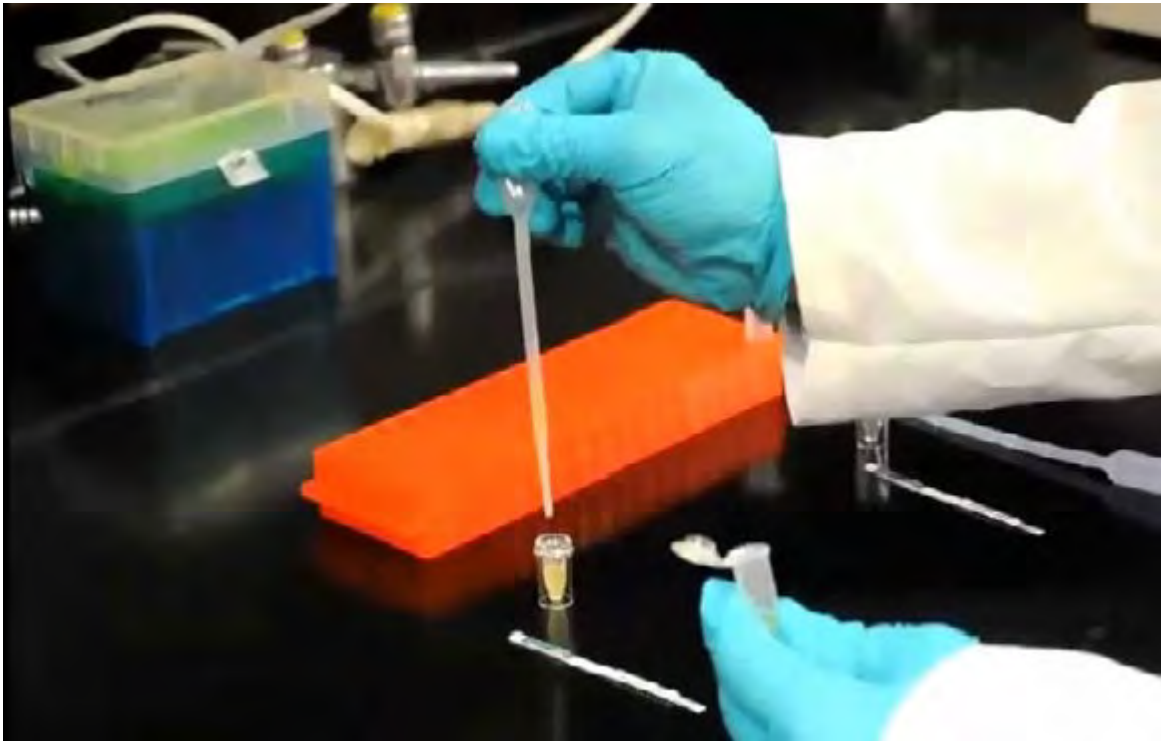
The primary goal of this project was to establish a system to assist local small-scale strawberry growers to develop a sustainable business in the middle Tennessee area. Two approaches were taken, including developing a system to reduce the risk of food poisoning caused by contamination



Strawberries picked and ready for sale at McCraw's Strawberry Ranch in Clarksville, Tenn.

of fresh strawberries, and assisting local growers with adoption of management practices for organic strawberry production. Specific objectives were to 1) determine microbial populations, particularly human pathogens, on fresh strawberries; 2) identify the potential points of contamination during production, shipping, and marketing; 3) determine the feasibility of developing a detection kit using protein dipsticks, which can rapidly and reliably test for the presence of human pathogens on fresh strawberries; and 4) develop teaching modules for sustainable organic strawberry

production, consisting of best management practices, food safety protocols, and new proven technologies, to be used by the cooperative extension service throughout Tennessee.



[Demonstration of Dipstick Assay](#) (video)

## Project Outputs and Impacts

Through this project, researchers developed a reliable tool for the detection of *Salmonella* and *Listeria* using a protein dipstick assay that can be used in the lab or in the field. This technology was delivered, via workshops, demonstrations and social media, to more than 3,000 people. The project also laid the groundwork for an aptamer-based detection system for *E. coli* and other pathogens that are more difficult to detect with the dipstick assay. Ten extension agents and eight farmers in five counties in middle Tennessee were trained in growing organic strawberries. Five cultivars were evaluated for yield and market potential as indicated by consumer preferences. Project leaders recommend 'Albion' and 'Chandler' because of their high yield and high consumer rating. A series of social media resources were developed to disseminate research results, including a [Facebook page](#), a [photo site](#), and a [project website](#). Videos were recorded for the social media sites and a number of demonstrations and workshops were given. Eight surveys were designed and conducted to explore consumers' taste preferences and awareness of food safety issues. Information was delivered through mail and survey sheets to more than 1,000 community members. Graduate students and faculty members led six presentations at regional and international conferences. Thirty acres of strawberries are now under new or improved management, paving the way for sustainable strawberry production in the Middle Tennessee area.

## Websites

- [Project website](#)
- [Facebook page](#)
- [Project photos](#)

## Video

- [Demonstration of Dipstick Assay](#)



McCraw's Strawberry Ranch in Clarksville, Tenn. was a site of experimental plots for the TSU strawberry project.



# Project Priority 6

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Reduce the postharvest product loss through the supply chain from production through distribution and sales

- **Reducing strawberry waste and losses in the postharvest supply chain via intelligent distribution management**  
— Jeffrey Brecht, University of Florida



Graduate student Francisco Loayza inspects Florida strawberries in the field during harvest and assigns quality ratings.

## Reducing strawberry waste and losses in the postharvest supply chain via intelligent distribution management

### Project Leader

- Jeffrey Brecht, University of Florida, Horticultural Sciences Department

### Project Collaborators

- Cecilia Nunes, University of South Florida, Department of Cell Biology, Microbiology and Molecular Biology
- Ismail Uysal, University of South Florida, College of Engineering
- Jean-Pierre Émond, University of Florida, Department of Agricultural and Biological Engineering
- Jeff Wells, Franwell, Inc.
- Jorge Saenz, Hussmann Corporation
- Gary Campisi, Walmart Stores

### Project Summary

Deterioration of strawberry quality during distribution can lead to consumer dissatisfaction, product losses and reduced sales. Quality deterioration is most strongly related to initial condition, temperature, and time from harvest to

consumer. The project team developed a shelf life model that uses the temperature history to predict remaining shelf life above a given quality level under various conditions, enabling intelligent distribution using a “First-Expired, First-Out” (FEFO) logistical approach. The applicability of this approach to strawberry distribution within the supply chain was demonstrated in terms of model accuracy, improved and more consistent quality, loss reduction and increased consumer satisfaction and sales. To carry out this project, supply chain tests were conducted in which the team evaluated initial quality and placed radio-frequency identification (RFID) temperature tags in strawberry flats at the farm site, then tracked temperature from fields to cooling facilities to distribution centers to stores and conducted additional quality evaluations at the distribution centers. The team conducted simulations using best- and worst-case scenarios to show how likely consumers will be to purchase strawberries from each lot and handling scenario. Results showed that consumers will be more satisfied with strawberries distributed to stores using a FEFO system based on quality and projected shelf life compared to the current “First In, First Out” (FIFO) practice.





Ricardo Badia and Francisco Loayza inspect freshly harvested strawberries in California and assign quality ratings.

## Project Outputs and Impacts

To accomplish project objectives, project team members met with the Walmart quality control team to get feedback and discuss how to meet the project objectives working within the Walmart system. A plan for testing the temperature and quality of shipments from farm to distribution center was established with Walmart quality control and two strawberry suppliers. A total of eight shipping tests were conducted from Dole Berry Farms in Florida to a distribution center in Illinois and from Eclipse Berry Farms in California to distribution centers in Washington, Alabama and South Carolina. Strawberries were inspected for quality using a visual quality chart at the field packing site and tracked with RFID temperature tags. At the distribution center, the strawberries were then re-inspected for quality and the temperature data was recorded. Variations

in temperature between pallets in the same shipment were shown to be considerable, leading to quality variations at the store and consumer levels. Simulations were conducted using the strawberry shelf life model and the temperature and quality data collected in the shipping tests to predict the remaining shelf life under various circumstances and using logistics such as FEFO compared to FIFO. Results indicated that the greater the variability among pallet temperatures within a trailer, the greater the benefits of using FEFO distribution instead of FIFO distribution to stores. As a result of this project, the concepts of FEFO were introduced to Walmart and the company is considering managing distribution center strawberry inventory on a pallet basis rather than the current trailer basis.

## Presentation

- [Reducing Strawberry Waste and Losses in the Postharvest Supply Chain via Intelligent Distribution Management](#)

## Video

- [Reducing Strawberry Waste and Losses in the Supply Chain](#)



[Reducing Strawberry Waste and Losses in the Supply Chain](#) (video)

# Project Priority 7

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Increase product value and economic return to growers and participants through the supply chain

- **Improved variety selection and sustainability of strawberries for the eastern United States** — Peter Nitzsche, Rutgers Cooperative Extension
- **Strawberry grower education and adoption of research innovations: technology transfer of production recommendations**  
— Penny Perkins-Veazie, North Carolina State University





Project Manager Jessica Buitrago and agricultural worker Jennifer Fisher plant a field trial at Snyder Research and Extension Farm in Pittstown, N.J. to test the performance of new advanced strawberry selections developed by Rutgers NJAES in comparison to current commercial varieties.

## Improved variety selection and sustainability of strawberries for the eastern United States

### Project Leaders

- Peter Nitzsche, Rutgers Cooperative Extension
- William Hlubik, Rutgers Cooperative Extension

### Project Collaborators

- Robert Swanekamp, Kube-Pak Corp.
- Timothy Nourse, Nourse Farms, Inc.

### Project Summary

Strawberry growers in the eastern U.S. need improved strawberry varieties to increase production and capture more of the regional market. Because of this, the Rutgers New Jersey Agricultural Experiment Station has invested in a long-term strawberry breeding program. This project expedited the evaluation of strawberry breeding selections by implementing 10 farmer observation trials on both organic and conventional farms, four university replicated trials, and consumer taste tests to provide a more rapid release and commercialization of improved cultivars. As a result, three advanced selections have been processed for patenting and will be released to the public. Additionally, this project tested larger scale propagation and distribution of nursery stock to two commercial nurseries. A series of videos were produced documenting progress of the project to educate farmers, nurserymen and consumers. More than 700 farmers, 66 extension educators, 1,000 consumers and others were reached through project activities and made aware of new Rutgers strawberries that may be available in the near future.

### Project Outputs and Impacts

As a result of this project, 10 farmers gained firsthand experience in growing the advanced strawberry selections on their farms and observed performance in their production systems. Ninety-seven farmers learned about the selections at three twilight educational meetings. An additional 616 farmers gained knowledge of the strawberry selections and their potential through winter educational meetings and grower newsletters. Nearly 150 consumers participated in taste tests comparing advanced selections to commercial varieties. Based on production trials and taste test results, the Rutgers team applied for patents for three advanced selections with the U.S. Patent and Trademark Office. Foundation stock material of three advanced selections were maintained for commercial nurseries. Two nurseries have requested licensing agreements to begin commercial production of one of the selections and have expressed interest in agreements for the others. Consumers learned about local strawberry production through tours, TV programs, radio segments, newspaper articles, educational videos, taste panels and Web-based press releases. Some 115 researchers and extension personnel gained knowledge about the project and the new strawberry selections through presentations at meetings and conferences. This has helped create a stronger research and extension network to advance regional sustainable strawberry production and strawberry variety development. Nearly 300 students and 53 Master Gardeners were made aware of the project through educational opportunities. They can use their increased knowledge of sustainable strawberry production to inform a greater audience.

Farmer David Specca inspects one of the new strawberry varieties, which was developed by the Rutgers University NJAES team and is now being trialed on his farm in Springfield Township, N.J. Specca commented, "These berries have consistently better flavor and for our farm market and pick-your-own farm, that is exactly what the customers want."

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## Publications

- [Rutgers New Jersey Agricultural Experiment Station \(NJAES\) Receives Funding for Strawberry Research](#)
- [Rutgers Fresh Strawberry Consumer Study — 2014 Growing Season](#)
- [What's in Season from the Garden State: Jersey Strawberries — The Breed Goes On](#)

## Presentation

- [Improved Variety, Selection and Sustainability of Strawberries for the Eastern United States](#)

## Videos

- [Rutgers Cooperative Extension Strawberry Project — First Quarter Report](#)
- [Rutgers Cooperative Extension Strawberry Project — Second Quarter Report](#)
- [Rutgers Cooperative Extension Strawberry Project — Final Report](#)

## Grower Cooperators

- Alstede Farms, Chester, N.J.
- Donaldson Farms, Hackettstown, N.J.
- Fernbrook Farms, Chesterfield, N.J.
- Giamarese Farm, East Brunswick, N.J.
- Hauser Hill Farms, Old Bridge, N.J.
- Hlubik Farms, Chesterfield, N.J.
- Honey Brook Organic Farm, Pennington, N.J.
- Simonson Farms, Cranbury, N.J.
- Specca Farms, Springfield, N.J.
- VonThun Farms, Monmouth Junction, N.J.

## Additional Test Sites

- Rutgers Cooperative Extension of Middlesex County, North Brunswick, N.J.
- Snyder Research Farm, Pittstown, N.J.
- Horticultural Crops Research Station, Castle Hayne, N.C.
- Wye Research and Education Center, Queenstown, Md.
- University of Maine (under David Handley)
- Penn State University (under Kathy Demchak)



[Rutgers Cooperative Extension Strawberry Project — Final Report](#) (video)





The Plants for Human Health Institute developed a simple, cost-effective post-harvest kit for growers and researchers to gauge the quality of strawberries in the field before they go to market.

## Strawberry grower education and adoption of research innovations: technology transfer of production recommendations

### Project Leaders

- Penelope Perkins-Veazie, North Carolina State University, Plants for Human Health Institute, Department of Horticultural Sciences
- Jeremy Pattison, North Carolina State University, Plants for Human Health Institute, Department of Horticultural Sciences

### Project Collaborators

- Gina Fernandez, North Carolina State University, Department of Horticultural Sciences
- Jonathan R. Baros, North Carolina Cooperative Extension, Plants for Human Health Institute
- Leah Chester-Davis, North Carolina State University Plants for Human Health Institute, Communications and Community Outreach
- Powell Smith, Clemson University Cooperative Extension
- Elizabeth Ponce, Lassen Canyon Nursery
- Debby Wechsler, North Carolina Strawberry Association
- Roy Flanagan, Virginia Cooperative Extension

### Project Summary

This project addressed three areas of strawberry production and post-harvest handling for North Carolina and the mid-South. The project objectives included developing



Dr. Jeremy Pattison, NCSU strawberry breeder and assistant professor visits a strawberry research plot.



[Postharvest Quality, Handling & Containers](#) (video)

improved production practices to stabilize yield variability due to weather; developing inexpensive and energy efficient cooling systems and improving fruit quality management; and mitigating financial risk while demonstrating the economic impacts of production improvements. As a result of this project, a fall growing degree-day (GDD) model was validated, identifying the best planting date and timing of row cover placement. The model was tested in three locations in North Carolina and yields were maximized when predicted planting dates were followed. Use of a heavy weight row cover increased yields an average of 37 percent. The yield of 'Camarosa,' which tends to have lower yields than 'Chandler,' was most improved by row cover. In contrast, Chandler had the least yield improvement with row cover. Postharvest shelf life of fully ripe and cooled fruit was seven days at 35° F. Use of the Pack 'N Cool trailer, set at 40° F, lowered fruit temperatures by 15° F within 60 minutes. A total of 402 growers, 56 extension agents and 235 students were affected by this research through on-farm work, a strawberry school and strawberry meetings.

## Project Outputs and Impacts

This project engaged eight growers in three states (N.C., Va., S.C.) in on-farm trials to test and develop planting recommendations that minimize yield fluctuations for the predominant cultivars in production, 'Camarosa' and 'Chandler.' A fall growing degree-day model was tested and recommendations were made for autumn planting and row cover placement based on the model. Because of the unusually harsh winter conditions the quality and weight of row covers was reassessed. It is now recommended to use

row covers with a minimum weight of 1.25 oz/yd<sup>2</sup>. Using these recommendations, a 37 percent increase in yields across 10 varieties was obtained. These locally harvested, fully ripe strawberries can be held 7 to 14 days at 35° F when promptly cooled. A demonstration of an easy-to-build cooling trailer, ideal for small and mid-sized growers, showed a 10° F drop in temperature within 30 minutes. By using these recommended practices for planting and row covers for increased yield and by using rapid cooling of fruit for improved fruit quality, growers can increase their bottom lines. These ideas were shared at the North Carolina Strawberry Association meeting, the 2014 Virginia Strawberry School and field days in the two states. Each of the growers involved with the project will continue to use the GDD model for planting and row covers. At least two of the growers have constructed the portable cooling trailer to rapidly cool berries and improve shelf life.

## Websites

- [NCSU Strawberry Growers Information website](#)
- [Project photos](#)

## Presentation

- [Strawberry Grower Education and Adoption of Research Innovations](#)

## Videos

- [Pack 'N Cool & Cold Storage Practices](#)
- [Postharvest Kits for Fresh Produce Quality](#)
- [Postharvest Quality, Handling & Containers](#)



# Project Priority 8

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Implement meaningful and constructive metrics for strawberry production sustainability

- **Creating life cycle inventory datasets to support meaningful and constructive strawberry production sustainability metrics**
  - Ganti Murthy, Oregon State University



Life cycle analysis shows that California has the lowest environmental impact per kg of strawberries produced.

## Creating life cycle inventory datasets to support meaningful and constructive strawberry production sustainability metrics

### Project Leader

- Ganti Murthy, Oregon State University, Department of Biological and Ecological Engineering

### Project Collaborators

- Daniel Legard, California Strawberry Commission
- Kathleen Demchak, Pennsylvania State University, Department of Horticulture
- Jayson Harper, Pennsylvania State University, Department of Agriculture Economics
- Joyce Cooper, University of Washington, Department of Mechanical Engineering, Department of Civil and Environmental Engineering
- Brian Hsu, Agricultural Research Service, USDA, National Agricultural Library
- Susan McCarthy, Agricultural Research Service, USDA, National Agricultural Library

### Project Summary

Life-cycle based sustainability metrics for strawberry production are important for continuous environmental and economic improvement, especially as product environmental attributes become a factor in trade. Robust data that support life-cycle based metrics are needed to implement meaningful and constructive sustainability metrics, yet such data do not yet exist for strawberry production or specialty crops as a whole. Therefore, the focus of the project was to 1) investigate state strawberry crop budgets as a formal and reliable source for data; 2) test the data using life-cycle assessment (LCA) results; and 3) suggest sustainability metrics for U.S. strawberry production. Data was collected using an “LCA extended crop budget” to standardize enterprise budget data collection among the top 10 strawberry producing states. Results indicate that LCAs for

strawberry production can be performed only with datasets specific to location because the production systems are significantly different across the regions. The LCA results and sustainability metrics will be peer reviewed and publicly disseminated through the USDA-National Agriculture Library LCA Digital Commons.

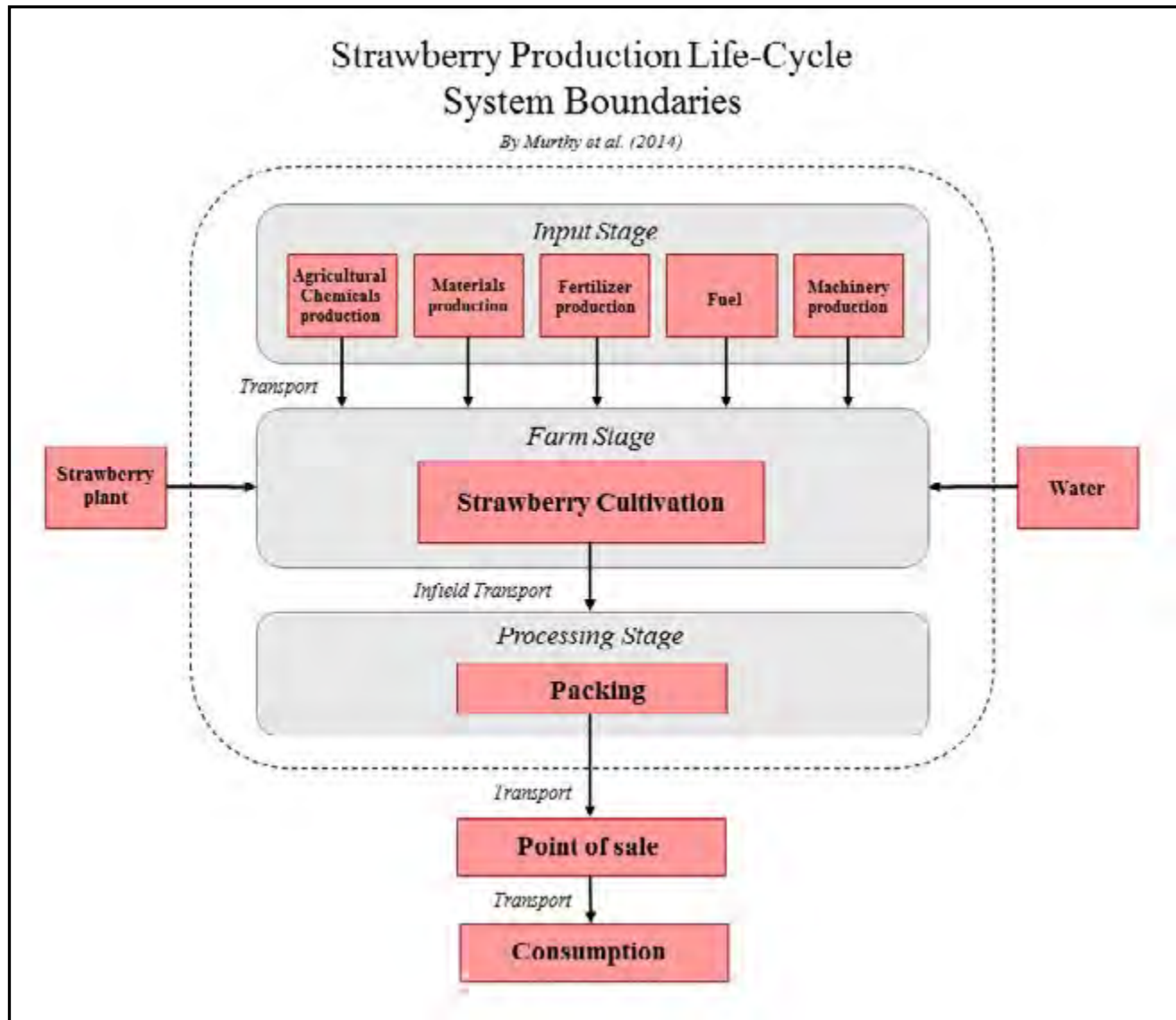
### Project Outputs and Impacts

Enterprise crop budgets from the top 10 strawberry producing states, including California, Florida and North Carolina, were collected and standardized for the LCA Extended Crop Budget tool. Using the data collected with the Crop Budget Tool and existing crop budgets, life-cycle inventory (LCI) data for three strawberry crop management practices were developed for California, Florida and North Carolina. Environmental impacts were quantified using the Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) assessment method. The results indicate that California production has the lowest environmental impact and Florida the highest, largely due to high yields in California and high chemical use in Florida. The use of plastic mulch had the highest contribution to environmental impacts in California, while fertilizers and chemicals had the highest environmental contribution in Florida strawberry production. Materials and fuel use dominated the contribution to environmental impacts in North Carolina strawberry production. Strawberry yield is the determining factor in the LCA analysis; therefore, any strategy to increase strawberry yields without increasing energy intensive inputs would reduce environmental impacts with the LCA. While the LCA can sufficiently analyze crop budgets within a particular state, caution must be used when comparing budgets from multiple states, as methods for data collection may vary.



## Environmental impacts for 1 kg of strawberry production

LCIA category	Unit	California	Florida	North Carolina
Acidification	moles of H <sup>+</sup> eq	0.0370	0.2086	0.1731
Global Warming	g CO <sub>2</sub> eq	64.67	412.69	308.22



## Presentations

- [Life cycle assessment of U.S. strawberry production \(PDF\)](#)
- [Developing Life Cycle Inventory Data for Science-Based Strawberry Production Sustainability Metrics](#)

## Website

- [Project website](#)

## Videos

- [Strawberry Enterprise Budget Tutorial, Part 1](#)
- [Strawberry Enterprise Budget Tutorial, Part 2](#)

## APPENDIX I – Production Resources

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### Publications

- [Best Management Practices to Protect Water Quality: A Guide for California Strawberry Growers](#), by Maren J. Mochizuki, Lea Corkidi, Oleg Daugovich, Julie P. Newman, Donald J. Merhaut, and Darren L. Haver
- [Cold Climate Strawberry Farming](#), First Edition, by the University of Minnesota
- [Constructing a Block and Fence Growing Bench for use with a Capillary Mat Irrigation System for Greenhouse Plant Production](#), by Stacy A. Adams and Ellen T. Paparozzi
- [Production Guide for Texas-Grown Strawberries](#), by Russ Wallace and Juan Anciso

### Tools

- [Interactive Sustainable Strawberry Budget](#) with [user-guide](#), by the University of Arkansas System Division of Agriculture
- [Strawberry Diagnostic Key](#), by North Carolina State University Cooperative Extension
- [Strawberry Extended Enterprise Budget tool](#), by Oregon State University in collaboration with the USDA-National Agriculture Library

## APPENDIX II – Websites

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### National Strawberry Sustainability Initiative

- [Website](#)
- [Blog](#)
- [Photo site](#)
- [YouTube channel](#)
- [Facebook page](#)
- [Twitter feed](#)

### [Center for Agricultural and Rural Sustainability](#),

University of Arkansas System Division of Agriculture

### Project Websites

- [Composting for Soil Borne Disease Control](#), the Gordon Lab, UC Davis
- [Hydroponic Strawberry Information Website](#), University of Arizona, Controlled Environment Agriculture Center
- [Strawberry Production Sustainability Metrics](#), Oregon State University
- [Winter Production of Nebraska Strawberries](#), University of Nebraska-Lincoln

## APPENDIX III – Videos

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### Project Videos

- [California Strawberry Production](#), University of California, Davis
- [Cold Climate Strawberry Farming Trailer](#), University of Minnesota
- [Demonstration of Dipstick Assay](#), Tennessee State University
- [Pivotal Times: The California Strawberry and Research on Compost for Strawberry Health](#), University of California, Davis
- [Placement of Additional Drip Lines to Enhance Fumigation and Irrigation Efficiency](#), University of California Cooperative Extension
- [Reducing Strawberry Waste and Losses in the Supply Chain](#), University of Florida
- [Strawberry Sunrise in Arizona](#), University of Arizona
- [Sustainable Strawberry Production in Arkansas](#), University of Arkansas at Pine Bluff
- [The Texas Strawberry Project](#), Texas A&M AgriLife Extension and Prairie View A&M University
- [The Use of Beneficial Soil Inoculants for Strawberry Tip Production](#), North Carolina State University

### Improved Variety Selection of Strawberries for the Eastern U.S., Rutgers Cooperative Extension

- [First Quarter Report Video](#)
- [Second Quarter Report Video](#)
- [Final Report Video](#)

### Organic Strawberry Production for the Southeast, University of Florida

- [Organic Strawberry Cropping Systems for the Southeast](#)
- [Cover Crops for Organic Strawberry Production](#)
- [Pest Management for Sustainable Strawberries](#)
- [Cultivar Assessment for Organic Strawberry Production](#)

### Strawberry Extended Enterprise Budget Tool, Oregon State University

- [Tutorial, Part 1](#)
- [Tutorial, Part 2](#)



## Production Videos

### **Arkansas Sustainable Strawberry Production,** University of Arkansas System Division of Agriculture

1. [Receiving Your Plants](#)
2. [Forming Beds and Laying Plastic](#)
3. [Planting Strawberry Plugs in High Tunnels](#)
4. [Fertilization and Irrigation for High Tunnels](#)
5. [Fertilization and Irrigation for Strawberry Fields](#)
6. [Winter Burn](#)

### **Arkansas Sustainable Strawberry Production** **Lecture Series,** University of Arkansas System Division of Agriculture

- [Cover Crops in Strawberry Production](#), David A. Dickey, M. Elena Garcia and Susan Frey, University of Arkansas System Division of Agriculture
- [Direct Marketing Strategies](#), Ron Rainey, University of Arkansas System Division of Agriculture
- [Food Safety Aspects of Strawberry Production](#), Kristen E. Gibson, University of Arkansas
- [Interactive Tool to Assess Costs, Revenues and Risks](#), German Rodriguez and Jennie Popp, University of Arkansas System Division of Agriculture
- [Site Selection, Preparation and Soil Nutrition in Strawberry Production](#), David A. Dickey, M. Elena Garcia and Susan Frey, University of Arkansas System Division of Agriculture
- [Strawberry Diseases: Biology and Integrated Management](#), Frank J. Louws, North Carolina State University
- [Strawberry Fumigation & Methyl Bromide Alternatives](#), Frank Louws, North Carolina State University
- [Strawberry Insect Pest Management](#), Donn Johnson, Barbara Lewis and M. Elena Garcia, University of Arkansas System Division of Agriculture
- [The Strawberry Plant](#), M. Elena Garcia, University of Arkansas System Division of Agriculture
- [Strawberry Virus Epidemics and Importance of Clean Plant Material](#), Ioannis E. Tzanetakis, University of Arkansas

### **Hydroponic and Soilless Strawberry Production,** University of Arkansas

1. [Introduction](#)
2. [Gutter System for Greenhouse Strawberry Production](#)
3. [Greenhouse Strawberry Bucket System](#)
4. [Fertilizer Injector Board](#)
5. [System for Controlling Fertilizer Delivery](#)
6. [Emitters Used to Deliver Fertilizer Solution](#)
7. [Fertilizer A and B Stock Formulations](#)
8. [Pollination of Strawberries in Greenhouses](#)
9. [Strawberry Harvesting Guidelines](#)
10. [Strawberry Cultivar Selection](#)
11. [Pest and Disease Control in Greenhouse Strawberries](#)
12. [Accumulated Wisdom on Growing Greenhouse Strawberries](#)

### **Strawberry Diagnostic Videos,** North Carolina State University

#### *Nutrient Deficiencies and Toxicities*

- [Nitrogen vs Phosphorous Deficiency](#)
- [Iron Deficiency](#)
- [Potassium Deficiency](#)
- [Boron Toxicity](#)
- [Nitrogen vs Sulfur Deficiency](#)
- [Iron vs Sulfur Deficiency](#)
- [Sulfur Deficiency](#)
- [Leaf Tissue Testing](#)

#### *Plant Disease*

- [Anthracnose Crown Rot — Initial Infection](#)
- [Anthracnose Crown Rot — Advanced Symptoms](#)
- [Anthracnose Fruit Rot \(\*Colletotrichum acutatum\*\)](#)
- [Black Root Rot Field Diagnosis](#)
- [Inducing Sporulation of Fungi](#)

#### *Pest Control*

- [Applying Predatory Mites](#)

### **Strawberry Post-Harvest Handling,** North Carolina State University, Plants for Human Health Institute

- [Pack 'N Cool & Cold Storage Practices](#)
- [Postharvest Kits for Fresh Produce Quality](#)
- [Postharvest Quality, Handling & Containers](#)

### **Winter Production of Nebraska Strawberries,** University of Nebraska-Lincoln

1. [Heated High Tunnel Construction](#)
2. [Bench Construction](#)
3. [Capillary Mat Construction](#)

