EVALUATION OF OREI'S FUNDED PROJECT: *RESILIENT SYSTEMS FOR SUSTAINABLE MANAGEMENT OF CUCURBIT CROPS* (NIFA AWARD NO. 2019-51300-30248)

FINAL EVALUATION REPORT

Prepared for:
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PART 1: INTRODUCTION

This external evaluation is focused on the process, products, outcomes, and implications stemming from the USDA NIFA OREI-funded project *Resilient Systems for Sustainable Management of Cucurbit Crops* (NIFA Award No. 2019-51300-30248) ('OREI cucurbits project'), led by Dr. Mark Gleason, Iowa State University of Science and Technology (Iowa State), with participating Co-Project Directors located at University of Kentucky and Cornell University. The evaluation study period spans the original three-year project period and includes products delivered through the end of its second no-cost extension period ending February 29, 2024.

BACKGROUND: SOCIETAL NEED AND PROJECT APPROACH

The OREI cucurbits project sought to address an important need in organic agriculture, namely, improved protection of organic cucurbit crops (e.g., muskmelon, acorn squash, winter squash, watermelon, and others) against bacterial and fungal diseases (e.g., bacterial wilt, cucurbit yellow vine disease, powdery and downy mildew), insect pests (e.g., cucumber beetles, squash bug, and squash vine borer), and weeds, which together cost organic growers more than $100 million annually and significantly limit organic growers' market opportunities. The project sought to explore and validate two primary innovative approaches to suppressing these threats while achieving consistently high marketable yields. The first approach was to conduct three years of university-based field experiments as well as on-farm trials with collaborating growers in the project's three focal states: Kentucky, Iowa, and New York. These experiments focused on the use of innovative, nylon-mesh row covers dubbed *mesotunnels*, erected three to four feet high—higher than low tunnels and lower than high tunnels, and used season-long, thus potentially conveying unique benefits. The second approach was to advance innovations in developing biological controls to suppress bacterial and fungal diseases. Together, these innovations shared the broader common goal of protecting and improving natural resources, including soil quality, natural-enemy insects, and pollinator communities, by obviating the need for insecticides. The two primary areas of innovation were investigated using a multi-disciplinary approach that included socio-economic exploration and inquiry to better understand the interests, behaviors, and concerns of organic vegetable crop growers, and factors possibly influencing decisions to adopt and sustain use of mesotunnels on the crops they manage. Through intentional and concerted outreach and development of informational resources, the project team aimed to reach agricultural advisors, growers, students, and other interested parties, across the Midwest and Northeastern regions and US more broadly, with high-quality, evidence-based information products to further awareness and grower consideration of these approaches.

In so doing, project objectives aimed to address five main priority areas of USDA's Organic Agriculture Research and Extension Initiative (OREI): **trialing innovative practices** that can mitigate pest and disease damage; **developing resources and tools for Extension professionals** to use in advising organic growers; **evaluating technologies to improve IPM** while safeguarding resources; **developing case studies** to educate undergraduates about organic cucurbit production; and identifying **socioeconomic constraints to adoption** of the new systems.

EVALUATION PURPOSE AND AUDIENCES

The purpose of the external evaluator's engagement throughout the project period was to facilitate and catalyze reflection and learning across the team and its advisors for iterative project improvement and understand the project deeply for optimal summative assessment. The purpose of this report is not only to evaluate the project's process and outcomes, but to characterize the successes, lessons, implications, and overall story of this multi-disciplinary effort.

The primary intended audiences for this evaluation report include the project director and co-directors across the three participating universities (Iowa State University of Science and Technology (Iowa State; ISU), the University of Kentucky (UK), and Cornell University (CU)), USDA NIFA OREI program leadership, and others who may be interested in understanding how an OREI multi-disciplinary initiative achieved its goals and successfully advanced innovation in organic agriculture.

This report is organized into three main parts to tell the story of the project's accomplishments and lessons learned. Following this introduction (Part 1), Part 2 describes the formative learning and key take-aways across project years and objectives. Part 3 provides a high-level review of project outcomes, and Part 4 discusses implications of project outcomes and reviews its challenges and factors contributing to success.

EVALUATION STUDY QUESTIONS, METHODS, AND LIMITATIONS

This evaluation's primary study questions were:

1. What **formative learning** occurred along the way? What are key take-aways from that learning? (Part 2)
2. What **outcomes** were achieved (Part 3)?
3. What were the strengths and lessons learned from the **research process**? (Part 4)
4. What are some **implications** of project outcomes in terms of the project's longer-term goals? (Part 4)

A utilization-focused approach[1] focused on the primary users and uses for evaluation activities guided this qualitative study. This meant that formative evaluation activities (e.g., evaluator-led interviews, meeting participation, and team-building activities) were designed with the primary users of formative evaluation activities front of mind – i.e., team leadership and all team members. This approach aimed to yield insights based on those activities for team reflection and project improvements when needed.

Qualitative evaluation activities included:

- Evaluator engagement in monthly project team and advisory panel meetings 2020-2023

[1] Patton, M. Q. 2008. Utilization-focused evaluation: The new century text (4th edition). Thousand Oaks, CA: Sage.

- Evaluator-led individual, qualitative interviews with project team members in 2021 (Year 1 First Round), 2022 (Year 2 Reflections), and 2023 (Reflecting on Project Process and Outcomes)
- Analysis and report out of individual interviews conducted with grower cooperators in 2021 and 2022
- Review of project research and extension products
- Analysis of activities and outputs in relation to project goals, objectives, and outcomes
- Characterization of learning, key take-aways, and outcomes

Evaluation findings in this report are based on integrated analysis of data and information from these activities.

Taking a purely qualitative approach to the evaluation activities was an intentional decision on the part of the evaluator in concert with the project leadership team. This was due in part to the project's structure in which socio-economic and other questions of interest to the research team regarding grower perceptions and potential adoption—questions which in other similar agronomic studies sometimes fall under the purview of an external evaluator—were explicitly addressed and led by the socio-economic objective team. The socio-economic survey included findings related to how growers prefer to receive information and resources from university research teams and other agricultural advisors which were used to inform development of the Year 3 growers survey and Objective 4 extension outputs.

PROJECT GOALS AND STRUCTURE

The overarching goal of the OREI cucurbits project was to investigate and validate two innovative strategies to assist organic cucurbit-crop growers in suppressing insect pests, weeds, and diseases to achieve consistently high marketable yields (Figure 1). The first strategy (**Objective 1 – Mesotunnel Field Trials**) was to optimize pollination and weed control with mid-height season-long row covers called **mesotunnels** to control disease and insect pests while maintaining soil and pollinator health. The second strategy (**Objective 2 – Biocontrol**) was to evaluate the effectiveness of biological controls including identification of effective agents, lab screening, and, if possible, field testing. Innovations across these first two objective areas were applied in university field trials and on-farm trials with cooperating growers located in Iowa, Kentucky, and New York.

FIGURE 1. Goals and structure of the OREI Cucurbit project

The team assessed economic and social questions related to the real-world potential for, and implementation of, these strategies using economic analysis, surveys of growers, and exploration of grower experiences and perceptions (**Objective 3 – Socioeconomic Understanding**). The team then shared findings and learnings both virtually and in person with audiences across the focal states of the study and beyond via field days, conferences, research publications, social media, podcasts, videos, and other online resources including the project website *The Current Cucurbit* (https://www.cucurbit.plantpath.iastate.edu/) (**Objective 4 – Extension and Outreach**).

This structure enabled the project's activities and outputs to work in parallel and at times collaboratively to make tangible contributions to the following longer-term goals:

1) **Control major and disease pests** all season to ensure consistently high marketable yield and profitability from organic muskmelon and winter squash production;
2) **Protect pollinators** and natural-enemy insects by eliminating the need for insecticide use;
3) **Suppress weeds** while **enhancing soil health** attributes; and
4) Gain additional **flexibility in disease management** through diverse physical and biological control options.

PROJECT TEAM AND COLLABORATORS

Led by Dr. Mark Gleason at Iowa State University, the project team consisted of nine co-principal investigators across the three universities, a project coordinator (Iowa State), three technicians (Cornell University), six graduate students (Iowa State and University of Kentucky), an external evaluator, and numerous undergraduate assistants each year. The project benefitted from the support and participation of a nine-person advisory panel, consisting of grower cooperators and others who provided insights, experience, and expertise over several years of the project.

APPROACH TO RESEARCH AND LEARNING

The nature of the core research in this OREI project was exploratory and qualitative in nature with emphasis on iterative agronomic learning in both the in-field university experiments as well as on-farm trials with collaborating growers. The scientific questions which served as focal points for the project's field components represented a constellation of related questions about weed management, foliar disease and insect pest control, and pollination and maintenance of beneficial insects. Along the way, much focus, trial, and experimentation was done, and learning was developed around mesotunnel construction; cucurbit varietal selections; tunnel microenvironments; time, materials, and labor costs and requirements; and other questions. Diverse approaches were borne out of each state's distinct natural soil, pest, and climate conditions as well as each team's unique logistics, capacity, interests, and lines of scientific inquiry. The project's research questions were ultimately best served through a range of custom approaches carried out at each university's field sites, in addition to those of each team's grower cooperators. Similarly, questions focused on identification, screening, and trialing potential biocontrol species to control against cucurbit bacterial pathogens required iteration, trial, and learning.

Each university team delivered a cohesive collection of insightful scientific findings informing the project's central research questions. Together, this new knowledge highlights a rich diversity of agronomic approaches and related socio-economic insights that can be considered by growers and future researchers as they continue to pursue the optimization of organic systems.

PART 2: FORMATIVE LEARNING AND KEY TAKE-AWAYS

Inherent to research, formative learning took place through the project and will continue beyond as research questions continue to be pursued by team members, new teams, and new sets of researchers. Learning took place in the team's regular work and interactions (described in Part 4), field and laboratory experiments, through sharing with advisors and external stakeholders during Extension events, and via formative evaluation activities, such as individual interviews and associated reports outs and team discussion, each of which allowed for reflection and broader thinking at points throughout the project. Formative learning as a group activity across the team facilitated the growth of shared understanding not only of the project activities and thinking of others but enabled shared understanding at a deeper level of the transdisciplinary science at play across the project's goals and objectives. This shared learning and understanding of the 'bigger picture' and integrated science was cited across the team as not only a benefit of the project to individual team members for their own understandings but also a key factor facilitating logistical coordination and propelling research innovation.

FORMATIVE LEARNING: FIELD TRIALS (OBJECTIVE 1)

Across the project's field trials formative learning and key take-aways (Figure 2) were myriad and are most comprehensively documented across the many project manuscripts, reports, and other online project resources. For **weed management**, early field trial learning resulted in decisions to experiment with mowing teff and other living mulches in the second field season and test efficacy against landscape fabric and bare ground under various tunnel configurations and conditions. Learning yielded mixed results but also success in demonstrating efficacy of mowed teff in some instances and in Year 3, higher marketable yields for some crops. Key take-aways for weed control management focus on the message that weed management decisions should be carefully planned in relation to both pollination conditions, opportunities, and tunnel/row cover treatment choices, in addition to cultivar selection, tunnel microclimate conditions, and location-specific climate and pest pressures.

For **pollination**, learning focused on trialing varying configurations of mesotunnel length in relation to entry points for pollinators, including introduced hives placed inside of tunnels, experimentation with opening tunnel ends to allow for pollinator entry and exit, and removing tunnel netting and sometimes putting it back on, at key points during the growing season. Learning highlighted differences in pollinator behavior as well as ease of management and harvest under different pollination scenarios.

Learning focused on foliar **disease management** and **insect pests** and yielded reduced disease under the mesotunnels, including an unexpected finding of powdery mildew significantly reduced under mesotunnels in some Year 2 trials. While cultivars, geographies, weather, and other factors yielded mixed results, Year 3 trials yielded significant suppression of CYVD and pest insects under mesotunnels, along with significantly higher marketable yields over alternatives, providing further learning and promise for use of mesotunnels for disease and pest protection.

FORMATIVE LEARNING: BIOCONTROL (OBJECTIVE 2)

Learning centered on control of cucurbit pathogens (Figure 2) represented early-stage *in vitro* and *in vivo* processes to create a foundation for future field trials. Learning in Year 1 focused on identification of the target cucurbit bacterial pathogens of interest, *Erwinia trachephila,* Et*,* and *Serratia marcescens,* Sm*)*;

identification of 20 biocontrol candidate bacteria, and the administrative and logistical gymnastics required to obtain and secure samples under the unusual laboratory closure and conditions brought about by the Covid-19 pandemic. Once laboratory experiments were up and running, continued work yielded incremental learning, new insights, and promise toward identifying biocontrol candidates able to suppress bacterial wilt, as well as progress in developing inoculation methods for use in CYVD pathogenicity assays.

FORMATIVE LEARNING: SOCIO-ECONOMIC UNDERSTANDING (OBJECTIVE 3)

Learning around the project's socio-economic objectives centered on questions central to the development of two Year 1 online surveys (Whole Team Survey and Year 1 Baseline Survey) and the Year 3 online Growers Survey. The Whole Team Survey collected information about economic and non-economic factors associated with grower's decisions to use mesotunnels and biocontrol approaches. The Year 1 Baseline Survey asked growers about their Year 1 experience using mesotunnels with their cucurbit crops. Development of survey items required cross-team discussions and information collection to obtain important metrics of interest, including cost analysis of use of mesotunnels for cucurbits and other crops. Each of the Year 1 surveys informed development of the Year 3 survey. While the Covid-19 pandemic prevented planned in-person engagement with growers to obtain insights on perceptions and parameters of interest for this purpose, team leads facilitated a coordinated approach to this collection of potentially important metrics via these surveys and gathered grower and team feedback on survey design ahead of launch. This early learning resulted in, among other insights, an understanding of the top factors considered most by growers when considering use of mesotunnels, namely, total cost, capacity to control pests and improve yield, and profitability. Early survey learning also found that grower interest in biocontrol centers on ease of use, effectiveness in reducing need for insecticides and fungicides, and potential to increase both quality and yield.

FORMATIVE LEARNING: EXTENSION AND OUTREACH (OBJECTIVE 4)

Formative learning relevant to extension and outreach activities included engagement to obtain practical information on growers' knowledge, perceptions, interests, and preferences for receiving extension information. Through the project's panel of grower advisors, informal discussions with farmers via extension field days, and using the Year 1 grower survey, the team learned more about the interests and preferences of growers, which then informed development of the project's extension resources. This development was paired with a diversity of practical new skills developed across the team focused on design and delivery of extension resources in formats such as social media, blog posts, YouTube How-to videos, and podcasts. Key take-aways from this work included that while growers may converge on their interest in cost-effectiveness and technical effectiveness of mesotunnel systems, data provided an important reminder that growers are diverse rather than monolithic about their preferences for seeking and obtaining agricultural technical information. These findings thus support the team's dedicated investment into developing a robust array of informational resources on the use of mesotunnels for cucurbit crops.

LEARNING AND KEY TAKE-AWAYS: FIELD AND LABORATORY EXPERIMENTS

Year 1

Key Learning

- Teff suppressed weeds but reduced yield
- Lowest yield from on-off-on tunnel treatment
- Foliar diseases reduced under tunnels
- Biocontrol candidates & target pathogens (*Erwinia trachephila, Serratia marcescens)* identified

Early decisions

- Mow teff in Year 2
- Continue trialing open-ends tunnels
- Study tunnel micro-environments
- Screen biocontrol candidates for pathogen suppression

Year 2

Key Learning

- Mowed teff and landscape fabric increased marketable yield for some crops & geographies
- Marketable yield mixed across tunnel configurations, crops & geographies
- Powdery mildew significantly reduced under mesotunnels
- Bacterial wilt suppressed by several biocontrol candidates in screening trials; Innoculation method yielded insights towards understanding causes of CYVD

Key Take-away

- Marketable yield strongly influenced by geography & crop: muskmelon vs. acorn squash

Year 3

Key Learning

- Mowed teff & landscape fabric gave significantly equivalent higher marketable yields than other treatments in some trials
- Marketable yield higher using full-season and on-off-on treatments in some trials
- CYVD and pest insects significantly suppressed with mesotunnels vs. uncovered plots
- Trials show bacterial wilt may be amenable to biocontrol; CYVD pathogenicity trials open way for study of biocontrol candidates & host-pathogen interactions

Key Take-away

- Mesotunnel treatments resulted in significantly higher marketable yields compared to uncovered plots

Project End

Key Take-aways

- Weed management should be carefully planned in relation to pollination strategy and tunnel treatment
- Consider pollination strategy in relation to crop, weed, pest, & disease mgmt. considerations
- Cucurbit biocontrol agents show promise
- Mesotunnels are effective barriers against pests and disease but further improvements are needed to assure adequate pollination and weed control

Accomplishments

- ✓ Growers Manual released
- ✓ Multiple peer-review manuscripts published, submitted, or in preparation
- ✓ *Current Cucurbit* website stewardship secured for at least 5 years
- ✓ Over 90 outreach resources incl. blogs, podcasts, videos, infographics & reports

Color Key

- Weeds
- Pollination
- Disease & Pest Management
- Biocontrol
- Integrated

FIGURE 2. Formative learning and key take-aways: Project Year 1 through project end

PART 3: PROJECT OUTCOMES

Project outcomes for an integrated and multidisciplinary research and extension project such as the OREI cucurbits project should reflect the established goals and objectives of the project and make meaningful contribution to a project's longer-term goals and other stated priorities. The OREI cucurbits project achieved its intended goals and objectives while making tangible and significant contributions to the research literature, extension and grower community informational resource base, and incremental steps in learning toward achievement of longer-term goals important to OREI NIFA, US agricultural, and society more broadly. Naturally inherent to a research endeavor, main outcomes focused on improved understanding - in other words, new evidence-based knowledge – across the project focal areas. Additional goals for the project including 1) connecting with growers and the broader organic vegetable crop community (project stakeholders) to obtain input from and connect these groups to the new knowledge products; and 2) providing education and career training to students and newer professionals and faculty through the course of project activities, graduate education, and related career development.

The outcome sections below provide a bird's eye view of these outcomes, with brief descriptions, especially as they are relevant to representing the project's primary goals and objectives achieved to demonstrate rounded accomplishments and inform future research. These handlebars are intended to be used as a guide to the more comprehensive scientific, economic, and extension-related project resources produced, all of which are available online at the project's YouTube channel or at the Current Cucurbit, which will be managed by the Northeast IPM Center in the future. Implications of these outcomes in relation to broader and longer-term goals are discussed in Part 4 of this report.

OUTCOME GOAL: IMPROVED UNDERSTANDING OF WEED SUPPRESSION IN MESOTUNNEL SYSTEMS

ACHIEVED: NEW KNOWLEDGE AND PROGRESS TOWARD UNDERSTANDING BETTER APPROACHES FOR WEED MANAGEMENT IN MESOTUNNEL SYSTEMS

- **Knowledge gained from mesotunnel weed management approaches including landscape fabric, living mulches, mowed living mulch (teff) and mowing-only (existing weeds) trialed**
- **Results and guidance shared with researchers, growers, Extension, and the broader public**

OUTCOME GOAL: IMPROVED UNDERSTANDING THE ROLE OF POLLINATORS IN MESOTUNNEL SYSTEMS

ACHIEVED: NEW KNOWLEDGE AND PROGRESS TOWARD UNDERSTANDING POLLINATOR – MESOTUNNEL SYSTEM COSTS AND BENEFITS

- **Knowledge gained from pollination and mesotunnel configurations designed, built, and trialed**
- **Results and guidance shared with researchers, growers, Extension, and the broader public**

OUTCOME GOAL: IMPROVED UNDERSTANDING OF PESTS AND DISEASE CONTROL IN MESOTUNNEL SYSTEMS

ACHIEVED: NEW KNOWLEDGE AND PROGRESS TOWARDS USE OF MESOTUNNEL SYSTEMS TO MANAGE PESTS AND DISEASE

- **Knowledge gained from mesotunnel configurations designed, built, and trialed across diverse cucurbit cultivars, tunnel configurations, geographies, and disease and insect pressures**
- **Results and guidance shared with researchers, growers, Extension, and the broader public**

OUTCOME GOAL: GAINING FLEXIBILITY IN DISEASE MANAGEMENT - BIOCONTROL

ACHIEVED: NEW KNOWLEDGE AND PROGRESS TOWARDS BIOCONTROL OF CUCURBIT BACTERIAL WILT

- **Knowledge gained from identification, screening, and experiments to use biocontrol against *Et***
- **Results and guidance shared with researchers, growers, Extension, and the broader public**

ACHIEVED: NEW KNOWLEDGE AND PROGRESS TOWARDS BIOCONTROL OF CUCURBIT YELLOW VINE DISEASE (CYVD)

- **Knowledge gained from identification, screening, and experiments on biocontrol against *Sm***
- **Results and guidance shared with researchers, growers, Extension, and the broader public**

OUTCOME GOAL: IMPROVED UNDERSTANDING OF THE SOCIOECONOMIC DIMENSIONS RELATED TO ADOPTION OF MESOTUNNEL SYSTEMS

ACHIEVED: NATIONAL SURVEY OF CUCURBIT VEGETABLE GROWERS

- **Results shared with researchers, growers, Extension, and the broader public**

ACHIEVED: ECONOMIC ANALYSIS OF IOWA FIELD EXPERIMENTS

- **Results and guidance shared with researchers, growers, Extension, and the broader public**

OUTCOME GOAL: CONNECT TO AUDIENCES AROUND MESOTUNNEL SYSTEM LEARNING

ACHIEVED: GROWER ENGAGEMENT IN THE OREI CUCURBITS PROJECT

- **Participating on-farm collaborators: 13**
- **In-depth interviews and analysis of grower experiences in each year of project**
- **Results and guidance shared with researchers, growers, Extension, and the broader public**
- **Broader vegetable crop community engaged via project and Extension activities and resources**

ACHIEVED: EXTENSION PRODUCTS AND RESOURCES

- **Over 90 informational products and resources shared with researchers, growers, Extension, and the broader public**

OUTCOME GOAL: PROVIDE EDUCATIONAL TRAINING AND CAREER DEVELOPMENT

ACHIEVED: STUDENTS EDUCATED AND ADVANCING

- **Graduate students trained, graduated, and/or advancing: 6**
- **Undergraduate students provide research opportunities and work experience: 8**

ACHIEVED: AGRICULTURE PROFESSIONALS TRAINED

- **Learning & Mentorship—Team members reporting learning new knowledge, skills, and approaches from others: 20**
- **Advancements—Team members advancing into new professional roles: 6**

PART 4: DISCUSSION

IMPLICATIONS FOR CONTROLLING MAJOR CUCURBIT INSECT PESTS AND DISEASE (LONG-TERM GOAL 1)

The diversity of approaches, geographies, outcomes, and lessons learned across this project provide several key take-aways and implications for controlling major cucurbit insects and disease (Project Long-term Goal 1). Broadly, the project further documented the value of using row covers for crops that do not have good alternative solutions for pest protection and made progress in documenting new ways of using row covers in organic agriculture. Grower inputs provided new ideas, creativity, and the freedom across the states and teams to experiment with real-world conditions and their own context-specific circumstances and preferences in the field.

> *Thinking back 20 years ago, we could not grow many of these crops organically because insects and bacterial pathogens were decimating. We are continuing to refine it through OREI. Now we can consistently grow these crops organically, so there are new opportunities for small farmers and more options.*

Team members concluded that this more agile, diversified approach to experimenting across the project's main areas of inquiry (disease and insects; pollinators; weed management; biocontrol; socioeconomic components; and extension) enabled a rich research experience, provided tangible results for current growers, and established a strong foundation for future research tackling these and similar questions.

IMPLICATIONS FOR PROTECTING POLLINATORS AND NATURAL-ENEMY INSECTS BY ELIMINATING THE NEED FOR INSECTICIDE USE (LONG-TERM GOAL 2)

The protection of natural populations of pollinators and other natural and beneficial insects remains a strong incentive to find workable approaches to pest and disease protection such as mesotunnels that can reduce or even eliminate the need for insecticide use, organic or otherwise. The use of mesotunnels for pest and disease protection is challenged by the need for crops to be pollinated while covered and for pollinators to thrive and interact with an organic system without additional threats or significant challenges. Through the flexible and innovative approaches taken in the OREI cucurbits project, a range of pollination approaches in the context of mesotunnels were studied; findings inform not only future research on cucurbits but potentially many other vegetable crops that could benefit from mesotunnels and require pollination. While some of the project's trials resulted in notable pollinator loss within tunnels, others provided evidence that mesotunnels may be able to result in consistently strong marketable yields without threatening natural or purchased pollinators; more research is needed. Future researchers will need to keep in mind that many other factors, such as weed management approaches, mesotunnel protocols, climate, weather, soil, endemic pests and disease, also influence marketable yields so must be considered when drawing conclusions about the costs and benefits of mesotunnel systems in relation to pollinators.

IMPLICATIONS FOR SUPPRESSING WEEDS AND ENHANCING SOIL HEALTH (LONG-TERM GOAL 3)

The OREI cucurbits project focused its weed management research on workable approaches for weed management within the relatively complex in-field context created using mesotunnel systems. Within the understanding that use of between-row groundcovers, or ‘living mulch,’ can deliver a number of potential co-benefits for soil health (e.g., increased soil organic matter; improved soil structure; enhanced microbiome activity; microclimate enhancements; control of erosion and certain pests), the project investigated various configurations and types of living mulch in each geography and across various cucurbit crops of interest. Results remained mixed across some trials and locations, yet trials managing weeds using mowed living mulch, such as teff (*Eragrostis tef) (*a drought-tolerant grass from Africa), achieved significantly increased marketable yields at levels comparable to those using landscape fabric, compared to bare-ground controls. While consideration for other factors remains important, the implication from these findings is that when landscape materials, labor, and other costs are considered, living mulches for weed management in mesotunnel systems may rival or outperform those using landscape fabric in some situations. In addition to the natural co-benefits mentioned, other co-benefits of living mulch compared to landscape fabric may include reduced agricultural waste and lower societal costs (e.g., decreased carbon costs from the landscape fabric lifecycle; increased climate resilience) more broadly. Soil health parameters should be further studied in the context of tunneled systems to better understand potential impacts. More research is needed across many crop types, tunnel systems, and geographies to learn more about how weed suppression and enhanced soil health may be best achieved while using mesotunnel systems.

IMPLICATIONS FOR GAINING FLEXIBILITY IN DISEASE MANAGEMENT THROUGH BIOCONTROL (LONG-TERM GOAL 4)

Management of bacterial diseases vectored by insects in cucurbits and other crops is especially challenging in the face of increasingly extreme weather events and shifting climate conditions across wide geographies of the US. Local ecosystems that once may have been able to hold disease vectors in check, previously providing an ‘ecosystem service’ of natural crop protection, are losing capacity to do so given new system imbalances and shocks caused by these shifts. US soil and croplands continue to endure heavy pressures from regular use of pesticides (including fungicides, herbicides, and nematicides), putting these natural ecosystems, including important bacterial, viral, and fungal systems, at further risk of imbalance or collapse. In addition to threatening human health, these threats are increasing pressure on growers’ bottom lines while only lowering longer-term pesticide efficacy in the face of rising costs. Organic and conventional systems alike face the challenge of limited options and large risks from use of synthetic pesticides. In the face of these threats, harnessing the power of natural systems by finding viable biocontrol solutions to protect US crops is of critical importance. The OREI cucurbits project achieved incremental successes towards such goals, as well as made a major breakthrough toward making biological control practical as an alternative to synthetic chemical insecticides. Project research showed that some identified strains of biocontrol bacteria targeting known pathogens were able to suppress bacterial wilt in cucurbit crops. Additionally, the OREI project yielded experimental evidence that cucumber beetles –previously known to spread only the cucurbit bacterial wilt pathogen (Et)—can also spread the CYVD bacterium from plant to plant, a finding with large implications for practical control of CYVD.

STRENGTHS OF PROJECT APPROACH AND STRUCTURE

The transdisciplinary approach and flexible, multi-state structure taken in this project were cited by the team as key strengths of the project which were reflected in the utility of findings to researchers as well as growers. While certain challenges were faced using different approaches across the geographies (e.g., lack of a singular experimental design implemented in all locations), in the eyes of the team, the benefits of the diversified project approach outweighed these limitations.

> *It was very interdisciplinary – very specialized people, thinking about very specific details. They knew what they were talking about and wanted to answer. Even though I felt comfortable with that, I also learned a lot – having such specialized people – I felt very comfortable with the group. – Graduate student team member*

The team cited the flexible design, in which each state determined its own research design within the broader parameters of project objectives, as an asset for bringing a good diversity of questions and perspectives to the project. Results in turn benefitted overall findings by providing a rich and diverse set of research results for different geographical regions, farm and crop types, and implications for future research and grower experimentation.

CHALLENGES AND LESSONS LEARNED

OVERCOMING CHALLENGES

The project's primary challenge was marked in Year 1 with the Covid-19 pandemic. The pandemic's primary impacts were the prohibition of all Year 1 fieldwork by the Cornell University team and other fieldwork delays at Iowa State and Kentucky, an eight-month delay in access to Iowa State laboratory facilities and associated biocontrol activities, and the prevention of many in-person meetings in the earlier stages of the project. This challenge did, however, enable for optimization of virtual meeting technologies (Zoom) and associated human adjustments.

> *We were able to do most of what we planned – impressive – we should pat ourselves on the back. We were in the middle of a storm [Covid pandemic], and we got through. That is one of the main highlights for this project.*

While communication and coordination, overall, was strong, some early communication and coordination across the team and its cooperating partners was challenged by the uncertainties of the pandemic situation, as well as weather events, reduced staffing for field trials, mismatches in modes of communication (e.g., one grower did not own a phone), some cross-cultural communication style differences, and, at times, challenges obtaining feedback from grower cooperators at a specific enough level to aid the research team.

Each of these challenges was remedied during the project through improved planning approaches including focused feedback guides for cooperators and team building activities. For example, early internal team dynamics were described as improved through a group activity utilizing resources focused on improving cross-cultural communication in teams.

Other challenges and lessons noted for future use cited by team leadership and members included the importance of regular and clear contact and communication with cooperating growers; soliciting pre- and post-season input and feedback from them at optimal times in relation to the growing season; and allowing for advisor/grower-specific breakout time in calls to give opportunity for sharing in smaller groups and separate from the research team. One team member pointed out that an idea for future projects would be to revisit roles across the project over time, perhaps annually, so that each team members' role and area/s of responsibility and/or commitment level were clarified for all, including each individual, and made more transparent to the entire group. In particular, it was also observed by one team member (not the Project Coordinator) that along with other project responsibilities, the role of Project Coordinator involves a large number of tasks and that future teams should consider spreading the level of effort across more team members of all ranks in future projects.

FACTORS CONTRIBUTING TO PROJECT SUCCESS: PROCESS AND PEOPLE

PROCESS: OPPORTUNITIES TO REGULARLY SHARE AND LEARN

Covid-era restrictions prevented an in-person annual meeting, and subsequent decisions were made to forego such meetings given the combination of highly impacted schedules and outside demands across the team along with high-functioning regular Zoom meetings, good participation, and project progress. In fact, across the team, opportunities to regularly convene to share and learn were cited as important, if not critical factors contributing to the project's success. Though often couched in a form of hesitation about advocating for the mundane, such opportunities, most often in the form of regular monthly all-team meetings, were regularly cited over the years of the project and at its conclusion as a central factor contributing to the project's success. Even among those for whom making regular meetings was most challenging from a scheduling perspective, these regular touchpoints guided by the strong leadership of the project's PI, and the Project Coordinator, were valued greatly. Regular monthly all-team meetings served as a place for all team members – from tenured faculty to new graduate students and all in between to come together, stay current with the project's activities and plans (thus all were privy to open and consistent information, cited by many as key), and most importantly, had ample time for cross-fertilization of ideas and information sharing among the team.

> *Having the communication we had was a big factor. We were spoiled on this project! Not every grant group will work well together. We really pulled together well from my point of view at least. It was good to have a fearless leader throughout the whole project.*

These virtual meetings conducted via Zoom were typically one hour long and organized around each of the project's four primary objectives, with presentation order alternating on occasion, either for scheduling or other prioritized purposes. Each objective's members would present updates as they saw fit, with plenty of time provided for short presentations as well as ample team discussion and Q&A of field season planning and designs, early findings, or other topics.

PEOPLE: TEAM, LEADERSHIP, AND ADVISORS

Several foundational factors provided the research team a leg-up from the project's start, namely, many of the project leadership were existing colleagues who had actively worked on prior projects with success. Multiple team members cited both their established relationships as well as prior topical knowledge as advantages which gave the whole team a level of confidence going into the project. Strong leadership by the project's PI, Dr. Mark Gleason, was cited universally as a key factor for the success of the project. Explained one, "He provided space for open communication – anyone could reach out and ask questions [at any time], which made for a very rich collaboration across the state teams." A highly valued additional role, that of the Project Coordinator, was also cited universally among team members as critical to the success of the project. The role of Project Coordinator, and the good work of this project's Coordinator specifically, was pointed to over and over throughout the course of the project by team members as a key factor for 'keeping the trains running on time.' The Project Coordinator role was described as 'unique' to this type of research project, and, with the role, the project was 'more rigorously structured' than many collaborative research efforts. Across the team, the role was cited as a feature from which future collaborative research efforts could greatly benefit, provided funding is allocated and an individual with key qualities is selected for the role, according to team members.

> *The Project Coordinator position is really important. I think a ton of energy is important – to really have the desire to excel and the energy to match.*

Synergy, feedback, and integration across the team because of this leadership and strong coordination became, early on, central characteristics of the team dynamic. Kindness and helpfulness across team members were also cited by many as factors contributing to the successful team dynamic.

> *I'm always paying attention to how people do things – I learned a ton from this process.*

Engagement, mutual respect, and a willingness to bring one's best to the team and project each played a role. This included participation by the project's advisory panel of committed cooperating growers who played an important role in providing real-world grower perspective and valuable input into the project, both in the form of their participation in regular advisory panel meetings as well as via their on-farm work.

> *'Cooperators' doesn't mean they do exactly what you say. As they do things differently, as long as they are conscientious and provide decent amount of feedback, we can learn things that we never anticipated learning, which is the*

> *true value of an on-farm trial. Treating folks with respect is really important They don't work for us; they are our peers. That's the way I see it.*

The team's leadership and organization keeping everyone on the same page were cited as key factors contributing to the ability for team members to help one another more readily.

> *The team made it fun to work on – I'm very grateful for the team we had. It's been good to see a lot of familiar faces that are go getters. I genuinely have a good feeling about our future work with them.*

Leadership yielded engagement, which in turn yielded cooperation. These attributes were cited by many on the team as aspects they look forward to helping instill in their future projects.

> *Learning a lot is an understatement. This has transformed my life.*
> *– Graduate student team member*

APPENDIX A: OREI CUCURBITS PROJECT TEAM, ADVISORS & COLLABORATORS

Iowa State University

Mark Gleason, Project Director
Gwyn Beattie, Project Co-PI
Laura Jesse, Project Co-PI
Lois Morton, Project Co-PI*
Ajay Nair, Project Co-PI
Jose Gonzalez, Project Coordinator
Sharon Badilla, Graduate Student
Nieyan Cheng, Graduate Student
Kephas Mphande, Graduate Student
Kaitlin Diggins, Undergraduate Research Intern

Cornell University

Sarah Pethybridge, Project Co-PI
Wendong Zhang, Project Co-PI**
Kellie Damman, Technician
Audrey Klein, Technician
Sean Murphy, Technician

University of Kentucky

Ricardo Bessin, Project Co-PI
David Gonthier, Project Co-PI
Mark Williams, Project Co-PI
Kathleen Fiske, Graduate Student
Alexis Gauger, Graduate Student

*Departed project in 2020
**Iowa State University 2020 - 2023

Advisory Panel Members/Grower Collaborators

Iowa

Hannah Breckbill
Jody Fisher
Gary Huber
Mark Quee
Ben Saunders

Kentucky

Bryce Bauman
John Bell
Maggie Dungan
Ford Waterstrat

New York

Elisabeth Hodgdon
Liz Martin
David Stern
Crystal Stewart-Courtens

APPENDIX B: RESEARCH AND EXTENSION PRODUCTS

JOURNAL ARTICLES

2022

Damann, K., Pethybridge, S., and Gleason, M. Battling Powdery Mildew on Organic Acorn Squash in Mesotunnels. Case Study. Plant Health Instructor. December 8, 2022. https://doi.org/10.1094/PHI_C_2022_06_0005

2023

Gonzalez, J., Gonthier, D., Pethybridge, S., Bessin, R., Nair, A., Zhang, W., Cheng, N., Fiske, K., Gauger, A., Damann, K., Murphy, S., Badilla, S., Mphande, K., and Gleason, M. 2023. Mesotunnels for organic management of cucurbit pests and diseases: tips for growers. NCPA 038, North Central IPM Center. Bulletin NCPA 038, North Central IPM Center, University of Minnesota, St. Paul, MN. 8 pp.

2024

Fiske, K., Cheng, N., Kuesel, R., Zhang, W., Bessin, R., Williams, M.A., and Gonthier, D. 2024. Row covers limit pests and disease and increase profit in organic acorn squash. Frontiers in Sustainable Food Systems 8:1347924.

Mphande, K., Badilla-Arias, S., Cheng, N., González-Acuña, J., Nair, A., Zhang, W., and Gleason, M.L. 2024. Evaluating pollination and weed control strategies under mesotunnel systems for organic muskmelon production in Iowa. HortTechnology 34:265-279. DOI: https://doi.org/10.21273/HORTTECH05379-23

Mphande, K., Beattie, G.A,, and Gleason, M.L. 2024. First report of cucurbit yellow vine disease caused by *Serratia marcescens* on cucurbit crops in Iowa. Plant Disease. doi.org/10.1094/PDIS-12-23-2716-PDN.

Mphande, K., Gleason, M.L., and Beattie, G.A. 2024. A quantitative *in vivo* pathogenicity assay for cucurbit yellow vine disease caused by *Serratia marcescens*.Plant Disease: Submitted.

Pethybridge, S., Damann, K., Murphy, S., Diggins, K.R., and Gleason, M.L. 2024. Evaluation of mesotunnels for organic muskmelon production in New York, USA. Renewable Agriculture and Food Systems: Accepted pending revision.

Pethybridge, S.J., Damann, K., Murphy, S., Diggins K., and Gleason, M.L. Gleason. 2024. Optimizing Integrated Pest Management in mesotunnels for organic acorn squash in New York. Plant Health Progress: https://doi.org/10.1094/PHP-08-23-0072-RS.

Rodriguez-Herrera, K.D., Ma, X., Swingle, B., Pethybridge, S.J., Gonzalez-Giron, J.L., Hermann, T.Q., Damann, K., and Smart, C.D. 2024. First report of cucurbit yellow vine disease caused by *Serratia marcescens* in New York. Plant Disease. 107:3276.

CONFERENCE PAPERS AND PRESENTATIONS

<u>2019-2020</u>

Bessin, R. 2019. IPM for small farms. IPM class, University of Kentucky, December 4, 2019. 20 students.

Bessin, R. 2019. Pumpkin Insect Management. Pumpkin webinar. December 19, 2019. 44 attendees.

Bessin, R. 2020. Scaling up IPM. Kentucky Vegetable Growers Association. January 6, 2020. 61 attendees

Bessin, R. 2020. Insect challenges from 2019. Lincoln Count, Kentucky, Produce Auction. January 16, 2020. 53 attendees.

Bessin, R. 2020. Managing key vegetable insect pests. Kentucky County Agent webinar, February 6, 2020. 53 attendees.

Bessin, R. 2020. Vegetable insect update. Growers School. Mt. Vernon, IL, February 5, 2020. 27 attendees.

Bessin, R. 2020. Vegetable insect pest update. South farm, University of Kentucky, February 18, 2020. 50 attendees.

Bessin, R. 2020. Outmaneuvering insect pests. Harlan County Webinar. June 4, 2020. 23 attendees.

Bessin, R. 2020. IPM for Small Farms. County Agent Training Webinar. 46 attendees.

Nair, A. 2020. Disease and pest management strategies in key vegetable crops. Iowa Fruit and Vegetable Growers Association, January 23, 2020. 35 attendees.

Nair, A. 2020. Pest Management Workshop. https://www.extension.iastate.edu/vegetablelab/iowa-vegetables-pest- management. April 9, 2020. 1,445 views.

<u>2021</u>

Fiske, K. 2021. Optimizing row cover systems for cucurbits in Kentucky, Kentucky Fruit and Vegetable Conference, Lexington, KY, January 12, 2021. 158 attendees.

Fiske, K. 2021. Optimizing row covers in cucurbit production. Symposium: Expanding the Pest Management Tool-kit: Adapting Pest Management Alternatives for Diverse Farming Communities. June 23, 2021. North Central Branch, Entomology Society of America. Virtual presentation. 28 attendees.

<u>2022</u>

Badilla-Arias, S., Gleason, M.L., and Beattie, G.A. 2022. Screening for biocontrol agents of cucurbit bacterial wilt in muskmelon. Poster presented at annual meeting of American Phytopathological Society, Pittsburgh, PA, August 2022.

Badilla-Arias, S., Gonzalez-Acuna, J., and Gleason, M. 2022. Optimizing pollination of organic acorn squash in mesotunnels in Iowa. Poster presented at annual meeting of American Phytopathological Society, Pittsburgh, PA, August 2022.

Fiske, K. 2022. Row cover systems for cucurbits: Insights from research and grower's perspectives. Kentucky Fruit and Vegetable Conference (January 4, 2022). Virtual presentation. 23 attendees in person.

Fiske, K., Bessin, R., Williams, M., Gonthier, D. 2022. Row covers provide sustainable resiliency to cucurbit pests. IPM Coordinators Meeting, Denver, CO. (February 28, 2022). Poster. Presented by Ric Bessin.

Fiske, K., Bessin, R., Williams, M., Gonthier, D. 2022. Use of row covers increases marketable yield and profit and decreases cucumber beetles and powdery mildew. University of Kentucky Department Retreat (August 12, 2022). Poster. ~50 attendees in person.

Fiske, K., Gonthier, D., Bessin, R., Williams, M. 2022. Row cover systems for cucurbits: Insights from research and grower's perspectives. Southeast Regional Fruit and Vegetable Conference (January 7, 2022). Virtual presentation. 35-40 attendees in person.

Gauger, A., Fiske, K., Gonthier, D. 2022. Foraging environment affects reproductive success in commercial Bombus impatiens colonies. University of Kentucky Department Retreat (August 12, 2022). Poster. ~50 attendees in person.

Gonthier, D. 2022. Limiting pests using exclusion netting in fruits and vegetables. University of Kentucky IPM Training School (March 9, 2022). Virtual Presentation. 20 attendees.

Gonthier, D. 2022. Pollination strategies for cucurbit crops under mesotunnels. Michigan State University & Great Lakes Fruit, Vegetable, & Farm Market Expo. Grand Rapids, MI (December 7, 2022). Oral presentation.

Mphande, K. Gleason, M.L., and Beattie, G.A. 2022. Developing a pathogenicity assay for *Serratia marcescens* on squash (Cucurbita pepo). Poster presented at annual meeting of American Phytopathological Society, Pittsburgh, PA, August 2022.

Mphande, K., Gonzalez-Acuna, J., and Gleason, M.L. 2022. Weed control on muskmelon in organic mesotunnel systems. Poster presented at annual meeting of American Phytopathological Society, Pittsburgh, PA, August 2022.

Pethybridge, S. J. 2022. Mesotunnels for integrated pest management of organic cucurbit production. Organic Cucurbit Field Day, Cornell AgriTech, Geneva, NY. Attendees = 20. Duration = 2 hours. Total contact = 40 hours. 9 August 2022.

2023

Badilla Arias, S., Gleason, M.L., and Beattie, G.A. 2023. Screening for biocontrol agents of bacterial wilt of cucurbits. National meeting of American Phytopathological Society, Denver, Colorado, August 13-16, 2023.

Gonthier, D.J. 2023. Plastics-based protection systems in organic agriculture. Conference on Reducing Plastics Along the Entire Organic Supply Chain. The Organic Trade Association, Washington, DC. May 9, 2023. Oral presentation.

Mphande, K., LaSarre, B., Gleason, M.L., and Beattie, G.A. 2023. Exploring the molecular mechanisms of pathogenicity and localization of *Serratia marcescens*, which causes cucurbit yellow vine disease. National meeting of American Phytopathological Society, Denver, Colorado, August 13-16, 2023.

Pethybridge, S. J., and Murphy, S. M. 2023. Feasibility of Mesotunnels for muskmelon production. Empire Expo, Syracuse, NY. Attendees = 100. Duration = 30 min. Total contact = 50 hours. 6 February 2023.

Pethybridge, S. J., Murphy, S. M., and Damann, K. 2023. Feasibility of Mesotunnels for muskmelon production. Mid-Atlantic Fruit and Vegetable Growers Convention, Hershey, Pennsylvania. 31 January 2023. Pp. 38-40. http://www.pvga.org/23-proceedings/. Attendees = 100. Duration = 30 min. Total contact = 50 hours. 31 January 2023.

Rodriguez-Herrera, K. D., Ma, X., Swingle, B., Pethybridge, S. J., Reiners, S., Nault, B., Day, C. T. C., DuBeer, C., Herrmann, T. Q., and Smart, C. D. 2023. A new bacterial disease of cucurbits in NY: Cucurbit yellow vine disease caused by *Serratia marcescens*. Cornell AgriTech Factsheet.

<u>2024</u>

Pethybridge, S. J. 2024. Mesotunnels for cucurbit production. UConn Extension Vegetable & Small Fruit Growers' Conference. Storrs, CT. Attendees = 175. Duration = 60 min. Total contact = 175 hours. 9 January 2024.

Pethybridge, S. J. 2024. Feasibility of mesotunnels for cucurbit production. 43rd Annual LI Agricultural Forum, Riverhead, New York. Attendees = 50. Duration = 60 min. Total contact = 100 hours. 11 January 2024.

PODCASTS

<u>2020</u>

Nair, A. 2020. Small Farms Podcast. Planting, cool-season-crop row covers, and high tunnels. March 24, 2020. 150 downloads.

Nair, A. 2020. Small Farms Podcast. Raised bed vegetable production. April 14, 2020. 75 downloads.

<u>2021</u>

Gleason, M., and Gonzalez, J. 2021. Podcast episode 1 - Mesotunnels and biocontrol for organic cucurbit crops in the Midwest and Northeast. September 2021. Duration: 37:21. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit- podcast/ep01-mesotunnels-and-biocontrol-organic-cucurbit-crops-midwest-and

Pethybridge, S., and Gleason, M. 2021. Podcast episode 2 - A New York state of mind on mesotunnels; with Sarah Pethybridge. September 2021. Duration: 26:58 https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/ep02-new-york-state-mind-mesotunnels-sarah- pethybridge

Gonthier, D., and Gleason, M. 2021. Podcast episode 3 – Pollination! The pillar of a good yield; with Dr. David Gonthier. October 2021. Duration: 32:42 https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/ep03-pollination-pillar- good-yield-dr-david-gonthier

Bessin, R., and Gleason, M. 2021. Podcast episode 4 – Cover crops, living mulches, capabilities & challenges of mesotunnel implementation; with Dr. Ric Bessin October 2021. Duration: 33:03. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/ep04-cover-crops- living-mulches-capabilities-challenges-mesotunnel. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/ep04-cover-crops-living-mulches-capabilities-challenges-mesotunnel

Beattie, G., and Gleason, M. 2021. Podcast episode 5 – Bacteria-eating viruses, and many more cool things, with Dr. Gwyn Beattie. October 2021. Duration: 32:17. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/ep05-bacteria-eating-viruses-and-many-more- cool-things-dr-gwyn-beattie

Iles, L., and Gleason, M. 2021. Podcast episode 6 - Bugs. Getting to know them; with Dr. Laura Iles. October 2021. Duration: 32:28. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/ep06-bugs-getting-know-them-dr- laura-iles

Zhang, W., and Gleason, M. 2021. Podcast episode 7 - Profitability and perspectives for adoption of mesotunnel technology; with Dr. Wendong Zhang November 2021. Duration: 40:57. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/ep07-profitability- and-perspectives-adoption-mesotunnel-technology-dr

Bell, J., and Gleason, M. 2021. Podcast episode 8 - An organic grower's vision of mesotunnels and living mulches; with John Bell. November 2021. Duration: 32:30. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/ep08- organic-growers-vision-mesotunnels-and-living-mulches-john-bell

2022

Beattie, G. 2022. Phages! Podcast episode. June 1, 2022. Duration: 26:09. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/trialing-mesotunnels-cornelluniversity.

Dantzker, H., and Diggins, K. Podcast episode. June 1, 2022. Duration: 37:00. What do growers think of mesotunnels? https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/what-do-growers-think-about-mesotunnels.

Murphy, S., and Damann, K. Podcast episode. June 1, 2022. Duration: 42:32. Trialing mesotunnels at Cornell University https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/trialing-mesotunnels-cornell-university.

Nair, A. Podcast episode. June 1, 2022. Duration: 33:47. Multi-crop use of mesotunnels. https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/trialingmesotunnels-cornell-university.

Williams, M. Podcast episode. June 1, 2022. Duration: 33:26. What is teff and why should organic growers care? https://www.cucurbit.plantpath.iastate.edu/currentcucurbit-podcast/trialing-mesotunnels-cornell-university.

2023

Bessin, R. and Gonthier, D. 2023. Duration: 36:14.Buy bees for mesotunnels? https://www.cucurbit.plantpath.iastate.edu/current-cucurbit-podcast/buy-bees-mesotunnels.

SOCIAL MEDIA AND YOUTUBE

LinkedIn

Gonzalez, J. 2022. LinkedIn. 15 posts totaling 6,095 impressions.

Twitter/X

Gonzalez, J. 2022. Twitter site: "The Current Cucurbit". 8,884 impressions, 132 followers.

The Current Cucurbit (project website). https://www.cucurbit.plantpath.iastate.edu/ Twitter impressions, January-October 2021: 1,031.

YouTube

Badilla, S. 2022. 5,000 Seedlings (Starting in Greenhouse excellent pest management) IPM Shorts 0:33. You Tube video, September 2022.

Badilla, S. 2022. IPM-ISU channel. How to Harvest Acorn Squash. 2:49. https://www.youtube.com/watch?v=ezERrfnjym8&list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3&index=20. YouTube video, October 2022.

Badilla, S. 2022. Organic control of weeds in acorn squash - 2022 experiment! 1:26. https://www.youtube.com/watch?v=o9hGgrz71RA. YouTube video. June 2022.

Damann, K., and Pethybridge, S. 2021. Reflecting on the 2020 preliminary results of the mesotunnel system in NY. March 2021. 87 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

Damann, K. 2022. ID powdery mildew on your cucurbits 1:34. https://www.youtube.com/watch?v=-xnUAZkJPX0. YouTube video. February 2022.

Damann, K. 2023. Everything hoops for a mestotunnel- step by step 5:24. https://www.youtube.com/watch?v=bOMCh4IEIsc. YouTube video. March 2023.

Dungan, M. 2022. How to make gravel snakes. https://www.youtube.com/watch?v=qRVRzK8bsc8. 4:39. YouTube video. October 2022.

Gleason, M. 2021. "An introduction to "Resilient systems for sustainable management of cucurbit crops" – January 2021. 239 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

Gonzalez, J. 2021. Interview with Jordan Scheibel: on-farm cooperator from Iowa. April 2021. 148 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

Gonzalez, J. 2021. Five things you didn't know about muskmelons. August 2021. 799 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

Gonzalez, J. 2022. Pollination experiments with muskmelon and squash bug warning! https://www.youtube.com/watch?v=rl8DeZ4T_zw. YouTube video, 1:53. October 2022.

Gonzalez, J. 2022. Difference between a male and female muskmelon flower. https://www.youtube.com/watch?v=GwX5IClCHsw. 1:21 YouTube video. October 2022.

Gonzalez, J., and Gleason, M. 2021. What re mesotunnels? Infographic, June 2021. 508 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

Morton, L.W., et al. 2021. Solutions from the Land. 177 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

Mphande, K. 2022. Getting to know the cucurbit yellow vine (CYVD) disease. 5:11. https://www.youtube.com/watch?v=NuXf6aq6OC8. You Tube video. April 2022.

Mphande, K. 2022. Trying 'teff' as a living mulch for weed management in organic muskmelon research.1:38.https://www.youtube.com/watch?v=u9nPkXPlhbA. YouTube video. June 2022.

Nair, A. 2021. Are row covers (mesotunnel) treatments modifying the growth cycle of muskmelon? August 2021. 287 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

Nair, A. 2021. Mesotunnel effects on cucurbit crop growth and tunnel microclimate: on-farm trials in Iowa, 2020. February 2021. 185 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

Nair, A, and Gonzalez, J. 2021. How to optimize organic weed control. October 2021. 624 views. https://www.youtube.com/channel/UCjyDwtnC4FDGKz1PU2QKrVw AND https://youtube.com/playlist?list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3

On-farm trial with mesotunnels at Scattergood Friends School, September 15, 2021. https://www.youtube.com/watch?v=6czx1_Drhm0

Williams, M., Nair, A., Bessin, R., and Gonthier, D. 2022. Organic Management Tactics for Cucurbit Crops. 1:06:55. https://www.youtube.com/watch?v=BsN4SRX3nL8&list=PLU1nNyLMXXaN-5tWuNbogkvJ4gLvpMCX3&index=19. YouTube webinar, October 2022.

TECHNICAL BULLETINS

Cheng, N., Zhang, W., Gonzalez, J., and Gleason, M.L. 2023. Controlling Pests and Diseases Using Mesotunnels: Understanding Organic Cucurbit Crop Growers'
Preferences and Choices. Report EB 05-2023, Charles H. Dyson School of Applied Economics and Management, Cornell University, June 2023.

Damann, K., and Pethybridge, S. 2021. Mesotunnels: Next Best Tool for Organic Cucurbit Growers in the Northeastern US. Produce Pages, Cornell University Cooperative Extension, April 2021. p. 6.

ONLINE RESOURCES: WEBSITE AND BLOG POSTS

2020

Badilla, S. 2020. Optimizing weed control under mesotunnel systems: Iowa State's experience with acorn squash. Current Cucurbit website blog post, October 16, 2020.

Cheng, N., and Zhang, W. 2020. How do we assess the economic efficiency of mesotunnels? An economist's take. Current Cucurbit website blog post, September 18, 2020.

Gleason, M.L. 2020. What's a mesotunnel, and what's it good for? Current Cucurbit website blog post, July 24, 2020.

Gonthier, D. 2020. Balancing pollination and pest control in cucurbit mesotunnel systems. Current Cucurbit website blog post, October 2, 2020.

Gonzalez, J. 2020. Planning for success: IPM approaches in organic cucurbit production. Current Cucurbit website blog post, August 28, 2020.

Morton, L.W. 2020. Crop diversification as a risk management strategy. Current Cucurbit website blog post, November 13, 2020.

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CLASSROOM TEACHING AND SEMINARS

Avery, C. 2021. Efficacy of pest control and pollination management in organic cucurbit production with row covers. November 30, 2021. Agricultural and Medical Biotechnology 395/399 Undergraduate Student Symposium, University of Kentucky, Lexington, KY. 20 attendees.

Gleason, M. 2021. Do mesotunnels make sense for organic cucurbit production? Seminar, Department of Plant Pathology, University of Wisconsin-Madison, December 7, 2021. 26 attendees.

Gonthier D. 2021. Multi-functional agriculture: Balancing pest/disease control with pollination: A case study of using row covers in squash. Classroom case study presentation. Agroecology SAG/PLS390 February 26, 2021. 21 attendees.

Gonthier D. 2021. Multi-functional agriculture: Balancing trade-offs to improve sustainability. University of Kentucky. Department of Plant and Soil Science. Department Seminar. March 23, 2021. 35 attendees.

Gonthier, D. 2021. Multi-functional agriculture: Balancing trade-offs to improve sustainability. Seminar, Department of Entomology, University of Kentucky, April 1, 2021. 30 attendees.

FIELD DAY PRESENTATIONS

Badilla, S. 2021. On-site presentation of OREI acorn squash field trials, Iowa State University Field Day, ISU Horticulture Research Farm, Ames, Iowa, July 22, 2021. 225 attendees.

Mphande, K. 2021. On-site presentation of OREI muskmelon field trials, Iowa State University Field Day, ISU Horticulture Research Farm, Ames, Iowa, July 22, 2021. 225 attendees.

Nair, A. 2021. Presentation during field day at OREI on-farm trial site, Scattergood Farm, West Branch, Iowa, September 15, 2021. 125 participants.

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Anonymous. 2022. Bacterial wilt of cucurbits. https://www.cucurbit.plantpath.iastate.edu/infographics. Infographic, The Current Cucurbit website.

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