Title:	Multi - barrier Management Strategies of Phytophthora blight in Peppers and Cucurbits

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Non-Technical Summary

Phytophthora capsici, causal agent of Phytophthora blight, is a serious pathogen in vegetable crops worldwide. **The goals** of this transdisciplinary SREP project are to develop a system-based approach that significantly reduces the risk of Phytophthora blight. We envision the development of a novel Phytophthora Management Risk Index (PMRI) based on integrating five risk components: Phytophthora Inoculum Level, Moisture, Host Resistance, Fungicide Resistance, and Soil Health. This practical concept provides an assessment of the risk of Phytophthora blight in any system and can be used to guide the incorporation of strategies to help minimize disease risk. We are proposing innovative strategies to significantly reduce losses to P. capsici and increase yield and profits. **Our objectives** are to: **i)** evaluate genetic diversity among isolates of P. capsici; **ii)** identify P. capsici-resistant genotypes that are more tolerant to drought or flooding; **iii)** develop sensitive diagnostic tools for detecting infection, and develop multi-barrier management strategies; and **iv)** evaluate economic and social impacts of developed strategies, and to disseminate knowledge and techniques generated through education and Extension outreach. The project will provide stakeholders with a new risk-based management approach (PMRI) using innovative integrated strategies. Our objectives address **five SCRI Focus Areas**: i) Research in plant breeding and genetics (25%); ii) Efforts to identify/address threats from pests and diseases (30%); iii) Efforts to improve production efficiency/profitability (10%); iv) New innovation and technology (25%); and v) Methods to prevent, detect, monitor, control food safety hazards in specialty crops (10%).

Accomplishments

Major goals of the project

Hypotheses, Objectives, and Goals

The long-term goal of this project is to develop an economically profitable multi-barrier system to manage P. capsici on vegetable crops based on sound research-based of information on water and soil management, cultural practices, varietal resistance, and fungicide programs for disease control to reduce the activities of this pathogen in field production and postharvest environment. Knowledge gained through this project will be translated into actionable recommendations and disseminated to stakeholders using avenues such as on-farm experiments and demonstrations, field days, workshops, producer meetings and conferences, project-specific websites, and news releases through websites and Extension offices.

Hypothesis 1: Populations of Phytophthora capsici are genetically diverse and genetic diversity in P. capsici may significantly

affect potential management options of the pathogen.
Objective 1: To conduct a nationwide survey of genetic diversity of isolates of P. capsici from irrigation water and vegetable fields.
1a). To determine the genetic diversity within and range of sensitivity of the isolates of P. capsici to currently used fungicides.
1b) To quantify and to better understand the potential relationship between the genetic diversity of the soil microbiome and P. capsici populations.
The overall goal is to provide guidance on gauging potential disease development based on pathogen genetics, fungicide sensitivity, and the soil microbiome to test the durability of disease mitigation strategies across a spectrum of soil types.

Hypothesis 2: Utilization of P. capsici-resistant crop cultivars with tolerance to extreme environmental footprints (e.g., drought or flooding) will reduce Phytophthora blight and increase crop yield.
Objective 2: To identify and evaluate crop cultivars, accessions, scion-rootstock combinations with P. capsici resistance that may also be more tolerant to drought and flooding.
2a). To evaluate resistance of pepper and cucurbit accessions and scion-rootstock combinations to different genetic groups of P. capsici identified in Objective 1.
2b). To breed for resistance of pepper and cucurbit to P. capsici.
2c). To assess stability of disease resistance under drought and flooding conditions.
The overall goal of the screening and breeding effort in pepper and cucurbit is the identification or development of lines with attributes in reducing the rate of infection, reducing soil inoculum potential (genetic soil disinfestation), while maintaining resistance under drought and flooding conditions, and identifying microbiome that is antagonistic to P. capsici and yet stimulatory to plant growth.

Hypothesis 3: Rapid and sensitive detection of P. capsici and integrated management strategies will result in improved management of Phytophthora blight.
Objective 3: To develop rapid and accurate diagnostic procedures for plant infection by P. capsici and develop multi-barrier strategies for effective management of the disease.
3a). To develop real-time diagnostic assays, including the use of Oxford Nanopore Technology (ONT), a promising sequencing technology, for on-site detection of P. capsici in irrigation water, plants, and postharvest fruit samples.
3b). To develop multi-barrier management strategies incorporating sensitive disease detection, resistant plant genotypes, and tolerance to drought and flooding.
3c) To quantify the effects of multi-barrier management strategies on disease and soil microbiome.
The overall goal is to develop sensitive and rapid disease detection methods to guide implementation of multi-faceted disease management programs that include preventing disease outbreaks, and reducing disease levels through disease resistance, tolerance to environmental footprints (drought and flooding), improved soil health, and improved food quality and safety.

Hypothesis 4: Management approaches developed in the project will provide the most economically profitable options with greater social impacts to producers engaged in the production of vegetable crops challenged by P. capsici.
Objective 4: To evaluate the economic and social impacts of developed integrated strategies and to disseminate knowledge and techniques generated through education and extension.
The overall goal is to provide producers and other stakeholders with research, extension, and educational materials on the efficacy and profitability of managing P. capsici using integrated strategies.

What was accomplished under these goals?

Objective 1
In Arizona, **Co-PI Hu** has recovered 20 isolates of Phytophthora capsici from each of the seven states plus additional isolates from melons and peppers in Summer 2025. Both A1 and A2 mating types have been identified in the isolates. They will be phenotypically characterized regarding mating type, race structure, and fungicide sensitivity to mefenoxam, fluopicolide, ethaboxam, mandipropamid, oxathiapiprolin, dimethomorph, cyazofamid, and Zampro. Biosurfactants, including rhamnolipids, are being assessed for their efficacy to inhibit the growth of P. capsici isolates. Their race structure and virulence diversity will be characterized using a set of New Mexico Recombinant Inbred Lines from New Mexico State University. Preliminary results based on mycelial growth indicated that all isolates are sensitive to all fungicides except dimethomorph and ethaboxam. **Co-PI Barberan** is assisting in storing soil samples in his laboratory and anticipating arrival of additional soil samples for storage.
In New Mexico, **co-PI Lozada** collected samples of P. capsici from different states for a total of 23 isolates and is maintaining them at NMSU. **Co-PI Acharya** has created a detailed online survey to collect data from the researchers involved in the P. capsici project, farmers involved in the production of the crops, and post-harvest crop handlers.
In Illinois, **co-PI Babadoost** conducted research to determining the efficacy of seven potential fungicides for P. capsici management in the laboratory and to determine virulence of six different isolates from various locations of the Midwest on

pumpkin seedlings in the greenhouse. This research is ongoing. In addition, a field experiment was conducted in pumpkin with fifteen treatments in a hot-spot area for P. capsici.
In Texas, **co-PI Somenahally** has completed DNA extraction on healthy and diseased soils from New Mexico State University (NMSU), obtained one sample from the University of Florida (UF) field trials, and has begun qPCR testing on samples that have been extracted.
In Mississippi, **co-PI Ali** has collected samples of P. capsici and tested sensitivity of the isolates against common active ingredients including dimethomorph, manipropamid, ethaboxam, and oxathiapiprolin. This research is ongoing. Five of the collected isolates were evaluated across mycelium growth, sporangium formation, and zoospore germination stages.
In New Jersey, **co-PI Wyenandt** evaluated the use of conventional and organic fungicides for the control of stem and fruit rot caused by P. capsici in bell pepper. This research is ongoing.

Objective 2
In Texas, **co-PI Crosby** developed six families of watermelon, between Citrullus lanatus and Citrullus amarus and Citrullus mucospermus, to screen for reported resistance genes. Seedling inoculations of P. capsici were carried out in a greenhouse study to confirm resistance in parents and F2 progeny. Resistant F2 progeny were then backcrossed to the C. lanatus recurrent parents. In the field, non-inoculated parents, F1, and F2 progeny were planted and vine and fruit data were collected to estimate heritabilities. Results showed one family demonstrated rind resistance to P. capsici. Those populations were planted in late August 2025 and the research is ongoing.
In New Mexico, **co-PI Djaman** is investigating the effects of different irrigation regimes on six pepper cultivars and three pumpkin cultivars on crop growth, yield, and susceptibility to P. capsici and development of Phytophthora blight. The three different regimes iclude full irrigation, 20% water saving, and 40% water saving. Preliminary results show yield increase at 20% water saving and yield decline in 40% water saving. This research is ongoing.
Objective 3a. Develop real-time diagnostic assays
In Florida, **co-PI Dufault** tested both biological controls and plant defense activators. Biological controls evaluated included Theia, Double Nickel, and Theia alternated with Presidio. Plant defense activators evaluated included KPhite, Aliette, Orondis, and Presidio. These are being evaluated as early interventions in the field to test their efficacy against P. capsici. This research is ongoing.
In New Mexico, **co-PI Fedio** collected and plated 10 water samples to determine presence of P. capsici. He is working on collecting water, soil, and pepper pod samples to detect P. capsici in high and low level Phytophthora areas in Las Cruces, NM and surrounding areas and working to extract DNA from P. capsici infested water. This research is ongoing.
Objective 3b. To develop multi-barrier management strategies
In New Mexico, **co-PI Sanogo** has conducted an experiment to evaluate the use of different application rates of a combination of fungicides (Actinovate, Root Shield, Double Nickel, MycoApply Endo, and MycoApply Soluble Maxx) against P. capsici in pumpkin and chile field trials. This research is ongoing. **Co-PI Lozada** has extracted high quality genomic DNA for each P. capsici isolate received from collaborators and submitted to the Arizona Genomics Institute for PacBio sequencing. This was completed on July 24, 2025 and sequence data was made available July 31, 2025.
In Mississippi, **co-PI Ali** has engaged in Oxford Nanopore Technology, DNA extraction, and isothermal assay development DNA from decaying tissue was extracted and confirmed using Qiagon DNEasy Plant Mini Kit and conventional PCR methods. An initial Oxford Nanopore Technology-based protocol for rapid detection of P. capsici has been developed and is currently optimizing in laboratory condition.
In Texas, **co-PI Somenahally** conducted greenhouse trials to investigate management of P. capsici using organic practices including anaerobic soil disinfestation, use of mustard seed meal, use of biochar, and forest soil inoculation. The treatments used were poultry manure, mustard seed meal with poultry manure, a chemical fertilizer control, chemical fertilizer with biochar, chemical fertilizer with mustard seed meal, and chemical fertilizer with forest soil inoculation. Significant shifts in the microbial community were observed. This research is ongoing.
Objective 4
In New Mexico, **co-PI Sanogo** is working with **Program Manager Fechner** on developing giveaway material for the next Spring Institute for Phytophthora Research and Extension (SIPRE) workshop, maintaining and updating the phytophthora.nmsu.edu website, and attending outreach events to provide information to stakeholders, farmers, researchers, and elementary, middle, high school, and undergraduate and graduate students. Several presentations (18 in total) were given at meetings of scientific societies and commodity groups. Additionally, 7 abstracts and extension/outreach materials were produced. Field and farmer visits occurred regularly to disseminate information of ongoing research and collected results to producers.

What opportunities for training and professional development has the project provided?

All co-PIs were engaged in hiring undergraduate, graduate, and post-graduate personnel. Co-PIs and post-graduate personnel provided training in pathological and microbiological techniques, developing skills in experimental design and data collection, and in presenting research projects to stakeholders and in scientific society meetings. Personnel has gained

experience in conducting meetings and workshops, summarizing research, and extension/outreach to growers, producers, stakeholders, and other relevant parties.

How have the results been disseminated to communities of interest?

Results have been disseminated through conferences, posters, oral presentations, field and grower visits, and outreach events. In spring 2025, the Spring Institute for Phytophthora Research and Extension was held in Las Cruces, NM in conjunction with the Annual New Mexico Chile Conference. This event brought in growers, stakeholders, researchers, teachers, and students from around the nation to learn about updates in phytophthora-based research in peppers and cucurbits. This event concluded with an open forum for any interested parties to ask questions or discuss ongoing research. Additionally, information has been disseminated through outreach activities to elementary, middle, and high school students at participating events. Other meetings included Illinois Pumpkin Day, Southern Illinois Vegetable Growers Meeting, Ninth Edition of Global Congress on Plant Biology and Biotechnology, Amish and Mennonite Vegetable Growers Meeting, International Symposium on Seed, Transplants and Stand Establishment of Horticultural Crops, APS-NCR Annual Meeting, field days, and departmental events.

What do you plan to do during the next reporting period to accomplish the goals?

In Arizona, **co-PI Hu** will explore the possibility of determining race structure in the field to find differences in A1 and A2 mating types. He will set up an experiment to evaluate the efficacy of fungicide treatments in suppressing Phytophthora blight in pepper in greenhouse and field conditions. New Mexico Recombinant Inbred Lines (NMRILs) will be planted and inoculated with zoospores of some P. capsici isolates to evaluate their phenotypic reaction in the lab and greenhouse.
In New Mexico, **co-PI Lozada** will continue to collect isolates of P. capsici from other collaborators. He will download genetic sequencing data, quality control, and store data in preparation for downstream analysis. He will conduct pangenome analysis following the processing of sequence data and conduct phenotypic screening for Phytophthora root rot resistance in the F2 population. He will analyze the data from the whole genome sequencing, hybridize parental lines of peppers in the greenhouse, and phenotype RILs for different P. capsici isolates. **PD Sanogo** will be collecting results from the ongoing pumpkin and pepper biological fungicide study in the field and will conduct a greenhouse study evaluating the efficacy of mushroom fruiting body (Chlorophyllum molybdites) and spent substrate (Pleurotus djamor var. roseus) on P. capsici in pepper. He will also be conducting an experiment evaluating genetic soil disinfestation using P. capsici in resistant pepper genotypes compared to susceptible genotypes and continue to maintain, update, and design aspects of the phytophthora.nmsu.edu website by adding presentations, posters, and other relevant information related to the project. He will be collecting water, soil, and chile pepper pod samples to give to **co-PI Fedio** for further analysis and P. capsici detection. **Co-PI Djaman** will conduct a second trial of effects of different irrigation regimes on chile pepper and pumpkin.
In Illinois, **co-PI Babadoost** will collect results of his ongoing fungicide and virulence experiments in the laboratory and the greenhouse.
In Texas, **co-PI Crosby** will harvest fruit from the watermelon field planted this year and screen it for P. capsici rind resistance using controlled inoculations. He will continue backcrossing in the greenhouse with advanced backcrosses from both field and greenhouse trials to be screened in spring 2026. He will conduct field trials of F2, BC1F2, and BC2 populations to evaluate fruit and vine traits. **Co-PI Somenahally** will run more greenhouse trials, continue running an analysis of the microbiome of healthy soils compared to diseased soils from NMSU and relevant UF samples, and will complete qPCR and DNA extraction on UF field trial samples.
In Florida, **co-PI Dufault** will repeat trials of biological control and plant defense activating compounds of watermelon in the field and explore ways to counteract effects of field topography on disease incidence. In addition, he will conduct trials on bell peppers focusing on integration of biocontrol agents and plant defense activators into conventional fungicide rotations as early season controls against P. capsici in watermelon. He will compile and analyze data from the first trial and continue to collect soil samples for analysis by **co-PI Somenahally** and commercial soil test services and continue to collect P. capsici isolates and maintain contact with UF extension experts and agents.

Participants

Actual FTE's for this Reporting Period

Role	Non-Students or faculty	Students with Staffing Roles			Computed Total by Role
		Undergraduate	Graduate	Post-Doctorate	
Scientist	0.5	0.2	0.5	1	2.2
Professional	0.5	0	0	0	0.5
Technical	1	0	0	0	1

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Actual FTE's for this Reporting Period

Role	Non-Students or faculty	Students with Staffing Roles			Computed Total by Role
		Undergraduate	Graduate	Post-Doctorate	
Administrative	0	0	0	0	0
Other	0	0	0	0	0
Computed Total	2.0	0.2	0.5	1	3.7

Student Count by Classification of Instructional Programs (CIP) Code

Undergraduate	Graduate	Post-Doctorate	CIP Code
4	6	3	01.11 Plant Sciences.

Target Audience

The audience reached by our efforts during this reporting period includes agricultural producers and industries involved in vegetable production, including state, regional, and vegetable grower associations. Other impacted target audiences include consultants, research scientists, graduate and undergraduate students, and K-12 educators.

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Products

DR 1020-006 Certification Statement

N/A, this project/program did not produce any scholarly publications and data assets as defined by DR 1020-006 during the reporting period.

Type

Conference Papers and Presentations

Status

Published

Year Published

2025

NIFA Support Acknowledged

YES

Digital Object Identifier (DOI)

Author ORCID(s)

Citation

Elms, R., Crosby, K., Smith, W., Jifon, J., and T. Isakeit. 2025. Evaluations Watermelon (Citrullus spp.) F2 Hybrid Populations for Phytophthora capsici Resistance. ASHS Conference, New Orleans.
Elms, R., Crosby, K., Smith, W., Jifon, J., and T. Isakeit. 2025. Evaluations Watermelon (Citrullus spp.) F2 Hybrid Populations for Phytophthora capsici Resistance. TAMU Plant Breeding Symposium.
Fechner, J. and S. Sanogo. 2025. Activity of extracts from Chlorophyllum molybdites and spent substrate of Pleurotus djamor var. roseus on sporangia production by Phytophthora capsici. The American Phytopathological Society Annual Meeting 2025.
Fullem, K., Beckham, K., Sanogo, S., Dufault, N. Evaluation of early-season application of Theia (Bacillus subtilis) on crown, root, and fruit rots of watermelon caused by Phytophthora capsici. APS Plant Health 2025 Conference, Honolulu, Hawaii, August 2-5.
Mamo, B., Fitzgibbon, M., Sanogo, S., Hu, J. 2025. Sensitivity of the Causal Agent of Phytophthora Blight in Peppers, Phytophthora capsici, to mefenoxam and new oomycote fungicides. American Phytopathological Society Plant Heatlh Conference 2025, Hawaii,

August 2025.
Matres, J. K., Nourbakhsh, S.S., Lozada, D.N. 2025. Global distribution and diversity of Phytophthora capsici infecting a broad host range revealed by mitochondrial genes. American Society for Horticultural Science Conference 2025. July 28-August 1, 2025. New Orleans, LA.
Matres J.K., Nourbakhsh, S.S., Lozada D.N. Global distribution and diversity of Phytophthora capsici isolates and variations in crinkler (CRN) effector genes. New Mexico Chile Conference 2025, February 3-4, 2025, Las Cruces, NM.
Khatiwada, A. and R.N. Acharya. 2025. Use of expert opinion to develop phytophthora blight index: An exploratory approach. Presented at the 2025 IFAMA World Conference on Food Security through Innovation and Sustainability, Ribeirao
Preto, Brazil, June 2025.
Prajina Neupane, Anil Somenahally, Terry Gentry, Jake Mowrer, Thomas Isakeit, Lauryn Coffman, Chastity Aguilar. Implementing organic practices to manage Phytophthora capsici in peppers: Implications on greenhouse gas emissions. Southern American Society of Agronomy. 2025.
Prajina Neupane, Anil Somenahally, Terry Gentry, Jake Mowrer, Thomas Isakeit, Lauryn Coffman, Chastity Aguilar. Evaluating
organic practices for greenhouse gas emissions and disease suppression. Tri-Society Conference. 2024.
Redhu, S. & Babadoost M. 2025. Evaluation of Effectiveness of Fungicides for Management of Illinois Phytophthora capsici in the Laboratory and Field. APS-NCR Annual Meeting. June 2025. Brooklin, South Dakota.
Sanogo, S. 2025. Achieving Microbial Balance for Soilborne Disease Management. New Mexico Chile Conference 2025, February 3-4, 2025, Las Cruces, NM.
Sanogo, S. 2025. Unpacking the concept of inoculum potential: a bibliometric analysis of its usage since 1932. APS Plant Health 2025 Conference, Honolulu, Hawaii, August 2-5
Sanogo, S., P. Lujan, J. Fechner, Q. Dobey, J. Barraza, and J. Consford. 2025. Enhancing microbial recruitment and persistence in cover crop mixtures for control of soilborne pathogens in chile pepper. APS Plant Health 2025 Conference, Honolulu, Hawaii, August 2-5
Talari, K., Waliullah, S., and Ali, E. 2025. Optimizing Oxford Nanopore Sequencing Technology for Rapid Onsite Diagnosis of Phytophthora capsici. ASHS Conference, New Orleans, Louisiana, July 28 – August 1.
Talari, K., Waliullah, S., and Ali, E. 2025. Oxford Nanopore Technology: Game-Changing Onsite Diagnosis for Phytophthora capsici. Mississippi Academy of Science Conference, Biloxi, MS, March 20-21.
Waliullah, S., Talari, K., and Ali, E. 2025. Improving Field-Based Diagnosis of Phytophthora capsici with Optimized Nanopore Sequencing. APS Plant Health 2025 Conference, Honolulu, Hawaii, August 2-5.

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Other Products

Type
Other

DOI or Other Persistent Identifier

Associated Publication DOI(s)

Author ORCID(s)

Description
Other publications: peer-reviewed articles and extension/outreach materials
Ali, E. and Chukwuma, F. Simple Tips for Plant Disease Diagnosis (Tri-fold). Alcorn State University Extension Program.

Babadoost M. Amish and Mennonite vegetable growers meeting - cucurbits. August 2025. Arcola, Illinois.

Babadoost M. Amish and Mennonite vegetable growers meeting - peppers. June 2025. Arthur, Illinois.

Babadoost, M. Illinois Pumpkin Day. September 2024. Belleville, Illinois.

Babadoost M. International Symposium on Seed, Transplants and Stand Establishment of Horticultural Crops. June 2025. Thessaloniki, Greece.

Babadoost M. Ninth Edition of Global Congress on Plant Biology and Biotechnology. March 2025. Singapore.

Babadoost M. Northern Illinois vegetable growers meeting – cucurbits. February 2025.

Rockford, Illinois.

Babadoost M. Northern Illinois vegetable growers meeting – peppers. February 2025. Rockford, Illinois.

Babadoost M. Southern Illinois vegetable growers meeting – cucurbits. February 2025. Mt. Vernon, Illinois.

Babadoost M. Southern Illinois vegetable growers meeting – peppers. February 2025. Mt. Vernon, Illinois.

Fullem, K. and Dufault, N. Plants Get Sick Too!

Fullem, K. and Dufault, N. Research Explorations in Environmental Health and Toxicology.

Redhu, S., Pandey, K.R., and Babadoost, M. 2024. Efficacy of selected fungicides for control of Phytophthora blight (Phytophthora capsici) of processing pumpkin, 2024. PDMR 28 (Online). https://doi.org/10.1094/PHP-11-24-0130-PDMR.

Sanogo, S. and Fechner, J. Becoming a Frontline Worker for Protection of Food, Agriculture, and Natural Ecosystems. April 2025. FFA Fest. Las Cruces, NM.

Sanogo, S. and Fechner, J. Becoming a Frontline Worker for Protection of Food, Agriculture, and Natural Ecosystems. November 2025. STEM Ag Day. Las Cruces, NM.

Sanogo, S., P. Lujan, J. Fechner, Q. Dobey, J. Barraza, and J. Consford. 2025. Enhancing microbial recruitment and persistence in cover crop mixtures for control of soilborne pathogens in chile pepper. Fabian Carcia Science Center Field Day, June 4, 2025. Las Cruces, NM.

Wyenandt, A. Diagnosing Important Diseases in Pepper – Reference Guide. Rutgers Cooperative Extension.

Wyenandt, A. Phytophthora and Pythium Control During Wet Weather. Rutgers Cooperative Extension.

Accession No. 1031511 **Project No. NMSANOGO-23G**

Type
Audio or Video

DOI or Other Persistent Identifier

Associated Publication DOI(s)

Author ORCID(s)

Description
VIDEOS

MinION Oxford Nanopore Technology for Rapid and Accurate Identification of Plant Pathogens
(https://www.youtube.com/watch?v=9ttPGaPnSU0)

Spore Trap for Downy Mildew Disease Monitoring
(https://www.youtube.com/watch?v=Pwux46aNZW4)

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Type
Other

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Description
IN THE NEWS

NMSU to host 2025 New Mexico Chile Conference Feb. 3-4
https://www.grantcountybeat.com/news/non-local-news-releases/other-nm-universities-announcements/nmsu-to-host-2025-new-mexico-chile-conference-feb-3-4

NMSU researcher to lead workshop on plant pathogen
https://newsroom.nmsu.edu/news/nmsu-researcher-to-lead-workshop-on-plant-pathogen/s/f425cb69-db5e-4ce2-b577-96a1f4b87e3e

New Mexico State University will be in charge of organizing a workshop on plant pathogens
https://essfeed.com/new-mexico-state-university-will-be-in-charge/

Changes/Problems
Lack of disease pressure in some fields has proven difficult and non-viable sources of P. capsici has limited infection in some greenhouse trials. Contrarily, low lying areas of fields have higher disease presence, complicating field research. Across the co-PIs, hiring of personnel was initiated and is ongoing, although the hiring process can be slow. Visa issues for foreign students have slowed down the hiring process. Percentage expenditure varied across Co-PIs ranging from 4-100% for Year 2.