ISSUE 2
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# SAME PROJECT

## IN THIS ISSUE



## SAME OBJECTIVES

***The long-term goals of SAME are to optimize models for site-specific cranberry fruit rot control recommendations, promote the adoption of integrated management methods on commercial beds, develop best management practices, and ultimately reduce fruit rot while enhancing fruit quality.***

1. ***Assess fruit rot pathogen populations across the major US production regions and monitor their sensitivity to fungicides.***
2. ***Evaluate the impact of environmental stressors and fertilizer on fruit chemistry and fruit rot symptom development.***
3. ***Identify genetic resources for fruit rot resistance and stress tolerance to guide breeding.***
4. ***Develop predictive models for fruit rot management and examine the economics of cranberry fruit rot management.***
5. ***Distribute tailored solutions to growers throughout the US through extension networks and training.***

***This initiative represents an important advancement toward sustainable cranberry production and the enhancement of fruit rot management practices within the industry.***

# BEATING THE HEAT

*Understanding How Short- and Long-Term Heat Stress Affects Cranberry Fruit Rot*

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As climate change intensifies, heat stress is becoming an increasingly significant concern for fruit crops, including cranberries. Across all cranberry-growing regions, growers are worried about the impact of rising temperatures on fruit quality and yield. This concern is particularly pressing in areas like New Jersey, where heat stress is already affecting cranberry production. One area of focus is whether heat stress during fruit development might be linked to an increased incidence of fruit rot, a major challenge for cranberry production.

To investigate this potential relationship, we are examining two types of heat stress: acute or short-term stress and prolonged or long-term stress. This study aims to shed light on how different heat stress scenarios affect cranberry fruit rot, providing insights to help growers mitigate these impacts.

During the 2024 growing season, we conducted both long- and short-term heat stress experiments on two commercial cranberry cultivars, ‘Mullica Queen’ and ‘Stevens’, at the Wisconsin Cranberry Research Station in Black River Falls, Wisconsin. Building on insights from a 2023 pilot study, we utilized two types of open-top chambers (OTCs) tailored for each type of heat stress. Wider and shorter OTCs were employed for long-term heat stress, as their design better retains elevated midday temperatures. In contrast, narrower and taller OTCs were used to simulate acute heat stress conditions (Figure 1).

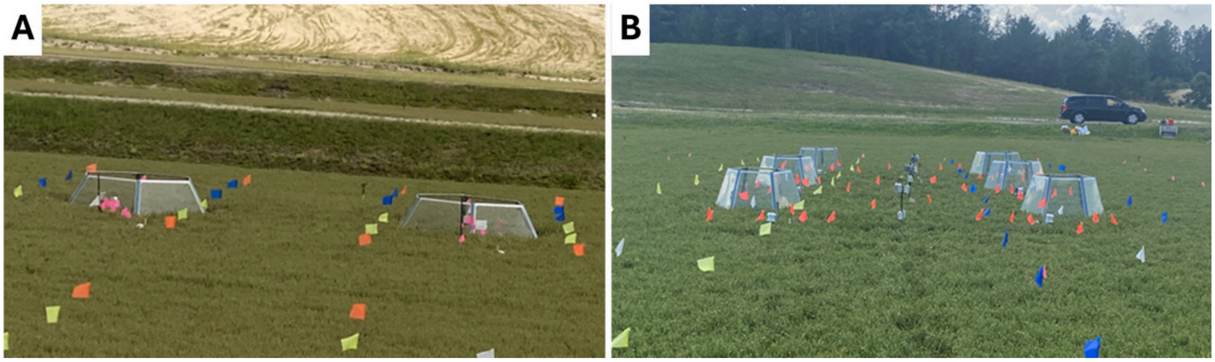



**Figure 1.** *Open-top chambers (OTCs) used to induce heat stress conditions in cranberry.* ***A.*** *Wider and shorter OTCs used for long-term heat stress.* ***B.*** *OTCs used for acute heat stress experiments.*

## *Long-term heat stress*

For the long-term heat stress experiment, we established four OTCs and four control plots per cultivar during the first week of June 2024, when cranberry plants reached the roughneck phenological stage (Figure 2). These OTCs were removed immediately before fruit harvesting in late September 2024. Throughout the period the OTCs remained in the field, canopy temperature and relative humidity were recorded every 10 minutes. Additionally, phenological data were collected weekly, and measurements of carbon assimilation and stomatal conductance were taken four times during the growing season using a CIRAS-3 Portable Photosynthesis System (PP Systems, Amesbury, MA). These measurements were used to evaluate whether higher temperatures negatively affect photosynthesis, which could in turn reduce cranberry plant productivity. This is a critical concern, as higher temperatures could potentially lead to lower yields, posing a significant challenge for cranberry growers in a warming climate.

**Figure 2.** *Open-top chambers (OTCs) and control plots established to study the effect of long-term heat stress on cranberry fruit rot.*

When the fruit had set and reached the pea-size stage, we inserted micro-thermocouples through the calyx to record internal fruit temperature until harvest (Figure 3). Temperature and relative humidity data were downloaded weekly, and the micro-thermocouples were checked regularly. If necessary, new fruits were selected and monitored to ensure consistent data collection. Additionally, phenological data were collected weekly to track potential differences in plant growth and fruit development. These fruit temperature measurements were critical for assessing whether higher fruit temperatures were associated with increased fruit rot incidence, providing valuable insights into the potential impact of heat stress on cranberry fruit health.

**Figure 3.** *Micro-thermocouple inserted into growing fruit to monitor internal fruit temperature during heat stress experiments. The micro-thermocouple was inserted through the calyx, 3 mm inside the fruit.*

### *Acute heat stress*

For the acute heat stress experiment, we applied four treatments to cranberry plots at different phenological stages of fruit development: pea-size, green, blush, and red berry stages. The treatments were designed to expose plants to a temperature of 40°C (104°F) for two hours at specific stages, with each treatment involving a varying number of "pulses" or instances of heat stress.

The first treatment included four pulses applied at all four stages (pea-size, green, blush, and red berry). The second treatment involved three pulses, starting at the green stage and continuing through the blush and red berry stages. The third treatment consisted of two pulses applied at the blush and red berry stages. The final treatment included a single pulse applied only at the red berry stage. We imposed the acute heat stress at these different developmental stages to determine whether cranberry fruit is more sensitive to heat stress—and consequently more prone to developing fruit rot—at specific stages of growth. Understanding the relationship between heat stress timing and fruit rot development could inform targeted management practices to mitigate heat stress effects during the most critical stages of fruit development.

To induce acute heat stress, we used a patio lamp with a 1600-watt infrared heating element positioned at the top of each OTC. Since the experiments were conducted in the field without access to alternating current electricity, generators were used to power the lamps. Inkbird Temperature Controllers were employed to maintain a consistent temperature of 40°C ± 0.5°C for two hours. To eliminate the effects of high temperatures from solar radiation, insulated blankets were placed over all sides and the tops of the OTCs. Control OTCs were similarly covered with insulated blankets but did not include a heating element. For each treatment and heat pulse, we used three heated OTCs and three control OTCs. Each OTC was considered a biological replicate (Figure 4).

Similarly to the long-term heat stress experiment, we measured a variety of variables to help relate the effects of the treatments to potential increases in fruit rot incidence. Immediately before installing the OTCs to begin the treatment, one thermocouple was placed at canopy level, and three micro-thermocouples were inserted into three fruits at the basal position in the upright to measure canopy and internal fruit temperatures, respectively. Additionally, sensors were installed to measure relative humidity. Along with collecting temperature data during the treatments, we also monitored phenology and recorded the percentage of fruit rot prior to the treatments. This comprehensive data collection allowed us to assess the relationship between heat stress and fruit rot development.

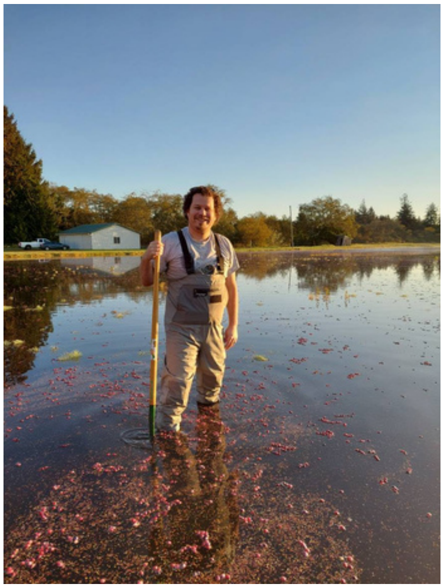

Figure 4. *Set up of the acute heat stress experiments.* ***A.*** *OTCs covered with insulation blankets. The first row of three OTCs includes patio lamps to induce a "pulse" of heat stress for two hours. The second row consists of control OTCs without lamps. Generators were used to power the patio lamps.* ***B.*** *Close-up of the OTC with a patio lamp on top. Canopy and fruit temperature sensors, as well as relative humidity sensors were installed.*

Before the commercial fruit harvest at the Cranberry Research Station, we selected a 0.2 $m^2$ (2 square feet) area from each OTC and control plot and collected all the fruit from that area. From these samples, we evaluated several key factors including yield, the percentage of rotten versus healthy fruit, fruit morphology—such as length, width, and cuticle thickness—and fruit chemical composition, which encompassed anthocyanins, total phenolic content, as well as sugar and acid content. Additionally, plant material was collected exclusively from the long-term heat stress experiment to assess various plant traits, including fruiting upright density, upright length, rebudding, and physiological parameters such as stomatal conductance, leaf area, and leaf thickness.

In conclusion, our experiments on both long- and short-term heat stress in cranberries aim to assess the potential impact of rising temperatures on fruit quality and productivity, particularly in relation to fruit rot incidence. The data collected in 2024, including fruit yield, rot percentage, morphology, chemical composition, and various plant traits, will provide valuable insights into how heat stress affects cranberry plants at different stages of development. We are currently evaluating this data to identify potential correlations between heat stress and fruit rot. As part of a two-year study, we will repeat both the long-term and acute heat stress experiments in 2025, collecting the same comprehensive set of data to confirm our findings and deepen our understanding of how heat stress influences cranberry production. This research will ultimately help inform management strategies to mitigate the effects of heat stress and improve cranberry crop resilience in the face of climate change.

# CRANBERRY FRUIT ROTS IN THE U.S. PACIFIC NORTHWEST

*Oregon and Washington are the fourth- and fifth-highest cranberry producing states, producing around 500,000 and 150,000 barrels per year, respectively. About a third of Washington's production is dry-harvest, which is unique as less than 5% of cranberry production nationally is dry-harvest. Harvest mechanisms and management throughout the year are both important in controlling cranberry fruit rot pathogens. Nationwide, over 15 fungal species have been identified as part of the cranberry fruit rot complex.*



***Don Valentine*** *in a flooded bog.*

As important as the management of the cranberry fruit rot complex is, there has been little published research on the complex within Oregon and Washington. As far as we are aware, the most recent published survey from these states was from 1993, and only looked at Washington beds, while the most complete report of rots in both states was published nearly a century ago. Recently, our lab completed a four-year survey of cranberry fruit rots in mature 'Stevens' beds in Oregon and Washington.

### *Main findings*

Over four years, we isolated nearly all major reported fruit rots, excluding *Monilinia oxycocci* ("cottonball") and *Phyllosticta vaccinii* ("early rot"). Historically, "cottonball" was one of the major field rots in Oregon and Washington cranberry fields, and we suspect cultivar differences, modern fungicides, and flood-harvest are potential contributors to its downfall as a main field rot. Nearly every other cranberry fruit rot, however, was isolated from each field over the course of the study, suggesting that despite variability year-to-year, it is likely that most mature fields in these states experience disease pressure from every group of the cranberry fruit rot complex (of course excluding "cottonball" and "early rot").

The moderate climate on the Pacific coast—the growing area for virtually all of Oregon and Washington cranberry production—is likely to contribute to distinct trends seen in this study. The height of summer sees little precipitation with average monthly highs that rarely reach 70° F. Overall rot levels tend to be lower than east coast production, though high rot years are not unheard of—with 2021 being one of those years. The moderate climate likely affects the composition of fruit rot expression as well. We found *Colletotrichum acutatum* species to be much more prevalent than *C. gloeosporioides*—the former maintaining a lower optimum growth temperature than the latter, though both cause "bitter rot". And a new, previously undescribed cranberry rot was found to be a potentially significant player in the cranberry fruit rot complex.

## *Characterizing a novel cranberry fruit rot:* Neofabraea actinidiae

One particular cranberry fruit rot fungus may be a regionally-important pathogen: *Neofabraea actinidiae*. Various *Neofabraea* species cause storage rots in kiwifruit, apples, and pears, but have not previously been reported to cause cranberry fruit rot, though *Neofabraea actinidiae* has previously been isolated from woody cranberry tissue. The *Neofabraea actinidiae* rot symptoms on cranberry are similar to "bulls-eye rot" found on apples and pears—an infection point and a discolored and outward radiating lesion, akin to a circular archery target. We have observed this cranberry rot in some Oregon and Washington beds at harvest, and more frequently as a storage rot in all beds studied.

***Left*** *Close-up of asymptomatic berries.*

***Right*** *Symptoms of* Neofabraea *infected berries.*

## *Digging deeper*

We are continuing to identify and characterize fungal isolates that have not previously been reported to infect cranberries, but which belong to various genera of known cranberry fruit rots, including *Coleophoma*, *Diaporthe*, and *Colletotrichum*. These different species may have important variations in pathogenicity, fungicide tolerance, and infection sources, the knowledge of which could contribute to better management practices. Awareness of additional pathogenic species within the cranberry fruit rot complex may aid efforts of the SAME project to adapt molecular (multiplex PCR) assays to rapidly detect and quantify cranberry fruit rot pathogens in plant tissues and cranberries.

## *Future Work*

This has been important and foundational research going into the SAME multi-state project, where we are following these fruit rot fungi from bloom through harvest, to determine when they are infecting berries. One of the many strengths of the SAME project is that the cranberry fruit rot complex is being studied simultaneously in all five major cranberry producing states over several growing seasons—a first. This will allow the SAME team to compare and contrast regional differences in the cranberry fruit rot complex. This may reveal management practices that significantly reduce the incidence of cranberry fruit rots.

# NITROGEN FERTILIZER EFFECTS ON CRANBERRY FRUIT ROT & CANOPY BIOPHYSICAL CHARACTERISTICS

*The increased use of nitrogen (N) fertilizers over the past century has significantly enhanced agricultural production and contributed to global food security. Nevertheless, the improper use of nitrogen can severely damage air, water, and soil quality, leading to biodiversity loss and exacerbating climate change. It is unclear how fertilizer N application affects fruit rot incidence in cranberry production.*

Cranberry originated from acidic and low fertile soils. Nitrogen is the most important element that influences both vegetative growth and fruiting in cranberry production. While many factors such as cultivar, age, and vigor of vines are important, soil fertility is one of the most important factors impacting yield and fruit quality. Nitrogen is an essential component of food constituents, particularly amino acids and proteins required for the growth of plants, animals, and humans. Optimizing cranberry production requires providing essential mineral nutrients in the correct amounts, forms, and at the right time. Nutrient management strategies should therefore be both flexible and environmentally sound.

Our goal was to determine the effect of nitrogen application rate on cranberry fruit rot. We set out to test whether nitrogen fertilizer provides increased substrate for microbial biomass and activity resulting in diverse microorganisms affecting fruit rot. In addition, external nitrogen may cause excessive cranberry canopy growth, thereby providing a conducive environment for high relative humidity (RH) that encourages fruit rot pathogens. To measure biophysical data, we deployed micro climatic sensors in each treatment. Previous work by Jeranyama unpublished showed high fruit rot incidence with increase in fertilizer N rate (Figure 1).

In the current study, we tested 40 lb N/acre and 100 lb N/acre levels of fertilizer N on cultivar 'Stevens' (ST) and 'Mullica Queen' (MQ). In this article we will show how the canopy relative humidity and canopy temperature were affected by fertilizer N rate in the two years in 'Mullica Queen' and 'Stevens' beds.

We found that the temperatures in MQ under 100 lb N/acre (Tmq100) and ST under 100 lb N/acre (Tst100) tended to be colder than MQ under 40 lb N/acre (Tmq40) and ST under 40 lb N/acre (Tst40) for both years, as depicted in Figure 2.

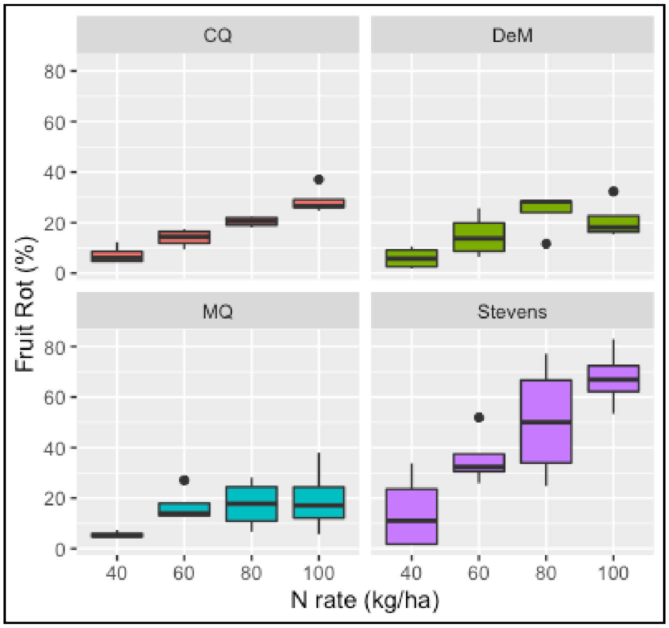



***Figure 1.*** *Fertilizer N rate effect on fruit rot incidence in five cranberry cultivars at State Bog, MA. CQ = Crimson Queen; DeM = Demoranville; MQ = Mullica Queen*

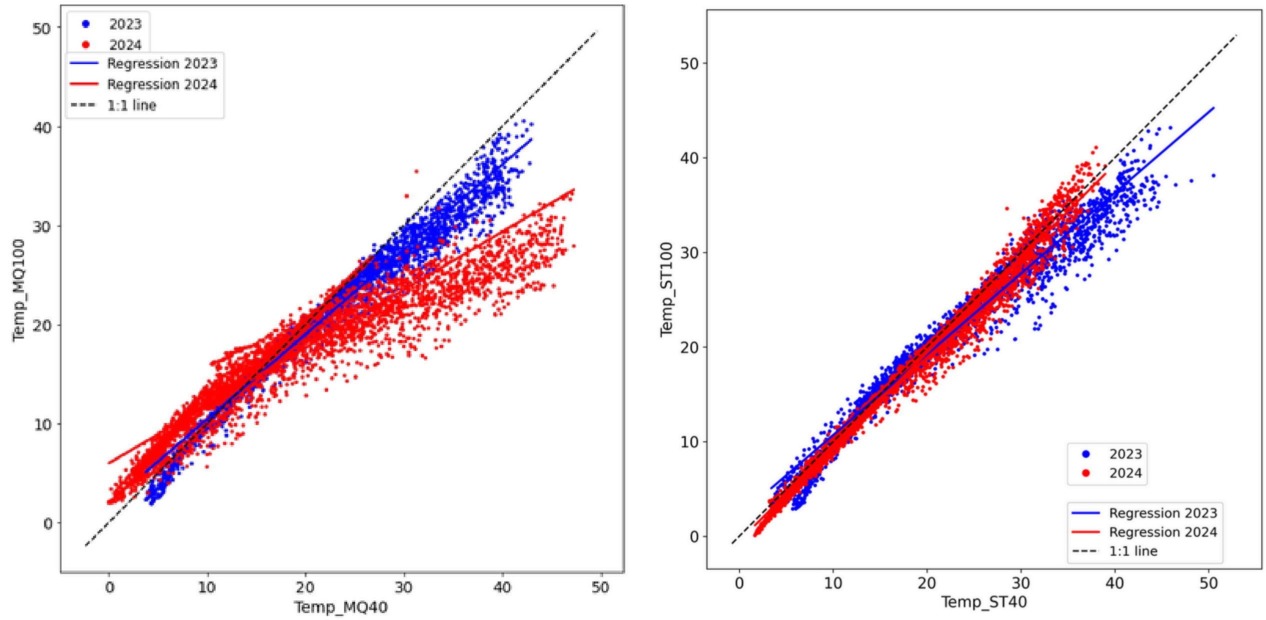



***Figure 2.*** *Fertilizer N rate effect on 'Mullica Queen' (a) and 'Stevens' (b) canopy temperature(oC) in 2023 and 2024 at State Bog, MA. MQ = 'Mullica Queen'; ST = 'Stevens'*

The majority of temperature points lie below the 1:1 line indicating that the 40 lb N/acre tend to be warmer being a more open canopy. Tmq100 was substantially cooler than Tmq40 in 2024 as compared to 2023, as indicated by steeper slope in the case of 2023 (closer to 1:1 line). Furthermore, the relative humidity under 100 lb N/acre tend to be greater than under 40 lb N/acre (Figure 3). Data points depicting RH data also shows that most points occur above the 1:1 line in the figure indicating that a lushy canopy produced by high N fertilizer application is associated with 100 lb N/acre has a tendency of keeping the canopy relatively humid. The conditions of moderately cool temperatures and high relative humidity at a higher N application are ideal for fungal pathogen and hence, higher fruit rot incidences. We have not yet isolated the fungal pathogens present and whether there is a difference in microbial populations and diversities under different fertilizer N regimes. Suffice to say that our data is pointing to a situation where a greater fruit rot incidence occurs under high fertilizer N application.

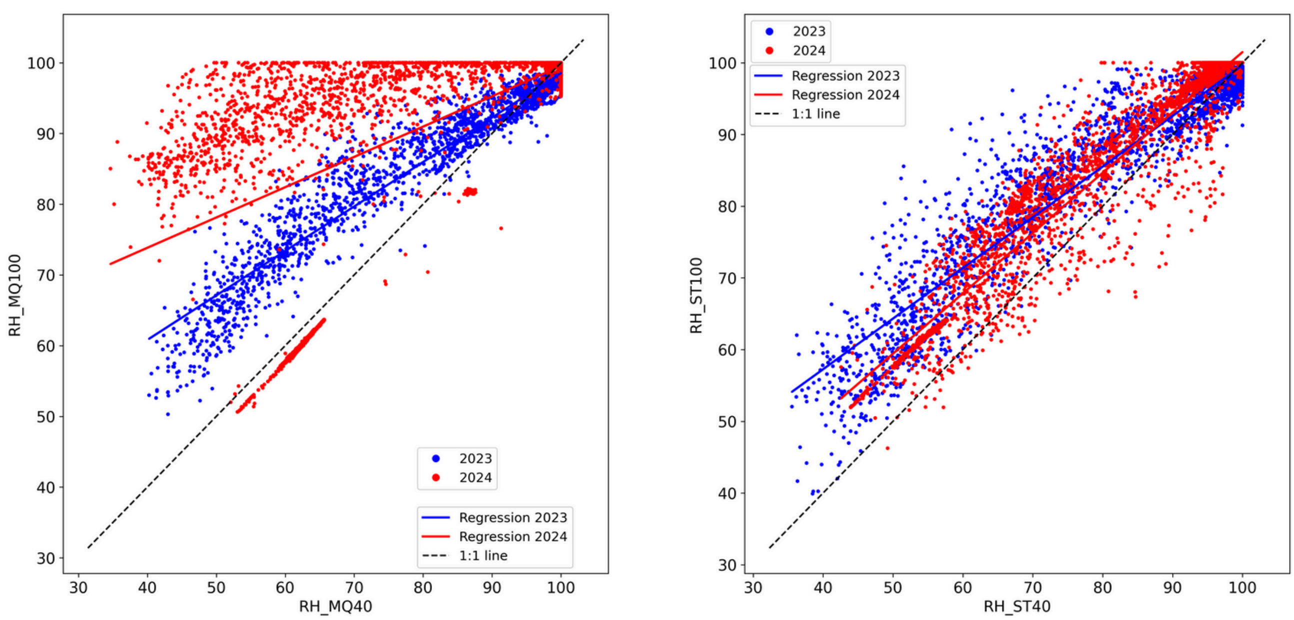



***Figure 3.*** *Fertilizer N rate effect on Mullica Queen (a) and Stevens (b) canopy relative humidity (RH, %) in 2023 and 2024 at State Bog, MA. MQ = Mullica Queen; ST = Stevens*

# RESEARCHER SPOTLIGHT

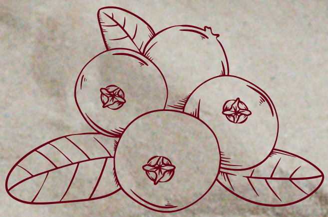
## EITHAN POZAS RODRIGUEZ

**What is the project you're working on for SAME about?**

I am currently working on multiple projects for SAME, collaborating with different groups on the pathological aspects of various experiments. My main project focuses on understanding the fungal community dynamics across different phenological stages of cranberry fruits. We are analyzing how fungal communities differ from flowers to green fruits to mature fruits and comparing two commonly used cranberry varieties in Wisconsin. I am also collaborating with the physiology group to evaluate the impact of sunlight stress on berries and its potential role in cranberry fruit rot development. Our main goal is to gain a deeper understanding of how cranberry fruit rot develops in the field and to offer potential solutions for managing this significant disease.

**What is something you like or find most interesting about your work?**

I love that, despite many years of research—since cranberry fruit rot was first associated with fungi in 1889—we still don't fully understand the etiology of the disease. There are many open questions and numerous factors at play, making cranberry fruit rot a fascinating and mysterious system to study. I also enjoy going to the field during different stages of the growing season, experiencing fruit development firsthand, and, of course, harvesting.



### *POSITION*

PhD student in the Fruit Crop Pathology Lab, Plant Pathology Department

### *LOCATION*

University of Wisconsin-Madison

### *ABOUT ME*

As an international student from Mexico, working with this unique crop has been an incredible experience. I've had the chance to visit various places in Wisconsin where cranberries are a central focus.

This opportunity has helped me appreciate the importance of considering how your science impacts the community and has highlighted the value of building strong relationships between scientists and growers.

**What are some challenges in your project?**

The challenge of working with a poorly understood disease is that while everything you discover is new, there is little preliminary information to guide your research. This lack of background makes it harder to design experiments. Additionally, cranberries pose technical challenges in the lab, especially for molecular techniques. They contain high levels of antioxidants, phenolics, and pigments, which are excellent for human health but complicate lab work.

**What do you hope to do in the future after your work here?**

I hope to continue researching plant-microbe interactions. I am fascinated by how plants establish ecological interactions with bacteria and fungi to support various biological functions. My goal is to develop a research program focusing on recognition of pathways between beneficial and pathogenic microorganisms. This research is not only important for advancing basic science but also has practical applications for agriculture and natural ecosystems. By better understanding how these relationships are established and maintained, we can use them to our advantage while also helping to preserve balance in natural ecosystems.

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# **SAME** AT THE 2025 WISCONSIN CRANBERRY SCHOOL MEETING



***Eithan Pozas Rodriguez, left,*** *a Plant Pathology PhD student at UW-Madison, presents his research on the impacts of shade and fungicides on cranberry fruit rot development at the 2025 Wisconsin Cranberry School annual meeting.*

***Dr. Jenny Bolivar-Medina, right,*** *Scientist in Plant and Agroecosystem Sciences at UW-Madison, presents her research on the effect of heat stress on cranberry fruit rot development at the 2025 Wisconsin Cranberry School annual meeting.*

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"Cranberry Fruit Rots in the U.S. Pacific Northwest" by Don Valentine and Dr. Virginia Stockwell, *USDA/Oregon State University*

"Nitrogen Fertilizer Effects on Cranberry Fruit Rot & Canopy Biophysical Characteristics " by Dr. Peter Jeranyama, *University of Massachusetts Amherst*

"Researcher Spotlight" by Eithan Pozas Rodriguez, PhD student, *University of Wisconsin-Madison*

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