2025 Annual Winter Meeting of the American Cranberry Growers Association

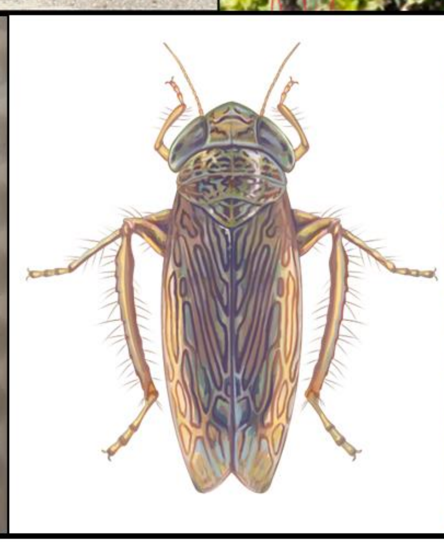
AMERICAN CRANBERRY GROWERS association

Rutgers University EcoComplex

Bordentown, NJ

Thursday
January 16, 2025

RUTGERS
New Jersey Agricultural Experiment Station



Presentation Summaries

ACGA Winter Meeting Program

Thursday, January 16, 2025

Rutgers EcoComplex, Bordentown, NJ

8:00-8:30 Registration and Coffee

8:30-8:50 Welcoming Remarks– ***Shawn Cutts*, President, ACGA**
Treasurer's Report ***– Shawn Cutts***

8:50-9:05 **Updates on the Fruit Rot Resistant Mapping Population CNJ14-31**
Sara Knowles, MS student, Department of Plant Biology, Rutgers University

9:05-9:20 **Landscape Effects on Pests, Natural Enemies, and Pollinators in Cranberries**
Yahel Ben-Zvi, PhD student, Department of Entomology, Rutgers University

9:20-9:40 **Update on Cranberry Weed Management for 2025**
Thierry Besancon, Associate Professor & Extension Specialist, Department of Plant Biology, Rutgers University, and *Wesley Bouchelle*, P.E. Marucci Center, Chatsworth, NJ

9:40-10:00 **Detection and Mapping of Carolina Redroot in Cranberry Bogs Using Deep Learning and Drones**
Thanh Nguyen, Associate Professor, *Hieu Nguyen*, *Duwon Ham*, *Merlie Kirschenbaum*, and *Jacob Stigum*, Department of Mathematics, Rowan University

10:00-10:15 **Break**

10:15-10:35 **Disease Management for 2025**
Peter Oudemans, Professor, P.E. Marucci Center for Blueberry & Cranberry Research & Extension, Rutgers University, Chatsworth, NJ

10:35-10:55 **Oh, the Berries You'll Grow! Breeding Progress and Future Directions**
Gina Sideli, Assistant Professor, Department of Plant Biology, Rutgers University *Jennifer Johnson-Cicalese,* Research Associate, *Sara Knowles* and *Thomas Spain*, Technicians, and *Nico Jimenez*, Postdoctoral Researcher, P.E. Marucci Center, Chatsworth, NJ

10:55-11:15 **Characterization of Cranberry Vine Disease and Identification of a Resistance Marker**
James Polashock, Research Plant Pathologist, and *Joseph Kawash*, USDA-ARS, P.E. Marucci Center, Chatsworth, NJ

11:15-11:35 **Updates on Pre-breeding for Environmental Stress Tolerance**

Jeffrey Neyhart, Research Geneticist, *Taylor Bainbridge*, Technician, *Lindsay Erndwein*, Postdoc, USDA-ARS, P.E. Marucci Center, Chatsworth, NJ; *Pawan Basnet*, Postdoc, and *Breanne Kisselstein*, Postdoc, USDA-ARS/ORISE

11:35-12:00 **Cranberry Institute – An Update**

Katherine Ghantous and *William Frantz*, Cranberry Institute, Carver, MA

12:00-1:00 **Lunch**

1:00-1:15 **False Blossom 1910-1970**

Peter Oudemans, Professor, P.E. Marucci Center for Blueberry & Cranberry Research & Extension, Rutgers University, Chatsworth, NJ

1:15–1:35 **Results from 2024 Insecticide Trials**

Cesar Rodriguez-Saona, Professor, Department of Entomology, Rutgers University, New Brunswick, NJ and *Robert Holdcraft*, P.E. Marucci Center, Chatsworth, NJ

1:35–2:05 **Management of Huanglongbing of Citrus: Lessons from São Paulo and Florida**

James Graham, Professor of Soil Microbiology, Citrus Research and Education Center, University of Florida, Lake Alfred, FL

2:05–2:35 **Compliance is Key: Major Takeaways from the State Pesticide Regulations**

Spencer Kerkhof, Environmental Specialist 1, Pesticide Compliance and Enforcement, Department of Environmental Protection

2:35 **Adjournment**- *ACGA Board of Directors Meeting*

Detection and Mapping of Carolina Redroot in Cranberry Bogs using Deep Learning and Drones

Thanh Nguyen[1*], Hieu Nguyen[1], Duwon Ham[1], Merlie Kirschenbaum[1], Jacob Stigum[1]
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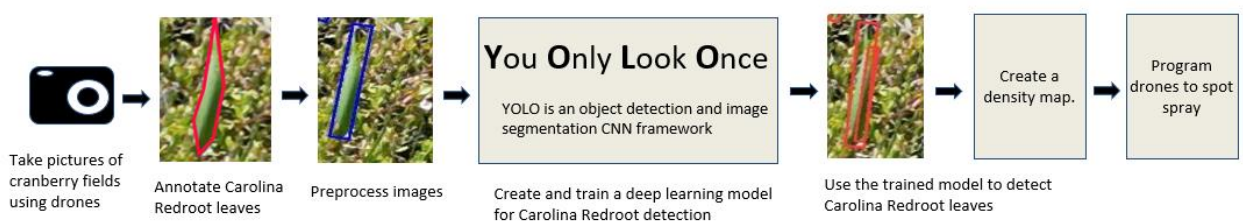
Motivation and research goal:

Carolina redroot is a problematic weed in cranberry bogs due to its aggressive growth, which competes directly with cranberry plants for essential resources like water, nutrients, and sunlight. Carolina redroot also spreads through rhizome propagation, during which underground roots spread out and create new nodes that will grow above the surface. Through these processes, Carolina redroot easily crowds out cranberry vines and reduces crop yields. Managing Carolina redroot is not only labor-intensive but also financially burdensome for cranberry growers.
Our project proposes a more affordable method for controlling Carolina redroot. We develop an intelligent and autonomous drone system which can:

- automatically detect the weed in cranberry bogs
- create a Carolina redroot density map, and
- perform spot spraying.

The workflow of the proposed autonomous Carolina redroot detection & mapping system:



The development of our Carolina redroot detection system is outlined in the above figure. It includes three phases:

Phase 1: Development of an artificial intelligence model for detecting Carolina redroot in cranberry bogs. This phase includes several steps: collecting images and videos of Carolina redroot in cranberry fields, manually annotating Carolina redroot leaves from the collected images, and building, training, and evaluating the performance of AI-based Carolina redroot detection models.

Phase 2: Apply the trained AI-based models to images collected from cranberry bogs and create Carolina redroot density maps to assist farmers in the weed management process.

Phase 3: Program autonomous drones to perform spot spraying. We use two different approaches. The first one is to use the density maps created in Phase 2. The second approach is to program the drones to perform both the detection and spot spraying simultaneously.

Results:
In 2023 and 2024, our project team collected a large set of 180 GB of images and videos of Carolina redroots in different times (May, June, July, and September). Due to the time-consuming process of manual annotation of Carolina redroot leaves, only a small number of images have been annotated. Nevertheless, a total of more than 7500 Carolina redroot leaves have been annotated.


Annotations of Carolina redroot leaves

We have built two AI-based Carolina redroot detection models. Both of them were built based on the same deep learning architecture but trained on two different data sets. The first data set contained aggressively-annotated Carolina redroot leaves, meaning that we annotated all areas in the images that we thought Carolina redroot leaves, even if they are not very clearly visible. The second data set contained conservatively-annotated leaves only, meaning that we only annotated leaves which are visibly clear.

To evaluate the performance of the developed models, we show in the table below the precision and recall of both models. Precision means the proportion of being true Carolina redroot leaves among the leaves detected by the models. Recall means the proportion of actual (more precisely, annotated) Carolina redroot leaves which are correctly detected by the models. Overall, our best model was able to detect about 70% of the Carolina redroot leaves that we manually annotated.

Method	Precision	Recall
Aggressive	0.7893	0.40211
Conservative	0.71888	0.71673

Precision and recall of the developed AI-based Carolina redroot detection models

The following figures show examples of detected Carolina redroot leaves in collected images.

CR leaves detected by the model

CR leaves detected manually

Future work:

We are currently working on developing algorithms for creating Carolina redroot density maps. In addition, we will also work on programming the drones to perform spot spraying autonomously.

Acknowledgements:

The project is supported by the New Jersey Department of Agriculture throw the Specialty Crop Block Grant program. It was also partially supported by Rowan University department of Mathematics, College of Science and Mathematics.

We would like to thank Pine Island Cranberry Farm (Chatsworth, NJ) for allowing us to collect images and videos of their cranberry bogs for this project.

Oh, The Berries You'll Grow! Breeding Progress and Future Directions

Gina Sideli, Assistant Professor; Nicolas Jimenez, Postdoctoral Scholar; Jennifer Johnson-Cicalese; Research Associate; Thomas Spain, Research Technician; Sara Knowles, Research Technician; Rutgers University, P.E. Marucci Center, Chatsworth, NJ.

Collaborators: Beverly Tepper, Professor, Rutgers; Jeffrey Neyhart, Research Geneticist, USDA-ARS

Background

Rutgers has a well-established cranberry breeding program which to date has resulted in seven cultivars. The breeding emphasis has been largely for quality (size, color), yield, low acidity, and fruit rot resistance. High yielding cultivars such as Crimson Queen, Mullica Queen and Haines have allowed for significant yield increases profiting the industry. Advanced selections for low acid are believed to be more palatable for human preference and have the potential for addition of less sugar input in processing. Further studies are underway to test this hypothesis with both juice and sweetened dried cranberries SDCs. Fruit rot continues to be a substantial threat to the industry justifying the need for research and potential release of a resistant cultivar. To expedite these efforts and gather unbiased, precise measurements, a computer vision system and algorithm for quantifying fruit rot (postharvest) in an individual plant has been developed and tested.

Results

Consumer study: Participants were recruited via Rutgers listservs and took a survey to qualify if they had familiarity with cranberry juice cocktail. Four low-acid cranberry selections and one cultivar control were tested in a consumer panel of 60 participants. Cranberry juice cocktail with 10% sugar was prepared for each cranberry selection/cultivar.

Sample A was found to have the right amount of sweetness for consumers. Sample B was noted to have a weak cranberry flavor. Sample C had the highest overall liking in sweetness, sourness, bitterness, astringency, thickness and cranberry flavor. Some panelists noted that sample C had an aftertaste. Sample D was least liked and had the lowest cranberry flavor. Sample D was also noted to be different from all other samples. Sample E was Stevens and recognized to be bitter and sour.

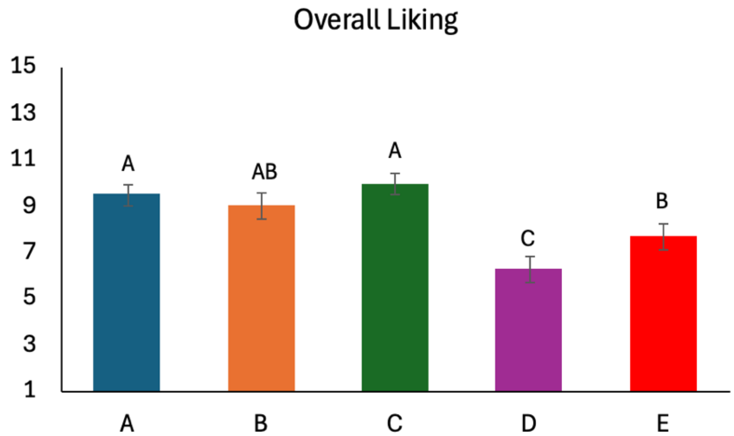


Figure 1. Consumer panel results of five cranberry cultivar/selections. Stevens was sample E (control)

Genetic Gain: Phenotypic data was collected from Rutgers germplasm collection, Rutgers cultivars, and breeding families and analyzed to understand breeding progress over time. The plots shown have each trait of interest and are separated by their category (Wild, Landrace, Breeding, Cultivar). It is clear there have been significant gains in fruit weight and titratable acidity (TA). For yield and fruit rot %, there is a considerable amount of variation to select on for future gains.

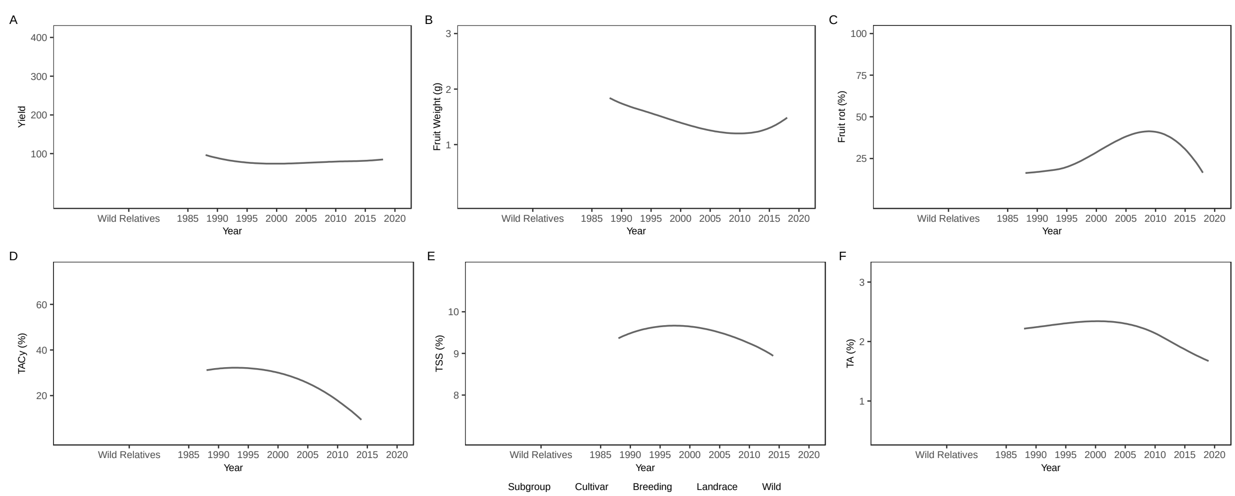


Figure 2. Graphic displaying the genetic gain for breeding traits. A). Yield B). Fruit Weight C). Fruit rot (%). D). TAcy (%), anthocyanin content. E). TSS, total soluble solids F). TA, titratable acidity

Fruit Rot Phenotyping: Fruit from about 250 selections were collected from breeding plots this fall to test a new method of data collection. With our computer vision system (camera, lights, mini stage), and algorithm (Neyhart berryai, unpublished) we were able to acquire images of fruit and calculate percent rot, TAcy, and size. This will enable the screening of hundreds of selections for fruit rot on a consistent, precise and expedient scale.

Characterization of Cranberry Vine Disease and Identification of a Resistance Marker

James Polashock, Joseph Kawash, and Lindsay Lindhult

Upright dieback in cranberry is common under certain conditions, although it is rarely reported to cause economic loss. The typical symptom is tip dieback of the uprights that can spread to runners, ultimately resulting in death of the affected uprights and runners. *Phomopsis vaccinii* and possibly other *Phomopsis* spp., are thought the be the primary casual agent(s). A field-grown population from the Rutgers breeding program was found to affected by a disease in which the symptoms of dieback appeared a little different than those of typical upright dieback. The symptoms include reddening and dying of whole uprights and some runners. Sensitivity to the disease appeared to be segregating in the population with some whole plots, planted with a single accession, dying shortly after planting, while others remained healthy. To determine if the casual agent was *P. vaccinii* or a different pathogen, we isolated and cultured a fungus associated with the disease. The fungus was tentatively identified to be *Colletotrichum siamense* using targeted DNA sequence data and morphological characters (e.g. spore size and shape). Reinfection of cranberry uprights with the fungus successfully replicated field symptoms, thus supporting the conclusion that *C. siamense* is the causal agent of the disease that we are calling 'vine disease'.

A QTL associated with vine disease susceptibility has been identified on chromosome 4. Marker development and validation are in progress.

Symptoms of cranberry vine disease in the field (left panel). The fungus was isolated from cut stems near the interface of live and dead tissue (middle panel). Representative culture (S6) on growth medium (right panel).

Results from 2024 Insecticide Trials

Cesar Rodriguez-Saona and Robert Holdcraft
P.E. Marucci Center, Rutgers University

Blunt-nosed leafhoppers (Figure 1) are pests native to North America that vector a phytoplasma that causes false blossom disease and can potentially affect other cranberry-producing regions across North America. In fact, other cranberry-producing regions in the USA are experiencing similar situations with observed increases in secondary pests due to changes in management practices, indicating that this is a nation-wide problem. In 2024, an experiment was conducted to compare the toxicity of a new insecticide with a grower-standard insecticide, Danitol 2.4EC, in controlling blunt-nosed leafhopper nymphs (Figure 1A) on cranberries.

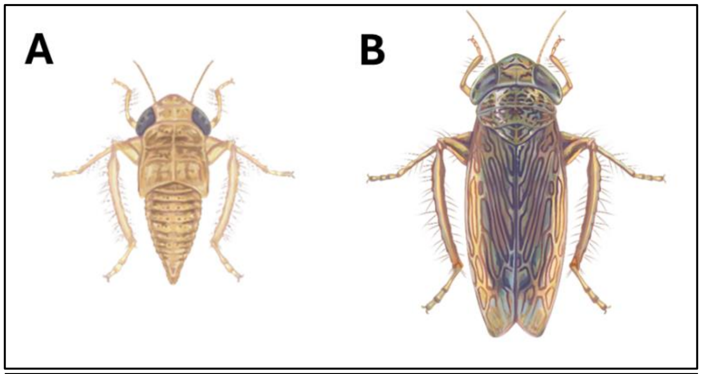


Figure 1. Blunt-nosed leafhoppers. (A) nymphs; (B) adults.

The study was conducted in a cranberry bed at the Rutgers P.E. Marucci Center in Chatsworth, New Jersey. Treatments consisted of three rates of the new insecticide, Danitol 2.4EC at 16 fl oz/acre, and an untreated control. Plots measured 1 m × 1 m and were replicated three times. Control plots received no insecticide application. Treatments were applied using an R&D CO_2 backpack sprayer equipped with a 1-L plastic bottle, calibrated to deliver 50 gal per acre at 30 psi. A single Teejet VS 110015 nozzle was used, dispensing 1.32 fl oz per plot.

Treatments were applied on 30 May 2024. Cranberry uprights were clipped from the central portion of each plot approximately four hours after treatment application (0 days after treatment, DAT), and subsequently at 4, 7, and 12 DAT (June 3, 6, and 11, respectively). Four cranberry uprights were inserted into florist water picks with open bottoms (Figure 2). The tops of the uprights with leaves were enclosed in assay containers made from ventilated 32-oz plastic deli cups with a hole cut in the bottom through which the water picks fit snugly (Figure 2). Leaves were removed from the base of the uprights before insertion, and the water picks were then placed in water-filled trays. Six assay containers (each considered a replicate) were prepared for each treatment, with five field-collected nymphs introduced onto the foliage in each container. Assay containers were placed

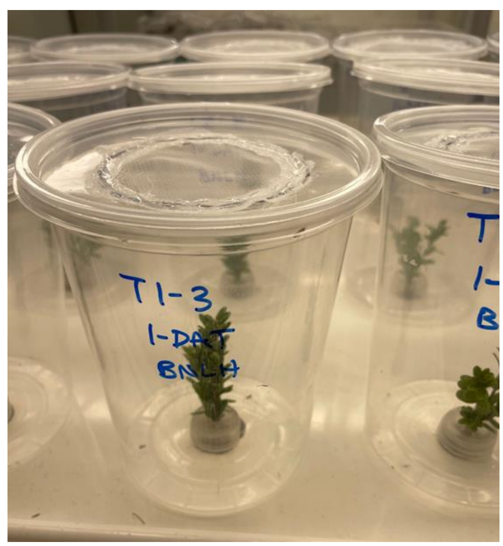


Figure 2. Bioassay set-up.

on a laboratory light bench with a 14:10 light-dark photoperiod and kept at ambient temperature (~23°C) for observation. Nymph mortality was assessed at 1 day, 3 days, and 6 days after setup by counting the number of live, moribund, dead, or missing nymphs in each assay container

At 0 DAT, the new insecticide showed low mortality (<15%) at 1-day post-exposure but resulted in high nymphal mortality (>80%) six days after exposure (Figure 3A). In contrast, Danitol achieved 100% mortality within a day (Figure 3A). By 4 DAT, the effectiveness of the new insecticide decreased, with mortality below 40%, while Danitol continued to show high lethality, maintaining 100% mortality at six days (Figure 3B). At 7 DAT, the new insecticide caused less than 30% mortality, whereas Danitol's efficacy remained high, with over 95% mortality (Figure 3C). By 12 DAT, the efficacy of the new insecticide was still low (<30%), and Danitol's efficacy dropped to less than 60% (Figure 3D).

These results indicate that the lethality of the new insecticide on blunt-nosed leafhopper nymphs increases with prolonged exposure. In contrast, Danitol provides high mortality even with shorter exposure times. The efficacy of the new insecticide diminished after 4 DAT, while Danitol remained effective up to 7 DAT.

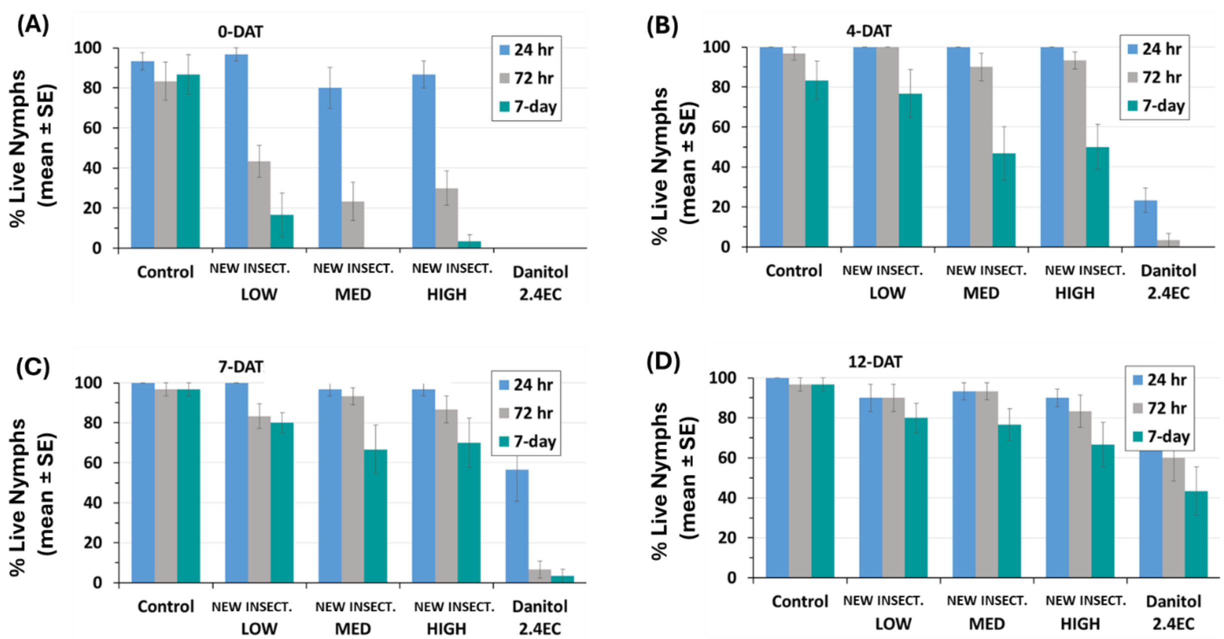


Figure 3. Toxicity of new insecticide and Danitol on blunt-nosed leafhopper nymphs. (A) 0 days after treatment (DAT); (B) 4 DAT; (C) 7 DAT; (D) 12 DAT.

Acknowledgements. We thank Kevin Massaro and Jennifer Frake for their assistance during the experiments and Lindsay Lindhult for creating the illustrations of the blunt-nosed leafhoppers. This work was supported by funding from Syngenta, the New Jersey Cranberry Research Council, the Cape Cod Cranberry Growers Association, the Cranberry Institute, and Ocean Spray Cranberries.

Disease Management for 2025

Peter V. Oudemans, Matt Hamilton, Luke Mackara, Chris Dib and Christine Constantelos
PE Marucci Center for Blueberry and Cranberry Research and Extension, New Jersey Agricultural Experiment Station, Rutgers, The State University

Introduction. Cranberry management prioritizes the delivery of firm, well colored fruit, suitable for inclusion in various value added products. The primary factors influencing fruit quality are provided in the Table below. All of these factors can become complex problems

Table 1. Factors affecting fruit quality

Factor	Impact on Quality	Cause
Fruit rot	Unusable fruit	Fungal infection
Over heating	Unusable fruit	Late season overheating
Phytotoxicity	Small, scarred or poorly colored fruit	Fungicide choice and timing

Cranberry fruit rot (CFR) is a critical component affecting cranberry yield. The impact of the disease is most significant, in the Northeast, however, losses can be severe in both the Midwest and Pacific Northwest. In research plots or unsprayed plantings losses can easily reach 100% in New Jersey while the impact becomes progressively less in more northern climates. Without effective fungicide options available it is estimated that a 20% reduction of the North American cranberry crop would result (Rice-Mahr and Moffitt, 1994).

Properly timed fungicide applications are the most effective approach for CFR management. In New Jersey there are 4-6 primary pathogens however, these can vary according to location (farm) and season. Overall, there have been more than 20 fungal species identified as causal agents of CFR and many of these are considered minor or may be significant as post-harvest fruit rotter's. Given the diversity of fungi, fungicide choice is key to successful and sustainable CFR management.

Persistent, surface acting fungicides such as chlorothalonil and mancozeb are the backbone of the CFR management. These fungicides are broad spectrum and provide protection against all of the species in the CFR complex and they provide strong protection against the build-up of resistance in fungal populations. It is unknown how fungicide type can impact the composition of the CFR population but differential sensitivity among species could be one factor affecting the makeup of the population. Discontinuation of these fungicides will therefore have unanticipated effects.

Overheating due to solar radiation is another major factor affecting fruit quality in some years. The symptoms can appear similar to fruit rot and in some cases fruit rot develops in the affected fruit. Therefore it is critical to distinguish overheating from CFR. Methods for control rely mainly on evaporative cooling, however, if misapplied, can enhance fruit rot through excessive canopy wetness (see Fact sheet attached).

Control of cranberry fruit rot is achieved by proper timing and sequence of fungicide applications. Timing is important because the fungi causing fruit rot tend to cause more infections that lead to rot during the flowering and early fruit development. Sequence is also important because different fungicides can affect the plant differently during development. Specifically, chlorothalonil (e.g. Bravo) can be phytotoxic to bloom but provides excellent protection during fruit development.

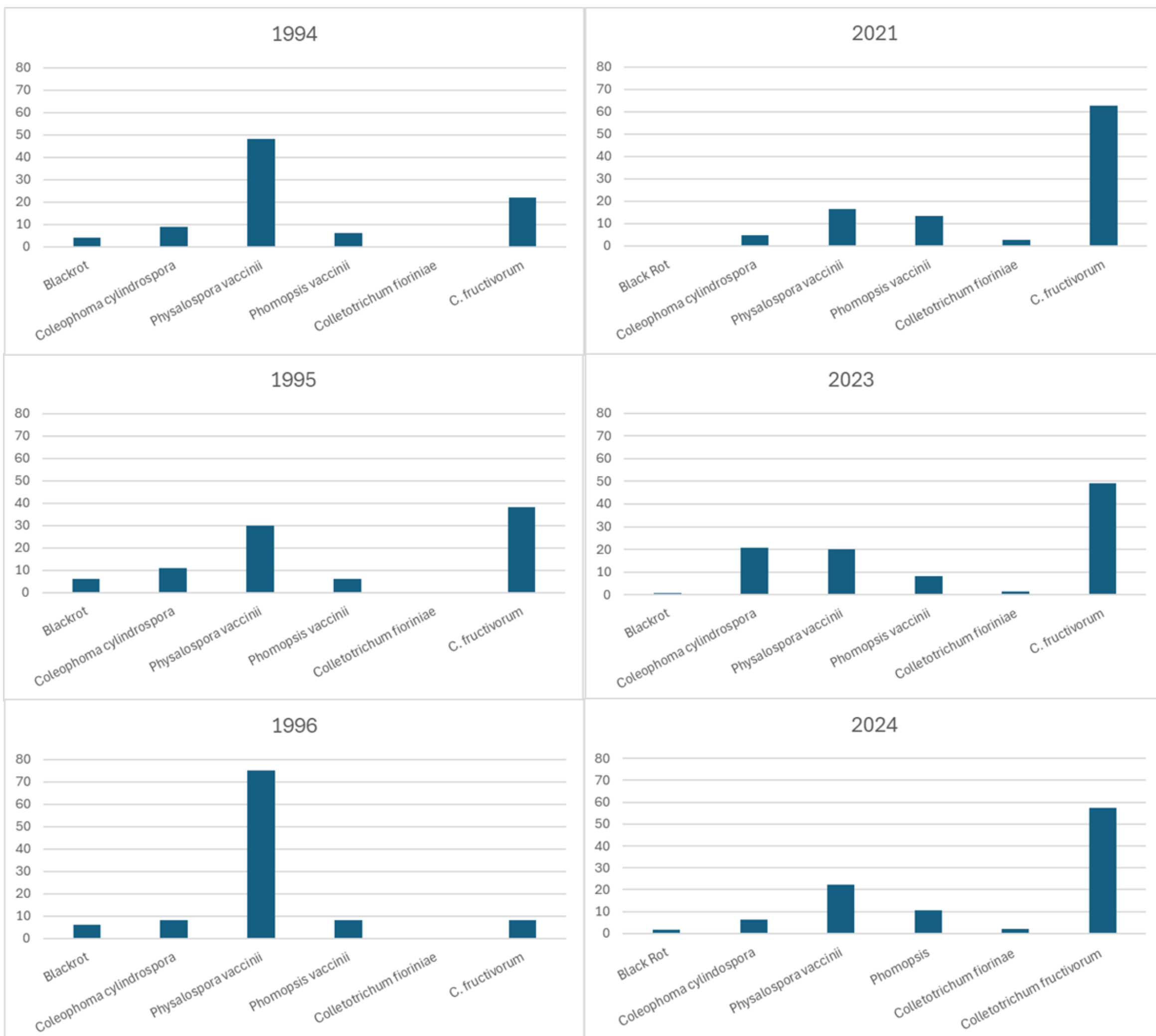
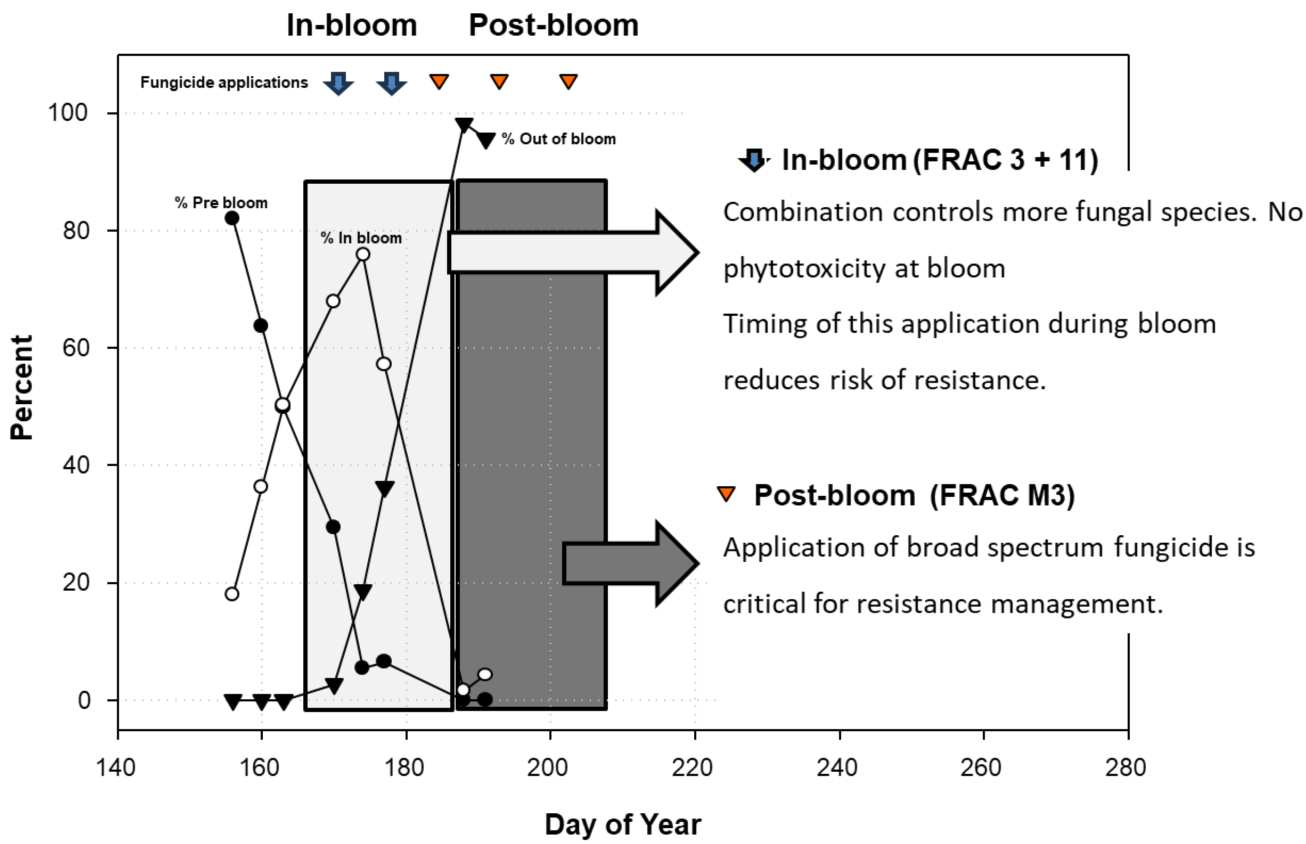


Fig 1. Incidence of cranberry fruit rot pathogens in New Jersey.

In-bloom sprays are the critical starting point for fungicide applications. Our research suggests that the 60% out of bloom stage is an important tipping point after which control declines rapidly. Therefore, fungicide applications prior to this are critical. Typically, combinations of azoxystrobin with a FRAC Group 3 fungicide provides excellent disease control in early applications and have little to no impact on fruit development. For post-bloom applications chlorothalonil has been the fungicide of choice. In general, for New Jersey, these applications begin in mid-June and all fungicide applications are complete by late-July (Fig. 2).



FRAC Group M Replacement:

Following chlorothalonil deregistration only FRAC Groups 3 and 11 will remain. Labelling prevents the use of more than 3 sequential group 11 fungicides and therefore it is critical to identify new fungicide groups.

<u>Identifying fungicides or fungicide combinations with efficacy against CFR.</u>

Group 3. Group 3 fungicides (azoxystrobin) are moderate risk fungicides, meaning that the risk for resistance is moderate. They all exhibit some level of systemicity, meaning that they will enter the plant and possibly move in the direction of water flow. This group of fungicides varies in efficacy against the different species in the CFR complex. Combinations with Group 11 can enhance the spectrum of action. Combination with P07 (formerly group 33) fungicides can enhance efficacy.

Group 11. Group 11 fungicides are high risk and resistance has been reported from Massachusetts cranberry beds. This group is translaminar which means they cross the plant cuticle but are not mobile within the plant. This group partners well with group 3 or certain group 7 fungicides.

Group 7. Group 7 fungicides have not been labelled for cranberry at this time. Certain members of this group have been submitted for registration through IR4. These are considered medium to high risk fungicides and resistance has been reported in several other small fruit crops. Partners well with Group 11 fungicides.

Group 29. Group 29 fungicides have not been labelled for cranberry at this time. Certain members of this group have been submitted for registration through IR4. This is a low risk group and can be used as a solo material. The one drawback is that this group is that they are nonsystemic and relatively nonpersistent and are dissipated from the plant surface within two weeks.

Group P07. Group P07 fungicides are a unique group that induce host plant resistance. These fungicides can have direct effects on fungi as well. They are highly systemic and have low risk for resistance. As a fruit rot fungicide they are low efficacy, however, in combination with some group 3 fungicides they enhance efficacy.

Developing Use Patterns:

The next challenge is to put together a program (Fig. 2) that provides sustainable and efficacious control. Over the past three growing seasons we have tested a variety of use patterns that include both labelled and products under consideration. Several use patterns have emerged that that provide equal or better control that the standard.

Implementation:

Registration is a key component. Both IR4 and the registrant are vital in the process. The Cranberry Institute is partner with IR4 and are critical in moving the registration forward. Following registration we will need to test use patterns on a progressively larger scale to follow any unexpected results.

Scald in cranberry fruit: Part 1
Understanding Causes

by

Peter Oudemans, Professor of Plant Pathology and Director , PE Marucci Center for Blueberry and Cranberry Research and Extension, New Jersey Agricultural Experiment Station, Rutgers, The State University

and

Giverson Mupambi, Extension Assistant Professor, Cranberry Physiology, Cranberry Station, University of Massachusetts Amherst

Published January, 2025

Introduction

Cranberry scald is a physiological disorder caused by overheating of the fruit and is sometimes misdiagnosed as fruit rot (Fig. 1). Scald was first recognized on cranberry beds in New Jersey in 1995 but since 2015 it has become a significant concern to commercial growers throughout the Northeast as well as other cranberry-growing regions. Environmental factors such as high ambient temperature, intense solar radiation, and low relative humidity contribute to fruit overheating in cranberry. New hybrid varieties tend to be more vulnerable since increased yields result in more berries being crowded into the upper canopy, where they are exposed to the sun. Fruit surface temperature in the upper canopy can exceed ambient temperature by more than 30°F during periods of high solar radiation.

Damage to cranberry fruit occurs when the internal temperature increases to the point that fruit tissues are irreparably damaged. Scald affects both the fruit surface as well as the internal tissues and symptoms appear within 24 hours after exposure to high temperatures (Croft, 1995). Initially, the fruit softens, and the underlying tissues discolor and become watery (Fig. 1). Typically, there is a firm margin between damaged and sound tissues unlike fruit rot, where the margin is indistinct. The heat-damaged fruit may eventually develop into fungal fruit rot within a few days if the fruit is already infected with pathogens.

Fig. 1: Cranberry fruit showing symptoms of scald. Note the distinct margin where overheating occurs. Damaged tissue can develop fungal rots as shown by the browning where fungal growth is beginning.

Causes of Scald:

High ambient temperature

Surface temperatures in cranberry fruit increase with increasing exposure to solar radiation. Fruit, especially those on top of the canopy, experience high levels of sun exposure. Direct solar radiation on exposed fruit surfaces causes scalding in two ways: (1) Photochemical reactions can occur under excess solar radiation leading to cellular damage in fruit. (2) Direct solar radiation acts as a heat source through its effect on radiant heating. Data collected in New Jersey (2015-2020) has shown a close relationship between solar radiation and internal berry temperatures.

The developmental changes of fruit can also affect the vulnerability to scald with vulnerability increasing as the fruit ripens. Antioxidants and pigments such as chlorophyll on the surface of the fruit can act as a defense against radiant heating by utilizing light energy to drive chemical reactions such as photosynthesis. Chlorophyll is the green pigment in plants that converts solar radiation into carbohydrates and is abundant in young fruit. As fruit matures, chlorophyll is replaced by red pigments (anthocyanins) and the solar radiation is now converted to heat. Thus, as fruit matures, the vulnerability to overheating from solar radiation increases.

External fruit surface temperature in cranberry can exceed ambient temperature by up to 30°F depending on factors such as solar radiation, wind speed, and relative humidity. The temperature of leaves in the canopy, the shaded ambient temperature, and fruit surface temperature can all be quite different and therefore use of traditional temperature monitoring methods does not tell the full story (**Fig. 2**).

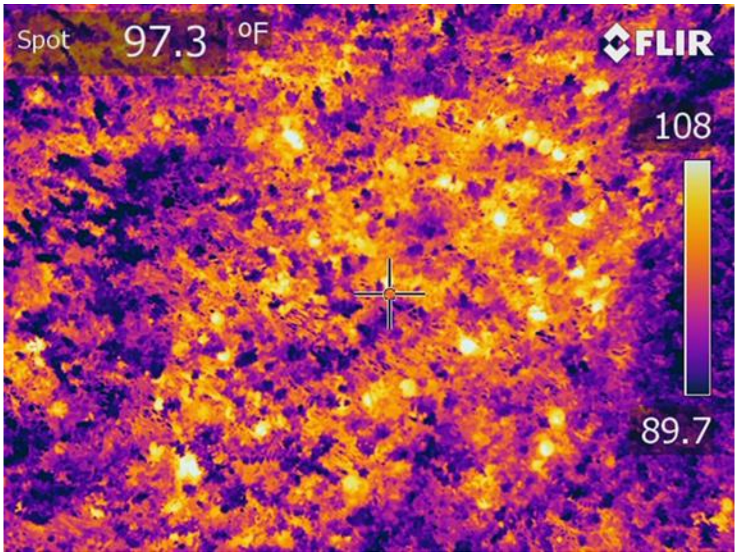


Fig. 2: Thermal image showing temperature differences in a cranberry canopy between fruit and leaves. Bright yellow represents higher temperatures while darker purple represents lower temperatures.

To understand the timing of scald, it is necessary to know the critical temperature where damage occurs. The temperature threshold is the temperature at which the metabolic processes in the cranberry fruit are interrupted and the tissues die. Previous research found the threshold to occur after fruit reach 108 °F for 2 hours.

Relative humidity

Relative humidity influences the initiation of scald by interacting with direct factors such as high temperature and excessive solar radiation. Low relative humidity increases stress under conditions which result in high evapotranspiration rates. Research has shown that dry air with relative humidity around 35 to 45% in combination with high ambient temperature and solar radiation increases the risk of scald development in cranberry.

Measuring microclimate and detecting overheating events

A simple weather station equipped with six sensors can provide enough data to measure and identify overheating events across a relatively large area (**Fig. 3**). The sensors should include a shaded temperature and relative humidity sensor as well as a leaf wetness sensor, a solar radiation sensor and a temperature probe (thermistor type) that can be inserted into an artificial berry (Shapeways.com). This simple weather station can be deployed to the field and record conditions leading to an overheating event.

Fig. 3: Components of a simple weather station that can be used by cranberry growers to monitor overheating conditions on their bogs.

For example, in August 2018, a particularly bad year for scald , nine overheating events were recorded in New Jersey(**Fig. 4**). These events were recorded using two temperature sensors, one inside the artificial berry and the other shaded. A threshold of 108°F (artificial berry temperature) was used to identify overheating events. It is important to note that the fruit becomes more vulnerable later in the season, so overheating events in early August coincide with a lower vulnerability, while events in late August and September are most critical.

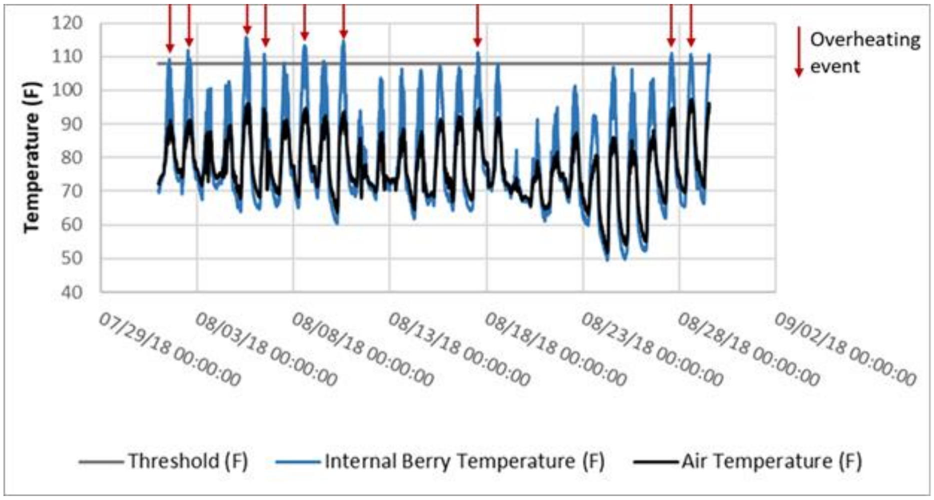


Fig. 4: Internal berry temperature and air temperature on a cranberry bog during August 2018. Red arrows indicate the possibility of an overheating event.

Scald development scenarios. It is difficult to provide a predictive model for scald since cloud cover, wind speed, ambient temperature, and solar radiation all interact to create the conditions that damage cranberry fruit. The motivation to predict is to provide proper and effective protection. Irrigation for evaporative cooling is critical but requires precision.

In Fig. 5 below, different scenarios are presented, indicating whether overheating may or may not occur leading to scald. In Fig. 5a the internal berry temperature was above the threshold of 108°F from approximately 10 am until 3:30 pm. During this period, unshaded fruits were very likely damaged by overheating. The ambient temperature was around 100°F, and there was very little cloud cover. The dew point was below 80°F, and it is expected that cooling by irrigation would be very effective under these conditions. In the next two examples, Fig. 5B and C, overheating is unlikely because of significant cloud cover (B) and low ambient temperature (5C). In Fig. 5D the berry temperature could remain above the 108°F threshold if there was less cloud cover. In this case, however, overheating did not occur because solar radiation was blocked by frequent cloud cover.

Take home points: Critical factors for risk of scald:

A. Ambient temperature above 90F
B. Low relative humidity
C. Clear skies with minimal cloud cover
D. High solar radiation
E. Internal berry temperatures exceeding 108F

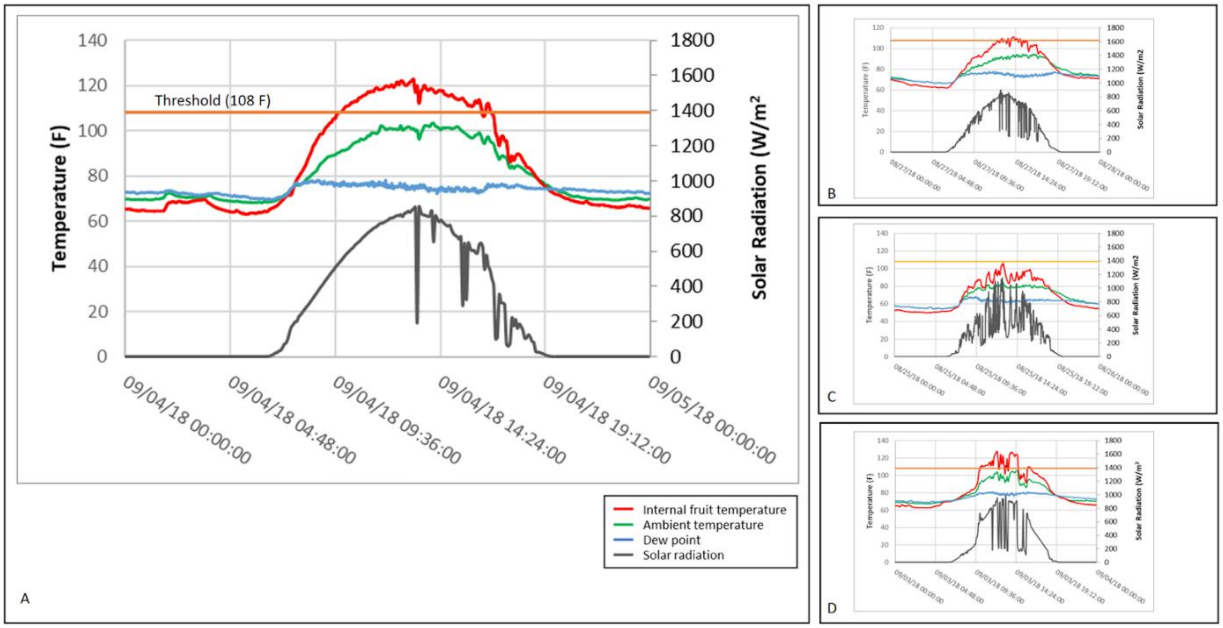


Fig. 5. Scenarios for the development of overheating on a cranberry bog. (See text for detailed description)

Information gaps

As the incidence of overheating in cranberry continues to increase with increasing temperatures, there is a need for additional research to assist cranberry growers with information that can be used for decision-making to protect their crops.

Further reading material

Croft, P.J., 1995. Field conditions associated with cranberry scald. HortScience, 30(3), pp.627-627. https://doi.org/10.21273/HORTSCI.30.3.627

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