2021 Annual Summer Meeting of the American Cranberry Growers Association

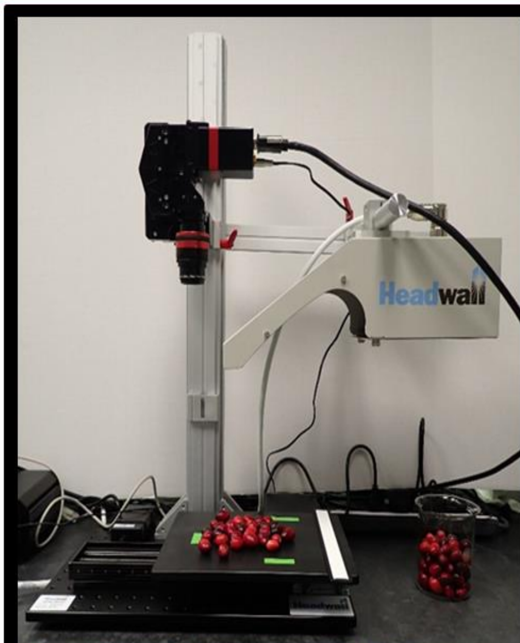
AMERICAN CRANBERRY GROWERS association

Rutgers University
Marucci Center

Chatsworth, NJ

Thursday
August 19, 2021

RUTGERS
New Jersey Agricultural Experiment Station





Presentation Summaries

American Cranberry Growers Association
2021 Summer Field Day

Thursday August 19, 2021

Rutgers University

P.E. Marucci Center for Blueberry & Cranberry Research & Extension,
Chatsworth, NJ

Parking will be available at the Center's shop (across cranberry bogs).
Transportation for tours will be provided at the Center.
Restrooms located at the Center, adjacent to Conference Room.

CRANBERRY BOGS

8:00–8:30 **Refreshments**

8:30–8:45 **Opening Remarks**
Shawn Cutts, President, American Cranberry Growers Association

8:45–9:05 **Non-destructive Detection of Systemic Cranberry Diseases using Hyperspectral Imaging (Bog 1)**
James Polashock, Research Plant Pathologist, and *Joseph Kawash*, USDA-ARS, P.E. Marucci Center, Chatsworth, NJ

9:05–9:25 **Debuting an In-Field High-Throughput Phenotyping Cart for Cranberry Breeding (Bog 1)**
Jeffrey Neyhart, Research Geneticist, USDA-ARS, P.E. Marucci Center, Chatsworth, NJ

9:25–9:45 **Weed Management Strategies for Newly Planted Beds (Bog 3)**
Thierry Besancon, Weed Science Extension Specialist, Department of Plant Biology, Rutgers University, and *Baylee Carr*, P.E. Marucci Center, Chatsworth, NJ

9:45–10:05 **Strategies for Improving Cranberry Fruit Quality (Bog 5)**
Peter Oudemans, Professor/Extension Specialist, Department of Plant Biology, Rutgers University, *Christine Constantelos*, *Matt Hamilton*, and *Julia Ciaccia*, P.E. Marucci Center, Rutgers University, Chatsworth, NJ

10:05–10:25 **Evaluation of Fruit Rot Resistant Selections for New Jersey (Bog 11)**
Nicholi Vorsa, Professor, Department of Plant Biology, Rutgers University, *Jennifer Johnson-Cicalese*, and *Peter Oudemans*, P.E. Marucci Center, Chatsworth, NJ

10:25–10:45 **Overview of the 2021 Season So Far (Bog 19)**
Lindsay Wells-Hansen, Senior Agricultural Scientist, Ocean Spray, Chatsworth, NJ

10:45–11:05 **2021 Insecticide Trials for Insect Pests (Bog 20)**
Cesar Rodriguez-Saona, Professor/Extension Specialist, Department of Entomology, Rutgers University *Vera Kyryczenko-Roth*, and *Robert Holdcraft*, P.E. Marucci Center, Chatsworth, NJ

POLE BARN

11:20–11:30 **Cranberry Statistics**
Bruce Eklund, State Statistician, U.S. Department of Agriculture | National Agricultural Statistics Service

11:30–12:00 **Plant Nutrition and Frost Protection**
Peter Jeranyama, Extension Associate Professor, Center for Agriculture, Food, and the Environment, UMass Amherst

12:00–1:00 **LUNCH**

1:00–1:30 **Farm Pesticide Safety Update: Hazard Risk Management from Label to Application**
Kate Brown, Program Associate—Commercial Agriculture, and *William Bamka*, Rutgers Cooperative Extension of Burlington County

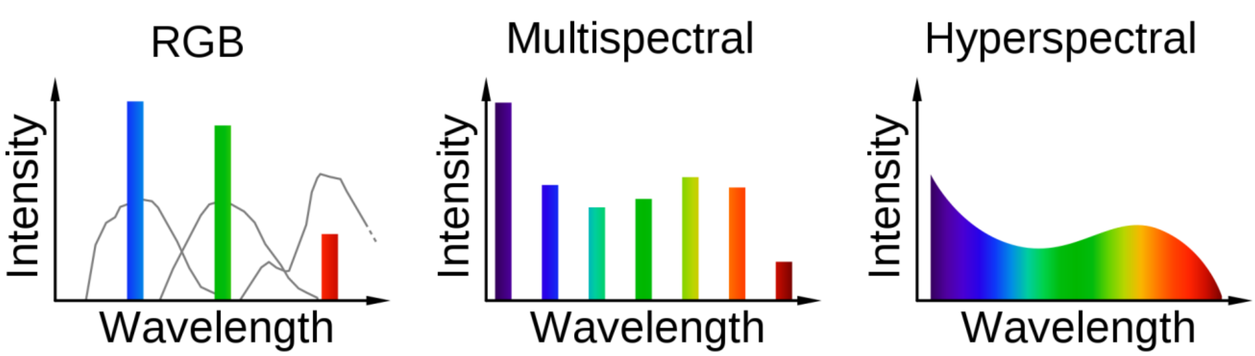
Non-destructive Detection of Systemic Cranberry Diseases using Hyperspectral Imaging

James Polashock **and** ***Joseph Kawash*****, USDA-ARS, Chatsworth, NJ**

Systemic diseases are those which spread throughout all or most of the plant. In cranberry, systemic diseases include viruses such as tobacco streak, blueberry scorch and blueberry shock. Bacteria can also cause systemic diseases, such as false blossom. Diagnosis in the field, based on symptoms, can be challenging. Symptoms can mimic many other disorders or diseases and thus be difficult to distinguish. In addition, diagnostic symptoms might not be present throughout the season (e.g. symptoms that affect flower morphology).

Definitive diagnoses are usually done 'destructively' in the laboratory. This process includes tissue collection from the field, grinding to isolate nucleic acid (DNA or RNA) or proteins, followed by detection using such methods as PCR (targeted detection of DNA) or ELISA (antibody-based protein detection).

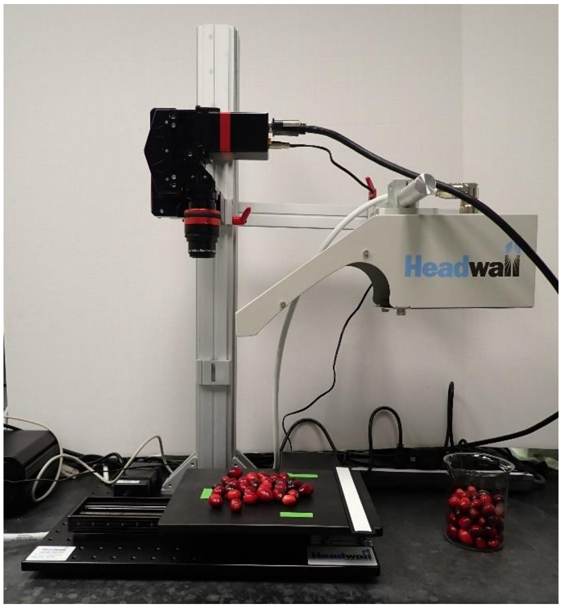
Our goal with this project is to develop a rapid detection system that can be used in the lab and the field, that does not rely on visible symptoms or destructive sampling. We have had success with hyperspectral imaging (HSI).



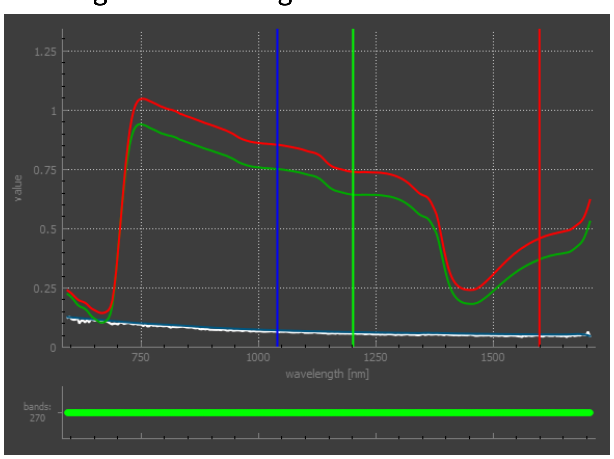
Lucasbosch, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

HSI is a technique that analyzes a wide spectrum of light instead of just assigning three channels (RGB) to each pixel. The HSI system we are using measures electromagnetic radiation from 600-1700 nm). Visible light is about 350-750 nm, so the system we are using starts in the visible spectrum (red) and goes into the near infrared.

Our benchtop system for lab analyses and testing is shown below. It consists of the 'camera' (hyperspectral sensor), movable stage, high intensity light source, and a hyperspectral data processing unit (HDPU).



We have started imaging fruit, as shown above, but have been focusing on leaves collected from cranberry plants with systemic diseases. Below is a sample spectrum from cranberry infected with tobacco streak virus (TSV). The green curve is healthy cranberry leaves and the red curve is TSV infected. Note that the reflectance (y-axis) differs for healthy vs. infected across most of the wavelengths shown (x-axis). This difference allows us to distinguish healthy vs. infected, based on hyperspectral image analysis. Our next step is to cart-mount the system and begin field testing and validation.



Sample spectrum of healthy vs. TSV infected leaves

***This work is partly funded by the NJ Blueberry and Cranberry Research Council

Debuting an In-Field High-Throughput Phenotyping Cart for Cranberry Breeding

Jeffrey Neyhart
Research Geneticist, USDA-ARS, P.E. Marucci Center, Chatsworth, NJ

In cranberry breeding, selections are made among genetically distinct clones primarily based on their *phenotypes*, or observable characteristics. For important traits such as fruit yield, quality, and rot resistance, these phenotypic measurements are often collected at only one or two timepoints, but are the result of growth, development, and environmental interactions that occur throughout the season. Further, because of the investment in time and labor needed to obtain phenotypic data, only a few traits may be observed on only a subset of clones. Developing high-throughput and automated phenotyping tools will allow us to assess larger populations and more rapidly and accurately identify superior clones for future varieties or as parents in breeding.

We are prototyping a custom-built cart for collecting in-field phenotypic measurements on cranberry breeding plots throughout the growing season. Recent advances in computer vision and machine learning have enabled phenotypic measurements of many traits to be reliably extracted from images. Therefore, our phenotyping cart prototype features construction and equipment designed to create uniform conditions for high-quality image capture.

For the 2021 season, we will collect and analyze images on a sample of breeding plots in an effort to predict end-of-season fruit yield. In future years, we hope to use image analysis and computer vision to collect measurements of traits such as:

- Vegetative vigor
- Flowering time
- Fruit set, development, and uniformity of ripening
- Canopy and fruit temperature
- Fruit rot and scald severity
- In-season fruit yield prediction

Figure 1. Top-down (nadir) view of a cranberry breeding plot from inside the phenotyping cart. The color chart is used to standardize colors so images can be compared.

Carolina Redroot Identification and Control

Thierry E. Besançon, Ph.D., Extension Specialist in Weed Science
Baylee L. Carr, Weed Science Field Research IV

Introduction

Carolina redroot (*Lachnanthes caroliniana*) is a perennial weed found in aquatic sandy acidic areas ranging throughout the eastern coast from Louisiana to Nova Scotia. Carolina redroot is classified as a high priority weed in cranberry bogs (Sandler 2018) where full sunlight exposure, sandy acidic soils and rapid alternation of wet and dry soil periods provide optimal conditions for this species to develop. Carolina redroot can spread by seeds, but most commonly through rhizome clonal propagation. Carolina redroot often forms monoculture patches in New Jersey cranberry bogs where its development is associated with cranberry vine death caused by fairy ring disease as well as other "stand opening" conditions of natural and anthropic origin.

Plant Identification

Carolina redroot is a monocot easily identified by its namesake red roots and rhizomes (Figure 1A). The leaves are simple, alternate, and blade-like (Figure 1B). As the summer continues, Carolina redroot will break through the cranberry canopy, eventually outgrowing it. Flower stalks are hairy and clustered ranging from 1.5 to 4 inches with yellow blooms (Figure 1C). Fruits produced by flowers are red with reddish-brown seeds inside (Figure 1D). When scouting early in the season for these weeds in cranberry bogs, it is important to look beneath the cranberry canopy. Emergence occurs late April to early May when water has been removed from the bogs and the soil starts to warm up.

Figure 1: Carolina redroot rhizome (A), leaf blade (B), flower stalk (C), and seedhead (D)

(Photo Credit: Baylee Carr and Thierry Besançon)

Impact on Cranberry production

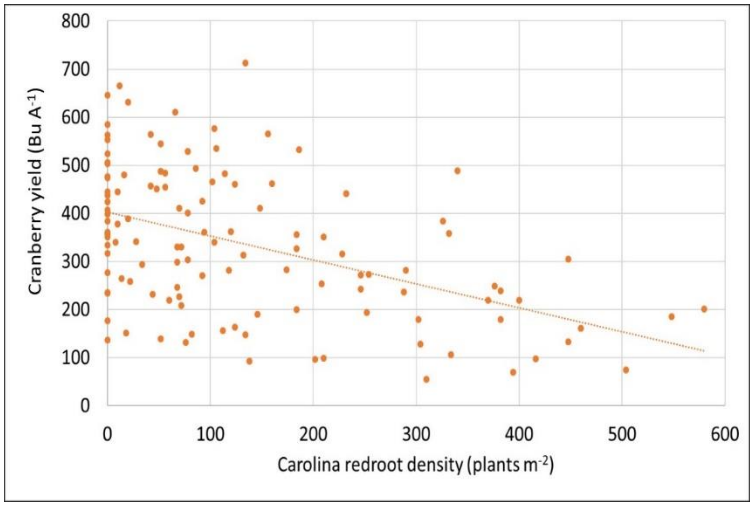


Figure 2: Impact of Carolina redroot density on cranberry fruit yield (Rutgers Weed Science)

The impact of a weed on a crop's yield tells us how consequential the weed may be. In recent studies conducted by the Weed Science team at the Rutgers P.E. Marucci Center for Blueberry and Cranberry Research, Carolina redroot in cranberry bogs accounts for significant economic loss, averaging $800/acre. Out of 120 individual plots assessed by the Rutgers University Weed Science program over the last 3 years, yield loss from redroot competition averaged 26%, reaching up to 80% when weed density exceeded 400 plants per square meter (Figure 2). These losses result from direct Carolina redroot competition for water, nutrients and light.

Additionally, pieces of redroot seed capsules can be collected with cranberry fruit during harvest operations and become problematic in the processing of cranberry products, further exacerbating the economic impact caused by this weed. The more weed debris in the bogs, the slower the cleaning process is and the more time and, thus, money spent to harvest. This issue also presents potential food quality and food safety concerns.

Carolina redroot harbors insect pests, interferes with pesticide spray deposition, and flowers of redroot are very attractive to native pollinators at a time when insecticides are applied to cranberries. Fleshy rhizomes of redroot are attractive to waterfowl (e.g., swans), which cause tremendous damage to bog topography when they feed on redroot in flooded bogs during winter months. Similar damages have been observed in Florida pastures where feral swine are feeding on Carolina redroot (Boughton et al. 2016).

Cultural Control

Strategies for controlling Carolina redroot should start with prevention. It is important to clean field equipment so that Carolina redroot seeds and rhizome fragments may not be introduced into cranberry bogs where this weed is not present. Unfortunately, some of the cultural practices associated with cranberry cropping encourage the development of Carolina redroot. As stated, the sandy, wet, acidic conditions are the perfect growing environment for the weed. Additionally, mechanical harvest of flooded cranberry bogs and circulation of flooding water from bog to bog create opportunities for broad dissemination of Carolina redroot seeds. Thus, plan harvest water flow from bog to bog so that, whenever possible, water is not moved from weed infested bogs into clean bogs.

Greenhouse studies conducted in 2018 support the idea that typical agricultural practices associated with cranberry cropping such as flooding or sanding will not impact the development of Carolina redroot (Besançon 2019a). Thus, holding the harvest flood for up to 4 weeks will not be effective at suppressing Carolina redroot contrary to what is observed for dewberry (Sandler and Ghantous 2021). Lack of light inhibited shoot growth and prevented the development of new rhizomes (Figure 3). Use of black tarp in small areas colonized by Carolina redroot such as patches of dead vines caused by fairy ring disease could help prevent further expansion of this weed.

Figure 3. Carolina redroot grown in full light (left) and under darkness (right)
(Photo Credit: Baylee Carr)

Management Calendar

The management calendar for Carolina redroot emphasizes early season split applications of preemergence herbicide followed by mid-season application of post-emergence herbicide before emergence of the floral stalk.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Emergence												
Flowering and seed rippening												
Pre-emergence treatment												
Post-emergence treatment												

Chemical control

Recommendations for controlling Carolina redroot stress proper timing of application to reduce the number of emerging shoots and prevent the formation of a floral stalk. Delayed herbicide treatments will result in ineffective preemergence applications as Carolina redroot may have already emerged or ineffective postemergence application that will not prevent the formation of a seedhead. Ongoing research evaluating strategies combining applications of napropamide and mesotrione for control of Carolina redroot have shown promising results with over 80% control by the end of the season after 3 years of repeated applications (Figure 4) (Carr et al. 2017, Besançon 2019b).

Treatment	Timing	Herbicide	Product Rate	Comments
Preemergence application	Mid-April following removal of winter flood	Devrinol 2-XT (napropamide 2 lb/gal) Devrinol DF-XT (napropamide 50%) Casoron 4G (dichlobenil 4%)	6 to 9 quarts/acre 9 to 18 lb/acre 100 lb/acre	Devrinol 2-XT has a 24c Special Local Need label in NJ allowing split applications until before cranberry bloom. These herbicides should be applied before Carolina redroot starts emerging to provide effective suppression of its growth. Effective control will only be obtained if these applications are followed by postemergence mesotrione application in mid-June. **The application of Devrinol DF-XT and Casoron 4G is limited to early spring prior to cranberry budbreak.**
Overlapped preemergence application	30 days after initial preemergence application but before cranberry bloom	Devrinol 2-XT (napropamide 2 lb/gal)	6 to 9 quarts/acre	This application will help suppress further Carolina redroot emergence. If rainfall does not occur, the treatment must be shallowly incorporated or irrigated-in following application with sufficient water to wet the soil to a depth of 2 to 4 inches. **The cumulated amount of napropamide applied each year cannot exceed 9 lbs/acre**
Broadcast foliar application	Mid-June to early July	Callisto or Motif (mesotrione 4 lbs/gal)	8 fl oz/A	This treatment should be coupled with preemergence applications (see below) for optimal Carolina redroot suppression. Apply mesotrione when Carolina redroot leaves emerged above cranberry canopy but before the emergence of a floral stalk. The use of a nonionic surfactant (NIS) at 0.25% v/v is recommended.
Spot foliar application for small areas infested by Carolina redroot	Mid-June to early July	Callisto (mesotrione 4 lbs/gal)	8 fl oz/A	Callisto received a section 24(c) Special Local Need Label in New Jersey that allows spot-treatment at up to 1.5 oz/gal for control of Carolina redroot. At 1.5 oz/gal, you can only spray out 5.3 gallons per acre per application to stay within the maximum labeled rate of 8 fl oz/A/application. Apply mesotrione when Carolina redroot leaves emerge above cranberry canopy but before the emergence of a floral stalk. The use of a nonionic surfactant (NIS) at 0.25% v/v is recommended.

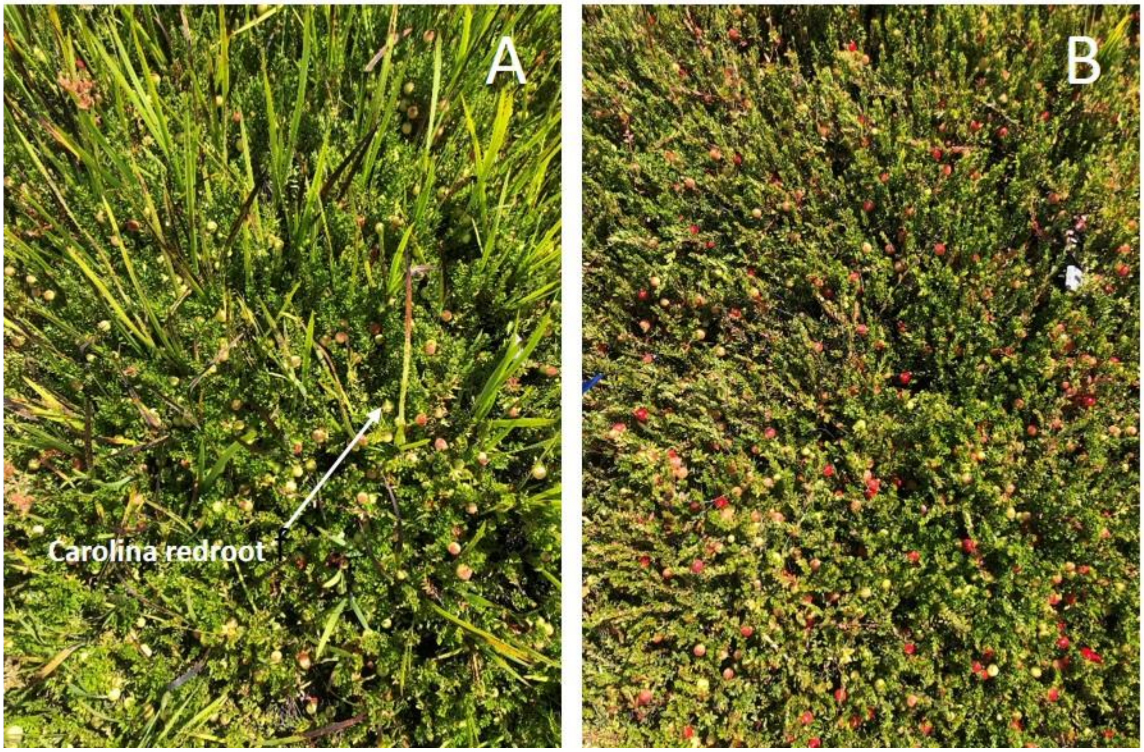


Fig 6. Carolina redroot in untreated plot (A) and in plot treated with split application of napropamide at 9 lb ai/a in mid-April and mid-May followed by mesotrione applied in mid-June (B).

Literature Cited

Besançon, T.E. 2019a. Carolina redroot (*Lachnanthes caroliniana*) vegetative growth and rhizome production as affected by environmental factors and planting depth. Weed Sci. 67(5): 572-579

Besançon, T.E. 2019b. What did we learn from two years of research on controlling Carolina redroot? American Cranberry Growers Association. https://pemaruccicenter.rutgers.edu/docs/19-ACGA-Abstract-WinterMeetingProgram2019.pdf (accessed 10 Aug. 2021)

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Sandler, H.A. 2018. Weed management in cranberries: a historical perspective and a look to the future. Agriculture 8 (138):1-20

Sandler, H.A. and K.M. Ghantous. 2021. Weed management. In: K.M. Ghantous, M. Sylvia, and D. Gauvin, editors, Cranberry Chart Book 2021-2023 Management Guide for Massachusetts. University of Massachusetts Amherst, Cranberry Station, East Wareham, MA. p. 41-67.

Strategies for Improving Cranberry Fruit Quality

Peter Oudemans, Christine Constantelos*, *Matt Hamilton*, *Julia Ciaccia*, and *Mike King
PE Marucci Center for Blueberry and Cranberry Research and Extension,
Rutgers University, Chatsworth, NJ 08019

Fruit rot disease is a complex of several fungi. As cultivars evolve and yields increase fruit rot becomes more significant in terms of loss. Broad spectrum fungicides are important for fruit rot control because they help manage the fruit rot populations away from fungicide resistance. Site specific fungicides, on the other hand, are highly effective and more precise in reaching a target. Increased reliance on site specific fungicides will result in a more dynamic and changeable fruit rot population.

Rapid methods for screening fungicides can improve the process of finding new fungicides for fruit rot control as well as characterizing the spectrum of action. In this research, we continue to identify new fungicides and fungicide combinations that show activity against the various species causing cranberry fruit rot. In Fig. 1, the visual results show the spore germination steps measured in the bioassay and different ways that fungicides affect this process. Treatments 3 and 8 (UTC) show the original spore (inoculum) forming a germ tube and an appressorium as well as new spores (conidia). T5 on the other hand shows only germination whereas T6 is completely inhibited. These results are quantified as shown in Figs. 2 &3. Preliminary results from the field trial suggest T3, T5, and T8 (UTC) have the highest levels of field rot while T1,2,4,6 are lower. These results show a good correlation with the lab results (Fig. 4). These results will be further confirmed with fruit rot at harvest followed by an analysis of the fungal species present.

Interestingly, T7 also showed high levels of fruit rot even though it is a commercial formulation of T6. This anomalous result may be due to the formulation of the product. It is important to understand the reason for this difference as it may help identify important formulation questions related to fungicides in cranberry. Two of the treatments (T4 and T6) are currently at different stages of registration for cranberry.

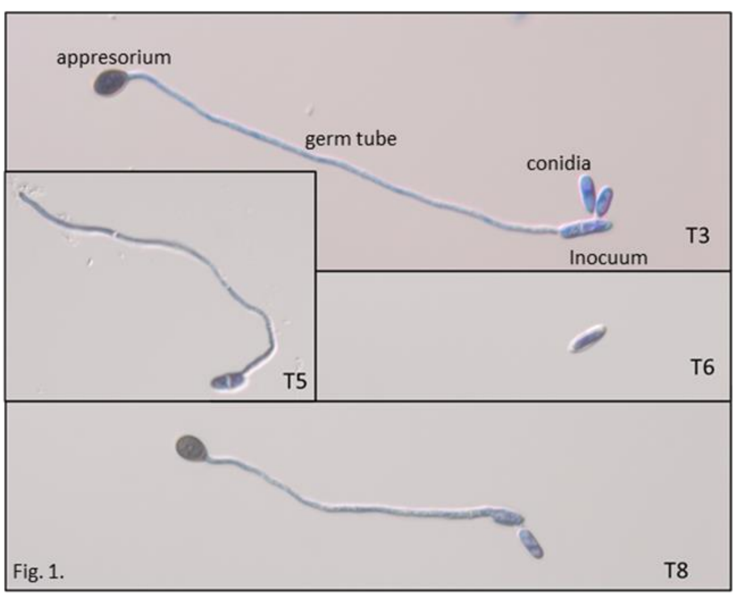
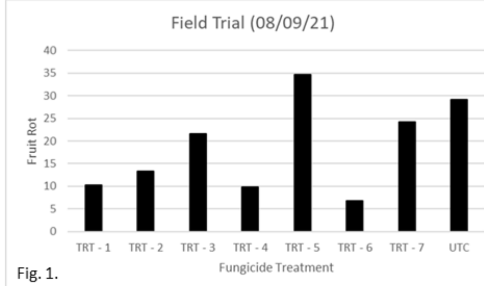


Fig. 1.



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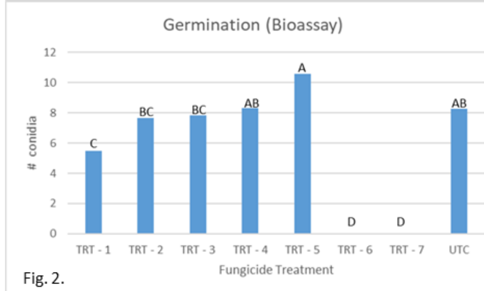


Fig. 2.

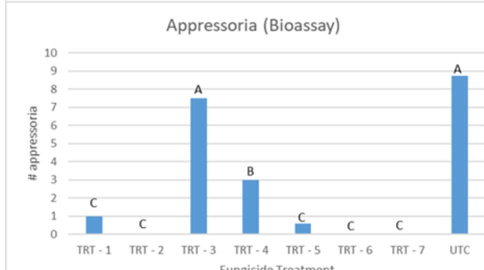


Fig. 3.

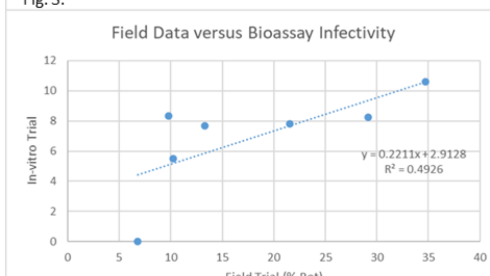


Fig. 4.

Evaluation of Fruit Rot Resistant Selections for New Jersey

Nicholi Vorsa, Professor, Department of Plant Biology, Rutgers University,
Jennifer Johnson-Cicalese, and *Peter Oudemans*, P.E. Marucci Center, Chatsworth, NJ

Managing the fruit rot disease complex is increasingly difficult for New Jersey cranberry growers, due to climate stress and restrictions on fungicide inputs. The Rutgers cranberry breeding program continues its intensive efforts to develop productive cultivars with enhanced resistance to fruit rot. Hundreds of crosses have been made, and thousands of progeny are being screened for fruit rot resistance (FRR). In conjunction with our breeding work, we need to learn how to manage potential new cultivars with enhanced fruit rot resistance. Reduced fungicide input is our goal.

Therefore, in 2015, our top FRR selections were planted in Bog 11 for fungicide trials along with Crimson Queen as a high yielding, but susceptible control (5 reps, 10' x 20'plots) (Fig. 1a). The nine selections were chosen from over 1600 progeny from our 1st and 2nd breeding cycles, and were based on best FRR, high yield, and berry quality. Most of the top selections have Budd's Blues as a parent (Fig. 1c), a variety that has long been known to exhibit excellent FRR, but unfortunately has <u>very</u> low yields. However, in these crosses with highly productive cultivars, e.g. Mullica Queen and Crimson Queen, we were able to recover Budd's Blues progeny with both good resistance <u>and</u> good yield. This observation provides evidence that FRR genes are different from those conferring poor productivity. Other sources of resistance that we have identified and that are utilized in these top selections include US89-3 (highly resistant, but small-fruited), and Cumberland (higher yielding, but just moderately resistant) (Fig.1).

In 2018, once the plots were established, they were divided into 5' x 10' subplots and received four fungicide regimens: 1) no fungicides, 2) two Indar/Abound applications <u>during bloom</u>, 3) two Bravo applications <u>after bloom</u>, and 4) standard fungicide treatments (I/A, I/A, Bravo, Bravo) (Fig.1b). Treatments were repeated in 2019 and 2020. Samples ($3ft^2$) were harvested each October to determine % rotted fruit and yield, for each selection and each treatment. The design was a split-plot randomized complete block, with selection as the primary factor and fungicide treatment as the secondary factor.

When fungicide treatments were compared, using the mean of all ten selections, significantly higher percent rotted fruit was found on untreated plots, as expected, and the lowest rot was found on standard treatment (I/A, I/A, Bravo, Bravo) (Fig 2a). However, there was not much difference between the Indar/Abound only treatment and the standard treatment. For yield (Fig. 2b), there was no difference between I/A only and standard treatments. Phytotoxicity was found on the Bravo-treated plots, on some selections more than others, that reduced both fruit size and yield.

If we compare the performance of the FRR selections when treated with the in-bloom I/A applications, significant differences were found in percent rotted fruit (Fig. 3a). CNJ05-80-2 and 47, two siblings, and CNJ06-22-10 had the lowest rot; all three of these selections were derived from crosses between two sources of FRR, Budds Blues and Cumberland, suggesting an additive effect which enhanced the resistance. All the FRR selections had a lower percentage of rotted fruit than Crimson Queen. Significant differences were also found in yield (Fig 3b), with

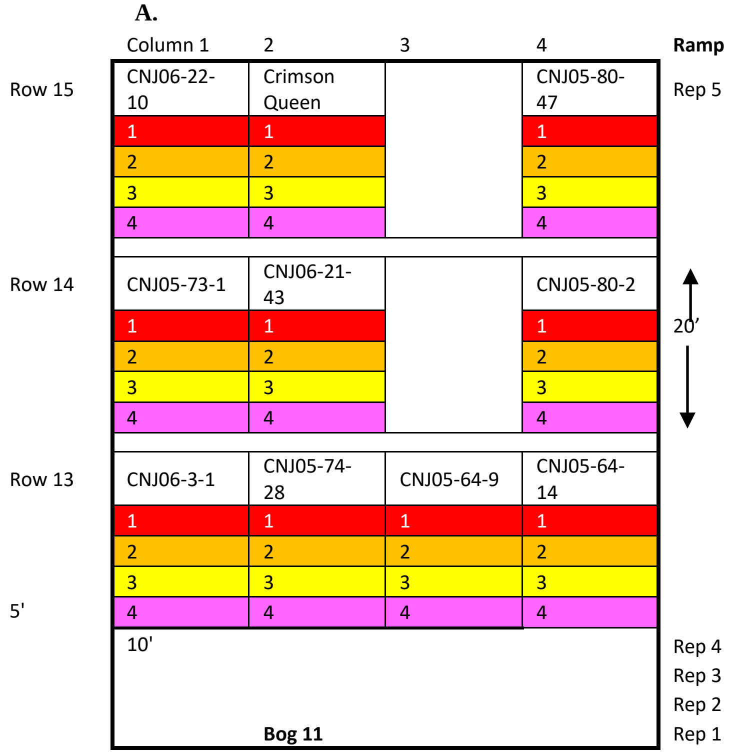
CNJ05-80-2 and 47 having the best yield, followed by CNJ05-64-14, a BB x CQ progeny which also had very low rot.

When the four fungicide treatments are compared for each FRR selection, some selections showed very little difference between the standard treatment and the I/A only treatment. For example, CNJ05-80-2 had better yields than the standard treatment all three years of the study, and better yields than Crimson Queen due to the reduced rot (Fig. 4). In addition, the Bravo only treatment (out of bloom) consistently had more rot in all selections than I/A only (in-bloom), suggesting possible similarity in mechanism of resistance. In other words, the Bravo treatments failed to provide additional protection against fruit rot in any of the selections. The timing of fungal infection and timing of subsequent rot development may be similar among FRR selections.

These FRR selections were also planted in large plot trials in Wisconsin, British Colombia, and New Jersey (Pine Island Cranberry and JJ White). Additional reduced fungicide trials will be performed on these grower trials. We are hopeful that one of the selections will consistently perform well enough to be released as a FRR cultivar. Due to the genetic resistance in these selections, it appears it will be possible to produce a good cranberry crop with reduced fungicide inputs. We continue to do crosses in an effort to 'pyramid' the multiple sources of resistance and evaluate new combinations. In addition, genetic markers associated with fruit rot resistance have been identified which may prove useful for accelerating the screening process for future releases. Thus, through additional breeding and selection cycles, we hope to develop cultivars with both enhanced FRR and higher productivity.

Figure 1. Fungicide treatments (B) on 9 FRR selections and a susceptible control, Crimson Queen (C), planted in Bog 11 in July 2015, 10' x 20' variety plots, and 10' x 5' fungicide treatment plots. Treatments on Rep 5 are shown below, selections and treatments are repeated in a randomized order in Reps 1-4 (A).

A.



B.

2019 & 2020 Fungicide Treatments					
TRT	# Sprays	SPRAY 1	SPRAY 2	SPRAY 3	SPRAY 4
1	0	X	X	X	X
2	2	I/A*	I/A	X	X
3	2	X	X	Bravo	Bravo
4	4	I/A	I/A	Bravo	Bravo

*I/A = Indar/Abound

C.

Fruit Rot Resistant Selections	
	Parents*:
CNJ05-64-9	BB X CQ
CNJ05-64-14	BB X CQ
CNJ05-73-1	BB X CQ
CNJ06-21-43	BB X MQ
CNJ05-74-28	BB X DE
CNJ05-80-2	CU X BB
CNJ05-80-47	CU X BB
CNJ06-22-10	BB X CU
CNJ06-3-1	MQ X 86-46

*Resistant parents: BB – Budd's Blues, CU – Cumberland, 86-46 – a progeny of Stevens x US89-3; Susceptible, high yielding parents: CQ - Crimson Queen, MQ – Mullica Queen, DE – Demoranville

Figure 2. Comparison of 4 fungicide treatments on % fruit rot (A.) and estimated barrels per acre (B.), using the 2019 mean of all selections.

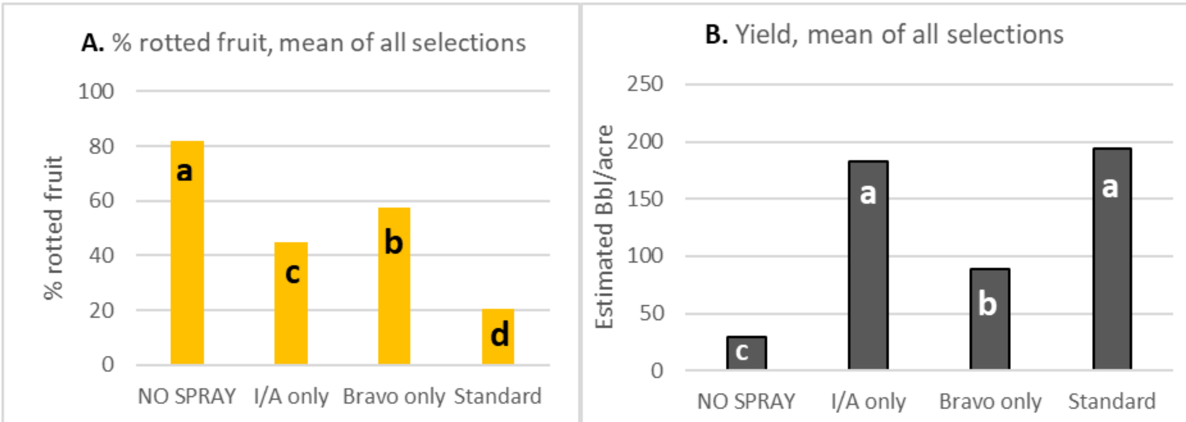


Figure 3. Performance of 9 fruit rot resistant selections and susceptible Crimson Queen when treated twice with Indar/Abound during bloom (Trt 2) in 2020; percent rotted fruit (A.) and yield (B.)

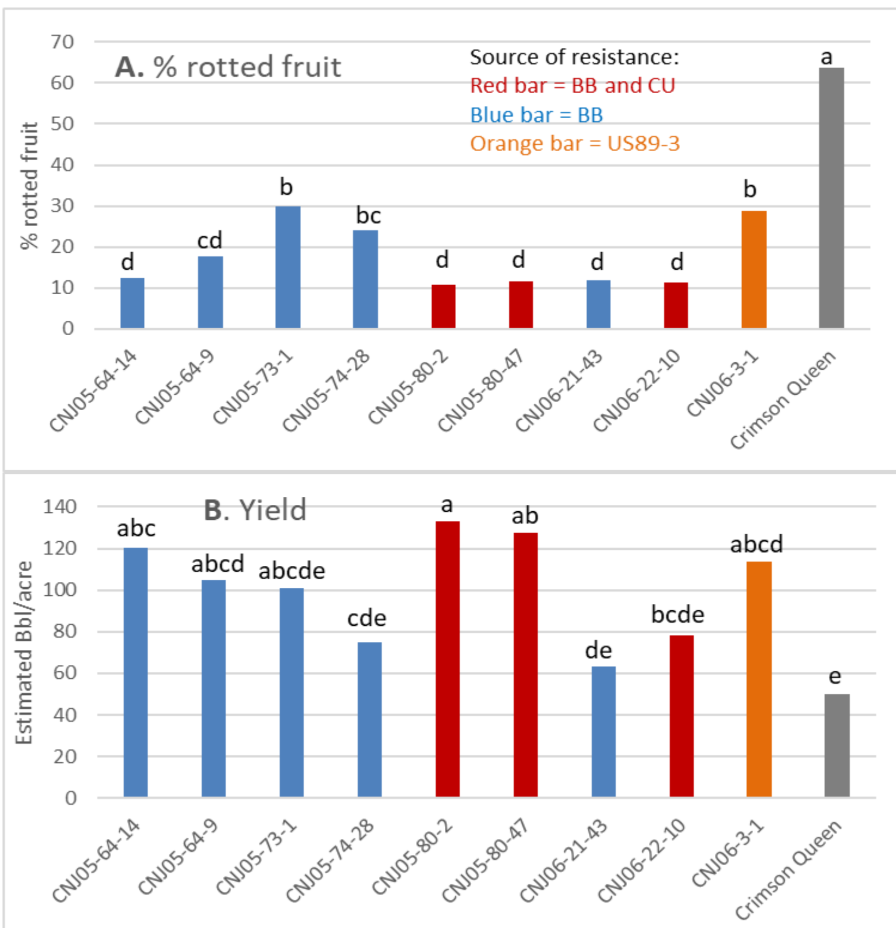
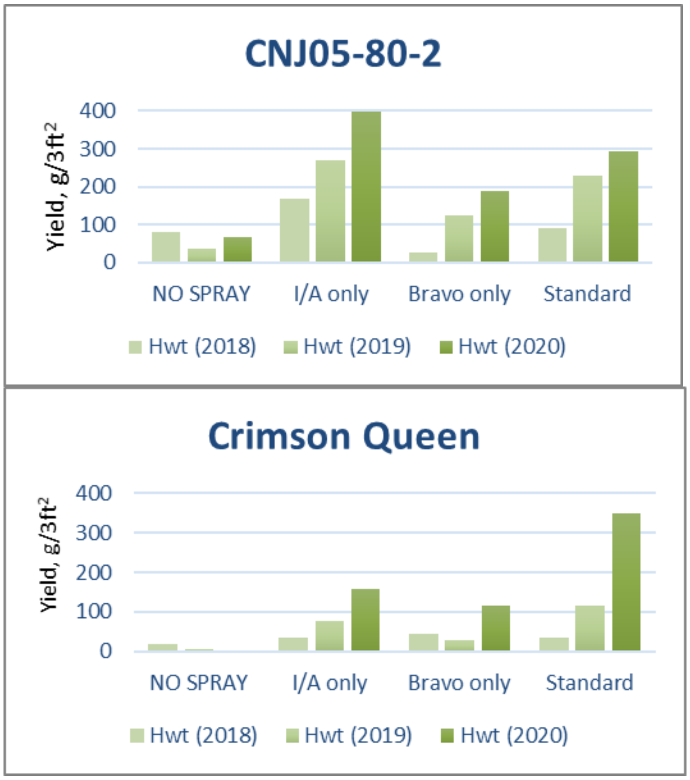


Figure 4. Comparison of fungicide treatments for experimental selection CNJ05-80-2 and Crimson Queen. When treated with Indar/Abound only, CNJ05-80-2 performed better than with the standard fungicide treatment, and performed better than Crimson Queen in all three years of the trial.



OVERVIEW OF THE NEW JERSEY 2021 SEASON SO FAR

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WEATHER & PLANT DEVELOPMENT

We started the 2021 season off with *many* nights of **frost** watch starting soon after water draw across the state. Many growers ran as many as twelve nights in a row, and temperatures hovered below normal for quite a while before returning to typical temperatures in mid-May. Overall, growers did a great job of protecting plants/terminal buds during these cold periods, and frost damage was localized and minimal in the state this year. Plant growth was quite variable within and among farms at the outset of the growing season; growth stage certainly differed by variety, location, and the time at which the winter flood was pulled, but there were differences in plant development even among farms that pulled water around the same time as well. In general, plant growth started to even out across farms as the season progressed despite these initial differences, and plant development seems to be trending slightly ahead this year compared to last year (remember that development in 2020 was slightly behind compared to normal, though).

After the substantial number of frost nights this spring, an early-season heatwave rolled in, bringing with it abnormally high temperatures and a series of thunderstorms in early June which pushed many of the earlier-maturing varieties into bloom a bit more quickly than expected. The weather then turned cooler again, and bloom progressed somewhat slowly on many farms at the beginning of the bloom period, making initial fungicide and fertilizer application timing challenging for some growers. Once bees arrived on most farms during the first two weeks of June, several stretches of temperatures in the 90's combined with well-timed rainfall helped bloom and fruit set progress at a fairly 'normal' pace. Consequently, fruit set looks good across the state so far, and berries have started to turn red and continue to size nicely as we move toward harvest.

INSECTS

Although it had been quite a few years since we'd had a substantial **Gypsy Moth** population in this area, Gypsy Moth larvae started to show up in some bogs in the state during the week of May 3rd this year and were present in high enough numbers to warrant treatment on some farms. Insecticide applications were well-timed and effective, and we escaped without substantial damage from this pest. After the Gypsy Moth (GM) outbreak, the insect populations were much more predictable, and in general, **Spotted Fireworm**, **Sparganothis Fruitworm** and **Blackheaded Fireworm** larval numbers were lower than 'normal', but populations were high enough to warrant a pre-bloom insecticide application on a few farms this year. It's possible that the populations were simply truly lower this year, and it's also possible that earlier-than-normal insecticide applications targeting gypsy moths (e.g., Intrepid®, Altacor®, etc.) had a residual effect on later-season emerging Lepidopteran pests like Sparg and Spotted Fireworm. Following suit with what we observed with first generation larval activity, Sparganothis moth trap counts were low this year, with most farms averaging less than 30 moths across all traps during peak flight, which was similar to what we observed in the 2020 season. Peak flight was reached during the week of June 28th on some beds on some farms, but not until the week of July 5th or later on other farms. For farms on which trap counts exceeded the action threshold, these later-than-normal peak flight dates made timing of insecticide applications especially challenging.

Blossomworms, which are typically a spotty pest here in NJ, were swept in high numbers on a few farms during our pre-bloom sweep sets this year, and some populations that went unchecked led to substantial crop loss damage in a few beds.

Blunt-nosed leafhopper (BNLH) nymphs started to show up in sweep nets during the week of May 17th, and after closely monitoring these populations, many growers chose to deploy a pre-bloom insecticide application (e.g., chlorpyrifos) when the BNLH action thresholds were met, especially in newer plantings and in false blossom-infested bogs to which a broad-spectrum insecticide had not been applied pre-bloom in several years.

Damage from root-feeding insects, especially **cranberry rootworm,** was observed on several farms this year, especially in younger (e.g., 4 to 5-year old) plantings. Interestingly, feeding suspected to be from adult beetles of cranberry rootworm was observed on berries and to a lesser extent, foliage, especially in beds exhibiting substantial vine damage from this pest. Growers who observed dead patches and confirmed that rootworm and/or other root-feeding insects were the cause of the damage applied a post-bloom imidacloprid (e.g., Admire Pro®) treatment for management.

Cranberry toad bugs are active now, numbers are generally low (<5 per sweep set on average) across the state to date, and no plant damage associated with toad bug feeding has yet been observed.

Cranberry flea beetles have been observed feeding on leaves in several beds; numbers are currently low (<10 per sweep set on average), and damage is minimal to date. Most growers will likely not have to treat for either of these later-season pests this year.

DISEASES

Fairy Rings were once again mapped using a combination of drone imagery and improved handheld GPS units on many farms that chose to treat for this disease this year, and soil soak treatments of fenbuconazole + azoxystrobin (e.g. Indar® + Abound®) were deployed on these rings in early- to mid-May. Treatment efficacy is somewhat variable to date, but treatments applied to smaller rings seem to be showing promise.

Berry scarring symptoms associated with virus infection are once again readily observed in all varieties this year. It's impossible to visually distinguish symptoms associated with ***Tobacco streak virus*** **(TSV)** from symptoms associated with ***Blueberry shock virus*** **(BlShV),** and both viruses affect cranberry plants similarly. Although there is no treatment for these viruses, it's important to look closely at prematurely reddening berries to confirm whether the cause of the reddening is viral or the result of a Sparganothis Fruitworm (or other insect) infestation.

The high temperatures and extremely high humidity that have dominated much of the 2021 season make the development of **cranberry fruit rot (CFR)** a concern. Unfortunately, some substantial fruit rot infestations have already manifested within the past few weeks, primarily in younger beds of newer cultivars that are not yet fully established. Hopefully these instances will remain limited, and CFR will not be an extensive problem for the state this year.

2021 Insecticide Trials for Insect Pests

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Due to restrictions in the use of broad-spectrum insecticides, cranberry growers have adopted new low-risk, softer insecticides. However, these changes in management practices have resulted in changes in insect pest complexes across cranberry-producing states. For example, populations of blunt-nosed leafhoppers in New Jersey and Wisconsin, two major cranberry-producing states in the USA, have increased in recent years. This is likely due to the decrease in use of broad-spectrum insecticides and increased adoption of insecticides that are more specific to lepidopteran pests (chewing caterpillars) such as Sparganothis fruitworm, spotted fireworm, and blackheaded fireworm but that do not have any control over piercing-sucking insects like leafhoppers.

Research is being conducted at the P.E. Marucci Center to: 1) Evaluate the efficacy of various insecticides against leafhoppers; 2) Determine the performance of leafhoppers on various cranberry varieties and possible mechanisms of resistance.

New insecticides. Currently, cranberry growers in New Jersey rely on two classes of insecticides: organophosphates (Lorsban and Diazinon) and carbamates (Sevin) applied pre-bloom to manage blunt-nosed leafhopper nymphs. These insecticides are under threat from the EPA Food Quality Protection Act. In addition, heavy reliance on insecticides with the same mode of action raises serious concerns on the development of insecticide-resistant pest populations. In 2021, we tested different classes of insecticides against blunt-nosed leafhoppers, which included sulfoxaflor (Closer), a recently registered insecticide in cranberries that belongs to a new class of chemistry the sulfoximines, and fenpropathrin (Danitol), a pyrethroid recently registered in cranberries. We also tested various entomopathogenic fungi including Beauveria and Metarhizium strains.

Host-plant resistance. Recently, cranberry growers have been presented with new opportunities to increase production through improved high-yielding cultivars, many of which were developed by Rutgers University. These new cultivars are being grown in all cranberry-growing regions (Northeast, Midwest, and West Coast). There is, however, little information available to growers on the susceptibility of these cultivars to insect pests. In a previous study, we demonstrated that one of these new cranberry cultivars is more susceptible to gypsy moth caterpillars, a pest of cranberries, than some of the older cultivars. However, no data are available on the susceptibility of these newer cultivars against other insect pests such as blunt-nosed leafhoppers. Early studies showed that Howes is more susceptible to blunt-nosed leafhoppers than Early Black; however, no studies have investigated the level of blunt-nosed leafhopper resistance in the newer cultivars. A better understanding of pest-host dynamics and resistance mechanisms will help develop better management recommendations for the newer cultivars.
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Approach:

A) New insecticides

In 2021, studies were conducted in semi-field (P.E. Marucci Center) to evaluate the efficacy of new insecticides against blunt-nosed leafhoppers nymphs. The following insecticides were evaluated: Lorsban, Closer, Danitol, and Beauveria and Metarhizium strains. Foliar applications of these registered and unregistered insecticides were applied to small (4-by-4 feet) cranberry plots (Figure 1). Toxicity of these insecticides was evaluated by placing leafhopper nymphs on insecticide-treated foliage. For this, five insecticide-treated uprights were inserted in florists' water picks, enclosed in a ventilated 40-dram plastic vial, and secured in Styrofoam trays. Leafhopper nymphs were then placed in the vial. Mortality was assessed 1, 3, and 7 days after transfer. Number of insects alive, dead, or missing was recorded.

Figure 1. Field setup for leafhopper insecticide trials.

B) Host-plant resistance against leafhoppers

Our main goal here was to better understand insect resistance among cranberry cultivars and integrate this information into IPM recommendations if feasible.

Cultivars and Insects: We tested resistance of eleven cranberry cultivars (Early Black, Howes, Ben Lear, McFarlin, Potter, Stevens, Franklin, Crimson Queen, Mullica Queen, Demoranville, and Haines) to blunt-nosed leafhoppers in greenhouse assays (Figure 2). Experiments were conducted at the Rutgers PE Marucci Blueberry/Cranberry Center (Chatsworth, NJ). Crimson Queen, Mullica Queen, Haines, and Demoranville are four new high-yielding cultivars recently released by Rutgers University. We also included seven "old" varieties (Early Black, Howes, Ben Lear, McFarlin, Potter, Stevens, and Franklin) for comparison in their resistance against blunt-nosed leafhoppers.

Figure 2. Greenhouse setup for leafhopper resistance trials.

Blunt-nosed Leafhoppers. In the greenhouse, early instar nymphs were placed with an upright of one of the cultivars in individual pots. Mortality and final weights were assessed after 21 days.

Mechanisms of resistance. For each variety, we will be measuring total phenolics using the Folin–Ciocalteu method as a proxy of plant defenses and levels of carbon and nitrogen as a proxy of plant nutrients.

New Jersey Agricultural Statistics

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New Jersey 2021 Cranberry Crop Forecast at 490 Thousand Barrels

New Jersey cranberry producers expect to harvest 490 thousand barrels in 2021, compared to 531 thousand barrels in 2020, according to Bruce Eklund, New Jersey State Statistician.

Massachusetts production is forecast at 2.10 million barrels, up 2% from the year before. Oregon producers expect to harvest 610 thousand barrels, up 1% from 2020. Wisconsin production is forecast at 4.70 million barrels, also up 1% from 2020 production. Total forecast for these four states is 7.90 million barrels compared to a realized 7.83 million barrels in 2020.

NASS released this production forecast within the August 12, 2021 crop report.

USDA's National Agricultural Statistics releases more detail 2021 Non-citrus Fruit and Nut Final Summary at a date to be determined in 2022. NASS released the detailed 2020 crop date in the Fruit and Nut Final Summary May 5, 2021.

The 'Crop Production' report and all other NASS reports are available online at www.nass.usda.gov

Or https://www.nass.usda.gov/Publications/Reports_By_Date/index.php

Cranberry spring frost protection and optimal nitrogen rates for second generation hybrids

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Spring Frost Monitoring

Cranberry growers have a hard time to decide when to start monitoring buds for potential spring frost damage. In this talk, I will present three thermal time models also known as growing degree day (GDD) models that can be a decision tools for when to start bud monitoring in spring. Currently, Massachusetts growers use the Dee Model to initiate temperature monitoring for spring frost protection, but lately its accuracy has come under scrutiny by growers and researchers alike. Although the thermal time model approach shows promise in cranberry frost monitoring, the inherent physiological changes that occur during development represents a source of uncertainty among different cultivar groups. Cranberry plants require a photoperiod of 13 hr. for normal bud break and flower development. Therefore, monitoring of air temperature in cranberry is usually initiated after the first long day (>13hr) of the year, which usually coincides with April 7th. The base temperature of the cranberry GDD model is 41^{o}F, whereas that of the Dee model is 44^{o}F. The three thermal time models agreed with respect to predictions of 162-180 GDD ^{0}F (90-100 GDD ^{0}C) in four out of the five years under consideration (2017-2021). The models varied by 1-2 d, which was well within model prediction error. In 2020, however, only the Dee Model and WI (41) Model were in agreement. The difference between these two models and the WI (80-41) was 10-11 days, which was significant.

Automated cycled irrigation for spring frost protection

Overhead (sprinkler) irrigation is commonly used for spring frost protection of cranberries. However, a general paucity of information exists on the horticultural and hydrological effects of on-off "cycling" of irrigation pumps based on pre-programmed temperature setpoints during frost protection. In my talk, I will discuss the relative effects of cycled and conventional frost irrigation on crop yield and water use (Olszewski, et al. 2017). Although the cycling treatment had more bud damage than the conventional, damage was observed on one or two floral initials. A cranberry bud typically has four to six floral initials and a damage in two floral initials means the remaining two to four initials will produce flowers and result in fruit production. Based on three years of monitoring, data show that cycled frost irrigation reduces seasonal water use from 33-80% compared to conventional frost irrigation. Values of cranberry yield were similar between the two methods or slightly higher for cycled frost irrigation. The conventional frost irrigation method always applied more irrigation water, possibly causing soil saturation and anaerobic conditions that are known to limit cranberry production. Based on these results, I will show that cycled frost irrigation can be as sustainable if not better than conventional.

Optimal nitrogen rates

Nitrogen (N) is the most important element in cranberry (*Vaccinium marcrocarpon* Ait.) production due to its impact on both vegetative growth and fruiting. However, N is also naturally deficient in acidic peatland soils, which require N fertilizer additions for commercial production of cranberry. Nitrogen fertilizer rates have been previously determined for native cultivars and for the first-generation hybrids, but field data to support N fertilizer recommendations for second-generation hybrids are lacking. To fill this gap, we conducted a replicated field experiment to develop N rate response curves for native, first- and second-generation hybrids, and to evaluate the effect of field fruit rot as influenced by fertilizer N rate on native and hybrid cultivars and effect of N rates on fruit quality. We tested the most common types of native ('Howes'), first-generation hybrid ('Stevens'), and second-generation hybrid ('Crimson Queen', 'Demoranville' and 'Mullica Queen') cultivars planted in Massachusetts cranberry bogs. Our results showed that fruit yield decreased at the N fertilizer application rate of greater than 100 lb N acre^{-1} for second-generation hybrids, 75 lb N acre^{-1} for first-generation hybrids. Native cultivars responded up to 50 lb N acre^{-1}. Vegetative biomass increased linearly with N rate regardless of cultivar. Fruit rot generally increased with N fertilizer application rate, with up to 40% fruit rot observed in 'Crimson Queen' at the highest N fertilizer rate of 200 lb N acre^{-1}. Fruit firmness, Brix and titratable acids decreased with an increase in N fertilizer rate. The results seem to suggest that for optimal fruit yield, N fertilizer recommendations for first-generation hybrids are inadequate for second-generation hybrids.