2019 Annual Winter Meeting of the American Cranberry Growers Association

AMERICAN CRANBERRY GROWERS association

Rutgers University EcoComplex

Bordentown, NJ

Thursday
January 17, 2019

RUTGERS
New Jersey Agricultural Experiment Station

ACGA Winter Meeting Program

Thursday, January 17, 2019
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***

8:50-9:10 **Cranberry Statistics**
Bruce Eklund, National Agricultural Statistics Service, Trenton, NJ

9:10-9:35 **What did We Learn from Two Years of Research on Controlling Carolina Redroot?"**
Thierry Besancon, Weed Science Extension Specialist, Rutgers University, P.E. Marucci Center, Chatsworth, NJ

9:35-10:00 **Cranberry Institute – An Update**
John Wilson, Cranberry Institute, Carver, MA

10:00-10:25 **Disease Management Progress 2018**
Peter Oudemans, Professor, P.E. Marucci Center for Blueberry & Cranberry Research & Extension, Rutgers University, Chatsworth, NJ

10:25-10:40 **Break**

10:40-10:50 **If a Picture's Worth a Thousand Words..... The Benefits of Using Remote Imagery to Manage Cranberry Bogs**
John Porter, Director of Agronomy, Skycision

10:50-11:15 **Cranberry Breeding Update: Pyramiding Genes for Fruit Rot Resistance, Genomics Work, and Fruit Chemistry Evaluations**
Jennifer Johnson-Cicalese, P.E. Marucci Center, Chatsworth, NJ and *Nicholi Vorsa,* Professor, Department of Plant Biology and Pathology, Rutgers University

11:15-11:35 **Understanding the Effects of False Blossom Disease on Cranberry Chemistry, Blunt-nosed Leafhoppers, and other Insect Herbivores**
Nakorn Pradit, Department of Entomology, Rutgers University, New Brunswick, NJ

11:35-12:00 **Management of Blunt-nosed Leafhoppers in Cranberries: Lessons Learned from Insecticide Trials**
Cesar Rodriguez-Saona, Professor, Department of Entomology, Rutgers University, New Brunswick, NJ; *Vera Kyryczenko-Roth*, and *Robert Holdcraft*, P.E. Marucci Center, Chatsworth, NJ

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

1:00 **Adjournment**- *ACGA Board of Directors Meeting*

What did We Learn from Two Years of Research on Controlling Carolina Redroot?

Thierry Besançon,
Weed Science Extension Specialist
P.E. Marucci Center for Blueberry and Cranberry Research and Extension
Rutgers University, Chatsworth, NJ

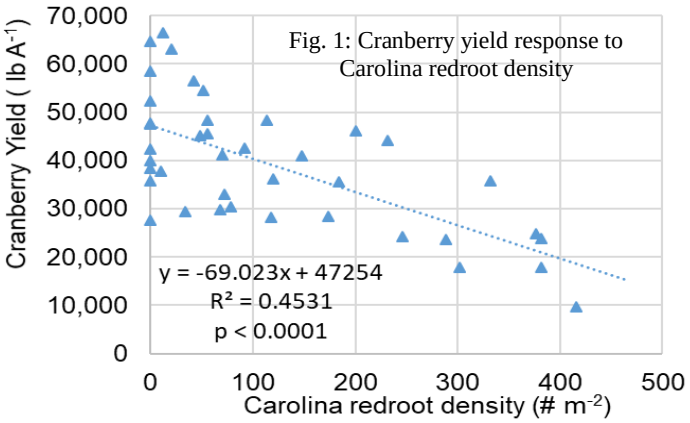


Fig. 1: Cranberry yield response to Carolina redroot density

The perennial nature of cranberry (*Vaccinium macrocarpon* L.) crop predisposes it to a diversity of weed species ranging from herbaceous weeds to woody perennial species, including Carolina redroot [*Lachnanthes caroliniana* (Lam.) Dandy] in New Jersey. Carolina redroot is a perennial herbaceous weed species belonging to the *Haemodoraceae* family. It competes for nutritional resources during the cranberry growing season, and can severely decrease cranberry yield (Fig. 1). Its rhizome also serve as a food source for wintering waterfowl that can cause severe uprooting damages of cranberry vines when bogs are flooded. Information regarding herbicidal control of Carolina redroot are limited and restricted to blueberry production (Myers et al. 2013).

Carolina redroot response to environmental factors

A greenhouse study was conducted in 2018 at the Rutgers University PE Marucci Center for Blueberry and Cranberry Research and Extension, Chatsworth, NJ, to determine the effects of various environmental factors on Carolina redroot vegetative and rhizomatic growth. The effects of planting depths, soil moisture content, redroot rhizome water content, rhizome submersion duration, and light conditions on Carolina redroot development were evaluated by assessing daily shoot emergence as well as plant height, above- and belowground biomass 45 days after planting. A logistic model fitted collected data the best.If timing of emergence increased with planting depth, this factor had very limited effect on Carolina redroot emergence and vegetative growth (Fig. 2). The required planting depth for reducing emergence by 50% was 16 cm, far beyond the 3 cm layer of sand applied for improving rooting of cranberry stolons.

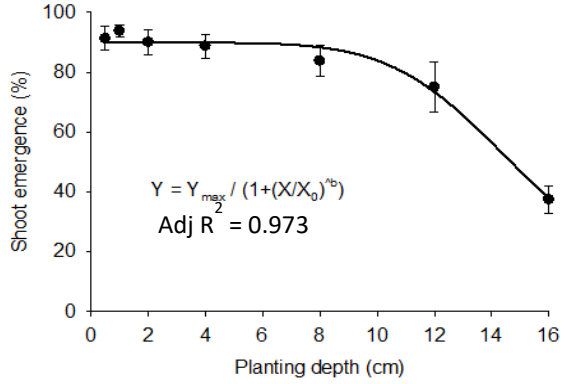


Fig. 2: Carolina redroot emergence response to rhizome planting depth

Fig. 3: Carolina redroot emergence response to rhizome planting depth

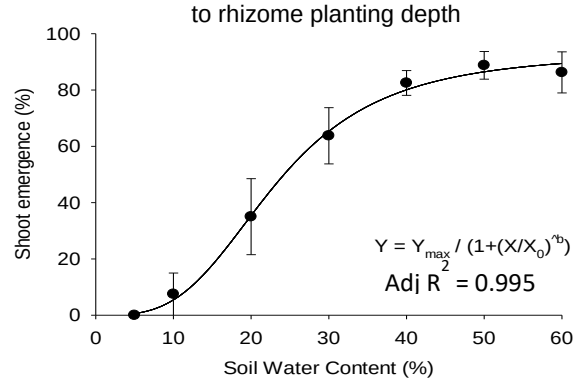
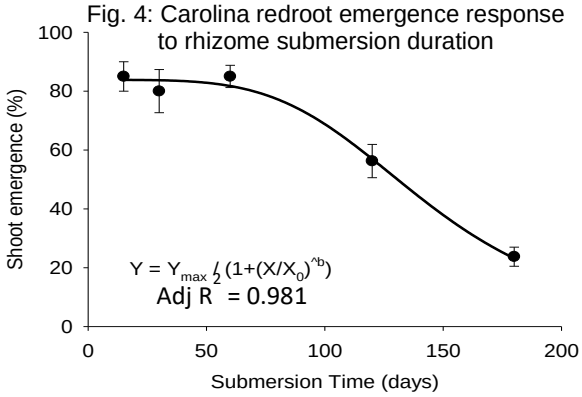


Fig. 4: Carolina redroot emergence response to rhizome submersion duration



Decreased soil water content affected shoot emergence (Fig. 3). However, the soil water content had to drop to 23% to reduce shoot emergence by 50%, showing that Carolina redroot can tolerate drought. Reduction of rhizome water content was the most effective factor for reducing Carolina redroot emergence, plant height, and shoot biomass with required rhizome water content for reaching a 50% reduction of these parameters ranging from 53% to 57%. If rhizome submersion duration had little effect on plant height, it had a more drastic effect on shoot emergence and biomass (Fig. 4). It took 143 days and 127 days for reducing these two parameters by 50%, respectively. Darkness did not influence shoot emergence but reduced root and shoot biomass by 75% and 53%, respectively, compared to the light conditions, and completely inhibited the development of new rhizomes.

Carolina redroot postemergence control

Greenhouse studies were conducted in 2017 in Chatsworth, NJ, to determine control of Carolina redroot aboveground vegetation and rhizome production with 10 herbicide active ingredients. Herbicides were applied as a single application on 10 to 15 cm tall plants. Mesotrione at 280 g ai ha^{-1} controlled over 90% of emerged shoots 63 DAT (d after treatment). Aboveground vegetation control 63 DAT with 2,4-D and FLZ01 reached 87% but was limited with glyphosate, not exceeding 40% 63 DAT. Mesotrione at 280 g ai ha^{-1} provided 88% control of roots and rhizomes (root/rhizome) 63 DAT. 2,4-D (90%), glyphosate (87%), and FLZ01 (85%) also showed excellent root/rhizome control. The greatest reduction of plant biomass compared to the untreated check (UNT) was noted with 2,4-D and mesotrione at 280 g ai ha^{-1}, with decrease from 73% to 80% for shoots, and from 82% to 88% for root/rhizome. Glyphosate had less impact on shoot biomass reduction (-56%) but similar effect on roots/rhizomes dry weight (-79%) than 2,4-D, and mesotrione. Concurrently, 2,4-D and FLZ01 reduced the number of secondary shoots 70% to 90% compared to UNT, whereas glyphosate and mesotrione completely inhibited emergence of new shoots.

Future Research

Future research will evaluate field applications of mesotrione in early summer when Carolina redroot regrowth occurs following the dissipation of PRE herbicides activity. As mesotrione received in 2018 a 24(c) Special Local Need label for use in cranberry, we will evaluate the effect of spot application a higher application rate for controlling Carolina redroot patches at the early stage of cranberry bed infestation.

Cranberry Institute – An Update

John Wilson
Cranberry Institute, Carver, MA

The Cranberry Institute was notified in early December that the European Union (EU) is proposing to cancel the use of chlorothalonil (Bravo). This is expected to be final by April so we will discuss the implications of this action to cranberry MRLs in the EU. At last year's ACGA meeting, we introduced the cranberry water model which EPA uses to assess the risk of pesticides in harvest water and winter floods. This model has prevented growers from using some newer chemicals already available to strawberry and blueberry growers. This past year, the CI hired Waterborne Environmental to help us understand this model and to work with us when we met with EPA last month. We will report on our meeting with EPA as well as our continuing work with chemical companies and the Rutgers IR-4 program to obtain new agriculture chemicals that can be used on cranberry.

We plan to report on CI Health and Communications Programs. The CI along with other Health Research Partners (including ACGA) is funding an interesting proposal that could help quantify proanthocyanidin markers in cranberry. This past year, the CI was promoting some of the new research findings from previous research and we will share some of those results. Finally, we discuss how the CI has been working behind the scenes to address some of the misinformation that gets reported about cranberry.

Disease Management Progress 2018

Peter Oudemans, Christine Constantelos, Timothy Waller, David Nuhn, Michael Mars
Dave Jones, Jacob Armitage, Langley Oudemans and Dan Flath
P.E. Marucci Center for Blueberry and Cranberry Research and Extension
Rutgers University, Chatsworth, NJ

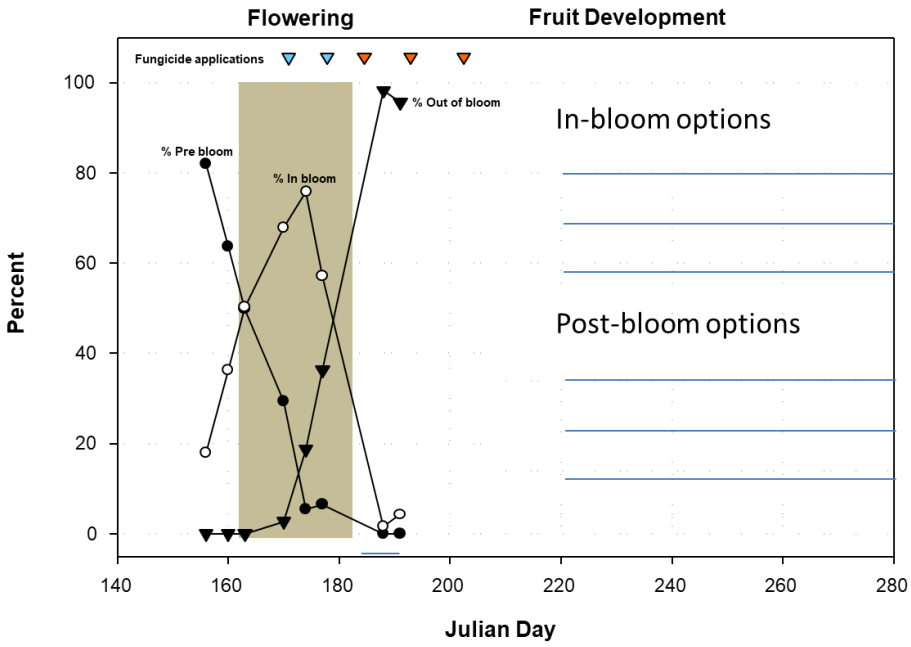
Today's presentation will cover three topics highlighting advancements in our project aimed at improving fruit quality. Production challenges were abundant this season, emphasized by the fact that 2018 was the wettest year on record (since 1895) and the sixth warmest summer, and many of the problems we typically see were compounded. Recommendations like "keep your canopy dry" were thrown out the window and fruit rot was unusually high with late season rots causing a large portion of the losses.

My research program has targeted fairy ring control for many years and one of the challenges has been early detection to reduce the volume of water needed to apply fungicides for disease management. To this end and together with Downstown Airport and Mike Little we have developed a system to detect and create treatment maps for fairy rings as small as 4' in diameter. The approach and implication of this will be briefly discussed.

Overheating due to excessive solar radiation is a second factor affecting fruit quality. Given the level of cloud cover for 2018 this was not a severe season. However, Aug. 30 and Sept. 3-4 were days where the conditions were ideal for overheating. Our research in this area includes development of detection methods as well as treatments to reduce the impact showed some positive results. I will discuss the use of shade cloth as well as some of the detection methods we are using.

Finally, our work on reducing fruit rot and monitoring the fungal populations resulted in some valuable data. First of all, the new fungicide Quadris Top which has shown very positive results in the past received a section 3 label this past summer. This fungicide will provide significantly better results than the older treatment of Indar plus Abound. We have also spent considerable effort investigating the negative impact of mancozeb (Dithane) and are developing recommendations for its use in future seasons.

In the final section of my presentation I will discuss options for frit rot control in 2019. I will use the diagram shown below to help design different programs taking into consideration factors such as code book changes, MRLs, phytotoxicity, timing, resistance management and efficacy.


Flowering
Fruit Development
Fungicide applications
% Out of bloom
% Pre bloom
% In bloom
In-bloom options
Post-bloom options
Percent
100
80
60
40
20
0
140
160
180
200
220
240
260
280
Julian Day

If a Picture's Worth a Thousand Words…
The Benefits of using Remote Imagery to Manage Cranberry Bogs

John Porter, Doctor of Plant Medicine
Director of Agronomy, Skycision

Remote sensing has been used in agriculture for over 40 years, but only recent advances in drone technology and changes to Federal Aviation Administration rules and regulations have made it available for growers to use on a daily basis to help them manage their crops. Due to these changes, the accounting firm Price Waterhouse Cooper stated in a recent report that drone technology applications will have a value of over $30 billion per year within the next ten years, much of that value in monitoring crop production.

Skycision, a data analytics firm that was started in 2015 by two graduate students at Carnegie Mellon University in Pittsburgh, PA, provides fruit and vegetable growers from coast to coast with high-resolution optical, stress (NDVI), and thermal imagery that help them quickly and easily identify problems caused by insects, pathogens, nutrition and moisture deficiencies or excesses, and temperature extremes. Current customers include cranberry, wine grape, orchard, strawberry, and vegetable growers.

As a result of this technology, growers are able to scout a field much faster and much more thoroughly than they can by foot and can detect crop stress much earlier than they can with their own eyes, reducing the amount of damage the stress agents will do to their crops. This can, of course, translate into lower pesticide usage and increased yields which could, in turn, result in a greater profit for the grower and a safer environment for everyone.

In addition to helping the grower detect the aforementioned "stress agents" sooner, the images can be also be used to help the grower predict yields, determine the optimal locations to place thermometers in a field to monitor for frost and excessive heat, evaluate the uniformity of irrigation systems (and as a result the uniformity of pesticide and fertilizer applications delivered through irrigation systems), and determine optimal watering rates and times. All at very affordable costs to the grower.

While Skycision is glad to process any images that a grower may take with his or her own equipment, most growers we work with choose to take advantage of our "Fly-as-a-Service" package in which an FAA-certified pilot equipped with state-of-the-art equipment flies as many acres as the grower would like to have analyzed, the grower being charged by the acre. These images are then processed in-house by a highly skilled staff led by a PhD-level scientist in remote imaging. Final images are then delivered to the grower via a secure web portal.

Cranberry Breeding Update: Pyramiding Genes for Fruit Rot Resistance, Genomics Work, and Fruit Chemistry Evaluations

Jennifer Johnson-Cicalese, P.E. Marucci Center, Chatsworth, NJ; *Joseph Kawash* and *James Polashock,* USDA-ARS, Marucci Center, Chatsworth, NJ; *Stephanie Fong* and *Nicholi Vorsa,* Department of Plant Biology and Pathology, Rutgers University

A major focus and objective of the Rutgers' cranberry breeding program since 2004 has been the development of commercially viable varieties with enhanced fruit rot resistance (FRR). Fruit rot is a major threat to the cranberry industry, which is exacerbated by recent increasing summer temperatures. Furthermore, the loss of label of effective fungicides for fruit rot management is a constant threat. We have 1) identified multiple genetic sources of FRR (Budd's Blues, US89-3 and Cumberland) and used them in our crosses, 2) established that resistance is heritable, and 3) successfully combined resistance with higher productivity. Now our goal is to combine, or pyramid, the sources of resistance, and make further genetic gains in FRR, yield, and fruit quality (Fig. 1).

After several years of field evaluation under severe fruit rot pressure, the best progeny from our 2005 and 2006 crosses were selected and planted in replicated plots in NJ, WI, and BC for further evaluation. Nine of these selections were planted in 2015 in 10' x 20' plots, 5 reps of each, and evaluated under various reduced fungicide regimes in 2018 by Peter Oudemans' lab, with the goal of developing fungicide recommendations for a potential new FRR variety. In 2019, six of these FRR selections will be planted in a grower's bed in ½ acre plots, for evaluation under commercial production.

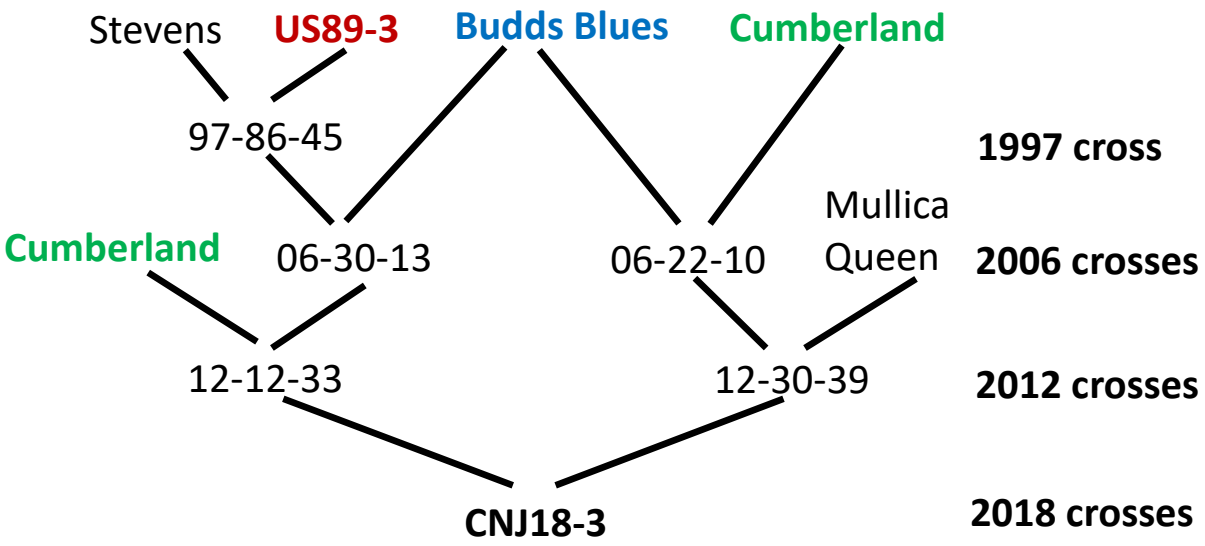


Figure1. Example of the next generation of crosses for fruit rot resistance, the best of 2nd and 3rd generation progeny were crossed to combine multiple resistance types with elite high yielding cultivars.

These best selections were also used in crosses amongst each other in 2012 through 2017 and nearly 5000 of their progeny have been planted in field plots (Fig. 1). Three years of evaluations of 1200 progeny from 2012 crosses (CNJ12) have identified **new** promising selections which **combine multiple sources of resistance**. We plan to rapidly establish the best of these in larger replicated plantings. Field evaluations of 2013 crosses have begun, and 2014-2017 crosses will be evaluated as they become established. Crosses among the best CNJ12's will continue in 2019. The genetic markers for FRR that have been identified will be tested with these new breeding populations.

Additional cranberry breeding objectives are to improve our cranberry genetic map, and identify genetic markers for traits of interest, including fruit rot resistance, organic acids, flavonoids and components of yield. Using new methods, we have recently assembled an improved cranberry reference genome that has helped to more accurately place QTLs, and represents an additional 13.8% of the genome. In an effort to lower the acidity of cranberry, we have identified an undomesticated germplasm accession with significantly reduced titratable acidity (TA of ≈1.5% vs. normal TA of 2.3-3.0), resulting from very low citric acid (≈ 1 mg/g vs normal of 8-11 mg/g) and identified a useful SSR genetic marker for this trait. This is the first characterization and molecular mapping of a low citric acid trait in cranberry. A better understanding of the genetics of these traits, and using markers to detect them in young seedlings could greatly improve the efficiency of our cranberry breeding program. Our contemporary breeding and selection program is developing cultivars better adapted to the current climatic stresses, and more suited to current industry needs.

Acknowledgements
Support: Karen DeStefano, Sue Vancho, Kristia Adams, Richard DeStefano and Crew, Peter Oudemans and Lab

Funding: USDA-SCRI-2008-51180-04878, USDA-NIFA-2013-67013-21107, Cranberry Institute, New Jersey Blueberry & Cranberry Research Council, New Jersey Agricultural Experiment Station Project 12160.

Understanding the Effects of False Blossom Disease on Cranberry Chemistry, Blunt-nosed Leafhoppers, and other Insect Herbivores

Nakorn Pradit, Cesar Rodriguez-Saona, and James Polashock
Department of Entomology, Rutgers University, New Brunswick, NJ;
P.E. Marucci Center, Chatsworth, NJ

Infection by a phytoplasma in the phloem tissue of cranberries causes false blossom disease (Fig. 1). Blunt-nosed leafhoppers (Fig. 2) are the only vectors of this phytoplasma. Symptoms of infection include malformation of the flowers such as shortened, discolored and streaked petals, enlarged calyx, straighten inflorescences, and floral changes to leaf structures (phyllody). Diseased plants produce uprights that are close together, forming a witches' broom, and that turn reddish earlier in the fall. The malfunction of flowers causes severe reduction in cranberry fruit production. In the early 1900's, false blossom disease became a major threat to the cranberry industry. This disease almost eliminated the cranberry industry in New Jersey and caused major problems in Massachusetts in the 1920s and 1930s. The development of resistant variety and effective chemical controls targeting the insect vector reduced the incidence of the disease in cranberry fields. However, changes in pest management practices in the past decade have caused the re-appearance of the disease in New Jersey cranberry farms. To control this disease, we need a better understanding of the molecular, chemical, and ecological interactions between this disease and its insect vector as well as other insect herbivores in cranberry plants.

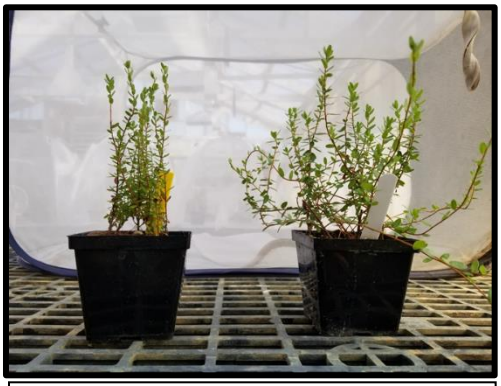


Fig. 1. False blossom infected plant (left), healthy plant (right)

Therefore, we have conducted studies to address the following questions:

1) Are phytoplasma-infected plants better hosts for blunt-nosed leafhoppers?
2) Are phytoplama-infected plants better hosts for non-vector herbivores?
3) Does phytoplasma infection change cranberry leaf chemistry?

Fig. 2. Blunt-nosed leafhopper nymph

Because the disease (i.e., phytoplasma) needs the vector (i.e., blunt-nosed leafhoppers) for its transmission from infected to healthy plants, we hypothesized that diseased plants are better hosts for its vector the blunt-nosed leafhopper and that diseased plants improve the performance of non-vector insect herbivores. We also hypothesized that phytoplasma

infection changes cranberry chemistry such as the emissions of volatile compounds, nutrient content, and chemical defenses.

For this, we compared the performance of blunt-nosed leafhoppers between infected and healthy plants (Fig. 3). Leafhopper nymphal survivorship was similar (75%) between infected and healthy plants. However, adult survival was 19% higher on healthy plants than on infected plants. Even though survival was lower, leafhopper adults were 16% heavier when feeding on infected plants.

Fig. 3. Assays with blunt-nosed leafhoppers

We also investigated the performance of three insect herbivores: spotted fireworm, Sparganothis fruitworm and gypsy moth on infected and healthy plants (Fig. 4). Larvae of all three species consumed more leaves of infected plants. Spotted fireworm and Sparganothis fruitworm larvae were 2 times heavier, and gypsy moth larvae 3 times heavier, on infected plants compared with healthy plants.

Infected cranberry leaves had higher levels of nitrogen, phosphorus, potassium, calcium, sulfur, manganese, boron, aluminium, and sodium. In contrast, levels of magnesium were lower in infected than uninfected plants, whereas levels of copper and zinc were not affected by infection. Flavonol levels, a class of chemical defenses, did not change by infection. However, infection reduced proanthocyanidin content. Levels of the defensive plant hormones salicylic acid, jasmonic acid, and abscisic acid did not differ between infected and healthy plants.

Fig. 4. Assays with non-vector herbivores

In summary, our results show that cranberry false blossom increases nutrient content and reduces defenses (i.e., proanthocyanidin levels) in cranberry leaves. These changes in plant chemistry affected growth and survival of the insect vector as well as non-vector insect herbivores. Future studies will be conducted to determine the effects of commercially-available elicitors of plant defenses on the disease and insect herbivores.

Acknowledgements: This work was funded by the New Jersey Cranberry Research Council Inc., the Cape Cod Cranberry Growers Association, and Ocean Spray Cranberries, Inc., and by Multi-state Hatch funds (Project No. NJ08252).

Management of Blunt-nosed Leafhoppers in Cranberries: Lessons Learned from Insecticide Trials

Cesar Rodriguez-Saona, Vera Kyryczenko-Roth, and Robert Holdcraft
P.E. Marucci Center for Blueberry and Cranberry Research and Extension
Rutgers University, Chatsworth, NJ

There is concern among cranberry growers of a potential increase in secondary pests, such as the blunt-nosed leafhopper, *Limotettix vaccinii*, because of recent changes in pest management strategies (e.g., adoption of new reduced-risk products and decreased applications of broad-spectrum insecticides). Therefore, an experiment was conducted in 2018 to test the efficacy of 10 pesticides (insecticides and acaricides) for controlling nymphs and adults of blunt-nosed leafhoppers (BNLH) in cranberries. The treatments and rates are shown in Table 1.

The experiment was conducted in a cranberry bog, cv. 'Ben Lear,' located at the Rutgers P.E. Marucci Center in Chatsworth, New Jersey. Plots were 91×91 cm each, replicated five times for nymphs and four times for adults in a randomized complete block design. Applications were made with R&D CO_2 backpack sprayer, using a 1-liter plastic bottle. The sprayer was calibrated to deliver 50 gal of volume per acre at 30 psi, using a single Teejet VS 110015 nozzle, yielding 39.1 ml per plot. Treatments were applied on the evening of 6 June for the assay with nymphs, and on the morning of 10 July for the assay with adults. Both assays followed the same protocol, with treated uprights randomly selected from the central portion of each plot. Uprights were clipped for use in the assays 1 day after treatment (1 DAT), such that sampling dates were 7 June and 11 July for nymph and adult assays, respectively. For all assays, four insecticide-treated uprights were inserted in a florists' water pick and enclosed in a ventilated 40-dram plastic vial. The water picks were then secured on Styrofoam trays. For assays with nymphs, five vials were setup for each treatment on 7 June and four BNLH nymphs were placed in each vial. For assays with adults, four vials per treatment were setup on 11 July and five BNLH adults were placed in each vial. Each vial was considered a replicate. BNLH nymphs and adults used in the assays were collected by sweepnet sampling on 7 June and 11 July from commercial cranberry farms in Chatsworth, New Jersey and used on same day of collection. Plants and insects were placed on a light bench in the laboratory at approx. 25°C on a 15:9 L:D cycle. Mortality was assessed 24 and 96 hours after exposure to treated foliage. The number of leafhoppers (alive or dead) was recorded. Percent control was calculated for each treatment as: % control = [1-(avg total leafhoppers on treated foliage/avg total leafhoppers on control foliage)]×100. Data were analyzed using ANOVA and means separation by Tukey test at $P = 0.05$.

BNLH nymphs were, in general, more susceptible to insecticides than adults (Table 1). Assail, Chem A, Closer, Cormoran, Sevin, and Lorsban provided > 95% control against leafhopper nymphs after 96 hrs of exposure. In contrast, only Chem A, Sevin, and Lorsban provided > 85% control against leafhopper adults after 96 hrs of exposure (Table 1). No phytoxicity symptoms were observed following any of the insecticide treatments.

Acknowledgements. This research was supported by industry gifts of pesticide and research funding and by the New Jersey Cranberry Research Council Inc., the Cape Cod Cranberry Growers Association, and Ocean Spray Cranberries, Inc.

Table 1. Efficacy of Insecticides against blunt-nosed leafhoppers

NYMPHS

Treatment	Rate/ac	24 hr			96 hr		
		% Live (mean ± SE)		% Control	% Live (mean ± SE)		% Control
Agri-Mek SC	3.5 floz	96.4 ± 3.6	A	(0)	92.9 ± 7.1	A	(0)
Assail 30SG	6.9 oz	44.0 ± 8.7	B C D	(50.7)	0.0 ± 0.0	B	(100.0)
Beleaf 50SG	2.8 oz	100.0 ± 0.0	A	(0)	78.6 ± 10.1	A	(7.0)
Chem A	6.4 floz	10.7 ± 7.4	D E	(88.0)	3.6 ± 3.6	B	(95.8)
Closer SC	4.25 floz	35.7 ± 6.7	C D	(60.0)	0.0 ± 0.0	B	(100.0)
Cormoran	12 floz	22.6 ± 10.2	D E	(74.7)	0.0 ± 0.0	B	(100.0)
Chem B	22 floz	67.9 ± 14.6	A B C	(24.0)	60.7 ± 13.7	A	(28.2)
Movento 480SC*	10 floz	78.6 ± 11.5	A B	(12.0)	71.4 ± 14.9	A	(15.5)
Sevin XLR	3 L	0.0 ± 0.0	E	(100.0)	0.0 ± 0.0	B	(100.0)
Lorsban 4E	3 pts	11.9 ± 7.9	D E	(86.7)	0.0 ± 0.0	B	(100.0)
Control	-	89.3 ± 5.1	A	-	84.5 ± 5.6	A	-

ADULTS

Treatment	Rate/ac	24 hr			96 hr		
		% Live (mean ± SE)		% Control	% Live (mean ± SE)		% Control
Agri-Mek SC	3.5 floz	35.0 ± 5.0	A B	(12.5)	35.0 ± 5.0	A B	(12.5)
Assail 30SG	6.9 oz	35.0 ± 9.6	A B	(12.5)	35.0 ± 9.6	A B	(12.5)
Beleaf 50SG	2.8 oz	55.0 ± 12.6	A	(0)	55.0 ± 12.6	A	(0)
Chem A	6.4 floz	0.0 ± 0.0	B	(100.0)	0.0 ± 0.0	B	(100.0)
Closer SC	4.25 floz	40.0 ± 8.2	A B	(0)	25.0 ± 9.6	A B	(37.5)
Cormoran	12 floz	40.0 ± 16.3	A B	(0)	30.0 ± 19.1	A B	(25.0)
Chem B	22 floz	35.0 ± 9.6	A B	(12.5)	35.0 ± 9.6	A B	(12.5)
Movento 480SC*	10 floz	37.5 ± 13.1	A B	(6.3)	37.5 ± 13.1	A B	(6.3)
Sevin XLR	3 L	0.0 ± 0.0	B	(100.0)	0.0 ± 0.0	B	(100.0)
Lorsban 4E	3 pts	5.0 ± 5.0	B	(87.5)	5.0 ± 5.0	A B	(87.5)
Control	-	40.0 ± 18.3	A B	-	40.0 ± 18.3	A B	-

*Movento treatment includes spray adjuvant: Dynamic 0.5% v:v.

Means within a column followed by different letters are significantly different (Tukey test, $P \leq 0.05$).

Numbers in parenthesis are % control = [1-(%live leafhoppers in treated / %live leafhoppers in control)] × 100.