

WISCONSIN CRANBERRY SCHOOL 2026 PROCEEDINGS



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COLOR CHANGE: CRANBERRY & FOOD SCIENCE

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Changes to the U.S. Dietary Guidelines

The U.S. Department of Health and Human Services released the 2025–2030 Dietary Guidelines for Americans (DGA) in January 2026.¹ The DGA is prefaced by the urgent need to revise the U.S. food system to reduce the burden of diet-related chronic diseases. The new DGA replaces the MyPlate communication strategy with an inverted food pyramid that emphasizes consumption of whole foods (Figure 1). The new dietary guidelines emphasize increased consumption of minimally processed foods while reducing intake of foods with added sweeteners, synthetic colors, or other food additives (Table 1).



Figure 1 – Graphic from title page of the 2020–2025 Dietary Guidelines for Americans. Accessed from [realfood.gov](https://www.realfood.gov).

Table 1 – Key messages from the 2020–2025 Dietary Guidelines for Americans relevant to cranberry foods.

Avoid highly processed packaged, prepared, ready-to-eat, or other foods that are salty or sweet, such as chips, cookies, and candy that have added sugars and sodium (salt). Instead, prioritize nutrient-dense foods and home-prepared meals. When dining out, choose nutrient-dense options.
Limit foods and beverages that include artificial flavors, petroleum-based dyes, artificial preservatives, and low-calorie non-nutritive sweeteners.
Avoid sugar-sweetened beverages, such as sodas, fruit drinks, and energy drinks.

Cranberry and Food Processing

The NOVA classification system is the most widely-used definition for degree of food processing. The NOVA categories are (1) Unprocessed or minimally processed foods; (2) Processed culinary ingredients; (3) Processed foods; and (4) Ultra-processed foods. The U.S. FDA has not defined the terms “Ultra-processed” or “Highly-processed”, but is actively working on a definition.² The new DGA defines “highly processed foods,” as *“any food, beverage, or engineered food-like item that is made primarily from substances extracted from foods (such as refined sugars, refined grains/starches, and refined oils) and/or containing industrially manufactured chemical additives.”*³

Cranberry food products are classified as NOVA categories 1, 3, and 4. Examples of unprocessed/minimally processed foods (e.g., NOVA 1) include 100% cranberry juice, whole fresh or frozen cranberries, and unsweetened dried cranberries. Processed cranberries (NOVA 3) include some sweetened juices and some cranberry sauces, while ultra-processed (NOVA 4) cranberry products include sweetened, dried cranberries, sweetened juice with additives, and cranberry-flavored products and drinks.

Consumers have access to digital tools that display the degree of food processing (e.g., [truetech](#)⁴), and may begin seeing products that are certified as non-ultra-processed foods.

Ongoing Research in Food Science

The Bolling group at the Department of Food Science at the University of Wisconsin-Madison is working closely with USDA cranberry scientists (Drs. Ikeda and Zalapa), and we are expanding our interdisciplinary collaborations at UW-Madison to address the healthfulness of processed cranberry products. Our ongoing projects include developing new analytical methods for cranberry tannins, describing the composition of new and existing cranberry cultivars, and determining the impact of drying and storage on cranberry bioactives. We are also working on developing methods to isolate cranberry anthocyanins that could be used as an alternative to synthetic colors or used to deliver health-beneficial A-type proanthocyanidins from cranberry (Figure 2). We are currently developing a polyphenol-lecithin-precipitate process to isolate cranberry polyphenols without the use of organic solvents. The isolated cranberry pigment contains polyphenols, and we have added this to chewing gum to leverage its potential to improve oral health by improving immune function.

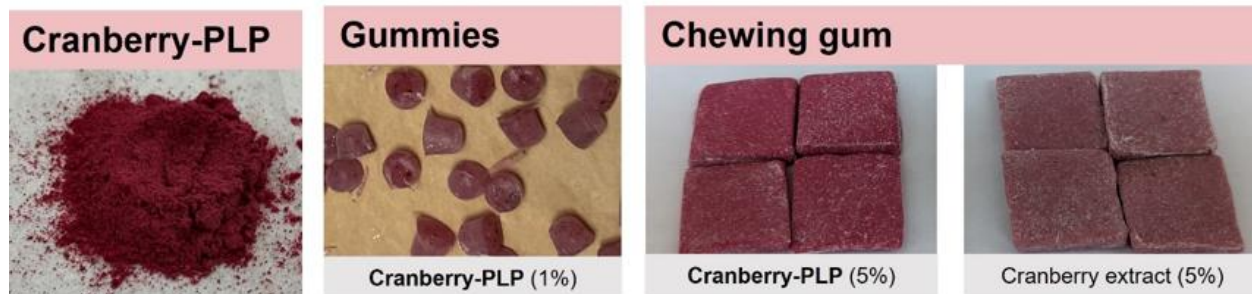


Figure 2 – Examples of cranberry pigments and products prepared from cranberry pigments. Abbreviations: Polyphenol-Lecithin-Precipitate, PLP.

Next Steps

The updated DGA has intensified consumer focus on limiting consumption of highly processed foods. The transition to minimally processed foods is expected to be a challenge, since highly processed foods make up 66% of the energy consumed in the U.S. diet. The cranberry industry will need to adapt to this shift by renewing its focus on the health-promoting aspects of cranberries and developing new, minimally processed foods with consumer appeal. Interdisciplinary and Food Science research will help inform and accelerate this process.

ACKNOWLEDGEMENTS We would like to acknowledge members of the Bolling group and collaborators who assisted with natural colors research, including Matthew Dorris, Rich Hartel, Klay Liu, Andrea Noll, Kate Sun, and Ray Van Cleve.

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THE EFFECT OF LONG-TERM AND ACUTE HEAT STRESS EVENTS ON CRANBERRY FRUIT ROT

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Background

Cranberry fruit rot continues to be one of the most unpredictable disease challenges for Wisconsin growers. Even when fungicides are applied according to recommendations, fruit rot severity can vary substantially from year to year, among cultivars, and across growing regions. In particular, cranberry production areas that experience consistently warmer temperatures during the growing season often report higher fruit rot pressure. These observations suggest that environmental stress, and especially heat stress, may play an important role in influencing fruit susceptibility to rot pathogens.

Goal of the Study

The goal of this research was to determine how both long-term warming conditions and short, acute heat stress events affect fruit rot expression when heat occurs during different stages of fruit development. Understanding these relationships will help clarify whether heat stress could be one of the triggers contributing to increased fruit rot in warmer years.

Experimental Approach

Field-based heat stress experiments were conducted during the 2024 and 2025 growing seasons using two cranberry cultivars, 'Mullica Queen' and 'Stevens.' We evaluated two different types of heat stress. Long-term heat stress was imposed using passive heating open top chambers (OTC) placed in the field, and designed to increase temperatures over extended periods from fruit development through harvest. Acute heat stress was imposed using OCTs with an active heating system that delivered short pulses of high temperature. Acute heat treatments consisted of three-hour pulses reaching 104 °F internal berry temperature, with vines receiving between one and four heat events between pea-size fruit stage and harvest. Environmental sensors were used to monitor temperature conditions during treatments. At harvest, fruit were evaluated for total yield, percent rotten fruit, and several quality-related traits, including fruit color development, phenolic content, and calcium concentration.

Results

Both long-term and acute heat stress treatments resulted in reduced yield compared with the control treatment. Yield losses were more pronounced in 'Mullica Queen,' indicating that this cultivar may be more sensitive to heat stress than 'Stevens.' In terms of disease response, acute heat stress consistently increased fruit rot incidence in both cultivars and in both years relative to the control. Fruit rot levels were generally higher in acute heat stress treatments than in the long-term heat stress treatments, suggesting that short extreme heat events may be particularly important in triggering fruit susceptibility to the diseases. Heat stress also affected some aspects of fruit quality. In 'Mullica Queen,' acute heat stress reduced fruit color development compared with controls. However, no consistent trends were observed for phenolic concentration or calcium content across treatments, indicating that these traits may not respond predictably under the conditions tested.

Summary and Implications for Growers

Overall, our results indicate that heat stress can reduce cranberry yield and that acute heat events, in particular, may increase fruit rot expression. These findings support the idea that extreme temperature events during the growing season could contribute to the higher and more variable fruit rot pressure observed in warmer years or regions. Continued work will focus on identifying the physiological mechanisms linking heat stress to fruit rot susceptibility and determining how timing and cultivar differences may influence risk.

ACKNOWLEDGEMENTS We would like to acknowledge the Wisconsin Cranberry Research Station, Justin, Max, and Gabby, for their support during trial deployment and data collection. This work was supported by the UW Gottschalk Endowed Chair Fund for Cranberry Research and by the USDA National Institute of Food and Agriculture (NIFA) Specialty Crop Research Initiative, award number 2022-51181-38322.

GROWER PANEL: MOISTURE MANAGEMENT

ROBERT DETLEFSEN, MIKE O'BRIEN, SETH RICE

INTERACTIVE GROWER SURVEYS REGARDING THE 2025 WISCONSIN GROWING SEASON

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Demographic Questions

What county are you from?

Adams	1	2%
Buffalo	0	0%
Burnett	0	0%
Douglas	0	0%
Eau Claire	1	2%
Iron	0	0%
Jackson	11	19%
Juneau	4	7%
Lincoln	1	2%
Monroe	10	17%
Oneida	4	7%
Portage	2	3%
Price	4	7%
Richland	0	0%
Rusk	0	0%
Sawyer	1	2%
Vilas	5	9%
Washburn	0	0%
Wood	14	24%

Has anyone from my farm participated on any boards or committees in the cranberry industry? (WSCGA, WCB, WCREP, CI, CMC, handler board, etc)

Yes, within the last 10 years	45	75%
Yes, but longer than 10 years ago	3	5%
No	12	20%

Rank your priorities that the Wisconsin Cranberry Board should consider, from most important (top) to least important (bottom)

horticultural research	3.68
health research	2.73
marketing	2.92
public education	2.00
new product development	2.77

Entomology

What was the main yield-reducing pest of the 2025 crop?

Insects	6	10%
Disease/rot	39	66%
Weeds	14	24%

Was your insect pressure in 2025:

Up from 2024	3	5%
Down from 2024	13	23%
Similar to 2024	40	71%

How many insecticide sprays did you apply in the 2025 growing season?

0	1	2%
1 to 2	26	44%
3 to 4	27	46%
5 to 6	4	7%
more than 6	1	2%

Was the flea beetle population on your marsh in 2025:

up from 2024	9	16%
down from 2024	18	31%
same as 2024	31	53%

How many sprays did you apply specifically for flea beetle in 2025?

0	31	53%
1	12	21%
2	15	26%
3	0	0%

What insecticide did you use for flea beetle control in 2025?

Assail	0	0%
Diazinon	10	29%
Venom	17	49%
Altacor	5	14%
Actara	8	23%
Imidan	1	3%
Capsanem	3	9%
other	7	20%

Have you noticed a reduction in yield in areas where you had flea beetle pressure the previous year?

Yes	13	22%
No	36	60%
Maybe	11	18%

How concerned are you about leafhoppers on your marsh?

Not concerned at all	30	49%
Slightly concerned	23	38%
Moderately concerned	7	11%
Very concerned	1	2%

How many times did you spray for leafhoppers in 2025?

0	53	91%
1	5	9%
2	0	0%
3 or more	0	0%

What do you plan to use in the early season to control insect pests?

Acephate (Orthene)	1	2%
Sevin (Carbaryl)	3	5%
Diamide (Altacor, Exirel, Verdepryn)	8	13%
A spinosyn (Delegate, Entrust)	14	23%
Phosmet (Imidan)	0	0%
A neonicotinoid (e.g., Actara, Venom, Assail, Admire Pro)	4	7%
Diazinon	2	3%
Fanfare	45	75%
Intrepid	7	12%
Other	4	7%

Physiology

In 2025 your yields were:

Higher than average	15	25%
Lower than average	30	49%
Similar to previous years	16	26%

In 2025 your fruit size was:

Bigger than average	3	5%
Smaller than average	30	50%
Similar to previous	27	45%

In 2025, your fruit firmness was:

Similar to previous years	50	82%
Better than in previous years	1	2%
Worse than in previous years	10	16%

In 2025, your fruit rot incidence was:

Similar to previous years	21	36%
Lower than in previous years	8	14%
Higher than in previous years	30	51%

Did you have yield losses due to cold damage during 2025:

yes	6	10%
no	47	78%
I'm not sure	7	12%

What kind of winter damage did you notice on your marsh?

Leaf drop on edges of bed	9	15%
Leaf drop on entire bed	9	15%
None	42	70%

How many times did you flood your cranberry beds for winter protection last season?

0 times	0	0%
1 time	1	2%
2 times	13	21%
3 times	28	46%
4-6 times	18	30%
7-9 times	1	2%
10-12 times	0	0%
13 or more times	0	0%

How confident do you feel when making the decision to flood for winter protection?

Very confident	36	55%
Somewhat confident	27	42%
Neutral	2	3%
Not confident	0	0%

How long does it take you to put on a winter flood from start to finish? (Answer in hours of flooding time, not labor-hours)

5 hours or less	0	0%
5-10 hours	0	0%
11-20 hours	13	20%
21-30 hours	28	42%
31- 50 hours	11	17%
41-60 hours	10	15%
61-80 hours	4	6%
more than 80 hours	0	0%

On average, how much does flooding for winter protection cost in fuel costs & resources (not labor) for your entire marsh?

\$500 or less	20	33%
\$501-1000	16	26%
\$1001-2000	14	23%
\$2001-5000	5	8%
\$5001-10,000	6	10%
\$ more than 10,000	0	0%

Do you believe the impact of flooding on plant health is well understood?

Yes, I feel well-informed	26	39%
Somewhat, but I have questions	30	45%
No, I think more information is needed	10	15%
I am unsure	1	1%

Do you believe flooding impacts the long-term health or productivity of your cranberry beds?

Yes, positively	37	59%
Yes, negatively	4	6%
No noticeable effect	6	10%
I'm not sure	16	25%

Have you found yourself flooding more frequently during recent warmer winters?

Yes, significantly more often	18	27%
Yes, slightly more often	35	52%
No, my flooding practices have not changed	9	13%
No, I am flooding less frequently	2	3%
Unsure	3	4%

How do you decide how long to keep the flood on for winter protection?

I follow science-based recommendations	41	60%
I rely on previous experience	53	78%
I ask other growers for advice	14	21%
I make an educated guess each year	22	32%
I am unsure	1	1%

Were your 2025 tissue tests lower in N than usual?

Lower than usual	5	9%
Close to usual	49	88%
Higher than usual	2	4%

Is overgrowth or excess vigor a problem in your marsh?

Yes	38	58%
No	26	39%
I don't know	2	3%

When you see overgrowth in your beds, do you adjust next year's fertilization plan?

Yes	58	85%
No	10	15%

Pathology

How many fungicide applications did you make in the 2025 growing season to control fruit rot?

0	18	28%
1	16	25%
2	21	32%
3	6	9%
more than 3	4	6%

What were the fruit rot levels on your marsh in 2025?

< 5%	50	78%
5-10%	13	20%
11-20%	1	2%
21-30%	0	0%
> 30%	0	0%

What is your level of confidence that fungicides applied during bloom provide good protection against fruit rot infections?

Very confident	15	24%
Somewhat confident	29	47%
Not very confident	18	29%

In your experience, how does canopy structure and density influence fruit rot incidence in your fields?

Has no noticeable effect on fruit rot	4	6%
Slightly influences fruit rot under certain conditions	16	24%
Moderately influences fruit rot most seasons	13	19%
Strongly influences fruit rot and is a key driver of disease risk	21	31%
Unsure / have not observed a clear relationship	13	19%

Which aspect of the canopy do you believe most affect fruit rot development through microclimate changes?

Airflow and drying time within the canopy	45	70%
Humidity and moisture retention	52	81%
Temperature control within the canopy	18	28%
Light penetration and shading	14	22%
Canopy does not significantly affect fruit rot	2	3%
Unsure	5	8%

Compared to other factors (e.g., weather, cultivar, fungicides), how important is canopy management in influencing fruit rot risk?

Not important	4	6%
Moderately important	20	32%
Very important	33	52%
Unsure	6	10%

Do you actively adjust canopy management practices to reduce fruit rot risk?

Yes, regularly	31	47%
Yes, occasionally	17	26%
No, but I believe it could help	15	23%
No, I do not believe canopy management affects fruit rot	2	3%
Unsure	1	2%

Which practice do you consider most important for managing canopy conditions related to fruit rot risk in cranberry?

Irrigation management	14	21%
Fertilizer management	34	51%
Sanding	10	15%
Pruning or mowing	3	4%
Flooding practices	1	1%
Bed renovation or thinning	1	1%
None / not applicable	1	1%
Unsure	3	4%

Did you see symptoms of the cranberry viruses (Tobacco Streak Virus and/or Blueberry Shock Virus) in 2025?

Yes	25	36%
No	38	55%
Not sure, did not look	6	9%

Weed Science

Do you have moss on your marsh?

Yes, sphagnum moss (low growing "spongy mat" moss)	30	44%
Yes, haircap moss (taller than sphagnum moss, like "little pine trees")	1	1%
Yes, both mosses	22	32%
Yes, but I'm not sure which type	10	15%
No moss on my marsh	5	7%

Do you feel that your weed pressure impacts cranberry yield?

No impact	12	17%
Yes, by 10% or less	44	64%
Yes, by 11 to 25%	8	12%
Yes, by greater than 25%	5	7%

Do you use Casoron in your established beds:

Yes, I use it every year	37	54%
Yes, but not every year	29	43%
No, I don't use Casoron	2	3%

When renovating, how concerned are you about weeds in the planting year?

Not concerned at all - I'm confident that the vines will outcompete early weeds and we have herbicides to catch up on weed control	4	6%
Mildly concerned	9	14%
Moderately concerned, but not the highest priority	17	27%
Very concerned - early weed control is a high priority	33	52%

Did you use QuinStar herbicide in the 2025 growing season?

No	37	57%
On some but not all of my beds	14	22%
On all my beds	14	22%

Do you plan on using QuinStar herbicide in the 2026 growing season if handlers allow it?

Yes, likely two applications	8	12%
Yes, likely one application	17	26%
Maybe	24	36%
No	17	26%

If you have used QuinStar in the past couple of years, how would you rate the overall weed control?

Excellent	4	9%
Good	9	21%
Moderate	8	19%
Fair	2	5%
Poor	1	2%
Not yet sure, will see how it looks in 2026	19	44%

When renovating, do you see weed species that are new to your marsh or the renovated beds?

Yes, often	7	11%
Occasionally	26	41%
No, just the usual suspects that are common on my marsh	31	48%

If yes, you do see new weed species after renovation, what do you think is the most common source?

New vines	11	32%
Bed sand	14	41%
Dike material	2	6%
Equipment	0	0%
Irrigation water	2	6%
Other sources	5	15%

Grower Submitted Questions

What is your rate of Casoron application?

<20#/ac	0	0%
20-28#/ac	10	17%
29-35#/ac	29	49%
36-39#/ac	7	12%
40#/ac or more	13	22%

What vine criteria do you use to make your first application of fertilizer? (choose multiple if multiple)

Berries just forming in ditch edge	20	35%
Berries obvious in ditch edge	5	9%
Berries just forming in bed middle	15	26%
Berries obvious in bed middle	5	9%
Vines are grass green	5	9%
Vines are lush emerald green	3	5%
Vines have yellowish hue indicating stress	17	30%
Vines have pinkish hue on top of leaf	2	4%
Vines have whorl on top	4	7%
New growth short (less than half-inch)	7	12%
New growth half-inch to 1 inch	6	11%
New growth > 1 inch	2	4%
current weather cooler than normal	1	2%
current weather higher humidity	2	4%
current weather includes rain	4	7%
canopy overgrowth status from prior year	9	16%

What vine criteria do you use to make the subsequent application of fertilizer?

Berries just forming in ditch edge	3	5%
Berries obvious in ditch edge	16	29%
Berries just forming in bed middle	12	21%
Berries obvious in bed middle	15	27%
Vines are grass green	4	7%
Vines are lush emerald green	4	7%
Vines have yellowish hue indicating stress	21	38%
Vines have pinkish hue on top of leaf	2	4%
Vines have whorl on top	1	2%
New growth short (less than half-inch)	6	11%
New growth half-inch to 1 inch	5	9%
New growth > 1 inch	0	0%
current weather cooler than normal	0	0%
current weather higher humidity	3	5%
current weather includes rain	8	14%
canopy overgrowth status from prior year	9	16%

What vine criteria do you use to determine your last application of fertilizer?

Berries just forming in ditch edge	0	0%
Berries obvious in ditch edge	1	2%
Berries just forming in bed middle	0	0%
Berries obvious in bed middle	13	30%
Vines are grass green	12	27%
Vines are lush emerald green	13	30%
Vines have yellowish hue indicating stress	11	25%
Vines have pinkish hue on top of leaf	8	18%
Vines have whorl on top	4	9%
New growth short (less than half-inch)	3	7%
New growth half-inch to 1 inch	4	9%
New growth > 1 inch	8	18%
current weather cooler than normal	1	2%
current weather higher humidity	1	2%
current weather includes rain	6	14%
canopy overgrowth status from prior year	16	36%

What is more concerning: fertilizer carryover or vine canopy carryover from year to year?

fertilizer carryover	4	8%
vine canopy carryover	49	92%

How critical is the length of new growth to your fertilizer application program as the fruit is developing?

it's the top thing I consider	2	4%
it's in the top 3 things I consider	39	70%
I consider it, but it's not in the top 3 things	12	21%
I don't consider it at all	3	5%

What fertilizer analysis do you prefer?

13-13-13	13	22%
11-11-11	0	0%
14-14-14	32	54%
6-24-2	0	0%
10-10-20	16	27%
21-0-0	11	19%
other	15	25%

GROWER PANEL: NITROGEN TIMING

ROCKY BIEGEL, KARL PIPPENGER, EDWIN HANSON

For more information on current grower practice guiding nutrition timing, refer to the

[Grower Submitted Questions](#)

from Interactive Grower Surveys Regarding the 2025 Wisconsin Growing Season in this publication.

PRE-REQUISITES AND ADVANCEMENTS TOWARDS PRECISION CRANBERRY GENE EDITING AND GENETIC ENHANCEMENT VIA CRISPR TECHNOLOGY

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Every living thing – from bacteria to plants to humans – is built from instructions stored in DNA. DNA is made of four chemical “letters” (A, T, C, G) arranged in long sequences. Those sequences act like a code that tells cells what to do and how to form human traits like eye color, hair structure, or even whether a plant can tolerate drought or be immune to disease. CRISPR (acronym of clustered regularly interspaced short palindromic repeats) originally evolved as a defense system in bacteria and archaea (very simple cells) to protect them against viruses. When a virus attacks, the bacteria capture a snippet of the virus’s DNA and store it in their own genome in a special region called a CRISPR array. These stored bits act like ‘mugshots’ – if that virus attacks again, the bacteria recognize it instantly. Therefore, the CRISPR system uses those stored sequences to target and destroy the virus’ DNA. The CRISPR system depends on proteins called Cas proteins (“CRISPR-associated” proteins). For example, Cas9 – a protein that behaves like molecular scissors, can cut DNA at very precise locations. In

the bacterial immune system CRISPR array, a snippet of viral DNA is turned into a piece of RNA and that RNA teams up with Cas9. The complex searches the cell for a matching viral DNA. When it finds a match, Cas9 cuts the foreign DNA, stopping the virus.

In the lab, scientists have borrowed this bacterial system, but with a twist, so it can target any DNA sequence they choose – not just viruses and then they can use it to make genetic changes advantageous to crops like corn, cotton, and strawberries. Plant scientists and breeders can design a short piece of RNA that matches the exact DNA sequence they want to change in a crop (like a custom address label). They attach this guide RNA to the Cas9 protein, and this Cas9 complex is ready to find its target. The complex travels inside a cell of the desired crop to find the desired DNA target. When the guide RNA finds a matching sequence, Cas9 cuts the DNA at that spot. This cut is the crucial moment – it's like slicing open the DNA instruction manual at a specific page and line. Once the DNA is cut, the cell naturally tries to repair the break. The cell can simply glue the broken ends back together. This quick fix often makes mistakes – it can add or lose letters – which may disrupt the gene and create a change in the crop. Scientists can also introduce a template DNA sequence along with CRISPR, and the cell can use it as a blueprint to copy in a corrected or new section of DNA. This enables precise changes – like repairing a faulty gene or inserting a new beneficial gene.

CRISPR is a revolutionary tool because that can be used to make cranberries better from yield to fruit quality and disease and pest resistance. However, there are several pre-requisites to make a genetically modified cranberry using CRISPR: 1) The CRISPR-Cas9 system must be developed and tested in cranberry using a reporter gene (test gene) and regenerated mutant cells must be confirmed, 2) Tissue culture techniques must be developed to produce viable plants with the modification, and 3) A significant gene target must identified and studied in detail, and the gene must have a large effect on a desirable cranberry trait. Target genes for horticultural or economically important traits in cranberry can be identified by conducting in-depth genetic studies. Overall, CRISPR implementation can be a lengthy endeavor. For example, pre-requisite 1, the development of a functional CRISPR-Cas9 protocol could take up to 5 years. Pre-requisite 2 or the development of a tissue culture regeneration system that can regenerate a fully functional modified plant could take another 5 years. Finally, pre-requisite 3 or the identification of significant gene targets with desirable effects in the cranberry crop is the most difficult and time-consuming part of this process. This process can take 5-20 years depending on the gene and the type of in-depth studies

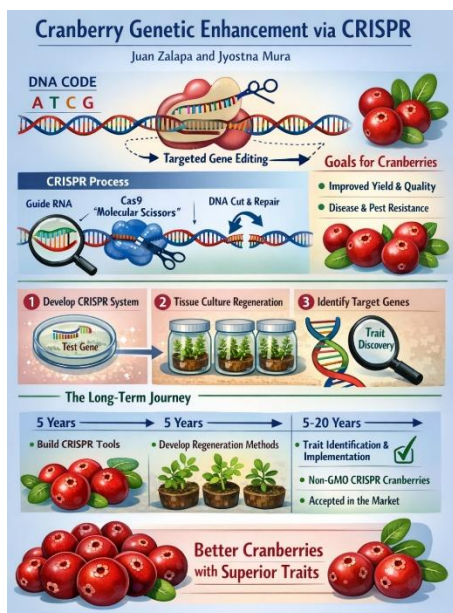
needed to understand how each gene works to allow the targeted modification to succeed.

To make CRISPR possible in cranberry, our cranberry science team first developed reliable tissue culture methods to regenerate whole plants from leaf explants, testing different hormone combinations and cultivars. Stevens performed especially well in regeneration trials. At the same time, we are establishing functional CRISPR-Cas9 transformation systems using *Agrobacterium tumefaciens* for whole-plant edits and *Agrobacterium rhizogenes* for root-level studies, including work on symbiotic genes. We have also been working towards providing the best gene targets for CRISPR- Cas9 modification and other molecular breeding applications by developing the critical genetic infrastructure needed. For example, we have sequenced the cranberry nuclear, mitochondrial, and plastid genomes, developed genetic markers, linkage maps, and a pangenome with annotated genes, conducted trait mapping studies such as quantitative trait loci (QTL) and genome wide association studies (GWAS), transcriptomics-RNA-SEQ-metabolomics studies, and used comparative genomics to leverage knowledge in other closely related species such as blueberries and even other unrelated species where information is available to apply it to cranberries. Based on all the genetic studies we have conducted in cranberry, we have several cranberry gene targets with potential to be used in CRISPR gene editing such the fruit color gene, firmness genes, acid-brix genes, ERM symbiotic genes, and cranblue-brix genes. However, there is still a lot to do to understand how these genes work and currently, we do not have any genes associated with disease resistances, which are a top priority, as studies are currently ongoing starting with the development of inoculation techniques, reproduction of symptoms, and/or conditions of the different diseases for subsequent genetic mapping and sequencing studies.

An important aspect of creating and deploying a CRISPR cranberry with advantageous traits is acceptance in the current market globally. In the U.S., a Genetically Modified Organisms (GMOs) is a plant, animal, or microorganism that has had its genetic material (DNA) changed using technology that generally involves the specific modification of DNA, including the transfer of specific DNA from one organism to another. In general, in the U.S., a CRISPR plant would not be considered a GMO if no genes are transferred from a different species. Thus, modifications can be made within the cranberry genome without the addition of any foreign genes, and the resulting modified plants may not be considered GMO. Cranberry breeding programs working on hybridizing closely related species such as blueberry and lingonberry or other *Vacciniums* could be of benefit given this definition and the resulting offspring would be

considered part of the cranberry genetic pool. Thus, early generation plants resulting from hybridization crosses could be used to splice desirable genes with major effect such the cran-blue brix genes into cranberries and accelerate improvement by avoiding the slow backcross breeding process. Consequently, viable hybrid populations such cran-blue and cran-ling-blue crosses open new opportunities in terms of genes and genetic knowledge to be used in cranberries from other *Vacciniums* in the USDA breeding program. Currently, the U.S. is the largest grower of commercial crops that have been genetically engineered in the world (RoundupReady, BT, Flavr Savr, Virus Resistance), and the development of CRISPR technology could be vital for the preparedness of the cranberry industry to respond to challenges in the future.

In summary, the development of CRISPR-Cas9 technology in cranberry represents a transformative opportunity for the industry's future. By combining advanced genome editing tools with strong tissue culture systems, comprehensive genetic research and molecular breeding, we are building a powerful platform for precise and efficient trait improvement. Although this process requires long-term investment and careful validation, the progress made in cranberry genome sequencing, trait mapping, and transformation techniques demonstrates strong momentum. As these foundations continue to strengthen, CRISPR-based and molecular breeding approaches will enable the creation of cranberry cultivars with improved yield, fruit quality, stress resilience, disease resistance, and sustainability. Ultimately, this work supports smarter breeding strategies and the creation of improved cultivars that benefit growers, consumers, and the broader agricultural community, helping to secure a productive and competitive future for the cranberry industry.



ACKNOWLEDGMENTS These project advances have been supported by USDA-ARS (project no. 5090-21220-007-00-D); USDA NIFA (project no. 2019-51181-30015; VacciniumCAP); Wisconsin Cranberry Growers Association, Ocean Spray Cranberries, Inc.; Cranberry Institute, Mariani Packing Co.

WISCONSIN CRANBERRY FUNGICIDE EFFICACY TRIALS – 2025 SEASON

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Introduction

The 2025 growing season in Wisconsin presented substantial challenges for cranberry disease management due to extreme weather variability. Rapid shifts between warm and cold conditions in spring, persistent heat and humidity during summer, and expanding drought conditions into fall created an environment in which disease development and fungicide performance were difficult to predict. These conditions provided an opportunity to evaluate fungicide efficacy under realistic and highly variable field conditions.

Environmental Conditions During the 2025 Season

Spring was characterized by extreme swings in temperature and moisture, ranging from record-breaking warmth to cold snaps, as well as alternating dry periods and heavy storm events. Summer conditions were dominated by sustained heat, high humidity, and multiple heat waves accompanied by warm nighttime temperatures. In contrast, fall conditions shifted toward drought, with warm, windy weather and limited rainfall persisting into the late season.

Trial Logistics

A total of five fungicide efficacy trials were conducted at the Wisconsin Cranberry Research Station using a 'Mullica Queen' bed planted in 2019. This bed is routinely managed as a disease-incubator system and received additional irrigation during bloom and post-blush periods to encourage fruit rot development. Fungicide applications were made at approximately 20% and 80% progress through bloom (June 20 and July 2), with select treatments applied after fruit set. Fruit were harvested on September 26 and evaluated for fruit rot incidence and yield. Despite efforts to enhance disease pressure, overall fruit rot incidence remained low, generally below 10%.

FRAC 7 Fungicide Implementation Trial

Succinate dehydrogenase inhibitor (SDHI; FRAC 7) fungicides currently in the development pipeline for cranberry were evaluated in an implementation trial. SDHI fungicides are most effective when applied preventively and can inhibit early infection processes. They are considered reasonably broad-spectrum and carry a medium to high risk for resistance development. Under the conditions of the 2025 season, no statistically significant differences in fruit rot incidence or yield were observed among treatments.

Experimental Products W, R1, and R2

Experimental fungicides W, R1, and R2 were evaluated based on promising results for blueberry fruit rot management in other production regions. These chemistries are associated with a low to medium risk of resistance development and may have potential for future OMRI listing. Similar to the FRAC 7 trial, no statistically significant differences in fruit rot incidence or yield were detected among treatments in this trial.

Systemic Acquired Resistance (SAR) Implementation Trial

Systemic acquired resistance (SAR) products, including Lifegard WG, were evaluated as biofungicides that activate plant defense mechanisms rather than directly targeting pathogens. These products are often used in combination with conventional fungicides and several are OMRI-listed. Across SAR treatments, including experimental products R2 and Lifegard, no statistically significant differences in fruit rot or yield were observed in 2025.

Experimental Fungicides *f* and *m*

Two additional experimental fungicides, designated *f* and *m*, were evaluated following encouraging results from New Jersey trials. Fungicide *f* is a contact material with low resistance risk and limited plant mobility, while fungicide *m* is systemic with both pre- and post-infection activity and a medium resistance risk. No statistically significant differences in fruit rot incidence were observed among treatments during the 2025 season.

UV Protectant Implementation Trial

A UV protectant product designed to mitigate sunburn and heat stress, but with no fungicidal properties, was evaluated following fruit set. Although this product is not registered for cranberry, previous evaluations in 2024 showed a significant reduction in fruit rot. In 2025, two post-fruit set applications were made; however, no statistically significant differences in fruit rot incidence or yield were observed.

Summary of 2025 Results

Across all five trials, low disease pressure limited the ability to detect statistically significant differences among fungicide treatments. While fruit rot incidence remained below levels typically associated with economic loss, these trials provided valuable insights into fungicide performance under highly variable environmental conditions.

Future Research Directions

Planned work for 2026 includes repeating select chemistries evaluated in 2025, re-evaluating fungicide use patterns for cranberry fruit rot management, and further exploring integrated disease management strategies. Continued work will focus on SAR products, newer synthetic modes of action, and in vitro screening of both novel and existing chemistries to assess efficacy and detect potential shifts in fungicide sensitivity.

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SCREENING OF SOILS FOR PRESENCE OF *STEINERNEMA CARPOCAPSAE* IN THE YEARS FOLLOWING INITIAL TREATMENT

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Objective

Determine whether the multiple years of cranberry flea beetle control observed with *S. carpocapsae* is due to a.) higher presence of *S. carpocapsae* in previously treated soils compared to untreated soils in subsequent seasons b.) high initial knockdown of flea beetle larvae in the initial season where treatment is deployed or c.) a combination of both factors.

Justification

Five years of previous work by the OSC WI Ag. Science Team has demonstrated that Capsanem (*Steinernema carpocapsae*) is highly effective at controlling cranberry flea beetle (*Systema frontalis*) when applied at a season total rate of 1.5 billion nematodes/acre in the month of June to severely infested beds. Trials conducted in

2023 at commercial field scale demonstrated that this 1.5 billion/acre rate divided into four weekly 375 million/acre applications in June can completely replace the need for insecticide inputs for cranberry flea beetle in July and August of the same season the applications are made (Jones and Potter 2023). Trials conducted in 2024 and 2025 demonstrated that at least two full years of flea beetle control are possible with just one year of applications (Jones and Potter 2024, Jones et al. 2025), and that four applications at 375 million nematodes/acre is the preferred management strategy for consistent, season long control of flea beetle in the year following application (Jones et al. 2025).

The possibility of multiple years of control with one successful year of nematode applications presented a promising new direction for flea beetle management. It is known that the cranberry flea beetle that feed within any given bed largely emerge from within that bed each year rather than coming in from the exterior (Jaffe et al. 2021). This information combined with the widespread anecdotal grower observation that flea beetle appear to take several years to re-establish any time a bed is renovated were key factors in initial interest and attempts at using *S. carpocapsae* for control. It was reasoned that a strong enough initial knockdown of the larval population would mean that it would take multiple years for the flea beetle population to recover within the treatment site. All this taken together, it is possible that the multi-year control is due to the strength of the initial knockdown combined with the fact that flea beetle only have one generation per year and are not entering a cranberry bed in high numbers from outside sources.

However, it was also estimated to be possible that another contributing factor was that *S. carpocapsae* is persisting in treated cranberry soils at higher rates than untreated soils, continuing to kill flea beetle larvae in subsequent seasons. Persistence of *S. carpocapsae* at statistically higher rates capable of delivering multiple years of kill following initial treatment has been recently documented in turf grass applications (Koppenhöfer and Sousa 2024), but the unique soil structure and water management dynamics of a cranberry bed needed to be studied to determine if a similar phenomenon could be replicated in these systems.

It is important to understand which of these variables is contributing to observed multi-year control because it dictates how this biocontrol strategy is communicated to

growers and influences how growers will need to think about maintaining a flea beetle population in the long term. If treated soils maintain high populations of *S. carpocapsae* after treatment relative to untreated soils, this suggests that growers may only need to “top off” the population with a lower rate of application every 2-3+ years in order to maintain healthy nematode populations in the soil, thus potentially saving on cost by avoiding usage of the high rate previously tested against severely infested sites (1.5 billion nematodes/acre). Conversely, if the prospect of multi-year control were solely due to the strength of the knockdown achieved within a single year of applications and the population of *S. carpocapsae* dies out after the year the treatment is applied, it would make more sense to “reset” a bed every 2-3 years using the high rate of 1.5 billion/acre, incurring more cost but ensuring that the number of adult flea beetle that emerge and successfully lay eggs in the treated bed is kept at an absolute minimum since no control can be expected beyond the initial year of applications.

Approach

In the 2023 growing season, three pairs of cranberry beds with a history of severe flea beetle infestation were identified at three separate central Wisconsin cranberry marshes. Beds at each of the three marshes were randomly assigned one of the following treatments:

1. No nematodes applied.
2. An application of 375 million nematodes/acre on approximately June 7th, 14th, 21st, and 30th.

In 2024, a new round of trials was deployed at three more marshes, with three sets of four beds at each property receiving one of the following treatments:

1. No nematodes applied
2. Two applications of 750 million nematodes/acre on approximately June 15th and 30th
3. Three applications of 500 million nematodes approximately June 10th, 20th, and 30th
4. Four applications of nematodes approximately June 7th, 14th, 21st, and 28th

All applications were made by a commercial grower either prior to 8AM or after 5PM. Irrigation was run for at least 30 minutes prior to the beginning of applications, continued to run during the applications, and was run for at least an additional hour after completion of the applications. All applications were made by a commercial boom spray rig with both pump and nozzle screens removed, and the operating pressure of

the boom was between 25 and 40PSI. Approximately 25-30 gallons per acre of water carrier were used.

Successful 2023 control was confirmed for the Capsanem treatment bed at all three sites using this method. The control continued in 2024 and was both below economic threshold in all treated beds for the full duration of the growing season and significantly lower compared to untreated control beds at all three sites. Successful control was also achieved at all three sites treated in 2024 at all treatment timings. One of the three sites did see significantly more flea beetle per week and in total in the two-treatment bed compared to the three and four treatment beds, but this population still remained under economic threshold and did not require treatment with synthetic insecticide.

No additional nematode applications were made to the 2023 or 2024 Capsanem treatment beds at any of the six sites in June 2025. Nematode presence in the soil was determined using a lab assay adapted from Cornell's Department of Entomology (Testa and Shields 2019). Six-inch depth soil cores were taken from treated and untreated beds at all six sites (~100/bed) in four evenly spaced, evenly distributed transects running parallel to the long sides of each bed. Collected cores were placed immediately in a cooler after collection to maintain soil temperature in the samples. All cores collected from within a bed were mixed after collection was complete, and about 6oz of soil mixture was placed into 30 individual 32oz. plastic cups per treatment bed. Seven waxworm larvae (*Galleria mellonella*), a universal susceptible host to *S. carpocapsae* were added to each cup, all cups were misted with sterile water, and the cups were inverted and held at room temperature for about a week. All *Galleria* were then evaluated as either alive or dead. All dead *Galleria* samples were submitted to the lab of Dr. Peter DiGennaro, the nematologist at the University of Wisconsin Department of Plant Pathology. Dr. DiGennaro's lab confirmed the causal species associated with mortality in all dead *Galleria* across all treatments and sites.

Results

Out of the 186 dead waxworms recovered from soil cores across all sites, none were found to be infested by *S. carpocapsae*. Four mealworms were found to be infested by *Oscheius onirici*, a native predatory nematode naturally present in Wisconsin cranberry soils. No other predatory nematode species were found in any of the remaining samples.

Discussion

The absence of *Steinernema carpocapsae* in all samples from treated beds suggests that this species does not persist in cranberry soils from year to year under standard Wisconsin growing conditions. There are a variety of reasons this may be the case, including prolonged flooding of the soil substrate and extreme winter cold conditions, but regardless of the cause it appears that the nematodes applied are not persisting in the bed beyond the initial season. This lack of persistence in cranberry soils compared to turfgrass systems where *S. carpocapsae* has been documented to remain active for multiple years likely reflects differences in these key environmental variables.

This suggests that the multi-year control observed in several years of previous trials was likely due to the strength of the initial knockdown rather than ongoing nematode activity in subsequent seasons. This matches with grower and consultant experience on the multi-year suppressive effect of renovating a bed, which destroys the majority of the larval population in the bed by scalping the sand and roots off to a depth of 10-12". Whether by nematode application or renovation, destruction of a population within a contiguous cranberry block typically results in low population pressure for 2-3 years at minimum in Wisconsin cranberry systems.

From a management perspective, these results have important implications for growers considering Capsanem as a long-term strategy for cranberry flea beetle control. Since persistence cannot be expected in cranberry beds, periodic full-rate (1.5 billion season total/acre split into four separate weekly 375 million/acre applications in June) "reset" applications at the full rate is likely to be necessary every two years to maintain effective flea beetle suppression, particularly at high pressure sites. Growers should consider setting marshes with a history of moderate to severe pressure from cranberry flea beetle on a nematode application rotation, much like a sanding schedule. It is clear at this time that applying at the full rate every year is not necessary, even at the sites with the worst pressure. Rather, it is likely that a full rate program scheduled every 2 years should deliver strong control of cranberry flea beetle and prevent growers from having to treat beds with synthetic insecticide.

ACKNOWLEDGEMENTS Koppert Biological Systems, cooperating growers.

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INVESTIGATING THE VIABILITY OF MULTI-YEAR CONTROL FOR CRANBERRY FLEA BEETLE USING CAPSANEM (*STEINERNEMA CARPOCAPSAE*).

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Objective

Evaluate the potential for multiple years of control following a single season of Capsanem treatment for a cranberry bed to bring down the economic cost of treatment per year for cranberry growers.

Justification

After five years of testing and field vetting, a consistent, effective protocol has been developed for using Capsanem (*Steinernema carpocapsae*) to control cranberry flea beetle without the need for additional synthetic insecticide. One of the biggest questions in this research trajectory that remains is how many years the control using this protocol can be expected to last. Analysis of data in 2024 suggested that an initial

year of applications could deliver a second consecutive year of control without additional applications. While promising, this result needed further replication to explore how consistently this result could be expected. Additionally, further work was needed to examine whether a third year of control after an initial successful year of applications could be expected. The multi-year control question is critical because cost of the nematode-based control protocol for flea beetle is expensive when considered as only a one-year cycle of control, roughly \$140/acre as of 2025 pricing. If the control can be expected to continue for more than one season without additional applications the following year, the economic cost per acre-per-year drops to just \$70/acre/year, making this protocol economically competitive compared to traditional reliance on 2-3 synthetic insecticides per year. At current price points, two applications of synthetic late season insecticide costs between \$50-75/acre depending on product. For high pressure sites, the current cost of treating a cranberry bed with three applications of effective insecticides is roughly \$70-100/acre based on recent grower survey data collected at the 2025 Cranberry Research Roundtable. This means that if the established protocol can consistently sustain control for two years, usage of Capsanem to manage cranberry flea beetle is roughly on par with normal financial input at two spray marshes and more economically viable at three-spray marshes. This project aimed to gather additional foundational data for the economic return surrounding this biological management protocol.

Approach

In Spring of 2023, three sets of two Stevens beds of the same age and flea beetle history were identified at three separate commercial cranberry marshes in central Wisconsin by the OSC Ag. Science Team using historical IPM data, named in this summary as Sites A, B, and C. Bed sets identified for this work at each site had flea beetle pressure categorized as severe based on IPM data dating back at least five years in order to ensure that the base population in each of the pair of beds was uniformly high going into the project. Beds at each site were randomly assigned one of two treatments: four applications of Capsanem at 375 million nematodes/acre or untreated control.

On June 7th, 14th, 21st, and 28th (2023) the Capsanem treatment bed at each of the three sites received an application of 375 million *S. carpocapsae* (Capsanem)/acre, for a total of 1.5 billion nematodes/acre across the four-week treatment season. Irrigation was turned on in the treatment beds at least 30 minutes prior to the nematode applications,

was left on during all boom applications, and was run for one hour after boom applications were complete to wash all nematodes off foliage and into the soil. Nozzle and pump screens were removed prior to the applications. Applications were made between 6 and 8AM at Site A, between 6 and 8PM at Site B, and between 10AM and 1PM at Site C. Applications were made with a standard boom spray rig at between 25 and 35PSI with 25-30gpa of water carrier per acre. Applications were recommended either between 6-8AM or 6-8PM due to concern over ultraviolet light and drying stress/mortality to applied nematodes, but the grower at Site C was unable to apply at these times due to application logistics, so the applications were made between 10AM and 1PM.

In June of 2024, additional contiguous blocks of four beds with a history of severe flea beetle pressure at three more sites, identified in this summary as Site D, Site E, and Site F. One bed within each block of four beds was randomly assigned one of the following four treatments:

1. No nematodes applied.
2. An application of 375 million nematodes/acre on June 7th, 14th, 21st, and 30th
3. An application of 500 million nematodes/acre on June 7th, 17-21st, and 30th.
4. An application of 750 million nematodes/acre on approximately June 14th and June 30th.

All applications were made prior to 8AM under the same boom and nozzle specifications utilized in 2024.

100-200mL of application solution was captured for each treatment directly from a boom nozzle during the application for each bed. Three individual 1mL droplets from each 100-200mL treatment sample were placed under a dissecting microscope and the first 30 nematodes observed in each droplet were counted and identified as either alive or dead to determine the estimated live count of nematodes in each treatment after they had passed through the pressurized sprayer environment. In 2023, a 1mL droplet of nematode solution from each treatment and each site was then placed on five mealworms per treatment per site to determine if the nematodes were still virulent after being applied through pressurized boom equipment. After treatment, mealworms were placed between two wet cotton rounds and then placed inside of a sealed petri dish. Five untreated mealworms were placed in cotton rounds and sealed inside of a petri dish to serve as untreated controls. Mealworms were checked every 24 hours after

exposure to nematodes and were categorized as either “alive” or “dead” at each rating point. This was done solely in 2023 to determine that the nematodes were consistently travelling through conventional cranberry application equipment and remaining virulent towards insect hosts.

Starting the first week of July in both 2023 (for site A, B, and C), 2024 (all sites), and 2025 (all sites) five researchers conducted 50 individual 20-sweep sets divided across ten transects evenly spaced across the bed (five 20-sweep sets per transect x 10 transects = 50 individual 20-sweep sets) for each treatment bed at all sites. This process was repeated weekly through the end of August in all three years. Flea beetle captured in each 20-sweep set were counted, and each 20-sweep set count total was added together within the treatment bed and data collection date for a weekly flea beetle catch total for the assigned treatment. Data from all years were subjected to ANOVA and subsequent pairwise testing.

Results

Nematodes survived the application process at a high rate, with greater than 97% rated “alive” during post-application checks at all application dates and sites (data not shown).

In 2025, Site B had significantly fewer flea beetles captured in the 2023 Capsanem treatment bed compared to the untreated control on weeks when flea beetle pushed above economic threshold, showing a third consecutive year of suppression in the Capsanem bed. However, monitoring at both Site A and Site C showed minimal difference between treatments in 2025, and both beds at each site had to be treated a single time 2025 for flea beetle, ending a nearly three-year long run without flea beetle insecticides beyond the Capsanem originally applied in 2023.

2025 monitoring at Site D, E and F generally showed strong control of flea beetle into the second year for all beds treated with 375 million nematodes per acre four times in 2024. Site E developed a single small hot-spot in early August, 2025 in the four-spray bed that was treated but the entire bed did require treatment in 2025. The two-spray bed and the untreated control at Site E had to be sprayed three times each. The three-spray bed was treated once. Site D never developed significant pressure in any bed in

2025, so no significant differences were observed between any treatments. Site F showed no significant difference between the two, three, or four spray treatments, but all treatments were significantly better than the untreated control.

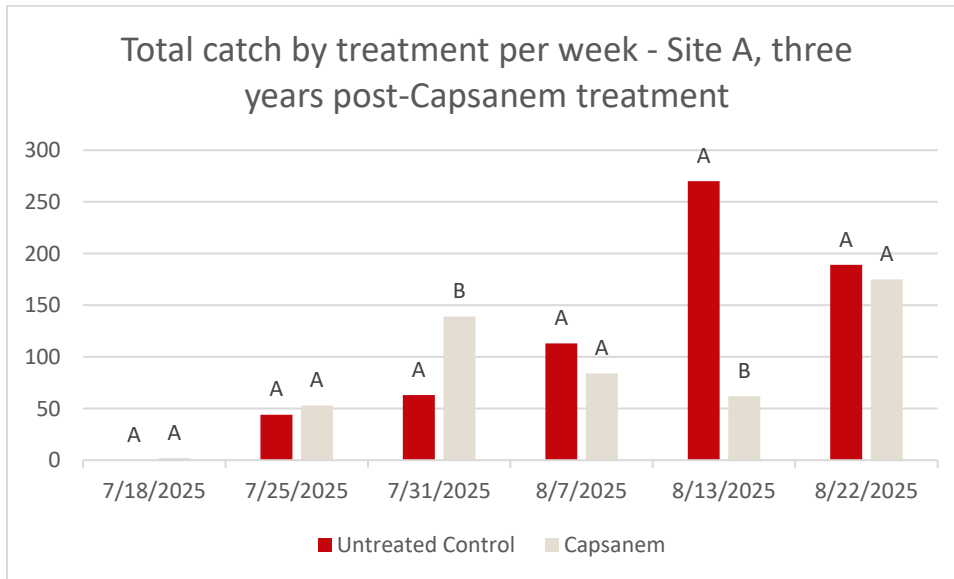


Figure 1 weekly total catch by treatment at Site A. The untreated control bed is significantly higher than the Capsanem treatment on 8/13/2025. The Capsanem bed is significantly higher on 7/31/2025. Both beds were sprayed with Acara on 8/1/2025. After the Actara treatment, the untreated control bed had numerically more flea beetle caught on the following three sampling dates, and differences were significant on 8/13/2025 ($p < 0.05$).

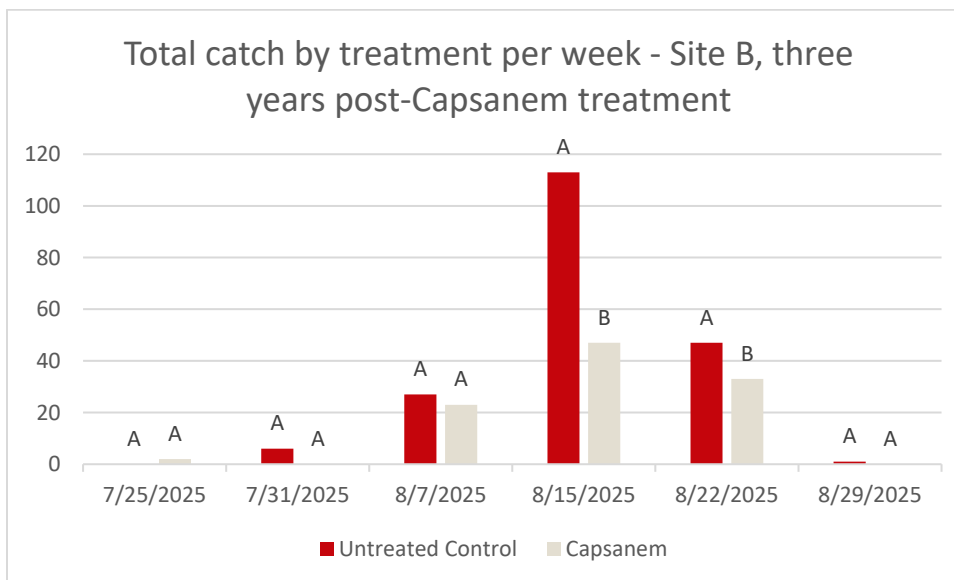


Figure 2 weekly total catch by treatment at Site B. The Untreated Control bed was significantly higher than the Capsanem bed on 8/15/2025 and 8/22/2025. Neither bed required treatment for flea beetle in 2025.

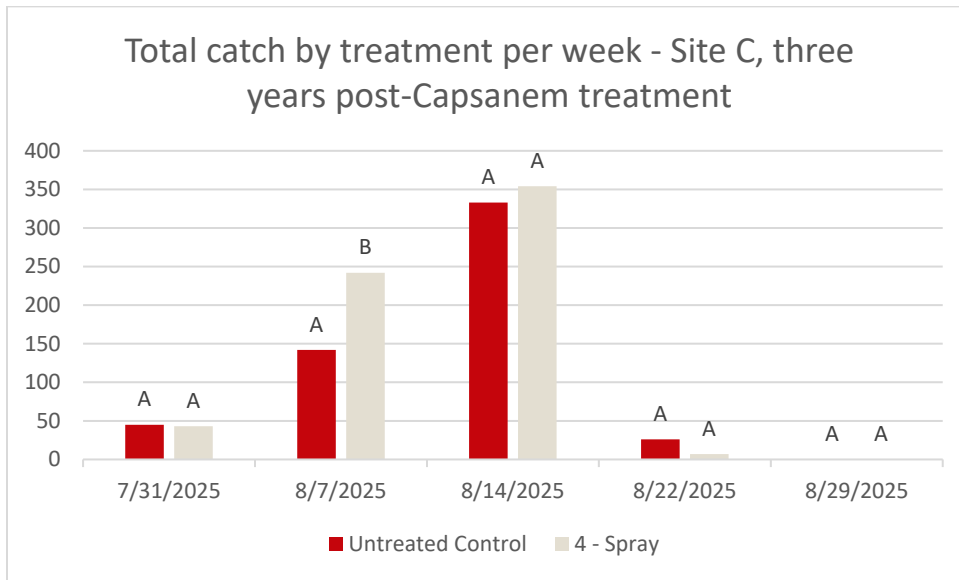


Figure 3 weekly total catch by treatment at Site C. The Capsanem bed was significantly higher than higher than the Untreated Control bed on 8/7. Both beds were treated with Diazinon AG500 on 8/15/2025.

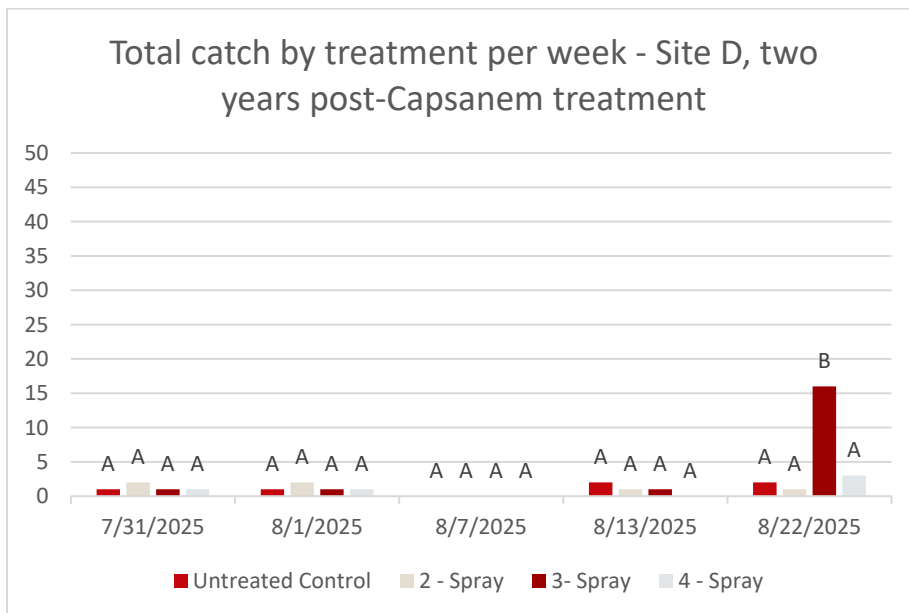


Figure 4 weekly total catch by treatment at Site D. The 3-spray treatment is higher than the other treatments on 8/22/2025, but still well below the economic threshold.

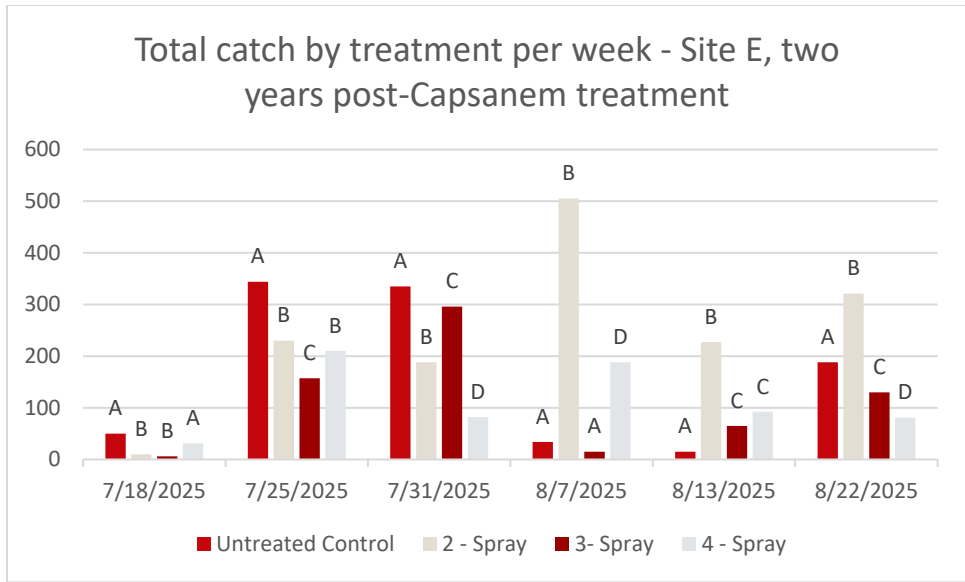


Figure 5 weekly total catch by treatment at Site E. The Untreated Control bed was sprayed with Actara (thiamethoxam) on 7/26/2025 and with Diazinon AG600 on 8/3/2025. The 2-spray bed from 2024 was sprayed with Actara on 7/26/2025, Venom (dinotefuran) on 8/8/2025, and with Diazinon AG600 on 8/13/2025. The 3-spray bed from 2024 was treated with Diazinon AG600 on 8/3/2025. The 4-spray bed from 2024 had an approximately 25x25 foot hotspot adjacent to the untreated control bed treated with Actara on 7/26/2025, but the rest of the bed was left untreated.

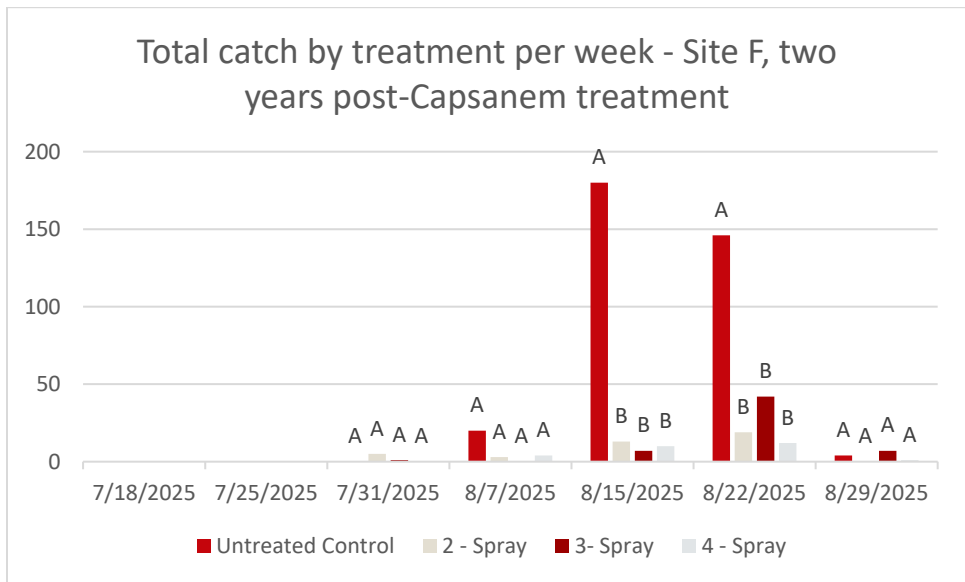


Figure 6 weekly total catch by treatment at Site F. The Untreated Control bed is significantly higher than the three other treatment beds on 8/15/2025 and 8/22/2025.

Discussion

This work suggests that a cycle of control with an initial round of applications can be expected to last roughly two seasons for most growers if four applications at 375 million nematodes/acre are used in the initial year. It is possible for growers with lower initial pressure that this could be longer, but since most growers that are utilizing Capsanem are growers with moderate to high pressure, the assumption of a two-year cycle of control is a solid estimate for growers in practical terms. Sites originally treated in 2023 with four applications of Capsanem did not consistently show a strong control of cranberry flea beetle in the third year following initial application, and the highest-pressure site treated in 2024 showed signs of recovery by the end of the second year of control. Due to the inherent variability of each individual marsh's population and environmental conditions, some variability is to be expected so at this time it is reasonable to suggest a generic outcome of a roughly two-year cycle with the assumption that some growers may see more than two years of control. The most important consideration is that in spite of variability of results, there have not been significant flea beetle issues in any bed treated with four applications of 375 million nematodes/acre in June in two years or less at any site over several years of research, with some sites showing suppression beyond the two-year cycle of control.

This year's multi-year work also sheds light on the optimal number of applications when multi-year control is the objective. While data is not always separable between two applications at 750 million, three applications at 500 million, and four applications at 375 million in June in the initial year of control, work in the past two years has demonstrated that the two-spray control strategy can be significantly worse than the three and four spray strategy in year one and to a larger degree, in year two, particularly when the base pressure of a site prior to treatment is high. Site E had the highest initial pressure prior to treatment in 2024, and while the two spray control strategy did result in a season below economic threshold, it was significantly worse than both the three and four application treatments in that season. In 2025, the two-spray bed had pressure on par or worse than the untreated control throughout the season and had to be sprayed more times than the untreated control bed (Figure 5). The three-spray treatment was also slightly worse than the four-spray treatment in 2025 at Site E (Figure 5).

Site D did not develop significant flea beetle pressure in 2025 so it could not be used to generate additional insight (Figure 4), but Site F showed significantly fewer flea beetles than the untreated control compared to all three Capsanem treatments. There were no

differences in year two between Capsanem treatments (Figure 6). Site D was the lowest pressure site prior to treatments in 2024, followed by Site F, followed by Site E.

When all this is taken together, it is likely that the quality of multi-year control by treatment selection is somewhat dependent on the pressure within a block of beds prior to treatment. However, given that quantifying pressure in a block of beds prior to treatment is an imprecise science, the best practice going forward to achieve multi-year control of cranberry flea beetle is to treat four times approximately every seven days in June with 375 million nematodes/acre in central Wisconsin.

At this point in time, the efficacy of Capsanem against cranberry flea beetle is well-established, and the research in this area has moved to the optimization phase, primarily focused on economics. Significant progress has been made in this area in the past two seasons. When this research started in 2021, the cost of a full acre of applications at the recommended rate was over \$200 USD/acre with the assumption of just one year of control. However, direct collaboration with Koppert Biological Systems, Inc. and several years of multi-year control research has brought the cost of this material down to about \$140USD/acre for a two-year control cycle, or roughly \$70USD/acre/year. Current pesticide portfolios place the approximate cost of three applications of effective flea beetle insecticide at about \$70–75USD/acre if the two cheapest EU-qualified products are used, these being Actara (thiamethoxam) and Venom (dinotefuran), with the added disadvantage that the vines are still considerably browned by flea beetle feeding at these severe sites even when effective insecticides are deployed. Two-spray flea beetle properties can expect to pay closer to \$50–60USD/acre using a combination of Venom and Actara, but this also comes with added disadvantage of vine browning due to feeding. As such, a two-year cycle of nematode control done in four total applications in one year represents a competitive approach to standard flea beetle control in as few or fewer applications than conventional insecticide. This strategy provides a consistent, economic solution to a perennial problem that will protect Wisconsin grower's ability to continue to produce fruit for international export.

Future research in the usage of *S. carpocapsae* will continue to focus on strategies surrounding multi-year control as well as a more precise understanding of the optimal start time of nematode applications as a function of soil temperature and other environmental variables. It will also examine optimization of the application timings for growers in northern Wisconsin regions.

ACKNOWLEDGEMENTS Koppert Biological Systems.

SCREENING THE VIABILITY OF CAPSANEM (*STEINERNEMA CARPOCAPSAE*) APPLIED THROUGH A DGI T-40 SPRAY DRONE

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¹Ocean Spray Cranberries Inc.

Objective

Evaluate viability of Capsanem (*S. carpocapsae*) after being run through a DGI T-40 spray drone at standard operating pressure and droplet sizing settings.

Justification

Several years of previous work have demonstrated applications of Capsanem (*Steinernema carpocapsae*) as a highly effective long-term solution for the control of the cranberry flea beetle (*Systema frontalis*). Previous research focused on applications made with cranberry boom spray rigs, the typical standard in Wisconsin cranberry. These systems typically operate between 30 and 40PSI with flat fan nozzles aimed downward towards the bed. The established management strategy using this product with a boom spray rig involves applying nematodes three to four times every seven to ten days in the month of June for a two-year cycle of control. While this is a generally acceptable system for most growers, this does require extra time in the boom during a busy time of year, leading to increased interest in whether an autonomous or semi-autonomous application using a standard spray drone might be equally effective in applying the product. This project aims to determine whether *S. carpocapsae* can survive applications made with an industry standard spray drone in standard operating conditions and further, whether it is equally virulent towards insect hosts after being applied in this way compared to individuals that were not run through a spray drone. The overall aim of this work is to continue expanding the ease of access to sustained flea beetle control for Wisconsin's cranberry industry while reducing reliance on late season synthetic pesticide applications.

Approach

A grower collaborator supplied a DJI T-40 spray drone for this trial. Capsanem was hydrated 30 minutes prior to application in a solution of approximately 100 million nematodes/gallon. Prior to running any material through the spray drone, the Capsanem solution was stirred to prevent settling and three 30mL samples were

collected from the mixing bucket to serve as controls for the experiment. After these samples were collected, about one gallon of the Capsanem solution was loaded into a DJI T-40 spray drone. Collection trays were placed underneath each spray nozzle array. Three 30mL samples were collected for each of the following three drone application settings:

- Nozzles removed, spray pump running to discharge spray liquid.
- Nozzles in place, spray pump running, and droplet size set to 310 micrometers
- Nozzles in place, spray pump running, and droplet size set to 500 micrometers.

All sprays were made at approximately 100PSI with the pump screen removed. All 30mL samples were transported to the OSC Agricultural Sciences lab immediately after collection. Three separate viability counts were conducted for each 30mL sample using a compound light microscope at 40x magnification. The first 30 nematodes observed in each sample were rated as either alive (exhibiting normal movements) or dead (characteristic straightening of nematode, no movement observed for at least 10 seconds). After rating each 30mL sample, the three samples from each treatment group were mixed. Five waxworms for each treatment were placed in between two moist cotton rounds and inoculated with a 10-microliter droplet of the nematode solution for the respective treatment. All waxworms were observed 24 hours later and rated as either alive (exhibiting normal movement and behavior) or dead (no movement observed).

Results

Viability counts indicated that nematodes survived at high rates passing through the spray drone under all tested conditions, with survival rates ranging from 93% to 97% compared to 96% in the untreated control. Differences were not significantly different, indicating uniform survival across treatment groups. Subsequent virulence assays using waxworms showed complete mortality (100%) within 24 hours for all drone-treated samples, regardless of nozzle configuration or droplet size, while the untreated control resulted in only 20% mortality. These findings confirm that the tested drone application settings did **not compromise nematode survival or virulence.**

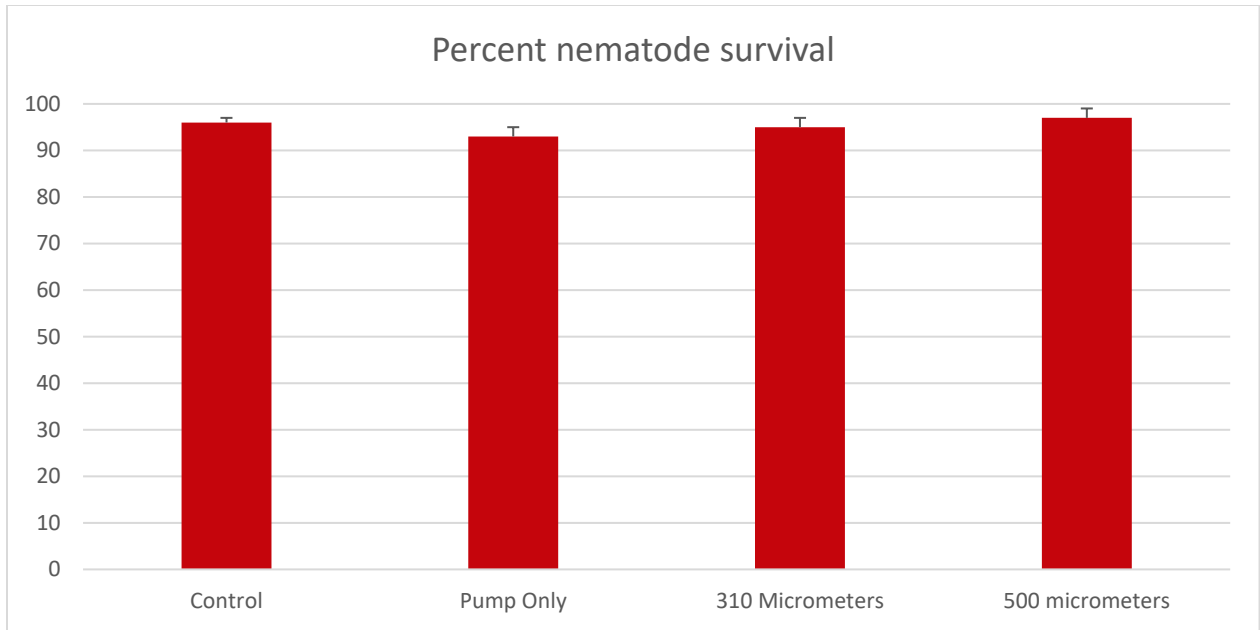


Figure 7 percent of nematodes rated "alive" in the three 30mL samples collected for each treatment group.

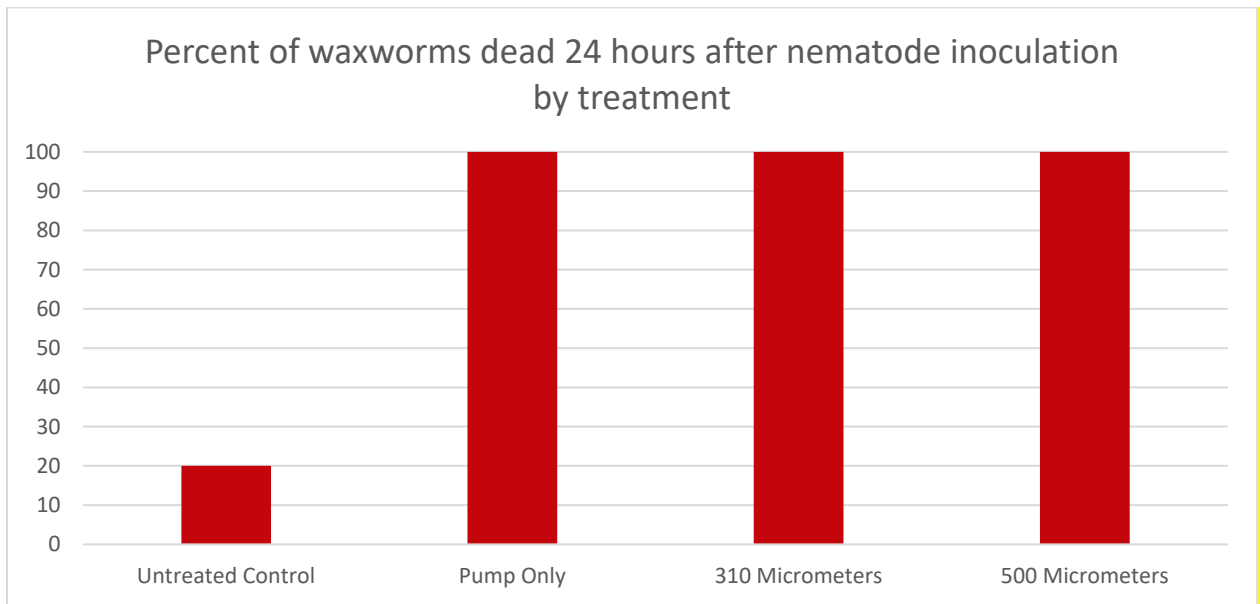


Figure 8 percent of waxworms for each treatment group rated "dead" 24-hours post-inoculation.

Discussion

The results of this trial demonstrate that Capsanem (*Steinernema carpocapsae*) maintains both high viability and full virulence after being applied through a DJI T-40 spray drone under standard operating conditions. Survival rates between 93% and 97% across all drone treatments were statistically comparable to the untreated control, and waxworm mortality reached 100% for all drone-treated samples by 24 hours post-inoculation. These findings confirm that drone-based delivery is unlikely to compromise

nematode performance, validating its use as a potential alternative to traditional boom rig applications.

This outcome represents a significant advancement in application flexibility. Traditional Capsanem programs require multiple boom rig passes during June - a period already filled with other management tasks. By enabling autonomous drone applications, growers could reduce labor demands and equipment scheduling conflicts while still achieving the same level of pest control efficacy. Traditional boom rig setups for applying Capsanem typically require 2-3 workers, while a drone setup can be conducted with just one.

Growers looking to use a spray drone for applying Capsanem should note that the other environmental and setup conditions identified for boom rig applications of the product need to be followed closely. Irrigation in the bed(s) needs to be turned on at least 30-60 minutes prior to any nematodes being applied. Applications need to be conducted early in the morning or late in the evening to ensure that nematodes are not killed by ultraviolet light and drying, preferably before 9AM or after 5PM during the month of June. Applications should be made targeting the research-established standard of a 1.5 billion/acre season rate applied as four separate 375 million nematode/acre applications made approximately every 7 days starting at the end of the first week of June in central Wisconsin. Irrigation should also be run for at least 60 minutes after applications conclude.

LAB INSECTICIDE SCREENING FOR CRANBERRY FLEA BEETLE

DAVE JONES, SARA POTTER, NATHAN FITZGERALD¹

¹Ocean Spray Cranberries Inc.

Objective

Evaluate the efficacy of four registered insecticides and one unregistered insecticide as potential management tools for cranberry flea beetle.

Justification

Screening insecticides for cranberry flea beetle is a high priority for the cranberry industry based on the past several years of survey data collected at the Wisconsin Cranberry Research Roundtable. Rapid lab testing allows for reliable, replicable evaluation of the potential fit of a product for more time-intensive field evaluation,

allowing the insecticide screening program to focus field testing solely on products identified through lab assessment as viable, saving time and resources. Lab analysis also allows for a more detailed view on the kill pattern in the days following application observed for each product, as this influences the general behavior of a product when scaled up to field conditions and impacts how products and expectations can be communicated to growers.

Approach

All products were applied at their maximum labelled rate in cranberry. The following treatments were tested on ten replicates per treatment in the OSC WI Ag Science lab:

1. Water treated control (UTC)
2. Syngenta – Unregistered Product A: 2.05 fl. oz/acre
3. Esteem (pyriproxyfen):
4. Cormoran (novaluran + acetamiprid)
5. Assail (acetamiprid)
6. Isarid (*Isaria fumosoroseus*)

Each replicate consisted of 20-30 flea beetles placed inside of a 32oz. plastic deli container. Ten fresh cranberry uprights with stems embedded in a 2" cube of hydrated floral foam were placed inside of each container when the beetles were placed in each container to serve as a food source, and an absorbent disc of paper towel was placed in the bottom of each deli container to prevent pooling of application water. All treatments were applied with a standard backpack sprayer with a water carrier equivalent of roughly 25gpa. Mortality was assessed at one hour, 24 hours, 48 hours, 6 days, and 7 days post-application. At each assessment timepoint all beetles in each enclosure were given one of three ratings: "unaffected" was assigned to all flea beetle exhibiting normal movements and feeding behavior, "affected" was assigned to all flea beetle exhibiting abnormal movement or behavior (rolling on back, uncontrolled leg twitching, cessation of mobility), and "dead" was assigned to all flea beetle that no longer exhibited movement or any other sign of life.

Results

Syngenta Product A, Cormoran, and Assail all showed significant control compared to the untreated control ($p < 0.05$), approaching 100% mortality by 48 hours following application (Figure 1). Esteem did not achieve significant control compared to the untreated control at any evaluation timepoint. Isarid achieved significant control

compared to the untreated control at only the seven-day post-application evaluation timepoint (Figures 1 and 2).

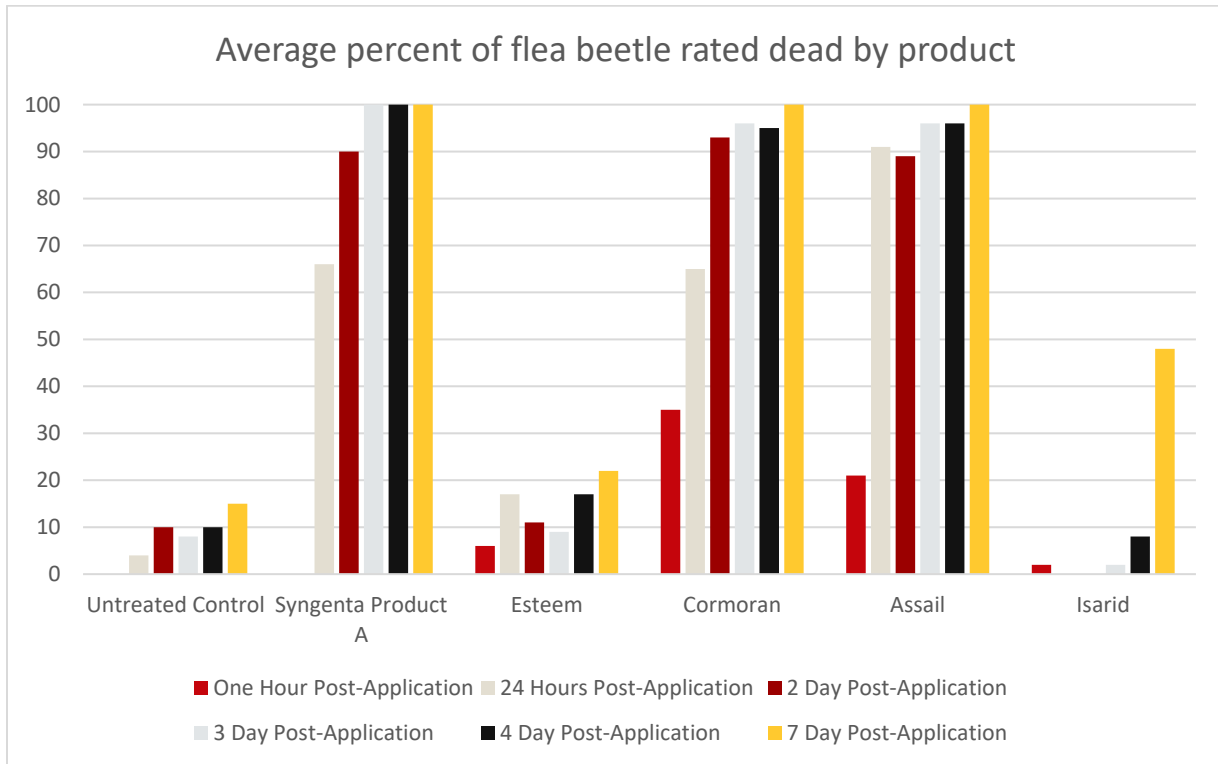


Figure 9 Average percent of flea beetle rated dead listed by product at each rating timepoint.

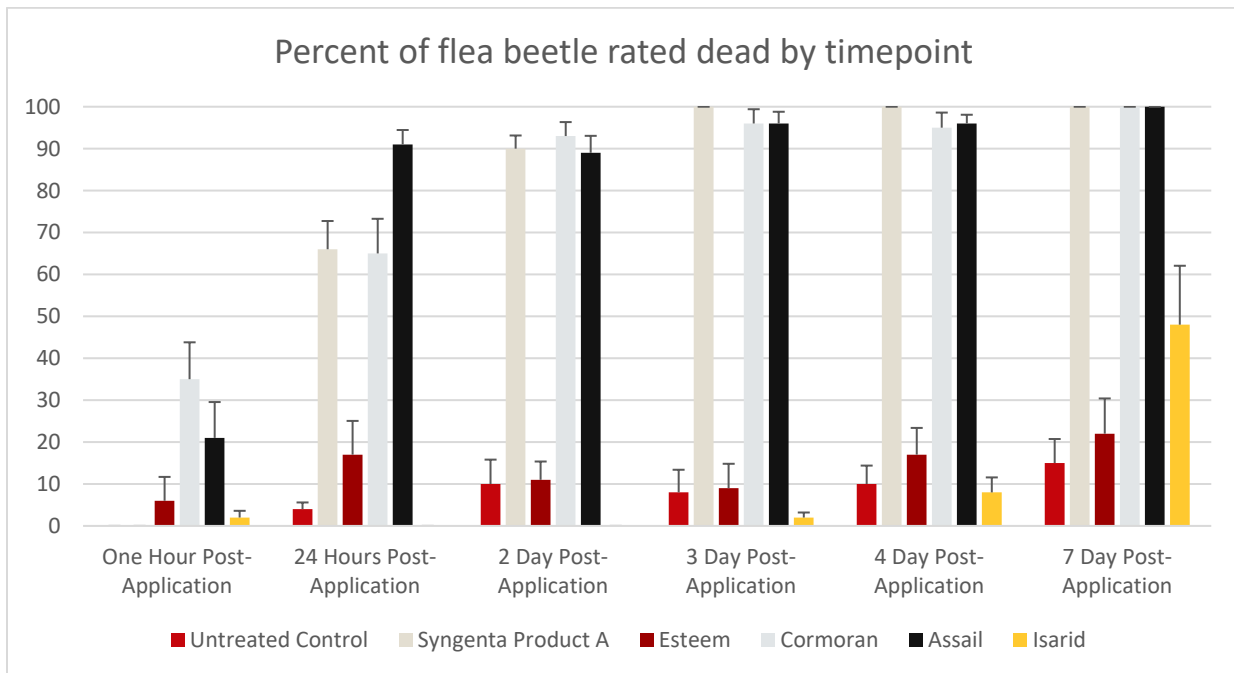


Figure 10 percent of flea beetle across all treatments rated dead at each rating timepoint.

Discussion

Syngenta Product A performed on par with Cormoran and Assail after the first 24 hours, reaching roughly 90% mortality by 48 hours and hitting 100% by day three. That places it in the same category as those two benchmarks, and far ahead of Esteem and Isarid, which never achieved meaningful knockdown in the same timeframe. While Assail and Cormoran aren't widely used for flea beetle control in cranberry due to lengthy pre-harvest intervals, they served here as strong comparison points for speed of kill due to high acute toxicity to flea beetle. If Syngenta Product A secures a label, growers could expect it to behave similarly to fast-acting standards, offering a new option for suppression of cranberry flea beetle.

The kill curve observed (slow start at one hour, sharp climb between 24 and 48 hours, and plateau near 100% by day three) suggests Syngenta Product A would likely deliver reliable control within two to three days under field conditions, assuming good coverage and favorable weather. The absence of early knockdown (0% at one hour) indicates it's not an instant-kill product, but its rapid acceleration after 24 hours points to strong ingestion activity once beetles resume feeding after the application. Additionally, these results suggest that Cormoran can be viewed comparably to Assail in flea beetle control capability. The 60-day PHI for water-harvested cranberry is restrictive for both products, but for early flea beetle pressure or late harvested beds, both products are worth consideration for July flea beetle control.

Esteem and Isarid did not demonstrate meaningful control of cranberry flea beetle in this lab screen. Esteem never achieved significant mortality compared to the untreated control at any timepoint, topping out at only about 22% dead beetles by day seven. Isarid performed even more slowly, showing no measurable effect until the final evaluation, where it reached roughly 48% mortality. This is far too late for practical use in managing adult outbreaks for growers during flea beetle emergence. These results indicate that neither product would provide the rapid knockdown needed during critical periods. In general, any active ingredient that does not achieve high mortality within three days in this lab assay does not typically deliver meaningful control of cranberry flea beetle in field conditions.

EVALUATING ALTACOR REDUCTION STRATEGIES FOR CRANBERRY FRUITWORM AND SPARGANOTHIS FRUITWORM MANAGEMENT IN WISCONSIN CRANBERRY

DAVE JONES, SARA POTTER, NATHAN FITZGERALD¹

¹Ocean Spray Cranberries Inc.

Objective

Evaluate alternative strategies to the standard two-Altacor management plan currently utilized on most Wisconsin cranberry marshes.

Justification

Current cranberry fruitworm and sparganothis fruitworm insecticide portfolios in Wisconsin are limited in diversity and are primarily reliant on Altacor (chlorantraniliprole). This product first came into the cranberry industry more than a decade ago and has since become a cornerstone material for cranberry fruitworm and sparganothis fruitworm management due to its bee-safe rating, strength of knockdown after application, and field longevity in the days following the application. This product's reputation as the gold standard for management of cranberry fruitworm and sparganothis fruitworm has led to a sharp reduction in other bee-safe materials used during bloom as well as a reduction in non-bee safe options used for the second application after bees are removed from the environment. This reduction in alternative chemistry use brings with it the concern of overuse over multiple years leading to the development of resistance in one or both of these pest populations. While there is currently no evidence that either pest has developed tolerance or resistance to either material, a preventative management plan is critical to preserve the longevity of one of the strongest materials that we have access to for control of these critical pests.

Approach

Two sites with historically high cranberry fruitworm pressure were selected, one in central and one in northern Wisconsin. Cranberry fruitworm and sparganothis fruitworm traps were deployed in the first week of June, 2025 at three separate monitoring locations across each marsh and were checked weekly through the conclusion of the experiment. All treatments listed below were applied at the maximum label rate in cranberry to six replicated 5ftx5ft square plots per treatment organized in an RCBD with three-foot walkways both between rows and between treatments within each row. A separate RCBD was used for the central and the northern site. The treatment bed

was an established bed of the Stevens variety at the central Wisconsin location and the Welker variety for the northern Wisconsin location. Treatment plots had the first insecticide for the assigned treatment applied at 70% out of bloom. For treatments with a second assigned insecticide (signified in the list below as the product listed after the "+" sign), the second treatment was applied 10 days later. Treatments were as follows:

1. Altacor eVo (chlorantraniliprole)
2. Altacor eVo (chlorantraniliprole) + Altacor eVo (chlorantraniliprole)
3. Altacor eVo (chlorantraniliprole) + Syngenta Product A
4. Altacor eVo (chlorantraniliprole) + Delegate (spinetoram)
5. Altacor eVo (chlorantraniliprole) + Actara (thiamethoxam)
6. Intrepid (methoxyfenozide)
7. Intrepid (methoxyfenozide) + Altacor eVo (chlorantraniliprole)
8. Intrepid (methoxyfenozide) + Syngenta Product A
9. Intrepid (methoxyfenozide) + Actara (thiamethoxam)
10. Esteem (pyriproxyfen)
11. Esteem (pyriproxyfen) + Esteem (pyriproxyfen)
12. Untreated Control

In mid-August 2025, all fruit from each of the 5x5 ft. square plots for all treatments were harvested. All infested berries were removed from each sample, counted, weighed, and characterized as infested by either cranberry fruitworm or sparganothis fruitworm. Any caterpillars found either dead or alive within berries were counted by treatment and identified by species. Data from all treatments were subjected to ANOVA, subsequent Bonferoni pairwise tests, and a ranked mean analysis.

Results

Products tested ranked consistently with one another across both sites in spite of higher base infestation levels overall at the northern site. The untreated control at both sites experienced the most severe pressure. The most effective product combinations were Intrepid + Altacor, Intrepid + Syngenta Product A, Altacor + Altacor, and Altacor + Syngenta Product A (Figures 3, 4, and 5). The least effective treatments in addition to the untreated control were Esteem, Intrepid + Actara, and Intrepid ([Figures 11, 12, and 13.](#))

Figures and Tables:

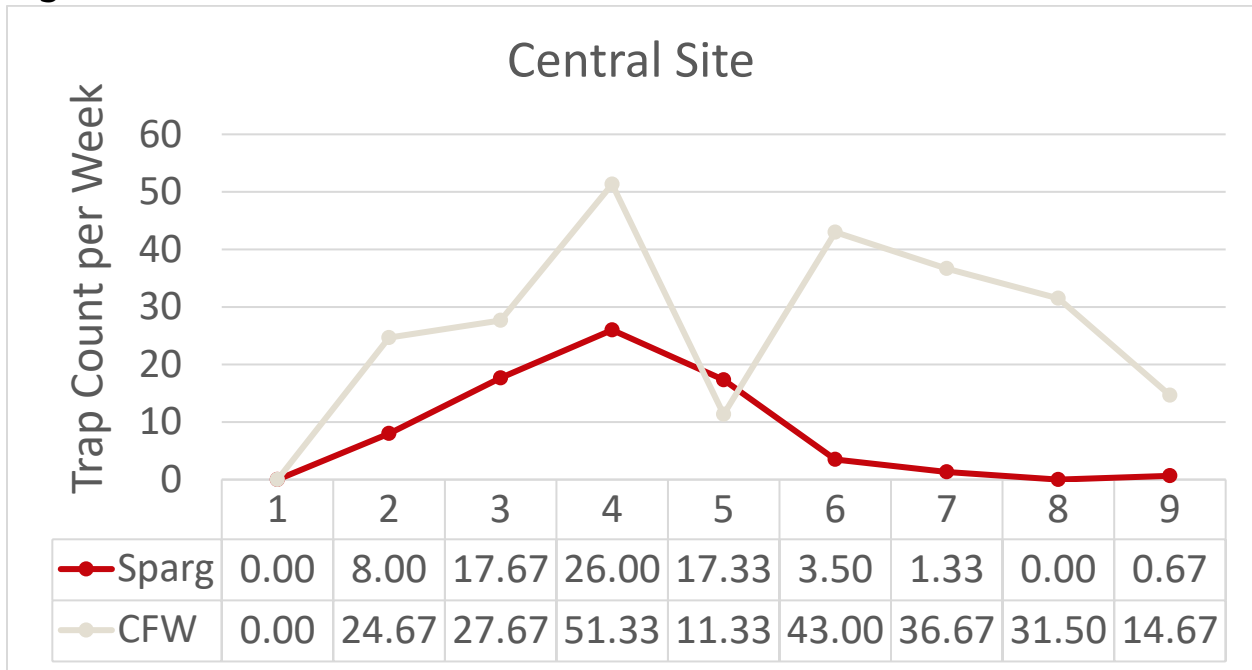


Figure 11 Average weekly flight totals for cranberry fruitworm and sparganothis fruitworm at the research marsh in central Wisconsin. Numbers peaked in the low 50s for cranberry fruitworm and in the mid-20s for sparganothis fruitworm. This flight data demonstrates that although the trial was designed for both cranberry fruitworm and sparganothis fruitworm, the 2025 data is predominantly reflective of cranberry fruitworm efficacy. This matches statewide trends in recent years.

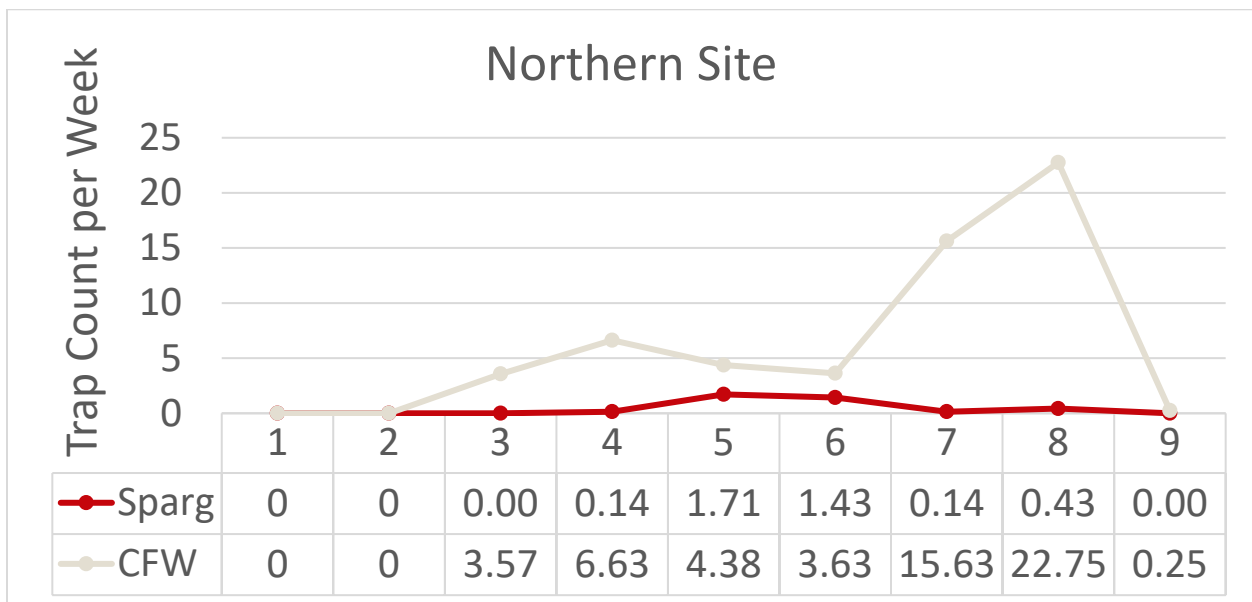


Figure 12 Average weekly flight totals for cranberry fruitworm and sparganothis fruitworm at the research site in northern Wisconsin. Average numbers peaked in the low 25s for this pest in 2025, with individual traps in one trap set peaking as high as 50 during peak flight. This flight data demonstrates that although the trial was designed for both cranberry fruitworm and sparganothis fruitworm, the 2025 data is predominantly reflective of cranberry fruitworm efficacy. This matches statewide trends in recent years.

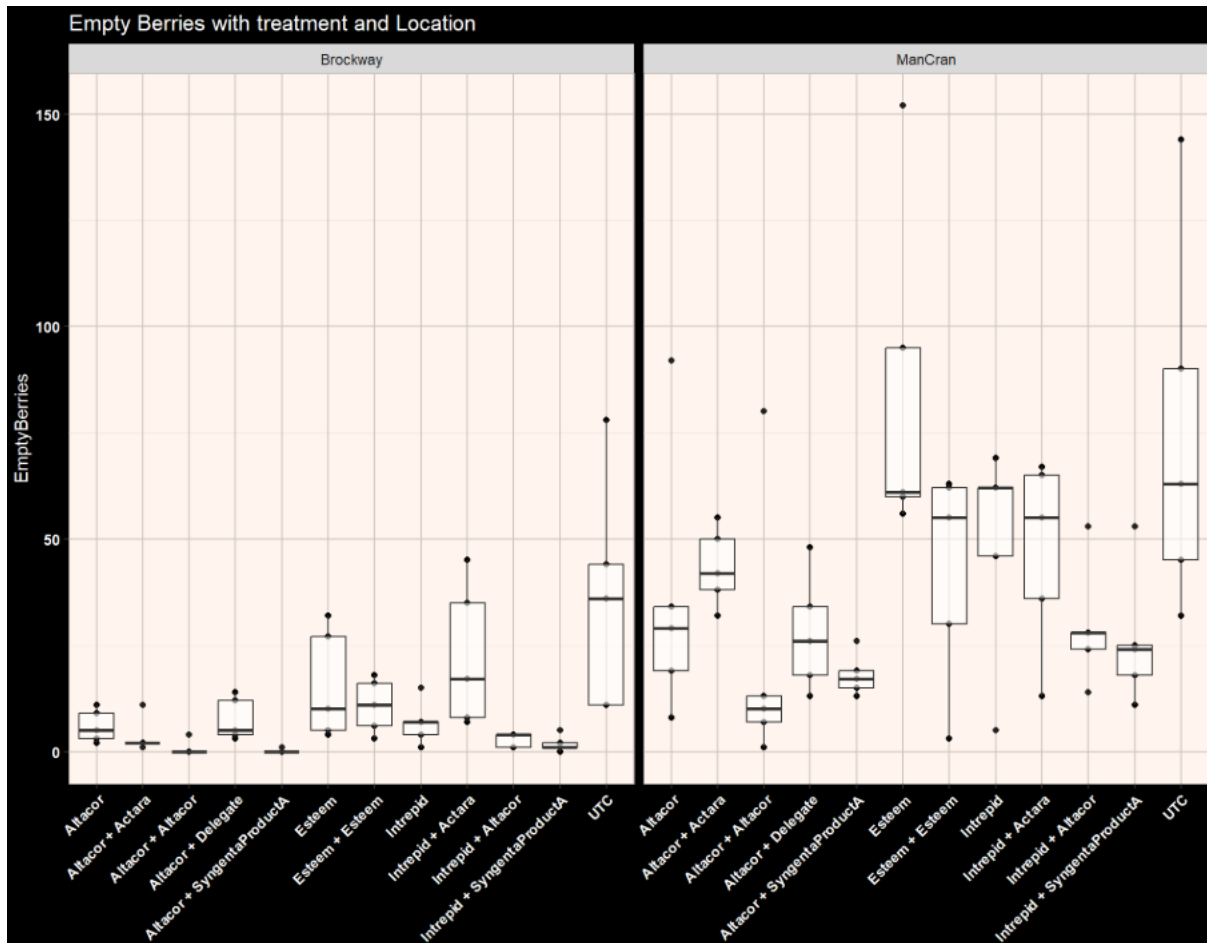


Figure 13 Box plot of empty berries by treatment at the central site (left) and the northern site (right).

Table 1 Bonferoni pairwise ranking of all treatments against one another pooled between the northern and central site at the 0.05 significance level.

Treatment	Avg. Empty Berries	Group
Untreated Control	55.4	A
Esteem	50.2	AB
Intrepid + Actara	34.8	BC
Intrepid	27.8	CD
Altacro eVo	26.7	CDE
Altacor eVo + Actara	23.5	CDE
Altacor eVo	21.2	CDE
Altacor eVo + Delegate	17.7	CDE
Intrepid + Altacor	16.1	DE
Intrepid + Syngenta Product A	14	DE
Altacor eVo + Altacor eVo	11.5	DE
Altacor eVo + Syngenta Product A	9.1	E

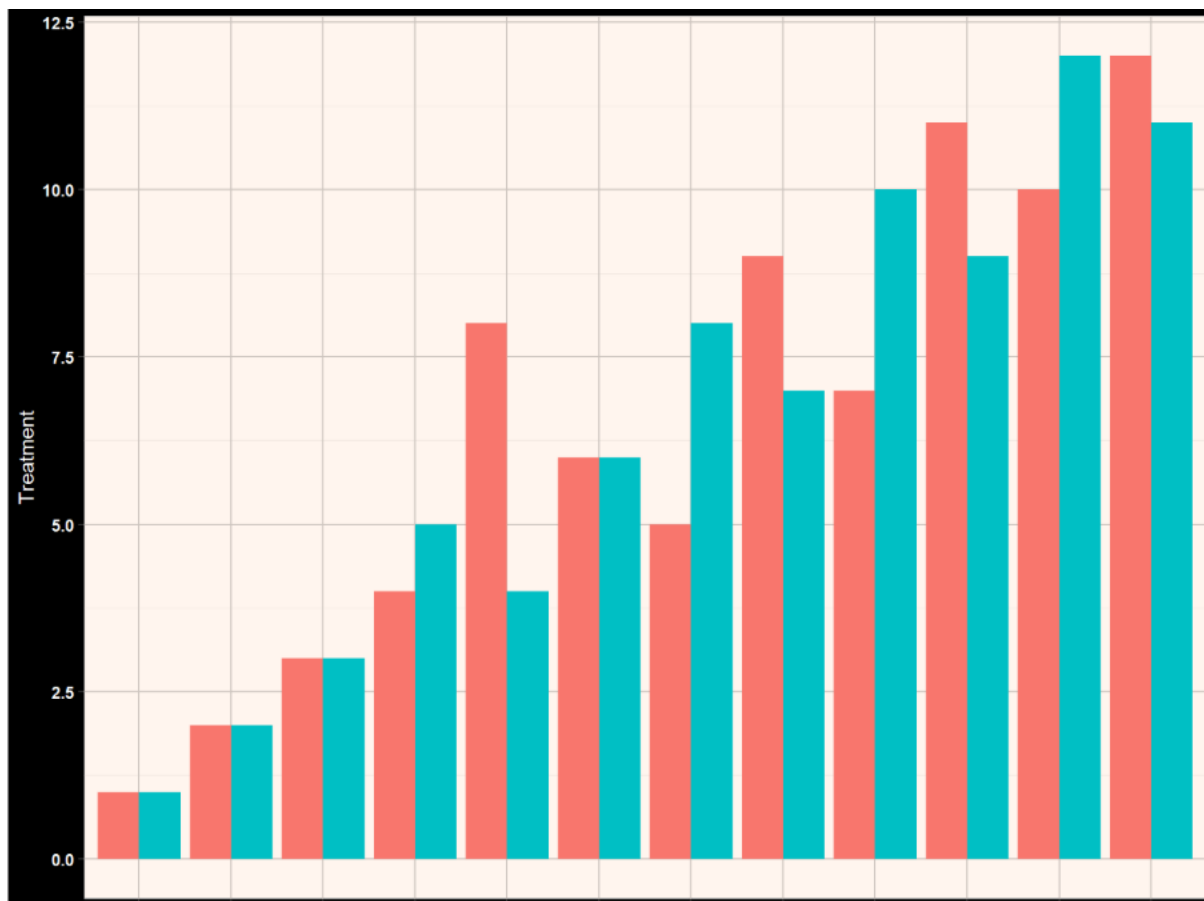


Figure 14 Ranked mean value of empty berries for each treatment and for each location. Note that “SPA” designates “Syngenta Product A.” Treatments, from left (lowest mean) to right (highest mean) are: Altacor + SPA, Altacor + Altacor, Intrepid + SPA, Intrepid + Altacor, Altacor + Delegate, Altacor single spray, Altacor + Actara, Esteem + Esteem, Intrepid single spray, Intrepid + Actara, Esteem single spray, Untreated Control.

Discussion

The economic threshold where a second application of Altacor or another insecticide will pay for itself is somewhat static by year and depends both on the price of the barrel, the price of the product itself, and on the size of an individual berry. Smaller berry varieties have a lower value per berry because each individual berry weighs less and growers are paid on weight of the crop. Conversely, a large-fruited variety like a Sundance or a Mullica Queen has a slightly higher per-berry value due to significantly higher average fruit mass. Also, consider current prices in Wisconsin in 2025 as considering the discussion below: Altacor eVO (\$42/A), generic Altacor (\$20/A), Delegate (\$50/A), Intrepid (\$25/A), and Actara (\$15). The following is a quick example of economic value assessment for a product in this study:

- To calculate this value for any product, divide one barrel by assumed price per barrel, and then multiply by the price point per acre for the product in question. This will give the number of barrels per acre that a product will have to protect to hit the break-even mark.
- Using Altacor to calculate this value: at a low price point of \$32/barrel for processed cranberries and taking the current cost of an application of Altacor eVo at \$42/acre, this means that an application of **Altacor eVo will have to protect AT LEAST 1.406 barrels of fruit/acre to pay for itself.**
- Now this can be used to make direct economic analysis within treatments in this trial. Assuming a 1.4 gram Stevens berry (a reasonable estimate in 2025 for the variety considering statewide data), consider a single application Altacor treatment that resulted in about 25 damaged berries per 5-foot square in northern Wisconsin. This comes to about one berry per square foot. An acre is 43,560 square feet, so assuming a 1.4 gram berry is infested in each square foot across the whole field that is $43,560 \times 1.4 = 60,984$ grams, or 134.4 pounds. That's 1.344 barrels per acre of loss when Altacor was sprayed one time. If a large-fruited modern hybrid is the variety of interest, simply insert 1.6-1.8 grams to this process for the per berry weight fruit estimate instead of 1.4 grams, which is a good average estimate for varieties like Mullica Queen and Sundance based on statewide data.
- Now, do this same calculation for the Untreated Control at the northern Wisconsin site. At about 76 berries per research plot or roughly 3.04 berries per square foot, it comes to $43,560 \times 3.04 \times 1.4 = 185,391$ grams, or 408.72 pounds per acre. That's a 4.08 barrel loss per acre in this treatment when nothing was sprayed at all.
- Finally, subtract the damaged berries from the treatment of interest (in this case, the single Altacor treatment example) from the damaged berries in the Untreated Control to see how much was saved with that application. $4.08 - 1.34 = 2.74$ barrels saved per acre with the Altacor. **That's about \$88 in berries saved per acre in a Stevens bed by applying the product compared to choosing to do nothing at all at a \$32/acre barrel price.**

When considering that adding a second application of Altacor 10 days later improves the fruit protected per plot by no more than 10-15 berries per plot even at the high-pressure sites in recent years, a very important point emerges. The point is this: **consider that in order to pay for itself, even at just a \$20 cost/application, a second follow-up application of any would have to save an additional 10-15+ berries per 25ft² research plot compared to the one-Altacor application to pay for itself.** So, unless a treatment shows a 10-15+ berry differential or greater compared

to a one-Altacor program, even at just an assumed cost of \$20/acre that second application has not paid its own bills (Figure 4).

In short, this simply isn't something that is consistently happening in Wisconsin in conventional processed acreage right now. Even at the worst site in this research, a second application of Altacor (or any other product) never improved the damage in a plot by more than about 10-15 berries per plot compared to spraying Altacor one time. This is critical to consider as a grower because at current market price for a barrel of cranberries, there is a huge difference between a *statistically* significant difference and an *economically* significant difference. An economic analysis when current market prices are considered paints a much different picture of current best management practice and shows us that in current market pricing, a two-spray program should be considered a luxury program reserved only for high value fresh fruit or extremely high-pressure sites, which have become rare in conventionally managed acreage in Wisconsin. The average conventional processed grower in Wisconsin simply isn't capturing profit with second applications in the current economic climate.

The common grower practice of continuing to make two Altacor applications each season and the unwillingness to tolerate as much as a berry or more per square foot across a bed is understandable since cranberry is a high value specialty crop. Certainly, at \$45-50+ a barrel growers would be having a different discussion today. However, until the price improves past the low \$30s, growers should consider that the crop is simply not worth enough right now to spend extra money on two insecticides for the cranberry fruitworm and sparganothis fruitworm complex unless pressure is abnormally high. At a time when growers are consistently asking for research to improve the economics of cranberry production, it is valuable to consider that based on research years of research, the average grower in Wisconsin using two applications of Altacor eVo every year can likely cut out a significant pesticide expense and still come out at least \$20-30+/acre ahead.

This data pattern also makes sense when considering base flight pressure and the historical reason that two-spray programs were originally developed for Wisconsin. Two spray programs for cranberry fruitworm and sparganothis fruitworm were designed with the key assumption that the field has a high population of both cranberry fruitworm AND sparganothis fruitworm. This is not a trend that was observed in this year's studies or in recent years. Cranberry fruitworm is historically low statewide against historical data, and sparganothis fruitworm is lower still, well below the economic threshold for even one application of sparganothis fruitworm insecticide.

This considered, there are two final points that should be considered from this and the past several seasons of work by this program. The first point of note from this work is that there are opportunities in the industry using both existing products and incoming registration to skip Altacor entirely for a season, or at the very least to cut it down to just one use per season. This saves both money and rotates the product, reducing the risk of Altacor resistance. Syngenta Product A performed exceptionally well when applied 10 days after an initial application of Intrepid at 70-80% out of bloom. **This program eliminated Altacor entirely and achieved a comparable result to using Altacor TWICE.** Syngenta Product A is not safe for bees, but if applied after the bees are removed from the system approximately 10 days after an initial application of Intrepid at 70-80% out of bloom, this product has the potential to significantly reduce reliance on Altacor each season and provide an option to rotate out of the product. It also performed exceptionally well when paired with an initial application of Altacor, outperforming all other treatments in this trial. This could reliably cut growers who insist on spraying twice for fruitworm regardless of pressure from two down to one Altacor application, taking further pressure off of the product. Both Intrepid and Esteem paired with a non-bee safe product need to be explored further based on results in 2025. Future efforts will also investigate Esteem at 70% out of bloom followed by either Altacor or Syngenta Product A applied 10 days later.

The final point to be made is that Actara is the weakest follow-up spray tested after an initial application of either Intrepid, Altacor, or Esteem compared to other options. It is also the cheapest at \$15/acre, and hits early cranberry flea beetle, which is one reason growers have become more interested in it in recent years, and some have started trying to use this product after the bees go to hit late fruitworm and early flea beetle at one go. However, based on results in recent years growers should note that the product is substantially weaker to second applications of Altacor against cranberry fruitworm and did not achieve a significant improvement over a single application of the respective first product at either site. In short, there hasn't been convincing evidence in recent years that applying Actara for cranberry fruitworm after the bees leave is any better than doing nothing at all. This product is best left on the shelf for fruitworm control and reserved strictly for cranberry flea beetle rather than an attempt at late cranberry fruit worm control.

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HOW CLIMATE VARIABILITY COULD CHANGE DISEASE PRESSURE IN CRANBERRIES

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Introduction

Growers across Wisconsin increasingly report that disease pressure in cranberry does not behave the same way it did several decades ago. Rather than a consistent increase in disease severity, the dominant challenge is increased variability in weather conditions from year to year. This variability complicates disease prediction, fungicide timing, and overall management reliability. Climate variability, defined here as shifts in temperature and precipitation patterns and the widening range of conditions experienced between seasons, has become a key driver shaping disease risk.

Why Climate Matters for Disease

Wisconsin cranberry production is experiencing warmer winters, heavier rainfall events, and greater year-to-year variability. Disease pressure is not necessarily higher every year but is far less predictable. Climate affects when infections occur, which pathogens dominate in a given year, and how well management tools perform. As a result, disease risk, timing, and consistency of control have become more difficult to anticipate.

Climate and the Disease Triangle

Plant disease is governed by interactions among the pathogen, host, and environment. Climate variability primarily alters the environmental component of this relationship by influencing leaf wetness, canopy humidity, vine stress, and overwintering survival. Consequently, the same cranberry bed managed with the same program may produce very different disease outcomes from one year to the next.

Fruit Rot: A Climate-Sensitive Disease Complex

Cranberry fruit rot is particularly sensitive to climate because it is caused by a complex of fungal pathogens. Infections often occur early in the season but may not become visible until late summer or fall. Wet bloom conditions promote latent infections, while warm, wet late-season weather favors symptom expression. Mild winters may increase overwintering inoculum, further elevating risk in subsequent seasons.

Management Implications for Fruit Rot

Traditional calendar-based fungicide programs are becoming less reliable under variable conditions. Fungicide performance can vary dramatically between years, and

dominant pathogens may shift season to season. Greater emphasis should be placed on bloom timing relative to weather, canopy drying, rotation of fungicide modes of action, and cultural practices that reduce humidity within the canopy.

Viruses: Indirect Climate Effects

To date, there is no evidence that cranberry viruses such as Blueberry shock virus or Tobacco streak virus are directly driven by weather. However, climate may indirectly influence virus dynamics by affecting vector populations and plant stress. Warmer winters may enhance vector survival, and longer growing seasons may extend periods of vector activity. Symptom expression may increase under stress even when infections occurred years earlier.

False Blossom Disease

False blossom disease differs from other diseases discussed here because it is caused by a phytoplasma and spread by the blunt-nosed leafhopper. Potential climate connections include earlier vector movement during warm springs, higher vector survival following mild winters, and denser canopies during wet springs that complicate scouting. Disease spread depends on synchrony among the vector, host, and pathogen, making timing of management critical.

Regional Differences within Wisconsin

Climate impacts are not uniform across Wisconsin. Central Wisconsin typically experiences higher humidity and more prolonged wetness, increasing fruit rot risk during wet years. Northern Wisconsin often has cooler nights and sometimes lower fruit rot pressure, though virus and false blossom risks may increase as warming trends continue. Local weather history and site-specific conditions must be considered when making management decisions.

What Growers Can Do

In the short term, growers should focus on bloom-based decision making, avoid repeated use of the same fungicide groups, and improve canopy drying where possible. Medium-term strategies include tracking problem beds year-to-year and integrating cultural and chemical tools based on weather patterns rather than calendar dates. Long-term resilience will depend on clean planting material, support for breeding resistant cultivars, and preparation for continued variability.

Ongoing Research

Current research efforts focus on identifying which fruit rot fungi dominate under different environmental conditions, improving diagnostic tools and risk prediction,

refining false blossom detection and management strategies, and determining virus prevalence and cultivar susceptibility across Wisconsin.

Summary

Climate variability, rather than uniform warming, is reshaping disease dynamics in Wisconsin cranberry production. Fruit rot, viruses, and false blossom respond differently to changing conditions, underscoring the need for integrated, flexible, and region-specific disease management programs.

ECONOMICS OF CRANBERRY FRUITWORM MANAGEMENT IN MODERN PEST PRESSURE CONDITIONS

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Abstract

Trial data collected through the Wisconsin Cranberry Insecticide Screening Program (WI-CISP) in recent years has shown consistent, separable differences between industry “gold standard” two-spray programs for cranberry fruitworm and sparganothis fruitworm. A significant number of growers statewide are consistently applying Altacor (chlorantraniliprole) two times per year, every year. However, a deeper dive into the quantity (and economic value) of fruit protected by the second spray currently included in many spray programs often tells a different story. There is consistently a difference between statistical significance and economic benefit when considering the second spray in modern two spray programs.

Cranberry fruitworm and sparganothis fruitworm flight pressure is historically low in the 2020s. Pest pressure dynamics have changed as flights have steadily fallen lower in recent years, and so too has the “worst case scenario” for attack by these pests. Over a two-year span, the worst damage suffered from cranberry fruitworm in any research site was 76 berries per 25 square feet. At a 1.4 gram Stevens berry, this is about just over 400 pounds per acre, or 4.08 barrels destroyed per acre when no control was deployed. This number would be closer to 4.7-5 bbl if the bed was a large-fruited modern hybrid. While this is not acceptable loss to any grower and is easily enough to justify insecticide application, this highlights how far the industry has come from the days when 40-50% of the fruit in a bed could be destroyed by cranberry fruitworm in a single season. In those days, flights would peak at 150-200+ moths/trap/week for both sparganothis fruitworm and cranberry fruitworm. Today, most marshes rarely see cranberry fruitworm flights over 50-60 moths/trap at peak. Sparganothis fruitworm is

less relevant, having been particularly impacted by the introduction of Fanfare (bifenthrin) since the first generation gets treated with the product before bloom. Northern Wisconsin has never had issues with this pest and central Wisconsin now averages roughly 25-30 sparganothis fruitworm/trap/week during the peak flight of the first generation. In short, Wisconsin has become a fruitworm-centric management system as opposed to a sparg + fruitworm system, and fruitworm flights have never been lower.

This matters when considering how much "extra" fruit is being protected with a follow-up application in modern systems with this lower grade pressure. Consider table 1 below, representing aggregate data from two high-pressure sites in 2025. The Altacor eVo treatment alone resulted in 21.2 infested berries per 25-foot square plot, or a little bit less than 1 berry per square foot. Now consider that at a per barrel price point in the low \$30s, any second spray would have to protect an extra 10-15 berries per plot MORE than the 21.2 protected by the one application of Altacor to hit a hypothetical \$25 dollar/acre product breakeven point (the infested average infested berries/plot need to be at least 10-15 smaller than 21.2 on the table). In short, this is not consistently happening in Wisconsin at trial sites. Even the best treatment combination in 2025 (Altacor + Syngenta Product A) improved outcome by just over 11 berries per plot compared to using Altacor eVo one time at 70% out (Figure 1). Also consider that trial sites selected for WI-CISP are specifically selected for high insect activity. If minimal economic benefit is consistently being observed at high pressure sites, most commercial growers will expect even less.

There are still some growers who will benefit from spraying two times for cranberry fruitworm. Those with abnormally high flights (particularly in large-fruited modern hybrids) or high value fresh fruit may need to continue the practice. But at the current price point on a barrel of conventional processed fruit, the majority growers in Wisconsin have an opportunity to at least consider the idea that taking applications down to a single, well-timed application of Altacor at around 70% out of bloom. This practice can save significant money during a challenging economic time.

Table 2 Aggregate data from 2025 showing average empty berries in a 25ft² research plot by treatment. All initial treatments (the first product listed) were applied at 70% out and the second product (listed after the "+" sign, where applicable) were sprayed 10 days later

Treatment	Avg. Empty Berries	Group
Untreated Control	55.4	A
Esteem	50.2	AB
Intrepid + Actara	34.8	BC
Intrepid	27.8	CD
Altacro eVo	26.7	CDE
Altacor eVo + Actara	23.5	CDE
Altacor eVo	21.2	CDE
Altacor eVo + Delegate	17.7	CDE
Intrepid + Altacor	16.1	DE
Intrepid + Syngenta Product A	14	DE
Altacor eVo + Altacor eVo	11.5	DE
Altacor eVo + Syngenta Product A	9.1	E

AI: WHAT IS, WHAT ISN'T, AND WHAT MAY BE

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Artificial intelligence (AI) is making headlines in agriculture, but it's not magic or brand new. AI is pattern recognition software that learns from examples. It's why your bank knows when your credit card number has been stolen and why your noise-cancelling headphones seem like magic. In agriculture, it's become increasingly useful thanks to cheap computing, widespread cameras and sensors, cloud storage, and better internet access.

There are two major types of AI used in agriculture. First, 'Operational AI' focuses on field-level tasks such as frost prediction, plant stress detection, or yield estimation. These models use data like weather history, drone imagery, or proximal sensors (e.g., temperature, moisture) to predict or classify. For example, an AI frost model trained on years of Wisconsin spring frost events can help growers plan protection more precisely. The second type, 'Language AI,' refers to large language models (LLMs) like ChatGPT, which excel at summarizing, organizing, and drafting text based on your inputs. These models are especially helpful in the office, not the field.

At the Wisconsin Cranberry School, NotebookLM—an experimental tool from Google—was used to summarize sessions and even generate a podcast-style audio summary. By

feeding it conference notes, the tool quickly produced readable overviews and organized content for inquiry. Similar language AI tools can help growers summarize scouting reports, organize handwritten notes, or query historical records. The key benefit is time savings and better access to information already in your system.

AI is most useful in familiar situations. For example, a frost model trained on calm, clear nights may predict well under similar conditions but could misjudge an advective freeze. Grower experience is still crucial, especially in edge cases. It's wise to treat AI as a decision support tool, not a fully autonomous system.

When evaluating AI tools, growers should ask: What data is it using? Was it trained on cranberries or a similar crop? Does it continue learning? What happens in unusual conditions? Can I verify its accuracy? Be wary of vague or overly broad claims, such as 'works everywhere' or 'fully automatic'. Good AI is transparent, focused, and grower-driven.

Getting started with AI doesn't require a tech overhaul. To begin adopting AI, start by building your own training dataset. Continuing our frost example, one could invest in reliable weather stations and consistently record frost observations. For a yield and development model, one could note key cranberry physiological stages—such as dormancy break, bud emergence, bloom, berry set, and signs of rot. These data could then be paired with observations from remote or proximal imagery, such as drone or satellite imagery, to build a predictive model.

In conclusion, AI isn't replacing growers; it's extending their expertise. With smart adoption and clear boundaries, AI can help cranberry producers make more confident, timely decisions while preserving the insight that comes from walking the beds and knowing the crop.

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Poster Sessions

ADVANCING FALSE BLOSSOM DIAGNOSIS AND VIRUS DETECTION IN CRANBERRIES: TOOLS AND INSIGHTS FOR GROWERS

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Cranberry production in Wisconsin has recently experienced renewed concerns surrounding virus incidence and cranberry false blossom disease (CFBD), both of which can contribute to reduced yield, poor fruit set, and long-term vine decline. However, limited data exist on virus prevalence across cultivars and the expression of CFBD symptoms under current production conditions. The objectives of this study were to (i) assess the prevalence of Blueberry shock virus (BSV) and Tobacco streak virus (TSV) in Wisconsin cranberry production systems and (ii) document CFBD symptomology to improve field diagnosis and scouting recommendations for growers.

During the 2025 growing season, a total of 249 cranberry plant samples representing 17 cultivars were collected from commercial production beds across Wisconsin. Samples were collected primarily in July following fruit set, when symptoms were most apparent, and were pooled by bed, resulting in 150 composite samples. All samples were screened for BSV and TSV using molecular diagnostic assays. Overall, 61% of pooled samples tested positive for at least one virus, with 32% positive for TSV, 27% for BSV, and 2% exhibiting co-infection. Virus incidence differed by cultivar, with 'Mullica Queen' showing higher TSV prevalence and 'Stevens' exhibiting higher BSV incidence.

In parallel, CFBD symptoms were documented across affected beds, including floral disfigurement, phyllody, virescence, upright elongation, witches' broom, poor fruit set, and early fall reddening. Symptoms were most visible from late spring through early summer but persisted into later portions of the season. Together, these findings highlight the widespread presence of cranberry viruses in Wisconsin and reinforce the importance of accurate diagnosis, targeted scouting, and continued research to support informed disease management decisions.

OPTIMIZING PHOSPHORUS USE IN CRANBERRY PRODUCTION

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Existing phosphorus (P) fertilizer recommendations for cranberry are decades old and merit reconsideration in light of increased fruit yields, increasing production costs, and implications for water quality. In older cranberry beds, legacy P accumulated from prior fertilizer applications might sustain current fruit production and allow for decreased fertilizer input. We partnered with three commercial cranberry growers to conduct P rate trials across beds of differing age (3 to 19 years since establishment), all planted with 'Mullica Queen'. Each bed was split into six plots (0.2 to 0.7 ac, depending on bed size) and each plot was randomly assigned to one of the following treatments: 0, 23, 46, 69, 92, or 115 lb ac⁻¹ of P₂O₅ as triple superphosphate (0-46-0) applied in late May or early June by growers using their equipment. Nitrogen was applied separately at grower standard rates in a fertilizer form that contained no P. Before P fertilizer application, soil test P (Bray extraction) averaged 72 ppm and did not differ consistently between 0-6 in and 6-12 in depths among marshes. Even in recently established beds, there was substantial legacy P below the fresh sand layer. The P concentration of leaf tip samples collected in late August increased strongly with P fertilizer application (*P* value < 0.01 at all marshes) and showed no relationship with bed age. All samples were in the "sufficient" range (> 0.1% P). The P concentration of harvested fruit also tended to increase with P fertilizer application, although trends were weaker than observed for leaf tip samples (*P* values 0.04 to 0.19 among marshes). Fruit yield did not respond to P fertilization at any marsh, but a yield response was not necessarily expected during the first year of this study. These initial results provide evidence for "luxury consumption" of P, whereby the cranberry plant can take up more P than immediately needed for fruit production. We will continue this work in subsequent years to further evaluate relationships among soil P, leaf P, and optimum P application rates.

PLANT-PARASITIC NEMATODES IN CRANBERRY

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Nematodes are microscopic, non-segmented roundworms that are among the most abundant animals on Earth, occurring almost everywhere, including soil, freshwater,

oceans, deserts, and extreme habitats. An estimated 100 billion nematodes can occur per acre in the top 15 cm of agricultural soil, representing a substantial component of soil biomass. Most nematodes are non-parasitic and free-living, feeding on bacteria around soil particles playing beneficial roles in soil food webs. Consequently, nematode abundance and diversity are widely recognized as indicators of soil health. However, some nematodes are plant-parasitic, causing significant agricultural losses worldwide, estimated at approximately \$100 billion annually. Plant-parasitic nematodes (PPN) feed on plant roots using a needle-like mouthpart, resulting in reduced root function, impaired water and nutrient uptake, and increased plant stress. PPN tend to thrive in sandy, acidic soils (pH 4.5–6.0), typical of cranberry beds. Because nematodes move only short distances on their own, their distribution within beds is strongly influenced by soil and water movement, leading to patchy infestations. Here we focus on four PPN relevant to cranberry production, listed from highest to lowest relevance: root-lesion, stubby root, sheath, and ring nematodes. For each group, we summarize key symptoms observed in cranberry beds, host associations, and biological traits that influence persistence and damage potential. Although nematode injury in cranberry typically appears as patchy vine decline, chlorosis, reduced root growth, and gradual yield loss, these nonspecific symptoms are easily confused with nutrient deficiencies or other stressors. Therefore, growers are advised to clean equipment between beds, manage weeds that host PPN, use clean planting materials, and use approved soil treatments according to state guidelines, to prevent and manage nematodes for long-term cranberry bed productivity.

UNSEEN ALLIES: HOW BACTERIAL AND FUNGAL DIVERSITY SUPPORTS CRANBERRY GROWTH?

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Cranberry (*Vaccinium macrocarpon* Ait., $2n = 24$) is a high-value horticultural crop adapted to unique acidic soil environments and widely recognized for its rich phytochemical profile and health-promoting properties. Over evolutionary time, plants have developed intimate and reciprocal relationships with root-associated bacteria and fungi, shaping mutual adaptation to edaphic and environmental conditions. These beneficial plant-microbiome associations play critical roles in nutrient acquisition, plant growth promotion, stress tolerance, and pathogen suppression. Understanding

rhizosphere microbial diversity is therefore essential for developing management practices that support beneficial microbial communities and improve cranberry productivity. In this study, we assess bacterial and fungal diversity in cranberry rhizosphere soils across contrasting pH conditions and identify dominant microbial taxa with functional and ecological significance. Physicochemical analyses revealed substantial differences between acidic and alkaline soils. Low-pH cranberry rhizosphere soils were dominated by acidophilic bacterial groups, including *Acidobacteria*, *Mucilaginibacter*, *Sphingomonas*, and *Acidothermus*, along with diverse beneficial fungi such as ericoid mycorrhizal (ErM) fungi, *Archaeorhizomyces*, *Mortierella*, *Solicoccozyma*, *Serendipita*, *Clavaria*, and members of Helotiales. Together, these microbial taxa contribute to efficient nutrient cycling, enhanced stress tolerance, and improved plant productivity under acidic soil conditions. In contrast, high-pH soils exhibited an increased abundance of Nitrospirae and Thaumarchaeota, microbial groups that promote nitrification through the conversion of ammonium to nitrate, leading to increased vegetative upright growth and reduced yield in cranberry. Elevated pH conditions also favored various opportunistic and pathogenic fungal taxa, including *Fusarium*, *Talaromyces*, *Neonectria*, and members of Pleosporales. As soil pH increased, the strong competitive advantage of acidophilic microbial communities diminished, likely compromising plant health and nutrient use efficiency and contributing to the observed decline in yield in high-pH plots compared to acidic controls. Further, laboratory experiments revealed two most promising ericoid mycorrhizal fungi *Hyaloscypha* and *Oidiodendron* maintained high biomass across pH treatments, while significantly acidifying their surrounding environment. These findings indicate that ErM fungi contribute to maintaining favorable rhizosphere conditions and could be incorporated into targeted microbiome-based management strategies for cranberry production.

WHAT IS IN A CRANBERRY: DIFFERENCES AMONG THE CULTIVARS

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Cranberry (*Vaccinium macrocarpon* Ait.) is widely recognized for its distinctive tart flavor and health-promoting phytochemicals, yet substantial variation exists among cultivars in sugar-acid balance and bioactive compound composition. Understanding these differences is critical for improving fruit quality and guiding breeding and utilization strategies. In this study, we investigated flavor-related traits and health-

associated metabolites across multiple cranberry cultivars and developmental stages to characterize cultivar-specific differences in sweetness, acidity, and phytochemical profiles.

Fruit from six cranberry cultivars—Stevens, Sundance, Mullica Queen, Crimson Queen, Haines and Sweetie—were sampled at four developmental stages (pea, sizing/blush, half-color, and mature). Soluble solids content (°Brix) and titratable acidity (TA) were quantified to assess sweetness, sourness, and sugar–acid balance. Additionally, a broader analysis of sugar–acid relationships was conducted using a panel of 280 cranberry genotypes at harvest. Untargeted metabolomic profiling was performed to evaluate chemical diversity and identify major classes of health-related compounds.

Across all cultivars, °Brix increased with fruit maturation, while TA remained relatively high, resulting in consistently low Brix/TA ratios characteristic of cranberry's intense tartness. Cultivar differences were evident: Sweetie and Stevens exhibited higher Brix levels and more favorable sugar–acid ratios at maturity, indicating improved flavor balance, whereas Crimson Queen showed the highest acidity and lowest Brix/TA ratio, contributing to a more sour sensory profile. Analysis of the 280-genotype panel revealed a weak but significant negative correlation between sugar and acid levels, suggesting partial physiological trade-offs between these traits.

Metabolomic analysis identified 1,483 compounds spanning 13 chemical classes, with flavonoids representing the most abundant group. Notable cultivar-specific differences were observed among health-related compounds. Mullica Queen contained the highest anthocyanin levels, Haines exhibited elevated proanthocyanidin and ursolic acid concentrations, and Crimson Queen and Sundance showed higher flavonol content. Vitamin C levels were relatively consistent across cultivars.

Together, these results demonstrate substantial genetic and developmental variation in cranberry flavor chemistry and phytochemical composition. This work provides valuable insights for breeding programs targeting improved flavor balance while maintaining or enhancing nutritional quality, and supports cultivar-specific applications in cranberry product development.

WHO LIVES IN CRANBERRY SOIL: BACTERIAL ISOLATES FROM OUR PROJECT

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Soils contain bacterial communities that provide essential benefits to plants. To utilize these beneficial microbes, we collected samples of cranberry roots, soils, and leaves, and isolated the associated bacteria. Some of the bacteria species we isolated have demonstrated plant-beneficial properties in other cropping systems. *Pseudomonas protegens*, inhibits growth of a fungal pathogen in grape leaves (Andreolli et al, 2019). *Bacillus amyloliquefaciens* can enhance plant stress tolerance, particularly salt and drought stress (Zalila-Kolsi et al, 2023). *Klebsiella variicola* has been observed to act as a biofertilizer, fixing nitrogen, solubilizing organic and calcium bound phosphorus (Wang et al, 2022). Particularly relevant to the cranberry system is *Chromobacterium vaccinii*, which is a promising biocontrol species originally isolated from a cranberry marsh and named for its host plant (Soby et al, 2013). *Burkholderia alba* is one species which has not yet been observed to be plant growth promoting but based on genetic studies it is likely to fix nitrogen, solubilize phosphorus, and produce root growth promoting hormones (Feng et al, 2025). Our goal is to evaluate our cranberry-collection isolates of these species for their ability to improve nutrient availability and reduce fertilizer dependence in commercial cranberry production.

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