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Editor

Generating Genetic Resources and Developing Cranberry Breeding Systems in the Cranberry Genetics and Genomics Lab (CGGL)

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The projects completed in the Cranberry Genetics and Genomics Lab (CGGL) during 2014 represent a critical leap in the development of a cranberry state-of-the-art marker assisted selection (MAS) program in Wisconsin. Cranberry genetic improvement has traditionally been slow and has not utilized genetic or genomic resources. As a result, the cranberry industry relies on only a handful of cultivars which are wild selections or 1st or 2nd generation hybrids of those wild selections (Table 1).

Table 1. Origin and release date of commercial cranberry cultivars

Cultivar	Type	Origin	Release
McFarlin	wild selection	MA, USA	1874
Searles	wild selection	WI, USA	1893
BenLear	wild selection	WI,USA	1901
Stevens	1st Generation Hybrid	USDA-ARS	1950
LeMunyon	wild selection	NJ, USA	1960
HyRed	2nd Generation Hybrid	UW-Madison	2003
GH1	1st Generation Hybrid	Grygleski	2004
Crimson Queen	2nd Generation Hybrid	Rutgers	2006
Demoranville	2nd Generation Hybrid	Rutgers	2006
Mullica Queen	2nd Generation Hybrid	Rutgers	2007
Sundance	2nd Generation Hybrid	UW-Madison	2011
BG	2nd Generation Hybrid	Grygleski	2012

Table 1. Shows the origins and release dates of commercial cranberry cultivation.

Figure 1. Example of 1ft x 1ft cranberry test plots intensively managed by grower collaborator and individually evaluated by researchers for various traits of importance.

Compared to almost all other commercial plant species, cranberry is relatively undomesticated and unselected. Because it is a perennial asexually propagated crop, cranberry genetic improvement has relied on phenotypic selection in very slow cycles that have released cultivars in 25 year intervals. The main cause of these intervals is the need to establish long term test plots of experimental hybrids in grower's marshes which are then phenotypically evaluated for nearly a decade. These test plots require intensive and expensive management techniques in order to ensure their long term genotypic purity (Figure 1).

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Generating Genetic Resources and Developing Cranberry Breeding Systems in the Cranberry Genetics and Genomics Lab (CGGL)

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In order to circumvent this problem of long interval selection cycles, a cranberry marker-assisted selection (MAS) program is being established at UW-Madison. Combined with a field-independent high throughput phenotyping system (Zeldin, unpublished), the MAS is a system that will allow UW researchers to increase breeding efficiency by using genetic information to predict a cranberry seedling's yield potential, vigor, disease resistance, fruit quality, or etc. prior to planting that seedling in the field for evaluation.

<u>In general there are three main components of a MAS program:</u>

1.) A set of genetic resources which includes molecular markers placed on a genetic map.

2.) Identification of genes associated with important agronomic traits using the molecular markers and genetic map.

3.) A system to follow the inheritance of the markers associated with traits of interest using the molecular markers and genetic map.

In the past year, more than 500 novel SSR markers have been developed and validated in the CGGL (Schlautman et al., 2015). These markers will serve as important landmarks in a cranberry SSR based genetic map as the Zalapa lab begins to search for the locations of genes involved in various traits of agronomic importance. Additionally, more than 373,639 single nucleotide polymorphisms (SNPs) have been identified using genotyping-by-sequencing technology and are being integrated into the SSR genetic map to continue the search for important genes to incorporate in a cranberry MAS program (Figure2).

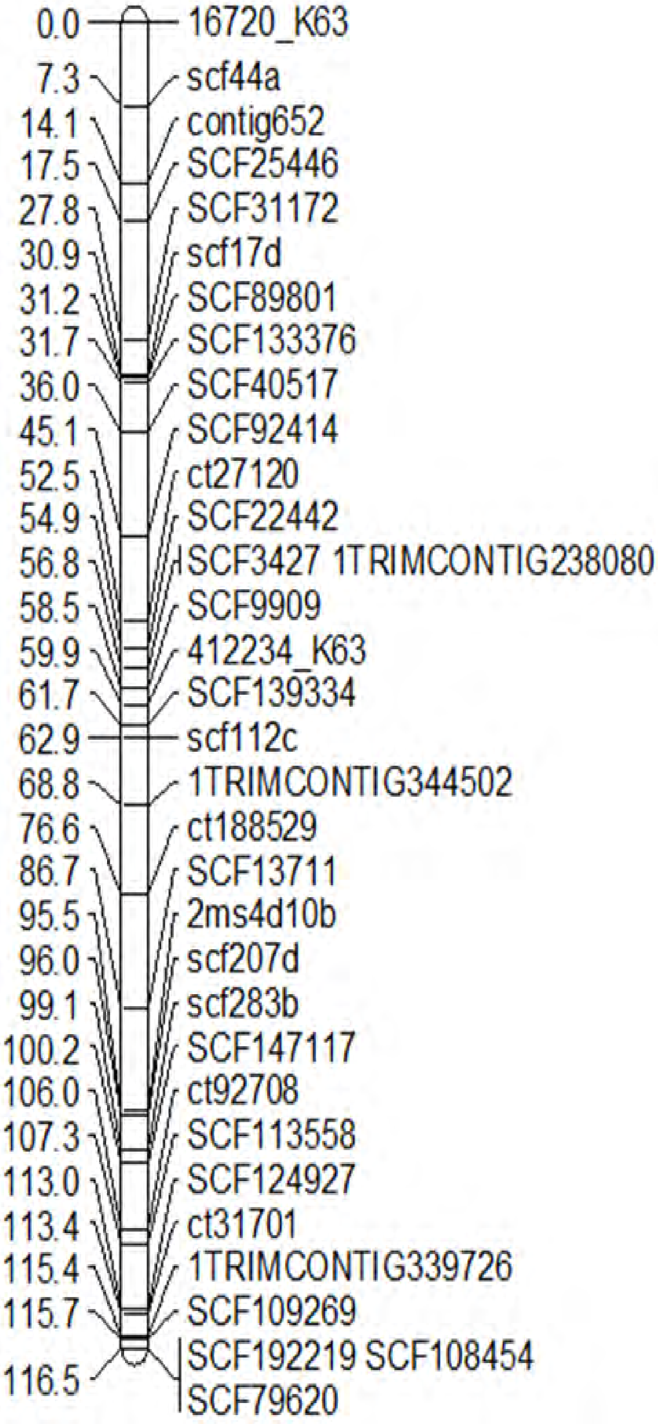

Figure 2. Example of a linkage group in the cranberry genetic linkage map. Vertical bar in the center represents a cranberry chromosome. Marker names are located on the right side of the chromosome and the markers genetic position (cM) is on the left side.

Generating Genetic Resources and Developing Cranberry Breeding Systems in the Cranberry Genetics and Genomics Lab (CGGL)

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One of the biggest limitations to establishing a MAS program is the identification of genes associated with important agronomic traits. In order to effectively perform this step, it is vital that cranberry researchers collaborate among themselves, growers, and industry leaders in deciding which traits are in most need of immediate improvement, and then additionally in designing methods for identifying and analyzing variation in the traits of interest.

Identifying molecular markers and/or genes linked to or associated with the trait of interest is usually accomplished using one of two methods: quantitative trait loci (QTL) mapping or association mapping. Both methods require large numbers of replicated test plots within controlled environments, and this process can take 3 or more years of phenotypic evaluation.

New additions to the CGGL in 2014 brought new ideas and expertise for designing more efficient phenotypic evaluation techniques. Specifically, by experimenting with imaging technologies for measuring traits such as plant vigor, fruit color, fruit size, and fruit shape, the program has expanded its capacity to analyze more plants each year (Figure 3).

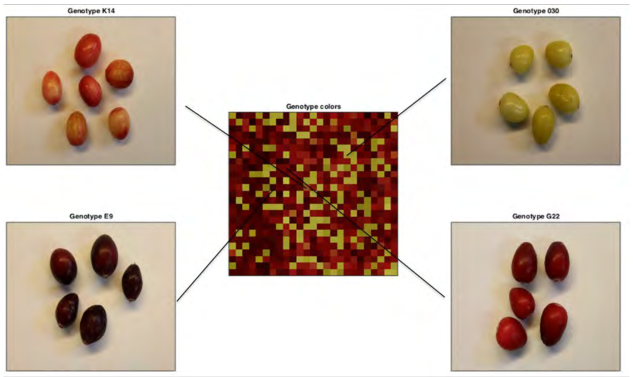

Figure 3. Example of using imaging technology to predict fruit size, shape, color, volume, and uniformity

In addition to our measurements of traits such as TAcy, Brix, and titratable acid to identify genotypes with improved fruit quality for juice and sweetened dried cranberries (SDCs), the CGGL has begun to develop methods for using a texture analyzer to measure variation in cranberry fruit firmness for use in improving slicing during SDC processing and in fresh fruit keeping quality (Figure 4)

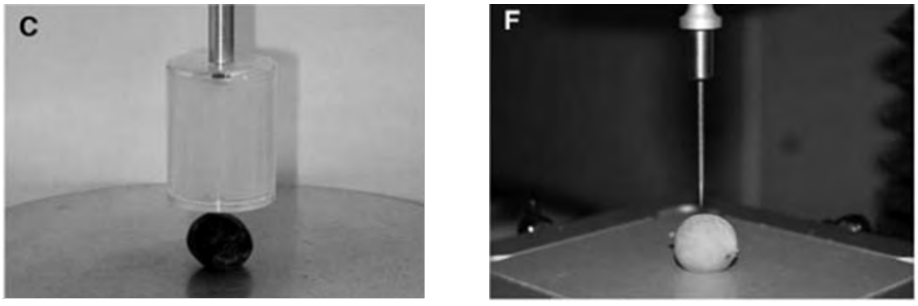

Figure 4. Example of texture analysis for measuring fruit firmness using c) a compression test and f) a puncture test (Rolle et al., 2012).

Conclusion:

The molecular markers tested and validated by the CGGL in 2014 (Schlautman et al., 2015) and the improved SSR genetic linkage map (Schlautman, unpublished) represent two important steps in the establishment of a cranberry MAS program at UW-Madison. These resources will be critical components for identifying QTL and marker associations with economically important cranberry traits related to yield, to genes involved in defense pathways of virus, insect, or fungal pathogens, and to genes associated with increased fruit quality for specific cranberry products. The new phenotyping methods and cranberry genetic resources developed in 2014, when combined with a high-throughput field independent breeding system, will be the key for the successful deployment of MAS program in cranberry aimed at generating superior cultivars which meet the current and future challenges of the Wisconsin cranberry growers and the U.S. cranberry industry.

References

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Soil Sampling on New Plantings

Pam Verhulst

Lady Bug IPM, LLC/ Consult with Pam, LLC

Growers are steadily becoming more efficient in cranberry production. A noticeable way they are doing this is by renovating. Whether it is to improve water management or replace a poor yielding variety, the whole process can be pretty hectic.

During this busy time it is important to remember your Nutrient Management Plan. Wisconsin's NRCS 590 Nutrient Management Standard requires growers to take soil samples from renovated beds/new plantings. The samples are to be taken before any fertilizer applications are made with the intention for growers to use the results as a fertilizer decision making tool. The 590 Standard states: "Collect soil samples for analysis at a rate of one composite sample per 5 acres of cranberry beds after the beds have been prepared for planting". Once your samples are collected, they should be sent to a certified soil test laboratory.

Happy Planting!

Early Season Insect Control

By: Suzanne Arendt

RedForest Crop Consulting, LLC

Before the use of insecticides, cranberry growers used flooding methods to control insects. Over time our industry has reevaluated the efficacy of such cultural methods in relation to our main insect pests. Research has shown positive kill results on several species, including spanworms, black headed fireworms, loopers and false armyworms. Sparganothis fruitworm flooding has had mixed results, but does certainly cause suppression. In some cases, flooding eliminated any need for additional control measures prior to bloom. Flooding causes a deprivation of oxygen which ultimately leads to death of the insects. Removal of "trash" during a flood is crucial as some insects will seek refuge on tall weeds/trees and grasses. Floods should be maintained over the canopy of the vines in order accomplish the removal of insect laden debris. The duration of flooding should be a full flood from minimum 24 hours to 36 or even 48 hours. The water needs to be "on" and "off" as quick as possible. The vine development should not exceed rough neck on the edges, in my experience, to reduce the risk to the cranberry plants.

In some cases flooding can cause the vines to be held back slightly compared to other acreage that was not flooded, however it appears that the vines do "catch up" over time. I have not heard of any crop reductions when a proper flood was used. If the clarity of your water is extremely murky, the oxygen levels may be quite low increasing your risk of vine injury. The cost per acre of flooding can be lower than an insecticide treatment especially on marshes that can gravity flow water and those with electric pumps. However, on other properties, the cost can be higher due fuel costs and difficulties maintaining the flood with additional man hours needed. Flooding your marsh to manage insects fits well in our Integrated Pest Management programs and is more eco-friendly than applying pesticides. Please keep flooding open as an option for controlling early season pests and discuss any questions or concerns that you have with fellow growers, consultants, and University staff.

Cranberry Journal—Grower Update

David Bartling—Manitowish Waters

For 2015 we are trying a new thing for the Cranberry Journal- grower updates with what is happening on various marshes around the state, for this issue David Bartling shares from his marsh in Manitowish Waters:

"Now that the leaves on the trees are beginning to emerge and the loons are wailing on the lake, spring has finally sprung here in the northwoods! Hoping that the weather cooperates with us today, we plan on putting the last of our spring herbicides on; Casaron has been applied on the majority of acres, and Evitol on a select few beds this year as a rotation of herbicides and to see its effectiveness. The buds are starting to turn white, but still have not begun to swell much even though we are close to a month ahead of last year; there was ice on the lakes until May 15!

With all the frost finally out of the beds, we plowed drain tile into two beds that we are renovating, which are now very quickly drying out and will be ready for planting in the next couple of weeks. We are planting Crimson Queens from mowings on one 2.7 acre bed and Mullica Queens from plugs on one 1 acre bed. This will be the first time we will be planting Mullica Queens on our farm."

Thanks David for the northern update.

Observations from the Field

Jayne Sojka

Lady Bug IPM, LLC

Bronzed vines and hurt buds are not unusual this spring. Please check out the pictures and form your own opinion. Leaf drop is also common on the ditch edges this spring.

These are some Grower thoughts of what may have happened:

- During harvest we used new equipment and were just trying to adjust speed, pressure and getting used to how the equipment worked. Things didn't show up then but it sure shows now.
- After harvest we pulled the water but it got cold and the vines may have been more vulnerable and they got hurt.
- After harvest we did NOT put our pipes back in and we did NOT bring the water up in the ditches, the vines may have experienced a drought.
- This spring my ice went out in three days. And shortly after the ice went out there was one day that it got real windy and cold and I did not have them covered. I may have put water back on too late.
- We didn't have much snow coverage. I typically rely on that blanket of snow.
- Mild winters are deceiving. This stress could have happened just before I flooded the first time as it was later than I normally flood.
- I re-flooded twice this spring maybe the leaf drop I see came from water being on longer than my typical 7 day interval!
- Wheel tracks from my harvest equipment.

It doesn't matter if you are a seasoned grower or a novice, things happen. The lesson in all of this is for us to figure out just what DID happen so we learn from it. For each of you there is a different scenario and one solution does NOT fit all situations. Talk about it with your neighbors and see what they did different and when they did it. Take pictures and put it with your notes so that in the future you can look back and share your discovery /solution with your team.

Remember, Cranberry plants are forgiving and as long as the root structure is green and viable they will mend.

Pre-Bloom Sprays—Any Benefit?

Patty McManus

Most fungicide use in Wisconsin on cranberries occurs during bloom and early fruit set stages to control cottonball and the fruit rot disease complex. But is there any benefit to pre-bloom applications, and if so, what are the options? If you don't want to read further, here's the summary: if you have a severe cottonball problem, then you should spray elongating uprights before bloom and again during bloom. If upright dieback was severe the previous year, AND a diagnosis has linked it to fungal pathogens, then you should consider spraying. Otherwise, there's little benefit to be gained from early sprays.

Cottonball: Cottonball has two infection stages. The first is when shoots are breaking bud and elongating; the second is during bloom when the fungus Monilinia oxycocci invades flowers and developing fruit. UW-Madison research has shown that if disease pressure is low (about 10-15% or less fruit infected the previous year), then two bloom applications are generally sufficient. At higher levels of disease, however, you should make two pre-bloom applications as well as spraying again during bloom. Effective fungicides that are labeled for pre-bloom: Indar (be sure to have the supplemental label on hand) and any of the propiconazole products (Orbit, Tilt, Propimax). Fungicides that are labeled pre-bloom that are not effective are copper and chlorothalonil (Bravo, Echo, Equus). We have no cottonball data on Tavano, a new polyoxin-D fungicide also marketed as Oso. For more information see UW-Extension bulletin A3194, Cottonball Disease of Cranberry as well as previous CCM articles, especially 2014 issue 2 (May 25), and the 2011 Cranberry School Proceedings.

Upright dieback and dying uprights: Every year in about late July through mid August we start to see uprights turning bronze in a scattered "salt and pepper" pattern throughout beds. Symptoms come on very quickly. We have not been able to consistently relate the problem to pathogens, insects, or a single environmental stressor. When we look for fungi, only rarely do we find a known pathogen. The symptoms are not typical of those caused by bacteria or viruses, although admittedly, we have not seriously investigated either of those possibilities. When we ask growers about soil and weather conditions, we learn that in some cases symptoms develop after hot, dry weather and in other cases after cool, wet weather. In some cases it's worse on vegetative uprights, and in others on fruiting uprights. Dieback is often severe even where various fungicides have been used, suggesting that fungi are not to blame. In a few rare cases, however, we have found known fungal pathogens, especially Colletotrichum and Phomopsis, in dying uprights. These two fungi are also known fruit rotters, so you don't want them to get out of control in a bed. If a diagnosis identified pathogens associated with dying uprights in the previous year, then a pre-bloom spray might be justified to protect the elongating uprights.

Not much research has been reported on upright dieback, so the following information on fungicides is based on what we know about their efficacy later in the season on fruit rot pathogens conducted by Lindsay Wells at UW-Madison and researchers in MA and NJ. Chlorothalonil (Bravo, etc.) is effective on both Phomopsis and Colletotrichum. With European Union and handler restrictions, however, chlorothalonil is not an option for many growers. Indar might protect uprights against Phomopsis, but in WI we have found it weak on Colletotrichum. I would not expect copper or propiconazole to be good protectants of uprights, because they are not effective against the fruit rot complex later in the season.

What about "bacterial stem canker" which is listed on the copper fungicide labels? Confusion reigns supreme! First, bacterial stem canker has never been described on cranberry. There is a disease called bacterial stem canker on blueberry. Also, many growers refer to cranberry stem gall as "canker." I suspect that a conflation of these facts this is how "bacterial stem canker" ended up being associated with cranberry on copper fungicide labels. Several years ago, a Ph.D. student under my guidance, Archana Vasananthakumar, found that common soil bacteria were associated with stem gall (see UW-Extension bulletin A3795, Cranberry Stem Gall). These bacteria produced high levels of the plant growth hormone IAA, which is known to induce irregular growth. We never tested the effect of copper on these bacteria, but I suspect it would be futile since the bacteria are deep within plant tissues and copper acts only on plant surfaces. Likewise, you could not expect copper to put a dent in bacterial populations in soil, nor would you want to, since soil bacteria probably do more good than harm.

Sparganothis Fruitworm

Christelle Guédot and Erin McMahan

UW-Madison Fruit Crop Entomology and Extension

This summer the Fruit Crop Entomology lab is starting a new series on bugs in Wisconsin cranberry. The first in this series is Sparganothis fruitworm, Sparganothis sulfureana ("sparg"). Sparg is one of the most damaging pest insects in Wisconsin cranberry.

Sparg is native to North America and is a polyphagous species, i.e. it can feed on many different types of plants. It has been found feeding on wild and cultivated crops, such as apple, alfalfa, hawthorn, blueberry, celery, strawberry, clover, cotton, corn, red, white and pitch pines, honey locust, willow, great burdock, and tall buttercup. Studies suggest, however, that it prefers to feed on cranberry, blueberry, loosestrife and sweetfern[1]. Research in New Jersey found that moth activity is generally confined to within ten yards of the marsh, which suggests that moths do not colonize cranberry beds from wild sources[1].


Mark Dreiling, BugGuide.Net

Adult Sparganothis fruitworm

Damage

Sparg larvae can cause extensive damage to cranberry foliage and berries, while the adults cause no damage. Sparganothis fruitworm has two generations each year. The first generation feeds on fresh new cranberry growth in the spring and continues to feed on and damage foliage until it pupates. Larvae weave leaves together with silk, creating enclosures where they can feed and hide from natural enemies and the elements. The second generation is even more damaging, because it feeds on berries, scarring and hollowing out berries. Larvae weave neighboring berries together with silk so they can easily travel between them, and each larva can feed on 3-5 berries during its development. Infested berries will turn prematurely red, and will shrivel up on the vine once the insect has completed feeding. Green berries may also have large feeding holes in them.


Sparg larva in its webbed retreat

Description and Life cycle

Sparg overwinter as first instar larvae in silken retreats in the detritus of the marsh floor. As soon as the plants begin to send up new growth in the spring, larvae travel up to the fresh upright tips to feed. They can also damage the crop by feeding on blossoms. Larvae range in color from a dirty whitish or brownish yellow to a darkish green. The older larvae will often have rows of small white spots on the back. Full-grown larvae can reach about ½" long.

Sparganothis fruitworm

Order: Lepidoptera (moths and butterflies)

Family: Tortricidae (leafroller family)

Scientific name: *Sparganothis sulphureana*

By mid-June the larvae pupate inside of their retreat of webbed leaves. Adults emerge in late June and early July and both male and female adult moths are a golden yellow with a brownish orange "x" that appears on their wings when folded. With wings folded, adults are 2/3" (male) or 5/8" (female) long. Within 1-2 days, the adults mate and the females deposit egg masses of 20-50 eggs on the upper side of the cranberry leaves. 9-12 days later, the second generation larvae emerge from the eggs. The earliest larvae feed on vegetation, but burrow into the berries as soon as the fruit begins to enlarge. The second generation causes the most damage to the crop because the larvae feed inside the berries. Mature second generation larvae are found in the fruit in late July, and will usually pupate within the fruit. The second adult flight occurs in late August and September2. The females lay eggs, and the first instar larvae overwinter on the marsh floor. Rarely, a third generation may occur during the year2.


Shawn Steffan, UW-Madison / USDA-ARS

Sparg egg mass with dark head capsules of developing larvae inside

Sparg vs. Cranberry Fruitworm

Sparg larvae can be difficult to distinguish from cranberry fruitworm larvae. Sparg larvae are usually longer and thinner and a darker dingy green compared to the bright green of a cranberry fruitworm. They also wiggle vigorously when disturbed while cranberry fruitworm do not. While early instar cranberry fruitworm larvae seal their entry holes in the berries with a silk cover, sparg larvae do not. Late instar sparg larvae make a large, ragged entry hole in berries and cast their frass (excrement) out of the fruit, but cranberry fruitworm fill the berries with frass.


Shawn Steffan, UW-Madison / USDA-ARS

Sparg larva inside a cranberry

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Sparganothis Fruitworm

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Monitoring

Pheromone traps can be used to monitor populations of male moths, providing an estimate of the initiation of the adult flight and of relative population densities. Monitoring can also be accomplished by sweep netting for larvae or by collecting and counting red berries. The economic threshold for sweep netting for sparg is 2 larvae per 20 sweeps2.

Control

Chemical control is often used for sparg management, however, integrating other management strategies is important for several reasons. In Massachusetts, the first serious outbreaks of this pest were only observed in the 1950's after the introduction of DDT. Researchers have since attributed these outbreaks to the loss of natural enemies caused by the spraying of broad-spectrum insecticides1. In addition, in parts of the East Coast, resistance of sparg to organophosphate insecticides has made these chemicals ineffective for control3.

Natural enemies can be very effective in controlling populations of sparg, particularly when caterpillars are protected from insecticides inside of their webbed retreats or inside the berries. The most effective natural enemies are parasitic wasps and flies that parasitize eggs and larvae1. The Steffan Lab will be evaluating parasitism of sparg in Wisconsin cranberry this summer.

Pheromone- based mating disruption techniques such as SPLAT® are currently being evaluated for commercial use and have shown promise4. A 24-30 hrs spring flooding has been shown to be effective in controlling sparg5 and more research is ongoing on this topic. Removing alternate hosts such as loosestrife and goldenrod can also be helpful.

Broad-spectrum insecticides including organophosphates such as Diazinon, Imidan and carbaryl, and selective insecticides like Insect Growth Regulators (e.g., Intrepid, Confirm, Rimon), spinosyns (e.g., Entrust, Delegate), microbial compounds (e.g., Grandevo and Venerate), neonicotinoids (e.g., Assail, Belay), and diamides (e.g., Altacor) can be used to control sparg populations. Below is a table of overall rating of insecticides from Jack Perry's trials (Table 1). If warranted, sprays can be applied at ½" of new growth, hook stage to start of blossom, and after bloom. These timings are fairly broad and do not relate to the specific sparg phenology on a specific growers' marsh. The best way to target sprays for a specific phenological stage (eggs, larvae or adults) of an insect on your marsh is by using your marsh-specific growing degree days. With your growing degree days and the degree day lookup table provided by the Steffan Lab (Table 2), you can predict developmental benchmarks for sparg6. Future research will determine appropriate spray timings based on this model for a more reliable and targeted approach to pest management.

Table 1. Effectiveness of foliar-applied insecticides against Sparg

	Rate / acre	**Sparg fruit-worm**
Grandevo 30G	3 lb	++
Venerate 94L	8 qt	++
Venom 70SG	4 oz	+
Closer 2.2SC	5.7 oz	--
Altacor 35WG	4.5 oz	+++
Assail 30SG	6.9 oz	++
Belay 2.1SC	4 oz	++
Delegate 25WG	6 oz	+++
Diazinon 4EC	3 qt	+
Imidan 70WP	4 lb	+
Intrepid 2F	16 oz	++
Confirm 2F	16 oz	++
Knack 0.86EC	16 oz	+
Lorsban 4E	3 pt	++
Rimon 0.83EC	12 oz	++

Performance rating scale: "--": inadequate control, "+": 70 – 79% control,"++": 80 – 89% control, "+++": 90%+ control

Finally, it is important to minimize sprays during bloom but also directly before bloom to avoid residual contact with our pollinators. Using reduced risk pesticides, such as Altacor, Confirm, Intrepid, or Venerate, especially around bloom will help protect our pollinators. Sprays after bloom should pay special attention to pre-harvest intervals, so as always, read and follow the label. Some insecticides face MRLs export limitations in cranberry so make sure to check with your handler before using them.

Happy growing season!

Sparganothis Fruitworm

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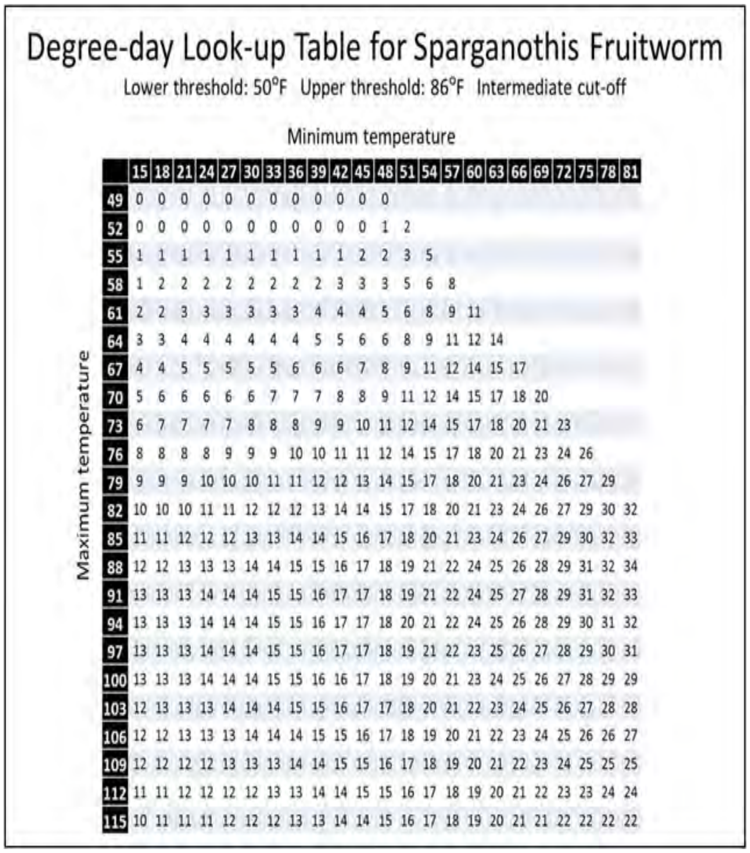
Table 2. Degree day look-up table for Sparg6.



Degree-day Look-up Table for Sparganothis Fruitworm

Lower threshold: 50°F Upper threshold: 86°F Intermediate cut-off

Minimum temperature

Maximum temperature

	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81
49	0	0	0	0	0	0	0	0	0	0	0	0											
52	0	0	0	0	0	0	0	0	0	0	0	1	2										
55	1	1	1	1	1	1	1	1	1	1	2	2	3	5									
58	1	2	2	2	2	2	2	2	2	3	3	3	5	6	8								
61	2	2	3	3	3	3	3	3	4	4	4	5	6	8	9	11							
64	3	3	4	4	4	4	4	4	5	5	6	6	8	9	11	12	14						
67	4	4	5	5	5	5	5	6	6	6	7	8	9	11	12	14	15	17					
70	5	6	6	6	6	6	7	7	7	8	8	9	11	12	14	15	17	18	20				
73	6	7	7	7	7	8	8	8	9	9	10	11	12	14	15	17	18	20	21	23			
76	8	8	8	8	9	9	9	10	10	11	11	12	14	15	17	18	20	21	23	24	26		
79	9	9	9	10	10	10	11	11	12	12	13	14	15	17	18	20	21	23	24	26	27	29	
82	10	10	10	11	11	12	12	12	13	14	14	15	17	18	20	21	23	24	26	27	29	30	32
85	11	11	12	12	12	13	13	14	14	15	16	17	18	20	21	23	24	26	27	29	30	32	33
88	12	12	13	13	13	14	14	15	15	16	17	18	19	21	22	24	25	26	28	29	31	32	34
91	13	13	13	14	14	14	15	15	16	17	17	18	19	21	22	24	25	27	28	29	31	32	33
94	13	13	13	14	14	14	15	15	16	17	17	18	20	21	22	24	25	26	28	29	30	31	32
97	13	13	13	14	14	14	15	15	16	17	17	18	19	21	22	23	25	26	27	28	29	30	31
100	13	13	13	14	14	14	15	15	16	16	17	18	19	20	21	23	24	25	26	27	28	29	29
103	12	13	13	13	14	14	14	15	15	16	17	17	18	20	21	22	23	24	25	26	27	28	28
106	12	12	13	13	13	14	14	14	15	15	16	17	18	19	20	21	22	23	24	25	26	26	27
109	12	12	12	12	13	13	13	14	14	15	15	16	17	18	19	20	21	22	23	24	25	25	25
112	11	11	12	12	12	12	13	13	14	14	15	15	16	17	18	19	20	21	22	23	23	24	24
115	10	11	11	11	12	12	12	13	13	14	14	15	16	17	18	19	20	21	21	22	22	22	22

DD Benchmarks

(accrued from March 1st)

- Flight starts: **596**
- Egg-laying: **681**
  - Peak flight (midway): **884**
  - End of egg-laying: **1,634**
    - Larval emergence: **895 – 1,890**

References to products in this publication are for your convenience and are not an endorsement of one product over similar products. You are responsible for using pesticides according to the manufacturer's current label directions. Follow directions exactly to protect the environment and people from pesticide exposure. Failure to do so violates the law.

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