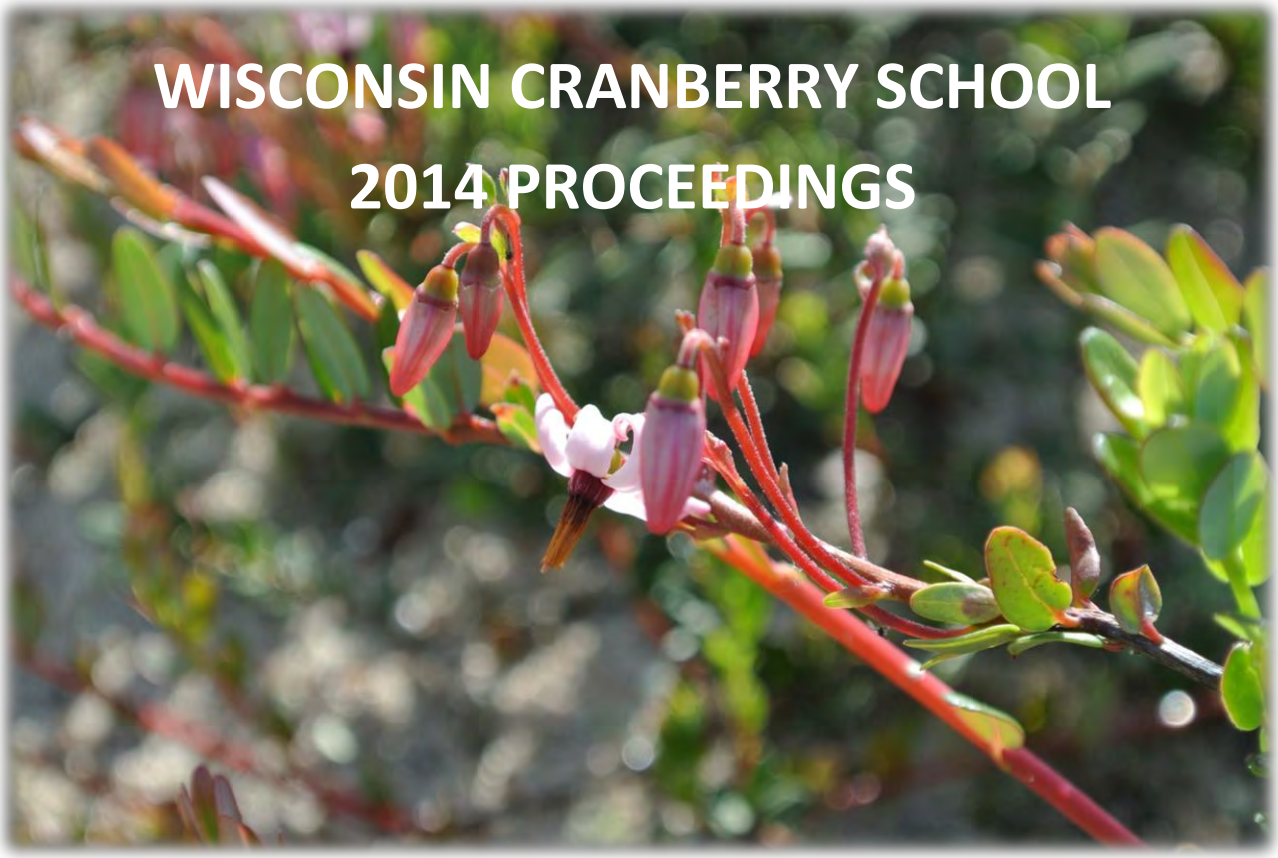
WISCONSIN CRANBERRY SCHOOL
2014 PROCEEDINGS



Volume 22

January 22-23, 2014

Holiday Inn Hotel and Convention Center

Stevens Point, WI

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UW Extension
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The Proceedings of the 2014 Wisconsin Cranberry School (Volume 22) and the Annual Report of the Wisconsin State Cranberry Growers Association were published by:

Wisconsin State Cranberry Growers Association
P.O. Box 365
Wisconsin Rapids, WI 54494
(715) 423-2070

For additional copies contact:
Wisconsin State Cranberry Growers Association

Madison, Wisconsin
April 2014

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U.S. CRANBERRY MARKETING COMMITTEE UPDATES AND PROGRAMS OVERVIEW

SCOTT J. SOARES

Executive Director, U.S. Cranberry Marketing Committee

The U.S. Cranberry Marketing Committee or CMC as it is typically referred to, was created per the interest of the U.S. cranberry industry by Federal Legislation in 1962 as a quasi-governmental agency under the USDA's Agricultural Marketing Service (AMS). In order to fulfill its mission the CMC works with the United States Department of Agriculture to execute global marketing and promotional activities, support or undertake related research initiatives and may issue volume control regulations when needed and as authorized.

The CMC is administered by a USDA Secretary appointed Committee of 14 members and 10 alternate members through staff that are located in Wareham, MA. Committee membership is established by the CMO and is intended to provide representation for all cranberry growers within the ten states of Connecticut, Massachusetts, Michigan, Minnesota, New Jersey, New York (long Island), Oregon, Rhode Island, Washington and Wisconsin. Authority for its actions is provided under Chapter IX, Title 7, Code of Federal Regulations, referred to as the Federal Cranberry Marketing Order (CMO), which is part of the Agricultural Marketing Agreement Act of 1937, as amended. This Act specifies cranberries as a commodity that may be covered, regulations that may be issued, guidelines for administering the programs, and privileges and limitations granted by Congress. The CMO has been amended several times since its inception to enhance the CMC's ability to expand market development projects and generic promotion programs in domestic and international markets.

The U.S. Cranberry Marketing Committee; Updates and Programs Overview presentation will provide information about the CMC, its structure and recent programmatic activities undertaken toward the fulfillment of its mission "*to ensure a stable, orderly supply of cranberry products as authorized and provided by the Federal Cranberry Marketing Order (CMO)".* The presentation will also provide an update on U.S. cranberry production and the most recent market policy established by the CMC.

S.J. Soares biography

Hired in May of 2012, Mr. Soares is the Executive Director of the Cranberry Marketing Committee (CMC), responsible for the expansion of U.S. cranberry business development projects in domestic and international markets.
Preceding the CMC, Mr. Soares served for 17 years at the Massachusetts Department of Agricultural Resources (MDAR) in a variety of leadership positions until his appointment by Governor Deval Patrick as the 18th Commissioner of MDAR in April 2009.

Mr. Soares has received numerous accolades throughout his career including the Government Leadership Award from the Cape Cod Cranberry Growers' Association in 2011 and the Environmental Leadership Award from the Massachusetts Nursery and Landscape Association in 2009.

Mr. Soares served seven years of active and reserve service to the U.S. Army and obtaining double major degree in Biology and Marine Biology from UMass Dartmouth

CRANBERRY DISEASE UPDATE

PATRICIA McMANUS and LINDSAY WELLS

Department of Plant Pathology, University of Wisconsin-Madison

Every year has its unique twists and turns in terms of weather, diseases, insects, and other sources of "drama" for cranberry growers. In this article we will summarize the main happenings related to cranberry diseases in 2013, with an emphasis on tobacco streak virus (TSV).

Dying uprights an ongoing problem. Every year growers submit samples to the UW-Madison Plant Disease Diagnostic Clinic, and we acquire additional samples when out and about on marshes. The types of problems we have seen over the past few years are summarized in the table. Although only half as many samples of dying uprights were tested in 2013 compared to 2012, the number of cases was possibly greater in 2013 than ever before. Many growers who submitted samples in past years did not bother in 2013, because we have never been able to link a pathogen to the dying uprights. On rare occasion we find *Phomopsis vaccinii*, the true upright dieback pathogen, but usually we find non-pathogens that commonly invade dead plants. Further, in many cases where the dieback is severe, it comes on very quickly and evenly across an entire bed. While this does not rule out pathogens, it is more consistent with an environmental influence such as heat stress.

Symptom type	2009	2010	2011	2012	2013
Root/runner rot	1	2	0	0	0
Leaf spots	2	3	1	0	0
Dying uprights	12	3	15	22	11
Fruit rot	5	27	7	8	3

In search of a possible link between environmental conditions and/or grower practices, we included a few questions about dying uprights during the anonymous "clicker" polling session. A large majority of respondents (80%) reported seeing this problem in at least a few beds. However, there was no clear answer for what type of bed environment (e.g., too wet, too dry) was associated with dying uprights. Most growers either did not like the choices we offered or thought the problem could not be blamed on just one factor. More than a quarter of growers are convinced that yield was reduced, while nearly half reported that the dying uprights did not appear to reduce yield.

At what level did you observe brown/bronze uprights in a salt/pepper pattern in 2013 on your marsh	Responses	
Did not see this at all in 2013	17	20%
Saw it in a few beds	50	60%
Saw it in many beds	16	19%
Saw it in all beds	1	1%
Totals	84	100%

If you did see brown/bronze uprights, they occurred in beds that were:	Responses	
Too dry	10	14%
Too wet	3	4%
Had poor ice cover, possible winter injury, or spring frost	8	11%
Treated with a particular pesticide	0	0%
More than 1 of the above	21	29%
None of the above	31	42%
Totals	73	100%

If you did see brown/bronze uprights, did you monitor the effect on yield?	Responses	
Yes, and there was reduced yield.	21	28%
Yes, and there was little or no effect on yield.	35	46%
No	20	26%
Totals	76	100%

Tobacco streak virus. In 2012 we found a strong correlation between a unique berry scarring symptom and TSV. In 2013 we conducted several experiments to learn more about TSV and its potential impacts on the cranberry industry. The findings are summarized below.

- **TSV overwinters in cranberry plants.** In 2012 we tagged several uprights that had scarred berries and that tested positive for TSV. We dug several, potted them, and allowed them to overwinter at UW-Madison. We put them in a greenhouse, and the new growth tested positive for TSV. Likewise, when we tested new growth from field plants in May, it tested positive. This indicates that TSV overwinters in cranberry plants.
- **TSV was detected in pollen.** Pollen from TSV-positive plants tested positive for TSV. Pollen from TSV-negative plants tested negative, indicating that there's not something "funny" about pollen that triggers false positive reactions. We were not able to transfer the virus by pollinating plants with infected pollen, nor could we reproduce scarring symptoms by wounding fruit and smearing the wounds with pollen. Our failure to reproduce symptoms might mean that the virus is not easily spread by contaminated feet that crush berries in the field, but further work is needed on this.

- **New evidence that TSV, rather than insects, causes scarring.** In 2012 we observed that when an upright had scarred berries, generally every berry on the upright was scarred, whereas nearby uprights had healthy looking berries. This suggested a systemic factor, which would be consistent with virus infection. In 2013, however, we noticed that plants that had scarred berries in 2012 did NOT show scarring in 2013 but did still test positive for virus. This phenomenon of scarring/necrosis followed by recovery has been observed on cherry and blueberry infected by viruses related to TSV. This convinced us that it is TSV itself rather than insects that cause symptoms. If it were insects, then we'd expect that at least some of the 2013 berries would be scarred, because they were in amongst uprights that did have scarred berries. While we do not think insects cause the scarring, insects may have a role in spreading infected pollen and/or creating wounds through which TSV infects.
- **There's another berry-scarring virus out there.** During the course of a survey to determine how widespread TSV is in Wisconsin cranberries, we found some scarred berries that tested negative for TSV. These were in older beds of Stevens and LeMunyon, while nearly all TSV detections were in beds of newer hybrid varieties. Upon further investigation, we learned that another virus, blueberry shock virus (BlShV) was likely responsible for scarring in the Stevens and LeMunyon samples.

- **Yield components are not obviously affected after plants have "recovered.**" As mentioned above, cranberry plants bore normal looking fruit in 2013 after they had scarred fruit in 2012. They "recover" but are carriers of the virus. In our limited studies, we found that recovered, TSV-positive uprights did not differ from healthy, TSV-negative uprights in the number of flowers per upright, percent fruit set, or berry weight. In the future we will repeat these experiments but also look at traits such as berry color, Brix, and storage quality of berries. During the year of symptom expression, scarred berries, such as those pictured, do not size up and are unmarketable.

Berries infected with TSV (top) and BlShV (bottom).

What can we expect from TSV in the future? TSV overwinters in cranberry in Wisconsin and is here to stay. The occurrence of symptoms in two very different growing seasons—hot, dry 2012 and more "normal" 2013—suggests that environment does not play a big role in symptom expression. The phenomenon of recovery needs to be investigated further, but our findings to date suggest that TSV will slowly work its way through a cranberry bed but will not devastate a bed in any given year. In beds where TSV occurs, yields have been good. Nevertheless, we will continue with research on viruses so that we can better determine what the longer-term effects might be and to identify practices that will limit spread and impact of viruses in cranberries.

WHAT AFFECTS YIELD? YIELD COMPONENTS, BUDS, AND CARBOHYDRATES

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University of Wisconsin-Madison, Department of Horticulture

Questions and/or comments may be directed to Lisa at lisamariewasko@gmail.com.

Yield is a complex trait influenced by plant (e.g., physiology and genetics) and environmental components. Furthermore, yield varies considerably across time and space. This variability is poorly understood and not captured in current methods of yield prediction. Growers and industry would benefit from an enhanced understanding of the dynamics affecting yield, which could be used to build better methods of prediction and improved crop management. This report summarizes three research projects that were undertaken as part of a doctoral thesis that sought to enhance the current understanding of cranberry yield. These projects ranged in scope and are described further below.

Project #1 – Yield Component Analysis

The objective of this project was to evaluate the relationship between yield and select physiological, environmental, and genetic components. Accomplishment of this objective was completed using statistical modeling of selected and measured components. Data for the project were collected from eight grower sites located in Wood county, Wisconsin, from 2010 to 2013. Both 'Stevens' and 'Ben Lear' data were collected from two cultivar beds at each location. The period of data collection included three 15-month growing cycles, which permitted data from the first two cycles to be used for model building and the final cycle for model testing/validation. A description of the components used in the study is provided in Table 1.

Table 1. Measured physiological, environmental, and genetic components collected across eight grower sites located in central Wisconsin.

Physiological[z]	Environmental[y]	Genetic Purity
Upright density	Temperature (°C)	Tested in the Zalapa lab[w]
Percentage of reproductive uprights	Light levels [PAR ($\mu mol \cdot m^{-2} \cdot s^{-1}$)]	
Flower count	Growing degree days (GDD)[x]	
Fruit set	Soil nutrients (2011 & 2012)	
Yield (previous & current)		
Nutritional status (2011 & 2012)		

[z]Data collected and averaged from four permanent 490 cm^2 subsample rings per bed; data from both 'Stevens' and 'Ben Lear' beds were collected at each site (16 beds total).

[y]Collected with Watchdog 2465 Plant Growth Station; data logged every 30 minutes from March 5 to Sept. 24, 2010; June 5 to Dec. 15, 2011 and 2012; GDD and PAR were summed and subdivided on a monthly basis from bud set (estimated to occur July 15) to harvest the following year.

[x]Perry et al (1986) and DeMoranville et al. (1996) methods; Perry method used a base temperature of 45 °F and the DeMoranville method used a base of 60 °F and maximum cutoff of 86 °F.

[w]Purity tested from eight runners per bed and with the use of 12 cranberry-specific alleles developed by the Zalapa lab; samples were considered off-type if one or two alleles were different.

A total of 66 components were modeled using a technique called regression analysis. Results indicated berry number and size were the best predictors of yield. In other words, most of the variability associated with yield is determined by berry number and size. Predictive models using berry number and size had coefficients of determination (R^2) exceeding 90% (R^2 for 'Stevens' and 'Ben Lear' were 0.99 and 0.94, respectively). The coefficient of determination is a metric used to assess the strength of a model and ranges from zero to one, with values closer to one suggestive of a "better" model. Thus, models incorporating berry number and size did an excellent job predicting yield. However, these models are not ideal for early crop forecasting, which requires predictions to be made before berry number and size are determined. Berry number was subsequently subject to the same regression analysis. Resultant predictive models were very poor and there was a lot of unexplained sources of variability that impacted our results. These results demonstrate that yield prediction for early crop forecasting remains a challenge, even when an array of components are utilized for model development. Prediction will likely remain challenging given the physiology of perennial fruit crops and the many environmental factors that influence yield, such as differences in grower management practices.

Based on the results of this project, we suggest future work be done to better understand the physiology of cranberry so that temporal and spatial variability can be minimized through developed grower management practices. Minimization of variability will help ensure a stable supply of cranberries, which could promote the sustainability of the cranberry industry. The remaining two projects in this report describes such work that attempts to better understand the physiology of factors influencing yield, namely bud development and seasonal changes in plant carbohydrates.

Project #2 – Characterizing the Potential for Rebud

The objectives of this project were to compare bud development, external bud appearance, and the potential for return bloom (i.e., "rebud") across several cultivars of cranberry that reportedly differ in biennial bearing tendencies. Data were collected in 2011 and 2012 from a grower located in Wood county, Wisconsin. Cultivars included in the study are 'Stevens', 'Searles', 'HyRed', and 'Crimson Queen.' Samples of 100 uprights were randomly collected per cultivar bed every two weeks from March 5 to Dec. 7, 2011. In 2012, sample sizes were reduced to 70 uprights per cultivar bed and entailed weekly sampling from July 5 to Aug. 30. Harvest and postharvest samples of uprights were also collected on Sept. 14 and Oct. 26, 2012. Reproductive and vegetative uprights were separated after collection and developing buds were examined using light and scanning electron microscopy.

Flower initiation in buds of both reproductive and vegetative uprights was found to occur July 10 and 29 in 2011 and 2012, respectively. An exception to this was found in 'Searles', in which few flower initials were found throughout the duration of the study. Evidence of tipworm was lacking and similar findings were found in preliminary studies of 'Searles' buds across three other sites. Overall, wider buds were more likely to contain flower initials, regardless of what type of upright the buds came from. However, overall bud width varied across cultivars. 'HyRed' and 'Crimson Queen' had larger buds than 'Searles', whereas 'Stevens' had intermediary bud sizes (data not presented). Rebud data indicated 'HyRed' and 'Crimson Queen' had the greatest potential rebud, whereas 'Searles' had the lowest (Table 2). Yield was similar between 'HyRed' and 'Crimson Queen' and lowest in 'Searles' (yield data not presented). Yield of 'Stevens' was similar to 'HyRed' and 'Searles'. These findings provide some of the first evidence of the enhanced rebud potential of newer cultivars. The physiological mechanism(s) underlying rebud remain to be explained and is further studied in the subsequent project.

Table 2. Rebud potential among select cultivars from a marsh located in Wood County, Wisconsin. Results summarize data collected from 2011 and 2012.

Cultivar	Rebud potential[z]
Searles	5.6 b[y]
Stevens	24.8 ab
HyRed	41.1 a
Crimson Queen	38.8 a
P value	0.0008

[z]"Rebud" is the percentage of reproductive uprights with flowers in terminal buds (i.e., mixed buds).
[y]Values are averages determined from samples collected after harvest in 2011 and 2012 (dates include 9 Sept. 2011, 11 and 24 Oct. 2011, 7 Dec. 2011, and 26 Oct. 2012); 'Searles' was not collected in 2012 due to renovation decisions made by the grower; means with the same letter within a column are not different at $P < 0.05$ using a Tukey-Kramer adjustment.

Project #3 – Carbohydrates and Rebud Potential

The objective of this project was to measure seasonal changes in nonstructural carbohydrates across cultivars that differ in rebud potential. Plant carbohydrates are generated by photosynthesis and are important for growth and development. A shortage of carbohydrates during the concurrent time of fruit set, berry development, and bud formation has been proposed to explain low fruit set and patterns of biennial bearing in cranberry. Yet, newer cultivars exhibit enhanced rebud potential and still produce large crops. These observations led to the measurement of nonstructural plant carbohydrates across cultivars that differ in rebud potential and patterns of biennial bearing. Such measurements may help clarify the potential role carbohydrates have in rebud and biennial bearing.

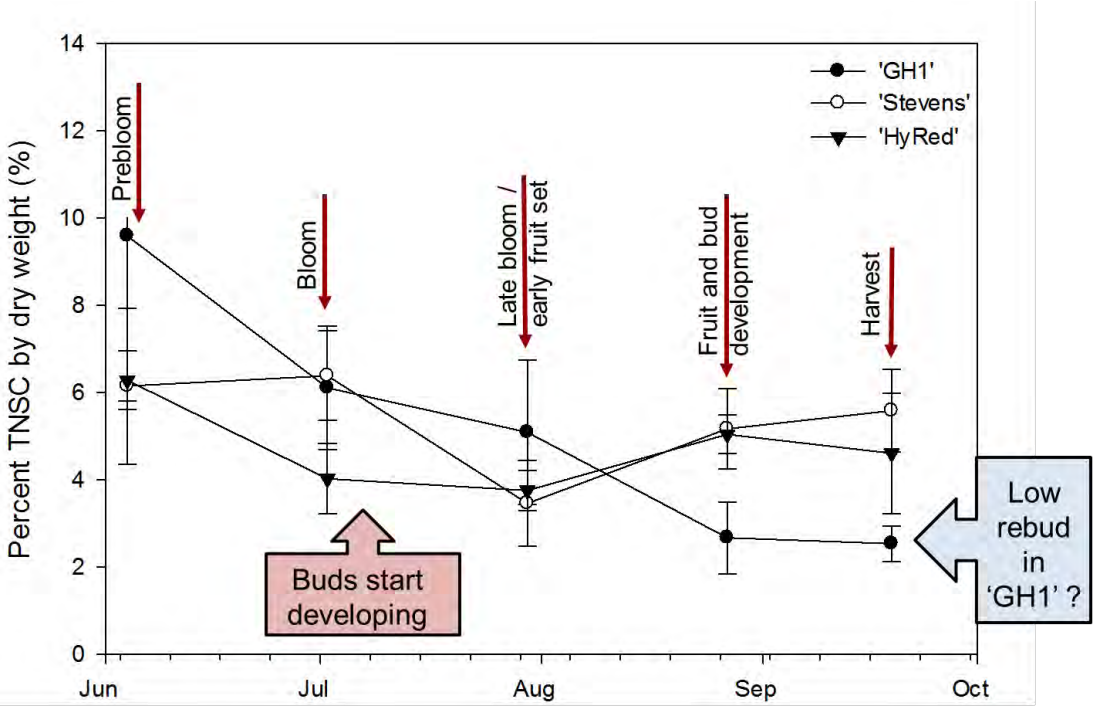
Samples of 'Gryglesky Hybrid 1' ('GH1'), 'Stevens', and 'HyRed' were collected from a marsh located in Juneau county, Wisconsin. Sampling occurred in 2013 and targeted six growth stages ranging from prebloom (June 4) to postharvest (Oct. 30). On each sample date, three cores comprising upright and root tissue were collected and processed within 48 hours after collection. Processing entailed separating reproductive from vegetative uprights (new and old growth were pooled), root washing, and drying of samples. Berries were also collected and prepared for carbohydrate analysis. Samples were later ground and carbohydrates were analyzed via high performance liquid chromatography. Concentrations of sucrose, glucose, fructose, and starch were quantified and used to calculate total nonstructural carbohydrates (TNSC), soluble sugars (SS), and starch. Yield data were collected from three 300 cm^2 quadrats per bed. The potential for rebud was also determined on Sept. 19 from a random sample of 100 uprights per cultivar bed.

Uprights had greater overall carbohydrate concentrations relative to roots and vegetative uprights had greater carbohydrate concentrations relative to reproductive uprights. There were no differences in carbohydrate levels in berries, which is suggestive that carbohydrate sink strengths among cultivars are equal when taken in context of the yield data. Yields were the same across all cultivars. 'GH1' had the lowest potential for rebud at 1%, whereas 'Stevens' and 'HyRed' had rebud potentials of 20% and 19%, respectively. The high upright density, floral induction, and fruit set of 'GH1' likely compensated for its overall lower rebud potential (data not presented).

Carbohydrates measured in reproductive uprights were initially the same and decreased with the advance of bloom and berry development (see example in Figure 1 for TNSC). Interestingly, carbohydrates began to increase in 'Stevens' and 'HyRed' during the Aug. 27 and Sept. 19 sampling

periods, which coincide with fruit and bud development. Concentrations did not increase in 'GH1', which also had overall lower rebud potential. These results are suggestive that carbohydrate limitations may promote biennial bearing by reducing rebud. However, it remains to be determined what other physiological and environmental factors influence these horticulturally important traits. Other factors, such as plant hormones and secondary metabolites, may interact with the environment or operate in isolation. Future research can further explore the nuances of rebud and develop management practices that optimize this trait.

Figure 1. Total nonstructural carbohydrates (TNSC) in reproductive uprights of 'GH1', 'Stevens', and 'HyRed'. Sample collection corresponded to the following growth stages with dates of collection in parentheses: roughneck to prebloom (4 June), full bloom (2 July), late bloom/early fruit set (30 July), fruit and bud development (27 Aug.), and fruit harvest (19 Sept.). Bars denote standard error.



Acknowledgements

Many thanks to those listed below for their financial and/or emotional support during my time in Wisconsin. Also, many thanks to the individual growers I had the pleasure to meet and work with. It is difficult to leave such a dedicated and wonderful group of growers. I wish the very best to the entire community comprising the cranberry industry!

- Wisconsin State Cranberry Growers Association and Wisconsin cranberry growers
- My PhD Committee (J. Colquhoun, R. Harbut, C. Barford, W. Bland, P. McManus, J. Palta, and J. Zalapa)
- The Department of Horticulture at the University of Wisconsin-Madison
- Biological & Biomaterials Preparation, Imaging, and Characterization Laboratory at the University of Wisconsin-Madison
- Jim Busse and the Bethke Lab
- The Zalapa & Patterson labs
- The Harbut lab – Beth, Sarah, Emily, Tom, Jesse, Mike, Adam, Clay, Veronica, and Tyler

2013 PESTICIDE SCREENING UPDATE: 2013 REVIEW & WHAT'S NEW IN 2014?

JACK PERRY[1], JED COLQUHOUN[1], PATRICIA MCMANUS[2], and CHRISTELLE GUÉDOT[3]

University of Wisconsin-Madison,
[1]Department of Horticulture, [2]Department of Plant Pathology, [3]Department of Entomology

FUNGICIDES & DISEASES

2013 Disease Status

- Disease pressure was generally light across the Wisconsin cranberry productions area
- Abound + Indar seem to be the industry standard
- Although some Bravo fruit flecking was noted, Bravo (and the generic chlorothalonil products) provided good disease control

EVITO, AFTERSHOCK – new in 2013

- Evito is an Arysta product; Aftershock is a Loveland product.
- Evito/Aftershock are formulated as 4 lb active/gallon liquids.
- Effective on fruit rot & early rot; cottonball control unknown.
- 2.0 - 5.7 fl oz is the use rate; 12 hour REI; 1 day PHI
- There are MRL export residue issues with these products – check with handlers.

REGALIA – new for 2014

- Regalia is a Marrone product; a 5% liquid formulation.
- Regalia is a bio-fungicide, based on a plant extract.
- As a biological it is approved for use in organic systems.
- In a limited number of trials Regalia has shown control of early rot and fruit rot.
- 1-3 quarts/acre is the use rate; 4 hour REI; 0 day PHI.
- Regalia does not have MRL export restrictions.

INSECTICIDES & INSECTS

ALTACOR – new in 2013

- Altacor is a Dupont product formulated as 35% water dispersible granule (WDG).
- Altacor is based on a new active ingredient = new mode of action = good fit for IPM resistance management.
- Excellent for "worms" control and has demonstrated good control of secondary insect pests.
- Altacor is deemed as "bee safe" for adult, foraging bees.

Note: insecticide applications when bees are present are highly discouraged and should be done only in emergency situations.

- 3.0 – 4.5 oz/acre is the use rate; 10 – 14 days residual control
- 4 hour REI; 1 Day PHI
- Altacor does not have MRL export restrictions.

CLOSER

- Closer is a Dow product formulated as a 3 lb active/gallon liquid.
- Closer is a new class of insecticide related to neonicotinoids in the Group 4C insecticide.
- Closer's effectiveness on "worms" is limited but it is effective on secondary insect pests.
- Closer is toxic to bees.
- 2.75 – 5.75 fl oz/acre is the use rate
- 12 hour REI; 1 day PHI
- Closer is likely to have MRL export restrictions.

VENOM

- Venom is a Valent product formulated as a 70% soluble granule.
- Venom is a neonicotinoid product, Group 4A insecticide.
- Venom's effectiveness on "worms" is limited but it is effective on secondary insect pests.
- Venom is toxic to bees.
- 2-4 oz/acre is the use rate; 12 hour REI; 7 day PHI
- Venom is likely to have MRL export restrictions.

Registered Cranberry Insecticides – What Works for What

	Tip Worm	Fruit Worm	Sparg FW	Span Worm	Fire Worm	Flea Beetle	Leaf Hopper	Bee Toxicity
Altacor	+	+++	+++	+++	++	++	+	--
Assail	+	++	++	++	++	+++	++	xxx
Belay	+	++	++	++	++	+++	++	xxx
Closer	-	+	+	+	+_	+++	+++	xxx
Confirm	--	+++	+++	+++	++	--	--	--
Delegate	+	+++	+++	+++	++	--	--	xxx
Diazinon	+	+	+	++	+	+++	+++	xxx
Grandevo	--	++	++	+++	++	--	--	--
Imidan	--	+	+	+	+	+++	+++	xxx
Intrepid	--	+++	+++	+++	+++	--	--	--
Knack	--	++	+	+++	+	--	--	--
Lorsban	+	+	+	+	+	+++	+++	xxx
Rimon	+	++	++	+++	+	+	-	--
Venom	--	--	--	--	--	+++	+++	xxx

+++ >80% control, ++ 70-80% control, 60-70% control; x = bee toxicity

GRANDEVO

- Grandevo is a Marrone product formulated as a 30% water dispersible granule.
- Grandevo is a bio-insecticide based on a soil bacterium. As a biological it is approved for use in organic systems.
- Grandevo is effective on "worms" but not effective on secondary insect pests.

Note: Best applied on small worms.

- Grandevo is deemed as “bee safe” for adult foraging bees.

Note: insecticide applications when bees are present are highly discouraged and should be done only in emergency situations.

- 2-3 lb/acre is the use rate; 4 hour REI; 0 day PHI
- Grandevo does not have MRL export restrictions.

HERBICIDES & WEEDS

No new herbicides become available in 2013 nor are any anticipated for 2014.
QuinStar (quinclorac) was registered in 2012 and there was some commercial use in 2013.
Quinclorac provides good control of dodder, marsh St Johnswort and yellow loosestrife.
Quinclorac does retard the development of maples.
There are benefits of Quinclorac + Callisto combination.
Use of a surfactant is a must.
There are MRL export residue issues with QuinStar – check with handlers.

RESEARCH PLANS FOR 2014

- Continue screening for new pesticides
- Upright dieback (if it returns) – identify cause & control
- Flea beetle control - control the larvae in soil
  Can 1 soil drench application replace 2 foliar applications?
- Are there benefits to using surfactants with fungicides and insecticides?

What’s in our pesticide future?
Will we lose the OP insecticides? They are targeted by EPA for environmental impact issues.
Will we lose the neonic insecticides? They are targeted by EPA for bee impact issues.
In the registration processes are the following new products:

Insecticides - 5
Fungicides - 3
Herbicides - 2

WHAT WAS UNIQUE IN 2013?

Terminal dieback was the attention-getter in 2013.
Terminal dieback became wide spread evident mid-season.
There has been much speculation as to the cause of terminal dieback but most possible explanations did not hold true across multiple marshes:

- Disease? Possibly, probably not
- Weather? Possibly, probably not
- Irrigation? Possibly, probably not
- Applied Pesticides? Possibly, probably not
- Variety Specific? Probably not; problem across most varieties

- Insect? Possible explanation: Cranberry toad bug, *Phylloscelis atra*

High populations of cranberry toad bug were associated with terminal dieback in Massachusetts in 2013.

- First described in Long Island, NY cranberries in 1914 - hasn't been seen much since
- Reduction in OP insecticide use may have caused toad bugs to re-appear (?)
- Quite small bug – 0.2" long
- Leafhopper-type that jumps (like a flea beetle)
- Feeds on old/new terminals but not at tip
- Feeds on vegetative and fruiting terminals
- Feeding kills terminals from feeding site outwardly
- A single generation/year that feeds at late blossom/early fruit set

Note: It is important to note that toad bugs were not detected in Wisconsin in 2013 - this may or may not have been the causal agent.

STUDY OF ECONOMICALLY IMPORTANT TRAITS IN CRANBERRY VIA BREEDING AND GENOMICS APPROACHES

JENNIFER BOLIVAR and JUAN ZALAPA

USDA-ARS Madison and University of Wisconsin-Madison, Horticulture Department, WI

The American cranberry (*Vaccinium macrocarpon* Ait.) is an edible fruit plant species native to North America, and important for the economy of Wisconsin. Cranberry has been cultivated for over two centuries, but only recently has it become popular among consumers due to the health benefits inherent to the red berries. Despite the importance of this fruit crop species for the State, which was responsible for about 60% of cranberry production nationwide for 2012, the breeding of cranberry is relatively new and slow process. In order to accelerate the selection of new cultivars with better yield and quality, it is imperative to learn more about basic biological, physiological, and genetics aspects that govern plant development and production in cranberry selections. Based on the previous considerations, the present project is focused in three main objectives. The first one is to study self-pollination capability of 5 commercial cultivars under greenhouse conditions, and study also the vigor of the progenies resulting from self-pollinations. Secondly, we will analyze yield traits and berry quality and nutrition from progeny of crosses among three commercial cultivars. Finally, via genomic techniques, we will study genes that are expressed during bud set in an alternate bearing cultivar and also identify potential gene candidates expressed in floral induction. The results of this project will contribute to understand both, important traits for cranberry breeding as well as to traits that affect cranberry crop production.

MULTI-SPECIES MATING DISRUPTION IN WISCONSIN CRANBERRIES

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Pheromone-based communication is a common mechanism by which insects can warn each other of danger, initiate the formation of aggregations, and find mates. The identification and isolation of insect pheromones have allowed researchers to monitor insect populations through pheromone traps, and to disrupt their chemical communication. Mating disruption (MD) is a pest management strategy where the specific sex pheromone of an insect species is applied to a field with the goal of limiting mate-finding. MD is highly specific to the target pest so it a) does not interfere with biological control agents, b) reduces the number of insecticide sprays, and c) combats resistance to insecticides.

In Wisconsin cranberries, three lepidopterans frequently attack the crop: the cranberry fruitworm (CFW), *Acrobasis vaccinii*, the sparganothis fruitworm (SFW), *Sparganothis sulfureana*, and the blackheaded fireworm (BHFW), *Rhopobota naevana*. The pheromones for all three species have been identified and are used to monitor moth flight. Mating disruption has been investigated as a method of pest control in cranberries for BHFW (e.g. Fitzpatrick et al. 1995, Baker et al. 1997) and there have been some preliminary trials with SFW as well (Polavarapu et. al. 2001). These studies showed that it was possible to attain significant mating disruption using pheromones incorporated in different types of dispensers. Two products were commercially available for use against BHFW, but they have been discontinued due to limitations with the dispenser.

This report summarizes the results of our two year study using SPLAT® as a pheromone carrier. SPLAT® (Specialized Pheromone & Lure Application Technology), developed by ISCA Technologies (Riverside, CA), is a food-grade wax emulsion that can be impregnated with synthetic pheromone(s). SPLAT® is a promising carrier compared to previously used products because it has a slow pheromone release rate, it is biodegradable, and it can be applied mechanically. In the first year of the study, SPLAT® containing a two species blend (targeting BHFW and SFW) was applied to 49 acres of cranberry split between four marshes. That season we applied SPLAT® as 3.2 g drops using a caulking gun, totaling approximately 300 drops/acre (Fig. 1A). In 2013, SPLAT® contained a three species blend and we treated 50 acres split between six marshes. The second year SPLAT® was applied using grease guns which allowed us to decrease the size of each drop. That season we used 1 g drops totaling around 1,000 drops/acre (Fig. 1B). Only one marsh was included both years, so we treated each site as a separate replicate.

There were three metrics of success for our project. First, we used standard pheromone-baited traps to measure the ability of male moths to find the traps within disrupted blocks. Pheromone traps attract males in the same way that female moths do, so if there is enough synthetic pheromone clouding the air within the crop, the males should not be able to track the pheromone signals coming from either the trap or a female. Thus, in a block with effective mating disruption, all traps should remain empty. Secondly, we determined female mating frequency by placing cages with female moths out at each site to evaluate if male moths were able to find the females. Lastly, we collected eggs and larvae found on and in developing cranberries to determine if there was a reduction in the second generation.

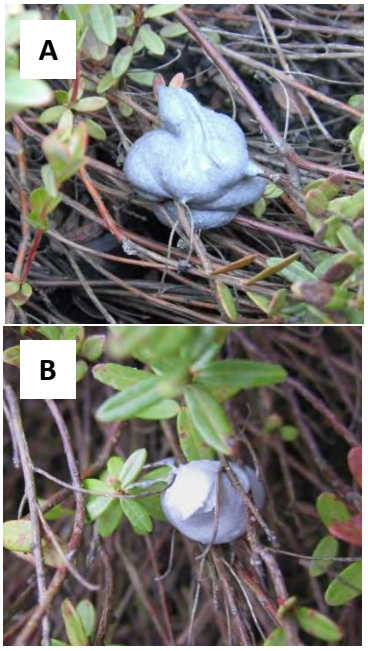

Figure 1. SPLAT® drop in (A) 2012 dispensed using a caulking gun and (B) 2013 dispensed using a grease gun. Both years the drops were applied directly to the cranberry vines

The trapping data and larval density data were analyzed using PROC MIXED (SAS Institute Inc. 2002-2004). To meet the normality assumption, the data were converted to ranks except for the CFW trapping data which were log transformed, and the CFW egg data which were analyzed using the raw numbers. The level of disruption was calculated by dividing the total number of moths caught in the SPLAT® traps by the total number of moths caught in the control traps at that location. This proportion was subtracted from one and multiplied by 100 to get a percentage. The percent disruption at each site was averaged to give the overall level of disruption for that moth species.

RESULTS

Blackheaded fireworm. Across the two seasons, we applied the BHFW pheromone at ten sites, but five of the sites had negligible BHFW populations so these were removed from the analysis. For the remaining five sites, the comparison of the number of moths caught in the SPLAT® block verses the control is depicted in Fig. 2A. We found that there was an overall significant treatment effect ($F_{1,61} = 4.22$, $P = 0.04$) and a significant week*treatment interaction ($F_{7,61} = 2.15$, $P = 0.05$) but the interaction was likely driven by the differences in the number of moths caught between weeks as flight progressed. Overall, there was 79% (se = 6.1) disruption at these five sites ranging from 93% to 56%. Certain marshes had zero or very few moths, and thus without a measurable moth population, we could not assay mating frequency or locate enough larvae to analyze.

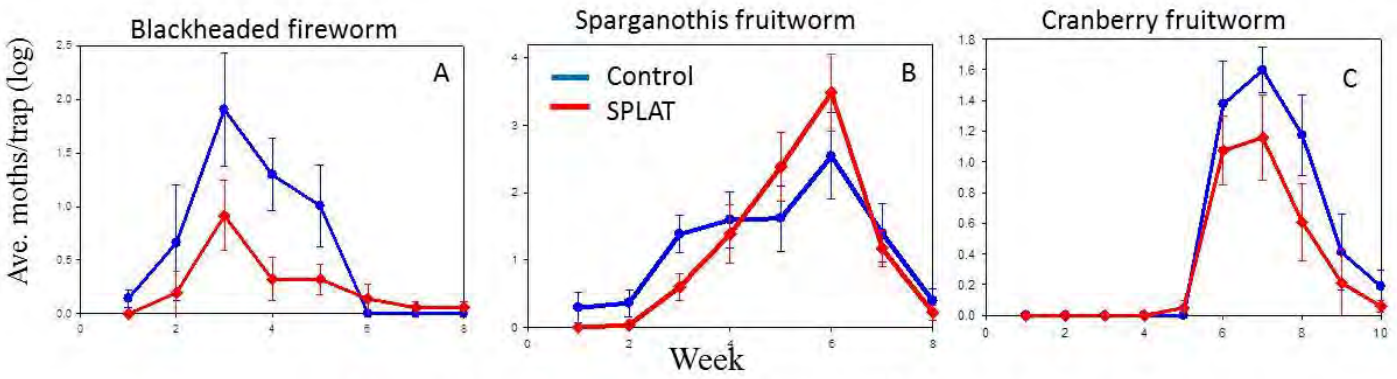

Figure 2. The average number of male moths caught in pheromone-baited traps in the control (blue line) verses SPLAT® treated (red line) blocks for (A) blackheaded fireworm, (B) sparganothis fruitworm, and (C) cranberry fruitworm.

Sparganothis fruitworm. The SFW pheromone was applied at ten sites. Two of the sites did not have SFW moths, so the remaining eight sites were used for the analysis. The comparison of the number of moths caught in the SPLAT® block verses the control is shown in Fig. 2B. For this species there was not a significant treatment effect ($F_{1,109}$ = 1.43, P = 0.23). Overall, we caught 78% (se = 44.1) more moths in the traps in the SPLAT® block verses the control. There were only two sites where we caught more in the control than the SPLAT® block. At the sites where we caught more in the SPLAT® block, we had an average of a 126% (se = 43.0) increase in moths and this reached as high as a 288% increase at one site. Regarding larval densities, very few SFW larvae were found in our collections, and there was not a significant difference between the number of larvae found across the three weeks of our sampling ($F_{1,28}$ = 2.06, P = 0.16). The female mating frequency data has not been analyzed at this point.

Cranberry fruitworm. The CFW pheromone was only used in 2013, but we had moths at all six of these sites, so all remained in the analysis. The commercial pheromone lures (manufactured by Great Lakes IPM) we were using did not attract moths, but after we switched to different lures (ISCA Technologies) in week 5, we were able to make a comparison between the numbers caught in the SPLAT® verses control blocks (Fig 2C). There was a significant treatment effect ($F_{1,48}$ = 5.40, P = 0.02). From weeks 6-10, across the six sites, five had more moths caught in the control block, averaging 66% (se = 11.8) disruption which ranged from 98% disruption to 35% disruption. One site however had 70% more moths caught in the SPLAT® block than the control, which brought the overall average level of disruption down to 43% (se = 24.6). Green berries were collected and inspected for CFW eggs and there was not a significant difference in the numbers found between the SPLAT® and control blocks ($F_{1,20}$ = 0.71, P = 0.41). The total number of CFW larvae found in prematurely red berries was also not significant ($F_{1,28}$ = 3.03, P = 0.09). In our collections, not every damaged berry contained a larva, so we also analyzed the difference in the total number of damaged berries between the two treatments. We found that there were significantly more damaged berries found in the SPLAT® blocks verses the control ($F_{1,28}$ = 6.03, P = 0.02). Since we found so few SFW larvae, and most of these berries

were full of frass (which is characteristic of CFW damage), the majority of the damage was likely due to CFW larvae. Because larval CFW burrow into the soil to pupate, we were not able to obtain adult moths to determine female mating frequency.

DISCUSSION

Overall, we had much variability in the level of disruption between species and between sites. For BHFW, at the sites with moths, it appears that we had successful disruption. This is encouraging since MD has been shown to successfully control BHFW using other carriers, so our data suggest that SPLAT® is sufficient to dispense adequate amounts of BHFW pheromone. SFW, on the other hand, did not have significant disruption, and it even led to an increase of moths at some sites. It does appear that we were getting some response from the moths, since perhaps they were being drawn in from other parts of the marsh, but the pheromone load in SPLAT® was not sufficient to disrupt mating. In year two, CFW moths were significantly disrupted, but there was still excessive larval damage in the SPLAT® blocks, so future work will investigate whether increasing the pheromone load will improve disruption.

As such a large scale project, many factors could be at play to explain why we saw an increase in the number of SFW moths and damaged berries in the SPLAT® beds. One possibility is that moths were being drawn in from other parts of the marsh. MD is most effective at a large scale, and we could only treat limited acreage. As we continue this study we will increase the acreage treated at each site to try and prevent moth immigration and isolate the true effect of the pheromone components. MD also works best when there are low pest densities, because in areas of high pest pressure moths can find each other by chance. Often preliminary insecticide applications are needed to reduce pest densities before MD is employed, and then MD keeps pest levels low.

In the future, we will be focusing only on a two species blend targeting BHFW and CFW. Because we did not see any level of disruption for SFW, and the pheromone is very expensive to produce, it is not economical to continue adding the SFW pheromone to the blend. However, we will increase the amount of CFW pheromone to try and get complete disruption. Pheromone-based MD has proven to be a successful non-insecticidal method of pest control in many cropping systems. As this study continues, we will further evaluate the potential for complete MD using SPLAT® with the ultimate goal of creating a functional MD program that can be incorporated into growers' integrated pest management programs.

ACKNOWLEDGEMENTS

We would especially like to thank our Wisconsin cranberry grower collaborators for allowing us to perform this research on their marshes. We also thank the Steffan and Zalapa lab personnel for all their help collecting and processing samples. This project was funded by the USDA-ARS, Wisconsin Cranberry Board, and the Cranberry Institute.

REFERENCES

Baker, T. C., T. Dittl, and A. Mafra-Neto. **1997**. Disruption of sex pheromone communication in the blackheaded fireworm in Wisconsin cranberry marshes by using MSTRS devices. J. Agric. Entomol. 14(4): 449–457.

Fitzpatrick, S. M., J. T. Troubridge, C. Maurice, and J. White. **1995**. Initial Studies of Mating Disruption of the Blackheaded Fireworm of Cranberries (Lepidoptera: Tortricidae). J. Econ. Entomol. 88(4): 1017–1023.

Polavarapu, S., G. Lonergan, H. Peng, and K. Neilsen. **2001**. Potential for mating disruption of Sparganothis sulfureana (Lepidoptera: Tortricidae) in cranberries. J. Econ. Entomol. 94(3): 658–665.

SAS Institute Inc. 2002-2004. SAS 9.3.1 Help and Documentation. Cary, NC: SAS Institute Inc.

ASSESSMENT OF RESISTANCE OF CRANBERRY VARIETIES TO INSECT PESTS

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Wisconsin's cranberry industry is currently looking for ways to improve sustainability and to integrate more Integrated Pest Management (IPM) strategies into growing practices. One important IPM tool is Host Plant Resistance; the heritable properties of plants that improve their natural resistance against insects and other pests. Although Host Plant Resistance is an important pest suppression strategy in many other cropping systems, it has been little studied or utilized in cranberries. Promisingly, the handful of studies that has been done with cranberry has indicated that some varieties may be more resistant than other ([1,2]). However, more research needs to be done with different pests and other varieties, including more varieties that are grown in Wisconsin.

Objective

The overall objective of this research is to assess the susceptibility of several cranberry varieties grown in Wisconsin (Stevens, Ben Lear, GH-1, Mullica Queen, HyRed, Pilgrim, Crimson Queen, Demoranville, and Early Black) to three of the most economically important cranberry pests: blackheaded fireworm, *Rhopobota naevana,* sparganothis fruitworm, *Sparganothis sulfureana,* and cranberry fruitworm, *Acrobasis vacinii* (Figure 1).

Figure1. The usual suspects: Blackheaded fireworm, sparganothis fruitworm, and cranberry fruitworm

The complete project will address three objectives:

1) Evaluate field population densities of the three target pests in different cranberry varieties.
2) Determine development rates and fecundity of the three target pests on different cranberry varieties in the laboratory.
3) Assess the susceptibility of the selected varieties to insect feeding damage by the target pests in the laboratory.

At this point, one season of the field population density study (objective 1) is complete and will be repeated next year. The second and third objectives will be started in the spring and summer of 2014.

Field Population Density Study

For this component, we chose five sites in Central Wisconsin, and looked at beds of six different cranberry varieties at those sites (Stevens, Ben Lear, GH-1, HyRed, Mullica Queen, and Pilgrim). For each variety, we placed four pheromone-baited traps in the center of the bed along the edge: one trap for each species of moth and a control trap with no lure. Traps were placed just off the dike between two beds of the same variety, so that we could ensure that the moths trapped were only from that variety. We changed the traps and counted the number of moths in each trap every week and compared the numbers across varieties throughout the season. We collected field data from June through August of 2013 and found a lot of variation of overall pest populations among the selected sites (Figure 2). We found no statistically significant difference in population densities among the different varieties for blackheaded fireworm (Figure 3), sparganothis fruitworm (Figure 4), or cranberry fruitworm (Figure 5). We will repeat the study next summer to confirm these results.

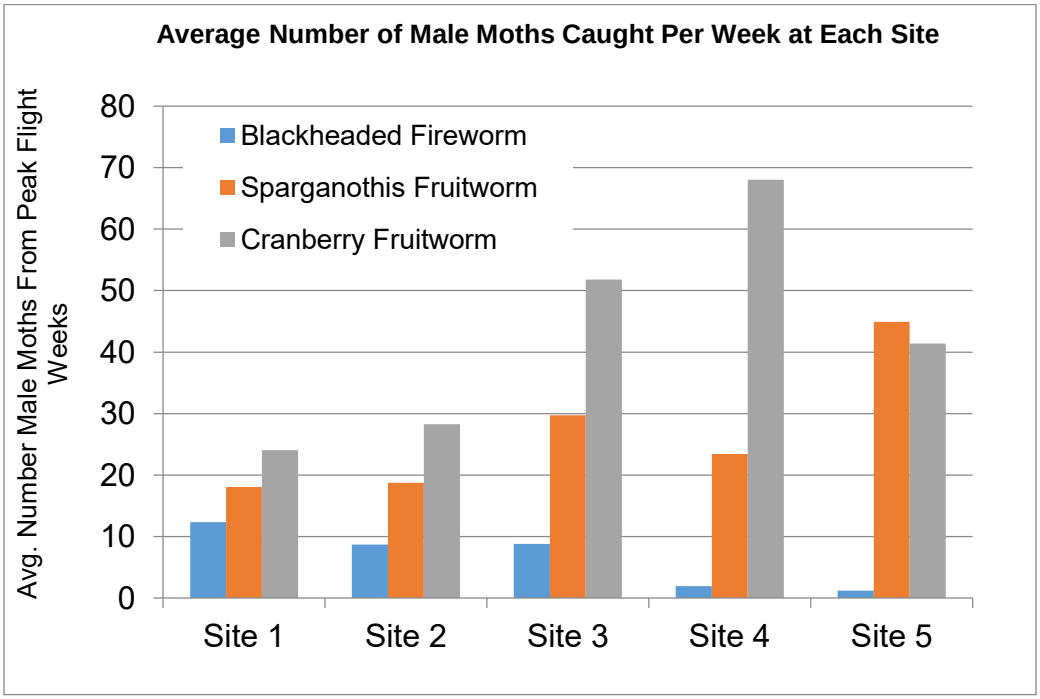

Figure 2. Graph showing the average number of males caught for all varieties during the peak flight weeks at each site. Colored bars indicate the different moth species.

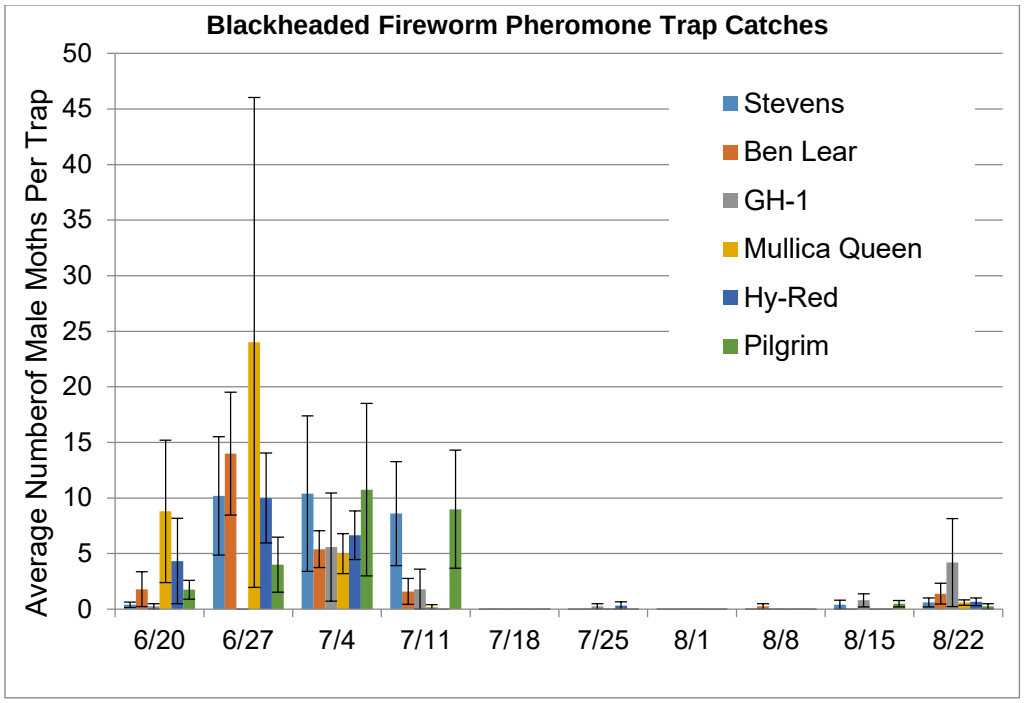

Figure 3. Average number of male blackheaded fireworm moths per trap for each variety for all of the weeks of the study. The different colored bars represent different varieties. The black bars indicate the standard error.

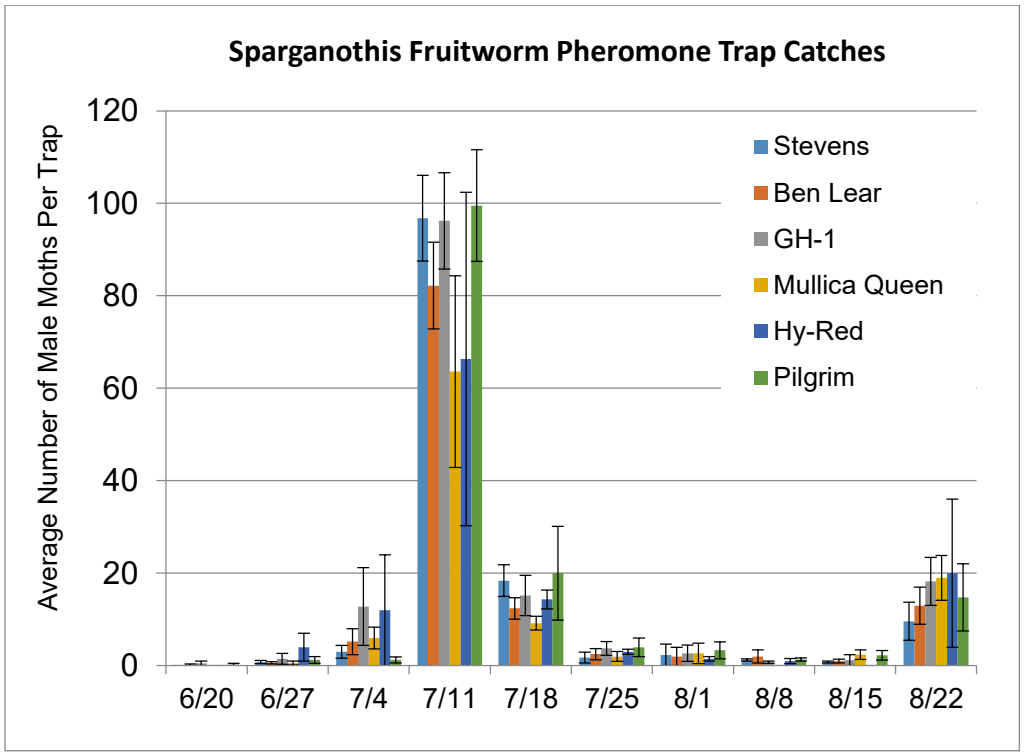

Figure 4. Average number of male sparganothis fruitworm moths per trap for each variety over all of the weeks of the study. The different colored bars represent different varieties. The black bars indicate the standard error.

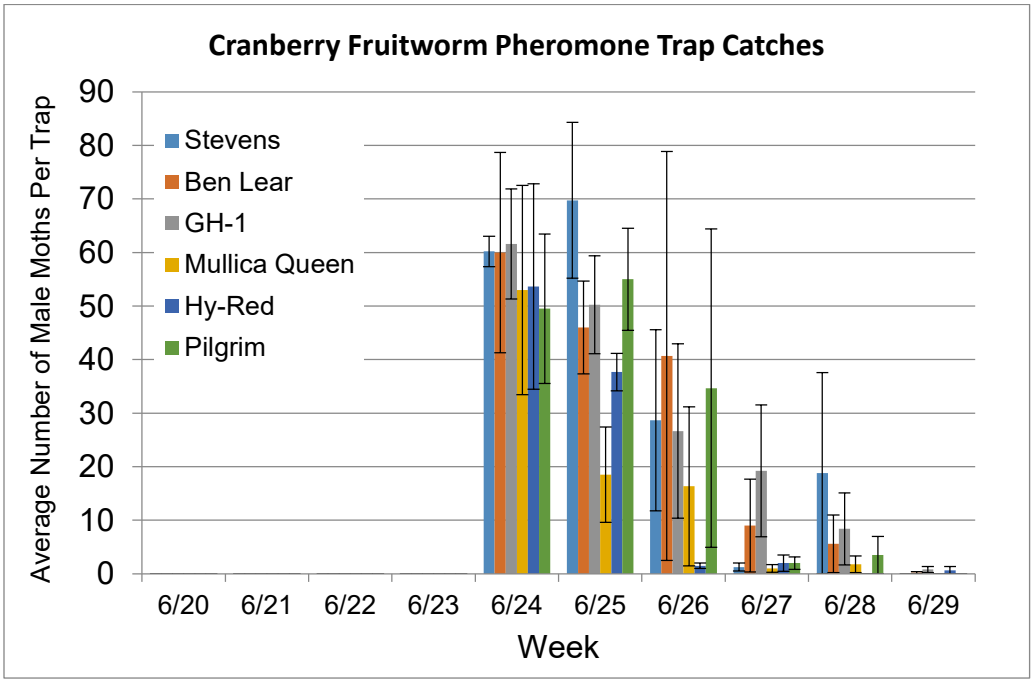

Figure 5. Average number of male cranberry fruitworm moths per trap for each variety over all of the weeks of the study. The different colored bars represent different varieties. The black bars indicate the standard error.

Future Research

For the next objective of the research, we will examine the performance of larval blackheaded fireworm and sparganothis fruitworm on different cranberry varieties in the laboratory and greenhouse. We will also test whether adult females of these two moth species have a preference of which variety to lay eggs on. Another component of the research will measure the damage sustained by each variety from insect feeding. Varieties will include Stevens, Ben Lear, GH-1, HyRed, Sundance, Mullica Queen, Crimson Queen, Demoranville, and Early Black. We will use insects from colonies that are being reared in the laboratory and cranberry plants from various sources, grown in a greenhouse.

Discussion

This summer's data did not show any significant difference in field population densities among the varieties. The data also showed variability of overall moth populations among the different sites. This variability is not surprising, and could be due to different management strategies, slight differences in conditions at the different sites, or hotspots of pest outbreaks in some sites.

We intend to repeat the field density portion of the project next summer to solidify our findings. Other field studies ([3]) have found a similar lack of trend in field populations. However, significant differences in insect performance have been found in other laboratory studies ([1,2]), so we expect to see significant results as well.

If we do find a more resistant variety, it can be incorporated into future planting decisions and breeding programs to help reduce the need for chemical control.

Acknowledgements
We are very grateful to the growers for allowing us to use their marshes for this study. Special thanks to the Wisconsin Cranberry Board Inc. for their funding and support. We would also like to acknowledge Jayne Sojka, Juan Zalapa, Brent McCown, Ron Amos, Cesar Rodriguez-Sanoa, Nick Vorsa and colleagues at Rutgers for their assistance and Tressa Franzmeier and other members of the Guédot lab for all of their help.

References

[1]Rodriguez-Saona C, Vorsa N, Singh AP, Johnson-Cicalese J, Szendrei Z, Mescher MC, and Frost CJ. Tracing the history of plant traits under domestication in cranberries: potential consequences on anti-herbivore defences. J Exp Bot. 2011;62:2633-2644.

[2] Neto CC, Dao CA, Salvas MR, Autio WR, and Vanden Heuvel JE. Variation in concentration of phenolic acid derivatives and quercetin glycosides in foliage of cranberry that may play a role in pest deterrence. J Am Soc Hortic Sci. 2010;135:494-500.

[3]Averill, A. 2010 Cranberry management update: insect update. Cranberry Station Extension meetings.Paper 91;2010 Jan 1. Available from http://scholarworks.umass. edu/cranberry_ extension/91

Additional References

Averill AL, Sylvia M.M. Cranberry insects of the Northeast: a guide to identification, biology and management. Amherst (MA):University of Massachusetts/Amherst; 1998.110 p.

Dittl TG, Kummer LD. Major cranberry insect pests of Wisconsin. Babcock (WI):Ocean Spray Cranberries, Inc.; 1997. Available from http://longbeach.wsu.edu/cranberries/documents/

POLLINATION IN CRANBERRY

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Pollination in cranberry involves many different pollinators that will transfer pollen grains from the anthers (male part) to the stigma (female part) of another flower. Pollen grains in cranberry come in form of tetrads, meaning four pollen grains adhering together. A study by Cane and Schiffauer in 2003 determined that in cranberry, only 8 pollen tetrads deposited on the stigma of a flower were sufficient to obtain optimal fruit set and berry mass. This finding is important as it allows to quantitatively assess how efficient a particular pollinator is at pollinating cranberry.

The most efficient pollinators are bees. There are ~25,000 species of bees worldwide, with ~4,500 solitary bees in North America and approximately 400 species in Wisconsin. Honeybees have been used for pollination in cranberry for decades, mainly because they are the most extensively managed pollinator in the world, accounting for 84% of all insect pollination. Honeybees are not native and were introduced in the early 1600s by settlers. In 2005, a survey conducted by USDA NASS in WI showed that 70% of operations used honeybees for their pollination services at an average of 1.8 colonies/acre; and 13% used bumble colonies. Recommendations on the number of hives per acre have not been established but numbers have increased over time to approximately 2-3 hives per acre currently (see also Hannah Gaines Day article on page 29). During this year's school "clicker" polling session, growers were asked how many honeybee hives per acre they brought in 2013. The majority (51%; n = 78) brought in 3-5 hives, 19% brought 1-2 hives, 9% brought in 6-8 hives and 14% brought in more than 8 hives.

Not all pollinators are equal and the effectiveness of a pollinator can be determined by looking at 1) the abundance of a specific pollinator and the frequency at which it visits flowers; 2) the pollination efficiency, such as the number of pollen grains deposited on a flower during a single visit, or the number of pollen grains collected during a visit; and 3) the fidelity to cranberry or how much they prefer cranberry over other flowers.

Honeybees are not necessarily the most efficient pollinator in cranberry as they often steal nectar without pollinating the flower and they do not show a strong preference for cranberry over other more nutritious flowers. The fidelity of honeybee colonies to cranberry varies from day to day and from colony to colony, with bees collecting 2-100% of cranberry pollen (Shimanuki et al. 1967; Cane and Schiffauer 2001).

Bumblebees are native with 49 species in the U.S. and 250 species worldwide. Bumblebees perform buzz pollination where they grasp the flower and vibrate their wing muscles rapidly

without moving their wings, shaking the pollen out of the anthers onto their body. This buzz pollination makes them very efficient pollinators of many crops, including cranberry.

The majority of bee species (90%) are solitary, where each female builds and provisions her own nest and lays eggs. Seventy percent of solitary bees nest underground while the other 30% nest in pre-existing wood cavities, such as beetle borer holes or hollow plant stems. Some cavity nesters have been developed as managed commercial pollinators, e.g. the alfalfa leaf cutting bee for alfalfa pollination and the blue orchard bee for cherry, apple, almond,… pollination. Some solitary species have been evaluated for commercial pollination in cranberry, for example *Megachile addenda* is a ground nesting bee that nests on cranberry dikes and in beds and can withstand flooding (Cane et al. 1996).

Comparisons of pollination efficiency between pollinator species

In 1994, McKenzie looked at the pollination efficiency of bumblebees compared to honeybees. He found that honeybees contacted the stigma of a flower much less often than bumblebees (41% vs. 96%, respectively) and only 3% of honeybees were observed foraging for pollen compared to 74% in bumblebees. More recently, Broussard et al. (2011) observed 63% honeybees foraging for pollen compared to 89% of bumblebees.

Cane and Schiffauer (2003) compared the pollination efficiency of honeybee (*Apis mellifera*), bumblebee (*Bombus affinis*), *Megachile addenda,* and alfalfa leafcutting bee (*Megachile rotundata*) (Figure 1). This study showed that bumblebees deposited more pollen than any other bee and set fruit in 80% of flowers visited. For honeybees, even though they deposit less pollen than bumble bees or *Megachile addenda*, they still deposit the 8 pollen tetrads required for optimal fruit set and berry mass (Figure 1a). Looking at fruit set, honeybees pollinated flowers such that fruit set in 50% of flowers they visited (Figure 1b).

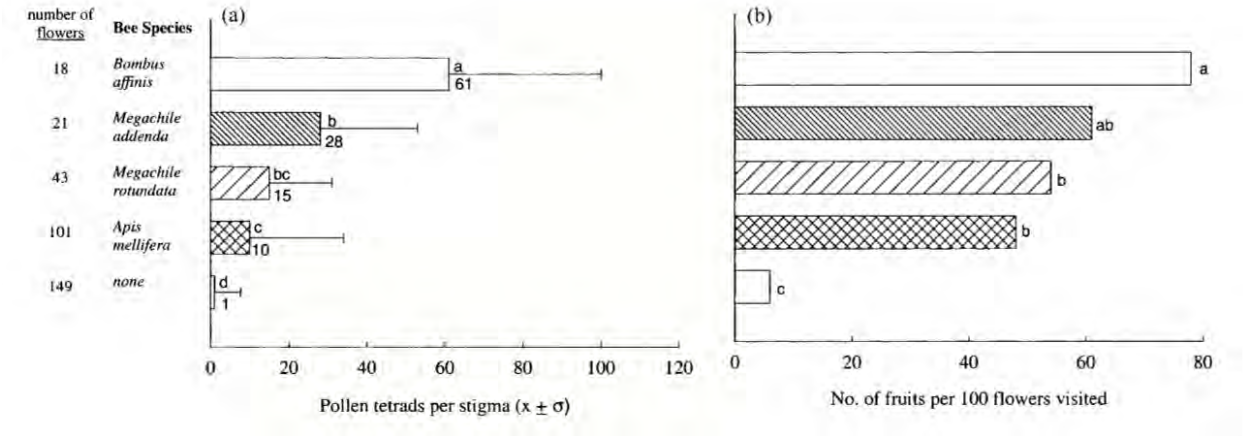

Figure 1. Differences between bee species (bumblebee, *Bombus affinis*; *Megachile addenda*; alfalfa leafcutting bee, *Megachile rotundata*; and honeybee, *Apis mellifera*) in single-visit pollen deposition (a) and predicted fruit set (b) of resulting cranberries. None refers to no pollinator. Bars with different letters are statistically different.

In a 2006 study, Evans and Spivak compared pollination services in cranberry with honeybees and without honeybees, thus relying solely on wild bees. They found that berry mass decreased by 50% without honeybees, from 0.06oz per berry with 3 honeybee hives per acre to 0.03oz with no commercial honeybees. In addition, without commercial honeybees, berry mass decreased in the center of beds as opposed to bed edges. This study also found that more pollen tetrads were deposited on stigma in mid and late bloom when honeybees were present (Figure 2a) and more flowers received at least 8 pollen tetrads with honeybees at mid-bloom than without honeybees (Figure 2b), suggesting that there might not be enough wild pollinators to pollinate cranberry flowers at mid-bloom.

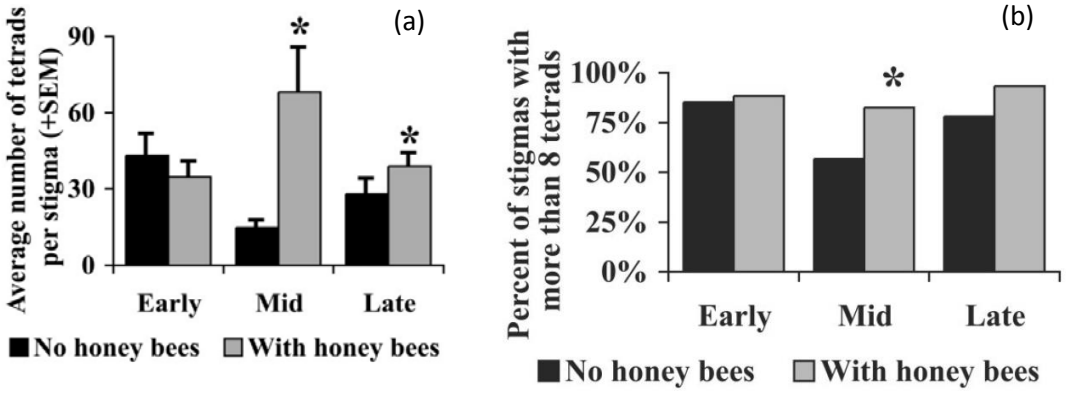

Figure 2. (a) Average number of pollen tetrads on each stigma examined for different bloom stage, with or without commercial honeybees. (b) Percent stigmas that received more than eight pollen tetrads at different bloom stage, with and without commercial honeybees. * indicates statistically significant differences.

In a recent study, Cariveau and Winfree (2012) observed bees visiting flowers in cranberry beds (Table 1). In this study, they found that honeybees were the most abundant bee in cranberry, accounting for 73% of 9,300 visits observed, while bumble bees represented 17% and wild bees 10% of these visits. Honeybees deposited on average 3.8 pollen tetrads, bumblebees 7.2 and wild bees ranged from 1.2 to 9.8 pollen tetrads per visit. The overall contribution (the number of visits x number of pollen tetrads deposited per visit) of these bees to cranberry pollination was 64% for honeybees, 28% for bumblebees, and 9% for other wild bees.

Table 1. Percent visits, number of pollen tetrads deposited per visit, and overall contribution of honeybees, bumblebees, and other wild bees in cranberry beds.

	Honeybees	Bumblebees	Other wild bees
% visits	73 ± 4%	17 ± 3%	10 ± 3%
# pollen tetrads/visit	3.8	7.2	1.2 - 9.8
Overall contribution	64 ± 5%	28 ± 4%	9 ± 2%

These studies taken collectively suggest that honeybees are usually effective pollinators (~8 pollen tetrads per visit), are present in very high numbers when commercially supplemented to

cranberry marshes, thus accounting for more visits to flowers, and are able to fly longer distances than wild bees (all the way to the center of beds).

Future research will address how the location of bee hives on the marsh impact bee visitation to cranberry flowers.

References

Broussard M., Rao S., and Stephen W.P. 2011. Native bees, honeybees, and pollination in Oregon cranberries. HortScience, 46: 885-888.

Cane J.H and Schiffauer D. 2003. Dose response relationships between pollination and fruiting refine pollinator comparisons for cranberry (*Vaccinium macrocarpon* [Ericaceae]). American Journal of Botany, 90: 1425-1432.

Cane J.H and Schiffauer D. 2001. Pollinator genetics and pollination: do honey bee colonies selected for pollen-hoarding field better pollinators of cranberry *Vaccinium macrocarpon*? Ecological Entomology, 26: 117-123.

Cane J.H., Schiffauer D., and Kervin L.J. 1996. Pollination, foraging, and nesting ecology of the leaf-cutting bee *Megachile* (*Delomegachile*) *addenda* (Hymenoptera: Megachilidae) on cranberry beds. Annals of the Entomological Society of America, 89: 361-367.

Cariveau D. and Winfree R. 2012. Cranberry Pollination of New Jersey Cranberries. Plant and Pest Advisory: Cranberry Edition Rutgers Cooperative Extension Rutgers, The State University of New Jersey 18(7): 1-2.

Evans E.C. and Spivak M. 2006. Effects of honey bee (Hymenoptera: Apidae) and bumble bee (Hymenoptera: Apidae) presence on cranberry (Ericales: Ericaceae) pollination. Journal of Economic Entomology, 99: 614-620.

MacKenzie K.E. 1994. The foraging behavior of honey bees (*Apis mellifera* L.) and bumble bees (*Bombus* spp) on cranberry (*Vaccinium macrocarpon* Ait). Apidologie, 25: 375-383.

Shimanuki H., Lehnert T., and Stricker M. 1967. Differential collection of cranberry pollen by honey bees. Journal of Economic Entomology, 60: 1031-1033.

USDA Wisconsin Agricultural Statistics Service. 2005 Cranberry production and pollination survey.

NATIVE POLLINATORS IN CRANBERRY – AN UPDATE

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(This paper is a brief summary of a PhD dissertation entitled "Do bees matter to cranberry? The effect of bees, landscape, and local management on cranberry yield" by Hannah Gaines Day, 2013.)

Honey bee decline and its consequences

Since 2006, honey bees in the United States have experienced drastic declines with an average of 30% of colonies lost each winter (Bee Informed Partnership et al. 2013). A mix of several factors, including pesticide exposure, disease, and poor diet have been implicated in this sudden loss of bees (Ellis et al. 2010). The result of this decline is fewer, weaker hives and increased rental fees for farmers. As farmers face decreased availability and increased costs, the option of alternative pollinators may become more attractive.

Native bees and crop pollination

Native bees are good alternative pollinators and, in some cases, are more efficient pollinators than honey bees (e.g., cranberry, Cane and Schiffhauer 2003). Unfortunately, native bee populations are also threatened with decline due to the loss of habitat from agricultural expansion, intensification, and pesticide exposure (Potts et al. 2010). Of the approximately 4,000 species of native bees in North America, the majority are solitary, which means there is no queen or large colony and they don't produce honey. They are also central place foragers, returning to the same nest after each foraging trip. Since their flight distance is limited by their body size and most bees are quite small, the presence of natural habitat close to the farm is vital to their survival.

Therefore, the first objective of this study was to document which species of native bees exist in Wisconsin cranberry, to understand how they are influenced by local farm management and the habitat in the surrounding landscape, and document the contribution they make to cranberry pollination.

Native bees, landscape, and local factors

To address the first objective, we selected field sites (i.e., commercial cranberry marshes) along a gradient of surrounding landscape from a high percentage of woodland to high agriculture within 1 km. Over three field seasons and 49 different marshes, we used pan traps to collect native bees. We collected yield, honey bee, and spray records from each site and estimated yield on a plot basis using square foot quadrats. At a subset of sites, we also established a cage study in which small plots were covered with fine mesh to exclude pollinators in order to compare cranberry yield with and without bees.

We collected 6673 specimens representing 182 different species of bees. As the amount of natural and wooded habitat in the surrounding 1 km of the marsh increased, native bee abundance and species richness also increased. Native bees also increased with higher spray intensity which suggests that spray intensity is correlated with other, bee-friendly practices such as spraying when bees are not

active. Yield was strongly correlated with the number of honey bee hives/acre but was not associated with the abundance or diversity of native bees. The results from our cage study, however, provided evidence that native bees do contribute to cranberry pollination. Even at sites where honey bees were absent, open plots had higher yields than plots where all bees were excluded.

Honey bees and cranberry yield

Although the focus of this research began with native bee pollinators, it quickly became evident that understanding the value of honey bees for cranberry pollination was a clear priority among growers. Specifically, growers wanted to know how many hives of honey bees they should use on their marsh. Current management recommendations call for 2-3 hives/acre, although growers actually use anywhere from 0-9 hives/acre. This discrepancy suggests that either the management recommendation is incorrect or that the optimal number of hives varies from site to site. Therefore, the second objective was to determine the optimal number of hives/acre to maximize yield.

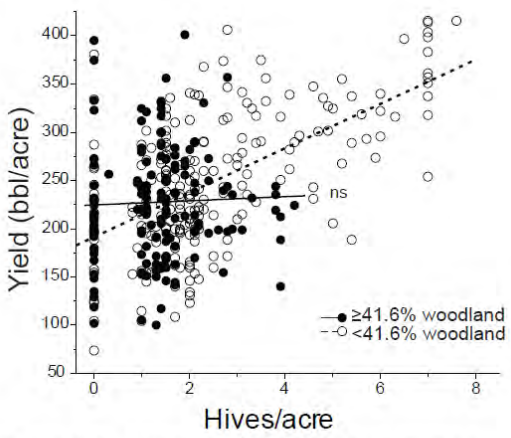

Figure 1. The relationship between hive stocking density and cranberry yield. Each point represents a single marsh in a single year.

To address this objective, we collected historical data regarding yield and hives/acre from approximately 40 cranberry growers in central Wisconsin for the time period 2000-2011. There was a strong positive correlation between yield and hives/acre, but only for marshes with a low percentage of woodland within the surrounding 1 km (fig. 1). For marshes with a high percentage of woodland in the surrounding 1 km, there was no relationship between yield and hives/acre. Thus, a single optimal density of hives/acre does not exist, although in certain landscapes, increasing the number of hives/acre will be beneficial. The effect of surrounding landscape on the effectiveness of honey bees may be due to the abundance of alternative floral resources outside of the marsh which could distract the bees from visiting cranberry flowers.

We also found that the variation in yield decreased with increasing hives/acre, but again, only at marshes in low-woodland landscapes (fig. 2). For marshes located in low-woodland landscapes, using more hives/acre both increases their yield and also provides insurance against low yields by decreasing the variation in yield.

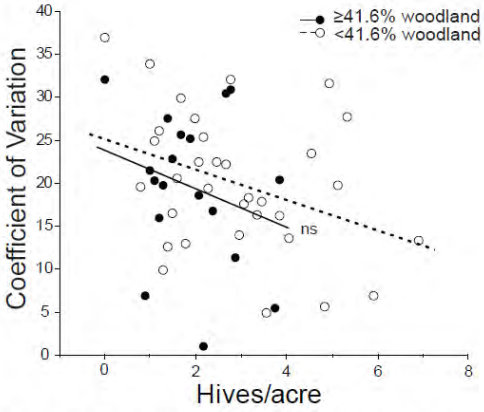

Figure 2. The relationship between hive stocking density and variation in cranberry yield.

This data also provides evidence that native bees contribute to cranberry pollination. When a marsh had no honey bee hives present, yield was not zero. To the contrary, average yield was economically competitive to marshes with honey bees, although the variation among sites was also quite large. Additionally, when honey bees were absent, marshes located in high woodland landscapes had marginally higher yields than marshes in low woodland landscapes. This suggests that the

contribution of native bees to cranberry yield varies by landscape context.

Non-bee factors and cranberry pollination

From the data from our first two objectives, we found that bees provide valuable pollination services to cranberry. An unexpected result from our cage study, however, was the discovery that even when bee pollinators were excluded, we still found cranberries within the cage. Previous research has clearly demonstrated that cranberry does not self-pollinate within a single flower (Cane and Schiffhauer 2003). Therefore, the third objective was to determine whether other, non-bee factors could effectively cause pollination in cranberry.

To address this objective, we did complementary greenhouse and field studies. In the greenhouse, we compared hand pollination ("hand"), manual agitation ("agitation"), and self-pollination without outside assistance ("undisturbed")(fig. 3A). In the field, we established cages in a single bed of Stevens cultivar to compare open, ambient pollination ("open"), wind pollination ("wind"), self-pollination without outside assistance ("closed"), and manual agitation ("agitation")(fig. 3B).

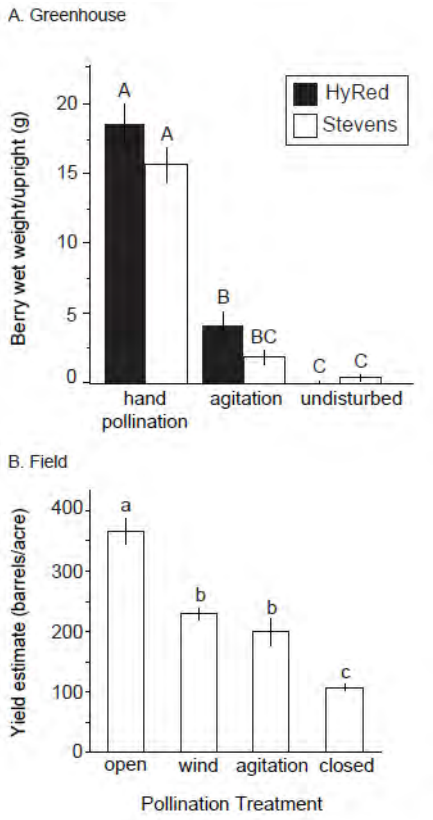

Figure 3. Yield estimates by pollination treatment.

We found that even in the absence of bees, cranberry is able to produce fruit. In the greenhouse, hand pollination was responsible for 80% of yield, while agitation was responsible for 20% of yield. In the field, we found that bees were responsible for approximately 45% of the yield, while agitation and non-bee factors were responsible for 55% of yield. This data provides evidence that even small agitation of the plants is enough to cause flowers to bump against each other and transfer pollen. The variation between field and greenhouse results may be due to differences in upright density (1706 uprights/m^2 in the field vs. 279 uprights/m^2 in the greenhouse) or the presence of uncontrolled variables in the field (e.g., thrips).

On-farm pollinator conservation

In response to bee decline, the government has prioritized incentives programs that include on-farm conservation practices for pollinators. Despite the importance of bees to cranberry pollination and the record of environmental stewardship among Wisconsin cranberry growers, participation has remained low. Our final objective was to gain a better understanding of why cranberry growers are not participating and create a list of recommended actions to increase participation.

To address this objective, we sent out a 50-question written survey in June 2011 to the entire mailing list of the WSCGA (n=250). This survey asked questions regarding current management practices, awareness of native bees, and participation in government-sponsored and non-government sponsored conservation programs.

We found that although none of the respondents were participating in an official program, 33% were managing habitat for pollinators anyway. This included planting flowering trees and shrubs for foraging bees and providing artificial nest boxes and brush piles for nesting resources. Additionally, 30%

of respondents reported that they have altered their management in some other way to protect pollinators including using reduced risk pesticides, delaying mowing of the dikes, or changing the time of day when they spray. Ninety percent of respondents were not aware of cost-share programs for pollinator habitat but 50% were interested in participating. Additionally, growers were discouraged from participating in cost-share programs due to lack of technical support and the amount of paperwork required to participate in government programs. From this survey, we suggest the following steps to increase participation in government-sponsored pollinator habitat programs: (1) increase outreach to promote and educate growers about the program, (2) increase the availability of technical support, and (3) reduce the amount of paperwork required for the growers to participate.

Conclusion

From our study, we clearly demonstrated that bees are important to cranberry production. Disentangling the contribution by native bees versus honey bees is difficult, although both seem to be important. The use of honey bees for cranberry pollination is very effective in certain landscapes but not in others, suggesting that there is no single optimal number of hives/acre. Furthermore, we demonstrated that a significant amount of pollination can occur when bees are absent due to agitation of the plants. This source of pollination is likely enhanced by increasing densities of flowering uprights.

Acknowledgements

We would like to thank all of the cranberry growers who so generously allowed us to do our research on their properties over the past 5 years. We would also like to thank the cranberry researcher group at UW-Madison, especially Eric Zeldin for help with the greenhouse study. We would also like to thank Tom Lochner, Jane Anderson, Jayne Sojka, Dan Mahr, Britt Searles, and Dan Cariveau for their support throughout this project. Specimen identification was done by John Ascher, Jason Gibbs, and Mike Arduser. Finally, we would like to thank all of the field and lab assistants who helped collect and process data, especially Collin Schwantes and Amanda Rudie. This research was funded by a Hatch Grant to C. Gratton and a NCR SARE Graduate Student Grant to H. Gaines.

References

Bee Informed Partnership, A. M. Spleen, E. J. Lengerich, K. Rennich, D. Caron, R. Rose, J. S. Pettis, M. Henson, J. T. Wilkes, M. Wilson, J. Stitzinger, K. Lee, M. Andree, R. Snyder, and D. vanEngelsdorp. 2013. A national survey of managed honey bee 2011-12 winter colony losses in the United States: results from the Bee Informed Partnership. Journal of Apicultural Research 52:44–53.

Cane, J. H., and D. Schiffhauer. 2003. Dose-response relationships between pollination and fruiting refine pollinator comparisons for cranberry (Vaccinium macrocarpon [Ericaceae]). American Journal of Botany 90:1425–1432.

Ellis, J. D., J. D. Evans, and J. Pettis. 2010. Colony losses, managed colony population decline, and Colony Collapse Disorder in the United States. Journal of Apicultural Research 49:134–136.

Potts, S. G., J. C. Biesmeijer, C. Kremen, P. Neumann, O. Schweiger, and W. E. Kunin. 2010. Global pollinator declines: trends, impacts and drivers. Trends in Ecology & Evolution 25:345–353.

TIMING OF TISSUE ANALYSIS IN CRANBERRY: NUTRIENT CONTENT CHARACTERIZATION IN NEW VARIETIES – FIRST YEAR RESULTS

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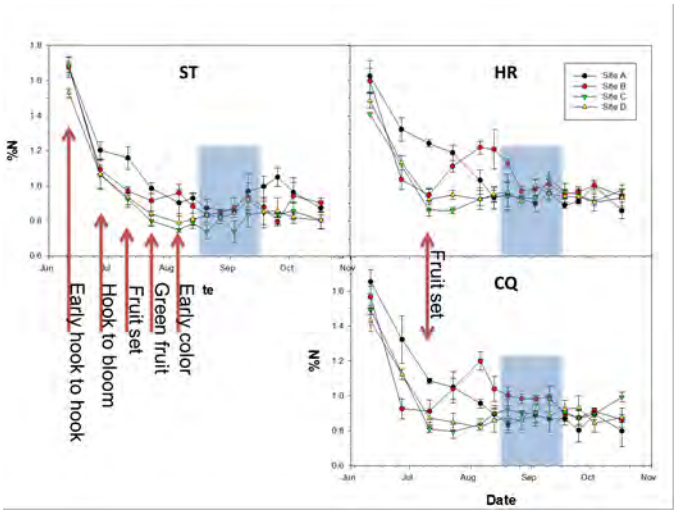
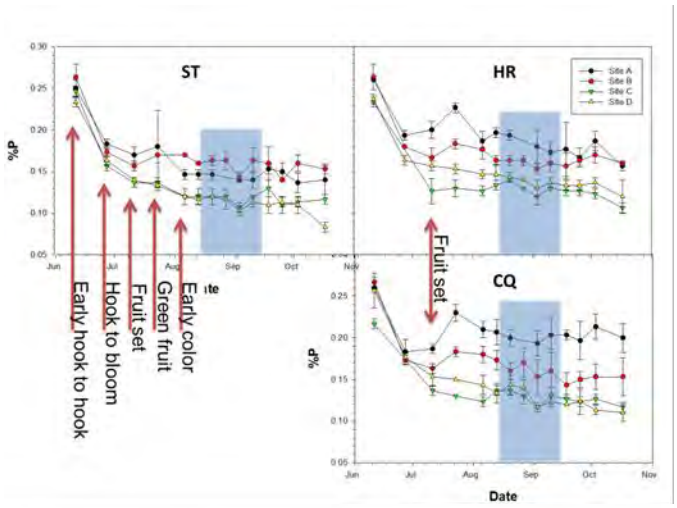
Tissue analysis results are a key part to fertilizer management decisions, and therefore it is important that samples are taken during the period of greatest stability for the most fundamental nutrients. These decisions can then inform the development of nutrient management plans and assist in sustainability goals, as well as the maintenance of a healthy crop. Current recommendations are to sample tissue between August 15 and September 15, the period of time that tissue is considered to be the most stable (Davenport et al., 1995). Several new cultivars recently introduced have not been evaluated for nutrient stability. These new cultivars have been selected for a number of traits, including earliness, high yield, enhanced color, and rebud potential, all factors that could have an influence on the timing and degree of nutrient demand within the plant. In addition, other factors may influence the relative stability of tissue nutrient content, such as variable environmental conditions and grower practices. The goal of this project is to 1) establish the window of nutrient content stability for two new varieties, 'HyRed' (HR) and 'Crimson Queen' (CQ) compared to a standard, 'Stevens' (ST), and 2) evaluate these patterns of tissue nutrient stability during the season in relation to parameters such as calendar date, plant phenological stage, and growing degree day, to determine the most suitable marker for the timing of tissue sampling.

Approach: To study patterns of nutrient stability, four sites were selected from the Cranmoor and Tomah areas. One bed of each variety was sampled at each site with pooled samples taken from each third of the bed. ST beds ranged in age from 17 to 22 years, while HR and CQ bed ages each ranged from four to seven years. New growth (minus flowers or fruit) was sampled and sent to AgSource Cooperative Services for analysis. Sampling was done every two weeks from early June to mid-August, then weekly until early October, for a total of 14 sample dates. Additional data that was collected included canopy height air temperature, plant phenology/stages of growth, fertilizer records, and yield. Results for the macronutrients, nitrogen (N), phosphorus (P), and potassium (K) are presented, as they will be of the greatest initial interest regarding the stability of the sampling window.

There has not been a definition of what "stability" should mean for these and other nutrients during a given period of time, since some variability is inherent. Here, values are plotted with the August 15-September 15 window boxed off in blue to allow for an easier visual inspection of the patterns.

Results and Discussion: For each nutrient, N, P, and K, content levels are highest early in the season, with subsequent decrease until generally reaching lowest values later in the season (Figure 1). Inclusion of stem below leaves means result values, especially of nitrogen, are likely underestimated, although it is the pattern of change of greatest interest here.





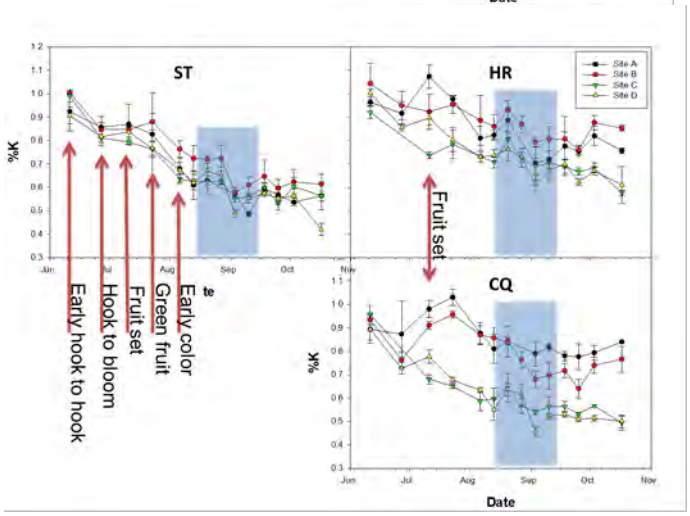


Figure 1: Seasonal nutrient content change for nitrogen (N), phosphorus (P), and potassium (K), in 2013 from four sites in the Cranmoor and Tomah areas. Each point is the mean value of three samples with standard deviation error bars. Blue boxes highlight the current recommended tissue sampling period of August 15 – September 15.

- *Nitrogen*: The clearest patterns of N content change occurred at sites C and D. At these sites ST reached its lowest levels and remained fairly stable around the time of filling green fruit to the onset of fruit color, while HR and CQ appear to reach this point slightly earlier, around fruit set. This might indicate that a slightly earlier sampling window could be possible in these newer cultivars, however, at sites A and B the patterns of %N content change were somewhat different. At site A, while content level s steadily declined, this happened much more gradually than at C and D. Generally stable levels were reached just by the start of the sampling window. The patterns at site B were initially similar to C and D, however, from fruit set to the beginning of the sampling window, there was a notable rise and decline in N content levels of HR and CQ, and possible slight similar effect in ST. In HR these levels were still declining during the first week of the sampling window.
- *Phosphorus*: It is interesting to note that even though a wide range of values were found, the %P content *pattern* for each cultivar at each site reached fairly stable levels by early August, regardless of the starting values at a given site. Sites C and D %P content were similar. At

these sites lowest levels were reached and essentially maintained, while the levels at sites A and B were distinctly higher.

- *Potassium*: The most notable trend in the %K content patterns for all sites and cultivars is that levels dropped in a fairly stepwise way in the middle of the sampling window. Content levels across the sites changed more similarly in ST than in HR and CQ, where levels rose over the month of July (from bloom to early fruit development) at sites A and B, while steadily declining at sites C and D.

Environmental and cultural factors were explored to explain the site to site variability in these seasonal patterns. Overall, the seasonal patterns from sites C and D were the most similar to each other, while the patterns from sites A and B often displayed similarities, as well as differences, such as in the patterns of %N. Factors of bed age, crop load (as yield), season fertilizer totals, or canopy-height air temperature did not appear directly related to these site differences. Sites A and B did apply the most K, although only the earlier timing of these applications at site A coincides with the patterns observed in HR and CQ. One possible factor might be the timing of fertilizer applications. Before mid-July site A had six applications to HR and CQ before (four to ST) and site B had three granular and two liquid applications (all cultivars), while sites C and D only had four applications each. Other factors that may be contributing include soil temperature (especially as it relates to canopy cover of the ground surface), soil moisture, and rates of organic nitrogen mineralization.

Conclusions: Distinct patterns of nutrient content change were seen between the cultivars and sites included in this study, although explanations for many of these differences are not clear. Also, it is not clear from this first year of data if HR and CQ reach levels of nutrient stability notably earlier than ST, but it largely appears that the nutrient stability windows for HR and CQ are comparable to ST. Therefore at this time we can conclude that the current recommended time period for tissue sampling (August 15 – September 15) is sufficient for all of these cultivars.

Next: The following steps will be incorporated for sampling during the next season:

- Focus sampling just before fruit set and early August.
- Define phenology differences between the cultivars.
- Collect soil temperature and moisture data.

Acknowledgements: Thanks to the participating grower-cooperators, the DATCP Specialty Crops Block Grant Program, and the student workers of the Fruit Crops Extension Lab.

Reference

Davenport, J., C. DeMoranville, J. Hart, K. Patten, L. Peterson, T. Planer, A. Poole, T. Roper, and J. Smith. 1995. Cranberry Tissue Testing for Producing Beds in North America. Oregon State University Extension Service, EM 8610.

2014 CRANBERRY SCHOOL GROWER SURVEY RESULTS

CHRISTELLE GUÉDOT, MATT LIPPERT, AND PATRICIA McMANUS

Following the enthusiasm for the 2013 live survey, we conducted a live survey with the growers present in the room at the 2014 Cranberry School. The survey was conducted using Turning Point 5 (Turning Technologies, LLC) software and clicker hardware. Growers were provided with clickers to allow for live anonymous responses to be collected. Questions were displayed on screens and respondents were allowed to select answers. After all responses were collected, the polling was closed, and the results of the survey were displayed on the screens. The Count column indicates the number of growers that responded and the Percent column indicates the % of respondents.

1) How did you make *most* of your production-related decisions in 2013?

	Responses	
	Count	**Percent**
I did what I've done historically	6	8%
I consulted UW resources	0	0%
I utilized private crop consultants	1	1%
I consulted fellow growers	0	0%
More than one of the above	70	89%
None of the above	2	3%
Totals	**79**	**100%**

2) What are your production practices, compared to other growers?

	Responses	
	Count	**Percent**
Similar	46	60%
Different	11	14%
I don't know but I'll find out in this session	20	26%
Totals	**77**	**100%**

3) Production practices among my fellow growers and me *differ most* in:

	Responses	
	Count	**Percent**
Frost protection	10	13%
Irrigation	14	18%
Nutrient management	21	27%
Pest Control	4	5%
Sanding	5	6%
Other	3	4%

I don't know		22	28%
	Totals	**79**	**100%**

4) Production practices among my fellow growers and me ***differ least*** in:

	Responses	
	Count	**Percent**
Frost protection	37	49%
Irrigation	2	3%
Nutrient management	0	0%
Pest control	9	12%
Sanding	10	13%
Other	1	1%
I don't know	16	21%
Totals	**75**	**100%**

5) Production practices among my fellow growers and me ***differ least*** in:

	Responses	
	Count	**Percent**
Frost protection	37	49%
Irrigation	2	3%
Nutrient management	0	0%
Pest control	9	12%
Sanding	10	13%
Other	1	1%
I don't know	16	21%
Totals	**75**	**100%**

6) We estimate yield on our marsh by:

	Responses	
	Count	**Percent**
Bud set	4	5%
Fruit set	13	17%
Counting berries within a given area	36	47%
Calculating number of fruiting uprights x fruitset (or similar calculation)	6	8%
Other method	9	12%
We don't estimate yield	9	12%
Totals	**77**	**100%**

7) What do you think is the most important factor affecting berry number?

	Responses	
	Count	**Percent**
Bud set during the prior year	15	21%

Number of fruiting uprights per unit area	12	17%
Average flower number per upright	2	3%
Fruit set	13	19%
Environmental factors (e.g., sunlight, temp., rain, etc.)	27	39%
None of the above	1	1%
Totals	**70**	**100%**

8) Do you track growing degree days?

	Responses	
	Count	**Percent**
Yes	40	51%
No	38	49%
Totals	**78**	**100%**

9) If you track growing degree days for which purpose(s) do you do this?

	Responses	
	Count	**Percent**
Insect control	17	28%
Fertilizing	3	5%
Both 1 and 2	23	38%
Other	5	8%
None of the above	13	21%
Totals	**61**	**100%**

10) Most of my decisions on fertility and nutrient management come from:

	Responses	
	Count	**Percent**
Insect control	17	28%
Fertilizing	3	5%
Both 1 and 2	23	38%
Other	5	8%
None of the above	13	21%
Totals	**61**	**100%**

11) Most of my decisions on fertility and nutrient management come from:

	Responses	
	Count	**Percent**
Experience & history	1	1%
Tissue test results	1	1%
Visual assessment of my vines	3	4%
More than one of the above	75	94%
None of the above	0	0%
Totals	**80**	**100%**

12) Did you apply nitrogen before bloom in 2013?

	Responses	
	Count	**Percent**
Yes	53	70%
No	23	30%
Totals	**76**	**100%**

13) If you applied nitrogen before bloom in 2013, will you do so again in 2014?

	Responses	
	Count	**Percent**
Yes	32	45%
No	7	10%
Not sure	32	45%
Totals	**71**	**100%**

14) Do you apply fertilizer after harvest?

	Responses	
	Count	**Percent**
Yes, nitrogen N	0	0%
Yes, phosphorus P	4	5%
Yes, potassium K	5	6%
Yes, NP&K	2	3%
No	69	86%
Totals	**80**	**100%**

15) Irrigation on our marsh is based on:

	Responses	
	Count	**Percent**
Regular timing (i.e. roughly the same time every year)	2	3%
Response to high temp & lack of rain	17	22%
Soil moisture measured in the field (tensiometer or ground water level float)	18	23%
Feeling the soil with my hand	16	21%
Wireless irrigation system (e.g. Hortau)	21	27%
Other	3	4%
Totals	**77**	**100%**

16) Are you relying on moisture sensors more now than 5 years ago?

	Responses	
	Count	**Percent**
Yes	54	68%

No		25	32%
	Totals	**79**	**100%**

17) If yes, greater reliance on moisture sensors has:

	Responses	
	Count	**Percent**
Resulted in water conservation	3	5%
Resulted in cost savings	2	3%
Both 1 & 2	44	71%
Not made a difference in water conservation or cost savings	13	21%
Totals	**62**	**100%**

18) Do you like digital sensors/monitors?

	Responses	
	Count	**Percent**
Yes	45	58%
No	7	9%
Don't know/never used them	26	33%
Totals	**78**	**100%**

19) With water conservation in mind, what is the best way to flood for winter?

	Responses	
	Count	**Percent**
All at once	28	37%
Layered	41	54%
Other	7	9%
Totals	**76**	**100%**

20) When planning to sand, what is the best way to flood for winter?

	Responses	
	Count	**Percent**
All at once	26	34%
Layered	46	60%
Other	5	6%
Totals	**77**	**100%**

21) Are you concerned about snow-covered beds not getting enough sunlight?

	Responses	
	Count	**Percent**
Yes	40	50%

No		40	50%
	Totals	**80**	**100%**

22) If you are concerned with the lack of sunlight in winter, how do you remove snow?

	Responses	
	Count	**Percent**
Plow or blow	11	18%
Roll	9	15%
Reflood	7	11%
More than one of the above	23	38%
Other	11	18%
Totals	**61**	**100%**

23) Do you grow "newer"hybrid cranberry cultivars (e.g., from UW, Rutgers, Valley Corp./Grygleski)?

	Responses	
	Count	**Percent**
Yes	61	74%
No	21	26%
Totals	**82**	**100%**

24) How many acres of newer hybrid cultivars do you grow?

	Responses	
	Count	**Percent**
0 acres	15	19%
Less than 5 acres	12	15%
5-15 acres	15	19%
More than 15 acres	37	47%
Totals	**79**	**100%**

25) Do you grow cultivars from the UW-Madison program?

	Responses	
	Count	**Percent**
Yes	34	43%
No	45	57%
Totals	**79**	**100%**

26) Do you grow cultivars from Valley Corporations/Grygleski?

	Responses	
	Count	**Percent**
Yes	44	58%
No	32	42%
Totals	**76**	**100%**

27) Do you grow cultivars from the Rutgers program?

	Responses	
	Count	**Percent**
Yes	37	47%
No	42	53%
Totals	**79**	**100%**

28) Which is the most important trait to breed into new cultivars?

	Responses	
	Count	**Percent**
High & consistent yield	56	71%
Insect & disease resistance	8	10%
Herbicide resistance	1	1%
Post-harvest storage quality	7	9%
Nutritional content	0	0%
Taste/sensory factors (sweetness)	4	5%
Cold Tolerance	2	3%
Other	1	1%
Totals	**79**	**100%**

29) Should we develop "GMO" cranberries (genetically modified organisms)?

	Responses	
	Count	**Percent**
Yes, we are already eating GMO corn & soybean, so why not cranberry?	5	6%
No, too controversial; we don't need this in the cranberry industry	57	70%
I know what GM means but I'm undecided on whether we should have GMO cranberries	16	20%
I don't know what GMO means	4	5%
Totals	**82**	**100%**

30) How many honeybee hives did you bring in 2013?

	Responses	
	Count	**Percent**
0	5	6%
1-2	15	19%
3-5	40	51%
6-8	7	9%
More than 8	11	14%
Totals	**78**	**100%**

31) How many bumblebee colonies per acre did you bring in 2013?

	Responses	
	Count	**Percent**
0	69	85%
1-2	7	9%
3-5	3	4%
6-8	1	1%
More than 8	1	1%
Totals	**81**	**100%**

32) When cranberry prices are low, do you bring in fewer hives or colonies of bees?

	Responses	
	Count	**Percent**
Yes	28	35%
No	51	65%
Totals	**79**	**100%**

33) If you use honeybee hives, how do you distribute them on the marsh?

	Responses	
	Count	**Percent**
All hives in 1 location	3	4%
Hives split across 2 locations	9	11%
Hives split across 3 locations	7	9%
Hives scattered in more than 3 locations	60	76%
Totals	**79**	**100%**

34) Our honeybee hives are predominantly located:

	Responses	
	Count	**Percent**
In the center of the marsh	18	23%
On the edge of the marsh near a reservoir, open field, or woodland	14	18%

On the edge of the marsh adjacent to another cranberry marsh	0	0%
Mix of above locations	45	58%
Totals	**77**	**100%**

35) How do you choose which surfactant to use with pesticide applications?

	Responses	
	Count	**Percent**
Advice from consultants or other growers	32	40%
Recommendations of the pesticide dealer	36	44%
I use the same surfactants every year, so I know they are safe on cranberries	10	12%
I don't use surfactants	3	4%
Totals	**81**	**100%**

36) If I had a choice in pesticide formulation, I would choose:

	Responses	
	Count	**Percent**
Granular	12	15%
Liquid	25	31%
Powder	4	5%
Doesn't matter as long as it works!	39	48%
Other	1	1%
Totals	**81**	**100%**

37) When the price of cranberries is low, we…:

	Responses	
	Count	**Percent**
Cut back drastically on pesticides regardless of how much they are needed	0	0%
Cut back somewhat	17	22%
Don't cut back on pesticides, we still need a good crop and healthy plants	62	78%
Totals	**79**	**100%**

38) Should the cranberry industry have a standard sanitary protocol, similar to what is done in hospitals and some greenhouses/nurseries?

	Responses	
	Count	**Percent**
Yes	17	21%
No	28	35%
Not sure	35	44%
Totals	**80**	**100%**

39) What is your top insect pest?

	Responses	
	Count	Percent
Flea beetle	9	11%
Black headed fireworm	4	5%
Cranberry fruitworm	40	48%
Sparganothis	21	25%
Tipworm	8	10%
None of the above	1	1%
Totals	**83**	**100%**

40) How many insecticide sprays do you typically make in a season?

	Responses	
	Count	Percent
0-1	0	0%
2-3	52	64%
4-5	26	32%
5-6	2	2%
More than 6	1	1%
Totals	**81**	**100%**

41) How many sprays are specifically for flea beetle?

	Responses	
	Count	Percent
0	47	57%
1	19	23%
2	13	16%
3	3	4%
4	0	0%
Totals	**82**	**100%**

42) We direct flea beetle sprays at:

	Responses	
	Count	Percent
Beds	31	39%
Dikes	0	0%
Both	12	15%
Don’t spray for flea beetle	37	46%
Totals	**80**	**100%**

43) Where do flea beetles spend the winter?

	Responses	
	Count	**Percent**
Usually in the dikes	11	15%
Usually in the beds	9	13%
Both in dikes and beds	45	63%
Neither in dikes nor beds	7	10%
Totals	**72**	**100%**

44) In what stage do flea beetles spend the winter?

	Responses	
	Count	**Percent**
Eggs	36	51%
Larvae	15	21%
Pupae	16	23%
Adults	4	6%
Totals	**71**	**100%**

45) Are your flea beetle treatments foliar sprays or drench applications?

	Responses	
	Count	**Percent**
Foliar	57	92%
Drench	5	8%
Totals	**62**	**100%**

46) Is spraying for flea beetle worth the expense?

	Responses	
	Count	**Percent**
Yes, but it depends on the intensity of infestation and what you spray	24	32%
Yes, but it depends when they show up during the season	5	7%
Both 1 & 2	37	49%
No	9	12%
Totals	**75**	**100%**

47) Can you identify thrips?

	Responses	
	Count	**Percent**
Yes	27	32%
No	58	68%
Totals	**85**	**100%**

Western flower thrips
http://www.ent.uga.edu/veg/solanaceous/thrips.htm

48) Did you notice an increase in the presence of thrips in 2013?

	Responses	
	Count	**Percent**
Yes	3	3%
No	24	28%
Don't know what they look like/ wasn't paying attention to thrips	60	69%
Totals	**87**	**100%**

49) Did you notice an increase in rose chafer in 2013?

	Responses	
	Count	**Percent**
Yes	9	11%
No	27	32%
Don't know what they look like	48	57%
Totals	**84**	**100%**

50) Did you apply insecticides for thrips or rose chafer in 2013?

	Responses	
	Count	**Percent**
Yes, for thrips	2	2%
Yes, for rose chafer	1	1%
Yes, for both thrips and rose chafer	2	2%
No, not for either of these insects	80	94%
Totals	**85**	**100%**

51) Of the weeds listed below, which are the most difficult to control given current management options?

	Responses	
	Count	**Percent**
Woody trees (maples & willows)	54	63%
St. Johnswort species	21	24%
Perennial grasses such as creeping red fescue and sweet vernal grass	9	10%
Goldenrod species	2	2%
Totals	**86**	**100%**

52) Are you seeing changes in weed pressure after scaling back on Casoron and/or Devrinol?

	Responses	
	Count	**Percent**
Yes	33	46%
Yes, but not sure it's because of scaling back on the two herbicides	13	18%
No, weeds are the same as always	26	36%
Totals	**72**	**100%**

53) Do you still use pre-emergence herbicides, such as Casoron, or do you rely more on post emergence options, such as Callisto?

	Responses	
	Count	**Percent**
Still use Casoron each spring	53	61%
We skip Casoron for 1-2 years and rely more heavily on Callisto	31	36%
We no longer use pre-emergence herbicides such as Casaron	2	2%
We don't use herbicides	1	1%
Totals	**87**	**100%**

54) To what percentage of your cranberry acres do you apply fungicides?

	Responses	
	Count	**Percent**
0%	24	31%
1-25%	12	16%
25-50%	7	9%
50-75%	4	5%
More than 75%	30	39%
Totals	**77**	**100%**

55) Do you use fungicides to control cranberry fruit rot?

	Responses	
	Count	**Percent**
Yes	50	62%
No	31	38%
Totals	**81**	**100%**

56) Do you use fungicides to control cottonball?

	Responses	
	Count	**Percent**
Yes	31	37%
No	53	63%
Totals	**84**	**100%**

57) Do you use fungicides to control upright dieback?

	Responses	
	Count	Percent
Yes	30	38%
No	49	62%
Totals	**79**	**100%**

58) Do you use fungicides to control Phytophtora root and runner rot?

	Responses	
	Count	Percent
Yes	4	5%
No	73	95%
Totals	**77**	**100%**

59) Which is your main fungicide?

	Responses	
	Count	Percent
Azoxystrobin (Abound)	19	23%
Chlorthalonil (Bravo, Echo, Equus, Daconil)	14	17%
Copper compounds (Champ, Kocide)	2	2%
Febuconazle (Indar)	1	1%
Mancozeb (Dithane, Manzate, Penncozeb)	1	1%
Propiconazole (Tilt, Orbit, Propimax)	1	1%
Don't have 1, rely equally on 2 or more	31	37%
Don't use fungicides	15	18%
Totals	**84**	**100%**

60) Did you observe scarred berries on your marsh that resemble virus injury?

	Responses	
	Count	Percent
In 2013?	7	9%
Prior to 2013?	7	9%
No, not seen and we have looked for it	52	65%
No, but we have not looked for it.	14	18%
Totals	**80**	**100%**

61) How would you describe your level of understanding of plant virus diseases prior to 2013?

	Responses	
	Count	**Percent**
Good	13	15%
Fair	64	75%
Didn't know plants got virus diseases	8	9%
Totals	**85**	**100%**

62) How would you describe your current understanding of plant virus diseases?

	Responses	
	Count	**Percent**
Good	19	22%
Fair	66	76%
Didn't know plant got virus diseases	2	2%
Totals	**87**	**100%**

63) Have you observed "yellow vine" on your marsh?

	Responses	
	Count	**Percent**
Yes	42	50%
No	31	37%
Don't know	11	13%
Totals	**84**	**100%**

64) Where you see yellow vines, the problem is associated with:

	Responses	
	Count	**Percent**
Conditions too dry	2	3%
Conditions too wet	4	6%
Treatment with Casoron	2	3%
Temperature extremes an/or rapid changes in temperature	6	10%
More than 1 of the above	22	35%
None of the above	27	43%
Totals	**63**	**100%**

65) Where you see yellow vines, symptoms develop:

	Responses	
	Count	**Percent**
First thing in the spring	3	4%
Just before bloom	6	9%

During bloom	2	3%
At fruit set/early fruit development	33	49%
Just before fruit maturation	13	19%
Not sure	11	16%
Totals	**68**	**100%**

66) Are you currently using alternative energy (i.e., something other than fossil fuels)?

	Responses	
	Count	**Percent**
Yes	19	41%
No	27	59%
Totals	**46**	**100%**

67) We plan on using alternative energy:

	Responses	
	Count	**Percent**
In 2014	11	28%
Within the next 5 years	2	5%
Within the next 6-10 years	5	13%
No plans for this	21	54%
Totals	**39**	**100%**

68) Thinking ahead 10-20 years, would you consider diversifying into other crops to be more resilient when cranberry prices are low?

	Responses	
	Count	**Percent**
Yes	14	34%
No	13	32%
Not sure	14	34%
Totals	**41**	**100%**

69) Nutrient management in new cultivars (e.g. HyRed, GH1, Mullica Queen Crimson Queen, DeMoranville, Sundance, etc.)

	Responses	
	Count	**Percent**
Similar to older cultivars	4	10%
Somewhat different compared to older cultivars	20	48%
Very different compared to older cultivars	10	24%

I don't know	8	19%
Totals	**42**	**100%**

70) How often do you perform tissue nutrient analysis from a given portion of your marsh?

	Responses	
	Count	**Percent**
Every few years	2	5%
Every year	36	88%
Multiple times a year	2	5%
Only if I see stunting of uprights and/or leaf discoloration	0	0%
Never	1	2%
Totals	**41**	**100%**

71) What application timing issue would you *most* like to see more research on?

	Responses	
	Count	**Percent**
Insecticides	7	18%
Herbicides	8	20%
Fungicides	5	13%
Fertilizers	17	43%
Not necessary, we've got the timing down for all of these	3	8%
Totals	**40**	**100%**

72) When planning to sand, what is the best way to flood for winter?

	Responses	
	Count	**Percent**
All at once	13	34%
Layered	24	63%
Other	1	3%
Totals	**38**	**100%**

73) If you use a late-water flood, what was the main reason?

	Responses	
	Count	**Percent**
Insect control	15	37%
Frost protection	9	22%
General clean up and "trash" removal	15	37%

None of the above		2	5%
	Totals	**41**	**100%**

74) Do you monitor dissolved oxygen when beds are flooded?

	Responses	
	Count	**Percent**
Yes	17	41%
No	24	59%
Totals	**41**	**100%**

75) At what temperature do you start protecting vines at cabbage head bud stage?

	Responses	
	Count	**Percent**
34-35^{o} F	12	29%
32-33^{o} F	10	24%
30-31^{o} F	6	15%
28-29^{o} F	9	22%
Less than 28-29^{o} F	4	10%
Totals	**41**	**100%**

76) At what temperature do you start protecting vines at bud elongation bud stage?

	Responses	
	Count	**Percent**
34-35^{o} F	17	43%
32-33^{o} F	17	43%
30-31^{o} F	3	8%
28-29^{o} F	1	3%
Less than 28-29^{o} F	2	5%
Totals	**40**	**100%**

77) At what temperature do you start protecting vines at hook bud stage?

	Responses	
	Count	**Percent**
34-35^{o} F	27	66%
32-33^{o} F	13	32%
30-31^{o} F	0	0%
28-29^{o} F	0	0%

Less than 28-29° F	1	2%
Totals	**41**	**100%**

78) At what temperature do you start protecting vines at fruit set bud stage?

	Responses	
	Count	**Percent**
34-35° F	28	70%
32-33° F	11	28%
30-31° F	0	0%
28-29° F	0	0%
Less than 28-29° F	1	3%
Totals	**40**	**100%**

79) What is the *main* advantage of newer cultivars over older cultivars?

	Responses	
	Count	**Percent**
Establish and come into bloom sooner	1	2%
Higher yields	35	83%
More consistent & predictable performance from one year to the next	6	14%
Totals	**42**	**100%**

80) What is the *main* disadvantage of growing newer cultivars?

	Responses	
	Count	**Percent**
Higher cost of plugs/vines	20	48%
Seem to be more susceptible to diseases	13	31%
Restrictions/rules regarding propagating and sale	9	21%
Totals	**42**	**100%**

81) Cultivar genetic (DNA) purity in cranberries is:

	Responses	
	Count	**Percent**
Important	22	49%
Not important	4	9%
Not sure, but I would like more information on how genetic purity might affect vine management and performance	19	42%

Totals	**45**	**100%**

82) Have you had vines tested for genetic purity?

	Responses	
	Count	**Percent**
Yes	24	56%
No	19	44%
Totals	**43**	**100%**

83) If you have had vines tested for genetic purity, has it influenced your management decisions (e.g., bed renovation plans)?

	Responses	
	Count	**Percent**
Yes	14	52%
No	13	48%
Totals	**27**	**100%**

84) How many pesticide (insecticide, fungicide, herbicide) sprays did you apply during bloom in 2013?

	Responses	
	Count	**Percent**
0	2	5%
1-2	22	55%
3-4	12	30%
More than 4	4	10%
Totals	**40**	**100%**

85) Which pesticides did you spray during bloom in 2013?

	Responses	
	Count	**Percent**
Fungicides	3	8%
Herbicides	0	0%
Insecticides	18	47%
More than one of the above	15	39%
None of the above applied during bloom	2	5%
Totals	**38**	**100%**

86) How many fungicide applications were made during bloom in 2013?

	Responses	
	Count	**Percent**
0	21	57%
1	9	24%
2	5	14%
More than 2	2	5%
Totals	**37**	**100%**

87) Which fungicide(s) did you spray during bloom in 2013?

	Responses	
	Count	**Percent**
Abound	4	11%
Bravo (Echo, Equus, Daconil)	4	11%
Indar	1	3%
Dithane (Penncozeb, Manzate)	0	0%
Copper (Kocide, Champ, Badge, Nu-Cop, Copper...	0	0%
More than one of the above	11	30%
No fungicide applied during bloom	17	46%
Totals	**37**	**100%**

88) How many insecticide applications were made during bloom in 2013?

	Responses	
	Count	**Percent**
0	5	12%
1	21	51%
2	12	29%
More than 2	3	7%
Totals	**41**	**100%**

89) Which insecticide(s) did you spray during bloom in 2013?

	Responses	
	Count	**Percent**
Altacor	13	34%
Intrepid	7	18%
Knack	0	0%
Confirm	9	24%
Dipel	0	0%

Grandevo		0	0%
More than 1 above		8	21%
No insecticide during bloom		1	3%
	Totals	**38**	**100%**

90) How many applications of Altacor did you make in 2013?

	Responses	
	Count	**Percent**
0	15	41%
1	12	32%
2	10	27%
3	0	0%
Totals	**37**	**100%**

91) How many applications of Altacor did you make during bloom in 2013?

	Responses	
	Count	**Percent**
0	5	71%
1	2	29%
2	0	0%
3	0	0%
Totals	**7**	**100%**

92) Which of the following are neonicotinoids?

	Responses	
	Count	**Percent**
Altacor, Knack, Intrepid	4	12%
Assail, Belay, Closer, Venom	27	79%
Imidan, Lorsban, Diazinon	3	9%
All of the above	0	0%
Totals	**34**	**100%**

93) Did you see positive results with Altacor on cranberry fruit worm in 2013?

	Responses	
	Count	**Percent**
Yes	21	58%
No	0	0%

Not sure	2	6%
Didn't use Altacor	13	36%
Totals	**36**	**100%**

94) Did you see positive results with Altacor on Sparganothis fruit worm in 2013?

	Responses	
	Count	**Percent**
Yes	13	39%
No	1	3%
Not sure	7	21%
Didn't use Altacor	12	36%
Totals	**33**	**100%**

95) Did you see positive results with Altacor on flea beetle in 2013?

	Responses	
	Count	**Percent**
Yes	4	11%
No	6	17%
Not sure	10	28%
Didn't use Altacor	16	44%
Totals	**36**	**100%**

96) How important do you think timing was for success of Altacor in 2013?

	Responses	
	Count	**Percent**
Extremely important	21	68%
Important	9	29%
Not important	1	3%
Totals	**31**	**100%**

97) Are you concerned about herbicide-resistant weeds on your marsh?

	Responses	
	Count	**Percent**
Yes, very concerned	15	36%
Somewhat concerned	22	52%
No, not at all concerned	5	12%
Totals	**42**	**100%**

98) Weedar 64 herbicide is not currently registered in WI cranberry. If the Weedar 64 Special Local Needs label for wiper applications were made available again in WI would you use it?

	Responses	
	Count	**Percent**
Yes, most definitely	28	68%
Maybe	10	24%
No	3	7%
Totals	**41**	**100%**

99) QuinStar herbicide was labeled for use in 2013 in Wisconsin. Did you try it?

	Responses	
	Count	**Percent**
Yes	5	12%
No, my handler didn't allow	16	39%
No, I didn't need it in my weed management program	7	17%
No, I want my neighbor to try it first	13	32%
Totals	**41**	**100%**

100) Do you wick-wipe weeds with glyphosate?

	Responses	
	Count	**Percent**
Yes, every year	35	85%
Yes, but not every year	6	15%
No	0	0%
Totals	**41**	**100%**

101) With which of the following herbicides should a surfactant be used?

	Responses	
	Count	**Percent**
Callisto	6	15%
Casoron	0	0%
QuinStar	0	0%
1 & 3	34	83%
All of the above	1	2%
Totals	**41**	**100%**

102) What educational value is there of this "clicker" session?

	Responses	
	Count	**Percent**
I like knowing what others are doing and seeing on their marshes	17	40%
I learn from the questions and discussion	2	5%
1 & 2	20	47%
Minimal educational value, but it keeps me awake	4	9%
No value whatsoever	0	0%
Totals	**43**	**100%**

103) The best time for researchers to present their findings is:

	Responses	
	Count	**Percent**
When the research has been repeated over 2-3 yrs. And the conclusions/recommendations are solid	18	44%
After yr. 1 so that we can make suggestions on how the project might be modified	19	46%
Not sure	3	7%
Other	1	2%
Totals	**41**	**100%**

104) The best time of year to hear research results is:

	Responses	
	Count	**Percent**
Cranberry School in January	33	80%
Spring meetings in March or April	0	0%
During the growing season	0	0%
No one answer, it depends on the topic	8	20%
Other	0	0%
Totals	**41**	**100%**

105) Which of the following social media would you use to get current information on cranberry production, if it were available in this form?

	Responses	
	Count	**Percent**
Facebook	5	12%
Twitter	2	5%

Blogs	2	5%
More than one of the above	7	17%
None of the above	25	61%
Totals	**41**	**100%**