Photo credit: Beth Ann Workmaster, UW-Madison

Volume 26

January 24-25, 2018

Holiday Inn Hotel and Convention Center

Stevens Point, WI

Sponsored by:

UW Extension
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Wisconsin State Cranberry Growers Association

Wisconsin Cranberry Research & Education Foundation, Inc.

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The Proceedings of the 2018 Wisconsin Cranberry School (Volume 26) and the 2017 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
February 2018

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INTRODUCTION TO CRANBERRY POLLINATION

CHRISTELLE GUÉDOT

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Pollination, in flowering plants such as cranberry, is the transfer of pollen grains from the anthers (male part) of a flower to the stigma (female part) of the same or another flower (Figure 1). Cranberry flowers have eight tube-like anthers that shed the pollen before the stigma elongates and becomes receptive (24-36 hrs after the pollen is shed). This process limits self-pollination and promotes cross-pollination, the pollination of another flower. In nature, the flowers at the base of the upright open first, allowing the flowers above to pollinate the flowers below as they start shedding pollen when the flower below becomes receptive. The stigma is receptive to pollination for up to 7 days.

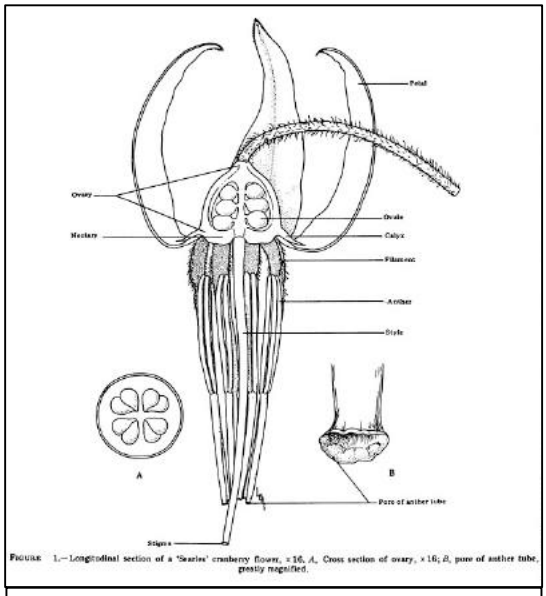

Figure 1. Reproduced from T. Roper. 1995.

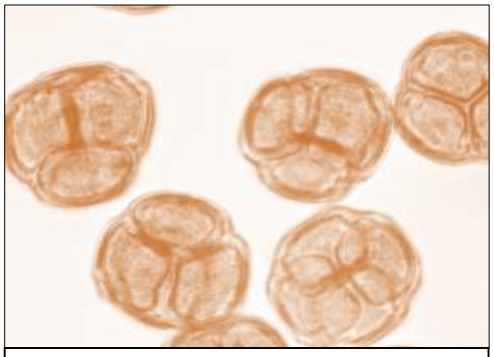

Figure 2. Cranberry pollen tetrads. Photo credit: A. Guzman, UW-Madison.

In cranberry, pollen grains adhere together in groups of four grains, forming tetrads (Figure 2). An individual flower produces about 7,000 pollen tetrads. Pollen germination is temperature dependent. A pollen grain germinates in about 48hrs on the stigma at 72° to 86°F, then grows a pollen tube that will grow to the ovary, where fertilization occurs to produce a fruit (Roper 1995).

Cranberry flowers produce nectar and pollen which constitute rewards for pollinators. Cranberry nectar is a sweet liquid with ~23% carbohydrates produced by nectaries found at the base of the flower (see Figure 1). Nectar is made of primarily simple sugars and trace amounts of amino acids, vitamins, phenolics, and other compounds. The amount of nectar in a cranberry flower is about 1.4 microliter. To put this in perspective, bee-pollinated flowers produce from 0.1 to 10 microliters of nectar, thus cranberry flowers are on the low end of nectar production. Cranberry flowers also produce pollen tetrads which are

made up of proteins (~12%) and lipids, and trace amounts of minerals, vitamins and other compounds.

In the absence of bees, cranberry flowers were shown to still be able to produce fruit, however, berry weight and yield decreased when bees were excluded (Gaines-Day 2013). In cranberry, eight pollen tetrads deposited on the stigma of a flower are sufficient to obtain optimal fruit set and berry mass (Cane and Schiffauer, 2003), and some pollinators studied in cranberry, including honeybees, are able to meet this minimum requirement during a single visit to a flower (reviewed in Guédot 2014). Recently, 182 species of native bees were documented to visit cranberry flowers (Gaines-Day 2013). More work has been done on cranberry pollination than can be summarized here and the next talks will provide more interesting information relating to cranberry pollination.

Literature

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.

Gaines-Day, H. 2013. Do bees matter to cranberry? The effect of bees, landscape, and local management on cranberry yield. Doctoral Dissertation University of Wisconsin, Madison, WI
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Roper T.R. 1995. Botanical aspects of pollination. Wisconsin Cranberry School Proceedings. 5: 7-10.

BUMBLE BEE RESPONSES TO FLOWER AVAILABILITY IN WISCONSIN CRANBERRY

JEREMY HEMBERGER AND CLAUDIO GRATTON

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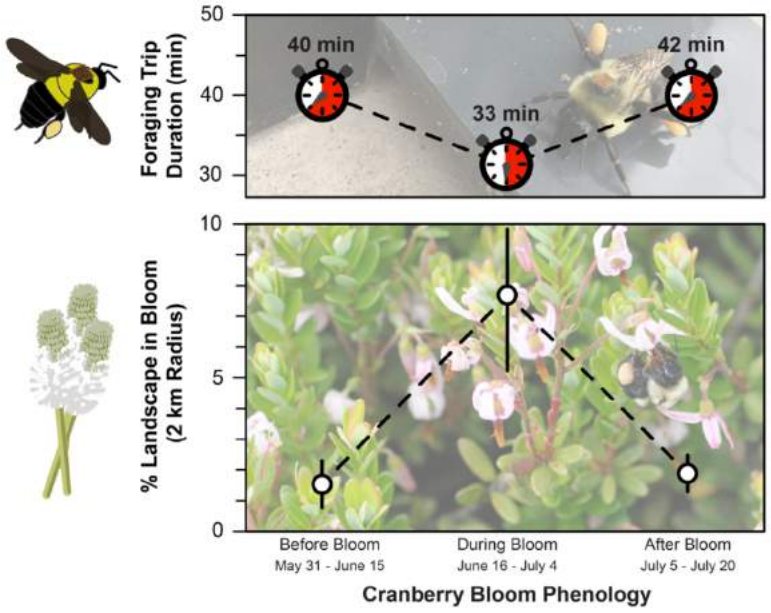
Take home messages:

1. Cranberry marshes have similar amounts of flowers in the surrounding lands, regardless of landscape type. Cranberry bloom increases the amount of flowers by over 400%.

2. Bumble bees switch to foraging on cranberry during bloom – collecting almost entirely cranberry pollen, and foraging more frequently and for less time each trip.

3. The landscape context of the marsh does not matter with regard to foraging behavior – bumble bees in high and low woodland marshes behave the same.

4. The flowers that sustain bumble bees outside of bloom are primarily found in "edgy" habitats, such as roadsides, field edges, and woodland edges. Woodlands still provide bumble bees with flowers during spring and early summer, as well as nesting habitat.



Summary Figure: Bumble bees foraged for less time during bloom when flowers are abundant. They also visit almost exclusively cranberry flowers during bloom.

Bumble bees are important pollinators of Wisconsin cranberries. However, our understanding of their contribution, behavior, and consistency regarding cranberry pollination is still rudimentary.

Like other crops, cranberry marshes are embedded into a variety of different landscapes that vary in both space and time with regard to the flowers that they offer to bumble bees. For example, landscapes containing more natural lands (e.g., woodlands, wetlands, and prairies) are known to contain flowers continuously throughout the course of the summer. Lands containing primarily crops also contain flowers (e.g., flowering crops), but these flowers are only available when crops are in bloom. Because bumble bees only feed on pollen and nectar, the amount of flowers in the landscape is essential for developing colonies.

As flower availability changes throughout the season (either naturally as with wildflowers, or as crops come in and out of bloom), we might expect that the behavior of foraging bumble bees would change, in kind. For example, bumble bees might forage on remnant natural habitats early in the season and then switch to gathering pollen and nectar from crops as they come into bloom. However, if there are more, or higher quality flowers in natural habitats, we might expect that bumble bees preferentially visit these flowers instead of the crop. Indeed, we know that honey bee contributions to cranberry pollination change as a result of the landscape context of the marsh. Work by Gaines-Day and Gratton (2016) showed that increasing honey bee stocking only increases cranberry yield in marshes surrounded by low amounts of woodland (Figure 1). Could this be the case for bumble bees, as well?

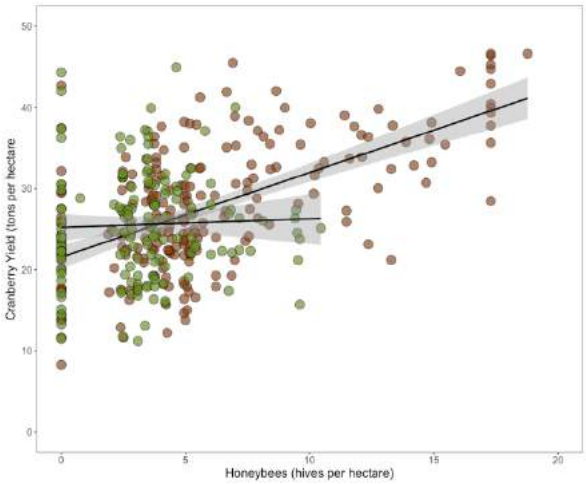


Figure 1: Honey bee associated yield increases only manifest in low woodland (brown) landscapes, not in high woodland landscapes (green). Gaines-Day 2016.

To explore this, we examined bumble bee foraging behavior across 14 different cranberry marshes in central Wisconsin. Because bumble bees are small and difficult to track across space, we instead examined the amount of time that foraging bumble bees spent search for food, also known as foraging trip duration. Using small radio tags (Figure 2), we recorded nearly 2,000 foraging trips from May-July in 2015-2016. We expected that, during bloom, foraging bumble bees would switch to foraging on cranberry flowers, reducing the amount of time that they searched for food. We also expected that bumble bee fidelity to cranberry might vary based on the amount of woodland surrounding a given marsh. To this end, we also surveyed flower abundance on marshes and the surrounding lands from May-July, expecting that marshes with more woodland would have more flowers than their low woodland counterparts.

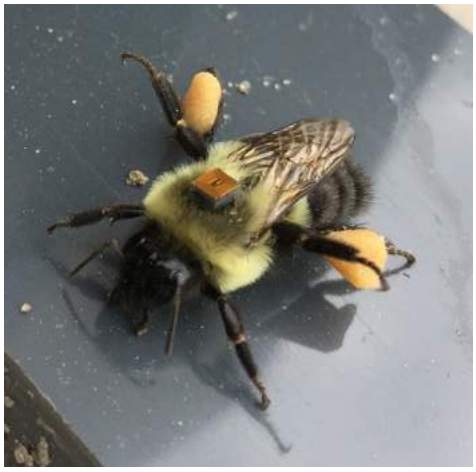


Figure 2: A bumble bee worker with an RFID tag affixed to its back. RFID tags are read using the same technology as the Illinois iPass system.

Our flower survey revealed that marshes with greater amounts of woodland did not, in fact, have more flowers. Low woodland marshes tended to have more flowers on average (particularly during bloom), as these landscapes contain more cranberry marshes, and therefore more cranberry flowers (Figure 3). Cranberry bloom increases the amount of flowers in the landscape by over 400% - a massive increase for foraging bees. Most importantly, our flower survey revealed that edge habitat (e.g., road, field, and woodland edges) contained the greatest amount of flowers to bees throughout the year. Because of this, edge habitats are extremely important to bumble and other wild bees, providing them with the pollen and nectar they need to feed their young. Woodlands still provide crucial flowers for bumble bees in the late spring/early summer, when queens are emerging to establish new nests. Additionally, woodland edges provide critical nesting habitat for bumble bees.

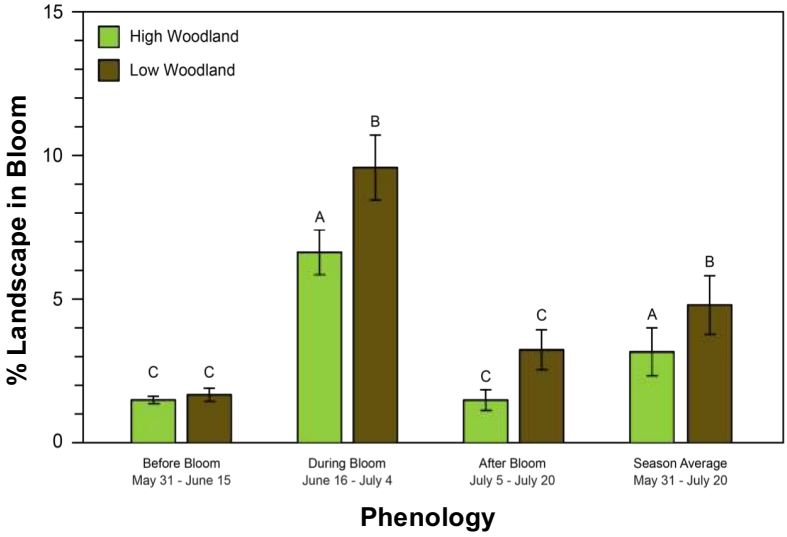


Figure 3: High woodland marshes had, on average fewer flowers than low woodland marshes.

Monitoring foraging behavior revealed that bumble bees respond to cranberry bloom, reducing the amount of time they search for food by 20% during bloom (Figure 4). Additionally, they increase the number of trips they take during bloom, suggesting that the time savings gained allows them to forage more frequently. The changes observed in foraging behavior are likely driven by cranberry bloom, as bumble bees returning to their nest were carrying almost exclusively cranberry pollen (Figure 5). In fact, bumble bees seem to prefer cranberry pollen as returning bees were carrying cranberry pollen even when cranberry flowers were relatively rare (before and after bloom). Contrary to our expectations, bumble bee foraging responses to cranberry bloom did not depend on the landscape context of a marsh. That is, bumble bees in high woodland marshes foraged similarly to those in low woodland marshes.

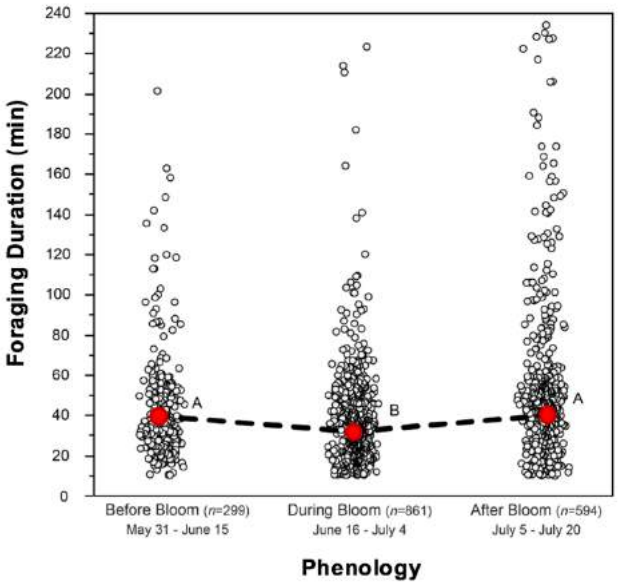


Figure 4: Bumble bee foraging time from May-July. Points represent individual trips; large red circles indicate period averages.

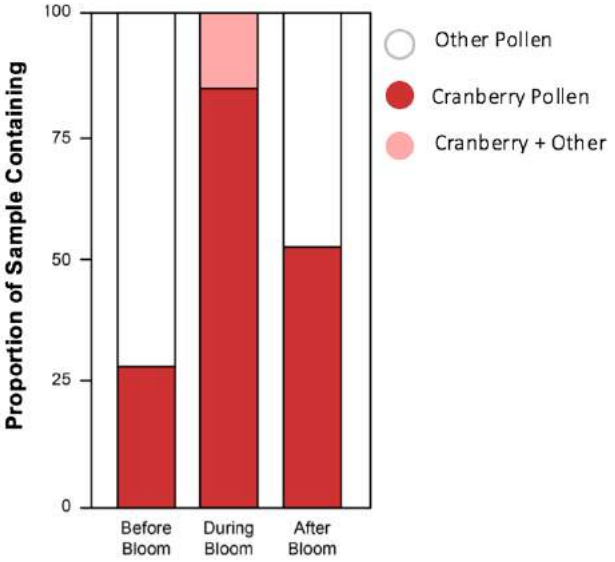


Figure 5: Proportion of pollen containing cranberry (red) collected from returning bumble bee foragers from May-July.

Next, I am working on building a statistical model that uses our flower surveys to predict the amount of flowers in the landscapes surrounding cranberry marshes across the growing season, from April to September. Using that, we will also work to predict the amount of wild bumble bees are likely in the surrounding landscape and able to provide pollination services to cranberry. Overall, we are interested in determining how many bumble bees need to be present to see acceptable yields. Doing this would afford growers additional data with which to make pollination management decisions, i.e., honey bee rental needs.

To accomplish this work, I will need yield data from 2016, 2017, and 2018 from as many marshes as possible. Additionally, having some basic data on mowing and weed management practices would help me to better calibrate my models. If you are interested in assisting me by providing data, please contact me using the information below. All yield and management data will be kept confidential and anonymous.

Contact: Jeremy Hemberger, hemberger@wisc.edu, (608) 622-2698

PARTNERSHIPS THROUGH POLLINATION. GROWERS, BEEKEEPERS, AND HABITATS.

DANIEL ZIEHLI

Department of Agriculture, Trade and Consumer Protection, WI

Growers and beekeepers each have unique habitats, meaning that their day to day operations are different and intersect when bees are on the marsh. It works best when each has a general idea of what is happening on the bog for the benefit of the bees. It is with communication and understanding that both can be successful and achieve the goal of a healthy and plentiful crop. There are pest and disease that honey bees and beekeepers battle. We talked about the main ones and how DATCP is there to assist growers and beekeepers. DATCP assists with the interstate movement of honeybee colonies to ensure growers receive healthy safe honeybee colonies. It is extremely important and is the law that DATCP receives notice of all honeybee colonies entering the state. We are always there to help. Beekeepers bringing bees to Wisconsin must file a form called "Intent to import". This form does not cost anything but it is required 10 days before shipping honey bees or used equipment into the state. ACTCP 21.13: {No person may ship live honeybees or used beekeeping equipment into this state without first reporting the import shipment to the department in writing. A single report may cover 2 or more shipments made in the same calendar year.} It is available on the DATCP web page under beekeeping. A migratory inspection for interstate movement of honeybees from DATCP is free and the cost to file the inspection is $50.00. This migratory inspection is good for 1 year. Once these bees or equipment leave Wisconsin, the beekeeper must file an import paper letting the state know when the bees are coming back. A regular apiary inspection is free and a grower may contact a DATCP apiary inspector on website or call (608) 244-4572 should they choose to have the department check out the honeybees or used equipment. On all inspections we check for diseases of honeybees and other pests that may be on the bee equipment. It is advisable for the grower to check with DATCP before receiving any honeybees to check the status of the beekeeper to make sure the beekeeper is complying with DATCP and to ensure the grower is getting disease-free strong colonies for their pollination services. Important note: should a beekeeper decide to abandon diseased hives or leave equipment on a marsh, the GROWER becomes responsible for the cost of the clean up by DATCP. This is why it is important to have contracts and be sure intent to import papers are filled.

In a nutshell: Import papers must be filed 10 days prior to shipment by beekeepers and are free (found on DATCP Website). Apiary inspection is free to grower and beekeeper, contact office at (608) 224-4572. Migratory inspection for interstate movement of honeybees and equipment is free. The cost is $50.00 to file it with DATCP.

IMPROVING POLLINATION SERVICES IN CRANBERRY

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Take home points:

1. Hives should be placed preferentially in the center of the marsh or at edges with natural habitat, avoiding proximity to water reservoirs, to increase visitation to cranberry flowers.
2. Supplemental sugar feeding to honeybee hives does not increase visitation to cranberry flowers and is not recommend as a way to improve pollination services in cranberry.
3. Two documents will be provided to cranberry growers at the spring workshops: a 1-page summary and a longer companion document of practices to improve pollination and protect pollinators in cranberry.

Bees are important pollinators because they ensure fruit set and increase fruit yield. In Wisconsin, 94% of cranberry growers use honeybees and 28% use bumblebees for their pollination services (Cranberry school 2016). On average, $140-210 per acre is spent on pollination services from honeybees (2-3 hives per acre).

Research and extension projects were conducted in the last years to improve pollination services in cranberry. Our goals were to: 1) assess the effect of hive placement on the marsh on honeybee visitation to cranberry flowers as a function of the surrounding landscape; 2) assess the impact of supplemental sugar feeding on honeybee visitation to cranberry flowers; and 3) develop management practices for pollinators in cranberry production.

Study 1: Effect of hive placement on the marsh on honeybee visitation to cranberry flowers as a function of surrounding landscape

Growers have reported observing rented honeybees flying off the marsh to collect resources other than cranberry, on and off the marsh. In addition, hives on marshes tend to be somewhat randomly distributed on a marsh, leading us to assess the impact of hive placement on honeybee visitation to cranberry.

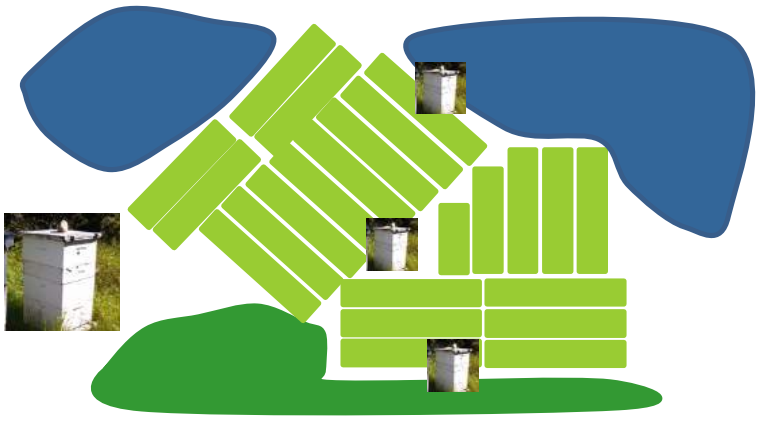

Figure 1. Marsh with hive layout. Blue represents water, dark green natural habitat, and icons are hives.

Ten cranberry marshes ranging from high to low woodland in a 1km radius around each marsh

were selected. Hives were placed at three different locations on a marsh: in the center of the marsh, at the edge of a marsh bordering natural habitat, and at the edge of a marsh along a water reservoir (Fig 1). The hypotheses are that hives in the center would be surrounded by cranberry and will entice honeybees to forage on cranberry flowers; the hives near a water reservoir would avoid water (due to the lack of resources on water) and forage on cranberry flowers; and finally, hives near natural habitat may forage on cranberry flowers less and find other resources off the marsh.

Figure 2. Pollen trap.

We placed pollen traps (Fig 2) at the entrance of each of the three hives placed at each marsh and collected pollen for 24hrs, twice a week during bloom. The pollen for each hive was then analyzed under microscope in the lab to identify the percent of cranberry (Fig 3) vs. non cranberry pollen at each hive.

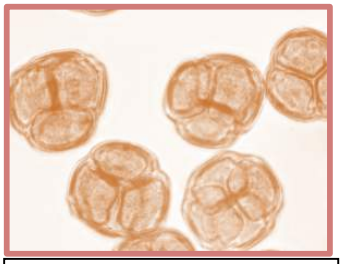

Figure 3. Cranberry pollen tetrads. Photo credit: A. Guzman, UW-Madison.

Overall, hives in high woodland landscape collected less cranberry pollen than those in low woodland. Hives near water reservoirs collected less cranberry pollen (16-37%) than hives in center (38-53%) or near natural habitat (32-58%) (Fig 4). The pollen diversity was higher in low woodland landscapes than in high woodland landscapes and was highest near natural habitat, followed by water reservoir hives, and center hives.

Our results suggest that, to optimize visitation by rented honeybees to cranberry flowers, hives should be placed in the center of a marsh or on the edge with natural habitat, avoiding proximity to water reservoirs. Water reservoirs are often surrounded by flowering plants and may provide resources that bees will tend to forage on during cranberry bloom.

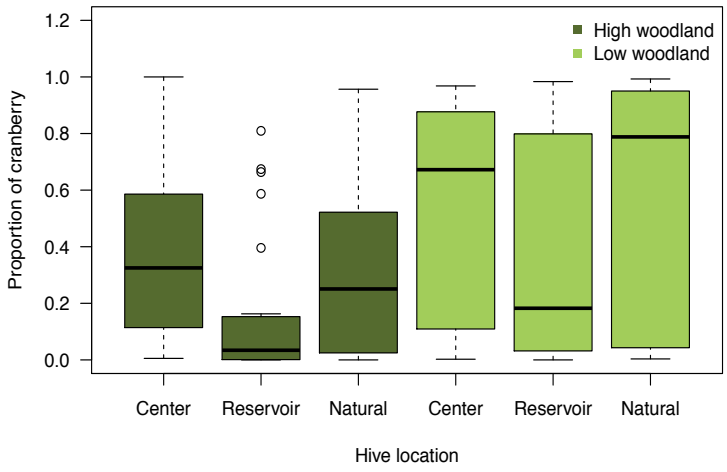

Figure 4. Proportion of cranberry pollen at different hive locations as a function of high to low woodland.

Study 2: Impact of supplemental sugar feeding on honeybee visitation to cranberry flowers

Cranberry flowers produce nectar and pollen that pollinators seek to feed themselves and their young. Cranberry nectar is a sweet liquid with ~23% carbohydrates produced by nectaries found at the base of the flower (see article Introduction to pollination P. 1-2). The amount of nectar in a cranberry flower is about 1.4 microliter, which tends to be on the low end of nectar production for a bee-pollinated flower. Thus, it is often thought that cranberry flowers do not provide a great reward in terms of the amount and quality of nectar bees may collect and that honeybees may forage elsewhere to meet these needs. Previous research by G. Martin presented at cranberry school in 2015 suggested that feeding hives with a sugar solution increased cranberry visitation by ~38% compared to non-fed hives. This study aimed at determining if the results by G. Martin were reproducible with commercial honeybee hives in Wisconsin and assess the impact of different sugar solutions on bee visitations to cranberry.

We fed hives a honey solution, sucrose solution, high fructose corn syrup solution, water (control 1), or nothing (control 2) by providing solutions at a rate of 1:1 (sugar:water). Hives were fed 1 gallon of solution in internal feeders, twice a week for 2-3 weeks, in 2016 and again in 2017. We used pollen traps (Fig 2) to determine the amount and proportion of cranberry pollen being brought back to hives.

In both years, we found no significant difference between the different treatments, suggesting that providing hives with any type of sugar solutions did not increase their foraging on cranberry flowers compared to control hives that received nothing or water.

Extension: Develop management practices for pollinators in cranberry

In 2015, WCB asked us to develop pollinator management practices (MPs) specific to cranberry. We (primarily Janet van Zoeren!) organized discussions with cranberry growers, beekeepers, and the WSCGA BMPs group to tailor MPs to the cranberry industry. Our aim was to facilitate beekeeper and grower cooperation, review the literature of other BMPs and the Wisconsin DATCP Pollinator Protection Plan. We presented at the 2017 spring workshops our plans to obtain feedback from the cranberry growers and provided articles in the Cranberry Crop Management Journal in 2017. Our final step is to release two companion documents at the 2018 spring workshops or upon request to cranberry growers: a 15-page informational document and 1-page summary fact sheet on practices to improve pollination and protect pollinators in cranberry.

This work was conducted by Aidee Guzman, Abby Lois, Hannah Gaines-Day and many other people in the Guédot Lab, the Steffan Lab, and the Zalapa Lab. Thank you very much to all of our grower collaborators (we could not do this without you!) and to the Wisconsin Cranberry Board, Ocean Spray, the Cranberry Institute, and private industry for funding these studies.

CRANBERRY FLORAL MERISTEM DEVELOPMENT DURING FALL AND SPRING

AMAYA ATUCHA, JENNY BOLIVAR-MEDINA, CAMILO VILLOUTA, AND BETH ANN WORKMASTER

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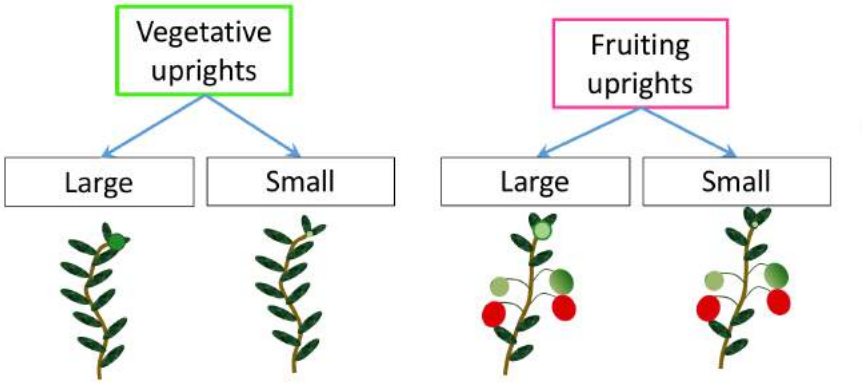
When looking at a cranberry bud after harvest to assess the potential of next year's crop, it is first noticeable that there are different types of uprights present. Some of those uprights had fruit during the recent growing season (fruit pedicels are still attached to the uprights), which are referred to as "fruiting uprights", and there are also uprights that did not produce any fruit during the recent growing season, which are referred to as "vegetative uprights" (**Figure 1**). A cultivar such as 'HyRed' is called "non-alternate bearing" or "rebudding" because most of the terminal buds be reproductive buds (and so will have flowers the following spring). However, **there are multiple sizes of terminal buds, ranging from large to small reproductive buds** and these ranges of bud sizes can be observed in both, fruiting and vegetative uprights (**Figure 1**).

Figure 1. Types of uprights (vegetative and fruiting) and sizes of their terminal buds (large and small) found in a cranberry bed during the fall.



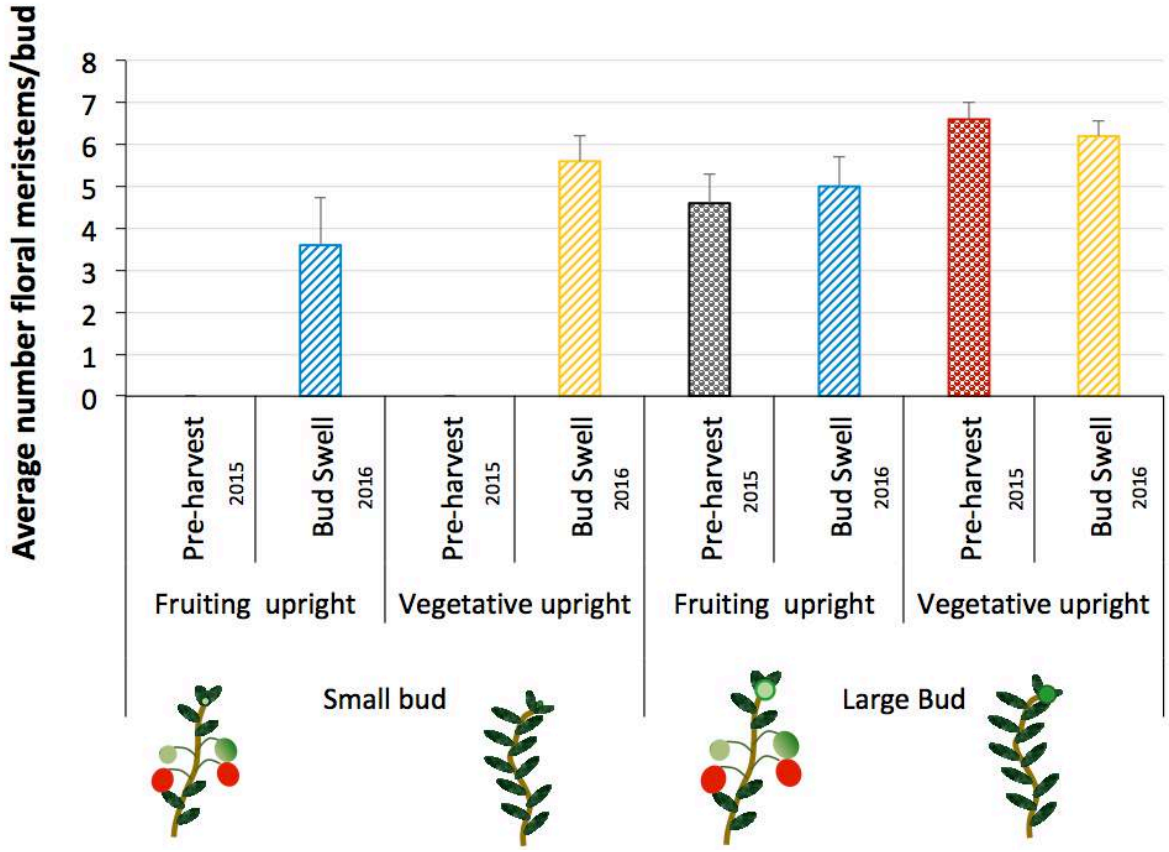
These observations raised several research questions our group was interested in exploring:

1) Do floral meristems continue differentiating during fall (after harvest) and spring (before bud break)?
2) Is the timing of floral structure (petals, anthers, etc.) development the same between buds on fruiting and vegetative uprights? If not, do they "even out" in development by bud break?
3) Do the buds from fruiting and vegetative uprights contribute equally to the next growing season's yield?

To answer these questions, we tagged sets of uprights during early fall, before harvest of 2015. Each set consisted of vegetative and fruiting uprights, with small and large size terminal buds. A set of uprights was collected from the field for microscopy analysis at: pre-harvest; post-harvest; before ice was made in the beds; after ice-off and at bud swell. A set of uprights was left until harvest of 2016 to evaluate yield.

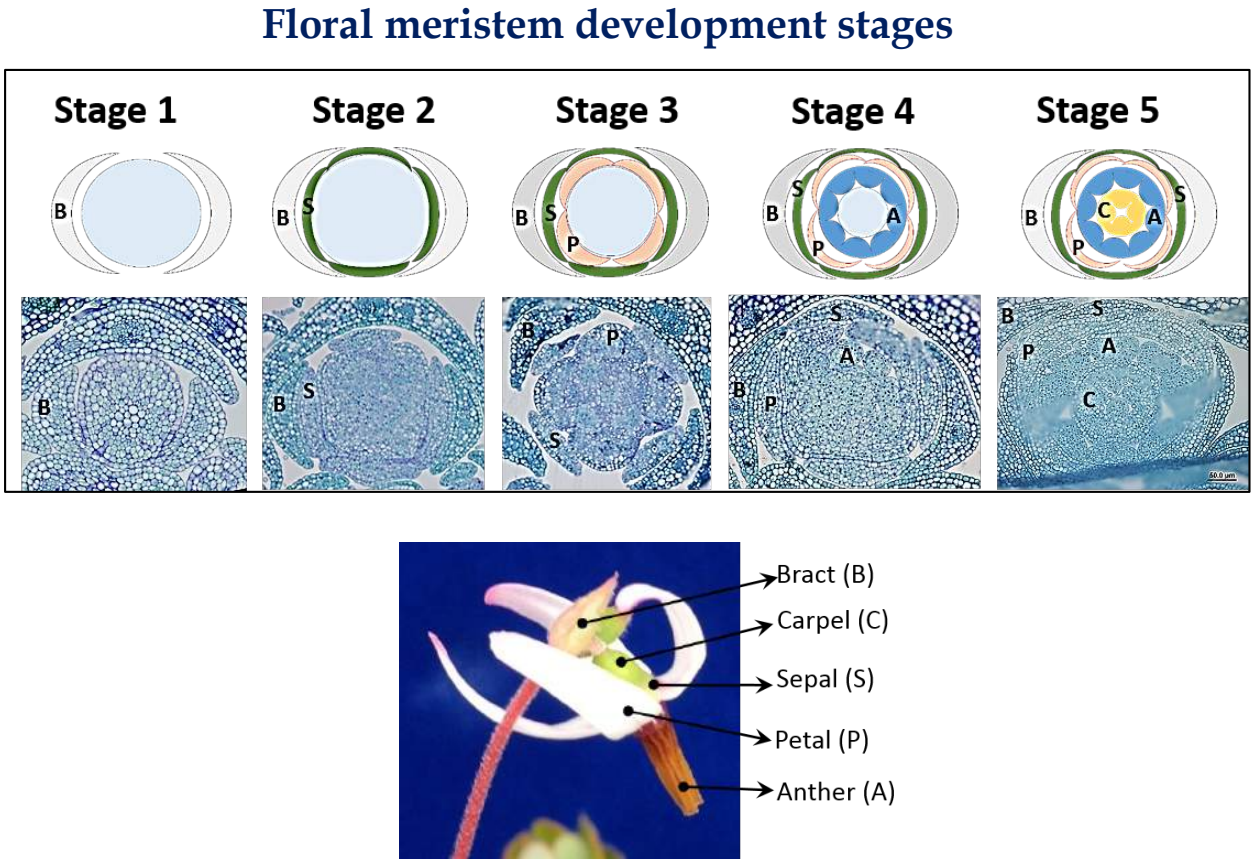
Results from our study show that small terminal buds in both vegetative and fruiting uprights had no floral meristems (assessed during 2015 early fall pre-harvest period). However, during the subsequent bud swell period (spring of 2016) floral meristems were found in the small buds of types of uprights. Fruiting uprights had an average of 3 to 4 floral meristems per upright, while vegetative uprights had 5 to 6 floral meristems per upright (**Figure 2**). In the case of large terminal buds, both fruiting and vegetative uprights already have floral meristems formed during 2015 early fall at pre-harvest (**Figure 2**).

Figure 2. Number of floral meristems observed in small and large buds from vegetative and reproductive uprights during 2015 early fall at pre-harvest and during 2016 spring at bud swell.



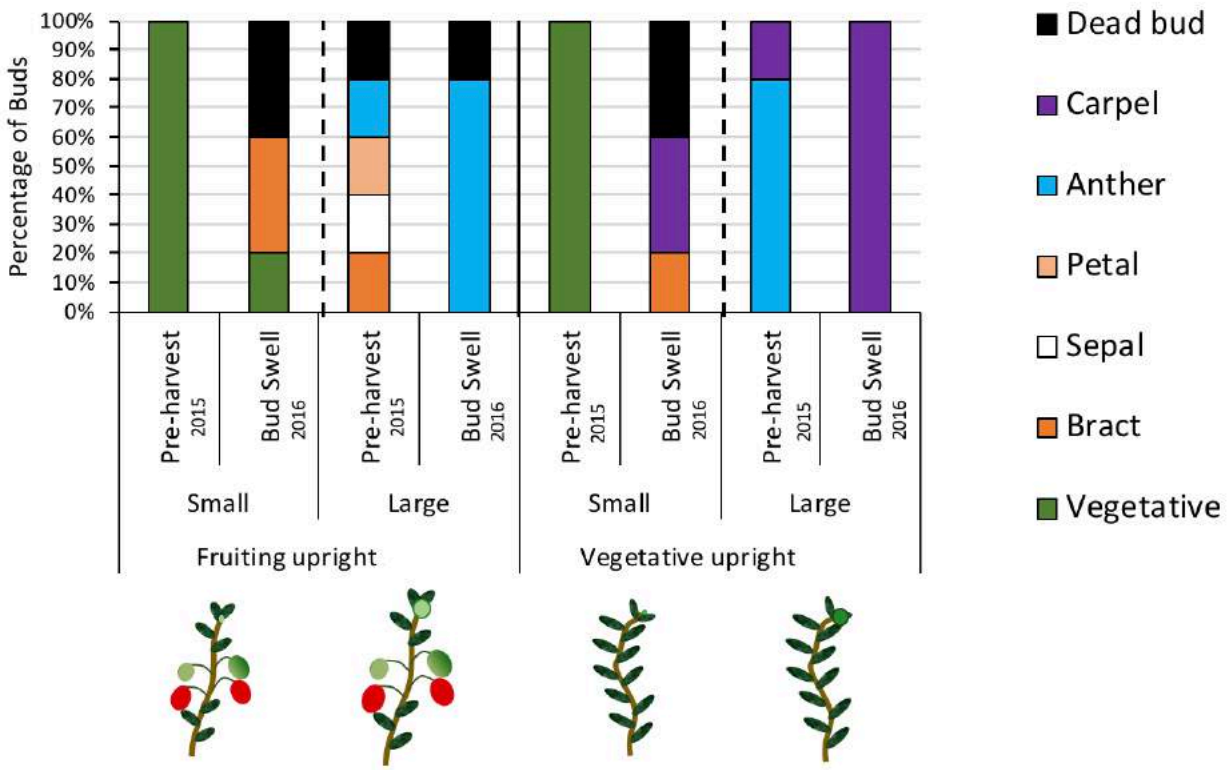
During the same sampling period, buds were also evaluated on the level of flower structure development of the floral meristems. Floral meristems go through a series of developmental stages in which the different structures of a flower are formed (**Figure 3**).

Figure 3. Development stages of cranberry buds. Stage 1 only bracts (B) are present; Stage 2: bracts (B) and sepal (S); Stage 3: bracts, sepal, and petals (P); Stage 4: bracts, sepals, petals, and anthers (A); and Stage 5 fully developed flowers with all structures: bracts, sepals, petals, anthers, and carpel (C).



During 2015 early fall at pre-harvest, small terminal buds of fruiting and vegetative uprights showed only vegetative structure (i.e., no flower structures were present). However, the during the 2016 spring, at bud swell, those small buds had developed to Stage 1 in fruiting uprights, while 40% of the vegetative uprights were already fully developed at Stage 5 (**Figure 4**). In the case of large terminal buds, buds were developed to Stage 1 and Stage 5 in fruiting and vegetative uprights, respectively, during 2015 early fall at pre-harvest. By the 2016 spring at bud swell, large buds of vegetative uprights had all the flower structures completely developed, Stage 6, while those of fruiting uprights where only at Stage 5 (**Figure 4**).

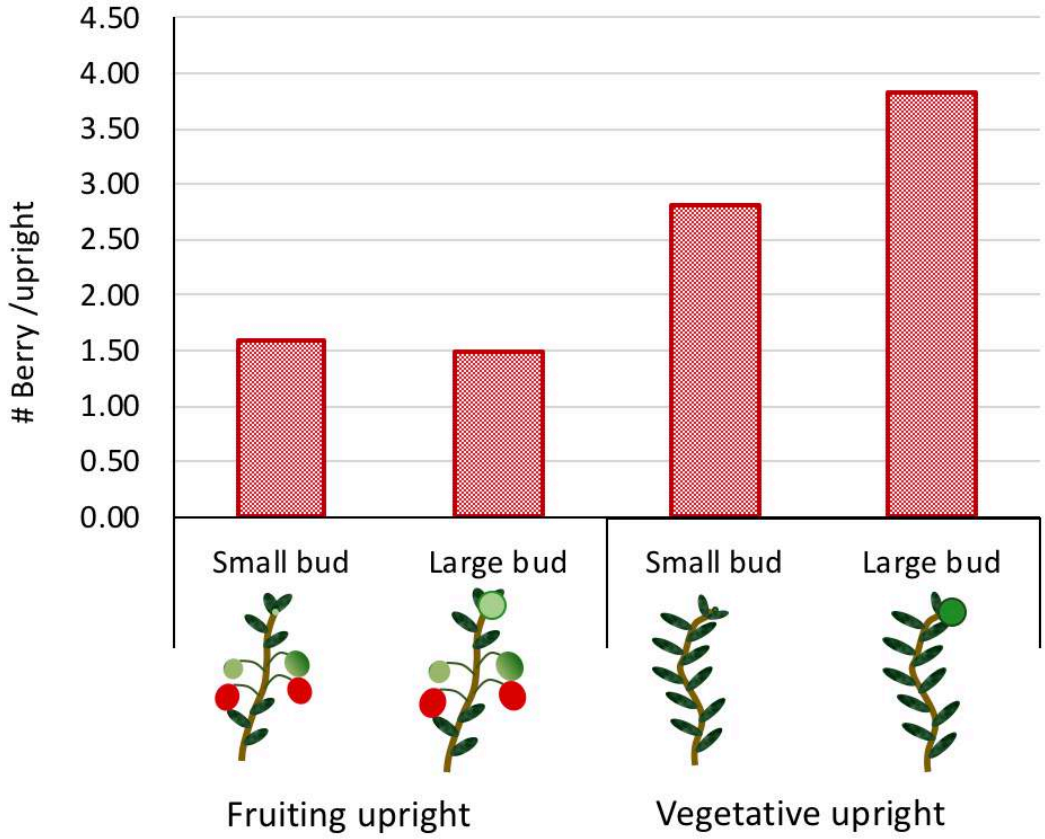
Figure 4. Percentage of buds with the most advanced floral meristems development stages during 2015 early fall at pre-harvest and 2016 spring at bud swell in the small and large buds of reproductive and vegetative uprights.



To evaluate the contribution of fruiting and vegetative uprights, and of small and large buds, on the following seasons yield, a set of vegetative and reproductive uprights were tagged during 2015 early fall and tracked through winter, spring, and summer until harvest in 2016. Most of the fruiting uprights in the 2015 fall, regardless of the size of the terminal bud, produced an average of 1.5 fruits per upright the following season (harvest 2016) (**Figure 5**). The uprights that were vegetative during the 2015 fall and had set a small bud, produced an average of 2.5 fruit per upright the following growing season (harvest 2016); while those that set a large bud produced 4 fruits per upright (**Figure 5**). In addition to estimate the contribution of the type of upright and the size of the buds to yield, the percentage of vegetative and fruiting upright found in a 1square foot area was evaluated during 2015 early fall and during spring of 2017. Vegetative and reproductive uprights accounted for 70 and 30%, respectively, of all the uprights in the areas evaluated in both years.

In summary, floral meristems continue differentiation during the fall and winter months. However, floral meristems on larger buds will have a higher degree of development during fall than those in small buds. Uprights that were vegetative during fall will produce a higher number of flowers and set more fruit during the following spring than those that were fruiting uprights, accounting for most of the fruit production in a bed.

Figure 5. Average number of berries produced per upright from the small and large buds that were set on the vegetative and reproductive uprights of the previous season.

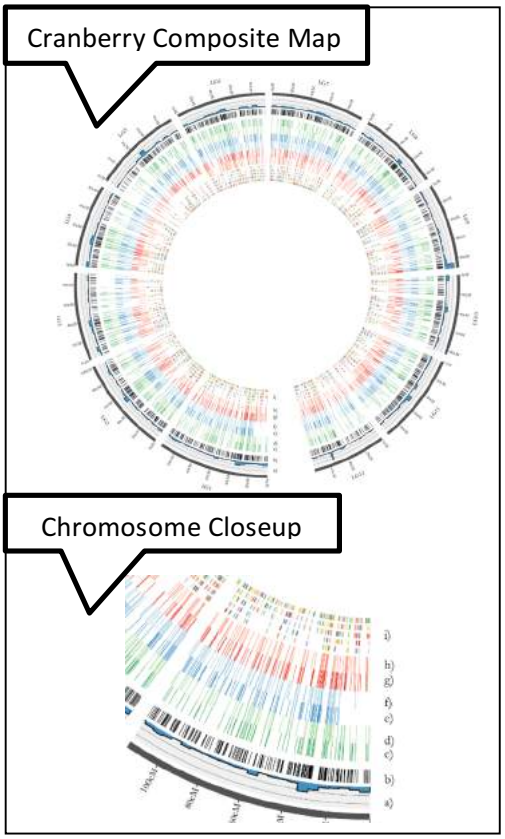


This research project has been led by Dr. Jenny Bolivar, a post-doctoral researcher working in my program, with the help of Dr. Beth Workmaster, Camilo Villouta, and undergraduate students working in the Atucha lab. We thank the funding support from the Wisconsin Cranberry Board, The Cranberry Institute, and Ocean Spray. Special thanks to Nicole Hansen from Cranberry Creek Cranberries.

ADVANCES IN CRANBERRY PHENOTYPING AND TRAIT MAPPING

JUAN ZALAPA AND THE CGGL TEAM MEMBERS AND COLLABORATORS

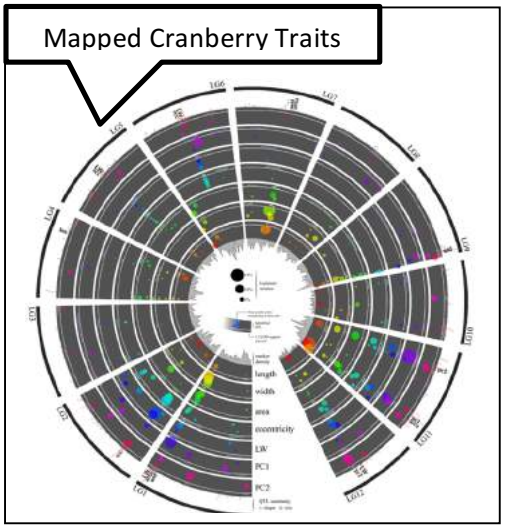
USDA-ARS Vegetable Crops Research Unit, Department of Horticulture, University of Wisconsin-Madison

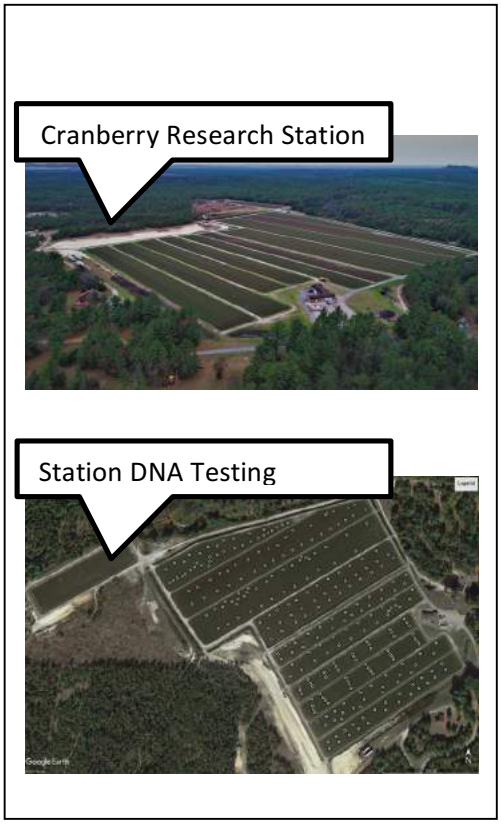


Molecular Mapping: A collaboration between New Jersey and Wisconsin resulted a composite high resolution cranberry genetic map based on three invaluable elite biparental consisting of 72 ('Stevens' x 'Crimson Queen'), 236 ('Mullica Queen' x 'Crimson Queen'), and 434 (BGBLNL95 x 'GH1') clones. First three three parental consensus maps, one for each elite cross, were developed, which then were combined into a the composite high-resolution cranberry map (Schlautman et al. 2015; Covarrubias-Pazaran et al. 2016; Daverdin et al. 2017; Schlautman et al. 2017a). These maps are essential for any and all future cranberry breeding or genetic studies to identify and integrate genes into breeding backgrounds and genotypes. The composite cranberry genetic map developed consists of transferrable and universal molecular markers of two types, simple sequence repeat (SSR) and single nucleotide polymorphic (SNP) markers. First, SSR markers were derived from next-generation sequencing (NGS) data available from the New Jersey and Wisconsin. SSR mining of NGS data resulted in the development of SSR markers sets consisting of 697, 54 and 61 useful SSRs. The SNP markers were derived from genotyping by genotyping by sequencing (GBS) experiments. The composite map was anchored with universal SSR markers. Subsequently, the SSR backbone map was augmented using SNP markers, and a composite cranberry map was developed containing 6073 markers (5437 SNPs and 636 SSRs) to represent the 12 cranberry chromosomes (Schlautman et al. 2017a). This high-resolution molecular map is an essential prerequisite for the genetic mapping of important traits and future marker-assisted selection in cranberry. Finally, we transferred the SSR markers to blueberry and developed a molecular map for comparative traits mapping and evolution studies in cranberry and blueberry (Schlautman et al. 2017b).

Marker-Trait Associations Discovery: We have collected three years of data in Wisconsin (W. Hatch, N. Hansen, E. Grygleski, P. Normington, and W. Normington) and New Jersey (N. Vorsa) for many traits. For example, we collected per plot data for total yield (g/900 cm2), total sound

yield (rot), berry size and weight, total fruit anthocyanin content (mg/100g FW), soluble solids (Brix), titratable acidity, and proanthocyanidin. Additionally, we collected data on 10 individual uprights per plot to determine upright (vertical stem) length of current season's growth, dry weight of leaves, total number of flowers (pedicels with and without fruit), number of berries, number of aborted flowers (pedicels without fruit), berry weight and status of terminal bud (vegetative or reproductive), the biggest berry for each upright measured for length, width, weight, and calyx diameter, seeds counted and weighed for each fruit, and the fruit categorized based on calyx shape, skin, and seed characters. Additionally, we created two high-throughput image phenotyping software packages that greatly increased our ability to efficiently phenotype yield and quality traits. They can process different horticultural traits such as top yield per square area and fruit morphological parameters such as length, width, two-dimensional area, volume, projected skin, surface area, color, among other parameters. The phenotypic data generated was used or is currently being used to identify and localize marker-trait associations for horticulturally important traits in cranberry. For each mapping cross, we combined available the phenotypic data and molecular map to establish the associations between traits and genetic markers. For each trait, we identified and localized map positions of markers-trait association. We also investigated the genetic correlations among traits, and the genetic effect interactions in each cross. Hundreds of marker trait-associations have been identified and localized in the composite high-resolution cranberry molecular map within and among genetic backgrounds for total yield, biennial bearing, fruit weight and size, fruit rot, fruit shape, anthocyanin content (mg/100g FW), soluble solids (Brix), titratable acidity, and proanthocyanidin. All the information is currently being compiled in the composite high-resolution cranberry molecular map. The construction of such composite high-resolution molecular map with trait-makers associations is one of the most important accomplishment in ~200 years of cranberry domestication, breeding, and genetics work.





Future Work: We have been working to provide growers and breeders phenotypic and molecular data to increase breeding efficiency. We have collaborated with Valley Corporation (E. Grygleski), Cranberry Creek Cranberries (W. Hatch, N. Hansen), Rutgers (N. Vorsa), and Saddle Mound Cranberries (P. Normington and W. Normington) to establish plantings, collect trait data, and generate molecular resources for trait mapping. Currently, available trait and molecular data on the three breeding populations studied is being used to determine superior individuals to be released to growers. For the next 5 years, we plan to keep collecting trait information to continue trait-mapping, conduct fine mapping to identify candidate genes, and develop molecular breeding methods based on the markers and genes identified. Traits such as anthocyanin content and color imaging resulted in excellent correlations with the available data collected, thus the identified genetic effects were very strong and will be easily usable for molecular breeding applications in the short-term. For complex traits such as yield that is affected by biennial bearing, our initial analyses indicate that more data is needed to refine the statistical prediction models, thus we will continue to collect productivity data and test methodologies to facilitate data collection, e.g., digital imaging, hyperspectral, microwave, etc. Additionally, we plan to map new traits such as fruit firmness and other fruit quality traits, particularly those related to the health properties of cranberries. In the future, the accumulated information in cranberry regarding phenotypic and genetic associations will make it possible to build invaluable statistical and genetic models for selection that will significantly reduce the time and effort to breed superior cranberry cultivars. We are currently moving forward with next-generation breeding at USDA-ARS and UW using molecular tools at the new Cranberry Research Station. The study of horticultural and commercially important traits and the identification of marker-trait associations will allow us to use molecular information in conjunction with traditional plant breeding to develop a molecular-assisted selection breeding program. We have already began using molecular markers to test the available Stevens beds Wisconsin Cranberry Station for genetic purity. Based on the genetic results and available yield data, best decisions will be made about renovation priorities for the 10 productions beds at the station. For our breeding plots, and based on our genetic research,

Saddle Mound Planting

Dubay Collection Preservation

UW-USDA Collection

our goal is to create new breeding stocks and genetically interesting populations to be planted in statistically augmented designs at the new Wisconsin Cranberry Station. Interesting segregating bi-parental populations and accessions will also be replicated throughout Wisconsin to test performance for our different growers. We have also been accumulating hundreds of cultivated cranberry accessions and seeds from elite crosses that we will plant at the station in statistically augmented and replicated designs. We also have hundreds of wild cranberry accessions preserved as potted plants in our UW-Madison greenhouses that we will plant in statistically augmented designs at the station. In this regard, we recently completed an exhaustive search and genetic analysis of wild cranberry populations in the U.S. We have detailed information about different habitats and genetic parameter information of many populations around the country, particularly about locations never explored before in Wisconsin and Minnesota. We plan to use these wild collections for breeding to preserve genetic diversity and bring new traits into cultivated varieties, particularly cold tolerance and other stress and pest related traits. In order to increase the number of breeding materials in our collection, in 2017, we gathered 8-12 fruit bearing uprights for most of the almost 100 varieties planted at the Dubay breeding collection. Our goal is to assess the Dubay collection in terms of genetic purity and integrity and preserve the unique genotypes identified as a part of our collection at the new Wisconsin Cranberry Station. Also, in 2017, we established a high-density planting consisting of 846 plants at Saddle Mound Cranberries. The planting consists of 132 Pilgrim selfs, 166 Stevens selfs, 80 HyRed selfs, 127 Sundance selfs, 95 BenLear selfs, 81 Pilgrim x LeMunyon selfs, 82 Stevens controls, 73 unique wild cranberries, and 10 BL x LeMunyon crosses. This planting was established using molecular information derived from our previous studies. Our goal is to leverage all available and future genetic information to conduct a molecular-assisted, inbred/hybrid cranberry breeding program. The high-density planting at Saddle Mound will serve as a model to provide information to plan the establishment of our breeding plantings at the new Wisconsin Cranberry Station.

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MINIMIZING THE RISK OF FUNGICIDE RESISTANCE

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Cranberry growers need to take into account several factors when developing a fungicide spray program. First, the fungicide(s) needs to be effective in controlling the disease(s) present. Some fungicides are known to have phytotoxic side effects, such as reduced fruit color in berries treated with mancozeb and flecks and burn spots on berries treated with chlorothalonil (e.g., Bravo). Crop handlers sometimes restrict use of certain products. Cost of application is a critical consideration, especially in times of low crop prices. The risk of fungicide resistance is not foremost in most growers' minds, but this too needs to be considered.

In a fungal population, individuals naturally vary in their sensitivity to a fungicide. Individuals that survive a fungicide spray go on to reproduce more individuals that can survive exposure to that fungicide. After repeated applications, more and more individuals in the population resist the fungicide, and eventually the fungicide fails to control disease. Thus, fungicide resistance is brought about by selection, and every spray is a selection event. How many sprays does it take for fungicide resistance to become a practical problem in the field? There are two main factors that determine this.

First, fungi almost never develop resistance to multi-site fungicides that act on many genes or physiological pathways. This is why chlorothalonil and mancozeb, both multi-site fungicides, continue to work on numerous diseases of a wide array of crops despite decades of use. However, fungicides that act on a single gene or physiological pathway are at great risk for fungi overcoming them, because it takes just one or a few naturally occurring mutations for the fungus to survive the fungicide. In cropping systems other than cranberry, some fungicides are overcome by resistant fungal pathogens after 15 to 20 sprays, or just 3 to 4 years of intensive use.

The second main factor driving fungicide resistance is the biology of the fungal pathogen. Fungi that go through many cycles in a single growing season and/or fungi that sporulate prolifically on the plant surface are adept at developing resistance. Growers need to spray several times per year to control such diseases, and every spray selects for the survival of fungicide resistant individuals in the population.

Cranberry growers are fortunate in that none of the major pathogens have "high risk" life cycles. To the best of our knowledge, most cranberry pathogens have just one or a few cycles of infection in a season, and most do not sporulate heavily on the plant surface. Note, however, that cottonball does sporulate on shoot tips just prior to and during bloom. In

Wisconsin, most cranberry growers spray fungicides three or fewer times per year. Thus, selection for fungicide resistance is much less than in some other cropping systems.

Despite the good news, there are reasons that growers should be knowledgeable of fungicide resistance and how to manage it. Unlike some crops for which there are dozens of fungicides in several classes, few fungicides are registered on cranberry. When we do get a new fungicide, it is often in a class with a very specific mode of action and therefore is at moderate to high risk of succumbing to resistant pathogens. In general, the more specifically a fungicide acts on fungi, the safer it will be to non-target organisms, including humans. That is the desired trend for new fungicides. In Wisconsin we have seen a shift away from chlorothalonil (Bravo) to more specific fungicides such as azoxystrobin (Abound), fenbuconazole (Indar), and prothioconazole (Proline). Finally, growers need to keep in mind that planting stock, whether it's plugs from a greenhouse or cuttings from the field, most likely are being treated fungicides—the very same fungicides that the grower will want to use. This is especially true for the newer, high-yielding cultivars. Thus, when you plant a new bed, you cannot assume that the pathogen population is starting at zero resistance. Rather, fungal pathogens will be introduced on cuttings and plugs, and those pathogen populations have already undergone several selection events.

Table 1 summarizes the risk of phytoxicity and the risk of fungicide resistance developing toward the most effective fruit rot pathogens. The last column lists resistance groups, or Fungicide Resistance Action Committee (FRAC) codes, that can be found on fungicide labels. Note that there are only multi-site inhibitors (M5 and M3) and two other resistance groups (3 and 11) from which to choose. For cottonball control (Table 2), the options are even more limited.

Table 1. Fungicides effective in controlling cranberry fruit rot

Fungicide	Phytotoxicity	Risk of resistance	Resistance group
chlorothalonil	yes	low	M5
mancozeb	yes	low	M3
difenoconazole (Indar)	no	med	3
prothioconazole (Proline)	no	med	3
azoxystrobin (Abound)	no	high	11
fluoxastrobin (Evito, Aftershock)	no	high	11

Table 2. Fungicides effective in controlling cranberry cottonball

Fungicide	Phytotoxicity	Risk of resistance	Resistance group
difenoconazole (Indar)	no	med	3
propiconazole (Orbit, Tilt, Topaz, Propimax)	no	med	3
azoxystrobin (Abound)	no	high	11

To prevent fungicide resistance, growers need to minimize selection. There are three main ways to do this. First, use cultural practices such as a post-harvest or early spring trash flood, to reduce overall pathogen populations, so that there will be fewer resistant individuals to select. Second, minimize the number of selection events (i.e., sprays). Third, by mixing unrelated groups of fungicides or alternating them in a spray program, you will reduce the number of individuals being selected by either fungicide. These principles can be implemented into spray programs that will control rot but delay the onset of fungicide resistance.

Four different possible 2-spray programs are described in Table 3. If only two sprays are applied, fungicide resistance management will be relatively easy. You can use fungicides from the same resistance group twice in a season without a great risk of selecting for resistance.

Table 3. Possible 2-spray programs for fruit rot management

Early-mid bloom	Late bloom-early fruit set
Indar + Abound	Indar + Abound
Proline	Proline
Indar + Abound	Proline
Mancozeb*	Indar + Abound

*Mancozeb is not effective on cottonball, and it can reduce berry color if applied to developing berries.

If you need to spray three or more times, then resistance management becomes more challenging, since there are so few fungicide groups available to cranberry growers. Four possible 3-spray programs are outlined in Table 4. In the first program, note that Proline is applied in the first (early-mid bloom) and third (10-14 days after fruit set) spray, but not in the second (late bloom-early fruit set) spray. Note also, that Indar is not mixed with Abound in the second spray. The reason for this is that Proline and Indar are both group 3 fungicides, and they should not be used three times in a row; we need to break it up with Abound (group 11). The other possible programs include multi-site inhibitors (Bravo and mancozeb) to relieve selection

by the group 3 and 11 fungicides. Despite their drawbacks, these multi-site inhibitors are useful for growers who spray three times per season most years.

Table 4. Possible 3-spray programs for fruit rot management

Early-mid bloom	Late bloom-early fruit set	10-14 days later
Proline	Abound	Proline
Proline	Bravo	Indar + Abound
Mancozeb	Proline	Indar + Abound
Mancozeb	Indar + Abound	Indar + Abound

In summary, fungicide resistance currently is not limiting cranberry spray programs, but it is a looming concern that should be taken into account when developing a spray program.

BIO-INSECTICIDES AND MATING DISRUPTION IN CRANBERRIES

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Two broadly virulent nematode species have been found in Wisconsin cranberry marshlands. Morphological and molecular analyses suggest that they are *Oscheius onirici*, a recently described nematode known to occur in both Europe and North America (Ye et al. 2018), and *Heterorhabditis georgiana*, another recently described nematode known to occur in the US (Nguyen et al. 2008). Both nematodes were recovered through the *Galleria* bait method from wild cranberry marshes in central Wisconsin, USA. *Oscheius onirici* belongs to the *dolichura*-group, and a *Bacillus*-like bacterium appears to be associated with this nematode, based on our microscopic and SEM observations. *H. georgiana* is a relatively large nematode and hosts the bacterium, *Photorhabdus luminescens* (Nguyen et al. 2008).

Our data suggest that these nematodes are capable of infecting larvae of the sparganothis fruitworm *Sparganothis sulfureana* Clemens (Lepidoptera: Tortricidae), the cranberry (red-headed) flea beetle *Systena frontalis* (Coleoptera: Chrysomelidae), the mealworm *Tenebrio molitor* L. (Coleoptera: Tenebrionidae), and the greater wax moth *Galleria mellonella* F. (Lepidoptera: Pyralidae). *O. onirici* has also been shown to attack and kill the cranberry fruitworm, *Acrobasis vaccinii* (Lepidoptera: Pyralidae) while it is overwintering within its hibernaculum. In greenhouse trials using field-collected cranberry sods, *O. onirici* controlled flea beetles as well as two commonly used, broad-spectrum insecticides. In larger-scale field trials, both *O. onirici* and *H. georgiana* performed equally well, suppressing flea beetle numbers far below that of controls.

Figure 1. *Dead larva of cranberry fruitworm, with* Oscheius onirici *nematodes emerging from the cadaver.*

Our results are important because these nematodes represent virulent entomopathogens for three key cranberry pests: the sparganothis fruitworm, the red-headed flea beetle, and the cranberry fruitworm. Thus, these nematodes could be developed into an effective bio-insecticide for use within the cranberry industry, as well as other agricultural industries.

The multi-species mating disruption (MD) program continues to be tailored for the unique production system of cranberries. Six years of field trials indicate that black-headed fireworm and cranberry fruitworm populations can be significantly, consistently reduced using MD. Importantly, berry infestation rates can be reduced below that of insecticides alone. The next step for commercialization of the technology is the development of an efficient means of deploying the pheromone carriers. Mechanization of MD deployment has explored retrofitting drones and the creation of novel extrusion devices for boom-arm applications. Both have worked but have also revealed drawbacks. Ongoing work is examining carriers that can be dispersed with standard fertilizer applications.

Figure 2. Retrofitted drone, applying MD product to commercial cranberries.

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MICROWAVE SENSING TECHNOLOGY FOR ESTIMATION OF CRANBERRY CROP YIELD: A PILOT STUDY

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The objective of our research is to develop a low-cost portable microwave sensing system to accurately and efficiently estimate cranberry yield. Microwave sensing technology offers several practical advantages over the conventional approach of handpicking and counting all berries within representative 1-ft. by 1-ft. square sites. Data acquisition is non-invasive; the berries remain on the vine. Each microwave observation of the cranberry canopy is captured on the order of a second. Additionally, the acquisition and processing of data is automated. Thus microwave sensing is much less time- and labor-intensive than manual handpicking and counting, and it permits broad spatial coverage for yield variability estimation within beds.

Microwave remote sensing systems have been previously explored by numerous research groups for the purpose of estimating a variety of crop-soil parameters, including leaf-area index, biomass, plant height, soil moisture content and vegetation water content. Ground-based systems, as opposed to air- or space-based, are well-suited for applications involving frequent monitoring, and they offer greater control over the measurement-acquisition setup and its orientation with respect to the canopy being illuminated, thereby enabling accurate performance evaluations against ground-truth data. We are interested in a ground-based system because of the availability of booms for suspension over the cranberry canopy and the mobility they provide for spatial variability mapping. Previous agricultural studies have been conducted using ground-based scatterometry systems on a wide variety of crops, as highlighted in Table 1. The frequencies used to interrogate the crops range from 1.25 GHz (near cellular communications frequencies) to 35.6 GHz. The primary focus of these studies was estimating vegetation biomass and soil moisture content.

Table 1

Authors	Crop type	Frequency
Ulaby and Jedlicka, 1984 [1]	Corn, sorghum, wheat	8.6, 13.0, 17.0, 35.6 GHz
Bouman, 1991 [2]	Sugarbeet, potato, wheat, barley	9.5 GHz
Chauhan, 1997 [3]	Alfalfa	1.6 GHz
Stiles and Sarabandi, 2000 [4]	Wheat	1.25, 5.3, 9.5 GHz
Prasad, 2009 [5]	Ladyfinger	9.9 GHz

The feasibility of a microwave sensing system for *cranberry yield estimation* hinges upon the existence of a non-negligible contrast in how microwaves interact with berries relative to the surroundings, e.g. leaves. The material properties that govern those microwave interactions are the relative permittivity and effective conductivity, collectively referred to as the dielectric properties. We measured the dielectric properties of cranberries and healthy and dried out leaves to establish the feasibility of using microwaves to sense the presence of cranberries in the bed. Figure 1 shows the measurement results of our dielectric characterization study. The dielectric properties of the canopy constituents are proportional to their water content, as illustrated in the progressive increase in permittivity from dried-out leaves to healthy leaves, and from healthy leaves to berry flesh. The properties of the cranberries are nearly as high as that of water due to the significant water content in fresh berries. The nearly 3:1 contrast between the berries and the background canopy across a broad frequency range indicates that there is a strong physical basis for discriminating pertinent fractional cranberry volumes in the canopy.

We have designed and constructed a first-generation microwave sensing system, shown in Figure 2. The system comprises a waveguide whose aperture is positioned above the canopy surface. The waveguide is connected via a phase-stable cable (not shown) to a portable microwave signal transmitter/receiver that is powered by a portable battery and controlled via a laptop. The waveguide illuminates the cranberry canopy with a low-power microwave signal. Reflections from the canopy travel back to the transceiver through the waveguide and cable, and the laptop logs the reflection data that is subsequently processed to estimate yield.

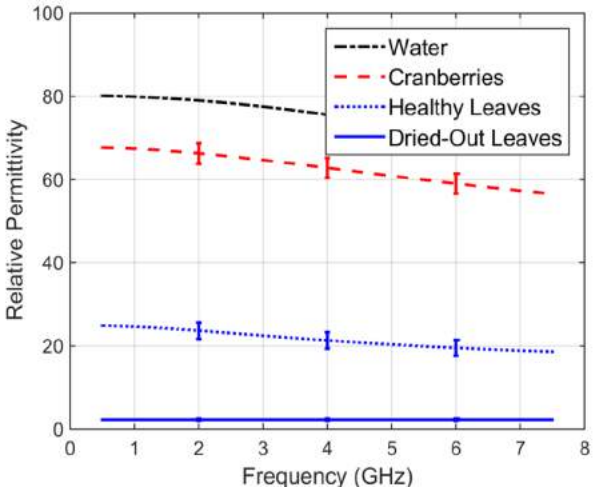

Fig. 1. Microwave-frequency relative permittivity of fresh cranberry tissue, fresh leaves, and dried - out leaves. Source: [5]

Fig. 2. A microwave waveguide suspended above the canopy surface in a cranberry bed in central Wisconsin.

We conducted a pilot study of the prototype system, collecting data from two testbeds in central Wisconsin in Fall 2017. Thirty representative 1-sq.-ft. sites were chosen from Testbed 1, and 20 from Testbed 2. We conducted 12 measurements per site by rotating and/or translating the waveguide above a square marker placed on the canopy surface. All of the cranberries within each 1-sq.-ft. site were harvested and counted to establish the ground truth for system calibration and performance evaluation. In total, there were 360 measured data sets for Testbed 1 and 240 measured data sets for Testbed 2. The number of berries in each site ranged widely from less than 50 to nearly 400.

We converted the measured data – the reflected microwave signals – to estimates of cranberry yield using well established statistical signal processing methods. We excluded data from the sites for which the ground-truth berry count was deemed to be a significant outlier. Each testbed had one such low-berry-count outlier, thereby reducing the number of sites to 29 and 19 for Testbeds 1 and 2, respectively, for a total of 576 measurement data sets. Our yield estimation procedure generated estimates within 50 berries of the true berry counts in nearly 70% of the test cases. When all 12 measurements per site were combined in a site-specific average measurement, the microwave-based estimates were within 50 berries of the true berry counts in approximately 80% of the test cases.

Our pilot study has established the feasibility of microwave sensing technology in estimating cranberry yield and provides a baseline yield-estimation accuracy that we expect to significantly improve upon with further research. In particular, a more extensive measurement campaign with a second-generation prototype deployed in representative cranberry beds will improve system calibration. An additional goal of further research involves transitioning to a boom mounted system for increased portability.

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NEW DIRECTIONS FOR MATING DISRUPTION IN WISCONSIN

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Key Points

- Mechanized SPLAT® extruders were retrofitted onto boom sprayers and used on 80 commercial acres in central Wisconsin.
- SPLAT + standard insecticide treated beds had fewer Cranberry fruitworm and Blackheaded fireworm adult moths caught in pheromone-baited traps compared with standard insecticide practices.
- Due to problems receiving SPLAT in a timely manner, as well as harvest residue, we have started to look for new pheromone carriers.

Mating disruption (MD) works by interfering with insect's mate finding capabilities. Under natural conditions, a female moth emits a pheromone, which the male follows to the source. With mating disruption, a synthetic pheromone mimic is dispensed in the field, inundating the cropping canopy with pheromones such that the male can't find a female, and they don't reproduce (Cardé and Minks 1995). This preempts the larval, feeding life stage from damaging the crop.

The USDA Cranberry Entomology Lab has been developing a MD program for Cranberry fruitworm (CFW), Sparganothis fruitworm (SFW), and Blachkeaded fireworm (BFW) since 2012 using SPLAT® as a pheromone carrier (Steffan et al. 2017). SPLAT® stands for Specialized Pheromone Lure and Application Technology and is produced by ISCA Technologies in Riverside, CA. It is a highly viscous, biodegradable wax, into which pheromones are imbued (Mafra-Neto et al. 2013). As the wax dries in the bed, pheromones are slowly released, lasting the duration of the moth flight. MD is a viable tool for these pests as they have a similar flight period, so a single application can be applied to treat all three. SPLAT® has several advantages over insecticide:

1- it doesn't affect non-target species,

2- it can be certified organic,

3- it has the potential to reduce some or all insecticide applications.

A challenge with using SPLAT® is its thick consistency makes it difficult to apply at field scales. Field trials in 2012 – 2014 required manual application using caulking and grease guns (Steffan et al. 2017). In 2015, Dr. Steffan teamed up with Dr. Brian Luck to build a better

dispenser for SPLAT®. By 2016, they had mounted a dispenser onto an Unmanned Arial Vehicle that was successfully piloted with pre-programmed flight coordinates (Chasen and Steffan 2016). For the 2017 season, we built 9 boom-arm mounted extruders to dispense SPLAT in a grid formation in the bed (Fig.1). We used the extruders on 80 commercial acres in central Wisconsin, across 4 marshes. The system was designed to be transported between marshes and used on variable boom designs. The extruders are made of steel and threaded rod, which serve to hold a 750 gram caulking tube loaded with SPLAT®. A stepper motor at the base of the tube is programmed to push on the base of the tube to dispense SPLAT®.

Figure A. SPLAT extruders mounted onto a boom sprayer.
Figure B. Close up of SPLAT extruder.

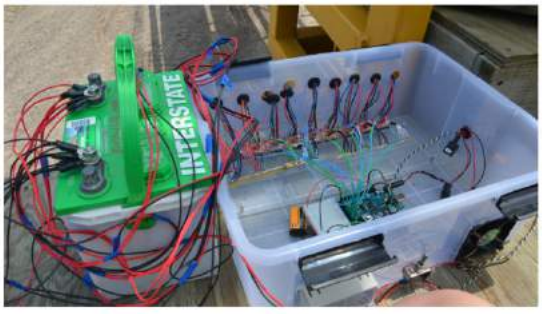

Figure C. Electronic components programed to dispense SPLAT at ideal dollop rate and 12 volt battery to power system.

Figure 1.

One metric used to determine the success of MD is monitoring pheromone-baited traps. If the male moth finds a pheromone trap, it's likely it would also be able to find a female, and the MD product did not adequately "mask" a male's mate finding capability. Fewer male moths found in the traps = higher success of treatment. The 2017 season saw successful disruption of CFW (Fig. 2) and BFW (Fig. 3) in SPLAT + standard insecticide treated beds compared with standard insecticide. There was not a reduction in male moth traps for SFW.

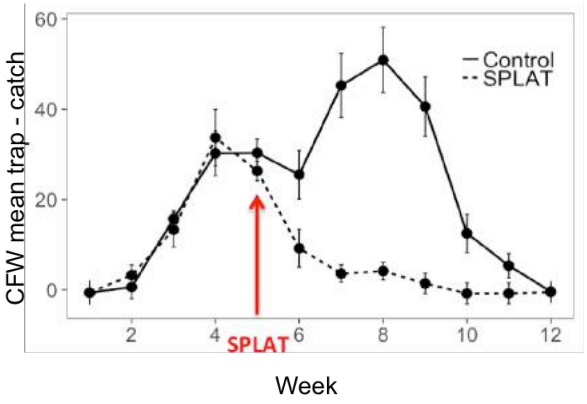

Figure 2. Male cranberry fruitworm moths (mean ± 1 SE). Control (solid line) and SPLAT-treated beds (dashed line) over a 12-week period.

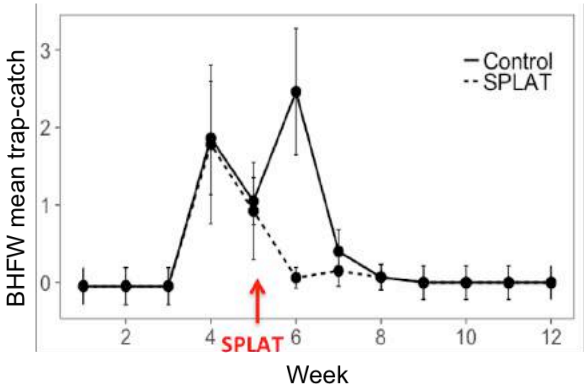

Figure 3. Male blackheaded fireworm moths (mean ± 1 SE). Control (solid line) and SPLAT-treated beds (dashed line) over a 12-week period.

Due to problems receiving SPLAT® in a timely manner and harvest residue, we are in the process of finding a better pheromone carrier. The new pheromone carrier will be similar in size to granulated fertilizer, so it can be applied using existing farm equipment. Several different materials are being assessed to determine whether they can: allow for slow release of pheromones, break down in the field, and be distributed in a grid pattern using fertilizer spreaders.

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HYPERSPECTRAL REMOTE SENSING OF CRANBERRIES IN WISCONSIN

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Spectroscopy

Light interacts with leaves in a variety of ways. Some of the light goes through the leaf, some is absorbed and re-emitted, and some is absorbed to make food for the plant. Finally, some light bounces of the surface of the leaf or off things inside the leaf. The amount of light at any wavelength that comes from the leaf is dependent on what the leaf is made of, how it is structured, and how thick it is.

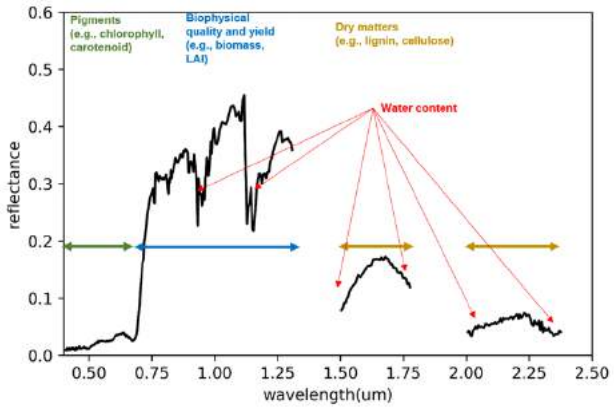

Figure 3. *Spectrum extracted from cranberry bed imagery collected by the HySpex full-range imaging spectrometer on September 15, 2017.*

Our lab catches and measures the light or radiation coming from leaves and plant canopies. From these measurements, we can infer the amounts of constituents in the leaf, like chlorophyll, nutrients, water content, pigments, and solids (Fig 1.). There is also the potential to detect plants stressed by disease or water availability, discern stages of development, and predict yield. This presentation is an overview of two pilot campaigns which are meant to explore the viability and utility of using spectral measurements to infer traits and characteristics of cranberry beds.

Spectral Sampling During Development

Leaf samples were collected at the hook, bloom, and pea-sized fruit stages of 3 beds, which grew Stevens, HyRed, and Mullica Queen varieties. Samples were collected from 3 zones (Fig. 2) within the bed, put on ice, and transported to the Environmental Spectroscopy Lab at the University of Wisconsin-Madison, where spectral measurements were performed on individual leaves using a hand-held spectrometer with a leaf clip attached through a fiber optic cable. Both new growth and old growth leaves were collected and measured. The goal here is to assess the viability of using

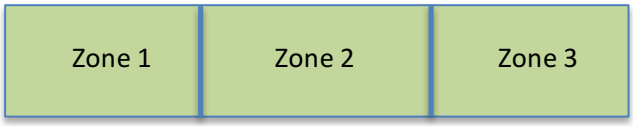

Figure 4. *Upright collection zones.*

chemical analysis in tandem with the spectra to create models that identify nutrient content at these different stages of development.

August Spectral Sampling for Nutrients

Between August 30th and September 9th of 2017, spectral measurements of cranberry plant canopies were collected from 41 beds, including 12 varieties, using a hand-held spectrometer. In each bed, several measurements were taken at 8 plots that followed two transects in each bed (Fig. 3). Another spectrometer measured and logged the spectra of a 99% reflectance white panel. This is used as a reference for incoming solar radiation when calculating relative reflectance.

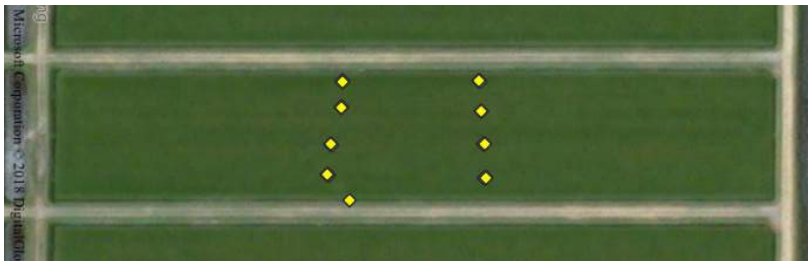

Figure 5. *Google Earth image of cranberry bed overlaid with the spectra locations. Each point in the bed represents 15 or more measurements. The point on the road is a marker measurement.*

Figure 4 shows spectra from two days of sampling, August 31st and September 8th. There is a great deal of range in the data, which is good, because greater variability in the spectra allows us to more easily assess traits and characteristics of the plants. This data will be combined with nutrient data provided by the grower and used to create models that can assess cranberry leaf nutrients. These models could then be applied to other cranberry beds without the need to collect samples for chemical analysis.

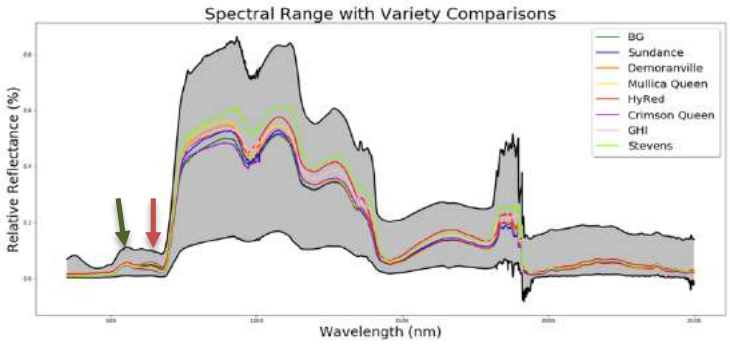

Figure 6. *Example spectra of different cranberry varieties and range of spectra collected on August 31 and September 8 of 2017. Green and red peeks of the visible spectrum denoted by green and red arrows respectively.*

Also note that spectra differ in shape between varieties. This is potentially useful, as some models may be species dependent. In these cases, the ability to identify varieties using spectra will increase the flexibility and usefulness of trait identification and

mapping software.

Since these spectra were measured after the plants had fruited, the cranberries themselves also influence the results. We can see a small peak in the green wavelengths at about 530 nm (green arrow), as would be expected with green vegetation. The cranberries result in a higher reflectance at about 670 nm (red arrow), which is the red part of the visible range. This is not seen in purely green vegetation, and so it is clear that the cranberries are contributing information to the spectra. The presence of cranberries in these measurements is both a complication and potential asset. While it will take some work to separate and quantify the influence of the cranberries and leaves on the spectra, if successful, it may be possible to assess traits of the cranberries themselves. We can visually identify the presence of cranberry pigments, but the cranberries are most certainly affecting the non-visible portion of the spectra, which could lend itself to cranberry quality assessment.

Imaging spectroscopy and Cranberry Beds

The Environmental Spectroscopy Lab recently acquired an imaging spectrometer (HySpex), which was flown as part of the second pilot study in cranberry plant spectroscopy. This spectrometer works the same way as a hand-held spectrometer, but collects many spectra at once along a line. The HySpex was mounted in a Cessna, and we collected hyperspectral images over a cranberry marsh on September 15th. As the plane flies over ground, the imaging spectrometer collects line after line of spectra, which then become an image (Fig. 5). Each pixel within the image represents an individual spectrum. As mentioned previously, figure 1 is one of these spectra. If one were to create an image from the visible part of the spectra, it would look like a normal picture. If an image is created from a non-visible portion of the spectra, as is in Figure 5, it reveals information that we cannot see with our eyes.

Figure 7. *Infrared (non-visible) imagery of a cranberry marsh (September 15, 2017). Note that infrared does not include thermal wavelengths in this case. The image is overlaid with Google Earth imagery.*

Moving Forward

This rich and unique dataset is the first step in creating models that can assess cranberry bed chemistry, leaf mass per area, water content, variety, health, and more. In addition, uses for this dataset extend to exploring methods for using canopy data under variable sky conditions, as intermittent clouds can produce situations where the sun reference and cranberry spectra

are collected in different amounts of sunlight. The second campaign was performed under both sunny and variable sky conditions.

During the summer of 2018, it is expected that canopy measurements will be collected before fruit forms, which will complement the data collected of fruited plants and allow us to assess the viability of predicting yield before fruit development.

In addition, the HySpex will be flown regularly in 2018, and will capture hyperspectral imagery of cranberry beds at different stages throughout the summer. This will allow us to map traits that we develop models for, like nitrogen, and explore the practicality of scaling such measurements up to the satellite level.

UNDERSTANDING PATTERNS OF COLD DAMAGE IN BUDS USING CONTROL FREEZING TESTS

AMAYA ATUCHA, CAMILO VILLOUTA, AND BETH ANN WORKMASTER

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During 2017, the fruit lab at UW-Madison has been working on understanding how and when freezing damage occurs in cranberry buds. As in many woody plant buds, freezing stress damage in cranberry is variable across different structures of the bud, often making evaluation challenging. The buds of woody plant species can survive freezing stress by either tolerating ice formation in the intracellular space, or by avoiding ice formation through a mechanism known as supercooling, in which water is maintained in the liquid state in portions of the buds, even when temperatures drop below the freezing point. During the last two years we have been working under the hypothesis that cranberry buds survive freezing stress through supercooling. However, based on our research, cranberry buds do not supercool, and we are now focusing on investigating how cranberry buds might tolerate ice formation during the periods of fall, winter, and early spring. We hypothesis cranberry buds are able to withstand freezing conditions by a process know as extra-organ freezing, in which water in the flower and vegetative meristems inside the buds is mobilized to other structures, such as bud scales, where ice has formed. In this way, ice does not form in the interior of the buds, and flower and vegetative meristems are protected (Figure 1). Through our work on flower primordial development during fall and winter (Bolivar-Medina et al. 2017), we have observed that bud scales of bud samples collected in the late winter and early spring present voids that could be an indication of ice formation during the freezing periods (Figure 2).

In an attempt to evaluate cold hardiness in cranberry buds, we have run controlled freezing tests every other week starting a week before harvest in 2017, and we have visually evaluated the damage in the different bud structures. As previously noted, visual evaluation of cold damage can be very challenging, because the damage can express in different structures and at variable intensity. Below we have compiled two sets of buds that were submitted to controlled freezing tests. Figure 3 illustrates the progression of damage found in buds collected from the field on September 7, 2017, and shows damage for a temperature range of 25 to -4 °F. Figure 4 shows buds collected on December 27, 2017, and shows damage for a temperature range of 14 to -40 °F. The first thing to notice is that buds collected during September are less hardy than those collected in December, as a significant amount of damage is observed at -4 °F in buds collected in September while those in December show significant less damage when exposed to the same temperature. Overall, we tend to see in both sets of buds that damage first appears in the bud axis (junction between the bud and the stem), where a brown necrotic area starts to form (Figure 3A and 4A). As the temperature keeps dropping, a second area of damage develops in the base of the bud scales (Figure 3B and 4B), and finally at the lowest temperature

tested the brown necrotic area extends and intensifies in the bud scales and bud axis (Figure 3C and 4C). These brown necrotic areas are the results of ice formation that ruptures the cell wall and membranes, resulting in the death of cells, which is expressed by tissue browning after thawing.

During the following seasons, we will continue our evaluation of patterns of cold damage using controlled freezing tests, and we will focus on determining if the symptoms we observed when buds are exposed to a range of freezing temperatures results in lethal damage or if the buds are able to recover and produce viable flowers.

Figure 1. Illustration of the hypothesis of extra-organ freezing as a mechanism of ice tolerance in cranberry buds, in which bud scales freeze first and pull water from the flower primordial to avoid ice formation. The picture on the right shows significant damage on bud scales and bud axis visible after thawing. However, the flower meristems have a lower degree of damage, probably as a result of water migrating to the bud scales where the ice was formed.

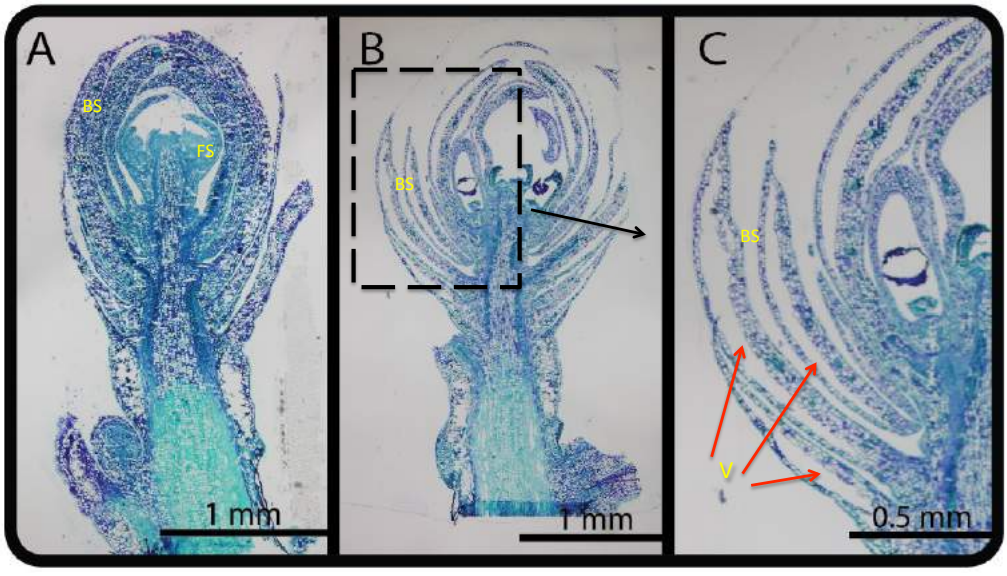

Figure 2. Histological work looking at flower primordial (FP) development during pre-harvest (A) and early spring (B and C) revealed the presence of voids (V) in the bud scales (BS) during early spring after ice-off (B and C), which likely formed by the presence of ice during freezing conditions, compared to buds collected during early fall (A) where the bud scales do not present any voids.

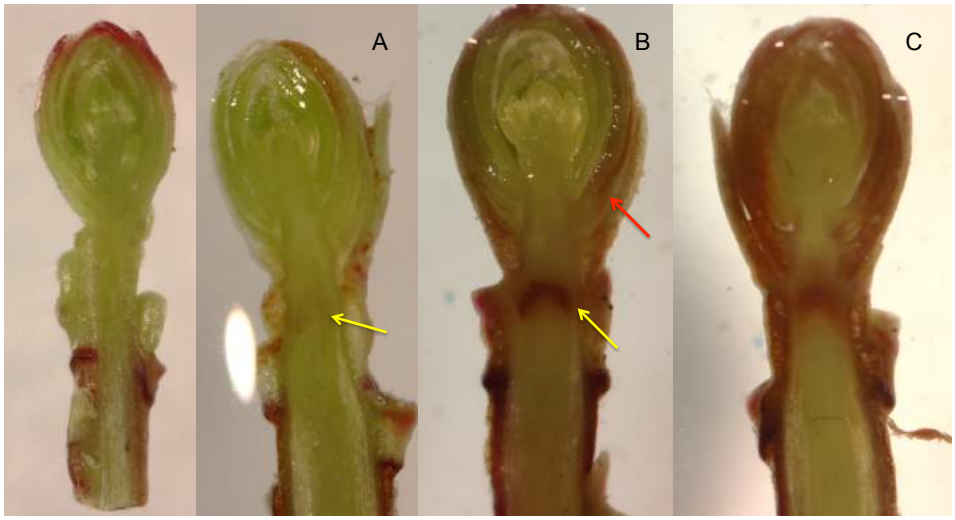

Figure 3. Cranberry buds sampled from the field September 7, 2017 and submitted to a controlled freezing test with temperatures ranging from 25 to -4°F. Picture A illustrates damage in the bud axis (yellow arrow). Picture B illustrates a higher intensity of damage in the bud axis and initial damage to the base of the bud scales (red arrow). Picture C illustrates the level of damage observed at the lowest temperature tested (-4°F) with most of the bud structures showing significant damage, however the center of the bud, containing the flower and vegetative meristems, is still green.

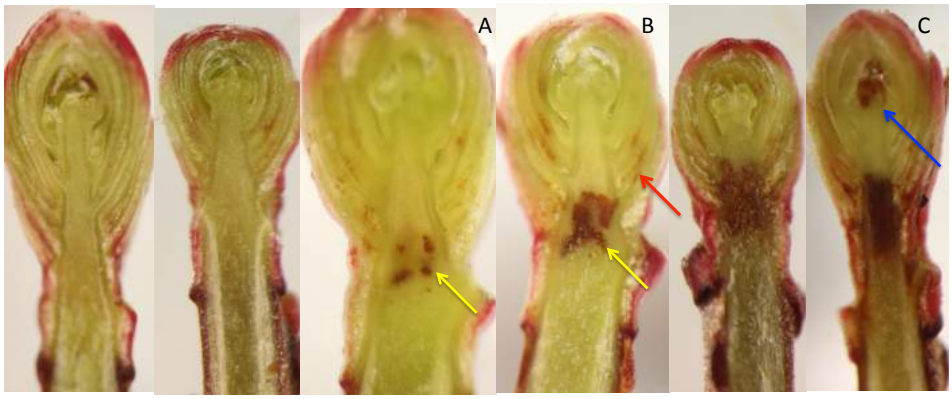

Figure 4. Cranberry buds sampled from the field December 27, 2017 and submitted to a controlled freezing test with temperatures ranging from 14 to -40°F. Picture A illustrates damage in the bud axis (yellow arrow). Picture B illustrates higher intensity of damage in bud axis (yellow arrow) and initial damage to the base of the bud scales (red arrow). Picture C illustrates the level of damage observed at the lowest temperature tested (-40°F), showing part of the vegetative meristem damaged (blue arrow).

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BENEFITS OF BATS: HOW TO ENCOURAGE INSECT-EATERS

HEATHER KAARAKKA

Wisconsin Department of Natural Resources, Wisconsin Bat Program

With over 1,300 species of bat found worldwide, bats are the second most diverse group of mammals after rodents. Bats have a wide variety of diets, and are important pollinators and seed dispersers of many of the foods we eat every day (Kunz, 2011). Many bat species are insectivores and act as pest control not only for human pests but agricultural and forestry pests as well. Bats are the primary predators of night-flying insects, and a single little brown bat can eat 600-1,000 insects in one hour. Pregnant and nursing females can consume their body weight in insects nightly to maintain their fast metabolisms.

Bats in Wisconsin have two different methods for dealing with winter when cold temperatures and absence of prey prevent them from foraging. Wisconsin has eight species of bats- four species are migratory and the other four species are hibernating bats. Hibernating bats use caves and mines in Wisconsin from September through April. All of Wisconsin's bats mate in the fall either during migration or at hibernation sites, and the female delays fertilization until spring when she emerges.

Bats need safe places to rest, give birth, and raise their young in summer. These important places are called roosts, and where bats roost depends on the species. Two bats in Wisconsin, the little brown bat and big brown bat, prefer to roost in bat houses, barns and other buildings. Most of the other species are found roosting in trees in the foliage or in cracks and crevices. The summer landscape is also where bats are foraging and where their ecological and economic benefits are revealed.

Bats have been shown to eat several insect pests including cutworms, cucumber beetles and leafhoppers (Whitaker 1995). One study investigated the economic impacts of bats to agriculture and estimated bats could be saving Wisconsin farmers alone $658 million annually, and $4 billion annually at the national scale (Boyles et al 2011). In addition to removing pests from the landscape and preventing crop damage, another study looked at impacts of excluding bats from corn crops and discovered it had a cascading effect where the corn had increased secondary infections from fungus at sites where bats were prevented from foraging (Maine and Boyles 2015).

We're learning about bat diet in Wisconsin through a multi-year study conducted at UW-Madison in Dr. Zach Peery's lab. Lead researcher Amy Wray collects guano samples from little brown bat and big brown bat colonies and uses molecular genetic analysis to identify prey items of bats even down to species. Traditional methods of analysis of bat diet through microscopy to identify prey remains in guano are generally unable to identify to the species level, and may be biased towards hard-bodied insects whose parts are undigested. Molecular

approaches allow for a more detailed look at bat diet. The bat diet project began in 2014, and some preliminary results show bats are eating a wide range of insects. Little brown bats are foraging on many different species of flies and moths while big brown bats eat different beetles. Note that molecular DNA analysis methods cannot identify abundance of insects consumed. The results are revealing only presence in diet in the form of original taxonomic units. From these preliminary results, I pose that possible cranberry pests bats may be consuming could include moths such as tip worms, fruitworms and fireworms, as well as cranberry flea beetle. To my knowledge, no research has been completed on bat activity at cranberry farms, so much remains to be learned about possible impacts bats may have on the crop.

A common method for surveying for bats is through acoustic detection. Bats echolocate in ultrasound when navigating and foraging. Humans are unable to hear bats naturally, but ultrasound detectors can record and play back bat echolocation. Most bat species have distinct calls and bats species can be distinguished by sonogram.

In 2017, I was fortunate to get in touch with Brian Potter and Dani Faber of Cutler Cranberry Farm who initially had questions about building bat houses and condos. I became interested in what kind of relationship bats may have with cranberry bogs, especially since cranberry is a major crop in the state and no one has investigated whether bat diet may include cranberry pests. I visited Cutler in June to see their new bat houses and placed several acoustic detectors for a night and collect some guano for analysis.

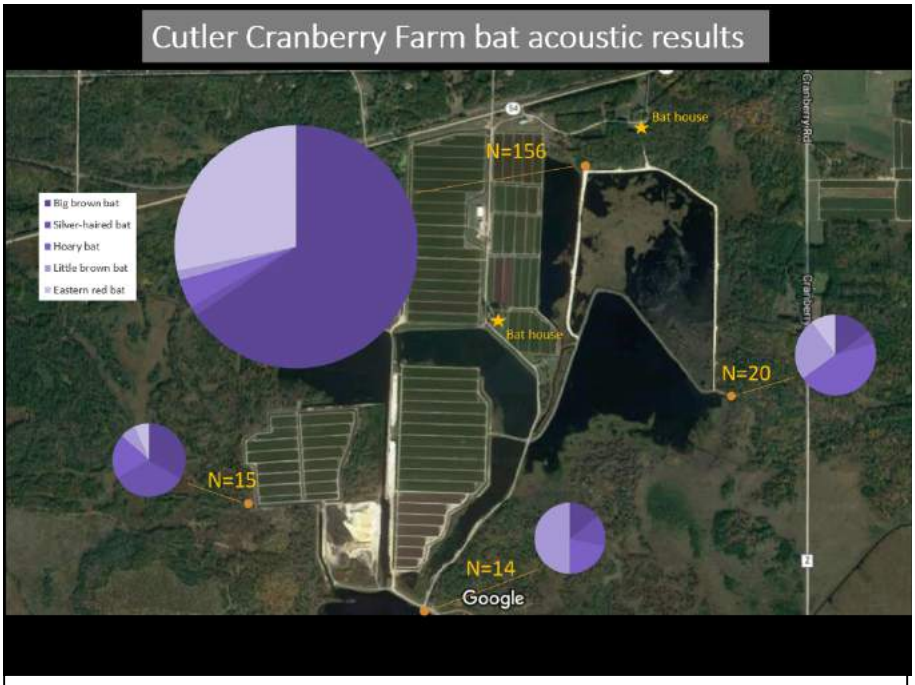

Figure 1. Acoustic results from Cutler Cranberry Farm from one night in June 2017. Size of chart indicates how many bat calls were recorded and color indicates different species.

Cutler has two locations around the farm where little brown bats are roosting in bat houses. To investigate bat activity on the farm, I placed four acoustic detectors around the farm for one night and recorded bat activity continuously. Bats are highly associated with water, so I placed detectors in areas near open water to get a snapshot of species and relative abundance of bats using the farm.

Figure 1 displays results from the detectors. There was a lot of activity from big brown bats and eastern red bats from the north detector, and the most common species recorded varied by location. The southern three detectors only recorded between 14 and 20 calls, which may seem like low bat activity and there are a couple reasons for this. The first is that only about half the calls from detectors can be identified to species because of noise and incomplete calls. The second reason for low bat activity is because of a bat diseased called white-nose syndrome that is decimating bat populations across North America.

White-nose syndrome (WNS) is a disease of hibernating bats and is caused by the fungus *Pseudogymnoascus destructans* that was first discovered in New York in 2006. White-nose syndrome causes mass mortality in infected sites and it is not uncommon to see declines of 80-100%. Wisconsin has four species of hibernating bats that are susceptible to the disease including the two that roost in bat houses and buildings. White-nose syndrome was first discovered in Wisconsin in 2014, and within three years, the majority of the state's hibernation sites were infected. In the east where WNS has been for 10 years, biologists are starting to identify survivors but in much lower numbers.

It is likely too late to prevent impacts of WNS in Wisconsin, but there may be opportunities to aid recovering bat populations. In summer bats need safe, warm locations to rest, give birth and raise their young. Recovering bats will still require these locations, and anyone can help bats by providing roosts in the form of bat houses. Research on bat houses has shown bats in our area prefer roosts that are close to water, about 10-15 feet in the air on a pole or the side of a building facing south or east. Place bat houses so they will get at least 6 hours of sun per day. You can learn more about building and placing bat houses online: dnr.wi.gov, keyword <bats>.

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USING BIG DATA AND MACHINE LEARNING TO OPTIMIZE CRANBERRY PRODUCTION AND ECONOMIC RETURNS

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Cranberry yield and quality vary significantly within a season among production beds, marshes and geographic locations. Additionally, production is inconsistent among years. In anecdotal observation, the variability in cranberry yield is much greater than in many other crops. Why do some beds produce 200 barrels/a while nearby beds or marshes produce over 700 barrels/a in the same growing season and with the same variety? Consistent, high-quality berry production would aid individual growers in terms of long-term planning and the industry relative to crop forecasting and utilization. Previous research efforts have focused on individual parameters, such as fertilizer quantity or herbicide choice, yet it is commonly accepted that production levels are a result of a multitude of factors.

Consistent cranberry production is challenged by several multi-variable issues that are often lumped in the general category of a "stressed" crop. Multi-variable issues require a systems approach with robust data to lead to confidence in the solutions. Additionally, an economic component can be included to help determine which parts of consistent yield are financially reasonable to address and which can't be solved (such as soil type), thus eliminating spending on inputs that don't add yield or quality.

Using a "big data" approach, we can determine the relationship among crop production parameters and berry yield and quality. The more data that is included, the more certain we can become about those relationships. We conducted a pilot project with Wisconsin cranberry growers using 2016 production year data (November 1, 2015 through October 31, 2016). Growers were engaged in developing the list of inputs where data collection was anticipated to affect berry yield and quality and in providing pilot data for initial analysis. Sixteen pilot growers entered intensive data from over 500 cranberry beds. Forty-one variables were included that fall broadly in 6 categories: broad production characteristics (such as soil pH), water management, pest management, fertility management and tissue tests, pollinator management, and cultural practices. The relationship among these characteristics and cranberry yield and quality (brix, color, firmness, fruit size, useable fruit and rot) are currently being explored.

In *preliminary* analysis, drivers of berry yield and quality were identified that were not anticipated but could be implemented with low front-end expense, such as reducing pre- and post-season irrigation and flood events that result in saturated soil that reduces vine productivity. Additionally, we found that splitting fertilizer use among several applications not only optimized yield but would reduce the environmental risk associated with nutrient runoff from amounts applied in excess of what the crop can use at one time. Each additional split-

fertilizer application (maintaining the same total seasonal amount) added 6.8 barrels per acre in the test study, but each additional pound of nitrogen added over the entire growing season only added 0.15 barrels per acre of berries (the average seasonal nitrogen was 42 pounds per acre). Some cultural practices that are unique to cranberry production, such as applying sand to stimulate new vine growth, were important to optimal yield. In the pilot test, growers lost 5 barrels per acre for each year that passed from the last sanding event. Others, such as the number of honeybee hives per acre, did not have a significant effect on production and represent areas where financial resources can be conserved, particularly given some recent challenges in renting and acquiring bees. Keep in mind this preliminary analysis was based on pilot data only - with the addition of more data, the machine learning described below and economic analyses we'll be able to strengthen this information greatly.

Next steps: We've submitted a Multi-State Specialty Crop Block Grant proposal with partners in Massachusetts and New Jersey to build upon the preliminary work. The primary objective for this project is to identify the economic "sweet spot" for practices that increase grower returns. We will use innovative "big data" analytics and machine learning to move precision agriculture from a *decision-support* tool to a *decision-making* system. In the current form, "big data" are used to describe what has happened, but the addition of machine learning, which approximates the underlying complex relationship between inputs and outputs, will add the critical prong of predictive ability. Neither a robust grower data set nor the novel analytics have impact unless the results are made available to growers in useful ways. We will create an online simulated bog interface (SimBog), similar to that used in gaming, which will allow growers to change inputs, weather, and marsh/bog characteristics to project yield and net return. In essence, growers will be able to "farm online" before making changes on their own farms, reducing risk by implementing data-driven changes.

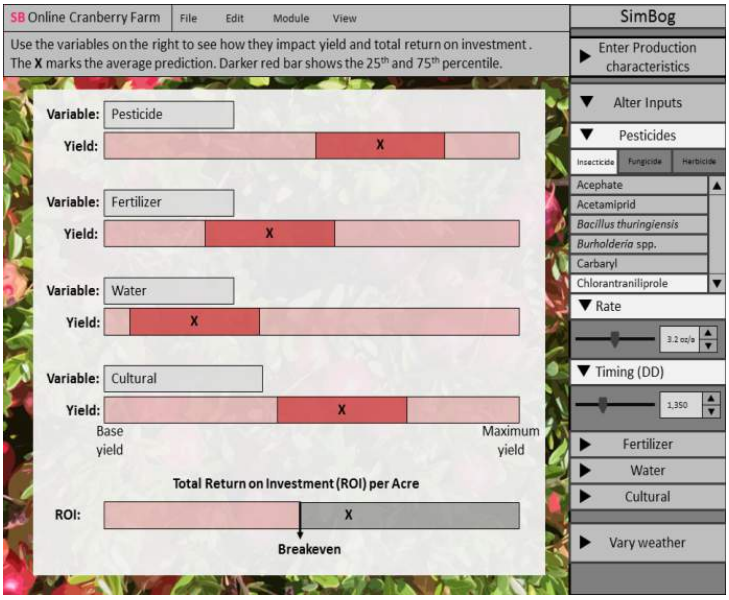

Figure 1. A simplistic schematic of SimBog - a user-friendly interface for growers to test different production scenarios and their impact on berry yield, quality and economic return on investment.

CRANBERRY PESTICIDES – REVIEW OF 2017 FIELD TRIALS

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Fungicides & Diseases

2017 Diseases Status - disease pressure was generally light across the Wisconsin cranberry productions area.

- Proline and Abound + Indar are the industry standards
- 2017 field trials - 8 Locations: 3 trials for fruit rot, 3 trials for early rot, 2 trials for cottonball.
- Proline, Abound + Indar, Abound, Evito, Quilt Xcel and Bravo provided good control of both fruit rot and early rot.
- Tilt/Orbit, Proline, Abound + Indar, Indar, Quilt Xcel and Evito provided good control of cottonball
- Although Regalia and Tavano/Oso generally suppressed fruit rots and cottonball when compared to the untreated checks, they did not perform as well as the top tier of fungicides. They are approved for organic cranberry production.

New Fungicides for 2017

Quilt Xcel 2.2L is a Syngenta package mix of Abound & Tilt/Orbit; tested at 21 oz/acre; has provided good control of fruit rots and cottonball in 2016 and 2017 research trials.

Kenja 3.3SC is a Summit Agro USA product; tested at 15.5 oz/acre; did not provide acceptable control of fruit rots or cottonball

Reducing the Number of Fungicide Applications: To reduce production costs there has been an interest in reducing the number of or eliminating all fungicide applications. Two applications of fungicides/season have been the standard recommendation. To investigate, in 2016 and 2017, 2 applications vs 1 application vs 0 applications of each Bravo, Abound + Indar, Proline and Regalia were tested. Four fruit rot trials each with heavy disease pressure in 2016 and four in 2017 with moderate disease pressure were conducted. In these trials, two applications of Bravo, Proline, Abound + Indar provide good disease control; a single application of these products provided marginally adequate disease control. Two applications of Regalia provided limited suppressed fruit rot; a single application of Regalia was inadequate. The recommendation for best control is for two applications. Two applications allow for some latitude in timing and cover extended infection periods. One application is risky and precise timing of the application is critical. No fungicide application is not recommended.

Factors Influencing Disease Severity Three decision factors may be considered in determining the need for the number of fungicide applications for a season: 1) if April and/or May are frequently wet from precipitation and/or frost protection irrigation there may be an increased potential for diseases 2) if April and May are warm there may be an increased potential for diseases and 3) if the bed has a chronic history of disease.

Rotation of Fungicides Should we rotate fungicides within a season or in alternating seasons? From a prevention of diseases developing resistance to a given fungicide standpoint this is a sound concept and worthy of considering. There is little evidence that rotation enhances the efficacies of products.

Insecticides and Bugs

2017 Insect Review - Insect pressure in 2017 was generally light. Fruitworms were present and required control measures. Registered products performed as expected. Fireworms were isolated problems. Tipworms were scarce. Flea beetles were a major problem. Altacor continues to be the primary insecticide of choice. Control of late season flea beetles is a challenge as control measures may be required relatively close to harvest - this precludes the use of several efficacious products that have longer pre-harvest intervals.

In 2017, trials were conducted to evaluate registered and candidate insecticides for control of tipworms, fruitworms, fireworms, spanworms, flea beetles and leafhoppers.

Insecticides evaluated in the 2017 trials were Altacor, Assail, Delegate, Diazinon AG600, Imidan, Intrepid, Confirm, Lorsban, Rimon, Cormoran, Venerate, Grandevo, and 5 experimental insecticides. The table below shows the cumulative performances of these insecticides of various target insect pests.

New Insecticide

Cormoran 1.5 SC is a package mix of Rimon (novaluron) and Assail (acetamiprid) from ADAMA. The cranberry use rate is 12 fl.oz./acre and the label impressively lists 22 insect pests as controlled. This product has provided good control of most of our cranberry insect pests, except tipworms, in research trials.

Candidate Products: Five candidate insecticides were evaluated in 2017. Four had good activity on several of our Wisconsin insect pests. Three of these are in-progress for registration.

Flea Beetles Flea beetles are relatively easy to control although some products are limited in use due to PHI constraints. For best control, multiple insecticide applications may be required. Insecticides that effectively control flea beetles and are registered for use on cranberries are Actara, Assail, Belay, Lorsban, Cormoran, Diazinon, Imidan, Altacor, Sevin, Orthene, and Delegate.

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
Closer	-	+	+	+	+	+	++	x
Confirm	--	+++	+++	+++	++	--	--	--
Movento	+++	--	--	--	--	--	--	--
Delegate	+	+++	+++	+++	++	--	--	xx
Diazinon	+	+	+	++	+	+++	+++	xxx
Grandevo	--	++	++	+++	++	--	--	--
Imidan	--	+	+	+	+	+++	+++	xxx
Intrepid	--	+++	+++	+++	+++	--	--	--
Lorsban	+	+	+	+	+	+++	+++	xxx
Rimon	+	++	++	+++	+	+	-	x

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

Weeds & Herbicides

The objectives of 2017 herbicide trials were 1) to seek control for weeds that are escaping our current herbicide programs and 2) to integrate pre-mergent and post-emergent herbicides.

***Escapes*.** Weeds that are currently not being controlled by our herbicides programs are maples, willows, popples, oaks, dewberry, northern St Johnswort, leatherleaf, poison ivy and mosses. Callisto will often controlled willows, popples, and oaks. The key to successful control was to not wait until late season for application. Early season applications were most effective. Callisto temporarily injured maples but did not kill them. Glyphosate worked well but the kill is slow. For the control of maples and leatherleaf, a three-way wiper mix of glyphosate + 2,4-D + a silicone surfactant at 1% v/v worked well. Caution: Not all glyphosate products allow the use of a surfactant. Be sure to read the labels and select a product that does not restrict the use of a surfactant.

Our research on sphagnum moss focused on CuSO4, with the following observations:

1) We investigated CuSO4 (98%) at 15 lb/acre in 40 gal/acre of finished spray.
2) CuSO4 applied to actively growing cranberries can be phytotoxic to cranberries so dormant applications were preferred.

3) Fall dormant applications did not work nearly as well as spring dormant applications.
4) This was not a one-shot cure. Dense moss may require several applications over a period of several years to keep knocking it back.
5) Bed flooding over the CuSO4 was detrimental to effectiveness.

New Herbicides. There are few new herbicides being brought into the market, although this is beginning to change as glyphosate-resistant weeds become common in GMO agronomic crops like corn and soybean. There are three candidate products pending cranberry registrations.

Generic Callisto. In 2017, five generic formulations of Callisto (mesotrione) were available. Those were Bellum (Rotam North America), Explorer (Syngenta), Incinerate (Winfield Solutions), Sotrion (Growmark) and Mesotrione 4SC (Willowood). In field trials there have not been significant differences between the generic products and Callisto or among the generic products.

Callisto – 2 Applications/Season. Callisto is currently limited to two applications regardless of rate as long as each application does not exceed 8 oz. Despite an appeal to increase the number of permitted applications/season but not the total active ingredient in a season, registrants have denied this request.

Future for Cranberry Pesticides

Currently there are three potential new insecticides, three potential new herbicides and three potential new fungicides in the registration process.

Some products in our pesticide arsenal have challenges to their registration:

Bravo	Export residues; reprieved for now
Evito	Export residues
Proline	Export residues
QuinStar	Export residues
Belay	Threat to bees; cancelled
Assail	Threat to bees
Lorsban / OP Insecticides	Threat to the environment; Export residues

Always remember to: 1) Read the pesticide label and 2) Check with the processor for approval to use.

2018 CRANBERRY SCHOOL GROWER SURVEY RESULTS

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Results of the live survey of growers present in the room at the 2018 Cranberry School are presented below. 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. Thank you for participating!

1) At what plant stage do you apply the first doses of fertilizer for the season?

	Responses	
	Count	**Percent**
Bud before break	9	15.5%
Rough neck	27	3.5%
Full Bloom	13	20.7%
After Fruit set	4	44.8%
Pea size fruit	5	20.7%
Totals	58	100%

2) Did you apply nitrogen fertilizer after harvest?

	Responses	
	Count	**Percent**
Yes, about 10% of the total N units in a year	1	1.7%
Yes, about 20% of the total N units in a year	0	0.0%
No	57	98.3%
Totals	58	100%

3) In 2017, fruit size was:

	Responses	
	Count	**Percent**
Smaller than average	38	64.4%
Similar to previous years	18	30.5%
Bigger than average	3	5.1%
Totals	59	100%

4) Did you fertilize more to increase fruit size?

	Responses	
	Count	**Percent**
Yes	17	28.8%
No	42	71.2%
Totals	59	100%

5) If you answered "Yes" in the previous question, did you fertilize with:

	Responses	
	Count	**Percent**
N	4	17.4%
K	4	17.4%
N+P+K	15	65.2%
Totals	23	100%

6) Did extra fertilizer increase fruit size?

	Responses	
	Count	**Percent**
Yes	4	13.3%
No	7	23.3%
I don't know	19	63.3%
Totals	30	100%

7) Would you repeat this practice?

	Responses	
	Count	**Percent**
Yes	19	70.4%
No	8	29.6%
Totals	27	100%

8) Did you irrigate your vines after harvest?

	Responses	
	Count	**Percent**
A. Yes, by raising the water table	32	56.1%
B. Yes, I irrigate with the sprinkler system	0	0.0%
C. A and B	2	3.5%
D. No	23	40.4%
Totals	57	100%

9) Before making ice, I flooded for winter protection:

	Responses	
	Count	**Percent**
1-2 times	28	49.1%
3-4 times	3	5.3%
I did not flood	26	45.6%
Totals	57	100%

10) I decide to make ice when temperature drops below:

	Responses	
	Count	**Percent**
20°F	4	7.0%
15°F	5	8.8%
10°F	13	22.8%
<10°F	35	61.4%
Totals	57	100%

11) Have you used the fungicide Proline (prothioconazole)?

	Responses	
	Count	**Percent**
Yes, good results	29	52.7%
Yes, fair to poor results	6	10.9%
No, I have not used it.	20	36.4%
Totals	55	100%

12) Do you use fungicides on new plantings to prevent leaf drop from early rot and establishment of other fruit rot pathogens?

	Responses	
	Count	**Percent**
Yes, always	23	41.8%
Yes, but only on certain varieties	15	27.3%
No	17	30.9%
Totals	55	100%

13) Do you cut back on fungicides after the bed fills in?

	Responses	
	Count	**Percent**
Yes, we stop after 3-4 years	7	12.3%
Yes, we cut back after 3-4 years & are afraid to not spray at all	13	22.8%
No, we treat new & established beds the same	29	50.9%
We don't use fungicides	8	14.0%
Totals	57	100%

14) Have you seen crop injury (e.g. flower burning, red flecks on fruit) associated with use of chlorothalonil (Bravo, Echo, Equus)?

	Responses	
	Count	**Percent**
Yes, at least in some years	15	27.3%
We use it, but we do not see injury	16	29.1%
We don't use chlorothalonil	24	43.6%
Totals	55	100%

15) Are you confident that you can identify berry scarring associated with viruses?

	Responses	
	Count	**Percent**
Yes	23	39.0%
No	36	61.0%
Totals	59	100%

16) You've heard all about TSV and blueberry shock viruses. Have you had blueberry scorch virus confirmed in samples from your marsh?

	Responses	
	Count	**Percent**
Yes	0	0.0%
No, and we did have samples tested	7	12.5%
Had samples tested but can't remember results	2	3.6%
No, but we did not have samples tested	47	83.9%
Totals	56	100%

17) Do you use more than one class of fungicides to control fruit rot diseases?

	Responses	
	Count	**Percent**
Don't use fungicides	10	18.2%
We use different fungicides, but not sure if they are in different classes	10	18.2%
Yes, we use more than one class of fungicide	35	63.6%
Totals	55	100%

18) Do you know what FRAC and IRAC codes are on pesticide labels?

	Responses	
	Count	**Percent**
Yes	24	44.4%
No	30	55.6%
Totals	54	100%

Comment: FRAC stands for Fungicide Resistance Action Committee and IRAC for Insecticide Resistance Action Committee. These committees have developed codes that place fungicides and insecticides in groups of different chemical modes of action to help users recognize chemicals that belong to the same group. By rotating chemistries from different mode of action groups, users can help minimize pesticide resistance.

19) What do you use for cottonball control?

	Responses	
	Count	**Percent**
We don't treat for it	37	66.1%
Propiconazole (Orbit, Tilt, Propimax)	6	10.7%
Fenbuconazole (Indar)	2	3.6%
Prothioconazole (Proline)	2	3.6%
Azoxystrobin (Abound)	8	14.3%
Other	1	1.8%
Totals	56	100%

20) Do you have moss on your marsh?

	Responses	
	Count	**Percent**
Yes, but only on a few weeds	47	81.0%
Yes, extensively across the marsh	2	3.4%
No moss on my marsh!	9	15.5%
Totals	58	100%

21) Do you feel your weed pressure impacts cranberry yield?

	Responses	
	Count	**Percent**
No impact	18	29.5%
Yes, but 10% or less	34	55.7%
Yes, by 11-25%	8	13.1%
Yes, by greater than 25%	1	1.6%
Totals	61	100%

22) For your weed control program in 2017, did you:

	Responses	
	Count	**Percent**
Use pre-emergent herbicides only	5	8.2%
Use psot-emergent herbicides only	2	3.3%
Use pre- and post-emergent herbicides	54	88.5%
I didn't use any herbicides	0	0.0%
Totals	61	100%

23) Do you feel that having more relatively new herbicides, such as Callisto, impacted the amount of herbicide you use?

	Responses	
	Count	**Percent**
I use less herbicide now than in the past	23	38.3%
I use more herbicide now than in the past	9	15.0%
I'm not sure or it depends on the year	28	46.7%
Totals	60	100%

24) When considering surfactants with your pesticides:

	Responses	
	Count	**Percent**
I use the same surfactant product every year, if possible	27	46.6%
I use whatever the dealer delivers with the pesticide	18	31.0%
I'm not that concerned about which surfactant brand I use	13	22.4%
Totals	58	100%

25) Are you concerned about the development of herbicide-resistant weeds on your marsh?

	Responses	
	Count	**Percent**
Very concerned	19	31.1%
Somewhat concerned	39	63.9%
Not at all concerned	3	4.9%
Totals	61	100%

26) In 2017, did you use Weedar 64 as a wiper application?

	Responses	
	Count	**Percent**
Yes	18	30.0%
No	42	70.0%
Totals	60	100%

27) Do you still wick-wipe weeds with glyphosate?

	Responses	
	Count	**Percent**
Yes, every year	42	71.2%
Yes, but not every year	15	25.4%
No, we don’t' wick-wipe weeds	2	3.4%
Totals	59	100%

28) The Wisconsin Stinger 24c label expired on 12/31/2017 and a new label has been requested. IF it's approved, would you use Stinger?

	Responses	
	Count	**Percent**
Yes, definitely	24	39.3%
Maybe	30	49.2%
No	7	11.5%
Totals	61	100%

29) The most economically important insect pest on your marsh in 2017 was:

	Responses	
	Count	**Percent**
Sparganothis fruitworm	19	33.3%
Cranberry fruitworm	17	29.8%
Black-headed fireworm	5	8.8%
Red-headed flea beetle	13	22.8%
Cranberry girdler	0	0.0%
Tipworm	3	5.3%
Other pest species	0	0.0%
Totals	57	100%

30) The second most economically important insect pest on your marsh in 2017 was:

	Responses	
	Count	**Percent**
Sparganothis fruitworm	13	22.4%
Cranberry fruitworm	25	43.1%
Black-headed fireworm	6	10.3%
Red-headed flea beetle	7	12.1%
Cranberry girdler	0	0.0%
Tipworm	5	8.6%
Other pest species	2	3.4%
Totals	58	100%

31) Are degree days recorded at your marsh for insect control?

	Responses	
	Count	**Percent**
Yes	21	35.0%
No	29	48.3%
I don't know, ask my scout!	10	16.7%
Totals	60	100%

32) Which of the following best describe how you keep track of degree-days?

	Responses	
	Count	**Percent**
I keep a running total based on daily high and low temp at my own marsh	9	15.8%
I keep a running total based on daily high and low temp of a local weather station	7	12.3%
Using online resources from USDA Cranberry Entomology Lab	9	15.8%
I don't keep track of degree-days	30	52.6%
What are degree-days?	2	3.5%
Totals	57	100%

33) Would you be interested in using degree days for precisely timing your spray to improve insecticide efficacy?

	Responses	
	Count	**Percent**
Yes	45	75.0%
No	15	25.0%
Totals	60	100%

34) What was the main yield reducing pest of the 2017 crop?

	Responses	
	Count	**Percent**
Insects	19	35.2%
Disease/Rot	12	22.2%
Weeds	10	18.5%
More than one of the above	13	24.1%
Totals	54	100%

35) Was your crop in 2017:

	Responses	
	Count	**Percent**
Up from 2016	18	29.5%
Down from 2016	31	50.8%
Similar to 2016	12	19.7%
Totals	61	100%

36) In 2017, we reduced these inputs:

	Responses	
	Count	**Percent**
We didn't	37	59.7%
Number of bee hives	2	3.2%
Labor	5	8.1%
Fertilizer	6	9.7%
Herbicides	1	1.6%
Fungicides	0	0.0%
Insecticides	1	1.6%
More than one of the above	10	16.1%
Totals	62	100%

37) Was your insect pressure in 2017:

	Responses	
	Count	**Percent**
Up from 2016	6	9.5%
Down from 2016	22	34.9%
Similar to 2016	35	55.6%
Totals	63	100%

38) How many honey bee hives per acre did you bring in during 2017?

	Responses	
	Count	**Percent**
0	6	9.5%
1	4	6.3%
2	19	30.2%
3	22	34.9%
4-7	11	17.5%
8 or more	1	1.6%
Totals	63	100%

39) How many bumblebee colonies per acre did you bring in during 2017?

	Responses	
	Count	**Percent**
0	48	77.4%
1-2	11	17.7%
3-5	2	3.2%
6-8	1	1.6%
more than 8	0	0.0%
Totals	62	100%

40) How many insecticide sprays did you apply in the 2017 growing season?

	Responses	
	Count	**Percent**
0	0	0.0%
1-2	24	38.1%
3-4	33	52.4%
5-6	6	9.5%
more than 6	0	0.0%
Totals	63	100%

41) Was your number of insecticide sprays in 2017:

	Responses	
	Count	**Percent**
Up from 2016	4	6.3%
Down from 2016	14	21.9%
Same as 2016	46	71.9%
Totals	64	100%

42) How much did you spend in 2017 on insecticides per acre?

	Responses	
	Count	**Percent**
$0-40/acre	4	7.8%
$41-80/acre	15	29.4%
$81-120/acre	24	47.1%
$121-160/acre	7	13.7%
$161-200/acre	1	2.0%
Totals	51	100%

43) Would you consider changing your management practices to protect pollinators?

	Responses	
	Count	**Percent**
Yes	49	80.3%
No	12	19.7%
Totals	61	100%

44) In terms of pesticide use, would you consider reducing pesticide applications during bloom to protect pollinators?

	Responses	
	Count	**Percent**
Yes, I would consider reducing insecticide applications during bloom	14	22.2%
Yes, I would consider reducing fungicide applications during bloom	0	0.0%
Yes, I would consider reducing both types of applications during bloom	39	61.9%
I wouldn't consider reducing either type of applications during bloom	10	15.9%
Totals	63	100%

45) Are you considering planting a pollinator garden to attract wild pollinators on your marsh?

	Responses	
	Count	**Percent**
Yes	10	15.9%
No	25	39.7%
I already have one	15	23.8%
Waiting to get more info before implementing on my marsh	13	20.6%
Totals	63	100%

46) How many sprays were specifically for cranberry fruitworm in 2017?

	Responses	
	Count	**Percent**
0	8	12.7%
1	36	57.1%
2	15	23.8%
3	4	6.3%
4 or more	0	0.0%
Totals	63	100%

47) How many sprays were specifically for sparganothis fruitworm in 2017?

	Responses	
	Count	**Percent**
0	18	29.0%
1	26	41.9%
2	15	24.2%
3	2	3.2%
4 or more	1	1.6%
Totals	62	100%

48) How many sprays were specifically for tipworm in 2017?

	Responses	
	Count	**Percent**
0	52	85.2%
1	8	13.1%
2	1	1.6%
3	0	0.0%
4 or more	0	0.0%
Totals	61	100%

49) How many sprays did you apply specifically for flea beetle in 2017?

	Responses	
	Count	**Percent**
0	33	53.2%
1	16	25.8%
2	10	16.1%
3	2	3.2%
4 or more	1	1.6%
Totals	62	100.0%

50) Was the flea beetle population on your marsh in 2017:

	Responses	
	Count	**Percent**
Up from 2016	7	11.1%
Down from 2016	19	30.2%
Similar to 2016	37	58.7%
Totals	63	100%

51) Do you typically flood in spring (mid- to late-May) for insect control?

	Responses	
	Count	**Percent**
Yes	19	30.6%
No	43	69.4%
Totals	62	100%

52) Are you in favor of a viable, effective pheromone-based mating disruption system for cranberries?

	Responses	
	Count	**Percent**
Yes	43	69.4%
No	3	4.8%
I don't know	16	25.8%
Totals	62	100%

2017 ANNUAL REPORT

WISCONSIN STATE CRANBERRY GROWERS ASSOCIATION

WISCONSIN STATE CRANBERRY GROWERS

Association



ANNUAL MEETING

January 24, 2018

Agenda

1:00 PM Call to Order

Minutes from the 2017 Summer Meeting
- Steven Bartling, Secretary

Election of Directors
- Steven Bartling, Chair - Nominating Committee

Report of the President
- Tom Gardner

Report of the Executive Director
- Tom Lochner

Special Presentations:

WSCGA Public Policy Program Strategies, Tactics and Action
- Ron Kuehn, Legislative Counsel, DeWitt Ross and Stevens

WSCGA Communications Programs – Setting the Stage for a Positive Image for Cranberry Growing in Wisconsin
- Kathryn Whitlock, Laughlin Constable

Report of Committees

Other Business

2:30 PM Adjourn

WSCGA Summer Meeting Minutes – August 9, 2017

Warrens, WI

The 2017 Wisconsin State Cranberry Growers Association Summer Meeting was called to order by President Tom Gardner on Wednesday - August 9, 2017 at 1:30 PM at the Wisconsin Cranberry Discovery Center in Warrens, Wisconsin. Tom Gardner welcomed the growers in attendance, and thanked the host staff and WSCGA staff, including Tom Lochner, Alex Skawinski, Crystal Johnston, and Tod Planer for coordinating the Summer Field Day event, along with the WSCGA Education Committee members. A recognition plaque was then presented to Wisconsin Cranberry Discovery Center, Warrens Cranberry Festival, and Vern Gebhardt Cranberry Co., Inc. for hosting this year's Field Day event.

Royalty – Tom Gardner introduced the Cranberry Festival Royalty from Warrens, WI. Members introduced themselves and shared information about the upcoming Warrens CranFest. Members included:

- Princess Lindsay Murdock
- Princess Stevie Peterson
- Queen Mackenzie Meyers was unable to attend

Secretary's Report – Tom Gardner referred to the 2017 Winter Meeting Minutes printed on pages 50-51 in the Summer Field Day Meeting Program Book. Nodji Van Wychen moved and Tyler Walker seconded a motion to waive reading of the January 18, 2017 meeting minutes and to approve minutes as printed. Motion carried.

WSCGA Board Members – Tom Gardner introduced to the audience each member of the WSCGA Board of Directors, including:

- Tyler Walker, Vice President
- Steven Bartling, Secretary
- David Amundson
- Jenna Van Wychen
- Not Present:
- Rocky Biegel
- Nicole Hansen
- Mark Mahoney
- Karl Pippenger, Treasurer

Special Guests – Tom Gardner introduced special guests attending the event and in the audience, including:

- Aaron Brower, UW Extension Provost
- Mary Ann Lippert, Wisconsin Dept. of Administration
- Dan Baumann, Wisconsin DNR
- Senator Patrick Testin
- Dan Baumann, Wisconsin Dept. of Natural Resources
- Sara Guild, Congressman Duffy's office
- Jeff Lyon, Deputy Secretary- DATCP
- Charlene Felkley, USDA
- Juli Speck, DATCP

Marsh Recognition – Tom Gardner noted that each year at the Field Day event, the WSCGA recognizes milestone marsh anniversaries. President Gardner announced the 25th anniversary of Al-May Cranberry in Pittsville and the 75th anniversary Olson Bros. Cranberry Co. in Warrens. As none of the previous growers were in attendance, recognition plaques will be mailed to them.

Executive Director Report
President Gardner invited Tom Lochner to present his Executive Director's report to the members. Lochner thanked the event hosts, the WSCGA Board of Directors, and the WSCGA staff for event planning and support. He expressed his appreciation to the UW Extension faculty and the Education Committee for their leadership and participation in providing the mini-clinics. Lochner also thanked the WSCGA Associate Members who were exhibiting, the on-site vendors and Lions Club catering, the Associate Member Committee, the volunteers from the Tomah High School golf and show choir clubs, and the WSCGA Grower Members in attendance for their support.

Lochner then provided an update on the Wisconsin Cranberry Research Station, starting with a brief history of the Wisconsin Cranberry Research & Education Foundation and also a summary of activities to date for the research station. Lochner detailed research station progress including the launch of a Capitol Campaign in 2014, work with USDA ARS to secure funds, site selection and review, plans for research plots and buildings, and next steps. The Foundation plans to close on the sale of the property prior to the 2017 harvest and move forward with bed renovations, buildings, and research plots in 2018.

Wisconsin Cranberry Leadership Class IV Introduction
Amy Gebhardt gave a brief description of the leadership program and introduced the members of Class IV, including:

Jenna Dempze, Gaynor Cranberry
Vanessa Dubick, Broken Arrow Cranberries
Trevor Gardner, Gardner Cranberry
Tristan Gardner, Badger State Fruit Processing
Dan Hauke, Crimson Star Cranberry
Clayton Heuer, Leola Cranberry
Jesirae Heuer, Edward Jones (Leola Cranberry)
Zach Heuer, Turner Creek Cranberry
Dennis Irwin, Farmland Management Services
Sandy Nemitz, James Potter Cranberry
Wes Normington, Saddle Mound Cranberry
Seth Rice, Flying Dollar Cranberry
Katie Sawyer, Saratoga Cranberry
Amber Schultz, Russell Rezin & Son, Inc.
Dean Weir, Farmland Management Services

Old Business – None

New Business – None

Adjourn – There being no further business, Tom Gardner entertained a motion to adjourn. June Potter made a motion to adjourn the meeting. Steven Bartling seconded the motion. All were in favor and motion carried. The Summer Meeting was adjourned.

Announcements – WCREF Sporting Clay Shoot coming up on August 18, 2017
– WSCGA Winter Meeting, Trade Show and Cranberry School is January 24-25, 2018
– Future Summer Meetings:
2018- Russell Rezin and Sons Cranberry
2019- DuBay Cranberry
2020- Wisconsin Cranberry Research Station at Robinson Creek.

Respectfully submitted by Alex Skawinski
on behalf of Steven Bartling – WSCGA Secretary

From the President – Tom Gardner

Welcome to the 2018 Winter Meeting, Cranberry School, and Winter Trade Show. This is a great opportunity to talk and exchange ideas, get an update on what's happening in the industry, and also to see what's new and support our Associate Members.

A special thank you to the WSCGA staff, the Education Committee and the Board of Directors, along with all those that help to make this event successful. As we enter into a new year, we have an opportunity to look at our business and what we have been doing, what has been working well, and what needs improving. Also being able to share and learn from others in the industry.

We are in an ever changing industry and we have certainly been through some tough times as we look forward to better days ahead. The tough times make us who we are. The Association is living the mission of helping the cranberry industry by providing information and working to build and maintain relationships with everyone crucial to your success. We have spent time focusing on those relationships and working in all areas that would make us proactive to any issues going forward.

I am reminded of the old cliché that tough times don't last but tough people do. We thank you for your commitment, support and participation in the Association. Together we will all do better. Have a great meeting!

From the Executive Director – Tom Lochner

At the WSCGA, we take great pride in our efforts to develop and implement programs that benefit our members and the Wisconsin cranberry grower in general. Working with our voluntary leadership, staff, and our consultants, we always evaluate our efforts based upon the mission statement of the organization. Being successful requires us to be in tune with growers.

2017 has been a successful and exciting year for WSCGA.

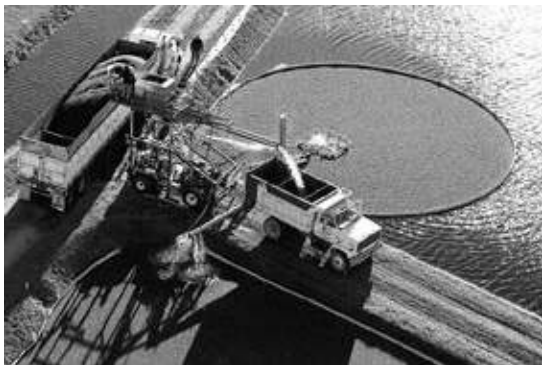
We were successful in the settlement of a lawsuit against the state of Wisconsin that would have required growers to be treated as point source dischargers and have to obtain permits like municipal and industrial waste water treatment facilities.

We were successful in completing a model floodplain ordinance that allows growers to continue to farm without obtaining additional permits while protecting the state's participation in the National Flood Insurance program.

We were successful in obtaining additional funding for research programs within the USDA ARS program on Campus including an additional position in plant physiology.

We were successful in working with the Wisconsin Cranberry Research and Education Foundation to finalize cooperative agreements with USDA ARS and complete the purchase of a farm to be developed into the Wisconsin Cranberry Research Station.

We were successful in conducting numerous grower education programs including a Cranberry Farm Safety Seminar, Early Season Workshops, the Wisconsin Cranberry School, Nutrient Management Training programs, updating the grower side of the WSCGA website, new videos and printed materials.



Our promotion program successfully implemented sampling at various events around the state, developing stories and promotions to encourage expanded use of cranberries and cranberry products by consumers.

Our Public Policy program continued its success of monitoring Federal and State rules and legislation to make sure that any impacts on growers would be positive. We supported public policies that would continue to promote the health of the industry in the state.

I could go on, but at the end of the day growers showed us their confidence on our success by supporting us in increasing numbers despite the difficult economic times.

As we look forward to 2018 and beyond we know we face challenges. We are working with the Wisconsin Cranberry Board, Inc. and the Wisconsin Cranberry Research and Education Foundation to map out a future plan to strategically address grower and industry needs. We will be asking you for your opinions and participation as we look out 3-5 years to make all of our organizations stronger and better able to serve you in the future.

WSCGA Annual Report

The Wisconsin State Cranberry Growers Association was formed in 1887 to serve the state's newly emerging cranberry industry. Some 130 years later, the organization continues to work to meet its mission of providing quality programs for members to enable the industry to prosper.

WSCGA is organized as a non-profit, non-stock corporation governed by a nine-member Board of Directors. The Board is advised by a number of committees and working groups on topics ranging from Public Policy to Promotion to Grower and Public Education. The Association employs professional staff and consultants. The Board, committees, staff and consultants work together as a team to develop and implement programs and policy for the organization.

The 2017 Annual Report highlights activities by the Association on behalf of its membership throughout the course of the year. These successes are due to the hard work of the grower and associate members who volunteer their time and talent to work with the Association's professional staff and contractors to advance the mission of the organization. We hope all growers and members of the industry will thank those who continue to work on their behalf and to join the WSCGA in these efforts.

THE TEAM – WSCGA Board of Directors 2017

Tom Gardner – President
Tom is part of Gardner Cranberry and Hay Creek Cranberry located near Pittsville. Tom joined the Board in 2012. He serves on the Public Policy and Environmental Affairs Committee, and the Personnel Committee.

Tyler Walker – Vice President
Tyler works with his family at Walker Cranberry Company in the town of Cranmoor, west of Wisconsin Rapids. He was elected to the Board in 2011. He serves on the Public Policy and Environmental Affairs Committee, and the Personnel Committee.

Karl Pippenger - Treasurer
Karl is part of the team at Cranberry Lake Cranberries in Phillips and owns and operates his own small cranberry marsh, “Pip’s Cranberries”. He participated in the 2013-14 Wisconsin Cranberry Leadership Development Program. He joined the Board in 2015, is the chair of the Administration Committee, and serves on the Nominating Committee.

Steven Bartling, Secretary
Steven and his family own and operate Bartling’s Manitowish Cranberry in Manitowish Waters. Steven serves as chair of the Nominating Committee and is a member of the Education Committee, Information Technology Subcommittee, and Research Committee. He participated in the WCREF Cranberry Leadership Development Program in 2012-13. He was elected to the Board in 2016.

David Amundson
David’s family operations, Wisconsin Moss Company and Amundson Cranberry, are located outside of Babcock where he farms with his wife, Jill. David was elected to the Board in 2009, served as Vice President in 2011, and as President in 2012-13.

Rocky Biegel
Rocky Biegel is part of Dempze Cranberry Co. and King Cranberries LLC. He joined the Board in 2017 and serves on the Nominating Committee.

Nicole Hansen
Nicole is part of Cranberry Creek Cranberries in Juneau County. She was elected to the WSCGA Board in 2009. She served as Vice President in 2010. She chairs the Research Committee, serves on the Education Committee and Nominating Committee, and represents the cranberry industry on the Board of Directors of the National Institute for Sustainable Agriculture. In 2013, Governor Walker appointed her to a seat on the citizen’s Board that oversees the Wisconsin Department of Agriculture, Trade and Consumer Protection.

Mark Mahoney
Mark joined the Board in 2011 and is part owner of Owen Rock Cranberries in Adams County, which served as the host site for the 2012 Summer Meeting, Field Day and Trade Show. He serves on the Public Policy and Environmental Affairs Committee, Personnel Committee, and Research Committee. He served as President in 2013 through 2016.

Jenna Van Wychen
Jenna joined the Board in 2017 and is part of Van Kow Cranberries and Wetherby Cranberry in Monroe County. She participated in the 2013-14 Wisconsin Cranberry Leadership Development Program.



WSCGA Committees

Public Policy and Environmental Affairs Committee

The committee is responsible for the development of recommendations on policy related to environmental issues as well as other state and federal regulatory and legislative actions that arise as part of the public policy advocacy program. The committee also makes recommendation on disbursements from the restricted account for water and wetlands.

WSCGA Public Policy and Environmental Affairs Members:

Bill Hatch - Chair	Greg Knorr	Russ Rifleman
Mike Bartling	Leroy Kummer	Gary Roberts
Tom Gardner	Mark Mahoney	Scott Schultz
Bryan Heuer	Fran Podvin	Craige P. Scott
Gary Jensen	Fred Prehn	Ryan Walker
Randy Jonjak	Dan Rayala	Tyler Walker
Bill Klouda	Andy Reitz	Luke Weiland

Administration Committee

The committee advises the WSCGA Board on the internal operations of the association. Its major responsibility is development of a recommendation for an annual budget for the WSCGA.

Administration Committee Members:

Karl Pippenger - Chair	Mike Moss	Scott Schultz
Bob Duckart	Fran Podvin	John Stauner
Bill Hatch	Russ Rifleman	

Education Committee

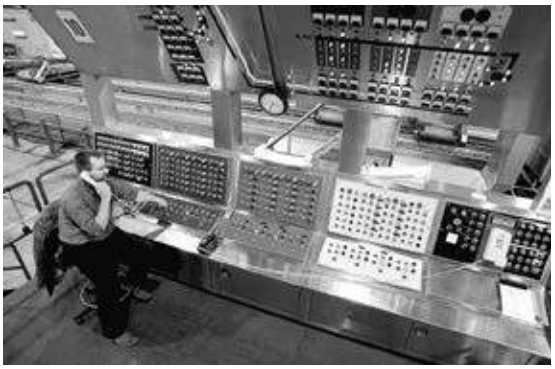
The main emphasis of the WSCGA mission is education, both of growers and the general public on cranberry growing. A large portion of this responsibility is assigned to the Education Committee, making it one of the key committees in the association. The committee meets with UW Extension faculty and others during the year to review and plan the various education programs for the association including the Wisconsin Cranberry School, early season workshops and the Summer Meeting and Field Day.

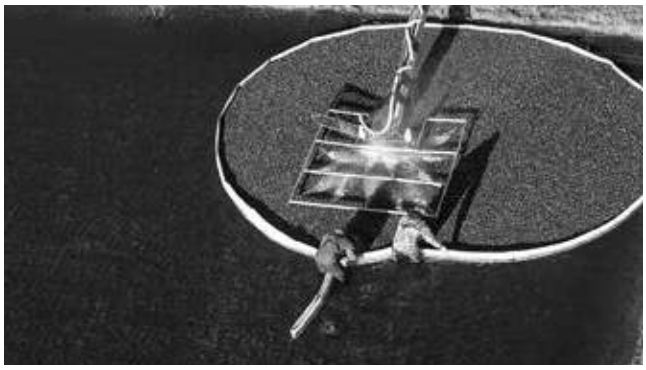
WSCGA Education Committee Members:

Christelle Guédot – Chair	Jason Hatch	Ben Tilberg
Steven Bartling	Matt Lippert	Nodji Van Wychen
Jim Bielmeier	John Moss	Pam Verhulst
Dani Faber	Andy Reitz	Lindsay Wells-Hansen
Steve Hahn	Jayne Sojka	
Nicole Hansen	Russ Sawyer	

Public Relations Committee

The committee is responsible for developing and implementing communication and promotion projects to generate a positive image of the industry in the state. That responsibility includes working with the media to tell the industry's story and working with other groups to help promote the state's largest fruit crop.





WSCGA Public Relations Committee Members:

Nodji Van Wychen – Chair	Fawn Gottschalk	Doug Rifleman
Robert Detlefsen	Edward A. Grygleski	Scott Schultz
Dani Faber	Leroy Kummer	Mary Smedbron
Amy Gebhardt	Gabriella Liddane	Bill Wolfe
Mike Gnewikow	Jessica Rezin	

Research Committee

The Board of Directors established the committee to provide growers with a forum to discuss research needs with University of Wisconsin research faculty and the cranberry research community on a national basis. The committee works cooperatively with the Wisconsin Cranberry Board, Inc. (WCB), The Cranberry Institute (CI), and others to identify grower research needs, coordinate projects to avoid duplication and to help establish priorities.

WSCGA Research Committee Members:

Nicole Hansen – Chair	Fawn Gottschalk	Russ Sawyer
Suzanne Arendt	Edward A. Grygleski	Scott Schultz
Steven Bartling	Jeff Habelman	Jayne Sojka
Stephen Brown	Gabriella Liddane	Ben Tilberg
Robert Detlefsen	Mark Mahoney	Pam Verhulst
Tim Dittl	John Moss	Andy Walker
Danielle Faber	Doug Rifleman	Lindsay Wells-Hansen
Mike Gnewikow	Ben Ryner	Bill Wolfe

Information Technology Subcommittee

This year the Board named a subcommittee of the Education Committee to work on redesign of the WSCGA Grower website and to analyze the best available technologies to provide growers with needed information. The group is utilizing a $39,500 Specialty Crop Block Grant from Wisconsin DATCP to create new tools for growers, crop consultants and researchers to use in the field.

WSCGA Information Technology Subcommittee Members:

John Moss, Chair	Dani Faber	Ben Tilberg
Steven Bartling	Russ Sawyer	Pamela Verhulst

Associate Member Committee

The Associate Member Committee provides input on topics including Associate Membership benefits, Summer & Winter Trade Shows, WSCGA NEWS advertising, Program Book & Buyers Guide publication advertising, sponsorships and member surveys. Committee members are polled for input on topics related to membership related topics and inquiries. The group meets prior to the Summer Meeting & Trade Show for an on-site visit and event planning.

WSCGA Associate Member Committee Members:

Tom Altmann	Casey Koback	Nicki Ryner
Amy Boson	Paul Roberts	Jay Weidman
Derek Johnson	Dawn Ruiter	

WSCGA Staff

Tom Lochner, Executive Director

Tom Lochner was named the first WSCGA Executive Director in 1988. Since then, the association has grown into a well-respected voice for the Wisconsin cranberry grower. The association expanded its education, communications and public policy programs. It took on the responsibility of providing administrative services to the Wisconsin Cranberry Board, Inc. to enable it to implement its research, education and promotion programs in a cost efficient manner. In 2004 the WSCGA also assisted the Cranberry Museum, Inc. develop and operate the Wisconsin Cranberry Discovery Center in the Village of Warrens. Most recently WSCGA has provided administrative services to the Wisconsin Cranberry Research and Education Foundation for its effort to establish a research station for cranberries in Wisconsin.

As the chief staff person, Tom serves as chief spokesman for the organization and represents WSCGA in interactions with University Research and Extension faculty and administration, as well as with Federal, State and local governmental organizations. He is also responsible for coordinating the activities of staff and various consultants who assist with communications and public policy programs. He serves as a liaison with industry groups, such as the Cranberry Institute and the USDA Cranberry Marketing Committee.

Over the course of his career, Tom has worked with the Board and committees on growing the programs and membership of the association. He believes in a team approach to program planning and development. This approach has resulted in active committees, an engaged and high performing Board, and high grower participation in WSCGA programs.

Alex Skawinski

Alex Skawinski joined WSCGA in December 2015. As the Administrative Assistant, she is responsible for keeping the office in Wisconsin Rapids up and running smoothly. Her responsibilities include the Associate Member programs, the Associate Member Committee, and working with the WCREF Development Fund Committee to plan and hold the annual Cranberry Open Golf Outing and the Sporting Clay Shoot.

She also manages the annual Trade Shows for WSCGA, which are premier events in the industry. For the Winter Trade Show, she coordinates exhibit space registrations, including online booth registration, as well as sponsorships and booth upgrades. At the Summer Trade Show, participation is also high on the part of exhibitors.

Alex works with Crystal Johnston on the Cranberry School registration, coordinating the publication of the WSCGA NEWS, and keeping the WSCGA website up-to-date and fresh with event information and resources. Alex has taken on responsibilities for conducting grower safety seminars and the redesign and upgrade to the Wiscran.org website.

Crystal Johnston

Cris joined the staff at WSCGA in 2005 as a part time bookkeeper. Her main responsibility is to keep the financial records for the association. She also assists as a back-up for staff support and assists at meetings and WSCGA events. Cris has additional responsibilities as Clerical Assistant managing the databases for the membership, the assessment forms and filings for the Wisconsin Cranberry Board, Inc. and serves as the office manager in purchasing supplies and equipment for the association. She provides administrative support to the Wisconsin Cranberry Research and Education Foundation.

She also serves as the bookkeeper for the Cranberry Museum, Inc.

Association Consultants:

Dewitt, Ross and Stevens, Legislative Counsel

DeWitt Ross & Stevens is a full service law firm with experienced attorneys in virtually all areas of practice. Throughout the firm, there are attorneys who have developed expertise in niche areas but still understand the big picture.

The Government Relations team of DeWitt Ross & Stevens is the largest lobbying group in Wisconsin. Because they are located directly on Madison's Capitol Square, often times WSCGA strategize with Legislative Counsel Ron Kuehn and Jordan Lamb and later head to the Capitol for meetings with legislators and other key policymakers.

Ron Kuehn began his career at Dewitt Ross & Stevens upon graduation from the University of Wisconsin Law School in 1971. Early in his career, he directed his practice into business law and, after a few years, expanded to government relations. Today, he exclusively works in state and federal government relations as the leader of the DeWitt Ross & Stevens, and Wisconsin's largest government relations practice group. Ron has been representing WSCGA since 1988, when the industry faced the most significant challenge to the rights of growers to access water. Throughout the years, Ron has worked for WSCGA on issues ranging from environmental quality and regulation to property taxes to transportation.

A key component of the ongoing governmental relations program is establishing relationships through regular communication with legislative and agency leadership, as well as with the grower community. These efforts over the past 20 plus years have positioned the industry so that it is able to respond to challenges, as well as initiate regulatory and legislative changes to help growers businesses.

Jordan Lamb's expertise in environmental regulation is a particular asset to WSCGA and our members, as they navigate the interplay between state and federal regulations and running a successful business. She is a major voice for us in the development and current rewrite of the State non-point source pollution program in NR151 and ATCP50. She played a major role in the development of Wetland Reform Legislation in last session of the Legislature and in developing protocol for dealing with floodplain issues with FEMA, DNR and county zoning offices. She has provided leadership on issues related to groundwater, drainage, artificial and navigable waterbodies to name a few.

Laughlin Constable, Communications and Public Relations

Laughlin Constable (LC) is a multi-faceted and full-service agency. The LC team is made up of a group of talented and creative public relations professionals with a wide variety of backgrounds. LC provides access to expertise for communications, public relations and social media programs for WSCGA.

Kris Naidl, APR, began working with WSCGA in 1994 and she has assisted the cranberry industry with a number of efforts, including strategic communications work to affect change in state regulations, branding, publicity and media relations, issues management, digital strategy and more. She has earned her national accreditation from the Public Relations Society of America (PRSA), and has been honored on numerous occasions from PRSA for her communications work to support Wisconsin's cranberry industry.

Katie Whitlock, APR, has worked with WSCGA for nearly three years, assisting the industry with communication efforts, including social media, media relations, issues management, event and sponsorship coordination, strategic planning and more. She has earned her national accreditation from the Public Relations Society of America (PRSA).

Alicia Wilson is an Account Coordinator at Laughlin Constable where she helps manage WSCGA's social media communications, event coordination, media relations and other efforts. She is a graduate of Marquette University in Milwaukee and has been with Laughlin Constable for two years.

WSCGA Service to Industry Award

The WSCGA Board of Directors presents the Service to Industry Award to individuals or groups who have provided outstanding service to the industry and association. The award is the highest recognition that the association provides. This year the organization is pleased to provide recognition to two individuals.

Ben Brancel

In 1972 Ben Brancel graduated from UW-Platteville with an animal science degree and returned to the family dairy farm. Shortly thereafter he married his wife Gail in December of that same year. Over the years, Ben served on the Portage School Board, as Town Chairman of Douglas Township, and many church and COOP boards. Ben's career has included chairing the United for Health Foundation for Wisconsin, overseeing the distribution of $300 million+ to both the Medical College of Wisconsin and the UW-Madison School for Madison. Ben served in the State Assembly for 11 years – co-chairing the joint Finance Committee and as Speaker of the Assembly. In November of 1997, he was appointed as Secretary of the Department of Agriculture, Trade and Consumer Protection. In 2001, he was appointed by President Bush to serve as Wisconsin's State Director of Farm Services Agency for the United States Department of Agriculture. In 2009 and 2010 Ben was the State Liaison for UW-Madison College of Agriculture and Life Sciences. In 2011, Governor Walker appointed him to serve as the Secretary of DATCP once again until he retired in August of 2017.

After retirement, Ben returned to the family farm full-time. His son Tod and Tod's wife Sondra own the land making them the 6th generation on Brancel Farms. Gail and Ben own most of the machinery and share in the ownership of the cattle.

Steve Hahn

Born in 1951 in Rockford, IL, Steve Hahn entered the agriculture industry at the grand age of 10, when the family moved to the rural area of Pittsville, WI. His chores included caring for the chickens and pigs they raised. At age 11, his father purchased a milk can route, which Steve was required to help work on every day.

At the age of 16, Steve began working in the cranberry industry in the summer of 1968, carrying irrigation pipe. But he kept one foot in the dairy industry continuing to help with his father's milk route until it ended later that year.

In 1971, Steve married Joanne, his high school sweetheart, and by the time 1974 rolled around, he was working full-time on one of the many cranberry marshes in Cranmoor, WI. Ten years later, he earned the title of Foreman, managing a crew of four growing 330 acres of cranberries.

By 1996, he was named Operations Manager until his departure in 2003, when he joined Farmland Management as one of their Area Managers, overseeing 400 acres of cranberries, while also living on and managing the Buena Vista and Evergreen marshes. The area manager positions were consolidated in 2007 and the full responsibilities were given to Steve based on his extensive field experience and his sound managing abilities. This move took him and Joanne off of the marsh, and for the first time, they had the opportunity to purchase their first house. Now managing 2,400 acres of cranberries, Farmland Management named him Regional Manager in 2017.

A firm believer in education, Steve has gained extensive knowledge not only in the field, but through involvement with the Wisconsin State Cranberry Growers Association, where he has served on the Education Committee for over 20 years and is currently on the Wisconsin Cranberry Research and Education Foundation Board. He recalls that his first attendance at cranberry school was in 1975 at the Wood County Auditorium that had about 35 attendees and one vendor.

Steve and Joanne have three grown children (Bill Hahn, Jamie Sturgul, and Misty Ferk) and 10 grandchildren. He plans to retire in 2018.

WSCGA Program Activities – 2017

Public Policy Advocacy

Policy Statement of WSCGA Public Advocacy Program

The WSCGA's Public Policy Advocacy Program strives for state and federal legislative outcomes that allow Wisconsin growers to farm in an environmentally and economically sustainable manner. Public Policy Program position statements and activities are weighed against this goal:

> Wisconsin cranberry growers support legislation, rules and policies that balance the conservation of important natural resources and the stewardship of resources by growers against the economic needs and benefits of cranberry growing in Wisconsin.

The following are priority areas for the WSCGA Public Policy Advocacy Program:

Environmental Policy and Regulation
The greatest threats – and opportunities – for the industry in public policy are in the area of environmental regulation. Whether it pertains to water access and quality, wetlands or the use of chemicals for crop production that growers use, WSCGA members expect their Association to represent their interests.

Water Access
An abundant and high quality water supply is the key to the success of cranberry growing in Wisconsin. As such, the highest priority for the WSCGA is to maintain and protect growers' ability to access surface and groundwater for their farming operations. Conducting normal farming operations to maintain and enhance water use and conservation must be protected and must continue to be allowed with limited regulation.

Water Quality
Cranberry farming practices face increasing scrutiny as to their impacts on water quality. WSCGA has lead efforts with UWEX, USDA NRCS, DNR and DATCP to address Best Management Practices to protect water quality. Maintaining the definition of return flow from irrigated agriculture as a non-point source is a priority for the WSCGA. Changes to the state water regulatory program need continuous monitoring. TMDL development for cranberry waters and the Statewide Nutrient Management Strategy are also priorities for WSCGA.

WSCGA also successfully intervened on behalf of Wisconsin growers in litigation against the State of Wisconsin which seeks to have cranberry growing classified as a point source of pollution. That case was settled in April in Dane County Circuit Court. Ron Ragatz of DeWitt, Ross and Stevens served as legal counsel for the Association in this litigation.

Federal/State Linkage
In many cases with environmental regulation, there is a strong and important relationship between Wisconsin and federal laws and regulation. This is the case with the Clean Water Act and floodplain regulation. As changes take place in federal programs, they impact the state as the delegated authority to administer those programs. At the same time, attempts to reform or revise state regulatory programs require federal approval. WSCGA and its Legislative Counsel continue to be vigilant in these areas.

With these identified priorities, WSCGA staff and leadership will closely communicate with the WSCGA Legislative Counsel to evaluate issues as they arise, assess risk and threats to the industry, and then determine the level of activity that is required to meet the organization's goal and mission.

Legislative and Legal Issues Update

After almost 12 months of legislative action, the Wisconsin State Legislature is heading into the home stretch of the 2017-18 legislative session. This session began in January 2017 and it will conclude sometime in early spring of 2018.

WSCGA's state advocacy program has been busy this session with the state budget bill, legislation to provide certainty to existing high capacity well owners, and participating in the development of multiple administrative rules related to environmental standards. Although there are still several months left in this legislative session, below is a summary of what we have been working on for WSCGA members this year.

ENACTED - 2017-19 State Budget Bill. The 2017-19 biennial budget contained a number of provisions that are important for Wisconsin cranberry growers including:

Transportation Budget Funding. After intense debate over transportation funding, the final transportation budget would rely on $402 million in borrowing and the DOT would be required to eliminate 200 jobs over the next two years. There would also be a new fee on hybrid vehicles ($75) and electric cars ($100) to generate additional transportation revenue over the biennium.

Repeal of IOH Sunset. The budget bill sent to the Governor would eliminate the January 1, 2020 sunset provision related to the Implements of Husbandry (IOH) / Agricultural Commercial Motor Vehicle (Ag CMV) no-fee permit program. This repeal of the sunset was supported by Wisconsin agriculture groups.

Producer-Led Watershed Protection Grants. The budget maintains funding of $500,000 over two years for producer-led watershed grants. The current program was created last budget and was a well-received by farmers and communities committed to nonpoint source pollution abatement. Fourteen producer-led watershed protection grants were issued in 2016. The program is widely-accepted and should be maintained.

Funding for High Capacity Well Studies. The budget bill provides $400,000 from the DNR's environmental fund to conduct the hydrologic evaluation and modeling of the impacts of high capacity wells on specific areas designated in 2017 Wisconsin Act 10. Under that legislation, the DNR "…shall evaluate and model the hydrology of Pleasant Lake in Waushara County, Plainfield Lake and Long Lake in the designated study area, and any other navigable stream or navigable lake located in the designated study area for which the department seeks to determine whether existing and potential groundwater withdrawals are causing or are likely to cause a significant reduction of the navigable stream's or navigable lake's rate of flow or water level below its average seasonal levels."

ENACTED - High Capacity Well Legislation – 2017 WI Act 10. On June 2, 2017, Governor Walker signed legislation creating a framework for the treatment of EXISTING high capacity wells that *no additional DNR review or approval* to repair, replace, reconstruct or transfer ownership of an existing high capacity well. In addition, the legislation requires the DNR to study the hydrology of three lakes in the central sands area of Wisconsin. This legislation was enacted as 2017 Wisconsin Act 10. This new statute provides much needed certainty for WSCGA growers with high capacity wells and irrigated farmland.

ENACTED – Drainage District Legislation – 2017 WI Act 115. The WSCGA worked with leaders from other commodity groups on legislation to address the potential elimination of the Leola Drainage District's "suspended" status as a result of legislative changes that were made in the 2015-17 biennial budget bill. On November 30, 2017, Governor Walker signed 2017 WI Act 115, which made a number of good changes and improvements to the management of drainage districts and also included a provision corrected the Leola District issue.

Wetland Reform Legislation. The budget debate is over and the legislature is back to the task of working on stand-alone legislation. Legislation targeting wetland reform has become a focus. Recently, Senator Roger Roth (R-Appleton) and Representative Jim Steineke (R-Kaukauna) introduced legislation aimed and providing additional wetlands reform. Assembly Bill 547 would reform Wisconsin's wetland permitting statutes by (1) eliminating the requirement for a permit for a discharge of dredged or fill material to a nonfederal wetland; (2) removing any regulation of "artificial wetland" (*i.e.*, the wetland was created by human action and has no prior stream history); and (3) streamlining Wisconsin's wetland mitigation program by prohibiting DNR from imposing any requirements or conditions under their mitigation program that exceed the federal standards in 33 USC 332.

In addition, Senator Van Wanggaard (R-Racine) and Representative Andre Jacque (R-DePere) have also introduced legislation that would remove artificial wetlands from the permitting requirements and mitigation requirements under current law. Assembly Bill 388 / Senate Bill 320 would exempt discharges to any "artificial wetland" from wetland permitting requirements. Under this legislation, an artificial wetland as a wetland inadvertently created by human modifications to the landscape or hydrology and for which there is no prior wetland or stream history, but excludes from the definition a wetland that is subject to federal jurisdiction and a wetland that serves as a fish spawning area or a passage to a fish spawning area.

It remains to be seen which, if either, of these legislative proposals regarding wetland regulation reform moves ahead this session. But both proposals have the potential to ease permitting burdens for Wisconsin farmers. The Roth/Steineke legislation will have a public hearing on December 21, 2017 before the Assembly/Senate Natural Resources Committees.

Elk Reintroduction. The Wisconsin DNR continues to expand the reintroduction of elk into Jackson County. In response to concerns from the WSCGA, the Department has been created and implemented a fencing program for those growers within the projected elk range who desire fencing to protect their cranberry beds from elk damage. Although the current program expired on December 31, 2016, the Department is considering extending the fencing program for growers who need an elk damage solution in the future.

Wisconsin River TMDL. Section 303(d) of the Clean Water Act (CWA) requires delegated states, like the State of Wisconsin, to determine every two years whether waterbodies are impaired, which means that they are not meeting designated uses or water quality criteria. The CWA is aimed at improving impaired waters such that they meet water quality standards. One tool used to improved impaired waters is the development of a TMDL.

TMDL stands for "total maximum daily load." It refers to the maximum amount of pollutants that a surface water can receive in a day and still meet water quality standards. TMDLs are developed for particular surface waters by the DNR and the US EPA.

The DNR is currently in the midst of developing a TMDL for the Wisconsin River. The Wisconsin River TMDL study area spans Wisconsin's central corridor from the headwaters in Vilas County to Lake Wisconsin in Columbia County, covering 9,156 square miles, approximately 15 percent of the state. It affects most of Wisconsin's cranberry growers.

As such, the WSCGA continues to monitor and participate in the development of this TMDL, as it could be used, at some point, to develop targeted nonpoint source performance standards for agricultural runoff in the Wisconsin River watershed.

Legal Update – *Coors v. Wisconsin Department of Natural Resources*

On June 10, 2016, James Coors, Lac Courte Oreilles Lakes Association, Inc. ("COLA") and Lac Courte Oreilles band of Lake Superior Chippewa, (the "Tribe") filed a lawsuit against the Wisconsin Department of Natural Resources ("DNR") and the Natural Resources Board. *Coors v. Wisconsin Department of Natural Resources*. The filing was a mixture of a petition for judicial review of an administrative agency decision and a civil lawsuit asking the Judge to determine certain legal issues.

In April 2017, the parties entered into a Stipulation which put the active litigation on hold and established a timeline for the DNR to develop site specific criteria ("SSC") for Lac Court Oreilles ("LCO"). DNR has complied with the first part of the timeline, culminating in the Natural Resources Board approving a scope statement for the development of the SSC for LCO. That approval triggered a 150-day timeline for DNR to develop the proposed SSC and to meet with the Petitioners, COLA and the Tribe within 30 of calculating the proposed SSC. The Judge has set a status conference for April 5, 2018, by which time all those deadlines should be met.

If all the required deadlines have been met and there are no procedural issues, the case will be dismissed. However, the Petitioners have reserved the right to reinitiate a lawsuit claiming that the cranberry marshes on LCO are “point sources” that are required under the Clean Water Act to have discharge permits. That is the issue that is important to WSCGA and its members, including but not limited to those growers on LCO. At this point, we do not know whether that issue may be actively pursued by Petitioners again.

WSCGA Federal Governmental Issues – 2017

The WSCGA Federal advocacy program was very active in calendar-year 2017. Federal activities include working with agencies on issue’s and members of congress and the Congressional Cranberry Caucus. The following is a list of issues addressed by the WSCGA and WCREF during calendar-year 2017. These include work by Broydrick and Associates on behalf of WSCGA and the WCREF along with direct activities by WSCGA with other state and national groups.

Research Funding

In 2015 WSCGA was able to secure an increase in the budget for the USDA ARS Cranberry Research Program of $750,000. Since the budget increase the WSCGA has been providing support to the Wisconsin Cranberry Research and Education Foundation to develop a cooperative agreement to make the funds available for the establishment of a cranberry research station. In September of 2016 a final agreement was signed to secure the funds for the project.

First and second year funding will be available to support the station. Funding in following years will be used to increase support of the two ARS positions at UW Madison and to add a third ARS Cranberry research program as well. The final cooperative agreement was amended this past year to access additional funds for the project and as a result the Foundation completed purchase of farm for development into a research station. All told, the agreements will provide about $1.1 million for the project.

Pest Management Tools

WSCGA has adopted a general policy to support the development of a toolbox of management practices for growers to use in their farming operations. These practices include cultural – such as flooding for pest control or sanding – as well as the use of chemical control options. The chemical control options may include new, softer pest specific compounds and traditional broad spectrum control. The organization encourages integrated use of these tools by growers through IPM.

As a result, WSCGA advocates continuing registrations for pesticides as long as their judicious use does not present an environmental or food safety risk. The Association works with the Cranberry Institute and other organizations to monitor proposals by EPA and others that impact grower use of pest control products and strategies. During the past year the WSCGA was active on a number of proposals.

USDA Purchases of Cranberry Products

WSCGA has been a leader in efforts to encourage USDA to use its authority under Section 32 to purchase cranberry products for school lunch programs and other feeding programs that the agency supports. The Association has worked with other groups to secure letters from members of the Congressional Cranberry Caucus and written directly to USDA requesting action.

Communications & Marketing Highlights from 2017

The WSCGA Communications Program is developed as part of a team effort with the Public Relations Committee and the team at Laughlin Constable. The overall objective of WSCGA's communications efforts is to promote the purchase and consumption of cranberries and cranberry products by emphasizing their taste, versatility and health benefits.

New Video Efforts

In 2017, WSCGA coordinated two new video efforts. The first was the development and production of a new educational video, which featured grower interviews and stunning footage to tell the story of Wisconsin's cranberry industry, show how cranberries are grown, and educate viewers about the history and economic impact of the industry and health benefits of cranberries. WSCGA also launched a series of short, "snackable" social media videos to help increase engagement across platforms. The first four social media videos were very well received, reaching more than 168,000 people. Additional videos have been created and will be utilized throughout the next year.

Web and Social Media

Laughlin Constable manages WSCGA's social media accounts, including Facebook, Twitter, YouTube, and – new this year – Instagram. This includes drafting and posting fun, engaging content on WSCGA's social media channels, managing comments and questions from consumers, and coordinating sponsored posts and ads to boost engagement. In 2017, WSCGA launched an Instagram channel, which is a photo-focused social media platform with a younger demographic than our primary audience on Facebook. The goal in establishing this channel is to help reach the next generation of cranberry consumers. 2017 was another strong year of growth for WSCGA's existing social media channels, especially Facebook – our core platform. Facebook page likes increased more than 51% in 2017, surpassing a milestone of 20,000 likes. In total, Facebook posts reached more than 2 million people in 2017. LC also assists with the WisCran.org content and analytics reporting.

Partnerships/Sponsorships

WSCGA uses grants from the Wisconsin Cranberry Board, Inc. for partnerships and sponsorships with the Milwaukee Brewers Radio Network, UW Badger Sports, Green Bay Packers and American Birkebiener.

Through its partnership with the Milwaukee Brewers Radio Network, WSCGA sponsored the umpire report during each game broadcast and provided radio spots to run during four Brewers baseball series. The team at Laughlin Constable helped coordinate the effort and produce the radio scripts.

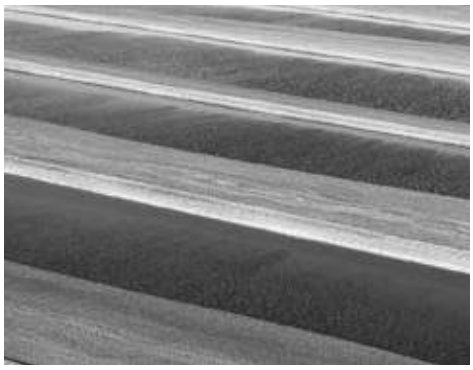
As part of the UW sponsorship, WSCGA sampled cranberries and cranberry products at UW events, including men's basketball, women's volleyball and men's and women's hockey games, as well as the Crazylegs Classic run. In 2017, WSCGA also sampled cranberries and cranberry products at the Green Bay Packers 5K Run, Training Camp and a Green Bay Packers preseason game. Finally, WSCGA sponsored the American Birkebeiner in 2017, which included the opportunity to sample and promote cranberry products as an exhibitor at the Birkie tradeshow.

Wisconsin State Fair

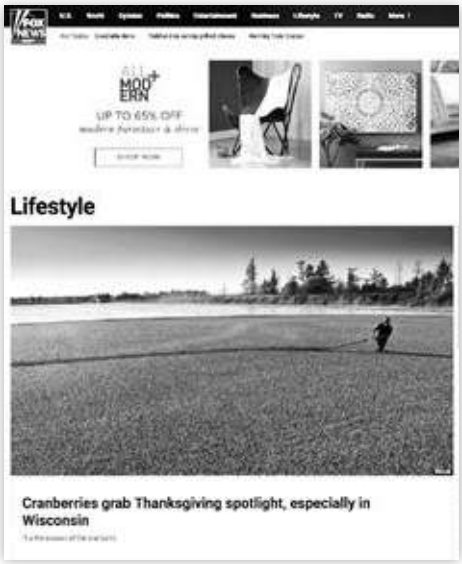
For more than two decades, Laughlin Constable has helped support the Wisconsin Cranberries booth at the Wisconsin State Fair. The 2017 booth experienced strong sales with Fair favorites like the Cranberry White Chocolate Chunk Cookie, Cran-on-a-Stick, dried cranberry snack packs, cranberry mango and cranberry lemonade bottled juice, and single serve cranberry cocktail. The booth also featured the popular mini marsh and other educational displays, including the model marsh which was updated with new branding this year and the new educational video. Laughlin Constable pitched media ahead of the State Fair, resulting in a Milwaukee Journal Sentinel article, and conducted media drops to radio stations on site, resulting in on-air and social media coverage. The team also coordinated social media efforts tied to the Fair, including a State Fair ticket giveaway with more than 270 entries. In total, social media efforts reached more than 90,000 people and helped drive traffic to the booth.

Fall Harvest Efforts

Each year, Laughlin Constable assists with WSCGA's media relations efforts surrounding the annual cranberry harvest. This year's media strategy included the early announcement of crop projection figures tied to Wisconsin cranberry messaging, as well as pitching media and coordinating marsh visits and interview requests throughout the harvest season with statewide and national media. Additionally, a major focus of the harvest season was supporting efforts of the U.S. Cranberry Marketing Committee Reverse Trade Mission, which brought 20 representatives from India and China to Wisconsin to experience harvest, and learn about cranberries and how to incorporate them into meals and snacks. WSCGA also partnered with a food blogger and Instagram influencer in December on a unique cranberry recipe, blog post and social media promotion.



In total, more than 370 print, online, radio and TV stories ran across the country during harvest, including coverage in every TV market in Wisconsin, Associated Press national coverage of the crop projection and Reverse Trade Mission effort, and feature coverage via the Chicago Tribune, Washington Post and Fox News. Overall, media relations efforts during harvest resulted in more than 225 million impressions.




Chicago Tribune
TRAVEL
AUTUMN ESCAPES
SEEING RED
Wisconsin rich with cranberry marshes

Research Programs

Research Coordination and Administration

Although the WSCGA does not have a direct research program, it does provide administrative services to the Wisconsin Cranberry Board, Inc. Under this agreement, WSCGA provides the staffing services that the WCB needs in order to operate. This allows WCB to maximize its investment in research, education and promotion programs on behalf of the Wisconsin growers and minimize administration costs.

As part of this service, the WSCGA also works with other cranberry groups to coordinate research activities to avoid duplication and to create synergies and partnerships to maximize the investments by growers.

Education Program Highlights

Education is a major component of the WSCGA Mission. The organization's Education Committee works throughout the year to present programs for growers on improving management practices with the goal of allowing growers to operate their farms in an economically sustainable manner.

Wisconsin Cranberry School

The 2017 Wisconsin Cranberry School was held at the Holiday Inn Hotel & Convention Center in Stevens Point, WI. With more than 375 registrants, the event provided educational sessions, an interactive grower management session, and a forum for growers and related affiliates to exchange ideas and best practices in the cranberry industry. The School is the signature education event for the WSCGA.

The annual program is sponsored as a collaborative effort by the Wisconsin Cranberry Research & Education Foundation (WCREF), the Wisconsin State Cranberry Growers Association, and UW-Extension.

A Pesticide Applicator Training and Certification (PAT) session with information and exam was provided on-site as a one-stop convenience to growers by Wood County Extension, and facilitated by Matt Lippert.

A popular session utilizing live CLKR technology provided growers with insights into industry management practices. A range of questions were posed to the audience; growers responded with their respective answers on the hand-held device, and could see an immediate summary of the results, which showed the percentages for each answer of each question.

Presentations by session speakers covered a diverse array of topics, from plant and insect phenology to cranberry variety improvement research, from cranberry virus and disease issues to the cranberry genetics and genomic program, from soil moisture monitoring to nutrient management and honeybee hive location research. There were also update research sessions on cranberry varieties and their resistance to insect pests, carnivorous arthropods activity after spring floods, fungicide applications effect on bee fidelity, pheromone mating / moth birth control in cranberries, cranberry pesticides update reports, and problematic weed management strategies.

Nutrient Management Training Session Held March 29

In late-March, about 50 people attended the Nutrient Management training sessions held in Wisconsin Rapids and co-sponsored by the WSCGA, USDA / NRCS, and UW Extension.

The full-day workshop in was designed to help cranberry farmers write their own nutrient management plans to meet DATCP requirements. Wisconsin DATCP also requires that farmers complete a department-approved training course at least once every four years to maintain their qualification.

Presentations were provided by NRCS, along with Pam Verhulst from Lady Bug IPM, and Amaya Atucha from UW Extension. Since the start of the program more than 400 growers have participated in the training to become qualified to write a nutrient management plan for their farm.

Early Season Grower Workshops Held April 11

The WSCGA and UWEX co-sponsored two early season grower workshops – one at Valley Corporation in Valley Junction, and the other at Elm Lake Cranberry in Wisconsin Rapids on Tuesday, April 11. More than 150 participants attended the two workshops, available to growers at no charge.

These events are held each spring to update growers on new management practices and strategies for the growing season, review of winter impacts on crop, new crop production tools available, and informal discussions on the upcoming growing season. Topics included Bravo restrictions / possible replacement options, growing degree day calculator, virus research updates, weed management strategies, pollination, cold hardiness and root physiology.

Updates and presentations were provided by UW researchers Amaya Atucha, Jed Colquhoun, Jack Perry, Patty McManus, Christelle Guedot and Beth Workmaster. Crop consultants also provided observations from the field.

Cranberry Farm Safety Seminar Held May 5

The Education Committee sponsored a safety training seminar at Russell Rezin and Son, Inc. The program featured respirator information and fit testing, Fork-Equipped Machine Safety General Farm Safety / Ergonomics / Heat Stress.

Summer Meeting, Field Day and Trade Show

The 129th Summer Annual Meeting, Field Day and Trade Show were held in Warrens Wisconsin with the Wisconsin Cranberry Discovery Center and the Warrens Cranberry Festival as hosts. Randy Gebhardt served as the host marsh and provided tours during the day. Bus tours of the marsh were held from 9:00 a.m. - 2:30 p.m. There were also 3 mini sessions for growers to attend and 87 on-site exhibits. More than 800 lunches were served between 11:00 a.m. and 1:00 p.m.

WSCGA NEWS

Each month, members of the WSCGA are provided with up to date information on the cranberry industry, news, activities and anything that would be of interest to the growers of Wisconsin's number one fruit crop. WSCGA coordinates the publication of the newsletter and solicits articles from a cross-section of organizations and individuals. The NEWS is distributed in both print and electronic form with over 600 people on the subscription list.

Weather Forecasting

The Wisconsin Cranberry Board, Inc. has provided funding for weather forecasting services for decades. WSCGA administers the program for the industry. Working with forecasters from Great Lakes Weather Services, daily forecasts are available online and via a toll free number. The forecasts are specific to cranberry farms and are an important tool for growers as they make decisions about management practices such as frost protection. The forecasts are available April 15 through October 31.

Associate Member Programs

The WSCGA has an active program for the businesses that support the industry in the state. Associate Membership in WSCGA allows these companies to participate in a wide variety of marketing opportunities. The most popular are the Winter and Summer Trade Shows, Advertising programs in the WSCGA NEWS and the Summer Meeting publications. Associate members are also actively involved in industry events such as the annual Cranberry Open Golf Outing and the Sporting Clays Shoot. A committee of the Associate membership works with WSCGA Staff to develop and conduct these programs. Highlights for 2016 include:

Winter Trade Show

The event conducted in conjunction with the Wisconsin Cranberry School and the WSCGA Winter Meeting, the 2017 Trade show was held on Wednesday, January 18 at the Holiday Inn Hotel and Convention Center in Stevens Point WI. The 2017 show included 84 exhibitors. In addition to the Expo Room and Main Hallway, exhibitor booth space was provided in the commons area adjacent to school session meeting rooms. All exhibitors are Associate Members of the WSCGA.

Trade show time was also increased for Cranberry School attendees, after the morning Opening Session. For maximum flexibility, the extra time allowed school registrants to visit exhibits prior to the start of the Cranberry School from 8:00 to 9:30 am, during scheduled breaks, and during the 2 designated lunch times. Trade Show exhibitors provided samples, demonstration, shared new materials, exhibited on-site equipment, and introduced new products and services.

Wisconsin Cranberry Leadership Development Program Class IV

A group of 15 new leaders for the program were announced at the 2017 WSCGA Summer Meeting. The group will complete their five class session with a final commencement on March 12 in Wisconsin Rapids.

The 15 class members include:

Jenna Dempze	Clayton Heuer	Wes Normington
Vanessa Dubick	Jesirae Heuer	Seth Rice
Trevor Gardner	Zach Heuer	Katie Sawyer
Tristan Gardner	Dennis Irwin	Amber Schultz
Dan Hauke	Sandy Nemitz	Dean Weir

The Leadership Development Program was created by the WSCGA and is made possible by grants from the Wisconsin Cranberry board, Inc. partial proceeds from WCREF Fundraisers and individual support.


Lifestyle

Cranberries grab Thanksgiving spotlight, especially in Wisconsin

NOTES

WISCONSIN STATE CRANBERRY GROWERS Association

WSCGA MISSION:

The mission of the Wisconsin State Cranberry Growers Association is to enable the cranberry industry in Wisconsin to prosper through the provision of grower information, responsible environmental stewardship, sound governmental policies and effective public communications.