NACREW Oral Presentations
[presenting author underlined]

Wednesday session #3
Casey Kennedy, Peter J.A. Kleinman, Carolyn J. DeMoranville, Kyle R. Elkin, Ray B. Bryant, and Anthony R. Buda. ARS, UMass Cranberry Station. Managing surface water inputs to reduce phosphorus losses from cranberry bogs.

Christopher Neill, Lindsay Scott, Casey Kennedy, Rachel Jakuba and Carolyn DeMoranville. Woods Hole Research Center. Nitrogen and Phosphorus Balances of Cranberry Bogs in Southeastern Massachusetts Coastal Watersheds.

Anne L. Averill and Martha M. Sylvia. UMass. Armored scale (Diaspididae) outbreaks in Massachusetts cranberry.

Natalie Eisner, Elissa Chasen, Brian Luck, and Shawn Steffan. University of Wisconsin Madison, ARS. Progress in the mechanization of mating disruption deployment.

Shane Foye and Shawn Steffan. UWisconsin and ARS. Native nematodes as new bio-insecticides for cranberries.

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Wednesday session #4
Silvio José Gumiere, Yann Périard, Alain N. Rousseau, Jonathan Lafond, Thiago Gumiere and Jacques Gallichand. Univ. Laval. Spatiotemporal variability of soil hydraulic properties under drainage and recharge cycles.

Guillaume Letourneau, Silvio J. Gumiere, Jonathan Lafond, Jacques Gallichand and Alain N. Rousseau. Univ. Laval. Optimization of Water Management of Cranberry Fields under Current and Future Climate Conditions

Katherine Ghantous and Hilary Sandler. UMass Cranberry Station. Moss as an emerging weed problem in cranberry.

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Thierry E. Besancon, Baylee L. Carr and Peter V. Oudemans. Rutgers. Screening of POST herbicides for controlling Carolina redroot (*Lachnanthes caroliana*) in New Jersey cranberry beds.

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ABSTRACTS

Session #3

Managing Surface Water Inputs to Reduce Phosphorus Losses from Cranberry Farms

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In Massachusetts, cranberry (*Vaccinium macrocarpon* Ait.) production accounts for one-fourth of US cranberry supply, but water quality concerns, water use, and wetland protection laws threaten the sustainability and future viability of the state's cranberry industry. Pond water used for harvest and winter flooding accounts for up to two-thirds of phosphorus (P) losses in drainage waters. Consequently, use of P sorbing salts to treat pond water holds promise in the mitigation of P losses from cranberry farms. Laboratory evaluation of aluminum (Al)-, iron (Fe)-, and calcium (Ca)-based salts was conducted to determine the application rate required for reducing P in shallow (0.4 m) and deep (3.2 m) water ponds used for cranberry production. Limited P removal (<22%) with calcium carbonate and calcium sulfate was consistent with their relatively low solubility in water. Calcium hydroxide reduced total P up to 66%, but increases in pond water pH (>8) could be detrimental to cranberry production. Ferric sulfate and aluminum sulfate applications of 15 mg L^{-1} (ppm) resulted in near-complete removal of total P, which decreased from 49 ± 3 to <10 mg P L^{-1} (ppb). However, ferric sulfate application lowered pH below the recommend range for cranberry soils. Field testing of aluminum sulfate demonstrated that at a dose of 15 mg L^{-1} (~1.4 Al mg L^{-1}), total P in pond water was reduced by 78 to 93%. Laboratory and field experiments support the recommendation of aluminum sulfate as a cost-effective remedial strategy for reducing elevated P in surface water used for cranberry production.

Nitrogen and Phosphorus Balances of Cranberry Bogs in Southeastern Massachusetts Coastal Watersheds

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Cranberry bogs make up an important part of the landscape, economics, and cultural heritage of SE Massachusetts. Because cranberry bogs use ponds and rivers as water sources and as discharge points, the control of runoff of both nitrogen (N) and phosphorus (P) to surface waters from cranberry farming is a concern for the health and management of fresh and estuarine waters in watersheds where cranberry bogs occur. We quantified the movement of N and P into and out of three cranberry bogs in the Weweantic and Wareham River Watersheds during one water year and annual cropping cycle. We combined measurements of water flow with measurements of dissolved and particulate N and P concentrations in different components of the annual farming cycle to estimate N and P input-output balances. Water budgets varied widely among bogs. Two bogs showed net movement of groundwater into the bog, one of which had very high inflow, and the third bog had net water flow into groundwater. Two bogs exhibited small net N imports (0.1 and 2.0 kg N ha^{-1}) in fluvial exchanges and one bog exhibited substantial N export (12.6 kg N ha^{-1}). Between 73 and 77% of all fluvial N exports exited in surface water during non-flood baseflows. Bogs exported between 2.1 and 4.5 kg P ha^{-1} in fluvial exchanges and 55 and 81% of all P export occurred during non-flood baseflows. High variability of net N exchange likely arose from the hydro-geographical setting in which the bogs occurred. The variation in the magnitude and direction of P exchanges was much less and depended less on bog setting. Given the finding of that most annual export of N and P occurred in surface water flows during times that water was not actively pumped onto or released from bogs, water management specifically aimed at N and P removal from the small but steady outflow of surface water during non-flood periods could be beneficial. Management might include additional storage time in ponds or increased naturalization of stream channels.

Armored scale (Diaspididae) outbreaks in Massachusetts cranberry

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Elevated populations of several new insect pests proved challenging to pest management programs that aimed to reduce inputs or eliminate broad-spectrum insecticides. Over the past 5 years, two species of armored scale, Dearness scale and more importantly Putnam scale, swept across a quarter of the MA cranberry acreage. Injury created multiple dead areas on beds. Management relied on an organophosphate spray at onset of bloom and timing was tricky, targeting the short-lived and vulnerable crawler stage. Additionally, over two different seasons, two species of tiny chrysomelid beetle, still unidentified, formed huge populations that fed on new growth and flowers. In 2017, sharp-nosed leafhoppers flooded sweep net samples at two sites, creating concern that blunt-nosed leafhopper, the vector of the phytoplasma that causes false blossom, would also soon be discovered. There are huge advantages to grower adoption of selective insecticides, but unexpected outbreaks may continue to disrupt our best-laid plans.

Progress in the mechanization of mating disruption deployment

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The American Cranberry, *Vaccinium macrocarpon* Aiton (Ericaceae) is the most significant fruit crop in Wisconsin, accounting for almost 85% of the states total value of fruit production. A challenge faced by cranberry growers is managing for insect pests that cause economic damage. Presently, growers use insecticides to manage insect pest populations. However, insecticides also cause mortality in beneficial insects - including pollinators and natural enemies. An alternative for reducing insect populations in cranberry marshes is Mating Disruption (MD), which uses pheromones to prevent and delay mating. MD systems function by sending out false plumes of the insect's sex pheromones – this interferes with the insect's ability to find a mate, preempting egg fertilization and reducing crop damage. Three major cranberry pests are *Sparganothis sulfureana*, *Acrobasis vacinii,* and *Rhopobata naevana*. These pests all use pheromones to communicate, which makes MD a viable tool for pest management. Specialized Pheromone and Lure Application Technology - SPLAT® (ISCA Technologies Inc., Riverside, CA) is a pheromone-infused wax, made of food grade materials that has the potential to replace or reduce insecticide application. The purpose of this study is to facilitate research and grower adoption of this technology by testing at field scales a mechanized applicator for SPLAT® and determining the level of control it provides for the three most detrimental pests of cranberry in Wisconsin.

Native nematodes as new bio-insecticides for cranberries

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In the summer of 2015, an effort was made in central Wisconsin to find an entomopathogenic nematode capable controlling Wisconsin's cranberry pests. Using a standard baiting method, a nematode of the *Oscheius* genus was collected from the mossy, sandy, peat-filled soils of a wild cranberry marsh. This nematode may be a new subspecies of the nematode *Oscheius onirici* Torrini (Rhabditida: Rhabditidae), and is tentatively referred to as *Oscheius onirici* sub. *wisconsinensis*. It is effective at killing sparganothis fruitworms in laboratory conditions designed to imitate the bed of a cranberry marsh. Furthermore, it can kill cranberry fruitworm prepupae in the lab. During the summer of 2016, a greenhouse-scale experiment confirmed that the nematode can suppress redheaded flea beetle populations at levels comparable to insecticides. A project is under way in Monroe County, Wisconsin, to test the nematode's flea beetle suppression abilities within a commercial marsh. Furthermore, some evidence from an *in vitro* bioassay suggests that a bacterium associated with the nematode, can antagonize the growth of fungi collected from infected cranberries. This bacterium, which is in the Bacillus genus, can even protect rye grass from the Rhizoctonia fungus, under laboratory conditions.

Predictive Models of Moth Development

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Degree-day models link ambient temperature to insect life-stages, making such models valuable tools in integrated pest management. These models increase management efficacy by predicting pest phenology. In Wisconsin, the top insect pest of cranberry production is the cranberry fruitworm, *Acrobasis vaccinii* Riley (Lepidoptera: Pyralidae). Control of this species is often complicated by the fact that the larvae feed entirely within the fruit. Timing of control tactics is therefore critical and generally targets the adult and egg stages. The first part of this research was conducted in the laboratory to determine the upper and lower temperature-mediated growth thresholds of this pest. Using field-collected *A. vaccinii*, we reared the larvae within cranberry fruit and monitored larval growth at a range of temperatures. This allowed us to calculate precise upper and lower developmental temperature thresholds. The second part of this research used these developmental thresholds to calculate degree-day accumulations in the field and to correlate these accruals to flight phenology as observed in pheromone-baited traps located at cranberry marshes in central WI. Future work will correlate degree-day accumulations to egg-laying and larval-hatch periods, providing a powerful predictive tool for pest management in cranberry production.

Session #4

Spatiotemporal variability of soil hydraulic properties under drainage and recharge cycles

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The installation of drainage systems can cause anthropic evolution of the soil profile. Natural consolidation, filtration and clogging of soil pores by colloidal particles may be accelerated by water management practices, such as irrigation, drainage and flooding, and could reduce the drainage capacity of the soil. X-ray tomography can be used to describe soil hydraulic properties at the small scale and to study several physical soil processes, especially those related to the migration of colloidal particles and consolidation. Wavelet analyses can decompose an observed time series of soil matric potential into various components that can be used to determine the temporal periodicity of drainage and recharge. The main objective of this study was to analyze the spatiotemporal variability in the hydraulic properties of a sandy soil and the time series of matric potential during repeated cycles of drainage and recharge from the bottom of a soil profile using a medical X-ray computerized tomography (CT) scanner and wavelet transforms. A soil column laboratory experiment was set up to monitor the pressure head, water inflow and outflow, and the movement of the tracers KBr and ZrO2. Tomographic scans have been used to analyze the spatiotemporal variability in the soil hydraulic properties. The results show that repeated drainage and recharge cycles greatly affect the evolution of soil hydraulic properties by reducing drainage and capillary capacities. Knowledge of the mechanisms responsible for this human-induced soil genesis is important for water management in agricultural systems. This information may allow prediction of soil evolution according to soil texture, drainage system design and water management, thereby anticipating and possibly controlling problems related to soil hydrodynamics.

Optimization of Water Management of Cranberry Fields under Current and Future Climate Conditions

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In North America, cranberry production is on the rise. Since 2005, land area dedicated to cranberry doubled, principally in Canada. Recent studies have shown that sub-irrigation could lead to improvements in yield, water use efficiency and pumping energy requirements compared to conventional sprinkler irrigation. However, the experimental determination of the optimal water table level of each production site may be expensive and time-consuming. The primary objective of this study is to optimize the water table level as a function of typical soil properties, and climatic conditions observed in major production areas using a numerical modeling approach. The second objective is to evaluate the impacts of projected climatic conditions on water management of cranberry fields. To that end, cranberry-specific management operations such as harvest flooding, rapid drainage following heavy rainfall, or hydric stress management during dry weather conditions were simulated with the HYDRUS 2D software. Results have shown that maintaining the water table approximately at 60 cm provides optimal results for most of the studied soils. However, under certain extreme climatic conditions, the drainage system design may not allow maintaining optimal hydric conditions for cranberry growth. The long-term benefit of this study has potential to advance the design of drainage/sub-irrigation systems.

Moss as an emerging weed problem in cranberry

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Moss is an emerging weed issue in Massachusetts and other cranberry growing regions. Although present in cranberry for decades as a minor weed, growers have recently begun to perceive it as becoming more widespread and difficult to control despite practices, such as improved drainage and water management, that should discourage moss growth. Of growers surveyed at the 2016 UMass Cranberry Management Update Meeting, 67% reported having moss on their farms (n=100), 41 % said they felt it was more common than it was 5 years ago (n=85), and 41% said they considered moss to be a problematic weed (n=96). Although the most commonly recognized and prevalent cranberry weed mosses are haircap (*Polytrichum commune*) and sphagnum (*Sphagnum* spp.), a recent sampling made in June of 2017 of State Bog in East Wareham found at least three additional moss species present (*Aulacomnium palustre, Ceratodon purpureus,* and *Entodon seductrix*).

Traditional control measures, such as spot treatment of moss patches with high rates of iron sulfate, are not adequate for managing large infestations. Recent work supported by Hatch funding has confirmed that currently registered herbicides, such as Casoron (60 lb/A), Evital (80 lb/A), Devrinol 2-XT (18 qt/A), QuinStar (8.4 oz/A x 2), or Callisto (8 oz/A x2), provided little to no control of moss.

Over the past four years, we screened several products including acetic acid (20% horticultural strength), an herbicidal soap (22% ammoniated soap of fatty acids), Moss-aside (22% potassium salts of fatty acids), Impede (an insecticide with 49% potassium salts of fatty acids), Oxidate (5.34% hydrogen peroxide), iron sulfate (a feed-grade powdered form of 92% ferrous sulfate with 30% elemental iron) applied via drop spreader, iron sulfate (a feed-grade powdered form 92% ferrous sulfate with 30% elemental iron) dissolved in water and applied by chemigation, Moss-out Liquid (a 35% ferric sulfate with 9.75% elemental iron product), Scotts Moss Control Granules For Lawns (17.5% ferrous sulfate), and FeRROMEC (liquid turf product 15% Urea Nitrogen, 3% Combined Sulfur, 6% Iron). Of these products, the only ones that injured moss and were not injurious to cranberry vines were the powdered iron sulfate (both applied as a powder and also dissolved in water), Scotts Moss Control Granules (also iron sulfate), and Moss-aside (22% potassium salts of fatty acids).

Several herbicides not currently registered for use on cranberry were screened between 2015 and 2017 for possible efficacy against moss: Aim (Carfentrazone; applied before cranberry budbreak), Chateau (flumioxazin), Method (aminocyclopyrachlor), Reflex (fomesafen), Sandea (halosulfuron), Zeus (sulfentrazone), and Zidua (pyroxasulfone). Chateau and Zeus both demonstrated good crop safety and moss control.

Biocontrol of Moss with Sodium Bicarbonate

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Cranberry growers struggle with controlling the presence of moss of different species in their fields. Few chemical treatments have been tested in the past with mixed results. In organic production, no solution is available for such control. A few web references mention the use of baking soda on driveways and other structures in order to eradicate mosse. The aim of this project was to assess the effectiveness of sodium bicarbonate to control moss in productive cranberry bogs without damaging the plants.
Many sources of information on the Web refer to a dose of 30 g / liter (4oz / gal) to control moss on driveway. In the first year, as an exploratory project, we conducted three tests on two types of moss from mid-May to mid-June. We tested four doses from 15 to 80 g / L (2 to 10.7 oz / gal) applied in four random blocks of 1 ft^2 for each dose. In the 2nd year, we try to adjust theses doses in order to apply the product with the boom. Project is still underway.

DATA COLLECTION AND ANALYSIS:
Observations for control effectiveness and regrowth of the moss were conduct 48 hours after each application of the product until mid-September. Soils samples from the root zone were taken every month in order to determine the effect of the bicarbonate on the pH of the soil. The SSE (Solution Soil Extract) method was used to measure the pH.

MAIN RESULTS:
The reference concentration found on the Internet revealed to be the most economical, effective and durable dose. The experiment show that 15 g (2 oz) / ft^2 is the best dose to use. The liquid treatment is to promoted: it allows a more uniform coverage on the crop. The principal problem seen at this point is the amount of water volume needed to apply a proper dose to control the moss. Haircap moss is easier to control. The use of sodium bicarbonate modifies the soil pH momentarily. After 2 months, we measured a return to normal pH values. No damage on cranberry plants were observed in the first year trials; treatments were done during spring dormancy of the cranberry plants.

CONCLUSION:
Sodium bicarbonate seems to be a very promising, effective and safe way to control different kinds of mosses. One year later after the first trial, we still see the efficacy of the bicarbonate: very weak growth (or none) of the cypress moss is seen in the plots from 2016. That product is accepted by Organic certification body, Ecocert, in Quebec but not yet registered by PMRA (Pest Management Regulatory Agency) in Canada. In the future, it would be a very good tool to use in both organic and conventional cropping systems to help growers manage moss in their fields.

Screening of POST herbicides for controlling Carolina redroot (*Lachnanthes caroliana*) in New Jersey cranberry beds

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New Jersey produced 27 million kg of cranberries in 2015 at a farm value of $22 million (USDA 2017). Cranberry beds in New Jersey are concentrated in the Pine Barrens coastal plain where soil conditions (sandy texture, pH 4.0 to 5.0, good drainage) are optimal for cranberry production. The perennial nature of cranberry production predisposes the crop to a diversity of weed species ranging from herbaceous weeds to woody perennial species. Among perennial weed species, Carolina redroot has been an increasing source of concern for New Jersey cranberry growers regarding the lack of sufficient control from their current management strategies. Carolina redroot is a perennial herbaceous monocotyledonous species member of the *Haemodoraceae* family whose common name is derived from the orange to red coloration of its roots and rhizome. Information regarding herbicidal control of Carolina redroot is extremely limited and mostly restricted to blueberry production (Myers et al. 2013). In order to address the issues of successfully managing Carolina redroot under extremely specific environmental and cropping conditions, a study was initiated in 2017 for evaluating the efficiency of ten postemergence herbicides to control Carolina redroot. Diquat at 560 g ai ha^{-1} provided over 90% control up to 21 days after treatment (DAT) but declined after 42 DAT with the emergence of new shoots. Control with mesotrione at 280 or 560 g ai ha^{-1} increased from less than 15% 14 DAT to 97% 63 DAT. Control increased from 14 to 63 DAT with flumioxazin at 210 g ai ha^{-1} (73%) and 2,4-D at 1,280 g ae ha^{-1} (60 %) whereas glyphosate at 1,260 g ae ha^{-1} did not achieve more than 48% control 63 DAT. Other herbicides tested (pronamide at 2,240 g ai ha^{-1}, clopyralid at 70 or 140 g ai ha^{-1}, quinclorac at 1,280 g ae ha^{-1}, carfentrazone at 35 g ai ha^{-1}, and fomesafen at 420 g ai ha^{-1}) provided less than 30% control from 21 DAT onwards. Control of Carolina redroot rhizomes/roots was greatest in plants treated with mesotrione (> 95%), glyphosate (90%), diquat (89%), 2,4-D (84%), and flumioxazin (78%). Non treated Carolina redroot shoot and root/rhizome fresh weight were 5.8 and 7.7 g, respectively. Greatest shoot and root/rhizome biomass reductions were noted with diquat, mesotrione at 280 or 560 g ai ha^{-1}, glyphosate, 2,4-D, and flumioxazin (0.7 and 0.7 g, 0.4 and 1.8 g, 0.3 and 1.2 g, 0.8 and 1.1 g, 1.1 and 1.3 g, 1.5 and 1.5 g, respectively). Clopyralid at 70 or 140 g ai ha^{-1} and fomesafen also reduced root/rhizome fresh weight (4.8, 5.7, and 3.1 g, respectively) but did not decrease shoot biomass. No secondary shoots growing from the rhizome were noted for plants treated with glyphosate, mesotrione, 2,4-D and flumioxazin.

Repeated applications of Callisto and Devrinol on newly planted cranberry vines

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To evaluate the weed control provided by various combinations of preemergence applications of Devrinol (napropamide) and postemergence applications of Callisto (mesotrione) in newly planted and 1-yr-old cranberry vines, six 2-yr experiments were conducted during 2009-2012. Three sites were treated in the year of planting plus the subsequent year (called "new plantings") and three sites were treated in their second year of growth plus the subsequent year (called "second-year plantings"). Ten treatments, delivered in 3,735 L ha^{-1} water, were administered each year: Devrinol at 3.36 kg ai ha^{-1} applied once, twice, thrice or once followed by (fb) one application of Callisto at 210 g ai ha^{-1}; Devrinol at 5.04 kg ai ha^{-1}applied once, twice or once fb one application of Callisto at 210 g ai ha^{-1}; Callisto at 210 g ai ha^{-1} applied once or twice; and nontreated. At new planting sites, plots receiving treatments other than a single Devrinol application had less total weed biomass compared to nontreated plots. At second-year plantings, all herbicide-treated plots had less total weed biomass than nontreated plots; in addition, plots receiving Callisto-only treatments had less total weed biomass than Devrinol-only treatments. Correlation analysis indicated that monocot biomass production was the primary positive predictor for total weed biomass. Herbicides did not adversely affect cranberry biomass production but overall vine colonization was poor for four of the six sites indicating that other factors, including cultivar choice, planting method, and water management, may play a larger role in rapid cranberry vine colonization than the suppression of initial weed biomass. Given the complementary range of efficacy for Devrinol and Callisto, a combination PRE-POST herbicide program of a low rate of Devrinol fb Callisto may be the most cost-beneficial program in many instances. If cost is a limiting factor, applying a single application of Callisto to a new planting should be included as a component of cranberry bed establishment since this practice consistently resulted in significantly less initial weed biomass compared to areas left nontreated.
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Big Data: Big Possibilities for the Cranberry Industry?

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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 very feasible to modify with reduced grower costs, such as through reducing pre- and post-season irrigation and flood events that result in saturated soil that reduces vine productivity. Other relationships were expected, such as a positive correlation between %N and fruit yield. Our next goals are to expand the initial pilot work, automate an analytical methodology that will be self-sustaining and refine cranberry production such that input levels are optimized for berry yield and quality.