## SCHEDULE OVERVIEW

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sunday June 22nd</strong></td>
<td>Guests arrive for pre-meeting winery tour on Monday</td>
<td></td>
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<tr>
<td><strong>Monday June 23rd</strong></td>
<td>Pre-meeting tour</td>
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<tr>
<td>9:00-5:15 pm</td>
<td>Registration</td>
<td>2nd Floor Atrium</td>
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<tr>
<td>4:30-6:30 pm</td>
<td>Welcome Social</td>
<td>Pearl Ballroom</td>
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<tr>
<td>5:30 pm</td>
<td>Dinner on your own</td>
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<tr>
<td><strong>Tuesday June 24th</strong></td>
<td>Registration</td>
<td>2nd Floor Atrium</td>
</tr>
<tr>
<td>7:30-9:00 am</td>
<td>Breakfast (included)</td>
<td>Pearl Ballroom 2-5</td>
</tr>
<tr>
<td>8:00-9:00 am</td>
<td>Welcome</td>
<td>Steel Pier</td>
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<tr>
<td>9:15-10:00 am</td>
<td>Paper Session I</td>
<td>Steel Pier</td>
</tr>
<tr>
<td>10:00-12:00 am</td>
<td>Viruses</td>
<td>Pearl Ballroom 2-5</td>
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<tr>
<td></td>
<td>Break</td>
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<td></td>
<td>Genetics &amp; Genomics</td>
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<tr>
<td>12:00-1:00 pm</td>
<td>Lunch (included)</td>
<td>Pearl Ballroom 2-5</td>
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<tr>
<td>1:00-4:40 pm</td>
<td>Paper Session I (continuation)</td>
<td>Steel Pier</td>
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<tr>
<td></td>
<td>Insect Pests</td>
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<td></td>
<td>Break</td>
<td>Pearl Ballroom 2-5</td>
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<tr>
<td></td>
<td>Blueberry Culture</td>
<td></td>
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<tr>
<td>5:30-7:30 pm</td>
<td>Wine and Cheese Mixer</td>
<td>Pearl Ballroom 1</td>
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<td></td>
<td>Poster Session and Meet with Sponsors</td>
<td>Pearl Ballroom 1</td>
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<tr>
<td>7:30 pm</td>
<td>Dinner on your own</td>
<td></td>
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<tr>
<td><strong>Wednesday June 25th</strong></td>
<td>Breakfast (included)</td>
<td>Pearl Ballroom 2-5</td>
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<tr>
<td>8:00-9:00 am</td>
<td>Paper Session II</td>
<td>Steel Pier</td>
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<tr>
<td></td>
<td>Blueberry History; Blueberry Weed Management and Phenology Prediction</td>
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<tr>
<td></td>
<td>Break</td>
<td>Pearl Ballroom 2-5</td>
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<tr>
<td></td>
<td>Breeding and Genetics</td>
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<tr>
<td>12:00-1:00 pm</td>
<td>Lunch (included)</td>
<td>Pearl Ballroom 2-5</td>
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<tr>
<td>1:00-3:40 pm</td>
<td>Paper Session II (continuation)</td>
<td>Steel Pier</td>
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<tr>
<td></td>
<td>Fungal Pests of Blueberry; Blueberry Extension</td>
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<tr>
<td></td>
<td>Break</td>
<td>2nd Floor Cave</td>
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<tr>
<td>3:40-4:40 pm</td>
<td>Business Meeting</td>
<td>Steel Pier</td>
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<tr>
<td>7:00 pm</td>
<td>Conference Banquet</td>
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<tr>
<td><strong>Thursday June 26th</strong></td>
<td>Loading of tour bus</td>
<td>Front of Hotel</td>
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<tr>
<td>7:30-8:00 am</td>
<td>Dinner (included)</td>
<td></td>
</tr>
<tr>
<td>8:00 am</td>
<td>Depart for tour</td>
<td></td>
</tr>
<tr>
<td>5:00 pm</td>
<td>Dinner (included)</td>
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</tbody>
</table>
PLANNING COMMITTEE

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PROGRAM

Sunday June 22\textsuperscript{nd}

Guests arrive for pre-meeting winery tour on Monday

Monday June 23\textsuperscript{rd}

Pre-meeting Tour of New Jersey Wineries

9:00  Tour will depart from Sheraton Hotel

Lunch will be provided

Tour and tasting of Renault Winery, Bellview Winery, Plagido Winery, and Amalthea Cellars

5:15  Return to hotel

4:30-6:30  \textbf{Registration}

5:30-7:30  \textbf{Welcome Social}

Sheraton Hotel, Pearl Ballroom

Snacks and refreshments

7:30  Dinner on your own
PROGRAM (CONTINUED)

Tuesday June 24th

7:30-9:00  Registration
8:00-9:00  Breakfast
9:00-9:15  Welcome: Dr. Bradley Hillman, Director of Research, New Jersey Agricultural Experiment Station.
9:15-10:00 Keynote Seminar

‘The History of the Commercial Blueberry Industry in New Jersey’

Mr. Joseph Darlington
5th generation blueberry and cranberry grower
PAPER SESSION I – Tuesday June 24th

Viruses
Moderator – James Polashock

10:00-10:20 VirFind – A new bioinformatics tool for virus detection and discovery using Next Generation Sequencing. Thien Ho and Ioannis E. Tzanetakis


10:40-11:00 Break

Genetics and Genomics

11:00-11:20 Genomics update on the tetraploid blueberry (Vaccinium corymbosum) linkage map and preliminary QTLs. Susan McCallum, Christine Hackett, Lisa J. Rowland, Nahla Bassil, Allan Brown, Jim Olmstead, Emily Buck, Jim Hancock, Chad Finn, Kelly Vining, and Julie Graham


11:40-12:00 Transcriptome analysis of the blueberry-mummy berry pathosystem. James Polashock, Kenneth Shim, and Tomasz Smolinski

12:00-1:00 Lunch
Insect Pests
Moderator – Cesar Rodriguez-Saona

1:00-1:20  Effect of propiconazole exposure to honeybees. Frank Drummond

1:20-1:40  Evaluating the efficacy and risk of insecticide rotation programs for management of Drosophila suzukii in southeastern blueberry production. Hannah Burrack and Jesse Hardin

1:40-2:00  The impact of spotted wing drosophila (Drosophila suzukii) on New Jersey blueberry IPM practices. Dean Polk, Gene Rizio, Caryn Michel, and Rebecca Meissner

2:00-2:20  Integrated pest management strategies to combat the invasive spotted wing drosophila. Oscar E. Liburd, Lindsey E. Iglesias, and Teresia W. Nyoike

2:20-2:40  Attraction of spotted wing drosophila to fruit volatiles. Cesar Rodriguez-Saona, John Abraham, and Aijun Zhang

2:40-3:00  Assessments of insecticide performance against spotted wing Drosophila for use in blueberry IPM programs. Rufus Isaacs, John Wise, and Steve Van Timmeren

3:00-3:20  Break

Blueberry Culture

3:20-3:40  Pre-harvest deficit irrigation effects on physiological parameters yield, fruit quality and antioxidants of Vaccinium corymbosum plants cv. Brigitta. Tomas Lobos, Jorge B. Retamales, Samuel Ortega-Farias, Maria de la Luz Mora

3:40-4:00  Evaluating field inputs for productivity and profitability in wild blueberry fields in Maine. David Yarborough and Jennifer Cote

4:00-4:20  Grow flushes and flower bud initiation on northern highbush blueberries. William Lindberg and Eric Hanson

4:20-4:40  Genetic diversity of Vaccinium angustifolium in managed and non-managed populations throughout its geographic range. Lee Beers, Jeannie Rowland, and Frank Drummond
POSTER SESSION AND MEET WITH SPONSORS – Tuesday June 24th

5:30-7:30 Wine and Cheese Mixer (Dinner on your own)

**Blueberry Culture**

Leonardite: a commercial source of humate. Erick D. Smith and James L. Jacobs

Effect of pruning severity and summer pruning on the growth of bush on ‘Misty’ southern highbush blueberry. Soo Gyeong Lee, Mi Hee Shin, Sung Bok Oh, Hong Lim Kim, and Jin Gook Kim

Pre- and post-emergence applications of herbicides for control of resistant fineleaf sheep fescue in wild blueberry fields in Maine. David Yarborough and Jennifer Cote

Safeguarding the blueberry industry through the National Clean Plant Network and Harmonized Nursery Certification Guidelines. Ioannis Tzanetakis and Rose Gergerich

Winter injury in northern highbush blueberry in Michigan. Mark Longstroth and Carlos Garcia-Salazar

**Blueberry Pollinators**

A pollination toolbox for wild blueberry growers. Frank Drummond, Kourtney Collum, Sam Hanes, Michael Wilson, and John Skinner

Flower morphology influences pollinator community with implications for cross-pollination: Observations in rabbiteye blueberry (Vaccinium ashei Reade). Hannah Burrack, David Tarpy, and Shelley Rogers

Assessing the status of commercial highbush blueberry pollination. Rufus Isaacs, Jason Gibbs, Elizabeth Elle, Cory Stanley-Stahr, Jamie Ellis, Jaret Daniels, Sujaya Rao, and George Hoffman
**Blueberry Breeding**

Highly fertile intersectional blueberry hybrids between *Vaccinium padifolium* Section *Hemimyrtillus* and *V. corymbosum* Section *Cyanococcus*. M.K. Ehlenfeldt and J.J. Polashock

Enabling ‘Fast-track’ blueberry breeding. Guo-qing Song, Aaron Walworth, James F. Hancock, and Vance Baird

The Michigan State University stable of northern highbush blueberry cultivars. Jim Hancock and Pete Callow

**Post Harvest**

Effect of pre-harvest deficit irrigation on post-harvest quality of *V. corymbosum* fruits cv. Brigitta. Tomas Lobos, Jorge B. Retamales, Samuel Ortega-Farias, and Maria de la Luz Mora

Development of internal browning of highbush blueberries (*Vaccinium corymbosum*), subjected to mechanical damage. Claudia Moggia, Guillermina González, and Gustavo A. Lobos

Influence of preharvest calcium-chitosan treatment on fruit quality and storage ability of ‘Duke’ blueberry. Hong Lim Kim, Yong Bum Kwack, Seong Cheol kim, Mok Jong Kim, and Jin Gook Kim

Fruit position and ripening affects blueberry postharvest fruit quality. Gustavo A. Lobos and Claudia Moggia

**Blueberry Genomics**

Elucidating cold acclimation pathway in blueberry by transcriptome and proteome profiling. Jose V. Die and Lisa J. Rowland

Next generation sequencing of rabbiteye blueberry (*Vaccinium virgatum* ‘Premiere’) and transcriptome comparisons to highbush (*Vaccinium corymbosum*) genomic resources. Timothy A. Rinehart
8:00-9:00  Breakfast at hotel

Blueberry History
Moderator – Nicholi Vorsa

9:00-9:30  Coville’s serendipitous association with blueberries leading to the Whitesbog connection. Charles M. “Mike” Mainland and Dr. Frederick V. Coville

Blueberry Weed Management and Phenology Prediction

9:30-9:50  Improvements in vegetation management practices in wild blueberry (Vaccinium angustifolium Ait.) associated with the use of spectral and precision agriculture technologies. David Percival, Gary Brown, and Thomas Harrington

9:50-10:10  Prediction of key phenological stages for NJ blueberries using climatological data. Peter Oudemans, Vera Roth, and Robert Muldowney

10:10-10:30  Break

Breeding and Genetics

10:30-10:50  Vaccinium elliottii and its use in breeding tetraploid highbush blueberries. Paul Lyrene

10:50-11:10  Self-fruitfulness of Rutgers advanced blueberry breeding selections. Nicholi Vorsa and Jennifer Johnson-Cicalese

11:10-11:30  Breeding southern highbush blueberries suitable for machine harvest for fresh marketing – progress and prospects. James Olmstead, David Norden, Werner Collante, and Paul Lyrene

11:30-11:50  Utilizing V. constablaei and V. ashei in germplasm and cultivar development. Mark K. Ehlenfeldt and Lisa J. Rowland

12:00-1:00  Lunch
**Fungal Pests of Blueberry**
Moderator – Gary Pavlis

1:10-1:30  Exobasidium leaf and fruit spot of blueberry in the southeastern United States. W.O. Cline, M.T. Brewer, P.M. Brannen, and H. Scherm

1:30-1:50  Causal agents of blueberry cane canker and twig blight in Michigan blueberry fields. Kasey Clemens, Annemiek Schilder, and Eric Hanson

1:50-2:10  Improved management of *Monilinia vaccinii-corymbosi* in lowbush blueberry in Maine. Seanna Annis

**Blueberry Extension**

2:10-2:30  Initial identification of issues with spray coverage in south Georgia blueberries. Renée Holland, Glen Rains, and Phil Brannen

2:30-2:50  Break

3:00-3:20  Expanding the vision for blueberry Extension. Eric T. Stafne, Kimberly Morgan, and Gary Pavlis

3:20-3:40  Advances in Organic Blueberry Management. Bill Sciarpapa

3:40-4:40  Business Meeting

7:00  Conference Banquet

Angelos Fairmount Tavern, Atlantic City, NJ.

Special guest Dinner Speaker

Denny Doyle

‘The Worldwide Blueberry Market’
FIELD TOUR – Thursday June 26th

8:00  Departure from hotel
9:00-9:30  Breakfast at P.E. Marucci Center for Blueberry & Cranberry Research & Extension, Chatsworth, NJ.
9:30-11:30  P.E. Marucci Center Field Tours
12:00-2:00  Whitesbog, Pemberton, NJ
           Birthplace of the Blueberry Industry in New Jersey
           Tour and Lunch
3:00-4:30  Mortellite Blueberry Farm and Packing House, Hammonton, NJ
           Theme ‘Food Safety’ – Wesley Kline, Rutgers Coop. Ext., County Agent
5:00  Dinner
     Tomasello Winery, Hammonton, NJ
     Tour vineyards. Barrel tasting room

Special Guest Dinner Speaker

Mark Dimitroff

‘Sugar Sand Opportunity: Landscape and People of the Pine Barrens’
VirFind – A new bioinformatics tool for virus detection and discovery using Next Generation Sequencing

Thien Ho*, Ioannis E. Tzanetakis
University of Arkansas, Department of Plant Pathology, Fayetteville, AR USA

Next generation sequencing (NGS) has revolutionized virology with many novel viruses discovered using platforms such as pyrosequencing and Illumina dye sequencing. A dedicated bioinformatics tool is necessary for the plant virology community, and VirFind was developed for this purpose. This is a pipeline that can (1) accept NGS or Sanger sequencing data, (2) map raw reads to reference genomes to filter out host sequences, (3) produce output files of additional host and virus reads with taxonomy and their corresponding Blastn and Blastx reports, and (4) perform conserved domain search with reads of unknown origin. To demonstrate its ability, we used VirFind to process more than 30 barcoded and multiplexed samples sequenced by either Illumina or 454 platforms resulting in the detection of all viruses known to infect the samples, the extension of the genomic sequences of three others, and the discovery of seven novel viruses. VirFind was tested by four independent external users with seven different datasets from plants or insects, demonstrating its potential to be used as a public and universal virus detection and discovery tool. VirFind is available at [http://virfind.org](http://virfind.org)
Molecular characterization and population structure of blueberry mosaic associated virus

Thekke-Veetil, T1*, Polashock, J2, Marn, M.V3, Plesko, I.M3, Keller, K.E4, Martin, R.R4, Annemiek Schilder5, Ho, T1 and Tzanetakis, I.E1

1Department of Plant Pathology, Division of Agriculture, University of Arkansas System, Fayetteville, AR 72701, USA; 2Marucci Center for Blueberry and Cranberry Research & Extension, Chatsworth, NJ 08019, USA; 3Agricultural Institute of Slovenia, Hacquetova 17, Ljubljana, Slovenia; 4USDA-ARS, Corvallis, OR 97330, USA, 5Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI 48824

Blueberry mosaic disease was first described several decades ago and the causal agent has not been characterized to date. Next generation sequencing using a mosaic-infected plant revealed the presence of an undescribed ophiovirus, tentatively named as Blueberry mosaic associated virus (BIMaV). Reverse transcription PCR using the primers developed from the genome of BIMaV detected the virus in 59 symptomatic samples collected from various blueberry growing regions in the United States, Canada, and Slovenia. The segmented genome of BIMaV is comprised of three single-stranded negative-sense RNAs (RNAs 1-3) encoding four proteins. The RNA 1 in the positive sense encodes a 23 kDa protein with very low identity to other viral proteins and a RNA dependent RNA polymerase. The RNAs 2 and 3 putatively encode movement protein (MP) and a nucleocapsid protein (NP) respectively. The population structure of BIMaV isolates was analyzed using the MP and NP open reading frames. The data revealed considerable sequence conservation in both proteins which are under strong purification selection. The information gathered will lead to the development of universal detection assays for BIMaV.
Genetics and Genomics

Genomics update on the tetraploid blueberry (Vaccinium corymbosum) linkage map and preliminary QTLs

Susan McCallum1*, Christine Hackett2, Lisa J. Rowland3, Nahla Bassil4, Allan Brown5, Jim Olmstead6, Emily Buck7, Jim Hancock8, Chad Finn9, Kelly Vining10 and Julie Graham1

1The James Hutton Institute, Cell and molecular genetics, Invergowrie, Dundee, Scotland; 2 Biomathematics and Statistics Scotland, Invergowrie, Dundee, Scotland; 3 USDA-ARS, Genetic Improvement of fruits and Vegetables Laboratory, Beltsville MD; 4 USDA-ARS, National Clonal Germplasm Repository, Corvallis, OR; 5 North Carolina State University, Department of Horticultural Science, Plants for Human Health Institute, Kannapolis, NC; 6 University of Florida, Institute of Food and Agricultural Sciences, Gainesville, FL; 7 The New Zealand Institute for Plant & Food Research Ltd (PFR), Palmerston North, New Zealand; 8 Michigan State University, E Lansing, MI; 9 USDA-ARS, Horticultural Crops Research Lab, Corvallis, OR; 10 Oregon State University, Center for Genome Research and Biocomputing, Corvallis, OR.

A genetic framework for future crop improvement is required to develop a thriving and sustainable blueberry industry. The genetic component of this project aims to build on the statistical developments derived from the software programmes TetraploidMap and JoinMap 4 to produce a genetic linkage map and identify fruit quality, health and agronomic related quantitative trait loci (QTL) in tetraploid blueberry. A mapping population of 94 progeny developed from two key US blueberry cultivars (Draper x Jewel) segregating for a number of important phenotypic traits (eg time to fruiting, plant habit, and fruit quality) has been utilised. A plethora of markers have been assessed including those derived from a microsatellite enriched genomic library (SSRs) as well as those constructed from expressed sequence tag libraries (EST-SSRs). Genotyping by sequencing (GbS) technologies have recently been developed in this reference mapping population which has generated thousands of additional SNPs across the blueberry genome. The high quality GbS SNPs which were suitable for linkage analysis (1135) were combined with EST-PCR and SSR markers generated from other technologies (181) to develop a draft linkage map with higher marker density and improved genome coverage. QTL for berry weight and total soluble solids (°Brix) evaluated over three different seasons in Scotland were then putatively identified. Implementation of marker assisted breeding, which links easily identifiable markers to complex traits requiring extensive field evaluations, can yield defined improvements in fruit quality across the cropping season in harmony with developments of disease resistances and agronomic traits.
A genetic linkage map has been constructed from an interspecific diploid blueberry population [(**Vaccinium darrowii** Fla4B x **V. corymbosum** W85-20) F₁ x **V. corymbosum** W85-23] designed to segregate for cold hardiness and chilling requirement. The map is comprised of 12 linkage groups (equivalent to the basic chromosome number of diploid blueberry) and totals 1448.7 cM. Included on the map are 280 markers based on expressed sequence tag-polymerase chain reactions (EST-PCRs), simple sequence repeats (SSRs), single nucleotide polymorphisms (SNPs), and randomly amplified polymorphic DNAs (RAPDs). The estimated map coverage is 85.7%, and the average distance between markers is 5.6 cM. The mapping population was evaluated for two years (2009 and 2010) for mid-winter bud cold hardiness and for three years (2011-2013) for chilling requirement under controlled conditions. Broad sense heritability of both cold hardiness and chilling requirement were high under these conditions with values of 0.88 and 0.86, respectively. One QTL for cold hardiness and one for chilling requirement were identified that were consistent over at least two years. A second weaker QTL for chilling requirement was detected in only one of the three years.
Transcriptome analysis of the blueberry-mummy berry pathosystem

James Polashock¹*, Kenneth Shim², Tomasz Smolinski²

¹USDA-ARS, Chatsworth, NJ; ²Delaware State University, Dover, DE.

Mummy berry disease of blueberry, casual agent Monilinia vaccinii-corymbosi, has two distinct phases- a blight stage of young foliage and flowers and a flower infection stage that leads to mummified fruit (pseudosclerotia). The flower infections stage requires conidia to germinate on the style and grow down the stylar canal and into the ovary. The cultivar Berkeley is very susceptible to the mummy berry fruit infection stage while the cultivar Bluejay is resistant. We reasoned that the resistance/susceptibility reaction might be 'expressed' in the style. Open flowers of both cultivars were pollinated with ‘Bluecrop’ pollen and inoculated with mummy berry conidia. Total RNA was isolated from the styles two days post pollination/inoculation. RNASeq libraries were prepared and sequenced using the Illumina HiSeqII platform. The resulting sequences were then quality- and adapter-trimmed with open-source software ‘cutadapt.’ Sequences were assembled using Velvet. This produced 37,354 contigs for ‘Bluejay’ and 36,202 for ‘Berkeley’ of the length of at least 200 nucleotides. The sequences were then BLASTed against the NCBI’s nucleotide database (blastn), which yielded 33,184,648 and 21,143,803 ‘hits’ for the two varieties, respectively. The hits were then mapped to their respective taxonomies. The data generated will help determine the key genes involved in the plant-pathogen interaction.
Insect Pests

Effect of propiconazole exposure to honeybees

Frank Drummond*
University of Maine, Orono, Maine.

A field experiment conducted over a three-year period (2011 - 2013) was designed to assess honeybee colony level effects of propiconazole exposure when foragers visited wild blueberry flowers. This experiment was a whole field experiment (paired: 1 field treated, 1 field not treated) testing residues of propiconazole on flowers under typical pest management applications. In all years, isolated non-sprayed fields and isolated treated fields were selected to place a set of colonies (range 10-20 colonies per field in a year) in each field throughout bloom (period of 1 month). Colonies were monitored every 2-4 weeks both during and after bloom throughout the spring and summer. Propiconazole concentrations in pollen and flowers, colony worker population, brood population, queen presence and health, queen egg laying rate, larval survival, worker longevity, hypopharyngeal gland size, and disease and parasitic mite prevalence were measured. I found that honeybee health effects of the commonly used fungicide, propiconazole, were not entirely consistent between years. Although I conclude that negative effects were documented. I found that overall exposure of honeybee foragers to residues on flowers does not reduce colony strength of worker or capped brood populations. Queen laying and capped brood survival also does not appear to be affected by exposure to sub-lethal doses of this fungicide. I did find evidence in all years to suggest that workers reared as larvae during bloom result in young nurse bees whose longevity is reduced, that neuroendocrine gland morphology is impacted, and that propiconazole might be repellent to foraging bees.

Evaluating the efficacy and risk of insecticide rotation programs for management of Drosophila suzukii in southeastern blueberry production

Hannah Burrack*, Jesse Hardin
Department of Entomology, North Carolina State University, Raleigh, NC USA.

Drosophila suzukii, frequently referred to as the spotted wing drosophila, was first detected in the southeastern United States in 2009, and in the subsequent years has become the most significant insect pest of cultivated berries, including blueberries. Female D. suzukii begin to attack soft-skinned fruit as they ripen by laying eggs just under the surface. The resulting larvae feed internally, damaging and contaminating fruit. There is zero tolerance for D. suzukii infestation in fresh market fruit, and vast majority of the blueberries grow in North Carolina are marketed fresh. Because of continuous high D. suzukii that may be present during harvest and the extreme risk associated with any infestation, growers have resorted to at least weekly insecticide applications beginning when fruit ripen and ceasing at the end of harvest. This management strategy necessitates the use of multiple insecticides, in a rotational management program. During 2013 and 2014, we have compared the efficacy of three candidate insecticide programs in blueberries and assessed associated potential risks, including pesticide residues and potential post-harvest non target impacts.
The impact of spotted wing drosophila (*Drosophila suzukii*) on New Jersey blueberry IPM practices

Dean Polk1*, Gene Rizio2, Caryn Michel1, Rebecca Meissner1
1Rutgers Cooperative Extension, Chatsworth, NJ, USA; 2Rutgers Cooperative Extension of Atlantic County, Mays Landing, NJ, USA, Retired.

Blueberry IPM programs for insect management had evolved to manage several key post bloom pests, most notably aphids and blueberry maggot. In recent years (2005-11), the use of scouting and spatial treatments, along with reduced risk insecticides produced programs which reduced insecticide use by more than 50% compared to standard whole farm calendar based sprays. There is a “0” tolerance for fly larvae in fruit, and spotted wing drosophila (SWD) can only be controlled with frequent OP, carbamate, pyrethroid, and spinosyn (+ Cyazypyr) insecticides. The need for frequent treatments of broad spectrum insecticides for SWD has led to decreased monitoring for other pests, along with a steady increase of insecticide use, both in terms of the number of applications and amount of a.i. used per acre. The use of the reduced risk neonicotinoid insecticides has decreased, while organophosphate and pyrethroid use has increased. The use of the reduced risk spinetoram (Delegate) has increased. The intense management required for SWD control has also led to increased labor costs for spraying and for monitoring harvested fruit.

Integrated pest management strategies to combat the invasive spotted wing drosophila

Oscar E. Liburd*, Lindsy E. Iglesias and Teresia W. Nyoike
Entomology and Nematology Department, University of Florida, Gainesville, Florida USA.

The spotted wing drosophila (SWD) *Drosophila suzukii* (Matsumura) is a relatively new invasive pest of soft skinned fruits in mainland United States. Adult flies oviposit in ripening fruits and the larva develops inside the fruit rendering it unmarketable. We investigated the movement of spotted wing drosophila (SWD) *Drosophila suzukii* (Matsumura) from adjacent wild host into southern highbush blueberry plantings using transparent deli cup traps baited with apple cider vinegar (ACV). Traps were deployed either on the perimeter or in the center of the blueberry planting at several locations throughout Florida. Traps were serviced weekly by emptying the contents into a collecting jar and replacing the baiting liquid (ACV). The number of SWD as well as other Drosophilids found in the traps was recorded in the laboratory with the aid of a dissecting microscope. In another study to identify additional tools that growers can use to manage SWD population, the efficacy of various insecticides from different classes was evaluated in a rotational program against SWD in a field test. Insecticides were applied at manufacturer’s recommended rates every 10-14 days beginning at ‘full green’ to the end of harvest. Approximately 4 rotations were used and insecticides were applied using an air-blast sprayer. All of the insecticides used in the rotational program performed well including those pesticides labelled for organic use. However, when individual pesticides were screened against SWD in the laboratory we recorded differences in the efficacy of various pesticides. IPM tactics including effective monitoring and the use of rotational sprays is discussed as a potential management program for SWD in southern highbush blueberries.
Attraction of spotted wing drosophila to fruit volatiles

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Native to Southeast Asia, the spotted wing drosophila (SWD), Drosophila suzukii, is a new invasive insect pest in the USA causing an increasing amount of damage to soft-skinned fruit crops such as blueberries, cherries, raspberries and strawberries. Unlike most other drosophilid species, SWD attacks ripening fruit. Current management programs rely heavily on chemical control. Here, we conducted studies to: a) investigate the behavioral and electroantennographic (EAG) responses of adult D. suzukii to volatiles from blueberry, cherry, raspberry, and strawberry fruit extracts; b) identify the antennally-active compounds from a highly attractive extract (raspberry) using gas chromatography-mass spectrometry (GC-MS) and coupled GC-electroantennographic detection (GC-EAD); and, c) test a synthetic lure containing the EAG-active compounds identified from the raspberry extract on adult attraction. Volatiles from all four fruit extracts were attractive to female and male D. suzukii in olfactometer studies and elicited strong EAG responses, with responses ranked as: raspberry ≥ strawberry > blueberry ≥ cherry. Principal component and GC analyses showed that the fruit extracts emit distinct volatile profiles. In GC-EAD experiments, 11 volatiles from the raspberry extract consistently elicited antennal responses in D. suzukii. In choice test bioassays, a synthetic lure containing the EAG-active blend in mineral oil attracted ~3 times more D. suzukii than control (mineral oil alone) lures. To our knowledge this is the first report of a behaviorally- and antennally-active blend of host-fruit volatiles attractive to D. suzukii, which offers promising opportunities for the development of improved monitoring tools.

Assessments of insecticide performance against spotted wing Drosophila for use in blueberry IPM programs

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In the past few years, spotted wing drosophila (Drosophila suzukii Matsumura) has become the dominant insect pest of blueberry production across the major northern hemisphere production regions. There has been a rapid response from research and extension programs as well as from growers and processors to address this significant new challenge, yet management of this pest is still dependent on insecticides to prevent infestation of fruit. This presentation will review current methods being used to evaluate the performance of insecticides against D. suzukii and will highlight North American rankings of insecticides for this pest based on the expert opinion of the WERA-1021 committee.
Blueberry Culture

Pre-harvest deficit irrigation effects on physiological parameters yield, fruit quality and antioxidants of *Vaccinium corymbosum* plants cv. Brigitta

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One of the most dramatic consequences of climate change is the low availability of water for agriculture. Irrigation is critical in highbush blueberries throughout the production season, especially during fruit development. Deficit irrigation (DI) has been used successfully in many fruit crops to conserve water without reducing yield, and in some cases, increasing fruit quality. The aim of this study was to determine the effect of DI on plant water relations, yield, and fruit quality of highbush blueberry cv. Brigitta. Six-year-old blueberry plants located in Colbún, Maule Region (Chile, lat. -35.686932, long. -71.4187), were subjected to four irrigation regimes according to crop evapotranspiration (ETc): 50, 75, 100 (control) and 125%. The effects of DI management were measured throughout the 2013-2014 production season. The results indicated low membrane lipid peroxidation content with 100, and 125% ETc. In addition, DI treatments affected berry quality but not shoot growth. The 75%, 100% and 125% ETc treatments resulted in similar yield and fruit quality (firmness, fruit size, titratable acidity, soluble solids and berry weight, antioxidant activity. The 50% ETc treatment resulted in higher water stress with higher membrane lipid peroxidation, low fruit quality (10 and 24% less size and berry weight compared to the control treatment) and antioxidant activity (29 and 23% less than control in DPPH and ORAC values).

Evaluating field inputs for productivity and profitability in wild blueberry fields in Maine

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The goal of the project was to provide growers with information on how different management systems affect the crop, its environment and the ecological and economical sustainability of blueberry production. A critical issue affecting growers is how to optimize increasingly expensive inputs to achieve economically and environmentally sustainable yields. We conducted a multi-disciplinary large-scale study of four cropping systems; organic, low, medium, and high that fit along gradients of capital inputs and potential environmental effects and quantify system effects on yield, fruit quality, pest communities, the environment, and economic effects of inputs. In the 2010-2012 cycle two fields per cropping system for a total of 8 fields, in 2011-2013 four fields per cropping system for a total of 16 fields. Leaf and soil samples were taken in the non-bearing year and weeds and blueberry were evaluated in June and July. Harvest on the organic and low input sites were by hand-rake and on the medium and high by mechanical harvester. There was large variation between years and locations. Leaf fertility levels were highest with high input site with N, P and B much higher and on the organic site leaf levels for N, P deficient but Ca higher. Weeds were highest in organic and low input system. Yields were highest in high input but with higher costs not most profitable. Data from both years verify trends that medium system was the most profitable. Low input fields were not profitable on most sites and organic yields lowest but with higher fruit value were profitable.
Grow flushes and flower bud initiation on northern highbush blueberries

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Highbush blueberries can produce multiple flushes of shoot growth depending on the cultivar and growing conditions. Each flush ceases with the abortion of the apical meristem and subsequent flushes initiate from axillary buds distal to the apical meristem. The purpose of this experiment was to describe the chronology of shoot growth flushes and to determine if the timing of flushes is related to the number of flower buds produced. Young plants of ‘Duke’, ‘Draper’, and ‘Liberty’ were monitored during an early, warm growing season (2012) and cooler later season (2013). The time of shoot growth initiation and termination, final shoot length, and flower bud numbers were recorded on eight plants of each cultivar. The first and second flushes occurred from May to July and accounted for the majority of growth. In 2012, the majority of flower buds developed on secondary shoots, whereas in 2013 the majority of flower buds were located on primary shoots. One hypothesis is that floral induction in blueberries occurs within 6 weeks following growth cessation. If this is true, the observed pattern of shoot growth creates a lengthy floral induction period starting as early as late June. We also observed that primary shoots that supported secondary flushes developed fewer flower buds than those that did not re-flush.

Genetic diversity of Vaccinium angustifolium in managed and non-managed populations throughout its geographic range

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Lowbush blueberry (Vaccinium angustifolium Aiton) can be found over a large geographic range that spans from Quebec south to North Carolina and from Nova Scotia west to Manitoba. Despite the large range, commercial harvesting of berries is primarily located in Maine, Quebec, and the Canadian Maritimes. The genetic diversity of this crop has never been evaluated over a large geographic area. EST-PCR molecular markers developed for use in highbush blueberry (Vaccinium corymbosum) were used to screen 202 lowbush blueberry clones from wild, non-managed populations in Virginia, West Virginia, Pennsylvania, New York, Vermont, Massachusetts and Maine. Managed populations were also evaluated in Maine including three paired managed/non-managed populations. Genetic relatedness between populations was assessed by analysis of molecular variance (AMOVA) and principal coordinates analysis (PCA). Spatial autocorrelation was used to identify any spatial structure. Paired populations were compared using multiple blocked paired permutations (MBPP) and multivariate analysis of variance (perMANOVA). Finally, population structure was assessed using Bayesian clustering methods. In all sampled populations the majority of the variance can be assigned to within the populations. Each population is highly diverse with each individual being unique with very little genetic similarity with other individuals in that population. As populations become spatially separated, spatial structure appears around 12km but is not evident after 100km. Among the sampled paired populations, the managed populations had fewer loci represented than their non-managed counterparts. No population structure was found among the sampled populations.
Blueberry History

Coville’s serendipitous association with blueberries leading to the Whitesbog connection

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What led up to the association between Frederick Coville and Elizabeth White? This 26 year association began in 1911 and continued until his death in 1937. The commercial highbush blueberry industry was born and became established during this period. Frederick Vernon Coville was born March 23, 1867 in Preston, NY, graduated from Cornell in 1887 and was hired by the US Department of Agriculture as a botanist in 1888. His USDA office, labs and greenhouses were in downtown Washington, D.C. Washington’s urban environment was the first of a number of key circumstances that influenced and hastened blueberry domestication and commercialization. Coville was concerned that his four children (Stanley 11, Katherine 9, Cabot 3 and Frederick 2) would never learn the rural skills that he had acquired in his childhood in central New York. This concern was addressed by spending several summer vacations in rural areas of New England. A geologist friend in Washington, Arthur Keith, told him about a farm, next to his parent’s farm, that was for sale near Greenfield, NH. The Covilles bought the 40 acre, former Alexander property, on May 2, 1905. The second key factor was the abundant blueberry populations of both highbush and lowbush that flourished in the surrounding fields. In 1906, less than a year after coming to Greenfield, Coville said: “that his interest was attracted to the subject of blueberry culture”. Previous attempts by others at establishing plantings had generally been unsuccessful. Coville collected seeds in 1906 and a colleague, George W. Oliver, began germination trials that fall. In 1907 Coville began greenhouse studies in Washington on the requirements for growing blueberries. When he returned to Greenfield in 1908 he brought and planted 179 seedlings that had been grown in Washington. Survival was 97% following a dry summer on the low-pH blueberry soil. The first outstanding bush for using in crosses was selected in July of 1908 in a pasture of his neighbor, Fred Brooks, for whom it was named. This was a very fortunate find, with many berries over 0.5 inches in diameter and with excellent flavor. Brooks became a parent or in the parentage of 13 of the first 15 USDA releases. In the short span of time from 1906 to 1910 he determined that blueberries require a moist but not wet soil and most importantly a low pH. Also determined were nutrient requirements, winter chilling importance, propagation techniques, breeding procedures including self-sterility and seedling management. All of this information was published in the 101 page Experiments in Blueberry Culture, USDA Bul.193, Nov. 15, 1910. The Whitesbog connection began in Jan. 1911 after Elizabeth White had read Experiments in Blueberry Culture and written to the USDA offering land and assistance. Commercialization followed this final indispensable key.
Blueberry Weed Management and Phenology Prediction

Improvements in vegetation management practices in wild blueberry (Vaccinium angustifolium Ait.) associated with the use of spectral and precision agriculture technologies

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Vegetation management trials were conducted during 2013 and 2014 with the use of 21, WeedSeeker® Model 650 sensors and associated control system used in tandem with a John Deere Starfire™ receiver and GreenStar™ 3 2630 display. Emphasis was placed on developing technologies for use in wild blueberry (Vaccinium angustifolium Ait.) production that apply pest control products in a precise manner only to targeted areas of interest. When herbicides were applied prior to the emergence of the wild blueberry shoots, competing vegetation was kept to a minimum with a fraction of the herbicide being used compared to plots that had treatments applied to the entire surface area (i.e., blanket application of a treatment). Similarly, when herbicides were applied post blueberry leaf drop in the autumn, excellent weed control was attained with herbicide usage reliant upon weed coverage present. The weeds that were most common in the field sites examined included sheep sorrel (Rumex acetosella), goldenrod (Solidago canadensis and Euthamia graminifolia), black bulrush (Scripus atrovirens), fescue grasses (Festuca spp.) and poverty oat grass (Danthonia spicata). In addition to providing an effective overall weed management tool and reduced herbicide usage, the system also provided a more effective and reduced risk means of controlling difficult to manage weed species (e.g., Festuca spp.).
Prediction of key phenological stages for NJ blueberries using climatological data

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Knowledge on timing of blueberry development can assist greatly with spray timing, introduction of honeybees for pollination and hiring labor for harvest. Traditionally the prediction of the phenology was based on experience and was not quantitative. In this paper we describe the collection, analysis and application of a 10-year data set that includes detailed phenological records coupled with climatological data to identify timing of key phenological events in blueberry development. For plant development we measured 5 stages of inflorescence bud break, open flowers, petal drop, and development of blue fruit, as well as shoot length. Weather stations located near the sites of data collection provided a suite of climate variables including air temperature. For the analysis we identified three key developmental stages: T3 Bud break which corresponds with the earliest disease management timing, open bloom which corresponds with pollination, and harvest date. Two varieties, Duke and Bluecrop showed very similar timing for T3 and open bloom, however Bluecrop was consistently later than Duke in terms of fruit ripening. Results demonstrate that the timing of the three key phenological stages follow a degree-day model using a base of 4.44°C (40°F). Using this data set we were not able to predict either the duration nor end of the bloom period. On average peak T3 in both Duke and Bluecrop occurred after ~320dd, bloom after ~585dd and Duke harvest began after ~1830dd. The information is provided to the general public via a website http://benedick.rutgers.edu/Blueberryweather/index.php.
Softwood cuttings from 80 seedlings of *Vaccinium elliottii* Chapman., which were 2 to 4 m tall, were collected from a 3-mile stretch along Perone Creek, in southwestern Alabama, 3 miles west of Silverhill, in August, 2013. Five cuttings were taken from each plant. Overall rooting success under mist in a greenhouse was over 90%. In February and March, 2014, 15 genotypes of cultivated tetraploid southern highbush blueberry growing in 10-liter pots, which were leafless, having been previously chilled, were placed in a bee-proof greenhouse. Approximately 200 unopened flowers on each plant were emasculated and pollinated with *V. elliottii* pollen. Thirty different *V. elliottii* clones were used as pollen sources. Except for a few highly-parthenocarpic plants, fruit set on the highbush ranged from 2.9% to 5.5%. Most of the first berries that ripened had from 0 to 2 well-developed seeds per berry. The low crossing success, similar to crosses made previously by various workers between tetraploid highbush cultivars and diploid *V. elliottii*, is likely due to a strong triploid block. The 80 *V. elliottii* clones, growing in 10-liter pots, were placed in a group outside the greenhouse in late January. Most of the plants flowered, but bee activity was very low, and fruit set was less than 50%. The first berries, which ripened during the first half of April, were small (about 0.3 grams) but had the rich aromatic flavor characteristic of *V. elliottii* from the western Florida panhandle and adjacent southwest Alabama.
Self-fruitfulness of Rutgers advanced blueberry breeding selections

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The Rutgers highbush blueberry breeding program is focused on the development of machine-harvestable varieties for the fresh market. New Jersey growers have relied largely on available migrant hand-labor for harvest. Increasing restrictions on management options, e.g., labor availability, increased pesticide re-entry periods, etc., have placed additional burdens on farm sustainability, making machine-harvestable fresh fruit varieties highly desirable. Another required trait in a new variety is self-fruitfulness. In large blocks of a single cultivar, most ova are self-fertilized, resulting in high seed abortion, resulting in reduced fruit set and size. Thus, many if not most highbush blueberry cultivars do not achieve maximum production in large single cultivar plantings, where self-fertilization predominates. Unfortunately, due to the high varietal diversity in typical breeding blocks, virtually all blueberry breeding programs measure fruitfulness in a fairly cross-pollinated environment. Therefore, we are now evaluating the self-fruitfulness of our machine-harvestability selections in controlled greenhouse crosses. This study evaluated 30 progeny (selections), representing 15 crosses, for self-fruitfulness in the greenhouse, as measured by fruit size, ripening period and fruit set. Respective flower clusters were pollinated with either the selection’s own pollen or pollen from ‘Sierra’, ‘Bluecrop’, or unrelated selections. Cross-pollinated flowers typically yielded larger, earlier ripening fruit for most selections. Relative to cross-pollinated clusters, fruit set was reduced, and fruit ripening was delayed by an average of 3 to 4 days and fruit size reduced by an average of 18% in self-pollinated clusters. However, self-fruitfulness varied widely among the 30 selections, with some exhibiting only a small effect, and others exhibiting a severe reduction in size, delayed ripening and reduced fruit set. Variation for self-fruitfulness between progeny of a given cross was also observed; reduction in fruit size with self-pollination ranged from 7 to 59% and ripening was delayed from 2 to 23 days. A second year of data is now being collected on these selections, including seed set counts, an important determinate of fruit size. In conclusion, a number of selections appeared to have comparable fruit set, fruit size and ripening season under self-pollination versus cross-pollinated flowers, making them good candidates for commercial production. However, a few of our selections exhibited severe self-unfruitfulness and would likely be unsuitable for the commercial grower.
Breeding southern highbush blueberries suitable for machine harvest for fresh marketing – Progress and prospects

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As worldwide production of southern highbush blueberries grows, concern about shrinking marketing windows, reduced labor availability and higher production costs have led to increased producer interest in machine harvest for fresh market (MFF) production. Producers in the southeastern U.S. have made breeder for MFF a priority in recent years. Beginning in 2009, a series of federal- and state-funded projects were initiated that led to the identification and characterization of key traits for MFF, and the subsequent integration of these into the University of Florida blueberry breeding program. The focus of much of the early crossing efforts has been to increase the prevalence of crisp fruit texture in the southern highbush breeding germplasm. Trained panels were used to develop descriptors for crisp blueberry fruit texture, and instrumental measurements were correlated with the descriptors. A FirmTech 2 measurement of over 250 g·mm\(^{-1}\) compression force was significantly correlated (R=0.72-0.81) with crisp texture, and can be used to quantify breeding selections. In 2013, ‘FL98-325’ (Indigocrisp™) was released based in part on MFF trial results. Indigocrisp™ is an early maturing southern highbush cultivar that is expected to complement existing later-maturing cultivars suitable for MFF. Currently, over 200 breeding selections having crisp fruit texture have been planted in two locations in Georgia and Florida for MFF evaluation.

Utilizing V. constablaei and V. ashei in germplasm and cultivar development

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An ongoing project has pursued the goal of incorporating the cold hardiness and late bloom of V. constablaei into a form that might be suitable for northern growers. Experimentation suggested that combining V. constablaei with V. ashei would allow the best aspects of both of these germplasms to be derived in an easily usable form. Such hybrids derive late bloom and cold hardiness from V. constablaei as expected, and many aspects of vigor from rabbiteye, but additional characters from both parents must be optimized to produce cultivar-quality material. The first commercial product of this introgression is the variety ‘Nocturne’, which achieves the majority of the goals desired in combining these germplasms. ‘Nocturne’ however is dark-fruited and is unlikely to achieve success as a mainstream cultivar. Among more advanced breeding populations, additional strategies have been implemented to enhance the recovery of commercially acceptable types. Season of ripening, bush form, cold hardiness, fertility, and fruit quality are among the issues involved in furthering the use of this material.
Fungal Pests of Blueberry

Exobasidium leaf and fruit spot of blueberry in the southeastern United States

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First identified in 1997, Exobasidium leaf and fruit spot has emerged as a significant disease of both rabbiteye and highbush blueberry in the southeastern US. Yield losses as high as 60% have been recorded on ‘Premier’ rabbiteye blueberry. The pathogen, recently described as *Exobasidium maculosum* M. T. Brewer, is a species unique to the region. The life cycle of the pathogen is currently not known. Infection of leaves and fruit appear to occur simultaneously in early spring, with leaf symptoms appearing in spring and berry symptoms most obvious when fruit ripens. Berry infections appear as green unripe spots on otherwise ripe, blue fruit. Leaf infection produces round, pale green spots averaging 7-8 mm in diameter that are white when viewed from below. Symptoms do not occur on later leaves, suggesting a springtime, monocyclic disease cycle. Disease incidence appears to be highest in wet fields with dense growth and poor air circulation. Fungicides applied beginning at bud break are effective in reducing severity, however there is evidence of resistance to some fungicides. Single, delayed-dormant applications of lime-sulfur have provided significant control in initial trials in Georgia.

Causal agents of blueberry cane canker and twig blight in Michigan blueberry fields

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Blueberry canker and twig blight symptoms are common in highbush blueberry fields in Michigan. The last survey of blueberry cane diseases in the state was conducted over 40 years ago, and cultivar prevalence and management practices have changed since then. In the summers of 2012 and 2013, 26 fields in Michigan and northern Indiana were scouted for canker and twig blight symptoms. Isolations were made from 25 symptomatic canes and 25 twigs per field. Fungal isolates were identified morphologically as well as by DNA sequencing of the ITS region. *Phomopsis vaccinii* was the predominant pathogen causing cane canker in Michigan blueberry fields. In addition, *P. eres* and *P. viticola* were detected for the first time. More diversity was noted in *P. eres* than in *P. vaccinii* with respect to the number of unique DNA haplotypes. *Colletotrichum* and *Botryosphaeria* spp. were also found in infected canes. Fields located in regions further south, such as Indiana and southern Michigan, had a higher canker incidence than northern sites. Predominant pathogens isolated from blighted twigs were *Phomopsis vaccinii*, *C. acutatum* and *Pseudomonas* spp. Bacterial twig blight was more common in 2012, especially on ‘Elliott’ blueberries, due to repeated frost events in the spring. Management of canker and twig blight should include pruning out of infected canes and preventative applications of fungicides such as Indar (fenbuconazole), Quash (metconazole) and Pristine (pyraclostrobin and boscalid).
Improved management of *Monilinia vaccinii-corymbosi* in lowbush blueberry in Maine

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Mummy berry blight, caused by *Monilinia vaccinii-corymbosi* is the most widespread disease of concern in lowbush blueberries in Maine. Real-time tracking of weather data from weather stations connected to the internet is being used to track infection conditions, and grower cooperators are reporting on scouting of fungal and plant development. This information is being provided to growers to improve their timing of fungicide applications to control Monilinia. Use of this system has resulted in fewer fungicide applications and increased control of mummy berry blight as reported by growers. Experiments are also being conducted to examine the germination of pseudosclerotia which typically germinate in mid April through to mid May in Maine. We have found that pseudosclerotia require a “maturing” stage in the ground before germination, and that there are organisms that consume pseudosclerotia after they have fallen. In preliminary experiments, approximately 880 chill hours (< 7C) were required to produce stalks, and higher numbers of stalks were produced after 1100 hours. Approximately 980 hours were required to produce pinheads or apothecia. Higher numbers of apothecia germinated after approximately 1100 chill hours and the most after 1400 hours. As chill hours increased, fewer post-chill hours appeared to be required to produce structures. These experiments will be repeated with the goal to develop a model of pseudosclerotia germination for improved timing of scouting in the spring.

Blueberry Extension

Initial identification of issues with spray coverage in south Georgia blueberries

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Blueberries are the number one fruit crop in Georgia, having an annual farm gate value of over $220 million. A multitude of diseases and pests continue to threaten this valuable crop. In order to effectively manage these diseases and pests, fungicides and insecticides continue to serve an important role in integrated pest management in blueberries. Two questions prompted by blueberry growers are which sprayer provides the best coverage and how effective is the practice of alternate row middle spraying. A field day was held in September 2013 to assess a variety of sprayers, including cannon, airblast, and boom, and in February 2014, an alternate row middle study was conducted to determine coverage when only spraying down every other row. Spray coverage was assessed in both using Kromekote cards and Vision Pink dye. Cards were analyzed using DropletScan™ software. Preliminary results are discussed. Results will be used to initiate more specific studies regarding sprayer coverage and efficacy.
Expanding the vision for blueberry Extension.

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Cooperative Extension programs are in a state of flux as new methods of information delivery are adopted by agents, specialists, and clientele. Online methods are crucial tools as the number of Extension specialists with specialization in blueberries shrink. Therefore, increased communications to develop collaborations among Extension personnel should be a priority. The All About Blueberries (AAB) CoP launched in 2010 and was motivated by six goals: (1) to improve insect and disease identification; (2) to improve blueberry production efficiency, productivity and profitability; (3) to educate about blueberry cultivation; (4) to improve grower profit margins; (5) to hasten adoption of new innovations and technologies; and (6) to improve the safe handling of fresh produce by emphasizing the importance of food safety in the consumer section and harvesting in the grower section. The AAB portal and its 36 contributing authors represent an ideal venue to showcase nationwide blueberry consumer and producer research and educational efforts. The AAB CoP can provide a platform for enhanced and strategic coordination among blueberry Extension specialists nationwide. Better coordination can lead to positive outcomes that result in more recognition of Extension as a critical aspect of the research-to-end user continuum. Pursuing online methods meet clientele needs and strengthen Extension’s reach to all stakeholders and audiences, nationally and internationally. Support and expansion of the blueberry eXtension portal has great potential to be a leader in developing efficient and effective Extension methods to reach existing clientele and new audiences.
Advances in Organic Blueberry Management

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The organic segment in the United States accounts for over 2% of food sales and reached over a total of $30 billion dollars in 2013 primarily in the fruit and vegetable categories. The number of organic farms in the United States is approaching 10,000 certified operations. When wild blueberries were first selected and cultivated in the early 1900’s, farming practices were essentially organic in nature. Early farmers established effective cultural practices, initiated mechanical weed management and took advantage of naturally occurring biological controls. To bolster these proven practices for modern organic production, the Rutgers Blueberry Working Group has provided information on several additional methods. Examples include:

- Weed Management – weed suppression between rows with plantings of fescue cultivars
- Weed Management – weed suppression within rows with landscape fabric and mulch
- Soil Management – organic compost from various sources within trench
- Water Management – trickle irrigation to minimize leaf wetness and diseases
- Disease Resistance – cultivar comparisons of disease susceptibility
- Organic fungicides – OMRI approved materials for botrytis and other pathogens
- Organic insecticides – Entrust/spinosad formulations for blueberry maggot and other pests
- IPM systems - pheromone trapping and monitoring

Small plot and grower demonstrations are evolving these various organic approaches to a comprehensive organic production system based on phenological factors and soil health. East coast, west coast, Canada, South America, Europe and Africa utilize some of these suggested practices as certified organic blueberry acreage steadily increases to meet national and global market demand.
Many blueberry growers in South Georgia have expressed interest about humate and its effect on fruit production. Presently, pine bark is used to amend soils to increase organic matter and lower pH. Pine bark, generally, is applied at a rate of 100 cubic yards per acre, costing from $800.00 to $1,200.00/A. To alleviate establishment costs, some growers incorporate Leonardite and/or its extracts humic and fulvic acids to increase organic matter. To extract humic and fulvic acid, the Leonardite is processed in a strongly basic aqueous solution, e.g. KOH. To precipitate the humic acid, the solution is adjusted to pH 1 with a mineral acid, e.g. HCl. Three Leonardite products, two humic acids and one unextracted Leonardite, were analyzed for nutrient content. Calcium levels were 5000 ppm in both extracted samples and 2070 ppm in the unextracted Leonardite. Potassium levels were 977 and 800 ppm in the extracted samples and 125 ppm in the unextracted Leonardite, suggesting humic acid reacted with KOH. Research on Leonardite products and the effect on blueberry production are limited. Rates of humate in ornamental horticulture suggest using 3% – 12% v/v% in potting media. This equates to 30 – 120 t for equivalent additions on a per acre basis. At these rates, the application of calcium will be 124 – 1200 lb/A. At levels of 900 lb/A calcium, establishing blueberry is not recommended. The analysis of these Leonardite products is insightful as soil nutritional amendments to blueberry.
The effect of severity of winter pruning and time of summer pruning on southern highbush blueberry 'Misty' was studied. The 3-year-old 'Misty' southern highbush blueberry trees were used. Six treatments were conducted: winter pruning [no pruning (control), standard pruning (30% removed), and sever pruning (50% removed)] and standard winter pruning + summer pruning (Jun. 20, Jul. 20, and Aug. 20). The number of new canes, secondary shoots, and length of canes were investigated after winter pruning. The treatment of standard winter pruning shows the highest numbers of new canes (no. 97) compared to that of no pruning (no. 87). In the case of severe winter pruning, the lowest new cane (no. 52) was sprouted. There were no significant differences in length of new shoot among the severity of winter pruning. After summer pruning, the number of buds were counted for all treatment on Nov. 5. The number of buds was highest (no. 894) in standard winter pruning with summer pruning at Jul. 20, followed by standard pruning (no. 784) > no pruning (no. 712) > sever winter pruning (no. 656) > standard winter pruning + summer pruning at Jun. 20 (no. 540) > standard winter pruning + summer pruning at Aug. 20 (no. 333). There were no significant differences in winter pruning and winter pruning with summer pruning ($p < 0.05$). In general, the improvement of light penetration to canopy, shaping of bearing shoots, and strengthened cane were observed in treatment of winter pruning combined with summer pruning at Jul. 20.
Pre- and post-emergence applications of herbicides for control of resistant fineleaf sheep fescue in wild blueberry fields in Maine

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Fineleaf sheep fescue (*Festuca filiformis*) is an introduced perennial grass in Maine wild blueberry (*Vaccinium angustifolium*) fields. Growers reported an herbicide-resistant population that has begun taking over local fields. Herbicides were evaluated for control of fineleaf sheep fescue and other weeds, and injury to blueberry. Pronamide (2 lb/a; all rates in product per acre) was applied in fall or spring. Terbacil (2 lb/a)/diuron (2 lb/a)/hexazinone (1 lb/a) or Trimix, rimsulfuron (4 oz/a), and linuron (2 lb/a) were Spring applied pre-emergence, and clethodim (8 oz/a) and foramsulfuron (1.5 oz/a) were applied twice post-emergence. Fall pronamide application resulted in the highest blueberry cover. Linuron and foramsulfuron had significantly higher initial phytotoxicity but overall levels were not unacceptably high; the plants grew out of it with the exception of minor phytotoxicity in the linuron treatment. The Trimix was most effective on broadleaf weeds, while foramsulfuron was the least effective. Fall pronamide was also significantly and consistently most effective in controlling fineleaf sheep fescue over time, followed closely by rimsulfuron, while clethodim and linuron were consistently ineffective. In conclusion, fall application of pronamide and pre-emergence application of rimsulfuron controlled fineleaf sheep fescue, and Trimix could be effective with low fineleaf sheep fescue pressure. Clethodim, linuron, foramsulfuron and spring application of pronamide were not effective control options under sheep fescue and/or broadleaf weed pressure. Since Hexazinone and Terbacil are Group 5 herbicides and Pronamide is Group 3 and Matrix is in Group 2, the use of these herbicides will prevent the development of resistant grasses.

Safeguarding the blueberry industry through the National Clean Plant Network and Harmonized Nursery Certification Guidelines

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The National Clean Plant Network (NCPN) was established in the 2008 Farm Bill under the auspices of USDA’s Animal and Plant Health Inspection Service (APHIS), the Agricultural Research Service (ARS) and the National Institute of Food and Agriculture (NIFA). NCPN consists of 19 clean plant centers located in 15 states and covers five specialty crops: fruit and nut trees, grapes, berries, citrus and hops. Three of the NCPN centers in Oregon, Arkansas and North Carolina are concerned with the testing, therapy, production and maintenance of high quality Foundation (G1) blueberry plants free of targeted systemic pathogens (viruses, phytoplasmas, crown gall, Xylella) for distribution to nurseries for propagation and eventual sale to growers. G1 blueberry blocks are maintained in carefully controlled facilities by federal or state agencies or some type of government/private joint program, or by private companies that maintain their proprietary material. In the United States, the propagation and production of blueberry nursery plants for sale is monitored and regulated by State Nursery Certification programs that vary widely in their requirements. Efforts to develop a model blueberry nursery certification standard and the major components of that standard will be discussed.
Winter injury in northern highbush blueberry in Michigan

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Michigan is a major production region for northern highbush blueberries (Vaccinium corymbosum). Most of Michigan’s blueberry fields are located close to Lake Michigan which moderates the winter cold. Winter temperatures are seldom below -20°C. Heavy snow downwind of the lake is common in the early winter. In 2014, the winter was extremely cold with high temperatures seldom above freezing. Several extremely cold episodes dropped low temperatures to near -25°C close to the lake and to -35°C away from the lake. The extreme winter cold and deep snow cover lead to a range of winter injury symptoms; shoot dieback, death of flower buds and sunscald. Road salt used to clear roads of snow and ice also causes significant shoot dieback and flower bud injury close to many roads. A heavy crop in 2013 magnified the effects of the cold. Poorly maintained or stressed plantings often showed more injury than healthy well maintained plantings of the same cultivar in the spring of 2014. New plantings were more susceptible than established fields. Damage was more noticeable in low areas where cold air collected and areas of the bush which were just above the snowline. The types of injury and their causes using examples from 2014 and previous winters will be discussed.

Blueberry Pollinators

A Pollination Toolbox for Wild Blueberry Growers

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A pollination toolbox was developed to facilitate workshops for wild blueberry (Vaccinium angustifolium Ait.) growers. The purpose of the workshop is to provide “hands-on” education about: 1) reproductive biology of wild blueberry; 2) the major pollinators, their life history and identification; 3) conservation and protection of native and commercial bee pollinators; 4) methodology for estimating fruitset, fruit drop, and pollinator field abundance; and 5) the use of a regression model for determining adequacy of pollinator field abundance. The workshop supplies a pollination toolbox to the growers which is comprised of the following materials: 1) a reference bee collection imbedded in plastic; 2) a “field-ready” fruitset estimation kit; 3) a “field-ready” pollinator abundance sampling quadrat; 4) five wild blueberry pollination and pollinator Extension color factsheets; and 5) a video (made in 2013) describing the estimation of fruit set and pollinator field abundance. A survey was given to growers at two workshops in 2014 to assess the workshop and pollination toolbox. This is an on-going project aimed at increasing the knowledge of wild blueberry pollination by growers so that sound decisions can be made in suitable pollination strategies and investments that fit the farm’s management philosophy.
Flower morphology influences pollinator community with implications for cross-pollination: observations in rabbiteye blueberry (Vaccinium ashei Reade)

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The narrow, long corolla of rabbiteye blueberries (Vaccinium ashei) presents a challenge to foraging pollinators, particularly honey bees (Apis mellifera), and variations in this floral morphology appear to alter the species composition of the visiting bee community. In particular, the rabbiteye var. ‘Premier’ exhibits abnormal flower morphology, with shorten and split corollas, and appeared to be visited by a different community of bee pollinators than nearby, simultaneously flowering varieties. We conducted observations to compare bee visitation rates at ‘Premier’ flowers to other common rabbiteye varieties (‘Powderblue’ and ‘Brightwell’) which have more typical flowers. Timed observations were conducted during 2009 and 2010, and significantly more A. mellifera and significantly fewer wild bees visited ‘Premier’ flowers when compared to other rabbiteye cultivars. This apparent resource partitioning may reduce cross-pollination, which is important for successful rabbiteye blueberry production but may also increase A. mellifera visitation. A similar visitation rate increase by A. mellifera in blueberries has been suggested to occur following nectar robbing by carpenter bees (Xylocopa spp.).

Assessing the status of commercial highbush blueberry pollination

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Highbush blueberry pollination is dependent on flower visitation by bees, and this is a critical component of achieving profitable crop yields. Flowers may be visited by honey bees, bumble bees, and many species of wild bees, but in large commercial fields the use of managed colonies of honey bees is the most common pollination practice. During 2013, commercial blueberry fields in British Columbia, Oregon, Florida and Michigan were sampled for their levels of pollinators and pollination. We found a range of honey bee and wild bee pollinator abundance, with flower visiting insects dominated by honey bees. The abundance of this pollinator was related to stocking density, which varied widely among and within fields. Wild bees were also variably abundant among fields, with their abundance varying with the proportion of wild habitat near the fields. Flower clusters were either open to pollinators, had them excluded, or were open and had supplemental pollen deposited. We found no evidence of pollinator limitation in Michigan fields, but there was significant limitation detected in British Columbia. These first year experiences within the Integrated Crop Pollination project will be discussed in the context of options for ensuring reliable and economical pollination of blueberries.
Blueberry Breeding

Highly fertile intersectional blueberry hybrids between *Vaccinium padifolium* Section *Hemimyrtillus* and *V. corymbosum* Section *Cyanococcus*

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*Vaccinium padifolium*, a species native to the Portuguese islands of Madeira, is distantly related to commercial blueberries, but has traits of notable value to conventional blueberry development. Among these traits are: upright structure, strong growth, abundant flowering and fruiting, superior self-fertility, fruit-cluster structure suited to mechanical harvesting, and repeat flowering. We used *V. padifolium* as a female in crosses with commercial blueberry and produced two highly fertile hybrids. These hybrids are intermediate in appearance to their parents, and their hybridity has been confirmed through DNA testing. These hybrids have been used in further crosses to a variety of conventional blueberry selections and have generated numerous secondary hybrids. The F₁ś and hybrids are undergoing field evaluations to evaluate their performance and to guide further use of this germplasm. Crosses have also been made to initially incorporate two other Section *Hemimyrtillus* species, *V. cylindraceum* and *V. arctostaphylos*.

Enabling ‘Fast-track’ blueberry breeding

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To develop an early-flowering highbush blueberry (*Vaccinium corymbosum* L.) for ‘Fast-track’ breeding, two blueberry-derived floral activators, the *FLOWERING LOCUS T* (FT)-like (*VcFT*) and the *SUPPRESSOR OF OVEREXPRESSION OF CONSTANS 1* (SOC1)-like (*VcSOC1*), were cloned from the cDNA library of the northern highbush blueberry cultivar Bluecrop. Both genes were placed under the constitutive *CaMV 35S* promoter and were then transformed into the highbush blueberry cultivar Aurora using *Agrobacterium tumefaciens*-mediated transformation. *VcFT*-overexpressing shoots continuously flowered under *in vitro* culture conditions. Greenhouse-grown *VcFT*-overexpressing plants were smaller than nontransgenic plants and showed continuous floral bud formation, and some flowered despite the long-day photoperiod and non-chilling temperatures in the greenhouse. *In vitro*-cultured *VcSOC1*-overexpressing shoots did not flower. Compared to nontransgenic plants, *VcSOC1*-overexpressing plants had similar plant size and more floral buds after one year of growing in the greenhouse, and some flowered before exposure to any chilling temperatures. Utilization of the *VcFT*-overexpressing plants for ‘Fast-track’ blueberry breeding is ongoing.
Over the last decade, the northern highbush blueberry breeding program at MSU has released six cultivars that span most of the blueberry season. ’Huron’ (2012) is an early season cultivar that follows ’Duke’, with very high fruit quality, an unusually late blooming date and strong winter hardiness. In the colder production regions, it has more stable production from year to year than ‘Duke’. ‘Huron’s negatives are that it can have a tight cluster and may be stemmy in hot weather. ’Draper’ (2004) is an early mid-season, very winter hardy variety that fruits a little before ’Bluecrop’ and has large, really firm fruit that have a “snap” and can be stored for long periods of time. The fruit can be mechanically harvested for the fresh market and its fruit hold extremely well on the bush during hot temperatures. Draper’s negatives are that it is a slow grower, is a little brushy and in some years produces a high number of small berries. ‘Osorno’ (2013) is a mid-season variety falling in the ‘Legacy’ season. It has exceptionally high quality fruit that are unusually resistant to high summer temperatures. It is only moderately winter hardy and can have floppy canes. ’Calypso’ is a very winter hardy, late mid-season variety that follows the harvest of ‘Osorno’ with large, firm fruit that have very high overall quality. It’s fruit are not as resistant to heat as ‘Osorno’. ‘Liberty’ (2004) is a very winter hardy, late variety with exceptional flavor, good storage capacity and high yields. It is very vigorous and produces unusually high yields as a young plant. Unfortunately, it’s later developing fruit can be poorly sized and it has a relatively thin skin that can crack. It is also subject to a cane die back in some regions, particularly British Columbia and south central Chile. ‘Aurora’ is a very winter hardy, very late variety that is 3 to 5 days after ‘Elliott’, but has larger, lighter colored fruit, higher yields and greater resistance to cracking. Its negatives are that its bush size is somewhat bushy, and its fruit can be tart unless allowed to hang until ripe.
Post-Harvest

Effect of pre-harvest deficit irrigation on post-harvest quality of *V. corymbosum* fruits cv. Brigitta

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Blueberries are highly sensitive to drought stress, especially during fruit development when fruit yields and post-harvest quality can be affected. Deficit irrigation (DI) has increased the quality of many fruit crops without reducing yield. The effects of drought on yield of fruit crops have been studied extensively but there is limited information on how pre-harvest water stress affects postharvest quality. The aim of this study was to evaluate post-harvest quality of *V. corymbosum* fruits under pre-harvest DI. Six-year-old highbush plants cv. Brigitta in Colbún, Maule Region, Chile, (lat. -35.686932, long. -71.4187), were subjected to four irrigation regimes replacing 50, 75, 100 (control) or 125% crop evapotranspiration (ETc): during 2013-2014 season. Fruit were harvested and stored for 30 and 60 d at 2ºC + 3 d at 18ºC. DI had inconsistent effects on berry weight loss in storage. At 30d, 100% ETc had the highest weight loss and the opposite occurred at 60+3 d. Water management also affected fruit quality and condition, but inconsistently. Titratable acidity was highest at 30+3 and 60+3 d for 75% ETc, while 125% ETc had lowest acidity in both dates. Firmness was not affected. Soluble solids were only significant for 30+3 d, with 50% ETc having the highest levels and both 100 and 125 ETc the lowest. Fruit size was not affected by treatments at 30+3, but at 60+3, 75% ETc had fruit with largest diameter. Only at 60+3 there were differences in the proportion of decay and dehydrated fruit, between 75% ETc and 125% ETc.

Development of internal browning of highbush blueberries (*Vaccinium corymbosum*), subjected to mechanical damage

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Susceptibility of blueberries (*Vaccinium corymbosum*), to develop internal browning (IB), was studied during 3 seasons. Hand harvested fruit (cvs. Duke, Brigitta and Elliott), were picked from orchards located in the southern region of Chile. During the first season, individual berries were dropped from different heights (0 to 128 cm) onto a hard plastic surface and a soft padding material. Berries were placed in clamshells, stored at 0ºC and evaluated after 30 and 45 days. On the second and third seasons, fruit were segregated at harvest by firmness (FirmTechII, Bioworks, g) and designated into 4 categories (soft to firm). Samples from each category were either dropped (32 cm, plexiglas) or non-dropped, kept at 0ºC and sampled every 7 days, up to 35 days. At harvest, and after each removal, plus 1 day at 10ºC, berries were evaluated for firmness, sliced through the equator and photographed for IB severity assessment, based on a 0 to 4 scale (0-100% of cut surface with IB). IB increased with higher drops for Brigitta and O’Neal, but no differences were found on Duke, which was characterized by soft fruit and high IB. In Brigitta, firmness loss was more related to height-drop than on the other varieties. Fruit dropped over the mouse pad had higher firmness and lower IB. When berries were segregated by firmness, a clear effect was seen on IB; in general, fruits with >180 g showed higher firmness retention and lower IB. The effect on storage time was dependent on variety and firmness at harvest.
Influence of pre-harvest calcium-chitosan treatment on fruit quality and storage ability of ‘Duke’ blueberry

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Blueberries ‘Duke’ (Vaccinium corymbosum) were treated either with CaCl2 40 mg·L⁻¹ + chitosan 20 mg·L⁻¹ or CaCl2 80 mg·L⁻¹ + chitosan 40 mg·L⁻¹ during the fruit development. The calcium-chitosan was treated 4 times at 31, 38, 45, and 52 days after full bloom (DAFB). The ‘Duke’ blueberries were harvested at 57 DAFB and stored at 10°C for up to 24 days. The effectiveness of the treatments was assayed by evaluating their quality parameters: weight loss, calcium content, firmness, soluble solids content (SSC), total acidity (TA), total phenol contents, and fungal decay. The calcium content in the fruit was significantly higher in the application of CaCl2 80 mg·L⁻¹ + chitosan 40 mg·L⁻¹ than other treatments. The weight loss, SSC, and TA did not show distinct tendencies within treatments. However, the applications of calcium-chitosan were effective in decreasing and delaying fungal decay on blueberry fruit (control 42% > CaCl2 40 mg·L⁻¹ + chitosan 20 mg·L⁻¹ 28% > CaCl2 80 mg·L⁻¹ + chitosan 40 mg·L⁻¹ 22%), thus resulting in increased storage ability of the blueberry.

Fruit position and ripening affects blueberry postharvest fruit quality

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Blueberries ripen over a period of 3-4 weeks and harvest is based mainly on fruit color, which does not take into account the variability, determined by the interaction of fruit position within the plant and its microclimate. Therefore a group of fruit may look acceptable when picked, but will quickly become overripe, and therefore unacceptable when reaching the consumer. Preliminary work at University of Talca, has consistently shown that almost 1/3 of the fruit within a clamshell have medium to low firmness. This study was carried out on cvs. Duke and Brigitta, evaluating fruit position within the plant (East-E and West-W) or maturity stage (75 and 100% blue). During the afternoon, fruit temperature from W was always higher (37°C) than E (32°C). Shoot water potential was higher in E during the morning and in W during the afternoon. At harvest and after 30-45 days at 0°C, fruit quality was assessed by fruit size, firmness and nutraceutical compounds (phenols and ORAC). When the whole plant was assessed at harvest, nutraceutical compounds increased up to 40% from 75 to 100% blue; these differences declined during storage, since values increased for 75% and decreased for 100%. Although, at harvest and storage, lower firmness was found on 100% blue, fruit size can be increased by 5-8% when harvesting at 100% blue.
Cold acclimation (CA) is a multigenic phenomenon involving overlapping stress responses. Transcriptome profiling and 2D-DIGE technology followed by MALDI-TOF and ESI-MS/MS spot identification were performed to better understand mechanisms responsible for the increase in freezing tolerance. By computational predictions, we annotated next generation 454 sequence assemblies from two blueberry cDNA libraries representing flower buds in the first and second stages of CA. Gene ontology functional classification terms were retrieved for 4,343 (80.0%) sequences. Contig analysis based on association with biochemical pathways identified the presence of certain transcripts related to carbohydrate and lipid metabolism with different stages of CA. This was concomitant with the differential presence of Zn finger functional domains and C3H-family transcription factors. Validation of results from the *in silico* approach was obtained using real-time qPCR. Our transcriptome database thus served as a rich resource for mining CA-responsive genes and identifying changes in expression in different stages of CA. Analysis of the proteome under similar conditions provides insights in the post-transcriptional regulation while study of different isoforms of the same protein may reflect post-translational modifications. Detailed analysis of proteins during the early steps of CA showed that they are not further modulated by freezing temperatures beyond about 400 hours, indicating that CA levels reached during the first and second stages of acclimation are sufficient to deal with winter. Our data are compared with those previously obtained in *Arabidopsis thaliana* and *Vitis vinifera*. Blueberry may be used to further understanding of the CA phenomenon with special features in woody species.
Next generation sequencing of rabbiteye blueberry (Vaccinium virgatum ‘Premiere’) and transcriptome comparisons to highbush (Vaccinium corymbosum) genomic resources.

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Vaccinium virgatum (syn V. ashei) is commonly known as rabbiteye blueberry and native to the Southeastern United States. Cultivars are typically grown from North Carolina south to Florida and west to Texas for commercial blueberry production. In the Southeast, plants exhibit superior environmental tolerance and have fewer disease and insect concerns that highbush varieties (Vaccinium corymbosum), although some southern highbush (Vaccinium corymbosum X Vaccinium darrowii) include V. virgatum in their genetic backgrounds. Extensive genomic work has been done on V. corymbosum, both diploid and tetraploid, but not much has been done with V. virgatum, which is hexaploid. Our study included five V. virgatum cultivars; TifBlue, Climax, PowderBlue, Austin, and Premiere. Tissues were collected from clonally propagated plants for each cultivar at multiple developmental stages including buds, berries, leaves, and roots. Tissue was also collected from root and leaves during drought treatments. First sequencing results were produced for all growth stages of ‘Premiere’ using Nextera kits and Illumina instruments. Transcriptomes were compared to existing genomic resources for highbush to determine the relative overlap.
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The U.S. Highbush Blueberry Council (USHBC) is a national research and promotion program that was established by a vote of blueberry growers and handlers in January of 2000.

Directed by elected council members with USDA oversight, the Council is funded by assessments on domestic highbush blueberries and highbush imports. Activities include blueberry health research and promotion as well as grower education in good practices.

Additional information about the USHBC can be found on our website at www.blueberrycouncil.com.

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