

USDA-NIFA Annual Report

Year 4

Progress Report

Title:	VacciniumCAP: Leveraging genetic and genomic resources to enable development of blueberry and cranberry cultivars with improved fruit quality attributes		
Sponsoring Agency	NIFA	Project Status	ACTIVE
Funding Source	Non Formula	Reporting Frequency	Annual
Accession No.	1020223	Grants.gov No.	
		Award No.	2019-51181-30015
Project No.	NC09879	Proposal No.	2019-03177
Project Start Date	09/01/2019	Project End Date	08/31/2024
Reporting Period Start Date	09/01/2022	Reporting Period End Date	08/31/2023
Submitted By		Date Submitted to NIFA	

Program Code: SCRI**Program Name:** Specialty Crop Research Initiative**Project Director**

Massimo Iorizzo

704-250-5400

miorizz@ncsu.edu

Recipient Organization

NORTH CAROLINA STATE UNIVERSITY

2701 SULLIVAN DR STE 240

Raleigh, NC 276950001

DUNS No. 042092122

Performing Department

Horticultural Science

Co-Project Directors

Lila, Mary

Perkins-Veazie PhD, Penelope

Departments

FoodBioprocessingNutritionSci

Horticultural Science

Non-Technical Summary

This project will establish a nationwide coordinated transdisciplinary research approach to develop and implement marker assisted selection (MAS) capacity in Vaccinium breeding programs, to enable breeders to select and pyramid fruit characteristics (FCs) that positively contribute to fruit quality and market value. Vaccinium crops (blueberry and cranberry) provides vital contributions to human health and well-being, and collectively constitutes the economic backbone of many U.S. rural communities. Vaccinium genetic and genomic resources are developing rapidly but have not been translated to routine practical application. Specific objectives are to: (1) establish a cost effective genotyping platform to expand marker-trait association analysis (MTA) in Vaccinium, exploiting the shared ancestry of Vaccinium crops; (2) identify DNA markers linked to fruit characteristics and elucidate how and which fruit characteristics affect fruit quality, relative to consumer preferences, decay during mechanical harvest, processing and distribution; (3) develop DNA assays to implement MAS in core Vaccinium core breeding programs with a common focus on fruit quality traits; (4) enlarge market potential, and increase consumption of Vaccinium fruits by using socio-economic knowledge of consumer preferences to inform breeding; and (5) enhance sustainability of cultivar development by transferring MAS technologies to public and private U.S. Vaccinium breeding programs through training current and future breeders as well as engaging the production, distribution, processing and marketing sectors, allied scientists, and consumers. This Coordinated Agricultural Project proposal addresses SCRI Focus Area 1 (70%) and Focus Area 2 (30%).

Accomplishments**Major goals of the project**

Status: Vaccinium (blueberry and cranberry) breeders have little empirical data to assign level of importance to fruit characteristics (FCs) relative to consumer preferences, decay during production, processing and distribution, and few tools to select for high fruit quality. As a result, blueberry and cranberry cultivars often produce fruit with inconsistent appearance, texture and sensory profiles that do not consistently meet consumer expectations, processing and production quality needs. The Vaccinium industry recognized the need to improve fruit quality as the key breeding target for continued success.

Mission statement: Address major bottlenecks for growth of U.S. Vaccinium industry, by creating a nationwide coordinated

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transdisciplinary research approach to develop and implement marker assisted selection (MAS) capacity in Vaccinium breeding programs, to enable breeders to select and pyramid fruit characteristics (FCs) that positively contribute to fruit quality and market value. In the long term, this mission will increase production of fruit with improved characteristics that meet the ever-changing industry, market, and consumer preferences.

Specific project objective are: 1) Establish genomic resources to enable effective association mapping studies in blueberry and cranberry; 2) Discover DNA markers and fruit characteristics that maximize industry profitability and match consumer preferences in blueberry and cranberry; 3) Deliver molecular and genetic resources to improve blueberry and cranberry fruit quality traits that maximize industry profitability and match consumer preferences; 4) Assess the potential socio-economic impact of blueberry and cranberry fruit quality improvements on market demand; 5) Engage U.S. Vaccinium breeders and stakeholder groups to transfer advanced phenomics and genomics tools to build a more coordinated and efficient cultivar development system.

What was accomplished under these goals?

Obj. 1. Expanded Genomic resources. A haplotype resolved assembly of a HortbluePetitexNui progeny (tetraploids) was developed. The assembly is resolving a complex locus linked to a QTL for anthocyanin content on chromosome 2. Finalized and released annotations of blueberry and cranberry cultivars and a pangenome graph. Initiated efforts for identification of dispensable genes that have fruit specific expression patterns. Advanced development of the Vaccinium Genotyping platform. Completed validation of the 22K blueberry and 17K cranberry genotyping platforms. Results confirmed that the platforms are highly informative across cultivated and wild blueberry and cranberry germplasms. Continued coordination of samples submission from member of the genotyping consortium, and secured a new discounted price for submissions in year 5. The consortium include 13 members representing public and publish breeding programs, from U.S., France, New Zealand, Canada and Italy and have genotyped 10,300 samples. Overall, these activities are expanding use of molecular tools in blueberry and cranberry breeding and research programs and facilitating genetic discoveries.

Obj. 2. Advanced phenotyping methods. Blueberry: 1) Evaluated relationship between acoustic system and mechanical texture analysis; 2) Continued to improve a web application to evaluate bruising rate. Cranberry: 1) Tested a new method to evaluate internal structure; 2) developed a trait ontology; 3) Developed software 'CARP' (Cranberry Assessment for Rot Prediction) to phenotype FRR. 4) Initiated development of a Hyperspectral Agricultural Research Vehicle for field phenotyping. Phenotyped genetic study sets (GenStudy). Blueberry: evaluated pH, TA, sugars, organic acids (by HPLC) in the NHB and SHB GenStudy sets (N=2,000). Cranberry: evaluated yield, vigor and fruit shape, size, internal and external appearance, Tacy, fruit weight, color, yield, % fruit rot, total anthocyanin, brix and TA, organic acids, multiple morphological, phenological traits (e.g. number of fruit per upright branch) and texture on self-pollinated plants (N=847), diversity panels (Rutgers. N=312, and Wisconsin, N=350), MP4 (N=141), MP5 (N=68) and MP6. Advanced FC genetic studies. Blueberry: completed QTL analysis for volatiles, anthocyanin content and composition, organic acids, TA, pH, sugars and texture. Major effect QTLs were identified for anthocyanin (acylated and glycosylated), 33 volatiles, citric acid, malic acid, quinic acid, shikimic acid, pH, and TA. No QTLs or very low effect QTLs were identified for sugars and texture, respectively. Except for volatiles that were not tested for multiple years all major QTLs were stable across multiple years. Efforts to identify candidate genes underlying major QTLs were initiated. Cranberry: completed three genetic studies for fruit rot resistance (FRR), epicuticular wax (ECW), size and shape related traits, chemistry (Tacy, TA, Brix), uprights and Yield traits. Highlights from these studies were: QTL for ECW overlap with QTLs for FRR, stable QTLs for Tacy and traits related to size and shape related were identified. Preliminary results from other genetic studies identified QTLs for TA, Benzoic acid and Malic acid, ECW and texture parameters. Fruit quality (FQ) studies. 1) completed one study to identify FCs that contribute to extended shelf-life. The study identified berry size and some mechanical texture parameters as traits that could be used to select for improved texture and appearance at harvest and post-storage. 2) Performed a new experiment to evaluate the relationship between sensorial texture and mechanical texture. 3) Completed evaluation of bruising rate.

Obj.3. Phenotyped germplasm for FC-QTL validation. Blueberry: phenotyped FCs (pH, TA, Sugars, TSS) on NHB (N=132), and SHB (N=101) ValStudy sets. Advanced validation of FC-QTLs. Blueberry: seven QTL regions associated with volatiles and chlorogenic acid, were considered validated since they were detected across multiple genetic backgrounds. Efforts to identify candidate genes and possible polymorphisms to target for DNA assay development were initiated. Advanced simple DNA assay design. Blueberry: KASP assays targeting SNPs associated with eucalyptol content were tested. Preliminary results indicated a mid-level prediction accuracy. Efforts to use haplotype information to increase prediction accuracy were initiated. Cranberry: validated a DNA assay using PACE technology targeting SNPs associated with epicuticular wax and FRR. The marker is highly sensitive. Initiated marker development for other QTLs. Leveraged FC phenotypic data for breeding selection. Blueberry and cranberry: continued making selections for genotypes with good performance for FC and propagated selections for trialing. Crosses of superior individuals were also performed and will be germinated in the fall of 2023 and spring 2024.

Obj. 4. Completed phenotyping blueberry sensory set. Finalized evaluation of pH, TA, TSS, sugars and volatiles on blueberry cultivars used for willingness to pay (WTP) study. Phenotypic, sensory and WTP data for 42 NHB and 40 SHB collected from two years, two locations was integrated and mining of the data to identify salient sensory attributes and fruit characteristics is

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ongoing. Finalized a study assessing WTP for cranberry products from fruit developed using CRISPR technology. The results indicated that consumers are in general averse to the use of alternative breeding methods such as CRISPR in cranberry production. However, the discount for added sugars in cranberry products is larger than the discount for CRISPR, implying that consumers may be more receptive of breeding methods such as CRISPR if its use results in products with reduced sugar content. Completed a study assessing consumer preference for labels associated with blueberry sensory quality (Sweet, Crunchy, Stay Fresh). Results indicated that "Stay Fresh" is the wording on the label of packaged blueberries that resulted in the lowest own price elasticity. This implies that the label "Stay Fresh" (a phrase that signals longer shelf life and freshness) could favor potential demand increase as compared to "Sweet" or "Crunchy." labels. Initiated distribution of a breeding priority survey. The outcomes of these studies are informing breeders and producers about possible strategies to reduce the negative impact of the added sugar labels on cranberry consumption and trigger purchase decisions and repeated purchases for blueberry.

Obj. 5. Updated On-line platforms: added new data and information in the GDV and VacCAP websites. Products made available through these platforms include: 1) seven newsletters; 2) seven instructional videos; 3) one VacCAP traits information sheets; 4) four webinar videos. **Maintained the VacCAP Twitter account** that has 379 followers and had 1,375 impressions/month in Y4. **Webinars:** delivered four webinars, attended by 148 participants. **Provided project updates** at 13 grower association meetings in U.S. **Project evaluation:** survey data, feedback and recommendations were collected from 48% of webinar participants, including breeders and scientists from public and private organizations, technical staff members, post-docs and students, and education/extension specialists. More than 80 percent reported that each webinar "greatly" or "moderately" improved their understanding of the topics (82% to 100% across four webinars) and almost all would recommend the webinars to others (93% to 100%). Feedback and recommendations gained from Y3 were integrated into Y4 activities, and feedback received in Y4 is being considered in planning future activities. Over 21,000 (11,842 GDV+ 9,251 VacCAP) users/viewers and 347 newsletter subscribers from >99 countries accessed VacCAP and GDV. Evaluation matrix indicates that the project is reaching a very broad audience and the resources/information generated in the project have a positive impact on this community.

What opportunities for training and professional development has the project provided?

Project participants include 6 post-doctoral researchers, 13 professionals and technicians, along with 18 graduate students and undergraduate students fully or partially funded by the project across all the VacCAP team programs. These trainees are participating in VacCAP activities for phenotyping, genomic analysis, DNA profiling, development of DNA informed breeding strategies, data management and communication. These personnel are gaining knowledge, experience, and skills in accurate measurement of fruit characteristics, fruit physiology, phenotyping engineering, statistical analyses, quantitative genetics, bioinformatics, design and implementation of genetic tests, and breeding program planning and management. In addition, these participants are members of project teams and undertake targeted training through webinars, workshops and one-on-one in-person training on texture analysis.

How have the results been disseminated to communities of interest?

Updates about the VacCAP project and preliminary results were disseminated to the scientific community, including the U.S. wide community of Vaccinium crop breeders, through 17 peer reviewed publications and 50 posters and oral presentations at regional, national and international conferences (including the American Society of Horticultural Science, Plant & Animal Genome conferences, National Association of Plant breeding annual meeting). The information was also disseminated to the broader Vaccinium community (producers, processors and distributors) through 16 oral presentations at commodity group meetings, 13 VacCAP/GDV newsletter and blog articles, and two articles in trade magazines. Four webinars and eight instructional videos were delivered to transfer project outcomes/deliverables. Stakeholders and the general public were also engaged by feeding project updates and new information related to the project mission through two web sites (VacCAP and GDV) and a Twitter account (@VacciniumCAP). To engage the public and students, VacCAP PIs participated in and/or organized 21 outreach events targeting K12 middle and high schools, college students and the general public. Events included blueberry and cranberry field days, science fairs, and short lab training classes. Outreach activities were aimed at introducing students and general public to plant science and horticulture, breeding, food science, and scientific lab experiences based on protocol/research. All these activities emphasized the importance of breeding programs for blueberry and cranberry production, and general crop production. These events contribute to enhance public understanding and interest in learning and careers in plant science and specifically in plant breeding.

What do you plan to do during the next reporting period to accomplish the goals?

Objective 1. Establish genomic resources to enable effective genome wide association mapping studies in blueberry and cranberry.

- Finalize identification of dispensable genes that have fruit specific expression patterns in the Vaccinium pan-genome to identify cultivar-specific genes associated with fruit quality

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- Finalize data analysis of cranberry testing data
- Continue coordination of samples submission for genotyping from the VacCAP genotyping consortium
- Prepare new manuscripts and complete manuscripts under re-revision for dissemination of results

Objective 2. Discover DNA markers and fruit characteristics that maximize industry profitability and match consumer preferences in blueberry and cranberry.

- Complete analysis of phenotypic data collected for FqStudy sets to identify FCs that contribute to reduced bruising and sensorial texture
- Complete genotyping cranberry diversity panel (Rutgers DP)
- Initiate efforts for functional characterization of candidate genes controlling FCs
- Continue QTL mapping in biparental populations and GWAS in GenStudy sets
- Prepare new manuscripts and complete manuscripts that are under re-revision for dissemination of results

Objective 3. Deliver molecular and genetic resources to improve blueberry and cranberry fruit quality traits that maximize industry profitability and match consumer preferences.

- Analyze phenotypic data collected during year 1-4 from the ValStudy sets
- Analyze blueberry DNA assay data (KASP) and evaluate possible use of haplotype on prediction accuracy;
- Continue testing DNA assays for organic acids, wax, and fruit shape that were developed for cranberry in more diverse populations to evaluate sensitivity and specificity
- Validate performance of genotypes selected during year 1-4 for advancing them into trials or for use as a parent in new crosses
- Plant seedlings so they are evaluated for their potential contribution to FC
- Prepare new manuscripts for dissemination of results

Objective 4. Assess the potential socio-economic impact of blueberry and cranberry fruit quality improvements on market demand.

- Finalize the analyses of the blueberry sensory and willingness-to-pay data collected in year 3
- Complete re-assessment of industry breeding priorities
- Prepare new manuscripts and complete manuscripts under re-revision for dissemination of results

Objective 5. Engage U.S. Vaccinium breeders and stakeholder groups to transfer advanced phenomics and genomics tools to build a more coordinated and efficient cultivar development system.

- On-line platforms: Update VacCAP and GDV and train core and non-core labs on GDV through new training videos.
- Develop new issues of the GDV newsletter to update national and international partners on new tools and resources available on GDV
- Continue developing new VacCAP trait information sheets
- Newsletter and other media: release three newsletters; publish articles in trade magazines; maintain VacCAP accounts on social media
- Webinars: deliver four webinars
- Workshops: engage core and non-core labs to transfer method used to evaluate fruit quality traits
- Develop instructional videos on the use of new methodologies for fruit quality phenotyping developed by our team members, as well as evaluation and comparisons of equipment available to stakeholders
- Commodity group meetings: disseminate progress and results to commodity group meetings
- Annual meeting: organize the VacCAP annual meeting (in-person and Zoom accessible, Gainesville, Florida)
- Continue to engage and educate the general public about the project outcomes and impacts through outreach activities on our website, newsletter, and social media
- Project evaluation: continue project evaluation activity to improve stakeholder engagement, communication, and effectiveness of extension activities.
- Initiate development of impact statements.

Participants

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Actual FTE's for this Reporting Period

Role	Non-Students or faculty	Students with Staffing Roles			Computed Total by Role
		Undergraduate	Graduate	Post-Doctorate	
Scientist	6.4	5.5	6.5	3.5	21.9
Professional	6	0	0	1	7
Technical	5.9	3.5	0	1.3	10.7000000000000000 01
Administrative	0.1	0	0	0	0.1
Other	0.3	0	0	0	0.3
Computed Total	18.7	9.0	6.5	5.8	40.0000000000000000 01

Student Count by Classification of Instructional Programs (CIP) Code

Undergraduate	Graduate	Post-Doctorate	CIP Code
9	7	6	01.11 Plant Sciences.

Target Audience

Blueberry and cranberry breeders; post-harvest physiologists, food scientists, germplasm collection curators, molecular geneticists, and other allied scientists of these crops; nurseries, producers, processors, marketers, and marketing organizations of Vaccinium crops; and consumers of these crops.

Products

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2022	YES

Citation

Mengist MF, MH Grace, T Mackey, B Munoz, B Pucker, NV Bassil, C Luby, M Ferruzzi, MA Lila and M Iorizzo. (2022). Dissecting the genetic basis of bioactive metabolites and fruit quality traits in blueberries (*Vaccinium corymbosum* L). *Frontier in Plant Science*, 13:964656.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2023	YES

Citation

Herniter IA, Kim Y, Wang Y, Havill JS, Johnson-Cicalese J, Muehlbauer GJ, Iorizzo M and Vorsa N. (2023). Trait mapping of phenolic acids in interspecific (*Vaccinium corymbosum* var. *caesariense* x *V. darrowii*) diploid blueberry population. *Plants*, 12:1346.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2023	YES

Citation

Erndwein L, Kawash J, Knowles S, Vorsa N and Polashock J. (2023). Cranberry fruit epicuticular wax benefits and identification of a wax-associated molecular marker. *BMC Plant Biol.* 23(1):181.

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Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2023	YES

Citation

Albert NW, Iorizzo M, Mengist MF, Montanari S, Zalapa J, Maule A, Edger PP, Yocca AE, Platts AE, Pucker B and Espley RV. (2023) Vaccinium as a comparative system for understanding of complex flavonoid accumulation profiles and regulation in fruit. *Plant Physiology*, 192(3), 1696–1710.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2023	YES

Citation

Nguyen HM, Putterill J, Dare AP, Plunkett BJ, Cooney J, Peng Y, Souleyre EJF, Albert NW, Espley RV and Günther CS. Two genes, ANS and UFGT2, from *Vaccinium* spp. are key steps for modulating anthocyanin production. *Frontiers in Plant Science*, 14 (2023): 1082246.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2023	YES

Citation

Jacobs M, Thompson S, Platts AE, Body MJA, Kelsey A, Saad A, Abeli P, Teresi, A Schillmiller SJ, Beaudry R, Feldmann MJ, Knapp SJ, Song G, Miles T and Edger PP (2023) Uncovering genetic and metabolite markers associated with resistance against anthracnose fruit rot in northern highbush blueberry, *Horticulture Research*, uhad169.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2023	YES

Citation

Lopez-Moreno H, Phillips M, Diaz-Garcia L, Torres-Meraz MA, de La Torre F, Berro I, Loarca J, Mura J, Ikeda S, Atucha A, Giongo L, Iorizzo M and Zalapa J. (2023) A Survey of Key Methods, Traits, Parameters, and Conditions for Measuring Texture in Cranberry (*Vaccinium macrocarpon* Ait.). *Horticulturae*. Apr 11; 9(4):479.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2022	YES

Citation

: Montanari S, Thomson S, Cordiner S, Günther CS, Miller P, Deng CH, McGhie T, Knäbel M, Foster T, Turner J, Chagné D and Espley R. (2022) High-density linkage map construction in an autotetraploid blueberry population and detection of quantitative trait loci for anthocyanin content. *Frontiers in Plant Science*. 13:965397.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2023	YES

Citation

Ma X, Gallardo RK, Canales E, Atucha A, Zalapa J and Iorizzo M. Would Consumers Accept CRISPR Fruit Crops if the Benefit Has Health Implications? An Application to Cranberry Products. *Agricultural and Resource Economics Review*.

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2023	YES

Citation

Maule AF, Diaz-Garcia L, Loarca J, Lopez-Moreno H, Johnson-Cicalese J, Vorsa N, Iorizzo M, Neyhart J and Zalapa J. (2023) Of Buds and Bits: A QTL Study on Traditional Upright Traits and Modern Plot Phenotyping in Cranberry (*Vaccinium macrocarpon* Ait.). *Frontiers in Plant Sciences – Plant Breeding*.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2023	YES

Citation

Lopez-Moreno H, Phillips M, Diaz-Garcia L, Torres-Meraz M, Jarquin D, Lazar F, Loarca J, Maule A, Ikeda S, Giongo L, Grygleski E, Neyhart J, Iorizzo M and Zalapa J. (2023) Multiparametric fruit textural trait development for harvest and postharvest in representative cranberry (*Vaccinium macrocarpon* Ait.) cultivars differing in texture. *Postharvest Biology and Technology*.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2023	YES

Citation

Ferrão FLV, C Luby, M Pottorff, GIP Casorzo, M Fentie Mengist, T Mikey, MA Lila, L Giongo, N Bassil, P Perkins-Veazie, M Iorizzo and PR. Munoz. Inference of the genetic basis of fruit texture and chemical component in Northern and Southern Highbush blueberries. *Scientia Horticulturae*.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2023	YES

Citation

Trandel-Hayse M, Oh H, Iorizzo M, Johanningsmeier S and Perkins-Veazie P. Blueberry cell wall composition helps to explain fruit firmness phenotypes. *ACS Food Science and Technology*.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2023	YES

Citation

Oh H, Pottorff M, Giongo L, Mainland CM, Iorizzo M and Perkins-Veazie P. Exploring shelf-life predictability of appearance traits and fruit texture in blueberry. *Postharvest Biology and Technology*

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2023	YES

Citation

Yocca AE, Platts A, Alger E, Teresi S, Mengist MF, Benevenuto J, Ferrão LFV, Jacobs M, Babinski M, Magallanes-Lundback M, Bayer P, Golicz A, Humann JL, Main D, Espley RV, Chagné D, Albert NW, Montanari S, Vorsa N, Polashock J, Díaz-Garcia L, Zalapa J, Bassil NV, Munoz PR, Iorizzo M, Edger PP (2023) Blueberry and cranberry pangenomes as a resource for future genetic studies and breeding efforts. *Horticulture Research*

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Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Under Review	2023	YES

Citation

Ma X, Gallardo RK, Canales E, Atucha A, Zalapa J and Iorizzo M. Consumers' Discount for Added Sugars: An Application to Cranberry Products Under Different Nutrition-Related Information Treatments. Journal of the Agricultural and Applied Economics Association.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Under Review	2023	YES

Citation

Ma X, Gallardo RK, Canales E and Iorizzo M. Quality-Related Descriptors to Increase Fresh Blueberries Purchase - Evidence from a Basket-Based Choice Experiment. Journal of the Agricultural and Applied Economics Association.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Knowles S, Kawash J, Spain T, Erndwein L, Johnson-Cicalese J, Polashock J and Vorsa, N. Exploring fruit chemistry in a fruit rot resistance American cranberry mapping population and QTL discovery. North American Cranberry Research and Extension Workers Conference. Chatsworth, NJ. August 21-24, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Knowles S, Kawash J, Johnson-Cicalese J, Polashock J and Vorsa N. Relationships between fruit rot resistance and horticultural traits in American cranberry (*Vaccinium macrocarpon* Ait.). American Seed Trade Association Vegetable & Flower Seed Conference. Orlando, FL. January 27-31, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Prasad R, Duiven J, Fraser A, Smits C, Vorsa N and Johnson-Cicalese J. Performance of high-yield cranberry selections from the Rutgers breeding program in southwestern British Columbia. North American Cranberry Research and Extension Workers Conference. Chatsworth, NJ. August 21-24, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Knowles S, Herniter IA, Traband R, Bowman C, Wang X, Lo S, Wysocki K, Chitwood DH, Johnson-Cicalese J, Jia Z and Vorsa N. Unusual leaf and fruit morphology in a low titratable acidity cranberry population. North American Cranberry Research and Extension Workers Conference. Chatsworth, NJ. August 21-24, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Bassil et al. VacCAP Develops High Throughput Genotyping Platforms for Blueberry and Cranberry. 2023. Annual Conference of the American Society for Horticultural Science. ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Clare et al. Assessment of the Flex-Seq Platform in Vaccinium. XXX Plant & Animal Genome, January 13-18, 2023, San Diego, California, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Nahla Bassil, Mandie Driskill, Shaun Clare, Ping Zheng, David Chagne, Sara Montanari, Susan, Thompson, Richard Espley, Patricio Munoz, Juliana Benevenuto, Dongyan Zhao, Moira, Sheehan, Molla Mengist Fentie, Lisa J. Rowland, Hamid Ashrafi, Kalpalatha Melmaiee, Ebrahiem Babiker, James Olmstead, Jessica Gilbert, Joel Kniskern, Juan Zalapa, James, Polashock, Massimo Iorizzo and Patrick Edger. Leveraging Vaccinium genomic resources for genotyping in blueberry and cranberry. XXX Plant & Animal Genome, January 13-18, 2023, San Diego, California, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Perkins-Veazie P., Massimo Iorizzo, Heeduk Oh, Farah Saeed and Changying Li. Fruit Bruising, Firmness, and Estimation of Cell Membrane Damage across Blueberry Genotypes. ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Bassil N., Driskill M., Clare S., Ping Zheng, David Chagne, Sara Montanari, Susan, Thompson, Richard Espley, Patricio Munoz, Juliana Benevenuto, Dongyan Zhao, Moira, Sheehan, Molla Mengist Fentie, Lisa J. Rowland, Hamid Ashrafi, Kalpalatha Melmaiee, Ebrahiem Babiker, James Olmstead, Jessica Gilbert, Joel Kniskern, Juan Zalapa, James, Polashock, Massimo Iorizzo and Patrick Edger. VacCAP Develops High Throughput Genotyping Platforms for Blueberry and Cranberry. ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Kawash J and Polashock J. 2023. Developing a new machine learning tool for improved genomic selection in non-model systems. Meeting: Mapping the Future of Agricultural Genome to Phenome Research in Kansas City, Missouri on June 15-16, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Erndwein L and Polashock J. 2023. Two-year survey of cranberry fruit rotting fungi detects azoxystrobin and thiophanatemethyl resistant Colletotrichum siamense. North American Cranberry Research and Extension Workers Conference in Absecon, New Jersey on August 21-24, 2023.

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Kawash J, Dehzangi I, Mehedi Azim S and Polashock J. 2023. Hyperspectral imaging and the application of machine learning for rapid phenotyping of cranberry samples. North American Cranberry Research and Extension Workers Conference in Absecon, New Jersey on August 21-24, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Lopez-Moreno H, Phillips M, Diaz-Garcia L, Torres-Meraz MA, Devi Mura J, Ikeda S, Johnson-Cicalese J, Vorsa N, Iorizzo M, Neyhart J and Zalapa J. 2023. Phenomics of Processing Industry Fruit Quality Traits for Genetic Mapping in the American Cranberry (*Vaccinium macrocarpon* Ait ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Lopez-Moreno H, Phillips M, Diaz-Garcia L, Torres-Meraz MA, Mura JD, Ikeda S, Johnson-Cicalese J, Vorsa N, Iorizzo M, Neyhart J and Zalapa J. 2023. Unraveling the genetic bases of fruit quality in the American cranberry. NACREW. Absecon, New Jersey, August 22, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Lopez-Moreno H, Phillips M, Diaz-Garcia L, Loarca J, Mura JD, Ikeda S, Vorsa N, Iorizzo M, Johnson-Cicalese J, Neyhart J and Zalapa J. 2023. Fruit Quality phenotyping for breeding and genetic studies in cranberry. Alejandra Torres-Meraz, NACREW. Absecon, New Jersey, August 22, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Cheng CH, Jung S, Lee T, Buble K, Humann J, Zheng P., ... and Main D. 2023. Open-Source Solutions for Efficiently Building Community Databases for Crop Genomics, Genetics, and Breeding Research. ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Main D. 2023. Hands-on Training for Effective Use, Data Contribution, and Options for Long Term Sustainability of Specialty Crop Community Databases. ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Jung S, Lee T, Cheng CH, Gasic K, Humann J, Yu J and Main D. 2023. Breeding Information Management System (BIMS) for Crop Breeders. ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Main D, Jung S, Lee T, Cheng CH, Zheng P, Gasic K, Humann J., ... and Buble K. 2023. Hands-on Training for Effective Use, Data Contribution, and Options for Long Term Sustainability of Specialty Crop Community Databases. ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Main D, Jung S, Lee T, Cheng CH, Zheng P, Gasic K, Humann J., ... and Buble K. 2023. Resources for Fruit Breeding Research in Databases for Rosaceae, Vaccinium, and Citrus. XXX Plant & Animal Genome, January 13-18, 2023, San Diego, California, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Humann J, Jung S, Jung S, Lee T, Cheng CH, Zheng P, Gasic K, ... and Main D. 2023. Updates on Genomic Data and Tools in Rosaceae, Cotton, Citrus, Vaccinium, and Pulse Crop Databases. XXX Plant & Animal Genome, January 13-18, 2023, San Diego, California, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Jung S, Jung S, Lee T, Cheng CH, Zheng P, Humann J, Gasic K, ... and Main D. 2023. Updates on Genetics Data and Tools in Rosaceae, Cotton, Citrus, Vaccinium, and Pulse Crop Databases. XXX Plant & Animal Genome, January 13-18, 2023, San Diego, California, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Bassil N, Jung S, Jung S, Lee T, Cheng CH, Zheng P, Gasic K, ... and Main D. 2023. Updates on Germplasm and Diversity Data and Tools in Rosaceae, Cotton, Citrus, Vaccinium, and Pulse Crop Databases. XXX Plant & Animal Genome, January 13-18, 2023, San Diego, California, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Iorizzo M, Lila M, Perkins-Veazie P, Luby CH, Vorsa N, Edger P, Bassil NV, Munoz P, Zalapa JE, Gallardo KR, Atucha A, Main D, Giongo L, Li C, Polashock JJ, Sims C, Canales E, Devetter L, Coe M, Chagne D, Colonna A and Espley R. (2023) VacciniumCAP, a community-based project to develop advanced genetic tools to improve fruit quality in blueberry and cranberry. *Acta Horticulturae*. 1362:71-80.

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Giongo, L., Ajelli, M., Pottorff, M., Coe, K., Perkins-Veazie, P., Bassil, N.V., Hummer, K.E., Farneti, B. and Iorizzo, M. 2023. Comparative study on texture: a key for blueberry quality breeding. *Acta Horticulturae* 1357, 107-114.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Perkins-Veazie, P., Ma, G., Pottorff, M., Lila, M.A. and Iorizzo, M. (2023). New tools for rapid fruit quality analysis in blueberry. *Acta Horticulturae* 1357, 193-198.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Iorizzo M., M.A. Lila, P. Perkins-Veazie, N. Vorsa, P. Edger, N. Bassil, P. Munoz, J. Zalapa, K.R. Gallardo, A. Atucha, D. Main, L. Giongo, C. Li, J. Polashock, C. Sims, E. Canales, L. M. Coe, D. Chagne, R. Espley and L. De Vetter. 2022. VacciniumCAP, a community-based project to develop advanced genetic tools to improve fruit quality in blueberry and cranberry. Proceedings of the ISHS International Symposium on Breeding and Effective Use of Biotechnology and Molecular Tools in Horticultural Crops. *Acta Horticulturae* 1362, 71-80

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Humann, J.L., Cheng, C.-H., Lee, T., Buble, K., Jung, S., Yu, J., Zheng, P., Hough, H., Crabb, J., Frank, M., Scott, K., Iorizzo, M. and Main, D. 2023. Using the Genome Database for Vaccinium for genetics, genomics, and breeding research. *Acta Horticulturae* 1357, 115-122

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Oh H, Mengist MF, Pottorff M, Giongo L, Perkins-Veazie P, Iorizzo M. Mapping QTLs for postharvest fruit texture and size characteristics in blueberry. Plant & Animal Genomics Conference (PAG) 30. January 13-18, 2023, San Diego, CA, USA. Poster

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Oh H, Mengist MF, Pottorff M, Giongo L, Perkins-Veazie P, Iorizzo M. Identification of QTLs related to fruit texture at harvest and postharvest in blueberry. Tools for Polyploids Workshop 2023. January 11-12, 2023, San Diego, CA, USA. Poster

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Trandel-Hayse M.A., Oh H., Johanningsmeier S., Iorizzo M. and P. Perkins-Veazie. Peel and Pulp Texture Parameters Are Negatively Correlated to Pectin and Cellulose Content in Ten Highbush Blueberry Cultivars. ASHS 2022 Annual Conference, July 29-August 3, 2022, Chicago, IL, USA. Poster

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Perkins-Veazie P., Ma G., Oh H., Trandel-Hayse M.A., Bassil N., Luby C., Munoz P.R. and M. Iorizzo. Development of a High-Throughput Method to Evaluate Soluble Sugar Content of Large Sets of Blueberry Fruit. ASHS 2022 Annual Conference, July 29-August 3, 2022, Chicago, IL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

M. Iorizzo. Genetics, genomics, germplasm improvement to advance breeding of berries. 1st Latin American Congress of Berries, August 24-25, Chillán, Chile.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Molla Fentie Mengist, Marti Pottorff, Lara Giongo, Ted Mackey, Felipe Ferrao, Mary Ann Lila, Claire Luby, Nahla Bassil, Patricio R. Munoz, Penelope Perkins-Veazie and Massimo Iorizzo. Assessing Genetic Parameters and Predictability for Shelf Life Parameters in Blueberry. ASHS 2023 Annual Conference, July 31-August 4, 2023, Orlando, FL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Mengist M.F. , M.H. Grace, T. Mackey, B. Munoz, B. Pucker, N. Bassil, C. Luby, M. Ferruzzi, M.A. Lila and M. Iorizzo. Investigating the genetic basis of bioactive metabolites and fruit quality traits in blueberries (*Vaccinium corymbosum* L.). XXX Plant & Animal Genome, January 13-18, 2023, San Diego, California, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Iorizzo M. Exploring fruit/vegetable nutrigenomic properties as new target traits to improve phytochemicals and nutrients uptake/health outcomes. 7th Annual UF Plant Science Symposium, January 30-31, 2023, Gainesville, FL, US.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Iorizzo M. *Vaccinium* CAP status and updates: advancing genetic and genomic tools to improve fruit quality in blueberry and cranberry. Southeast Regional Fruit & Vegetable Conference, January 6, 2023, Savannah, GA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

M. Iorizzo. Leveraging genetic and genomic tools to improve bioactive delivery/use from fruit and vegetables. CNR – ISPA, Italy. November 15, 2022.

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Borges et al. 2023. Development of molecular markers for flavor improvement in autotetraploid blueberry. Polyploid across the tree of life, May 9-12, 2023, Palm Coast, FL, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation

Munoz P. 2023. Advancing Genomic Methods and Knowledge in Blueberry. Plant and Animal Genome. XXX Plant & Animal Genome, January 13-18, 2023, San Diego, California, USA.

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Munoz P. Strategies applied to the selection and development of new blueberry varieties. In Te Puke, New Zealand, June 15, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Munoz P. Generating tools and resources for a more informed breeding process. Cornell University College of Agriculture and Life Sciences seminar series, October 02, 2022. Ithaca, NY

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Munoz P. Generating tools and resources for a more informed breeding process. Rutgers Fall graduate program seminar series. November 18, 2022. Newark, NJ

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Munoz P. Breeding Blueberry for Improving Eating Experience. Minnesota Plant Breeding Center Seminar Series, May 12, 2023.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Munoz P. Strategies applied to the selection and development of new blueberry varieties. 1st Latin American Congress of Berries, August 24-25, Chillán, Chile.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation

Martensson K, Loarca J and Zalapa J. Analyzing cranberry fruit quality and internal structure. UW-Madison Undergraduate Research Symposium, December 12, 2022, Madison-WI.

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Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation
Zalapa J and H Herline. Varietal trial bed expansion: building the future genetic structure of cranberry. Proceedings article in the 2023 summer cranberry meeting and Field Day, page 19-20.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation
Zalapa J. USDA-ARS Food Science and Fruit Quality Ad hoc committee research roundtable meeting. Madison WI. 3-29-2023.

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation
Zalapa J. Cranberry research at the Walnut Street greenhouse UW, CALS Leadership tour. UW-Madison. 5-22-2023

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation
Zalapa J. Cranberry cultivar fruit quality and yield discussion with UMass-Amherst. Zoom meeting. 4-11-23.

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation
Zalapa J. Cranberry cultivar fruit quality and yield discussion with Wisconsin growers. Zoom meeting. 4-21-23.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Other	2023	YES

Citation
Giongo L. Blueberry breeding program at FEM: an integrated approach to innovate through new varieties for Northern and Southern Europe – MacFruit 2023 Rimini, Italy, May 3-5.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation
Giongo L. Quality evaluations and requirements at harvest and postharvest for new cultivars of highbush blueberry. 11th Blueberry Conference Warsaw, Poland, March 9-10, 2023

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2023	YES

Citation
Giongo L. Developments and impacts of fruit quality analyses in blueberry: a focus on texture and postharvest. International Blueberry School, 2nd May 2023, Ancona, Italy.

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2022	YES

Citation

De Vetter L. Breeding Efforts in Berry Crops Growing By Leaps and Bounds. Growing Produce, Dec 20, 2022. https://www.growingproduce.com/fruits/berries/breeding-efforts-in-berry-crops-growing-by-leaps-and-bounds/?utm_source=gp&utm_medium=twitter&utm_campaign=2212

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2022	YES

Citation

Mirtillo, a caccia dei geni per renderlo migliore. Terra e Vita, n. 34-2022, November 11.

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Luby C., Hislop L., M. Iorizzo, L. Giongo, A. Atucha, L. Wasko DeVetter and Russo J. Blueberry Shelf Life. April 18, 2023. <https://www.vacciniumcap.org/sites/default/files/inline-files/VacTrait%20Shelf%20Life.pdf>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

DeVetter and Bassil. 2023. VacCAP: Improving Fruit Quality. Oregon State University Blueberry Field Day. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Lopez-Moreno H, Phillips M, Diaz-Garcia L, Torres-Meraz MA, de La Torre F, Berro I, Loarca J, Mura JD, Ikeda S, Atucha A, Giongo L, Iorizzo M, Zalapa JE. 2023. A survey of key methods, traits, parameters, and conditions for measuring texture in cranberry (*Vaccinium macrocarpon* Ait.). U Mass Cranberry Management Update. East Wareham, Mass., January 25, 2023. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

M. Iorizzo. VacCAP Project updates. North Carolina Blueberry Council – 57th Annual Open House and Trade Show, January 10, 2023, Fayetteville, NC, USA. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Polashock J and Sarowar S. Gene Functional Analysis in Cranberry. American Cranberry Growers Assoc. Winter Meeting, Bordentown, NJ, January 19, 2023. Presentations for Growers or Other Industry Stakeholders

Progress Report

Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Johnson-Cicalese J, Vorsa N, Knowles S and Spain T. Update on Cranberry Breeding Projects. American Cranberry Growers Assoc. Winter Meeting, Bordentown, NJ, January 19, 2023. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Kawash J and Polashock J. 2023. Updating Approaches to Fruit Rot Resistance Research. American Cranberry Growers Assoc. Winter Meeting, Bordentown, NJ, January 19, 2023. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Erndwein L, Kawash J and Polashock J. Cranberry Fruit Epicuticular Wax Benefits and Identification of a Wax-Associated Molecular Marker. American Cranberry Growers Assoc. Winter Meeting, Bordentown, NJ, January 19, 2023. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Munoz P. Research update and new cultivars. Florida Blueberry Growers Association. October 20, 2022. Howdy on the hill, FL. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Zalapa J. Mini clinic: Cranberry variety trail and VaCap traits showcase. Wisconsin Cranberry Growers Association summer meeting. Black River Falls, WI, August 9, 2023. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Zalapa J. Cranberry Research Round Table. Zalapa Lab Summary of activities, including VaCcap report to the Wisconsin growers. November 17, 2022. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Zalapa J. Wisconsin Cranberry Board Research Report. Black River Falls, Wi, March 15, 2023. Presentations for Growers or Other Industry Stakeholders

Progress Report

Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Zalapa J. Wisconsin State Cranberry Growers Association meeting. Black River Falls WI, July 6, 2023. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Giongo L. Blueberry breeding program at FEM: an integrated approach to innovate through new varieties for Northern and Southern Europe. May 21, 2023 Meeting with Spanish and Chilean growers. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Giongo L. Blueberry breeding program at FEM: an integrated approach to innovate through new varieties for Northern and Southern Europe. July 6, 2023 Meeting with Spanish growers. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Giongo L. Blueberry breeding program at FEM: an integrated approach to innovate through new varieties for Northern and Southern Europe. July 11, 2023 Meeting with Italian growers. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Giongo L. Blueberry breeding program at FEM: an integrated approach to innovate through new varieties for Northern and Southern Europe. July 13, 2023 Meeting with English growers. Presentations for Growers or Other Industry Stakeholders

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Atucha A, Russo J, DeVetter L and Iorizzo M. Understanding the W85 Blueberry Genome. VacCAP Newsletter Issue 6, March 2023. <https://www.vacciniumcap.org/w85genome>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Atucha A, Russo J, DeVetter L and Iorizzo M. Exploring the New Frontier of Flavonoid Genetics in Blueberry. VacCAP Newsletter Issue 6, March 2023. <https://www.vacciniumcap.org/frontierofflavonoidgenetics>

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------------------------------	----------------------------

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Atucha A, Russo J, DeVetter L, Lopez-Moreno H and Zalapa J. Survey Says: How the Zalapa Team Is Identifying the Best Methods for Measuring Texture Traits in Cranberry. VacCAP Newsletter Issue 7, June 2023. <https://www.vacciniumcap.org/texturesurvey>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

DeVetter L. A Tribute to Bernadine Strik – Berry Goddess. VacCAP Newsletter Issue 7, June 2023. <https://www.vacciniumcap.org/bernadinetribute>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Trandel-Hayse M. A Deeper Look Into Blueberry Cell Wall Composition and Fruit Firmness Phenotypes. VacCAP Newsletter Issue 8, August 2023. <https://www.vacciniumcap.org/blueberrycellwallcomp>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Russo J. VacCAP for All: Cranberry Fruit Epicuticular Wax Benefits and Identification of a Wax-Associated Molecular Marker. VacCAP Newsletter Issue 8, August 2023. <https://www.vacciniumcap.org/sites/default/files/inline-images/VacCAP%20for%20All%20Cranberry%20Wax.pdf>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2022	YES

Citation

Humann JL and Main D. Genome database for Vaccinium newsletters, Issue 5, (October 2022). <https://www.vaccinium.org/sites/default/files/files/GDV%20Newsletter-Oct2022.pdf>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Humann JL and Main D. Genome database for Vaccinium newsletters, Issue 6, (January 2023). <https://www.vaccinium.org/sites/default/files/files/GDV%20Newsletter-Jan2023.pdf>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Humann JL and Main D. Genome database for Vaccinium newsletters, Issue 7, (April 2023). <https://www.vaccinium.org/sites/default/files/files/GDV%20Newsletter-Apr2023.pdf>

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Accession No. 1020223

Project No. NC09879

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Humann JL and Main D. Genome database for Vaccinium newsletters, Issue 8, (July 2023).
<https://www.vaccinium.org/sites/default/files/files/GDV%20Newsletter-Jul2023.pdf>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2022	YES

Citation

Trandel-Hayse M, Oh H, Iorizzo M, Johanningsmeier S, Perkins-Veazie P. 2022. Blueberry cell wall composition helps to explain fruit firmness phenotypes. Fla State Hort Soc, Scientific note

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2023	YES

Citation

Zalapa J., F. Lazar, F. De la Torre, H. Lopez-Moreno. 2023. The Importance of Genetics in Cranberry Production. College of Agricultural and Life Sciences Division of Extension Integrated Pest Management Program Nutrient and Pest Management Program. Wisconsin Fruit Program. Available Online: https://ipcm.wisc.edu/wp-content/uploads/sites/54/2023/04/UW_CranberryBacktoBasics.pdf

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2022	YES

Citation

Iorizzo M. Autopolyploid Inheritance & Heterozygous Reciprocal Translocation Shape Chromosome Genetic Behavior on December 16, 2022. Webinar presentation.

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Bassil N. and S. Clare. Two New Flex-Seq-EX-L High Throughput Genotyping Platforms for Blueberry and Cranberry on January 26, 2023. Webinar presentation.

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Polashock J. Wax On, Acid Off: Approaches to Cranberry Fruit Improvement on April 24, 2023. Webinar presentation.

Type	Status	Year Published	NIFA Support Acknowledged
Other	Other	2023	YES

Citation

Montanari S. Understanding the Genetic Control of Anthocyanin Content in Blueberry on May 25, 2023. Webinar presentation.

Other Products

Accession No. 1020223

Project No. NC09879

Product Type

Databases

Description

GDV data updates. The Genome Database for Vaccinium (GDV, <https://www.vaccinium.org>) is an online community database providing access to integrated Vaccinium peer-reviewed genomic, genetic, and breeding data and analysis tools. During year 4 of the project twenty-two new blueberry and ten new cranberry genomes from the Vaccinium Pangenome Project (https://www.vaccinium.org/bio_data/2703087) and the Vaccinium darrowii Camp genome were added to GDV. The gene, mRNA, and functional annotation information for all the genomes were added to the database and the genomes were added to the BLAST and JBrowse genome tools. The *V. darrowii* genome and the three best blueberry (Duke, Earlie Blue, Elliot) and cranberry genomes (Budd's Blues, Garwood Bell, Native Budd's Blues) from the pangenome project were added to the PathwayCyc and Synteny Viewer genome tools. GDV also hosts the structural graphs from the Vaccinium Pangenome Project (<https://www.vaccinium.org/node/1251207>). For genetic data, we curated data from 5 manuscripts and added 5 genetic maps, 128,438 genetic markers, and 368 QTL. During year 4, GDV was accessed by 5,722 users from 84 countries, with 11,842 visits and 129,418 pages served (Google Analytics)

Product Type

Databases

Description

GDV tools updates. Improvements and upgrades were done to the tools deployed on GDV. The Breeding Information Management System (BIMS), used to manage private breeding program data, now imports images from the Field Book App and supports BrAPI v1 and v2 Field Book calls. We added the ability to load GWAS data to the database, and search and view GWAS data in the MegaSearch and MapViewer Tools. And also added an ortholog/paralog search to MegaSearch and orthologs are also displayed on the gene/mRNA feature pages. The genotype search was also added. We have also added the ability to load gene annotation information to the database for use in the coming year. Crosslinks between germplasm records and the Fruit and Nut database are now available as well. In addition to making all MainLab modules compatible with PHP8, the following modules were released: TripalMap v2.0, ChadoSearch v2.7, and Tripal MegaSearch v1.4. The lab is also working on updating the modules to be compatible with Drupal 10 and Tripal 4.

Product Type

Databases

Description

Vaccinium CAP project website (<https://www.vacciniumcap.org>).

- During year 4 we continued to refine design for optimal access to project information and update content with new webinars, VacCAP traits, short video, newsletters.

- Website stats summary (September 1, 2022–August 31, 2023)

- o 9,251 pageviews

- o Top 5 Pages Based on Views

- o ? Home | VacCAP

- o ? About | VacCAP

- o ? Newsletters | VacCAP

- o ? Team | VacCAP

- o ? News | VacCAP

- o 2,698 users

- o Top 5 Counties Based on User Locations

- o ? United States (1,700 users)

- o ? China (225 users)

- o ? Australia (71 users)

- o ? Canada (66 users)

- o ? India (41 users)

- o 3,320 sessions (1.23 sessions per users)

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Product Type

Other

Description

Social Media. A twitter account (@VacciniumCAP) was maintained to disseminate information about the project as part of the social media strategy, in conjunction with a YouTube channel (<https://www.youtube.com/channel/UCpAdvtTEebzZjvJ4SJcoXwg>).

- Twitter Stats (September 2022–August 2023)

 - o 379 followers

- YouTube (September 2022–August 2023)

 - o 1,215 video views

 - o 104.7 hours of watch time

Product Type

Audio or Video

Description

Webinars. The following four webinars were made available on VacCAP:

- Autopolyploid Inheritance & Heterozygous Reciprocal Translocation Shape Chromosome Genetic Behavior on December 16, 2022. Presenter: Dr. Massimo Iorizzo. 45 participants.

- Two New Flex-Seq-EX-L High Throughput Genotyping Platforms for Blueberry and Cranberry on January 26, 2023.

Presenters: Dr. Nahla Bassil and Shaun Clare. 42 participants.

- Wax On, Acid Off: Approaches to Cranberry Fruit Improvement on April 24, 2023. Presenter: Dr. James Polashock. 29 participants.

- Understanding the Genetic Control of Anthocyanin Content in Blueberry on May 25, 2023. Presenter: Dr. Sara Montanari. 32 participants.

For videos see here: <https://www.youtube.com/@vaccaproject2641>

Product Type

Other

Description

Genotyping platform. Continued coordination of sample submission for the Vaccinium genotyping consortium. Three new partners submitted 2000 samples which total 10,300 samples. The platform is available for use through LGC.

Product Type

Other

Description

Blog. US Department of Agriculture dives into blueberry and cranberry genotyping. <https://blog.biosearchtech.com/us-department-of-agriculture-dives-into-blueberry-and-cranberry-genotyping>

Product Type

New Germplasm

Description

Cranberry. At the Rutgers program new breeding populations carrying fruit rot resistance and new germplasm have been added to the cranberry breeding program, and new field plots established. Developed new half sib-families based on phenotypic data collected from VacCAP. Material will be planted in 2024. At the USDA-Wisconsin program twenty lines were selected for yield and improved quality traits from the high density cranberry breeding nursery at the USDA-ARS cranberry breeding program in WI. Also, developed seed for eight half sib-families using #35 as a male Potter's Favorite, Stevens, Sundance, Pilgrim, HyRed, Ruby Star, WSU108, Ben Lear. Material will be planted in 2024.

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Blueberry. At the UF program, a bi-parental population with contrasting volatile content was created for further molecular marker validation. Progenies were planted in the field in May 2023. From the GenStudy and ValStdy sets superior flavor individuals were selected based on the data generated with the VacCAP project. Using texture and acoustic data at the FAM program over 300 blueberry lines were selected and were moved into the next phase on the breeding program. At the USDA program 53 selections were made for quality traits and 16 selections were used to make new crosses.

Product Type

Protocols

Description

New methods and protocols to evaluate cranberry fruit Texture, External Appearance, Internal appearance were implemented at two USDA labs and three university labs (UW-Madison, Rutgers, and U. Mass) where staff and students were trained. Building upon this first implementation step, new training activities are planned to transfer and update the method to other core and non-core labs during Y5.

Product Type

Survey Instruments

Description

Distributed a survey to blueberry and cranberry growers across the United States to elicit the breeding priorities. Re-assessing breeding priorities will guide the direction of future research efforts.

Product Type

Audio or Video

Description

Video training. Seven "how to" videos for GDV were released. These short videos provide instruction and training on how to use the tools and features available on GDV. The following videos were released:

1. Humann JL and Main D. Learn how to start with a trait, find an associated GWAS, view the gene, and then find an ortholog! <https://youtu.be/MRLqwEh68Gk?si=36AM4Q0zBd3aZnMa>
2. Humann JL and Main D. Learn how to search and view traits and associated data. <https://www.youtube.com/watch?v=nKo8c7s5pHc>
3. Humann JL and Main D. Learn how to search and view GWAS data. <https://www.youtube.com/watch?v=MRLqwEh68Gk>
4. Humann JL and Main D. Learn how to view genomes linked to genetic maps. <https://www.youtube.com/watch?v=ZHn-tlHKhfw>
5. Humann JL and Main D. Learn how to search markers. https://www.youtube.com/watch?v=NrwYZB_ywsg
6. Humann JL and Main D. Learn how to overlay Omics Data in PathwayCyc <https://youtu.be/qhSTmzBZCLQ?si=eJiZF0ZCozSMwjyO>
7. Humann JL and Main D. Learn how to BLAST to mRNA details to JBrowse <https://youtu.be/FBN9s4-a7BU?si=HI8UMUrgfjAiPo8N>

Product Type

Other

Description

Fostered collaborations: VacCAP activities fostered multiple collaborations. Zalapa lab has been working with Breeding Insight to transfer phenotyping methods into PlantCV a platform develop by BI. Collaboration with Breeding Insight also led to develop trait ontology for both blueberry and cranberry.

Changes/Problems

The delay of funding release from the USDA-NIFA during Year 1 and COVID-19 requirements during 2020-2022, delayed multiple activities and led the team to request a one-year no cost extension. A summary of affected activities and alternative

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plans are summarized below:

Obj. 1. Development of genotyping platforms was delayed. As a result, delivery of the genotypic data for genetic studies expected in Y4 was delayed and will be completed in Year 5. Obj. 2. Delay in the delivery of genotypic data delayed some of the genetic studies. To ensure success of the genetic studies and expand our capacity to detect and validate QTLs across studies, additional materials including four mapping populations and a new cranberry diversity panel were added to the project for genetic studies. A new method with increased throughput to evaluate organic acids (OA) was used to during year 4 and analysis is planned to be completed during Year 5. Due to COVID-19, and the loss of a key PI due to illness evaluation and analysis of cranberry data at Rutgers was delayed. During year 4 evaluation of fruit texture and structure was completed, and data analysis will be performed during year 5. Obj. 3. Due to the delay in completing genetic studies, validation of QTLs was also delayed. To facilitate integration of novel QTLs that are expected to be detected from genetic studies that are being delayed, team members imitated efforts to anchor QTLs identified during Y1-Y4 in mapping populations, and from previous studies into the blueberry and cranberry physical maps. Efforts to perform functional characterization of candidate genes were also initiated. As new QTL studies are being completed, this framework will facilitate identification of QTLs that overlap across multiple studies and will be considered as validated across multiple genetic stocks. Obj. 4. Due to logistic difficulties in accessing large amounts of fruit from selected blueberry cultivars, as well as feedback from stakeholders on research questions with higher priorities, the proposed research on consumer behavioral response to fruit tasting using biometric parameters was re-designed into a new study to elicit the sensory quality attributes that would increase demand.