NC STATE UNIVERSITY

Blackberry and Raspberry:

Breeding program. Fernandez, G.E., Perkins-Veazie, P. North Carolina State University, Cornell University

- Yield and post harvest attributes from 35 raspberry and 1 blackberry selection were collected over the past 2 years. We have identified one floricane fruiting raspberry, 2-3 primocane fruiting raspberry, 1 floricane fruiting blackberry to place in replicated trials. We have several unique genotypes that will be sent to the USDA Germplasm repository or licensed to companies once the program winds down. ***Objective 1, 2 and 4***

Pairwise Rubus GXE Study. Katie-Sheehan Lust, Gina Fernandez, North Carolina State University, Cornell University, University of Arkansas, University of British Columbia/BC Berry Cultivar Development Inc., and the USDA (Corvallis, OR)

- This is a collaborative effort with Pairwise, and Plant Sciences Inc (Watsonville, CA) to uncover the genetic potential in the genus *Rubus*. The collaborators maintain the same five cultivars in each of their six geographically distinct locations and phenotype the same set of traits that contribute to plant architecture, fruit quality, and yield components. The cultivars being evaluated include red raspberries, blackberries, and a black raspberry. This evaluation is being done to increase understanding of the effects of genotype, environment, and their interactions on the expression of the traits of interest in *Rubus*. NCSU is leading the analysis of the GXE data. ***Objectives 1 and 3***

Development of Markers for Raspberry Breeding. Hamid Ashrafi, Katie-Sheehan Lust, Gina Fernandez, Helena Hysong and Pairwise Inc. (2021)

- A total of 30 Raspberry whole genome sequencing data were provided by Pairwise Inc. The reads were mapped to black raspberry genome (v3) that can be downloaded from GDR. The SNP markers (3.4 Million) were identified using an in-house SNP identification pipeline. The SNPs were annotated using the GFF file of the genome. The validation experiment for these markers is underway as a part of Katie's MS thesis. ***Objective 1***

Long cane trials of raspberry. Lisa Rayburn, Gina Fernandez, Brian Jackson. NCSU. (2021-202?)

- In cooperation with Lewis Farm, we are developing a long cane raspberry production system for SENC. Raspberries are a high value crop that are not

grown commercially in this area due to disease pressure and high temperatures during the natural harvest window. Protected culture, early harvest and an annual production system may make this a viable enterprise for local sales. We are investigating the use of a pine bark blend substrate as an alternative to the industry standard coco coir. The pine bark substrate would be a local product, less vulnerable to supply chain disruptions and significantly less expensive. It can also be amended preplant and allow the grower to utilize a more simplified fertility program. Weather and supply chain disruptions resulted in a late pull out, bud break problems and an inability to collect yield data this year. Observations from this growing season have resulted in modification of the pine bark substrate. The improved substrate mix will be trialed against coco coir in the 2022 growing season. Observation during the 2021 growing season will also inform the variety selection and pull out dates for the 2022 season. ***Objectives 2 and 4***

On-farm blackberry trials of USDA, NCSU and U. Arkansas cultivars. Gina Fernandez, Extension agents and growers in NC, SC and VA. Funded by the SRSFC.

- This trial was established to evaluate Chads/USDA's eastern adapted cultivars in multiple locations. Two sets of on farm trials included the following cultivars: Galaxy, Twilight, Eclipse, Ponca, Ouachita and Von. We distributed 5 plants of 5 of the above cultivars to 28 counties in NC for planting at local PYO farms, extension offices, youth gardens and community gardens. We also distributed 25 plants of 5 of the above cultivars to farms in NC, SC and VA. Participants are asked to conduct taste tests and provide us with the feedback in 2022. At least one location will be collecting yield data. ***Objectives 1, 2, 3 and 4.***

Enhancing blackberry canopy light distribution with reflective groundcovers. Kon, T.M., K. Blaedow, H. Burrack, G. Fernandez, J. Hopkins, J.C. Melgar, P. Perkins-Veazie, G. Schnabel, and S. Villani. (2021). Funded by the North American Bramble Growers Research Foundation. ***Objectives 2 and 4***

- Reflective groundcovers can have profound impacts on vegetative growth, productivity, and fruit quality in several Rosaceous cropping systems, but research on caneberry has been limited. Trials were initiated in SC and NC to compare the effects of sod and reflective groundcovers on canopy microclimate, bud phenology, yield, fruit quality, SWD infestation, disease incidence, and vegetative growth of 'Osage' and 'Prime-Ark® Traveler' blackberry. No differences were found in postharvest life, fruit composition, or gray mold infection among treatments in 2021. SWD populations were significantly reduced with reflective groundcover in three of four sampling periods. The experiments will be repeated in 2022 to determine if further evaluation is justified.

Improved management of primocane-fruiting blackberry. Kon, T.M, G. Fernandez, P. Perkins-Veazie, and S. Villani. (2021-2023). Funded by the North Carolina Department of Agriculture and Consumer Science, Specialty Crop Block Grant Program. ***Objectives 2,3 and 4***

- Primocane-fruiting blackberry cultivars are less susceptible to frost and freeze damage, can extend the production and marketing season, and reduce pruning costs. Primocane-fruiting cultivars can be grown successfully in western NC, but yield limitations are observed in some instances. We initiated a two-year trial to optimize cane management strategies for primocane fruiting blackberry. Effects and interactions of cane bending, defoliation, and cane density were evaluated on 'Prime-Ark® Traveler'. Effects on light interception, yield responses, fruit composition, post-harvest life, and cane architecture were evaluated. Treatments will be applied to the same plots in 2022 to determine cumulative effects.

Increasing lateral branching of primocane-fruiting blackberry with 6-benzyladenine and GA_3. Kon, T.M and G. Fernandez. 2020-2021. Funded by the Southern Region Small Fruits Consortium. ***Objective 2***

- Inadequate lateral branch development on primocanes can have negative consequences on blackberry productivity and profitability, since yield is positively correlated with lateral branch number. This research was initiated to determine if lateral branching can be stimulated via PGRs, rather than reliance on summer pruning (tipping). We evaluated a range of 6-BA + GA_3 rates to determine the relationship between PGR concentration and lateral branch development on 'Ouachita' primocanes. While lateral branching can be stimulated by PGRs, effective treatments also increased cane height. The experiment will be repeated in 2022.

Evaluation of gibberellic acid and prohexadione calcium for cane management in novel and standard height blackberries. Worthington, M., T. Kon, and C. Johns. (2021). Funded by the Southern Region Small Fruits Consortium. ***Objectives 2 and 4***

- The University of Arkansas System Division of Agriculture fruit breeding program developed blackberry germplasm with brachytic dwarfism for landscape/garden and commercial purposes. The specific mechanisms of this growth habit are generally unknown. In coordinated studies in AR and NC (project led by Johns and Worthington) we sought to determine if gibberellin synthesis and metabolism may be related to dwarfism of three genotypes. Effects and interactions of exogenous PGRs (GA_3 and prohexadione calcium) and genotype ('Babycakes®', Ponca, and 'Natchez') on cane architecture were evaluated. Data is currently being summarized and analyzed.

<u>Blueberry & Huckleberry:</u>

VacciniumCAP: Leveraging genetic and genomic resources to enable development of blueberry and cranberry cultivars with improved fruit quality attributes. USDA-NIFA-SCRI-CAP program. 2019-2023. M. Iorizzo, P. Perkins-Veazie, M.A. Lila, NC State University, Kannapolis NC; Luby, N. Bassil, J. Zalapa, J. Polashock, USDA-ARS; N. Vorsa, Rutgers University; P. Munoz, C. Sims, University of FLorida; K. Gallardo, L. De Vetter, D. Main, Washington State University; C. Li, University of Georgia; E. Canales, Mississippi State University; D. Change, R. Espley, Plant and Food Research Ltd (New Zealand); L. Giongo, Fondazione Edmund Mach (Italy). ***Objective 1, 3 and 4***

Genetic study for fruit characteristics: M. Iorizzo

- Completed a genetic study for pH, Titratable acidity, total soluble solids and fruit weight in a bi=parental population derived from a cross between Reveille and Arlen, developed by Dr. James Ballington at NCSU breeding program. A high-density linkage map was constructed using 17k single nucleotide polymorphisms markers. In total 18 QTLs for fruit quality traits were detected, including seven loci for fruit weight, three loci for titratable acidity, five loci for pH, and three loci for total soluble solids. Ten of these loci were detected in more than one year. We also reported the association between fruit quality traits and metabolites detected by Proton nuclear magnetic resonance analysis directly responsible for these fruit quality traits. Organic acids, citric acid, and quinic acid were significantly ($P < 0.05$) and positively correlated with titratable acidity. Sugar molecules showed a strong and positive correlation with total soluble solids. Overall, the study dissected the genetic basis of fruit quality traits and established an association between these fruit quality traits and metabolites. *See Molla we al., 2021.* ***Objective 1***

Fruit quality traits in blueberries from multiple sources. Perkins-Veazie, P., Iorizzo, M., Oh, H., Munoz, P., Bassil, N. Part of the VACcaps NIFA-SCRI grant.

- About 9,000 fruit samples from Oregon and FL were evaluated for soluble solids content, pH, and titratable acidity. Soluble solids content was found to be slightly higher in OR material compared to FL while pH and titratable acidity were very similar. Surprisingly, the titratable acidity was between 0.1 and 0.5 citric acid equivalents for 85% of the samples, regardless of fruit source. ***Objective 1***

Closing the gap in delivery of fruit and vegetable benefits. FFAR seeding solutions program. 2017-2022. M. Iorizzo, M.A. Lila, M. Ferruzzi, Colin D.K. NC State University, Kannapolis NC.

- **Evaluate anthocyanin bioaccessibility in blueberry germplasm**. Applied a novel high-throughput in vitro gastrointestinal digestion model to phenotype bioaccessibility of phenolics in a diverse germplasm collection representing cultivated highbush blueberries. Results revealed significant ($P < 0.05$) differences between accessions, years, and accession by year interaction for

relative and absolute bioaccessibility of flavonoids and phenolic acids. Broad sense heritability estimates revealed low to moderate inheritances of relative and absolute bioaccessibility, suggesting that besides environmental variables, genetics factors could control bioaccessibility of phenolics. Acylated anthocyanins had significantly higher relative bioaccessibility than non-acylated anthocyanins. Correlation analysis indicated that relative bioaccessibility did not show significant association with fruit quality or raw concentration of metabolites. The study also identified accessions that have high relative and absolute bioaccessibility values. Overall, combining the bioaccessibility of phenolics with genetic and genomic approaches will enable the identification of genotypes and genetic factors influencing these traits in blueberry. *See Molla et al. 2020.* ***Objectives 1 and 3***

Blueberry Breeding and Molecular Genetics Program- Hamid Ashrafi- NCSU Raleigh, Jessica A. Spencer- NCSU Castle Hayne.

- Three years of yield and fruit quality data have been collected on 15 cultivars from other breeding programs alongside advanced NCSU selections from bushes planted in 2014-2016. One NC selection is in the process of being patented; several others have been put into grower fields for trialing although based on data, 5 will be fast tracked for patenting. Six other selections show much promise but need further trialing. We're currently working on a trialing agreement with Auburn University as they begin their new blueberry breeding program and will be sending them 24 patented and advanced selections to trial in 3 locations. Yield (8 plants) and mechanical harvest (22 plants) trials are planted yearly in November in Castle Hayne, NC for anyone interested in trialing with us. Individual results are disseminated to cooperates and may be disseminated at grower meetings if allowed by trialing agreement. ***Objective 1, 3, and 4***

Evaluation of Advanced Southern Highbush Selections for Splitting, Self-Fertility, and Fruit Quality Traits- J. Spencer, H. Ashrafi; Funded by the Southern Region Small Fruits Consortium and NC Agricultural Foundation.

- In 2021, 89 cultivars and selections were sorted into good, soft, split, stem tears, and other damage and tested for Brix, titratable acidity, berry size, weight, and firmness using a Firmtech 2 (Bio-works, Inc, Wamego, KS). When sufficient berries were harvested, 25 whole ripe berries were selected from the "good" category and soaked overnight in distilled water. The 25 berries were drained and sorted into good, soft, and split classes. Accessions with more than 15 "good" berries were run on the Firmtech 2 to measure for changes in firmness due to water uptake. A total of over 400 split assays were performed. Fifteen accessions were also ran on a texture analyzer (Stable MicroSystem Ltd., Godalimng, UK) fitted with a 2 mm flathead probe. Data analysis is ongoing. ***Objective 1 and 3***

Optimization and Production of Tissue Cultured Advanced Blueberry Selections for Multi-State Trialing- J. Spencer, H. Ashrafi; Funded by the Southern Region Small Fruits Consortium and NC Agricultural Foundation.

- Our current medium uses ½ WPM and ½ Anderson's Rhododendron media (AR) with MS vitamins, supplemental calcium nitrate, and 2mg/L trans-zeatin riboside. This formulation has proven more successful than wholly WP or AR medium alone. A recent study found that a mix of Olive Media (OM) and WP was also more successful than either alone in the southern highbush cultivar O'Neal. As we could not find a ready-made source of OM, we picked two of the components (potassium nitrate and glutamine) in OM that were lacking or minimized in our media and tested them at different rates on four different selections for our first experiment. Potassium nitrate caused initial growth but swift plant mortality. Glutamine seems to impart some benefit compared to the standard based on genotype and rate. Analysis of shoot and callus weight, as well as shoot number and length, is ongoing, but preliminary results suggest supplementation with glutamine and possibly 1/4x potassium nitrate may be appropriate for selections that prove recalcitrant in standard media. In 2022, we will continue our media optimization experiments by trialing potassium phosphate and magnesium sulfate supplementation. In addition, we will be trialing responses to liquid media using We Vitro (wevitro.magentallc.com) gravity wells and PlantForm (www.plantform.se) temporary immersion bioreactors as research has shown favorable responses of Vaccinium spp. to these methods of tissue cultures. ***Objective 1 and 2***

Genotype, environment, year, and harvest effects on fruit quality traits of five blueberry (*Vaccinium corymbosum* L.) cultivars. USDA-NIFA-AFRI Program. Lauren E. Redpath, Marcia Gumpertz, James R. Ballington, Nahla Bassil and Hamid Ashrafi.

- Our research aimed to assess the genotypic performance of five blueberry cultivars, including 'Echota', 'O'Neal', 'Reveille', 'Summit', and 'Sunrise'. The selected cultivars were phenotyped for various fruit quality-related traits over two sequential harvests in two years and two locations. Our results indicated that genotype is a major source of variation for most phenotypic traits. Further, the effect of Y × H as well as G × Y × H, significantly affected the majority of studied phenotypic traits. Within the studied genotypes, 'Reveille' and 'O'Neal' phenotypic stability were consistent across locations and years, with 'Summit' characteristics stable across years, locations, and harvests. Clonal plant replicates within genotype, harvest, and environment, as well as individual fruit measures were the most significant source of variability. ***Objective 1 and 3***

Nuclear DNA contents and ploidy levels of North American *Vaccinium* species and interspecific hybrids. USDA-NIFA-AFRI Program. Lauren Redpath, Rishi Aryal, Nathan

Lynch, Jessica A. Spencer, Amanda M. Hulse-Kemp, James R. Ballington, Jaimie Green, Nahla Bassil, Kim Hummer, Thomas Ranney, and Hamid Ashrafi.

- The objective of this study was to use flow cytometry, *k-mer* distribution analysis, and known pedigree information to evaluate genome sizes (2C nuclear and 1Cx monoploid), and ploidy of diverse accessions from *Vaccinium* sections and species. A total of 369 accessions were samples, including a diversity panel (DP) of 251 inter- and intra-specific hybrid *Vaccinium* accessions as well as 118 non-hybrid *Vaccinium* species across multiple sections were sampled from the North Carolina State University blueberry breeding program and the National Clonal Germplasm Repository. The nuclear DNA content was analyzed via flow cytometry. The mean (range) DNA content of diploid, tetraploid, and hexaploid reference species was 1.20 pg (0.99 pg in *V. crassifolium* 'Well's Delight' to 1.41 pg in *V. caesariense* NC79-24), 2.37 pg (2.11 pg in *V. corymbosum* 'Concord' to 3.01 pg in *V. corymbosum* DE599), and 3.64 pg (3.24 in *V. constablaei* NC83-21-2 to 3.80 in *V. virgatum* 'Premier' and NC4790), respectively. Of the 369 unique accessions analyzed for ploidy, 259 were tetraploid, 46 were diploid, 1 was triploid, 51 were pentaploid or aneuploid with 2C values between tetraploid and hexaploid values, and 12 were hexaploid. Tetraploid hybrid pedigrees, which involved hexaploid crosses within three prior generations, had a 2C value range between 2.22 pg and 2.59 pg. Anticipated pentaploid 2C DNA content is ~3 pg; however, the interspecific pentaploid and aneuploid progeny 2C DNA content ranged from 2.61 pg to 3.15 pg. We speculate some of these progenies to be near tetraploids with extra chromosomes from hexaploid progenitors. Further karyotyping of these individuals is necessary to ascertain aneuploidy anomalies. This research provides an expanded knowledge base of genome sizes, ploidy, and reproductive pathways for diverse species and hybrids to enhance future breeding, improvement, and the genomic study of blueberry. ***Objective 1, 3***

Genome-wide association mapping of fruit quality-related traits in a diversity panel of blueberries. USDA-NIFA-AFRI Program. Lauren Redpath, Rishi Aryal, Amanda M. Hulse-Kemp, James R. Ballington, Kim Hummer, Jaimie Green, April Nyberg, Nahla Bassil, and Hamid Ashrafi.

- This study presents a comprehensive evaluation of eighteen fruit and agronomic traits paired with target capture genotyping utilizing 59,302 custom probes to identify trait-associated markers in a genome wide association study (GWAS). Evaluated phenotypic traits included fruit size, weight, color, firmness, puncture-ability, soluble solids content, and titratable acidity, as well as agronomic traits of days to budbreak, full bloom, initial fruit maturity and full fruit maturity. A total of 33,701 high-quality, high-confidence SNPs were identified, of which 9,855 SNPs aligned to twelve developed scaffolds, among which 21 significant SNPs were identified to have trait-associations. Candidate genes were encoded by these SNPs with functions in anthocyanin acylation, firmness, fruit density,

acidity, and flower development. The SNPs identified in this panel can be useful in further identification of other unquantified novel characteristics. These data can be implemented in marker assisted selection and development of advanced molecular breeding programs in blueberries. ***Objective 1, 3***

Genome sequence of Monilinia vaccinii-corymbosi sheds light on mummy berry disease infection of blueberry and mating type. Yow, A.G.; Zhang, Y.; Bansal, K.; Eacker, S.M.; Sullivan, S.; Liachko, I.; Cubeta, M.A.; Rollins, J.A.; Ashrafi, H.

- In this study, PacBio sequencing and Hi-C interaction data were utilized to create a chromosome-scale reference genome for Mvc. The genome comprises nine chromosomes with a total length of 30 Mb, an N50 length of 4.06 Mb, and an average 413X sequence coverage. A total of 9399 gene models were predicted and annotated, and BUSCO analysis revealed that 98% of 1,438 searched conserved eukaryotic genes were present in the predicted gene set. Potential effectors were identified, and the mating-type (MAT) locus was characterized. Biotrophic effectors allow the pathogen to avoid recognition by the host plant and evade or mitigate host defense responses during the early stages of fruit infection. Following locule colonization, necrotizing effectors promote the mummification of host tissues. Potential biotrophic effectors utilized by Mvc include chorismate mutase for reducing host salicylate and necrotrophic effectors include necrosis-inducing proteins and hydrolytic enzymes for macerating host tissue. The MAT locus sequences indicate the potential for homothallism in the reference genome, but a deletion allele of the MAT locus, characterized in a second isolate, indicates heterothallism. Further research is needed to verify the roles of individual effectors in virulence and to determine the role of the MAT locus in outcrossing and population genotypic diversity. ***Objective 1, 3***

<u>Grapes:</u>

Establishment of PD resistant cultivar evaluation trials in North Carolina. Hoffmann, M., Volk, E. (2021-?) Funded by the NC Grape and Wine Council; ***Objectives 1,2 and 4;*** Results will be disseminated on crop portal and newsletters. Next reporting period: still vineyard establishment.

Establishment of fresh market muscadine cultivar trials in North Carolina. Hoffmann, M., Volk, E., Spencer, J., Ballington, J., Bland, T. in collaboration with Worthington, M., Bloodoworth, J. and Conner, P. (2021-?). Funded by NC Grape and Wine Council; ***Objectives 1, 2 and 4;*** Results will be disseminated on crop portal and newsletters. Next reporting period: still vineyard establishment and next harvest of already established vines.

Precise Indoor Vine Conditioning (PIVC): Improve flowering in grapes. Hoffmann, M.;

Freedman, K., Collado, C., Hernandez, R.; (2021-?) Funded by USDA Speciality Crop Block Program and NCSU. ***Objectives 2 and 4;*** Dissemination of research results through journal articles, scientific and grower conferences; Next year: Investigating container size, carbon storage and AMF products.

Evaluation of Grapevine Trunk Disease Severity and Management in NC. Hoffmann, M., Volk, E., Kreis, R., Villani, S., Bleadow, K. (2021-2022). Funded by USDA Speciality Crop Block Program. ***Objectives 2 and 4;*** Dissemination of Results through several conferences, extension publications; Next reporting period: Repeat of field trials, Evaluation of best management practices, Development of identification protocols for the PDIC.

Investigating pruning for fresh-market muscadines in NC; Hoffmann, M., Volk, E. (2020-2022); Funded by NCDA New and Emerging Crops Program. ***Objectives 2 and 4*****;** results will be disseminated at the annual muscadine grower conference; Next year: Trials will continue for several years.

Pre-liminary Studies on the efficacy of a peptide to control Botrytis in Chardonnay*;* Hoffmann, M.; Volk, E. (2021). Industry sponsored research. ***Objective 2***

Development of an Under-Vine Cover Crop Guide. Snyder, E., Gisie, G., Hatch, T., Hoffmann, M. (2021-2022). Funded by the Southern Region Small Fruits Consortium. ***Objective 4;*** Finished online website guide and publication aim is April 2022. Demonstration plots are seeded at a NC vineyard.

Development of a comprehensive Fresh-Market Muscadine Extension Program. Hoffmann, M., Perkins, P., Johnston, L., Tregealge, D., Mauney, C. (2021-2023). ***Objective 4;*** Funded by the NCDA New and Emerging Crop Program. Program is developed and will be disseminated through multiple outlets (e.g. webinar/school in 2022).

Fruit composition of seedless and seeded muscadine. Perkins-Veazie, P., Hoffmann, M., Threlfell, R. Funded by the Southern Small Fruits Research Consortium (2021); ***Objective 3.***

- Peel, pulp, and juice of seeded and seedless muscadines were compared for composition, anthocyanins, and phenolics. Peel was highest in anthocyanin and phenolic content.
- Soluble solids content and titratable acidity were slightly higher for seedless types (RazzMaTazz, JB-09-15-3-9, JB 06-30-2-20, Oh My, JB-08-38-1-10) than for seeded types (Hall, Triumph, Summit, Lane, Paulk, Nesbitt, Supreme).
- Amount and anthocyanin profiles were similar in peel of seeded and seedless purple types. Phenolic acid and flavonol content was slightly higher in seedless peel compared to seeded while flavanones were similar in seeded and seedless types. We did not find indications that seedless muscadines were strongly

different in composition from seeded types.

Strengthening and expanding muscadine markets. Hoffmann, M., Perkins-Veazie, P (funded by the NC New and Emerging Crops Program, 2020-2022). ***Objective 3***

- Comparison of seeded and seedless muscadine shelflife. Grapes were held at 2 C and evaluated weekly for weight loss and appearance. Most of the genotypes were still acceptable after 4 weeks storage; a few such as Lane were still acceptable in appearance and taste up to 49 days storage. Seedless types are generally smaller in size and this increased weight loss about 2% more over a 28 day storage period.
- No one variable uniformly affected appearance. In bronze types, darkening of color was the first negative attribute while in purple types, appearance of light brown streaks and shriveling gave a negative appearance. Excessive softening of grapes was a problem for Hall, Summit, and Nesbitt longer than 28 days storage.

Strawberry:

Development and integration of next-generation propagation practices to enhance the resilience of the strawberry supply chain (PIP-CAP). Hoffmann, M., Hernandez, R., Fernandez, G., Liu, Z., Schweizer, H., Nitzsche, P., Kubota, C., Jackson, B., Boldt, J., Durner, E., Gomez, C., Shinsuke, A., Holmes, G., Weber, C., Galdi, G., Daugovich, O., Samtani, J., Tregeagle, D. (2021-2025). Funded by the USDA-NIFA SCRI Program. ***Objectives 1, 2 and 4***

Genome Wide Association Studies in an Octoploid Strawberry Biparental Population Discover QTLs for Hemibiotrophic and Necrotrophic Infection Resistance to Colletotrichum acutatum and C. gloeosporioides. Chacon, J.G., Olukolu, B., Iorrizo, M., Louws, F.J. & Fernandez, G. ***Objectives 1, 2***

- This project identified QTLs and determined the influence of epiphytic or endophytic organisms (metagenomics). No clear influence of other organisms were detected, but the total amount of QTLs related to the traits of interest were established in 5 QTLs for anthracnose fruit rot (AFR), 1 QTL for anthracnose crown rot (ACR), 1 QTL for *C. acutatum* hemibiotrophic leaf infection (HBI) and 2 QTL for *C. gloeosporioides* HBI.
- Recently we participated in the development of a molecular marker for ACR resistance in collaboration with Dr. S. Lee (et al 2021) from the University of Florida. We hope to continue further collaborative work to develop molecular markers for another QTL found for ACR and potentially for hemibiotrophic leaf infection resistance.

Strawberry breeding and germplasm screening. Fernandez, G, R. Schiavone, G. Chacon, P. Perkins-Veazie. Funded by the Fullbright, NC Strawberry Association, NCDA Specialty Crop Grant. NC Plant Breeding Consortium Funds. ***Objective 1,3***

- The breeding program continues to make crosses, evaluate seedlings, make

selections and collect yield data and fruit data (total soluble solids, pH and titratable acidity) on advanced selections and cultivars including the newer CA cultivars. Yield data from replicated trials is posted on the NCSU strawberry portal. https://strawberries.ces.ncsu.edu/straberry-breeding-progam/replicated-cultivar-and-selection-breeding-trials/

- We have established a long-term *in vitro* culture conservation of strawberry germplasm in our breeding program in cooperation with the NCSU Micropropagation and Repository Unit
- We use Field Book App for phenotyping and find it very useful (although not user friendly at first)
- We have screened most of our germplasm with the markers developed by RosBREED and others including FAPFRU (perpetual flowering), FaFAD1 (δ-Decalactone Peachy flavor), FaOMT (Mesifurane sherry-like flavor). We have fingerprinted all our germplasm using multiplexed SSR's.

Evaluation of strawberry cultivars and LCN advanced selections. Hoffmann, M., Volk, E., Poling, B. in collaboration with LCN, Cottle Farms and Flavor First. (2020-?). Funded by the NC Strawberry Association. ***Objectives 1, 2 and 4;*** Results are disseminated through newsletter, field day and grower conference

Evaluating the pathogen and weed control efficacy of heat releasing substances in combination with steam. Hoffmann, M., Volk, E., Jennings, K., Neal, J., Louws, F., Fennimore, S. (2019-2022). Funded by the USDA-MB Transition Program. **Objective 2;** PoC studies; Results are disseminated through scientific conferences and publications.

Elderberry:

Moving American elderberry into mainstream production and processing. Thomas, A…..Perkins-Veazie, P., Moncada, M., Hoskin, R., Lila, M. Funded by USDA-NIFA-SCRI (2021-2025), led by University of Missouri. ***Objectives 1,2 and 4***

This CAPs grant will explore practical ways to improve American elderberry production and harvesting, utilize fruit in processing, and evaluate a fruit product in brain health protection as well as compositional assays.

Other small fruit crops:

Goumi berry (Elaeagnus multiflora) suitability in North Carolina. Perkins-Veazie, P. and Hoffmann, M. (2020-2023) Funded by the NC Emerging Crops Program. ***Objectives 2, 4;***

- Goumi is a relative of Autumn Olive (makes own N, drought resistant) but with larger fruit and without the tendency to become invasive. The fruit are orange to red and contain extremely high amounts of lycopene (>300 ug/g). We established 'Sweet Scarlet' and 'Red Gem' in a 2 row field planting (spring of

2021) to follow growth, fruit harvest systems, and fruit quality. Plants appear to be branching more at the base than attaining height in the loamy clay soil.

Include any data, germplasm/cultivar descriptions, research results, etc. that you would like to discuss at the meeting.

Pairwise Rubus GXE Katie-Sheehan Lust, Gina Fernandez, North Carolina State University, Cornell University, University of Arkansas, University of British Columbia/BC Berry Cultivar Development Inc., and the USDA (Corvallis, OR)

VacciniumCAP: Leveraging genetic and genomic resources to enable development of blueberry and cranberry cultivars with improved fruit quality attributes. USDA-NIFA-SCRI-CAP program. 2019-2023. Iorizzo et al.

Developing Genomic Tools for Breeding High Quality Blueberries. USDA-NIFA-AFRI program 2019-2021. Ashrafi et al.

Precise Indoor Vine Conditioning (PIVC): Improve flowering in grapes. Hoffmann, Freedman, Collado, Hernandez.

Development and integration of next-generation propagation practices to enhance the resilience of the strawberry supply chain (PIP-CAP). Hoffmann et al.

Peer-reviewed Publications

Saket Chandra, Youngjae Oh, Hyeondae Han, Natalia Salinas, Ashlee Anciro, Vance Whitaker, Jose Guillermo Chacon, Gina E. Fernandez, Seonghee Lee. 2021. Comparative Transcriptome Analysis to Identify Candidate Genes for FaRCg1 Conferring Resistance Against Colletotrichum gloeosporioides in Cultivated Strawberry (Fragaria ×ananassa). Frontiers in Genetics. 12: https://doi.org/10.3389/fgene.2021.730444

Kraft Laura J., Sit Tim L., Diepenbrock Lauren M., Ashrafi Hamid, Aryal Rishi, Fernandez Gina E., Burrack Hannah J. 2021. Detection of Fruit Meals Within Laboratory-Raised and Field-Trapped Adult Drosophila suzukii (Diptera: Drosophilidae) Guts. Frontiers Ecol. Evol. https://doi.org/10.3389/fevo.2021.719645

Mengist, M.F., Bostan, H., Young, E. Kay, K.L., Gillitt, N., Ballington, J., Kay, C.D., Ferruzzi, M.G., Ashrafi, H., Lila, M.A. and M. Iorizzo. 2021. High-density linkage map construction and identification of loci regulating fruit quality traits in blueberry. Hortic Res 8, 169 (2021). https://doi.org/10.1038/s41438-021-00605-z

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