

Title: Enhancing blackberry canopy light distribution with reflective groundcovers

Principal Investigators:

Tom Kon, Assistant Professor, Department of Horticultural Science, North Carolina State University, Mountain Horticultural Crops Research and Extension Center, 455 Research Drive, Mills River, NC 28759; Phone: 814-404-4295; Email: tom_kon@ncsu.edu; FAX: 828-684-8715

Karen Blaedow, Small Fruits and Vegetable Production Agent, North Carolina Cooperative Extension Service, Henderson County Center, 100 Jackson Park Rd, Hendersonville, NC 28792; Phone: 828-697-4891; Email: karen_blaedow@ncsu.edu; FAX: 828-697-4581

Hannah Burrack, Professor, Department of Entomology and Plant Pathology, North Carolina State University, Campus Box 7634, Raleigh, NC 27695; Phone: 919-513-4344; Email: hannah_burrack@ncsu.edu; FAX: N/A

Gina Fernandez, Professor, Department of Horticultural Science, North Carolina State University, Department of Horticultural Science, Campus Box 7609, Raleigh, NC 27695; Phone: 919-513-7416; E-mail: gina_fernandez@ncsu.edu; FAX: 919-515-7747

Jeff Hopkins, Farm Manager, Musser Fruit Research Center, Clemson University, 604 S Friendship Rd, Seneca, SC 29678; Phone: 864-882-0028; Email: hopkin4@clemson.edu; FAX: 864-656-0276

Juan Carlos Melgar, Associate Professor, Department of Plant and Environmental Sciences, Clemson University, 105 Collings St., Clemson, SC 29631; Phone: 864-656-4562; Email: jmelgar@clemson.edu; FAX: 864-656-4960

Penelope Perkins-Veazie, Professor, Department of Horticultural Science, North Carolina State University, Plants for Human Health Institute, 600 Laureate Way, Kannapolis, NC 28081; Phone: 704-250-5419; E-mail: pmperkin@ncsu.edu; FAX: 704-250-5428

Guido Schnabel, Professor, Department of Plant and Environmental Sciences, Clemson University, 105 Collings St. 220 BRC, Clemson, SC 29631; Phone: 864-656-6705; Email: schnabe@clemson.edu; FAX: 864-656-4960

Sara Villani, Assistant Professor, Department of Entomology and Plant Pathology, North Carolina State University, Mountain Horticultural Crops Research and Extension Center, 455 Research Drive, Mills River, NC 28759; Phone: 828-684-3562; Email: smvillan@ncsu.edu; FAX: 828-684-8715

Grower Cooperator:

Dalton Rhodes, Rhodes Berry Farm, 305 Whitehead Rd, Hendersonville, NC 28792; Phone: 828-674-5966; Email: daltonr@g.clemson.edu

Rationale: In most temperate fruit crops, inadequate light distribution can have negative effects on productivity, fruit quality, and flowering. Light distribution is primarily managed in blackberry production systems by pruning and training. Without adoption of narrow, planar pruning and training systems (Takeda, 2013), blackberry canopies have a complex, disorganized architecture with poor light distribution in the lower canopy. Inherent vigor of blackberry, particularly in the southeastern US, can result in excessive shading of the interior and basal canopy. *Rubus* is relatively shade tolerant and can compensate for limiting light conditions (Fernandez and Pritts, 1996). However, excessive shading resulted in delayed or incomplete flower formation (Caillouet et al. 2016; Gallagher et al., 2015) and had negative effects on fruit quality (Stafne et al., 2017). Shaded blackberry canopies can provide a microclimate conducive to insect infestation (Diepenbrock and Burrack, 2016; Schöneberg et al., 2020) and pathogen development (Ellis, 2008).

In other Rosaceous cropping systems, reflective groundcovers had profound impacts on vegetative growth, productivity, and fruit quality (Privé et al., 2011; Kon unpublished). Reflective groundcovers are not to be confused with plastics and organic materials that are frequently used as a weed barrier, or reflective films (mylar). Reflective groundcovers are woven textiles composed of polymers that are designed to be durable (can withstand orchard traffic) and can be used across multiple seasons (Fig. 1). These groundcovers reflect light from the orchard floor and enhance light distribution in the lower canopy. In addition to reflecting photosynthetically active radiation (PAR; 400-700 nm), some of these groundcovers reflect ultraviolet radiation (UV; 250-400 nm). PI Kon evaluated several different commercially available reflective groundcovers over a two-year period in apple. All reflective groundcovers evaluated reflected similar levels of PAR (Fig. 2), but UV reflection varied widely among groundcovers (Fig. 3).



Fig. 1. Reflective groundcover in blackberry (Hendersonville, NC; 14 April 2020). Fabric was deployed shortly after bud break. Advanced bud development was observed, which resulted in significant flower bud damage during a series of spring frost/freeze events. Therefore, we propose to evaluate deployment after the frost-free date.

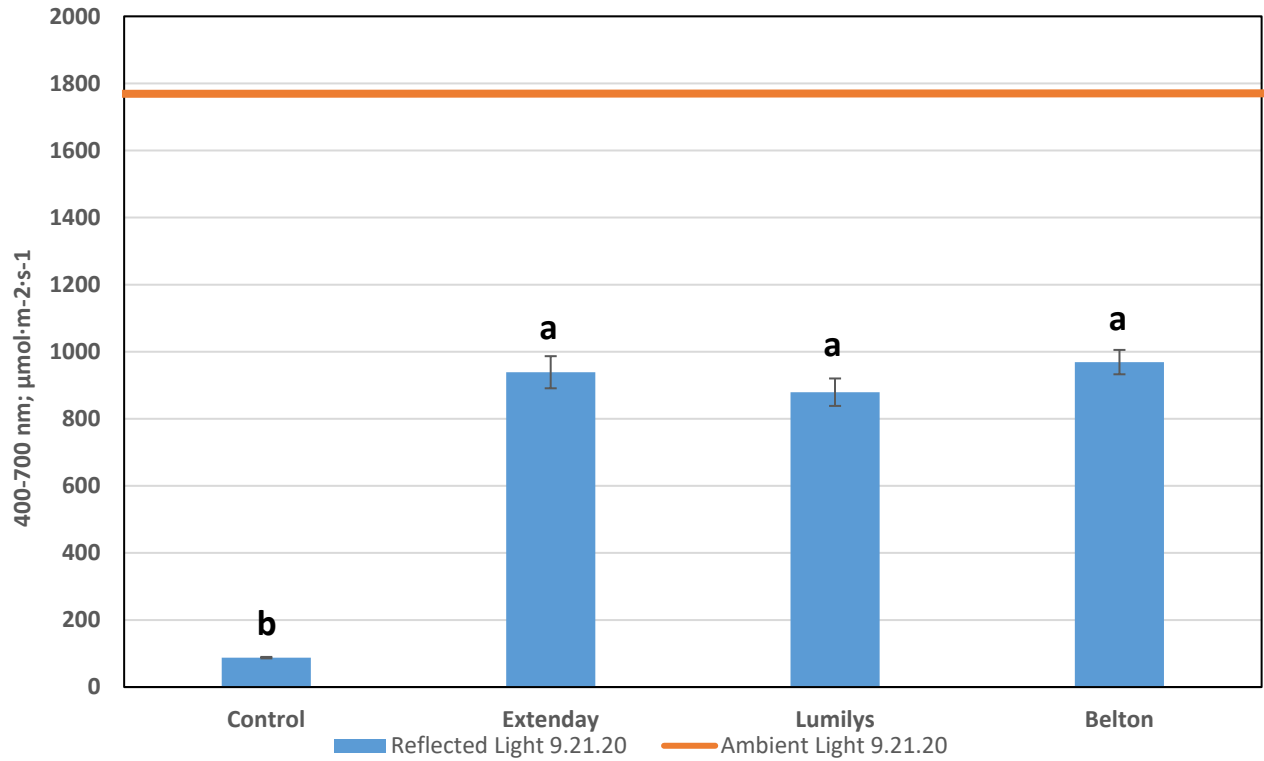


Fig. 2. PAR reflectance measured on a cloud-free day (9.21.20). Data are means \pm SE (n = 5). Mean separation between treatments by Tukey's honest significance difference test, $P < 0.05$.

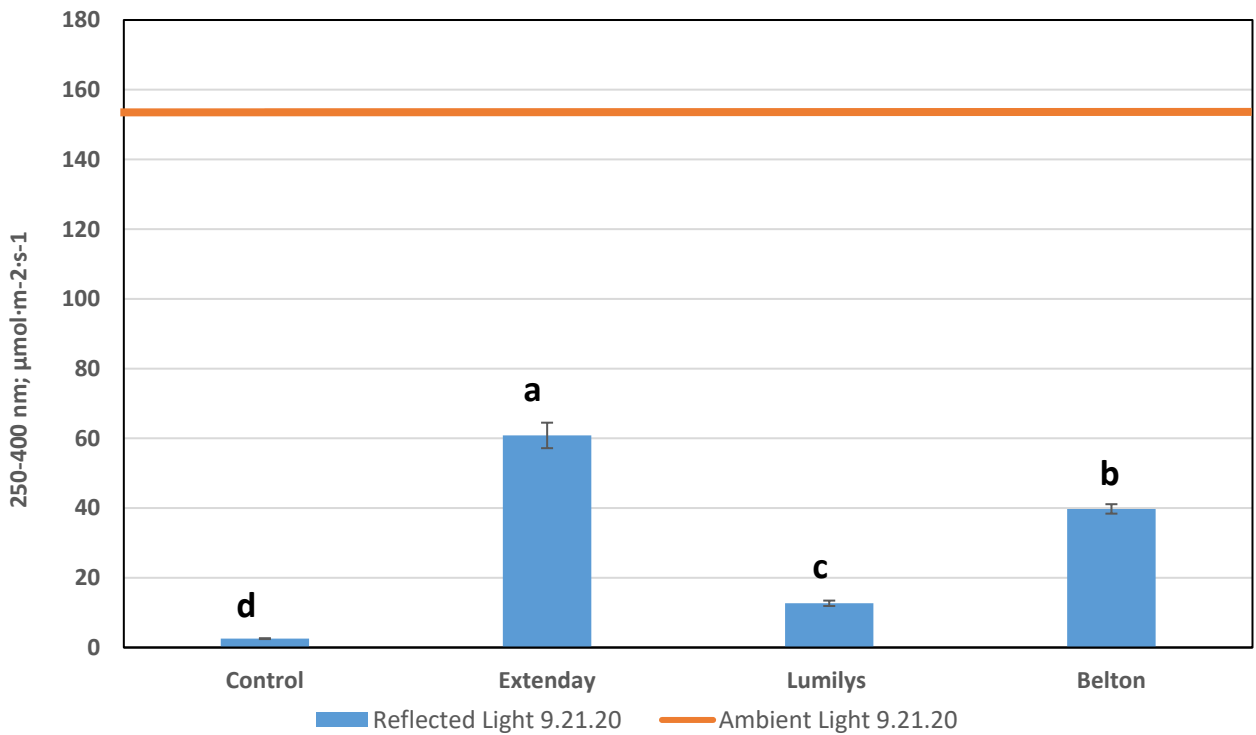


Fig. 3. UV reflectance measured on a cloud-free day (9.21.20). Data are means \pm SE (n = 5). Mean separation between treatments by Tukey's honest significance difference test, $P < 0.05$.

To the best of our knowledge, caneberry research with reflective groundcovers has been limited, unreported, and/or is proprietary. Research on red raspberry in New Brunswick, Canada demonstrated that season-long deployment of reflective groundcovers dramatically altered the canopy microclimate in *Rubus* production systems. Reflected PAR was increased by 45% with a reflective groundcover (Comeau et al., 2012) when compared to a sod groundcover. Canopy air temperature was not influenced with reflective ground cover, but relative humidity and soil temperature was reduced 5% and 34%, respectively (Comeau et al., 2012 and 2013). Use of a reflective groundcover increased marketable yield (48%) and fruit weight (11%) relative to an untreated control (Comeau et al., 2012). Combining reflective groundcovers with rain shelters increased the marketable yield of raspberries by 67%, suggesting potential utility in high tunnel production systems. While vegetative and reproductive biomass was increased, the biomass of spur blight infected tissues was reduced with reflective groundcover treatments. The authors suggested that increased UV light in the basal canopy may explain this response, but UV light was not quantified (Comeau et al., 2012). Reflective groundcovers had no effect on Botrytis fruit rot incidence or shelf-life, but the research planting used was managed organically (Comeau et al., 2012).

No detrimental effects were found on ground beetle communities with reflective groundcover treatments (Comeau et al., 2012 and 2013). However, effects on key insect pests and beneficials were not evaluated. *Drosophila suzukii* (spotted wing drosophila; SWD) is the most devastating economic pest of caneberries. SWD fruit infestation was highest in the interior and basal blackberry canopy (Diepenbrock and Burrack, 2016). Since shade and high humidity increase SWD infestation, reflective groundcovers may make the interior and basal canopy less hospitable for SWD.

One potential concern with use of reflective groundcovers in blackberry is related to potential impacts on fruit disorders, particularly white drupelet reversion. Several environmental factors are associated with white drupelet revision, including UV-B light, relative humidity, precipitation, and rainfall (Bolda, 2009). UV radiation was suggested as a key factor in increased incidence of white drupelet development, and as humidity is displaced from the canopy by hot dry air, there is a risk of enhanced UV light penetration. Bolda (2009) suggested that fruit in the interior canopy may not be acclimated to UV and is more susceptible to white drupelet reversion. Canopy shading with 30% shade cloth resulted in a significant reduction in white drupelet reversion incidence (Stafne et al., 2017). The UV reflective properties of commercially available reflective groundcovers can range widely (Fig. 3; Kon, unpublished). If increased UV from reflective groundcovers is problematic, perhaps use of groundcovers with low-UV reflectance would be appropriate. Aside from effects on soluble solids and fruit firmness, effects of reflective groundcovers on blackberry fruit composition have not been reported. Cyanidin is the major anthocyanin in blackberry and has been found to be promoted by increased solar intensity and UV-B light in apple (Chen et al., 2019; Henry-Kirk et al., 2018). Groundcovers with increased UV reflection would be expected to increase blackberry pigmentation.

In short, the deployment of reflective groundcovers dramatically alters the canopy microclimate and could have many interesting and/or potentially useful responses in blackberry production. To

our knowledge, this technology has not been formally evaluated in the southeastern US on blackberry. To determine if this technology has merit in blackberry production, we propose a preliminary assessment of reflective groundcovers in floricanes and primocane production systems. This proposal is aligned with several research priorities of the North American Bramble Growers Research Foundation, Inc., specifically: 1) pruning and training systems to improve production, 2) dealing with heat/UV damage to fruit using horticultural management, 3) management of SWD, and 4) non-chemical strategies for pest control.

Objective: 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.

Procedure:

Experiment 1. The experiment will be conducted in a 6-year-old ‘Osage’ blackberry planting at Clemson University’s Musser Fruit Research Center in Seneca, SC (latitude 34.602540°, longitude -82.874700°). The irrigated planting has a 0.9 m x 4.0 m spacing, is trained to V-trellis, and is managed to adhere to commercial standards. This site is 728’ in elevation, has Cecil sandy loam soils, and average annual rainfall of ~57”.

Reflective groundcover (Extenday USA; Union Gap, WA) will be placed adjacent to plots (9 m long x 3 m wide) on two rows and will be secured using a proprietary mounting system per manufacturer recommendations. Reflective groundcover will be deployed after the frost-free date (April 10) and will persist until late fall. Untreated plots (sod groundcover) will be included for comparison and all plots will be adequately buffered to minimize edge effects. The experiment will be replicated four times and treatments will be assigned in a completely randomized block design. Minimal pesticides will be applied to plots to ensure that pathogen and insect effects can be observed.

Canopy microclimate. Throughout the course of the experiment, environmental monitoring of interior canopy temperature and relative humidity will occur using data-logging sensors. Prior to harvest, PAR interception and reflectance (400-700 nm) by groundcovers will be quantified using a ceptometer (AccuPAR PAR/LAI Ceptometer Model LP-80; Decagon Devices Inc., Pullman, WA) on two uniform plants per plot. PAR measurements will occur proximal to solar noon on a cloud free and uniformly cloudy day. Measurements will occur in the upper and lower canopy on the east and west sides. The ceptometer will be held in a horizontal position for all measurements. Light interception will be determined with ceptometer sensors oriented toward the sun. Light reflectance will be quantified by inverting the sensor (facing the ground) at each canopy position and direction. Similarly, UV radiation incidence and reflectance (250-400 nm) will be quantified using a UV meter (LightScout UV Meter and Sensor; Spectrum Technologies, Inc., Plainfield, IL). Measurements will occur at the same canopy positions described above.

Bud phenology, flowering, fruit set, and harvest date. Timing of flowering, blossom density (no. flowers per cm² cane diameter), fruit set, and date of first harvest will be evaluated on three floricanes per plot. Shifts in timing and volume of harvest will be quantified and compared.

Yield responses. When fruit reach a commercially acceptable level of maturity, three plants per plot will be harvested two to three times per week. Marketable yield, unmarketable yield, average fruit weight (25 berry sample per harvest) and length of harvest season will be determined. Since light environment may influence fruit physiological disorders, the proportion of fruit with specific disorders will be quantified, if warranted.

Fruit quality and post-harvest life. Across three harvest dates, two to three half pint clamshells from each plot will be used to quantify post-harvest life and fruit composition. One to two clamshells per harvest will be held at 4 °C and 90% relative humidity for 7 days. Samples will be rated for weight loss, mold, leakage, and red drupelet development. The remaining clamshell per plot/harvest date will be frozen at -20 °C, then used to determine °brix, titratable acidity, total anthocyanins, and total phenolics.

Pest and disease incidence. SWD infestation can occur as soon fruit begin to change from green to pink but is highest in red and ripe fruit. We will begin to assess SWD infestation once sufficient fruit in plots are red. At least 30 berries per plot will be collected weekly and larval presence will be assessed via salt extraction (Van Timmeren et al. 2017). Larvae will be separated based on size (small, medium, and large) as a proxy for age. If observed, effects on other commercially important insect pests will be documented. In addition, the incidence and severity of economically important diseases (particularly *Botrytis cinerea*) will be evaluated biweekly in each plot. Specifically, 50 fruit for each replicate and treatment will be incubated separately and equidistantly for 3 days in a moist chamber and assessed for gray mold decay. Additionally, common leaf spot diseases (e.g. Septoria leaf spot, Pseudocercospora leaf spot) and cane and leaf rust will be evaluated on primocanes and floricanes on 14-day intervals beginning mid-June 2021.

Vegetative growth. After harvest, a morphometric characterization of floricanes will occur. Five canes per plot will be cut at the base and moved to the lab for analysis. Basal cane cross-sectional area will be determined, and number of fruiting nodes per cane will be counted. The number of lateral branches per cane will be counted. On each lateral branch, nodes will be counted and length will be measured. Leaves will be excised, counted, and leaf area per cane will be determined with a leaf area meter. Fresh and dry weight of each tissue type (cane, lateral branches, and leaves) will be determined. Prior to leaf senescence in the fall, this process will be repeated on primocanes.

Statistical Analysis. The experiment will be of two treatments with four replications arranged in a randomized complete block design. The PC version of SAS (version 9.4; SAS Institute, Cary, NC) will be used to carry out all statistical analysis. Independent-sample t test's in PROC TTEST will be used to analyze differences between the two treatments.

Experiment 2. The experiment will be conducted in a mature 'Prime-Ark Traveler' commercial blackberry planting (Rhodes Berry Farm; latitude 35.408151°, longitude -82.371271°). The irrigated planting has a 0.76 m x 4.27 m spacing and managed in a single-cropping system (primocane crop only). This site is 2200' in elevation, has Hayesville loam soil, and receives ~50" annual rainfall.

Treatments are as follows: 1) sod groundcover, 2) Extenday® DayBright (Extenday USA; Union Gap, WA) and 3) Lumilys® WH-100 (Beaulieu International Group; Waregem, Belgium). Reflective groundcovers will be placed adjacent to plots (9 m long x 3 m wide) on two adjacent rows and will be secured using proprietary mounting systems per manufacturer recommendations. Reflective groundcovers will be deployed after the frost-free date (May 15) and will persist until late fall. Treatments will be adequately buffered to minimize edge effects. The experiment will be replicated five times and treatments will be assigned in a completely randomized block design.

Treatments effects on canopy microclimate, bud phenology and fruit set, fruit quality and post-harvest life, pest and disease incidence, and vegetative growth will be determined as described in Experiment 1. While we expect that pesticides used will reduce SWD populations, they are often still detectable in commercial production systems. A complete characterization of yield will not be possible at this commercial operation; however, plots will be sampled bi-weekly to estimate effects on average fruit weight.

Statistical Analysis. The experiment will consist of three treatments with five replications arranged in a randomized complete block design. Tukey's honest significance test in PROC MIXED will be used to test mean separation among treatments at $P = 0.05$.

Timetable: This is a one-year project request. The project will be initiated in March 2021. All data will be collected, analyzed, and submitted by the December 2021 reporting deadline.

Budget:

<i>Labor:</i> Summer research intern	\$2,268
- 208 hours*\$10/hour = \$2,080	
- Fringe (9.05%) = \$188	
<i>Supplies:</i> Reflective fabrics and mounting systems	\$2,732
- <u>Extenday</u> : One 1640' X 9.8' roll + mounting system = \$2,085	
- <u>Lumilys</u> : One 328.5' X 9.8' roll + mounting system = \$647	
<i>Total Request:</i>	\$5,000

References cited:

Bolda, M.P. 2009. White drupelet. UC IPM Pest Management Guidelines, Caneberries. UC ANR Publication 3437. <<http://ipm.ucanr.edu/PMG/r71800111.html>>

Caillouet, O. C. (2016). The Effects of Shade on Growth, Development and Yield of a Primocane Fruiting Blackberry, 'Prime-Ark 45' to Extend the Market Season. *Horticulture Undergraduate Honors Theses* Retrieved from <https://scholarworks.uark.edu/hortuht/4>

Chen, W., Zhang, M., Zhang, G., Li, P., Ma, F. 2019. Differential regulation of anthocyanin synthesis in apple peel under different sunlight intensities. *Intl. J. Molecular Sciences* 20:6060.

- Comeau, C., J.-P. Privé, and G. Moreau. 2012. Beneficial impacts of the combined use of rain shelters and reflective groundcovers in an organic raspberry cropping system. *Agriculture, Ecosystems and Environment* 155:117-123.
- Comeau, C., J.-P. Privé, and G. Moreau. 2013. Effects of reflective groundcovers on ground beetles (Coleoptera: Carabidae) in red raspberry (*Rubus idaeus*) cropping systems. *J. Appl. Entomol.* 137:264-274.
- Diepenbrock, L.M. and H.J. Burrack. 2017. Variation of within-crop microhabitat use by *Drosophila* (Diptera: Drosophilidae) in blackberry. *J. Appl. Entomol.* 141:1-7.
- Ellis, M.A. 2008. Botrytis fruit rot “gray mold” of strawberry, raspberry, and blackberry. Ohio State University Factsheet. PLPATH-FRU-36 <<https://ohioline.osu.edu/factsheet/plpath-fru-36>>
- Fernandez, G.E. and M.P. Pritts. 1996. Carbon supply reduction has a minimal influence on current year’s red raspberry (*Rubus idaeus*) fruit production. *J. Amer. Soc. Hort. Sci.* 121(3): 473-477.
- Gallagher, E.J., K.W. Mudge, M.P. Pritts, and S.D. DeGloria. 2015. Growth and development of ‘Illini Hardy’ blackberry (*Rubus* subgenus *Eubatus* Focke) under shaded systems. *Agroforest Syst.* 89:1-17.
- Henry-Kirk, R.A., Plunkett, B., Hall, M., McGhie, T., Allan, A., Wargent, J., Espley, R. 2018. Solar UV light regulates flavonoid metabolism in apple (*Malus x domestica*). *Plant Cell Environ.* 41:675-688.
- Privé, J.-P. Russell, L., and A. LeBlanc. 2011. Impact of reflective groundcover on growth, flowering, yield, and fruit quality in Gala apples in New Brunswick. *Can. J. Plant. Sci.* 91:765-722.
- Schöneberg, T., A. Arsenault-Benoit, C.M. Taylor, B.R. Butler, D.T. Dalton, V.M. Walton, A. Petran, M.A. Rogers, L.M. Diepenbrock, H.J. Burrack, H. Leach, S. Van Timmeren, P.D. Fanning, R. Isaacs, B.E. Gress, M.P. Bolda, F.G. Zalom, C.R. Roubos, R.K. Evans, A.A. Sial, and K.A. Hamby. 2020. Pruning of small fruit crops can affect habitat suitability for *Drosophila suzukii*. *Agriculture, Ecosystems & Environment* 294:106860.
- Stafne, E.T., A. Rezazadeh, M. Miller-Butler, and B.J. Smith. 2017. Environment affects white druplet disorder expression on three blackberry cultivars in south Mississippi. *HortTechnology* 27(6): 840-845.
- Takeda, F., D.M. Glenn, and T. Tworowski. 2013. Rotating cross-arm trellis technology for blackberry production. *J. Berry Res.* 3: 25-40.
- Van Timmeren, S., L.M. Diepenbrock, M.A. Bertone, H.J. Burrack, and R. Isaacs. 2017. A filter method for improves monitoring of *Drosophila suzukii* (Diptera: Drosophilidae) larvae in fruit. *J. Integrated Pest Management.* 8(1): 1-7.

1/12/2021

197 Spring Creek Rd
Pittsboro, NC 27312

Proposal Title: **Enhancing blackberry canopy light distribution with reflective groundcovers**

NC State Reference No. **118922**

NC State Principal Investigator: **Dr. Thomas Kon**

Amount Requested: **\$5,000**

Dear North American Bramble Growers Association:

This letter transmits the subject proposal referenced above from North Carolina State University (NC State) to your organization on behalf of NC State's Principal Investigator Dr. Kon. Included with this letter, you will find a statement of work, budget, and any other documentation required to accompany the proposal. Please forward this letter and proposal to the appropriate administrative officer within your organization to inform them that the appropriate administrative officials at NC State support this proposal and are prepared to negotiate an agreement if said proposal is selected for funding. If you need any additional information regarding this proposal or NC State's public service, research or educational missions, please contact the Sponsored Programs office at:

North Carolina State University
ATTN: Sherrie Settle or other Authorized Organizational Representative
Sponsored Programs & Regulatory Compliance Services
2601 Wolf Village Way, Suite 240, Campus Box 7514
Raleigh, NC 27695-7514
Phone: 919-515-2444 Fax: 919-515-7721 Email: sps@ncsu.edu

Various NC State business information useful during a proposal's review and the preparation of an agreement may be found on the attached Information Sheet or online at:

http://www.ncsu.edu/sparcs/proposal/project_info.php. From this site you can access and print documents such as NC State's A-133 Audit report, F&A Agreement, etc. For informational purposes, please note that NC State is not delinquent on any federal debt and is not presently debarred, proposed for debarment, declared ineligible or voluntarily excluded from covered transactions by a Federal department or agency. On behalf of the University, please accept my gratitude for your organization's review and consideration to fund this important work.

For North Carolina State University,



Holly Lipkovich,
CALs Director of Research Administration

Attachments: Information Sheet, Proposal and Budget, Other Required Documents
Copied: College of Agriculture & Life Sciences Research Office, SPARCS via PINS System

Animal Welfare Assurance Number: A3331-01	Integrated Post Secondary Education Data System Number: 19913
Authorized Organizational Representative: Sherrie Settle Director of Sponsored Programs Research Administration/SPARCS 2601 Wolf Village Way, Suite 240 Raleigh, NC 27695-7514 P:919.515.2444, F:919.515.7721, E:sps@ncsu.edu	North American Industrial Classification System (NAICS): 611910
	Office of Scientific Integrity Certification Code: 0578204
	FFATA Executive Compensation: NC State is exempt from providing this information.
Central Contractor Registration: Active	System for Award Management Registration (SAM): Active
Cognizant Audit Agency and CAS Filing: DHHS, Division of Cost Allocation 330 Independence Ave., SW Cohen Building, Room 1067 Washington, DC 20201 Contact: Shon Turner, P: 214.767.3261	Remittance Address: Office of Contracts & Grants 2701 Sullivan Dr., Suite 240 Admin Services III, CB 7214 Raleigh, NC 27695-7214 P: 919.515.2153, F: 919.515.4693, E: CNGHelpDesk@ncsu.edu
Commercial and Government Entity (CAGE) Code: 1E7H9	Signatories: Sherrie Settle, Stefanie Saunders, Martina Krzywicki, Wendy Moore, and others listed: https://research.ncsu.edu/sparcs/proposals/proposals-ids/#signatories
Congressional District: NC-002	Standard Industrial Code (SIC): 8221
Contractor Establishment Code: 04 300 222 K	Year of Incorporation: 1887
Cost Accounting Standards (CAS) Disclosure Statement Approval Date: February 7, 2003	Information for the following can be found at the web address: http://research.ncsu.edu/sparcs/proposals/proposals-ids/ <ul style="list-style-type: none">• F&A Rates and Federal Rate Agreement• A-133 Audit Report• Board of Trustees• Executive Officers• Financial Code of Conduct• Financial Statements• Insurance Coverages• Internal Revenue Service W-9 Should you have any questions or concerns, please contact NC State Sponsored Programs via: <ul style="list-style-type: none">• Phone: 919.515.2444• Fax: 919.515.7721• Email: sps@ncsu.edu
County: Wake, North Carolina	
Defense Logistics Info Service No.: 0002315	
Department of Defense (DOD) Property Control Review and Approval Date: 9/8/2000	
Dept of Health and Human Services Anti-Discrimination Assurance: Filed, May 4, 2000	
Dun & Bradstreet Number: 042092122	
Employer Identification Number (Tax Identification Number) EIN/TIN: 56-6000-756, 12 digit: 1566000756A1	
Federal Interagency Committee on Education: 002972	
Federal Purchasing System Review: 4/12/1995	
Government Property: Cap Asset Mgt Sys flags GP, Audited annually for source title, & disposition	
Human Subject Assurance No: FWA00003429	

Personnel:

Musser Farm Research Support Staff (Hopkins). Will assist in groundcover deployment, plot maintenance, harvest data collection, fruit sampling for Experiment 1.

Chris Clavet; Research Specialist (Kon). Will assist in groundcover deployment, environmental, horticultural, and SWD data collection, reporting, and statistical analysis for Experiments 1 and 2.

Diana Vercillo; Temporary Research Technician (Kon). Will assist in groundcover deployment, environmental, horticultural, and SWD data collection, data entry, and fruit sample transport for Experiments 1 and 2.

Tatiana Zuber; Temporary Research Technician (Kon). Will assist in groundcover deployment, environmental, horticultural, and SWD data collection, data entry, and fruit sample transport for Experiments 1 and 2.

Cassandra Detrio-Darby; Temporary Research Technician (Kon). Will assist in groundcover deployment, environmental, horticultural, and SWD data collection, data entry, and fruit sample transport for Experiments 1 and 2.

Rachel Kreis; Plant Pathology Research Assistant. Will assist with foliar and fruit disease evaluations and data entry for Experiments 1 and 2.

BIOGRAPHICAL SKETCH

Thomas M. Kon

Assistant Professor, North Carolina State University
Mountain Horticultural Crops Research and Extension Center
455 Research Drive
Mills River, NC 28759
Phone: (828)684-3562
E-mail: tom_kon@ncsu.edu

EDUCATION

Ph.D. 2016. The Pennsylvania State University. Degree in Horticulture.

M.S. 2012. The Pennsylvania State University. Degree in Horticulture.

B.S. 2009. University of Nebraska. Degree in Horticulture.

PROFESSIONAL EXPERIENCE

Assistant Professor, Department of Horticultural Science, North Carolina State University, Mills River, NC, Jan. 2017 – Present.

Instructor, Department of Horticultural Science, North Carolina State University, Mills River, NC, Sept. 2016 – Dec. 2016.

PROFESSIONAL RESPONSIBILITIES

70% Research; 30% Extension. Develop and deliver research-based solutions to improve orchard practices and enhance the economic and environmental sustainability of the southeastern apple industry (NC, SC, and GA). Physiological effects, environmental interactions, and/or economic consequences of orchard management decisions are determined, reported, and integrated into recommendations for apple producers.

REFEREED PUBLICATIONS (Since 2017)

- **Kon, T.M.**, J.R. Schupp, M.A. Schupp, and H.E. Winzeler. 2020. Thermal shock as an apple crop load management strategy. I. Stigmatic receptivity, pollen tube growth, and leaf injury in response to thermal shock temperature and timing. *HortScience* 55:625-631.
- **Kon, T.M.**, J.R. Schupp, M.A. Schupp, and H.E. Winzeler. 2020. Thermal shock as an apple crop load management strategy. II. Pollen tube growth and spur leaf injury in response to thermal shock temperature and duration. *HortScience* 55:632-636.
- **Kon, T.M.**, G.E., Fernandez, P. Perkins-Veazie and K. Blaedow. 2020. Managing vigor of blackberry with prohexadione calcium: effects on primocane and florican development. *Acta Hort.* 1277:329-335
- **Kon, T.M.**, J.R. Schupp, K.S. Yoder, L.D. Combs, M.A. Schupp. 2018. Comparison of chemical blossom thinners using ‘Golden Delicious’ and ‘Gala’ pollen tube growth models as timing aids. *HortScience*. 53:1143-1151.

- **Kon, T.M.** and J.R. Schupp. 2018. Apple crop load management with special focus on early thinning strategies: a USA perspective. Hort. Rev. 46:255-298.
- Schupp, J.R., H.E. Winzeler, **T.M. Kon**, R.P. Marini, T.A. Baugher, L.F. Kime, and M.A. Schupp. 2017. A method for quantifying whole-tree pruning severity in mature tall spindle apple plantings. HortScience 52:1233-1240.

SELECT PUBLISHED ABSTRACTS (Since 2017)

- **Kon, T.M.** and C.D. Clavet. 2020. Organic aminoethoxyvinylglycine is an effective alternative in reducing apple preharvest drop. HortScience (In press).
- Tonapi, K.V., A. Malladi, and **T.M. Kon**. 2020. Apple fruit size is enhanced with increasing 6-BA application number. HortScience (In press).
- **Kon, T.M.** and C.D. Clavet. 2019. Enhancing ‘Fuji’ apple red fruit color with reflective fabrics. HortScience 54(9):S254. (Abstr.)
- **Kon, T.M.** and C.D. Clavet. 2018. Effects of leader bagging, 6-benzyladenine (6-BA), and GA 4+7 plus 6-BA on lateral branching of 3rd leaf ‘Gala’ apple. HortScience 53(9):S325-S326. (Abstr.)
- **Kon, T.M.** and J. Schupp. 2017. Comparing the efficacy of blossom thinning chemicals on ‘Golden Delicious’ apple. HortScience 52(9):S284-S285. (Abstr.)

SELECT EXTENSION PUBLICATIONS

- **Kon, T.M.** 2019. Growth-regulating chemicals. In: 2019 Integrated orchard management guide for commercial apples in the southeast. P. 81-89. North Carolina Cooperative Extension Service.
- **Kon, T.** and J. Schupp. 2019. Blossom Thinning Apples with Lime Sulfur: Old Dog – New Trick. Southern Appalachian Apples. <https://apples.ces.ncsu.edu/2019/03/blossom-thinning-apples-with-lime-sulfur-old-dog-new-trick/>

EXTENSION ACTIVITIES

- 81 Oral Presentations
- 12 Poster Presentations
- 47 Extension Publications/Technical Reports

SERVICE AND PROFESSIONALISM

- The American Pomological Society. Executive board member, 2019-2022; Advisory committee member, 2018-2019; Member 2015 to present.
- Pomology Professional Interest Group for the American Society for Horticultural Science. Chair, 2019-2020; Chair-elect, 2018-2019; Secretary, 2017-2018.
- Plant Growth Regulator Professional Interest Group for the American Society for Horticultural Science. Chair-elect, 2020-2021; Secretary, 2019-2020.
- *Ad hoc* Reviewer – HortScience; HortTechnology; The Journal of the American Pomological Society

KAREN BLAEDOW

100 Jackson Park Road, Hendersonville, NC 28792 · 828-697-4891
karen_blaedow@ncus.edu

EDUCATION

DECEMBER 2002

B.A. BIOLOGY

COLLEGE OF CHARLESTON, SOUTH CAROLINA

MAY 2006

M.S. PLANT AND ENVIRONMENTAL SCIENCE

CLEMSON UNIVERSITY, SOUTH CAROLINA

WORK EXPERIENCE

DECEMBER 2017-CURRENT

VEGETABLE AND SMALL FRUIT PRODUCTION AGENT, NORTH CAROLINA
COOPERATIVE EXTENSION, HENDERSON COUNTY

Provide technical and educational assistance to commercial vegetable and small fruit farms.

AUGUST 2013-CURRENT (PART-TIME DATA ANALYSIS ASSISTANCE)

BIOLOGICAL SCIENCE TECHNICIAN, USDA-ARS WENATCHEE, WA

Research on postharvest physiological factors affecting apple storage and quality.

OCTOBER 2012-AUGUST 2013

JUNIOR SCIENTIST, UNIVERSITY OF MINNESOTA, ST. PAUL, MN

Research focused on accessing the invasion risk of *Panicum virgatum* in restored prairies as well as the role biofuel crops could play in the biological control of soybean aphid.

DECEMBER 2008-MAY 2012

HORTICULTURE EXTENSION AGENT, NORTH CAROLINA STATE COOPERATIVE
EXTENSION, GOLDSBORO, NC

Responsible for designing, implementing, and evaluating educational programs in the natural sciences and horticulture.

SEPTEMBER 2007-DECEMBER 2008

RESEARCH TECHNICIAN, NORTH CAROLINA STATE UNIVERSITY, RALEIGH, NC

Research focused on plant-pathogen epidemiology studies as well as GMO disease resistant peanut evaluations. Managed the laboratory and served as a supervisor to undergraduate and part-time assistants.

MAY 2006-AUGUST 2007

JUNIOR SCIENTIST, UNIVERSITY OF MINNESOTA, ST. PAUL, MN

Research support to projects directed at improving the understanding of the biology, ecology, and management of soybean pathogens and diseases in MN.

JUNE 2004-MAY 2006

RESEARCH ASSISTANT, CLEMSON UNIVERSITY, CLEMSON, SC

Researched *Armillaria* root rot management in peach orchards and in daylilies.

PUBLICATIONS

- Kon, T.M., G.E. Fernandez, P. Perkins-Veazie, and K. Blaedow. "Managing vigor of blackberry with prohexadione calcium: effects on primocane and floricanes development" *Acta Horticulturae* 1277. 47 (2020) 329-335.
- Eckberg, James O., Michael D Casler, Gregg A Johnson, Laura L Seefeldt, Karen E Blaedow, and Ruth G Shaw. "Switchgrass population and cold-moist stratification mediate germination" *Crop science* 55, no. 6 (2015): 2746-2752.
- Fahrner, Samuel J., Jonathan P. Lelito, Karen Blaedow, and Brian Aukema. "Factors Affecting the Flight Capacity of *Tetrastichus planipennis* (Hymenoptera: Eulophidae), a Classical Biological Control Agent of *Agrilus planipennis* (Coleoptera: Buprestidae)" *Environmental Entomology* 43, no. 6 (2014): 1603-1612.
- Blaedow, K.E., Baumgartner, K., Cox, K. D. and Schnabel, G. 'Natural infection of an herbaceous host by *Armillaria*: a case study on *Hemerocallis*', *Canadian Journal of Plant Pathology*, 32: 3 (2010), 351 – 360
- Malvick, D.K., and K.E. Bussey. Comparative analysis and characterization of the soybean sudden death syndrome pathogen *Fusarium virguliforme* in the northern United States. *Canadian Journal of Plant Pathology* 30 (2008):467-476.
- Amiri, A., Bussey, K.E., Riley, M.B., and Schnabel, G. Propiconazole inhibits *Armillaria tabescens* in vitro and translocates into peach roots following trunk infusion. *Plant Dis.* 92 (2008):1293-1298.
- Bussey, K. and G. Schnabel. *Armillaria* sp. Found to Infect Daylily Plants. *The Daylily Journal*. 61 (2006):192-195.
- Schnabel, G., K. Bussey, and P.K. Bryson. First report of *Armillaria* root rot in daylily. *Plant Dis.* (2005)89:683.

SMALL FRUIT CONSORTIUM GRANTS

- Seasonal variation in blackberry nutrient concentration of primocane and floricanes leaves in Prime-Ark 45 and Traveler in double and single cropping systems. 2018. \$5,000 awarded. Gina Fernandez (PI), Daniel Shires (Co-PI), Karen Blaedow (Co-PI).
- Evaluation of cane and spur pruning effect on Traminette crop yield and fruit composition. 2019. \$5000 awarded. Cain Hickey (PI), Karen Blaedow (Co-PI)
- Development of a cultivar selection smartphone app for southeastern US bunch grape and muscadine vineyards. 2019. \$5,000 awarded. Cain Hickey (PI), Karen Blaedow (Co-PI)
- Investigation of mechanized fruit zone leaf removal on yield and berry parameters in *Vitis vinifera* cv. 'Chardonnay' and 'Merlot'. 2019. \$5000 awarded. Mark Hoffman (PI), Karen Blaedow (Co-PI)

Hannah J. Burrack

Professor & Extension Specialist

Department of Entomology & Plant Pathology North Carolina State University

Professional Preparation

Ph.D., 2007, Entomology, University of California, Davis.

M.S., 2006, Entomology, University of California, Davis. *Received concurrent with Ph.D.*

B.S., 2002, Rural Sociology, University of Wisconsin, Madison

B.S., 2002, Entomology, University of Wisconsin, Madison

Appointments

August 2020-present Platform Lead, , Education & Outreach, Plant Sciences Initiative, North Carolina State University

March 2018-present University Faculty Scholar, North Carolina State University

July 2017-present Professor, North Carolina State University, Department of Entomology & Plant Pathology

July 2013-June 2017 Associate Professor, North Carolina State University, Department of Entomology

September 2007- June 2013 Assistant Professor, North Carolina State University, Department of Entomology

HIGHLIGHTS – Activities from 2007 to present

Service – Manager for 4 USDA NIFA national grant panels. Member of 19 additional grant review panels. Serve or have served on 10 university or college committees. Serve or have served on 8 department committees.

Total program funding received while at NCSU – \$11,174,340

Peer reviewed publications – 64

Technical and extension publications – 45 technical reports, 19 management & production guides

Presentations to scientific audiences – 52 invited, 77 submitted

Engagement with extension and outreach stakeholders – 393 presentations to a total audience of 26,737 international, national, and state stakeholders; featured in over 90 newsletter and popular press articles

Online content development – Developed or contributed to 10 websites

Teaching – Lead instructor for 1 course & team teach 1 course; Presented 50 guest lectures in 9 courses in Entomology, Horticulture, and Crop Sciences Departments

Selected Products (of 37 in last 5 years)

Author status: ^aUndergraduate advisee, ^bMS advisee, ^cPhD advisee, ^dPost doctoral scholar, ^eVisting scholar, ^fResearch associate/staff, ^gCorresponding author

Kokotovich^d, A.E., J. Delborne, J. Elsensohn^c, **H. Burrack**. 2020. Emerging technologies for invasive insects: the role of engagement. *Annals of the Entomological Society of America*. <https://doi.org/10.1093/aesa/saz064>

Stockton, D.G., A.K. Wallingford, G. Brind'amore, L. Diepenbrock^d, **H. Burrack**, H. Leach, R. Isaacs, L.E. Iglesias, O. Liburd, F. Drummond, E. Ballman, C. Guedot, J. Van Zoeren, G.M. Loeb. 2020. Seasonal polyphenism of spotted-wing *Drosophila* is affected by variation in local abiotic conditions within its invaded range, likely influencing survival and regional population dynamics. *Ecology and Evolution*. 2020; 00: 1– 17. <https://doi.org/10.1002/ece3.6491>

- Kraft^c, L., D.A. Yeh, M. Gomez, and **H.J. Burrack**. 2020. Determining the effect of postharvest cold-storage treatment on the survival of immature *Drosophila suzukii* in small fruits. *Journal of Economic Entomology*. toaa185, <https://doi.org/10.1093/jee/toaa185>
- Schöneberg, T., A. Arsenault-Benoit, C.M. Taylor, B.R. Butler, D.T. Dalton, V.M. Walton, A. Petran, MA. Rogers, L.M. Diepenbrock^d, **H.J. Burrack**, H. Leach, S. Van Timmeren, P.D. Fanning, R. Isaacs, B.E. Gress, M.P. Bolda, F.G. Zalom, C.R. Roubos, R.K. Evans, A.A. Sial, and K.A. Hamby. 2020. Pruning of small fruit crops can affect habitat suitability for *Drosophila suzukii*. *Agriculture, Ecosystems and Environment*. 294. <https://doi.org/10.1016/j.agee.2020.106860>
- Toennisson^f, T.A., J. Klein^e, and **H.J. Burrack**. 2019. Measuring the effect of non-crop flowering plants on natural enemies in organic tobacco. *Biological Control*. 137. <https://doi.org/10.1016/j.biocontrol.2019.104023>
- Nelson^c, P.N., **H.J. Burrack**, and C.E. Sorenson. 2019. Arthropod carrion influences plant choice, oviposition, and cannibalism by a specialist predator on a sticky plant. *Ecological Entomology*. 45(2): 182-189. <https://doi.org/10.1111/een.12787>
- Slone^b, J.D. and **H.J. Burrack**. 2016. Integrated pest management practices reduce insecticide applications, preserve beneficial insects, and decrease pesticide residues in flue cured tobacco production. *Journal of Economic Entomology*. DOI: <http://dx.doi.org/10.1093/jee/tow191>

Synergistic Activities

Lead Project Director for Sustainable Spotted-wing *Drosophila* Management, a USDA Specialty Crop Research Initiative and Center for Excellence project involving 22 lead PIs at 13 institutions throughout the United States, 2015-2020. This project coordinated national research, extension, and education efforts to develop biology-based management strategies for *Drosophila suzukii*, commonly referred to as the spotted-wing drosophila, a devastating invasive pest of soft-skinned fruit crops globally. I remain Co-Project Director for a continuation of this project led through University of Georgia.

Lead Instructor, Writing for Scientific Journals. Lima, Peru, 18 February-24 February 2020. I developed and led a five day intensive writing workshop for scientists at universities and research centers around Peru with support from the Perú Ministerio de la Producción, Programa Nacional de Innovación en Pesca y Acuicultura, and the Fundación para el Desarrollo Agrario (FDA).

Volunteer, USAID Partners for the Americas Farmer-to-Farmer Program. Rio Grande do Sul, Brazil. 29 November-15 December 2015. The purpose of this visit was to share knowledge about spotted-wing drosophila (*Drosophila suzukii*) biology and management with scientists and farmers in southern Brazil, where this invasive insect has been present since 2013. During a week-long visit, I visited 14 farms producing strawberries, blackberries, raspberries, blueberries, and grapes, which was facilitated by Dr. Regis Sivori, EMBRAPA Uva e Vinho (Grape and Wine), Vacaria, RS. Dr. Sivori and I also presented two workshops, at EMBRAPA Bento Gonçalves and Vacaria.

Thesis Advisor and Postgraduate-Scholar Sponsor

Graduate students (total 7 doctoral, 9 masters): Davila Rocio (MS anticipated 2022, visiting scholar 2019), Dillard DeShae (PhD anticipated 2023), Elsensohn Johanna (PhD anticipated 2020), Gundry Shawnee (MS 2018), Howell Forrest (MS 2016), Kraft Laura (PhD anticipated 2021), McPhie Douglas (MS 2016), Merchan Alejandro (PhD 2016), Nelson Peter (PhD 2018), Pulkoski Melissa (MS anticipated 2022), Rivera Monique (MS 2011), Rogers Shelley (MS 2012), Slone Jeremy (PhD 2019, MS 2016), Suits Rachel (MS 2013), Swoboda Bhattarai Katherine (PhD 2017), Zilnik Gabriel (PhD 2020)

Post-doctoral advises (total 4): Barnhill-Dill, Katie (NC State Univ), Diepenbrock Lauren (U Florida), Hardin Jesse (USDA APHIS), Kokovich Adam (NC State Univ),

Visiting scholars (total 5): Aly Marwa (Minia Univ, Egypt, 2016), Dominguez Nelson (Zamarano Univ, Honduras, 2017), Klein Joana (Univeridade Federal do Rio Grande do Sul, Brazil, 2015), Zheng Yanan (Shenyang Agricultural University, China, 2015)

Curriculum Vitae
Dr. Gina E. Fernandez Professor
Department of Horticultural Science,
North Carolina State University, Box 7609 Raleigh, NC 27695-7609

Education

- Ph.D. Cornell University, Ithaca, NY. 1994. Pomology.
- M.S. University of Minnesota St. Paul, MN. 1987. Horticulture.
- B.S. Ripon College, Ripon, WI. 1981. Biology.

Professional History

- 2019-present: John D. and Nell R. Distinguished Professor. NCSU. Extension: 68%, Research: 23%, Academic: 9%.
- 2010 – 2019: Professor, Dept. Hort. NCSU, Raleigh, NC.
- 2010 January – June: Visiting Scholar, University of Kwa-Zulu Natal, Pietermaritzburg, SA.
- 2002-10: Associate Professor/Extension Specialist, Dept. Hort. NCSU, and Raleigh, NC.
- 1996 - 2002: Assistant Professor/Extension Specialist, Dept. Hort. NCSU, and Raleigh, NC.

Selected Professional Activities

- Convenor and Editor, XI International *Rubus* and *Ribes* Symposium, 2015
- Major advisor/committee member on 23 MS and PhD graduate student committees
- Teach Small Fruit Production course, HS 422, at North Carolina State University
- Chair of North America Bramble Growers Research Foundation, 1999-2016

Selected Extension and outreach activities:

- Southern Region Small Fruit Consortium Agent Training coordinator of trainings at least once every other year, 2002 –present. <http://www.smallfruits.org/training.html>
- Design and post information on Blackberry and Raspberry Information Portal, NCSU. <https://rubus.ces.ncsu.edu>
- SE Regional Fruit and Vegetable Conference, Caneberry and Strawberry talks, 2008-present
- Helped to establish a commercial blackberry industry in the region through regional yield trials in the 90's-2010's, organize grower meetings with marketers in the early 2000's and training of agents and growers on production basics at state and regional meetings in the 2000's. Valued at \$15M annually.

Professional Service off campus:

- The North American Bramble Growers Association, Research Foundation Committee Chair, 1998 - 2017
- American Society Horticultural Science
 - Small Fruit and Viticulture Working Group Chair 2001
 - Small Fruit Publication Committee Reviewer/Chair, 1997, 2000, 2010
 - SR ASHS Fruit Session Program Chair 2014
- RosEXEC Committee. 2014-2017.

Recent Honors and Awards

- North American Raspberry and Blackberry Association, Distinguished Service Award. 2019
- SR ASHS Distinguished Research Award, 2018
- SR ASHS Blue Ribbon Extension Award, Caneberry Guide, 2018
- Southern Region American Society for Horticultural Science (ASHS) Extension Blue Ribbon Communication Award 2011 for the Blackberry & Raspberry Growers Information Portal.

Recent Grant Awards

(Career total \$3,337,742/\$1,428,640 to GF)

- Breeding Flavorful Disease Resistant Strawberry Cultivars. 01/01/2020 - 12/31/2021, NC Department of Agriculture & Consumer Services. \$105,609.00/\$105,609.
- Sustainable Soil Management Practices for Strawberries: Diverse Approaches for Facilitating Adoption. 2014-2015. (Prime--Walmart Foundation). \$103,784.00.
- Trialing advanced strawberry selections in the Southern Region. 2015-17. SRSFC. \$10,000.
- Development of New Strawberry Varieties Adapted to the North Carolina Plasticulture System, 2015-18. NCSA. \$39,500.
- Trialing Advanced Strawberry Selections in the Southern Region of the US. 2015-2018. NASGA. \$23,483.

Recent Peer Reviewed Publications

1. **Fernandez, G.**, Pattison, J., Perkins-Veazie, P., Ballington, J. R., Clevinger, E., Schiavone, R., Gu, S., Samtani, J., Vinson, E., McWhirt, A., & Chacón, J. (2020). 'Liz' and 'Rocco' Strawberries, *HortScience*, 55(4), 597-600. Retrieved Jun 24, 2020, from <https://journals.ashs.org/hortsci/view/journals/hortsci/55/4/article-p597.xml>
2. Samtani, J.B., C.R. Rom, H. Friedrich, S.A. Fennimore, C.E. Finn, A. Petran, R. W. Wallace, M. P. Pritts, **G. Fernandez**, C.A. Chase, C. Kubota, B. Berefurd. 2019. The status and future of the strawberry industry in the United States. *HortTechnology*. DOI: <https://doi.org/10.21273/HORTTECH04135-18>
3. Jibrán R, J. Spencer, **G. Fernandez**, A. Monfort, M. Mnejja, H. Dzierzon, J. Tahir, K. Davies, D. Chagné, D. and T. Foster. 2019. Two Loci, RiAF3 and RiAF4, Contribute to the Annual-Fruiting Trait in Rubus. *Front. Plant Sci.* 10:1341. doi: 10.3389/fpls.2019.01341
4. Jacobs, R.L., T. B. Adhikari, J. Pattison, G. C. Yenchó, **G. E. Fernandez**, and F. J. Louws. 2019. Assessing Rate-Reducing Foliar Resistance to Anthracnose Crown Rot and Fruit Rot in Strawberry. *Plant Disease*, Vol. 104, No. 2: 398-407.
5. [David P. Livingston III, Tan D. Tuong, Mark Hoffman, Gina Fernandez](https://www.jove.com/video/58025/protocol-for-producing-three-dimensional-infrared-video-freezing): 2018. [Protocol for Producing Three-Dimensional Infrared Video of Freezing in Plants](https://www.jove.com/video/58025/protocol-for-producing-three-dimensional-infrared-video-freezing). doi: 10.3791/58025 <https://www.jove.com/video/58025/protocol-for-producing-three-dimensional-infrared-video-freezing>. Issue 139. e58025.

Selected Extension Publications

- Southeast Caneberry Production Guide. Southern Region Small Fruit Consortium. 2016. Gina E. Fernandez, Elena Garcia and David Lockwood. Extensively Revised. NCCES. <https://rubus.ces.ncsu.edu/spotlight/caneberry-production-guide/>
- Sustainable Practices for Plasticulture Strawberry Production in the Southeast. 2015. Amanda McWhirt, Dr. Gina Fernandez and Dr. Michelle Schroeder-Moreno. http://content.ces.ncsu.edu/sustainable-practices-for-plasticulture-strawberry-production-in-the-southeast/#section_heading_4750
- Teach from the Garden: Strawberries. 2013. Publication Number: 4H-527 Job Number: 13-CALS-3373. <ftp://ftp.soil.ncsu.edu/Driscoll/strawberryproject/>
- Blackberries for the home garden. 2011. <http://www.ces.ncsu.edu/hil/pdf/blackberries.pdf>
- Social Media
 - Twitter: @NCteamrubus
 - Blog: <http://teamrubus.blogspot.com/>
 - Facebook: TeamRubus

Juan Carlos Melgar

Associate Professor of Pomology and Extension Specialist

Department of Plant and Environmental Sciences

105 Collings Street, 218 Biosystems Research Complex, Clemson, SC 29634-0310

864-656-4562 office | 864-656-4960 fax | jmelgar@clemson.edu

Research and Extension Interests

My research and extension goals are to solve problems in fruit tree growing that can have significant economic, social and environmental impacts. Research in the last years focused on the effect of abiotic/biotic stresses, with an emphasis on climate variability, and water and nutrient management on physiological responses of fruit tree species (peach, blackberry, citrus).

Education and Training

2006 Ph.D., Crop Production and Protection, University of Cordoba, Spain

2000 Agricultural Engineer, Crop Production, University of Cordoba, Spain

Professional Experience

2014-Present: 70% Research, 30% Extension

06/2020-Present Associate Professor, Plant and Environmental Sciences, Clemson University

08/2014-06/2020 Assistant Professor, Plant and Environmental Sciences, Clemson University

09/2010-07/2014 Assistant Professor, Citrus Center, Texas A&M University-Kingsville

08/2009-07/2010 Research Associate, Aula Dei Experiment Station, Spanish Council for Scientific Research (CSIC-Spain)

01/2007-09/2009 Postdoctoral Researcher, Citrus Research and Experiment Center, University of Florida/IFAS

Professional Activities

Scholarship Awards Committee, American Society for Horticultural Science, 2017-Present

Nominations Committee, Southern Region American Society for Hortic. Science, 2015-Present

Mentees (graduate students, past 5 years)

Katherine Ann Kule. 2020, M.S. Graduated in December 2020

Amanda Accampo. 2019, M.S. Graduated in August 2019

Qi Zhou. 2019, Ph.D. Research Specialist, University of California, ANR

Brian Lawrence. 2018, M.S. Current Ph.D. student, Clemson University

Jaine Allran. 2017, M.S. Research Specialist at Weyerhaeuser

Recent and Relevant Grants

Nineteen grants awarded as PI for a total of \$1,472,934 at my current position at Clemson University. Furthermore, I am also a co-PI in several multi-state, transdisciplinary grants with a dual component of research and extension.

Synergistic Activities

My research studies are interdisciplinary, and I always work closely with soil scientists, root physiologists, plant pathologists, breeders, entomologists and other horticulturists. This has been reflected in my publications and the students I advised.

Refereed Publications (last 4 years)

- Lykins S, Scammon K, Lawrence BT, **Melgar JC**. 2021. Photosynthetic light response of florican leaves of erect blackberry cultivars from fruit development into the postharvest period. *HortScience*. In Press.
- Campbell D, Sarkhosh A, Brecht J, Gillett-Kaufman J, Liburd O, **Melgar JC**, Treadwell D. 2020. Bagging organic peaches reduces physical injuries and storage decay with minimal effects on fruit quality. *HortScience* 56(1): 52-58
- Lawrence BT, **Melgar JC**. 2020. Variable fall climate conditions on carbon assimilation and spring phenology of young peach trees. *Plants* 9: 1353
- Lawrence BT, **Melgar JC**, Dallmann, MJ, Ouellette DR, Hu M, Schnabel G. 2020. Field performance and susceptibility to fungal pathogens of eleven blackberry cultivars. *Int. J. Fruit Sci.* 20(sup2): 605-616
- Zhou Q, **Melgar JC**. 2020. Tree age influences nutrient partitioning among annually removed aboveground organs of peach. *HortScience*, 55(4):560-564
- Demiral MA, **Melgar JC**, Contreras B, Kusakabe A, Uygun M, Küçük Kaya S. 2020. Responses of salt-stressed citrus plants to foliar-applied proline. *Eurasian J. Soil Sci*, 9(1): 66-74
- Park JW, **Melgar JC**, Kunta M. 2019. Plant nutritional deficiency and its impact on crop production. In: Bioactive molecules in plant defense: signaling in growth and stress. Jogaiah, S and Abdelrahman M. (Ed.) Springer International Publishing. pp.231-258
- Zhou Q, **Melgar JC**. 2019. Ripening season affects tissue mineral concentration and nutrient partitioning in peach trees. *J. Plant Nutr. Soil Sci.* 182: 203-209
- Simpson CR, **Melgar JC**, Nelson SD, Sétamou M. 2019. Growth and yield responses under different grove floor management strategies for water conservation in young grapefruit trees. *Sci. Hort.* 256: 108567
- Kunta M, Guzman L, Garcia AC, del Rio HS, **Melgar JC**, Louzada ES. 2019. Evaluation of physiological parameters in Citrus plants transformed with cyclic nucleotide gated ion channel (CNGC) gene. *Acta Hort.* 1230: 107-115
- Allran J, Schnabel G, **Melgar JC**. 2019. Peach bagging in the Southeastern U.S. *J Amer. Pomol. Soc.* 73: 38-46
- Lawrence BT, **Melgar JC**. 2018. Variable fall climate influences nutrient resorption and reserve storage in young peach trees. *Front. Plant Sci.* 9: 1819
- Lawrence BT, **Melgar JC**. 2018. Harvest, handling and storage recommendations for improving postharvest quality of blackberry cultivars. *HortTechnology*. 28(5): 578-583
- Penella C, Calatayud A, **Melgar JC**. 2017. Ascorbic acid alleviates water stress in young peach trees and improves their performance after rewatering. *Front Plant Sci.* 8: 1627
- Hu M-J, Peng C, **Melgar JC**, Schnabel G. 2017. Occurrence and potential causes of peach skin streaking. *Plant Disease* 101: 1601-1605
- Nishikawa, F., Louzada, E., **Melgar, J.C.**, Kunta, M. and Setamou, M. 2017. Effects of planting bed height and the use of plastic mesh as ground cover on the flowering of citrus trees. *Bulletin of the NARO, Fruit Tree and Tea Science* 1: 1-8

Penelope Perkins-Veazie

North Carolina State University
Plants for Human Health Institute
Department of Horticultural Science
Phone: 704.250.5419 Fax: 704-250-5428
600 Laureate Way, Kannapolis NC 28081
penelope_perkins@ncsu.edu

Research Focus: Postharvest methods and storage technologies for fresh fruits and vegetables, and assessment and screening methods for bioactive compounds in fresh produce.

Educational Background

PhD, University of Florida, Horticulture, 1988
MSc, University of Florida, Horticulture, 1985
BSc, University of Maine-Orono, Plant and Soil Sciences, 1981

Professional Experience

Professor, Dec 2008-present, North Carolina State University, Horticultural Sciences Department
Plant Physiologist, 1988-2008, USDA-ARS, South Central Agricultural Research Laboratory
Adjunct Associate Professor, 1988-2008, Oklahoma State University, Department of Horticulture and Landscape Architecture
Adjunct Associate Professor, 1994-2008, University of Arkansas, Department of Horticulture
Adjunct Associate Professor, 2001-present, University of Maine, Department of Food Science and Nutrition

Scholarly and Professional Honors

Outstanding Research Award, American Society for Horticultural Science, 2015
Blue Ribbon Extension Award, Pack N Cool, American Society for Horticultural Science, Southern Region, 2013
Outstanding Paper Award, Vegetables, American Society for Horticultural Science, 2011
Executive Board Member at Large, American Society for Horticultural Science, 2009-2011
Keynote speaker, 4th International Cucurbitacea Conference, China, 2009
President, American Society for Horticultural Science, Southern region, 2008
Fellow, American Society for Horticultural Science, 2007
Keynote speaker, Third International Cucurbitacea Conference, Australia, 2005
L. M. Ware Award for distinguished research, Southern region, American Society for Horticultural Science, 2003
Excellence in Extension Publication Award, Southern region, American Society for Horticultural Science, 2003
Excellence in Extension Publication Award, Southern region, American Society for Horticultural Science, 2003

Selected Refereed Journal Articles (total 130)

- Trandel, M.A., Perkins-Veazie, P., Schultheis, J. 2020. Predicting hollow heart incidence in triploid watermelon (*Citrullus lanatus*). *HortScience* 55:1920-1926. <https://doi.org/10.21273/HORTSCI15361-20>
- Fernandez, G., Pattison, J., Perkins-Veazie, P., Ballington, J.R., Clevinger, E., Schiavone, R., Gu, S., Samtani, J., Vinson, E., McWhirt, A., Chacon, J.G. 2020. ‘Liz’ and ‘Rocco’ strawberries. *HortScience* 55:597-600. <https://doi.org/10.21273/HORTSCI14516-19>
- Spalholz, H., Perkins-Veazie, P., Hernandez, R., 2020. Impact of sun-simulated white light and varied blue:red spectrums on the growth, morphology, development, and phytochemical content of green- and red-leaf lettuce at different growth stages. *Scientia Horticulturae* 264:109195 <https://doi.org/10.1016/j.scienta.2020.109195>
- Devi, P., Perkins-Veazie, P., Miles, C.A. 2020. Rootstock and plastic mulch effect on watermelon flowering and fruit maturity in a *Verticillium dahlia*-infested field. *HortScience* 55:143801445. <https://doi.org/10.21273/HORTSCI15134-20>
- Devi, P., Perkins-Veazie, P., Miles, C. 2020. Impact of grafting on watermelon fruit maturity and quality. *Horticulturae* 6:97 <https://doi.org/10.3390/horticulturae6040097>
- Attavar, A., Tymon, L., P., Perkins-Veazie, P., Miles, C.A. 2020. Cucurbitaceae germplasm resistance to verticillium wilt and grafting compatibility with watermelon. *HortScience* 55:141-148. <https://doi.org/10.21273/HORTSCI14631-19>
- Shanley, A., Zwetsloot, J.J., Jurrisen, T.J., Hannan, C., Zwetsloot, K.A., Needle, A.R., Bishop, E., Wu, G., Perkins-Veazie, P. 2020. [Daily watermelon consumption decreases plasma sVCAM-1 levels in overweight and obese postmenopausal women](https://doi.org/10.3390/nut706019) *Nutrition Research* 76:9-19.
- Veazie, P., Cockson, P., Henry, J., Perkins-Veazie, P., Whipker, B. 2020. Characterization of Nutrient Disorders and Impacts on Chlorophyll and Anthocyanin Concentration of *Brassica rapa* var. *Chinensis*. *Agriculture* 10:461 <https://doi.org/10.3390/agriculture10100461>.
- Jahnke, N.J., Dole, J.M., Bergmann, B.A., Ma, G., Perkins-Veazie, P. 2020. Extending Cut *Paeonia Lactiflora* Pall. Storage Duration Using Sub-Zero Storage Temperatures. *Agronomy* 10: 1694 <https://doi.org/10.3390/agronomy10111694>.
- Lucas, E.A., Yuhua, M., White, K., Perkins-Veazie, P., Beebe, M., Peterson, S., Payton, M.E., Smith, B.J. 2020. Freeze-Dried Watermelon Supplementation Has Modest Effects on Bone and Lipid Parameters of Ovariectomized Mice. *Prev. Nutr. Food Sci.* 25:41-49.
- Fall, L.A., Perkins-Veazie, P., Ma, G. and McGregor, C. 2019. QTLs associated with flesh quality traits in an elite × elite watermelon population. *Euphytica* 215:30-35.
- Hartman, J.L., Perkins-Veazie, P., Wehner, T.C. 2019. Citrulline and arginine are moderately heritable in two red-fleshed watermelon populations. *HortScience* 54(2):200-205.
- Hartman, J.L., Wehner, T., Ma, G., Perkins-Veazie, P. 2019. Citrulline and arginine content of taxa of cucurbitaceae. *Horticulturae* 5 (1):22 <https://doi.org/10.3390/horticulturae5010022>
- Siddiq, M., K. Dolan, P. Perkins-Veazie, J.K. Collins. 2018. Effect of pectinolytic and cellulytic enzymes on the physical, chemical, and antioxidant properties of blueberry juice. *LWT International* 92:127-132.
- Bertucci, M.B., Jennings, K.M., Monks, D.W., Schultheis, J.R., Perkins-Veazie, P. 2018. early season growth, yield, and fruit quality of standard and mini watermelon grafted onto several commercially available cucurbit rootstocks *HortTechnology* 28 (4), 459-469.
- Basinger, N., Jennings, K., Monks, D., Mitcham, W., Perkins-Veazie, P., Chaudhari, S 2017. In-row vegetation-free strip width effect on established ‘Navaho’ blackberry. *Weed Technol.* 1-5. doi:10.1017/wet.2017.85
- Perkins-Veazie, P. 2017. Postharvest storage and transport of blackberries. In: *Blackberries and their Hybrids*, CAB Intl, pp. 266-282.

CURRICULUM VITAE

GUIDO SCHNABEL, PH.D.

PROFESSIONAL PREPARATION

- 1997: Universität Hohenheim, Stuttgart, Germany: Ph.D. Plant Pathology
1993: Justus Liebig Universität, Giessen, Germany: M.S. Agricultural Sciences
1990: Justus Liebig Universität, Giessen, Germany: B.S. Agricultural Sciences

EMPLOYMENT

- 2012-present: Professor, Department of Plant and Environmental Sciences, Clemson University
2005-2011: Associate Professor, Department of Entomology, Soils, and Plant Sciences, CU
2000-2005: Assistant Professor, Department of Plant Pathology and Physiology, CU
1997-2000: Research Associate, Department of Botany and Plant Pathology, MSU
1995-1997: Graduate Research Assistant, Bavendorf, Universität Hohenheim, Germany
1993-1995: Graduate Research Assistant, Universität Bonn, Germany
1992-1993: Lab Assistant, Institut National De La Recherche Agronomique, Angers, France

HONORS AND AWARDS

- 2019 Named Associate Editor of the Journal *Pesticide Biochemistry and Physiology*
2017 Ulysses P. Hedrick Award from the American Pomological Society
2017 Centennial Professorship Award, Clemson University
2017 Southern Region IPM Center Friends of IPM – Bright Idea Award for Creation of MyIPM
2017 Ernie Christ Memorial Lecture, Mid Atlantic Fruit & Vegetable Convention, Hershey, PA
2016 Edmond C. Calavan Lecture, Dept of Plant Pathology, University of California Riverside
2015 Excellence in Extension Award, American Phytopathological Society
2015 Godley-Snell Award for Excellence in Agricultural Research at Clemson University
2014 Elected Member of the North Carolina Strawberry Grower Advisory Board
2014 The ‘Smart Way’ To Manage Resistance Award, StrawberryDoc, LLC–Awards Program
2013 Recognition of Outstanding Services as Plant Disease Senior Editor. APS
2012 Excellence in Research and Resistance Monitoring Program, StrawberryDoc, LLC–Award
2011 Lee Hutchins Award for Excellence in Tree Fruit Research, APS
2010 Recognition of Outstanding Services as Plant Disease Associate Editor. APS
2007 Cooperative Extension Service Team Award, Clemson University (Peach Team)
2006 Cooperative Extension Service Superior Performance Award, Clemson University
2003 Communication Award, National Association County Agricultural Agents

Selected Peer-reviewed publications (45 publications since 2017)

Dowling, M. E. and G. Schnabel 2020. Understanding plant diseases with art and technology. **Int. J. Hort. Sci.** 20:959-966.

Dowling, M., N. Peres, S. Villani, and G. Schnabel 2020. Managing Colletotrichum on fruit crops; a ‘complex’ challenge. **Plant Dis.** 104:2301-2316.

Chen, F., G. Schnabel and others 2020. Histone H3 gene is not a suitable marker to distinguish *Alternaria tenuissima* from *A. alternata* affecting potato. PlosOne. <https://doi.org/10.1371/journal.pone.0231961>

Miller, S. B., K. Gasic, G. R. Reighard, W. G. Henderson, P. A. Rollins, M. Vassalos, and G. Schnabel 2020. Preventative root collar excavation reduces peach tree mortality caused by *Armillaria* root rot on replant sites. **Plant Dis.** 104:1274-1279.

Munoz, M. G. Schnabel, W. Bridges, and J. E. Faust 2020. Expression of pink pigmentation in rose petals and its relationship with *Botrytis cinerea*. **PHP.** 21:152-156.

Cechi, A., Melanie L. Lewis Ivey Rachel R. Kaufman, Karen P. Bryson, and Guido Schnabel 2020. Quinone outside inhibitor-resistant *Colletotrichum nymphaeae* isolates from strawberry lack mutations in cytb gene. **J. Plant Pathol.** Doi 10.1007/s42161-020-00565-8.

Bennett, K., Vargo, M., Schnabel, G. (2020). Calcium application method impacts Botrytis blight severity on petunia flowers. **HortScience**, 55, 192-195.

Bennett, K., Jent, J., Samarakoon, U. C., Schnabel, G., Faust, J. E. (2020). Reduction of Botrytis cinerea infection on petunia flowers following calcium spray applications. **HortScience**, 55, 188-191.

Lawrence, B., G. Schnabel and J. C. Melgar 2020. Field performance and susceptibility to fungal pathogens of eleven blackberry cultivars. **Int J Fruit Sci.** <https://doi.org/10.1080/15538362.2020.1749922>.

Chen, S., M. Hu, and G. Schnabel 2020. Paralogous CYP51s of *Colletotrichum* spp. Mediate Differential Sensitivity to Sterol Demethylation Inhibitors. **Phytopathology** 110:615-625.

Li, Y., S. S. Tsuji, M. Hu, M. P. S. Camara, S. J. Michereff, G. Schnabel, and F. Chen 2019. Characterization of difenoconazole resistance in *Lasiodiplodia theobromae* from papaya in Brazil. **Pest Manag. Sci.** 76:1344-1352.

Chen, F., S. S. Tsuji, Y. Li, M. Hu, M. A. Bandeira, M. P. S Camara, S. J. Michereff, G. Schnabel 2020. Reduced sensitivity of azoxystrobin and thiophanate-methyl resistance in *Lasiodiplodia theobromae* from papaya. **Pestic. Biochem. Physiol.** 162:60-68.

Dowling, M. E. and G. Schnabel 2020. Understanding plant diseases with art and technology. **Int. J. Hort. Sci.** In press.

Cosseboom, S. D., G. Schnabel, and M.J.Hu. 2020. Competitive ability of multifungicide-resistant *Botrytis cinerea* in a blackberry planting over three years. **Pestic. Biochem. Physiol.** 163:1-7.

Munoz, M., J. E. Faust, and G. Schnabel 2019. Characterization of *Botrytis cinerea* from commercial cut flower roses. **Plant Dis.** 103:1577-1583.

Cechi, A., Stahlecker, J., Dowling, M. E. and G. Schnabel 2019. Diversity in species composition and fungicide resistance profiles in *Colletotrichum* isolates from apple. **Pestic. Biochem Physiol.** 158:18-24.

Schmitz, L. T. and G. Schnabel, 2019. Infrequent occurrence of peach skin streaking and the role of rainwater attributes on symptom development. **Plant Dis.** 103:2606-2611.

Sara M. Villani

Department of Entomology and Plant Pathology
North Carolina State University

Mt Hort Crops Res and Ext Ctr
Mills River, NC 28759

Education

Ph.D. (2016) Plant Pathology. Cornell University

B.S. (2005) Chemistry. State University of New York at Geneseo

Professional Appointments

Assistant Professor; Department of Entomology and Plant Pathology, North Carolina State University (12/2019-present)

Extension Assistant Professor; Department of Entomology and Plant Pathology, North Carolina State University (12/2015-12/2019)

Selected Refereed Research Publications (last 4 years)

- Agnello, A.M., Breth, D.I., Tee, E.M., Cox, K.D., **Villani S.M.**, Ayer, K.M., Wallis, A.E., Donahue, D.J., Combs, D.B., Davis, A.E., Neal, J.A, English-Loeb, F.M. 2017. *Xylosandrus germanus* (Coleoptera: Curculionidae:Scolytinae) occurrence, fungal associations, and management trials in New York apple orchards. J. Econ. Entomol. 0:1-16.
- Villani, S.M.**, Ayer, K., and Cox, K.D. 2016. Molecular characterization of the *sdhB* gene and baseline sensitivity to penthiopyrad, fluopyram, and benzovindiflupyr in *Venturia inaequalis*. Plant Dis. 100: 1709-1716.
- Villani, S.M.**, Hulvey, J., Hily, J.-M., and Cox, K.D. 2016. Overexpression and upstream characterization of the *CYP51A1* gene in isolates of *Venturia inaequalis* resistant to difenoconazole. Phytopathology. 106:562-571.
- Tancos, K.A., **Villani, S.M.**, Kuehne, S., Borejsza-Wysocka, E., Breth, D., Carroll, J.E., Aldwinckle, H.S., and Cox, K. 2016. Prevalence of streptomycin resistant *Erwinia amylovora* in New York apple orchards. Plant Dis. 100:802-809.
- Villani, S.M.**, Biggs, A.R., Cooley, D.R., Raes, J.J., and Cox, K.D. 2015. Prevalence of myclobutanil resistance and difenoconazole insensitivity in populations of *Venturia inaequalis*. Plant Dis. 99:1526-1536.
- Munck, I., Tanguay, P., Weimer, J., **Villani, S.M.** and Cox, K.D. 2015. Impact of white pine blister rust on resistant cultivated *Ribes* and neighboring Eastern white pine in New Hampshire. Plant Dis. 99:1374-1382.
- Frederick, Z. A., **Villani, S.M.**, and Cox, K.D. 2015. The effect of delayed-dormant chemical treatments on demethylation inhibitor (DMI) sensitivity in a DMI-resistant population of *Venturia inaequalis*. Plant Dis. 99:1751-1756.
- Villani, S.M.** and Cox, K.D. 2014. Heteroplasmy of the cytochrome b gene in *Venturia inaequalis* and its involvement in quantitative and practical resistance to trifloxystrobin. Phytopathology 104:945-953.
- Frederick, Z.A., **Villani, S.M.**, Cooley, D.R., Biggs, A.R., Raes, J.J., and Cox, K.D. 2014. Prevalence and stability of qualitative QoI resistance in populations of *Venturia inaequalis* in the Northeastern United States. Plant Dis. 98:1122-1130.

Selected Extension Publications

Villani, S.M and Walgenbach, J.F. 2017. The Ambrosia Beetle Invasion of Western NC Apple Orchards. North Carolina State University Extension Plant Pathology Portal (<https://plantpathology.ces.ncsu.edu/2017/06/the-ambrosia-beetle-invasion-of-western-nc-apple-orchards/>)

Villani, S.M., Walgenbach, J.F., Kon, T.K., Kelley, W.T. 2017. Ambrosia Beetle Taking a Toll on Henderson County Apples. Henderson County Center Extension Portal. (<https://henderson.ces.ncsu.edu/2017/05/ambrosia-beetle-taking-toll-on-henderson-county-apples/>)

Walgenbach, J., Parker, M., **Villani, S.**, Mitchem, W., Lockwood, D., Eds (2017). 2017 Integrated Orchard Management Guide for Commercial Apples in the Southeast Pest and Orchard Management Program.

Villani, S.M., Ed, (2016) Disease Control for Forest, Christmas, and Ornamental Trees. 2017 North Carolina Agricultural and Chemicals Manual.

Selected Published Research Abstracts and Proceedings

Villani, S.M., Calvin, J., Kreis, R.A., and Walgenbach, J. 2017. Apple trees in decline: Stress, alcohol, and some opportunistic friends. Presented at the Great Lakes Fruit Workers Meeting, Port Huron, MI, November 2017.

Ayer, K.A., **Villani, S.M.**, and Cox, K.D. 2017. Sensitivity and resistance management for the SDHI fluxapyroxad in the apple scab pathogen *Venturia inaequalis*. 107:XX.

Johnson, K.A., Kreis, R.A., and **Villani, S.M.** 2017. Evaluation of fungicide efficacy and application timing for the management of Glomerella leaf spot and fruit rot in North Carolina. Phytopathology. 107:XX.

Villani, S.M., Ayer, K. and Cox, K.D. 2016. Baseline sensitivities to SDHI fungicides and characterization of the *sdhB* gene in *Venturia inaequalis*. Phytopathology. 106:S4

Ayer, K.M., **Villani, S.M.** and Cox, K.D. Fungi in the wood: The fungi associated with the ambrosia beetle, *Xylosandrus germanus* and its galleries in *Malus x domestica*. 2016. Phytopathology. 106:S4.

Ayer, K., **Villani, S.M.**, and Cox, K.D. 2015 Fungi in the wood: The fungi associated with the black stem borer and its galleries in *Malus*. 2015 Great Lakes Fruit Workers Meeting, Geneva, NY, November 2015.

Selected Invited Presentations

Villani, S.M. 2017. Explanations for failure: Using molecular approaches to define single-site fungicide resistance in *Venturia inaequalis*. Department of Plant, Soil, and Microbial Sciences Seminar, Michigan State University, February 2017.

Villani, S.M. 2017. Resisting resistance: Incorporation and preservation of SDHI fungicides for disease management. Michigan State University Tree Fruit IPM School, Traverse City, MI, February 2017.

Villani, S.M. and Cox, K.D. 2017. Management of apple scab beyond the models: Lessons learned from cultivar selection and off-season fungicide applications. Michigan State University Tree Fruit IPM School, Traverse City, MI, February 2017.

Villani, S.M. 2017. MyIPM App: Hands on Workshop. Oconee County Fruit Grower Meeting, Clemson University Extension, January 2017.

Villani, S.M. 2016. Reducing the Guesswork: Diseases Forecasting in Specialty Crops. Presented at the 6th Annual Horticulture Industry Integrated Pest Management Symposium, Asheville, NC, September 2016.