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ABSTRACTS FROM THE SOCIETY OF NEMATOLOGISTS ANNUAL MEETING 2018

CAENORAHBDITIS ELEGANS TRIACYLGLYCEROLS AS BIOMARKER FOR EXPOSURE TO PESTICIDES. **Abdel-Rahman, Fawzia[1, 4], S. Jamadar[2], T. Nguyen[3], K. Anthony[3], and M. A. Saleh[3]**. [1]Department of Biology, [2]Department of Environmental and Interdisciplinary Sciences, [3]Department of Chemistry, Texas Southern University. Houston, Texas 77004. [4]Plant Pathology research Institute, Agricultural Research Center. Egypt.

The free living soil nematode *C. elegans* is uniquely known to have certain fatty acids composition particularly very high level of the polyunsaturated fatty acids, specifically C:20 with 1,2,3,4, and 5 double bonds which exist mostly in the triacylglycerol (triglycerides) and phospholipids. Exposure to mercury (Hg) compounds from environmental and food sources are a significant threat to public health. Organomercuric compounds such as phenyl mercuric acetate (PMA), an herbicide, can cause harmful damage to the nervous system. *C. elegans* studies showed that chronic exposure to mercury compounds induces neuron degeneration likely due to the increase in reactive oxygen species (ROS). The nematode *C. elegans* is a major model organism in environmental toxicology, developmental biology, neurobiology, host pathogen interactions, aging research, and pharmacology. Experimental advantages of the *C. elegans* model include a fast reproductive cycle, a transparent body, known cell lineages, and a fully sequenced genome. Furthermore, its hermaphroditic nature (self-fertilization) allows raising a large number of homozygous animals in short time, and the presence of males allows mutations to be moved between strains. The full developmental cycle of *C. elegans* from eggs to fertile adults takes about 2–3 days at 20 °C, and can be cultured easily and inexpensively in the laboratory. When *C. elegans* were chronically exposed to sub lethal doses of phenyl mercuric acetate for a complete lifecycle, the exposure was resulted in no death, however it quantitatively reduced the triacylglycerols with the polyunsaturated double bonds. These types of polyunsaturated fatty acids are related to neurobehavioral and neurosignaling of the worm. It was evident that the exposed nematodes had a higher level of reactive oxygen species (ROS) relative to the control, which may be related to the reduction of the polyunsaturated triacylglycerols concentration. Triacylglycerols were extracted from freeze-dried nematodes using chloroform and methanol 2:1 (v/v). The crude lipid extracts were purified using thin layer chromatography to select only the neutral triacylglycerols. The qualitative and quantitative chemical analysis of triacylglycerols composition was determined using high-resolution accurate mass Liquid Chromatography/Mass Spectrometry Quadruple Time of Flight Agilent System (LCMSQTOF), using Masshunter B07 software for data interpretation. The destruction of the polyunsaturated triacylglycerols was recovered and restored when the Selenium was included in a bioassay, and revealed the ability of Selenium to counteract the effects of PMA induced lipid profiling of *C. elegans*. The results were replicated three times.

THE ROLE OF NICOTINAMIDE ADENINE NUCLEOTIDE (NAD) IN TOMATO RESISTANCE AGAINST ROOT-KNOT NEMATODE. ***Abdelsamad, Noor* [1], H. Regmi[1, 2], J. Desaeger[2], and P. DiGennaro[1]**. [1]Department of Entomology and Nematology, College of Agriculture and Animal Science, University of Florida, Gainesville, USA. [2]Gulf Coast Research and Education Center, University of Florida, Wimauma, USA.

Root-knot nematodes (RKN; *Meloidogyne* spp.) are among the most damaging pests to tomato production in the United States and worldwide, with damage ranging from 25-100% yield loss. Host resistance conferred by the *Mi* gene in tomato is effective against some species of RKN (e.g. *M. incognita*, *M. javanica* and *M. arenaria*); however, there are virulent species and lines including. M. *hapla* and *M. eterolobii* that break *Mi*-mediated resistance. Triggering innate plant immunity using chemical elicitors is a proven strategy to combat plant pathogens and we believe this method may augment or supplement *Mi*-resistance in tomato against virulent RKN infection. Nicotinamide adenine dinucleotide (NAD) is one such chemical elicitor that regulates plant defense responses to different biotic stresses. In this study, we investigated the role of NAD in the context of induced tomato innate immunity and RKN pathogenicity in two tomato cultivars; VFN and Rutgers, with and without *Mi*, respectively. Single soil drench application of NAD 24 hours before nematode inoculation significantly induced defense response pathways, reduced infective-juveniles penetration, and increased plant mass in both cultivars. Importantly, we observed no direct toxic effects of NAD on nematode viability and infectivity. The results presented here suggest that NAD induces resistance against RKN pathogenicity in presence or absence of tomato *Mi* gene, likely through accumulation of tomato basal defense responses rather than direct effect on the infective-juveniles behavior.

ENHANCING THE BIOLOGICAL CONTROL POTENTIAL OF ENTOMOPATHOGENIC NEMATODES: PROTECTION FOM DESICCATION. **Acar, Ismet, and B. Sipes.** Department of Plant and Environmental Protection Sciences, University of Hawaii, Honolulu, HI 96822.

Entomopathogenic nematodes (EPNs) are obligate parasites of insects. EPNs have a broad host range, are easily mass reared, and kill insects within 48 hours. EPNs are safe for vertebrates, plants, and nontarget organism. On the other hand, EPNs have disadvantages that make them less effective against foliar insect pest. EPNs are sensitive to desiccation, ultraviolet (UV) radiation and high temperatures. Our goal is to improve the efficacy of aboveground application EPNs by protecting them against desiccation and UV radiation. Barricade is a proprietary fire-protection product that prevents desiccation. One thousand IJ of *Steinernema feltiae* were exposed to Barricade gel at 0, 0.5, 1, 2 and 3% aqueous concentrations for 8 hours and evaluated for mortality. All EPNs were alive, infected, and killed all mealworms within 48 hours after of exposure to the different Barricade solutions. In the next experiment, 1000 IJ of *S. feltiae* were placed in 0, 0.5, 1, 2, or 3% Barricade solutions and exposed to sunlight for 1, 2, 3, 4, 5 and 6 hours. A similar experiment was conducted in a dark incubator at 25°C. At each hour, moving EPN were counted, and all EPN inoculated onto mealworms. Barricade gel protected the EPNs for up to 4 hours in direct sun. Number of live EPNs gradually decreased from 85% at 1 hour to 35% after 4 hours and to 22% after 6 hours exposure. EPNs that survived desiccation killed inoculated mealworm within 48 hours. Barricade gel at 1% and 2% provided greater protection ($P < .001$) in the controlled incubator than in direct sunlight. Protection lasted up to 6 hours in the incubator. Barricade gel at 1% afforded better protection for EPNs ($P < .001$) exposed to direct sun compared to other Barricade concentrations. EPNs viability can be enhanced with Barricade.

EFFECTS OF COVER CROPS ON TWO *HETERODERA GLYCINES* POPULATIONS FROM TWO FIELDS OF NORTH DAKOTA. **Acharya, Krishna and G. P. Yan.** North Dakota State University Department of Plant Pathology, Fargo, ND 58108.

Effects of cover crops on soybean cyst nematode (SCN; *Heterodera glycines*) host range and population reduction were evaluated under greenhouse and microplot conditions. To evaluate the host range, twenty-one cover crops/cultivars and two susceptible soybeans (Barnes and Sheyenne) were planted in small 'cone-tainers', each containing about 100 cm^3 of soil naturally infested with each of two SCN populations (HG type 0 and 7) and kept in a growth chamber at 27° C for 35 days. After 35 days, white females were extracted from roots and soil of individual plants and counted under microscope to estimate female index (FI = average number of SCN females on each crop/ average number of SCN females in susceptible check Barnes, x100). Out of the twenty-one crops, SCN populations did not reproduce (FI = 0) on 13 crops suggesting non-hosts. However, the SCN reproduced on eight crop species and cultivars; Austrian winter pea, crimson clover, forage pea, field peas (Aragorn and Cooper), hairy vetch, and turnips (Pointer and Purple Top) with FIs of less than 10, suggesting them as poor-hosts for at least one of the SCN populations. The hosting abilities of those crops were further confirmed by artificial inoculation using the two SCN populations. The results showed similar responses for SCN reproduction except for turnip (Pointer) and field pea (Aragorn), with at least one of the SCN populations having FIs slightly greater than 10. To evaluate the ability of population reduction, ten cover crops including annual ryegrass, Austrian winter pea, carinata, faba bean, foxtail millet (Dixie), radish (Daikon), red clover (Allington), sweet clover, turnip (Pointer), and winter rye (Dylan) were evaluated further in microplot experiments in the years of 2016 and 2017. Crops were planted in early August and grown in large plastic pots; each containing 5 kg of SCN infested soil from each field under natural conditions. The experimental design was Randomized Complete Block Design with five replications for each treatment. After 75 days of growth in the external environments, soil samples were collected from each pot, nematode were extracted, and SCN eggs were counted to determine the Reproductive Factor (RF: final/initial SCN egg number). The nematode population reduction by each crop was also determined as a percentage of density reduction (PR = (Initial - final density)/ initial density, x 100%) of SCN by each crop. All tested cover crops except Austrian winter pea had significantly ($P < 0.0001$) lower RF for SCN populations (RF: 0.33 to 0.56) compared to the controls, non-planted control and susceptible soybean (Barnes) (RF: 0.92 to 2.43) in both years. The population reductions of SCN by the cover crops ranged from 44 to 67%. Annual ryegrass and radish consistently reduced more SCN numbers than others with an average PR of 65 and 67%, respectively, for both years. The results suggested that most cover crops reduced the SCN populations in controlled microplot conditions, and can be used for managing SCN as well as understanding the mechanisms of SCN population reductions by cover crops.

PHOSPHORUS DRIVES THE EVOLUTION OF NEMATODE LIFE HISTORY TRAITS AND GENOME ARCHITECTURE. **Adams, Byron J.[1,2], X. Xue[1], B. Adhikari[3], Breana Simmons[4], B. Ball[5], J. Barrett[6], A. Perkes[7], M. Martin[8] and D. H. Wall[9].** [1]Department of Biology and Evolutionary Ecology Laboratories, Brigham Young University, Provo, UT 84602. [2]Monte L. Bean Life Sciences Museum, Brigham Young University, Provo, UT 84602. [3]USDA-APHIS, Beltsville, MD 20705. [4]Department of Math and Science, East Georgia State College, Swainsboro, GA 30401. [5]Global Institute of Sustainability, Arizona State University, Tempe, AZ 85281. [6]Department of Biological Sciences, Virginia Tech University, Blacksburg, VA 24061. [7]Department of Biology, University of Pennsylvania, Philadelphia, PA. [8]Arizona College of Osteopathic Medicine, Midwestern University, Glendale, AZ, USA. [9]Department of Biology and Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO, USA.

Organismal growth and development relies on gene transcription and protein synthesis, requiring vast amounts of phosphorus (P) that is primarily sequestered in the sugar-phosphate backbone of ribosomal RNA. Thus, the availability of elemental phosphorus is one of the most limiting factors to organismal growth and development. We hypothesized that nematode populations evolve adaptive responses to phosphorus limitation that are associated with life history traits and that these adaptations are reflected in their genome architecture. Comparing populations of the same species (*Scottnema lindsayae, Plectus murrayi)* from nearby P-rich and P-poor soil ecosystems, we found that compared to populations in P-rich environments, nematodes in P-poor environments have 1) less somatic P, 2) larger body size at maturity, 3) lower rates of gene expression, and 4) fewer copies of rDNA in their genome. Experimental evolution assays conducted in the laboratory revealed that after as few as 30 or as many as 120 generations *Caenorhabditis elegans and P. murrayi* growing in P-poor media evolved 1) slower growth rates, 2) delayed reproduction, 3) longer reproductive cycles, 4) larger body size, 5) decreased rates of transcription, and 6) decreased rRNA gene copy number. We suggest that rapid loss of rRNA gene copies from the genome is a plastic adaptive solution for regulating the sequestration of environmental phosphorus into RNA for efficient growth and development in environments that are highly phosphorus limited. These findings have important implications on the evolution of organismal life history traits and ultimately the development of trophic complexity in terrestrial ecosystems.

LOG-TRANSFORMING COUNT DATA GIVES YOU THE WORST OF BOTH WORLDS: WRONG SAMPLE MEAN AND WRONG VARIANCE ESTIMATES. **Alake, Gideon[1], I. A. Zasada[2], P. DiGennero[1], and E. van Santen[3].** [1]Entomology and Nematology Department, University of Florida, PO Box 110620, Gainesville, FL 32611. [2]U.S. Department of Agriculture - Agricultural Research Service, Horticultural Crops Research Laboratory, 3420 NW Orchard Avenue, Corvallis, OR 97330. [3]Statistical Consulting Unit, Institute of Food and Agricultural Sciences, University of Florida, PO Box 110500, Gainesville, FL 326011.

Biological and ecological studies often produce non-normal count data that do not satisfy the assumptions to which parametric data analyses such as the analysis of variance (ANOVA) could be applied. For decades, square root and logarithmic transformation methods have been the recommended frameworks to 'normalize' count data and make them amenable to parametric statistical tests. While log-scale data transformation [log(count+constant)] is a common practice among biologists and ecologists, there is, however, no practical justification given for its persistent use. There has been a shift, in recent years, towards embracing model-based method such as the generalized linear models (GLM) or generalized linear mixed models (GLMMs) in the analysis of count data. By contrast, the GLM/GLMM-based analysis approach to count data estimates fixed and random effects parameters on the Poisson/negative binomial scale, which are the probability distributions that led to the data. In this study, we (1) reanalyzed nematode count data from a publication of the second author and (2) conducted a simulation experiment to investigate the performances of the different techniques of analyzing count data. The simulation followed the outline given in Stroup 'Generalized Linear Mixed Models: Modern Concepts, Methods and Applications', using two treatment groups. Our simulated count data – 1000 repetitions – were generated through a Poisson random number generator without and with random effects. Data were analyzed with a normal, lognormal, Poisson or negative binomial distribution function in SAS PROC GLIMMIX (SAS/STAT 14.1), calculating both least square means and the variance of a mean; for a Poisson-distributed data the variance must be equal the mean. As expected the mean and variance of the 1000 repetition, analyzed using the Poisson distribution functions, were very close to the simulated value. If the same data were analyzed using a normal distribution function the estimated mean was close to the simulated value, but the mean estimate of variance was much smaller. Allowing each treatment group to have its own variance resulted in variance estimates that were closer to the mean, but still smaller than the true value. Back-transforming the estimates derived from an analysis using the log-normal distribution function resulted in mean estimates much lower than the simulated values. Treatment variances were derived using the delta rule. Treatment variances thus derived were an order of a magnitude smaller than the true value; for a Poisson random variable the treatment variance must equal the treatment mean. The consequence would be an overly optimistic assessment of treatment differences.

GROUP BEHAVIOR AND THE ROLE OF SEMIOCHEMICALS IN NTOMOPATHOGENIC NEMATODE HOST LOCATION. **Alborn Hans T.** USDA ARS Center for Medical Agricultural and veterinary Entomology, Gainesville FL 32608.

It is well established that herbivore-induced plant volatiles (HIPVs) released from wounded leaves attract natural enemies of herbivores. Utilization of this plant response has become a fundamental part of above ground IPM programs. Similarly, roots can release HIPVs that beneficial organisms such as entomopathogenic nematodes (EPN) can utilize to find their host insects. Despite similarities, below ground interactions are more complicated than above ground interactions since volatile organic compounds (VOCs) typically are more abundant below ground. Moreover, below ground VOC can also be produced or modified by microorganisms, humidity and soil particles which can result in rearrangement of HIPVs to new compounds or affect their dispersal. Thus, to understand below ground interactions it is fundamentally important to work with intact systems. We report progress on low impact in vivo (green house or field), in-soil sampling of VOCs, that when combined with thermal desorption GC/MS analyses makes it possible to monitor changes in the composition and diffusion rates of VOCs. Despite being primitive organisms with limited number of neurons EPNs cope well with the complexity of below ground VOC and demonstrate a remarkable capacity for behavioral plasticity and intra- as well as inter-species semiochemical communication. We show how HIPVs, in combination with aggregation and trail pheromones makes mass infection of host insects possible and discuss the ramifications for such behavioral plasticity in the context of belowground multitrophic interactions. Finally, we demonstrate how these new analytical techniques and the newly discovered EPN learning and group behaviors can be utilized to improve the use of EPNs in IPM programs to enhance biological control of insect pests.

IDENTIFICATION OF THE BACTERIAL SYMBIONT FROM ENTOMOPATHOGENIC NEMATODE (*OSCHEIUS*) AND ITS BIOLOGICAL CONTROL POTENTIAL. **Alhussaini, Abdulrahman, Sipes, B, Wang, K.-H, Cheng, Z.** Plant and Environmental Protection Sciences Dept., University of Hawaii. Honolulu, HI 96822.

Entomopathogenic nematodes (EPN) are associated with mutualistic bacteria that infect and kill the host insect. *Oscheius* belongs to the Rhabditidae and has characteristics that associated with EPNs. The objectives of this research were to identify the symbiotic bacteria from *Oscheius* isolates from Hawaii and determine bacterial pathogenicity on mealworm (*Tenebrio molitor*) larvae. Bacteria were isolated from *Oscheius* isolates BI 1a-2, BI 12a-5, OJ 4a-5, OJ 5b-1 and compared with that of *Steinernema feltiae* MG14. Either nematodes, or nematode infected mealworm larvae were cut or crushed and gut contents or hemolymph were streaked on TZC medium. Symbiotic bacteria were identified using PCR. We found that one isolate of *Serratia* sp. and two isolates of *Enterococcus* sp. were associated with *Oscheius* samples from Hawaii. For bacterial pathogenicity assays, mealworm larvae were fed a bacteria-inoculated diet or directly injected with bacteria into the hemolymph. *Oscheius* isolates from Hawaii are an EPN that could be used as biological control agents against insect pests.

PLANT-PARASITIC NEMATODES: RESPONSE TO CHANGING PRECIPITATION REGIMES ACROSS A CLIMATIC GRADIENT. **Ankrom, Katharine, A. L. C. Franco, and D. H. Wall.** Biology Dept., Colorado State University, Fort Collins, CO 80523.

We hypothesized that populations of endoparasitic and ectoparasitic plant feeding nematodes would respond differently to water additions and reductions. Specifically, that ectoparasites populations would increase with added precipitation than endoparasites. Climate models forecast an intensification of the global hydrological cycle. The distribution, structure, composition, and diversity of plant populations and communities will be affected by altered precipitation regimes, having long reaching consequences for ecosystems. Plant response to precipitation changes is of the utmost importance for an ecosystem because varied precipitation can influence a significant plant interaction, herbivory. Belowground plant parasitic nematodes (PPN) directly impact plant productivity and survivorship, indirectly affect rhizosphere interactions, and play an integral role in soil food webs. However, the response of PPN to changes in precipitation are little known, especially in grasslands where maintaining plant productivity for grazing livestock is central to local economies. To test how shifts in precipitation may affect grassland ecosystems, specifically plant interactions with PPN, a large-scale field experiment was set up across three biomes, representing a gradient of precipitation from arid desert to mesic grasslands: Jornada Desert grassland, NM (JRN), Shortgrass steppe, CO (SGS), and Tallgrass prairie, KS (KNZ)s. A manipulative experiment with additions and reductions of precipitation during two consecutive years was used to test PPN responses to changing precipitation patterns via rainout shelter systems. The cross-biome experiment showed an overall trend of the plant parasitic nematode genera diversity increasing along the spatial water-availability gradient, having the greatest number of genera groups (27) in the mesic KNZ site. Although precipitation treatments did not affect the generic composition of PPN communities, differences among dry and wet years in relation to the long-term average were significant at all three sites (npMANOVA Jornada: df = 2, F = 42.4, $r2 = 0.36$, $P = 0.01$; Shortgrass df = 2, F = 20.98, $r2 = 0.21$, $P = 0.01$; Konza: df = 2, F = 23.80 $r2 = 0.23$, $P = 0.01$). When considering the feeding habits of PPN more complex patterns and differences among sites emerge; at the SGS and KNZ grassland sites ectoparasite relative abundance had a positive correlation with increasing precipitation. Differences in year affected total abundance of PPN: in 2016 the average number of ectoparasites was 597 ± 424, 908 ± 735, and 1334 ± 846 for JRN, SGS, and KNZ respectively. In 2017 these same sites increased with 372 ± 114, 2478 ± 2054, and 2930 ± 1368 ectoparasites. Annual differences at each site had a stronger effect than rainfall manipulations on nematode populations. The divergent changes in PPN feeding habit types in response to inter-annual variation in precipitation across a regional biome gradient provides some insights into the possible response of plants to herbivory to varied precipitation with climate change.

PLANT-PARASITIC NEMATODES ON SUGARBEET IN NORTH DAKOTA AND MINNESOTA. **Ashmit K. C., G. P. Yan, K. Acharya, R. Baidoo, and A. Plaisance.** North Dakota State University, Department of Plant Pathology, Fargo, ND 58108.

Plant-parasitic nematodes (PPN) are among the economically important pests that reduce the yield of sugarbeet worldwide. To determine the incidence, abundance and distribution of plant-parasitic nematodes on sugarbeet, a survey was conducted in the Red River Valley area of North Dakota (ND) and Minnesota (MN). In 2016 and 2017, a total of 217 soil samples were collected from fields with sugarbeet or a history of sugarbeet production. In addition, 48 samples were collected from tare soils in sugarbeet piling stations in ND and MN in 2016, and two samples from sugarbeet fields in Montana (MT) in 2017. Soil samples were collected randomly using a zig-zag pattern across each field. Seventy-two and 65% of the fields surveyed were positive for PPN in 2016 and 2017, respectively. The incidence and average population density of major genera of PPN identified from sugarbeet fields were *Heterodera* (incidence = 11–18%; average population density = 1609/200 g of soil), *Helicotylenchus* (24–53%; 167/200 g of soil), *Tylenchorhynchus* (35–40%; 159/200 g of soil), *Paratylenchus* (24–32%; 114/200 g of soil), *Pratylenchus* (4–10%; 40/200 g of soil), *Paratrichodorus* (5–10%; 38/200 g of soil) and *Xiphinema* (1–5%; 34/200 g of soil). *Criconemella* (1%; 23/200 g of soil) and *Hoplolaimus* (1%; 20/200 g of soil) were not detected in 2016, while they were detected at low densities in 2017. Four group of plant-parasitic nematodes such as *Helicotylenchus, Paratylenchus, Xiphinema* and *Heterodera* were identified at very low densities from tare soils in sugarbeet piling stations in 2016. Plant-parasitic nematodes *Heterodera, Helicotylenchus* and *Tylenchorhynchus* seemed to be more dominant and abundant during two-year sampling periods. Published species-specific PCR assays were used for species identification. Amplification and sequencing of the ribosomal rDNA gene were used to confirm the species identities. The cyst nematodes out of 24 samples from ND and MN were identified to be *Heterodera glycines* whereas the cyst nematodes from MT were *H. schachtii*. From our surveyed locations in Red River valley of ND and MN, we haven't identified any *H. schachtii* so far. Other nematode species identified include *Paratrichodorus allius*, *Pratylenchus neglectus*, and *Helicotylenchus pseudorobustus*. Among species identified, *P. allius* and *H. schachtii* can be a concern for sugarbeet production, as these nematodes have been reported to cause yield loss in major sugarbeet growing areas in the world. Accurate identification of these nematodes and their distribution across the region will help determine effective pest management strategies for improved sugarbeet production.

COMPARASION OF THE PREDATORY ACTIVITY OF DIFFERENT NEMATODE-TRAPPING FUNGI AGAIST NEMATODE SPECIES. **Bae, Chang-Hwan[1], D. G. Kim[2], N. S. Park[2] and H. I. Kang[2].** [1]Bioresource Utilization Dept., National Institute of Biological Institutes, Incheon, Korea. [2]College of Natural Resources and Life Science, Pusan National University, Miryang, Korea.

Nematode trapping fungi develop trap and consume nematodes are an important part of the subsoil ecosystem and they share a special predator-prey relationship. Four nematode-trapping species, *Arthrobotrys oligospora*, *A. brochopaga*, *A. sinensis*, and *Monacrosporium thaumasium*, were collected from soils in Korea. and tested their predacity against five different nematode species in three feeding groups, *Pratylenchus penetrans* (plant-parasitic), *Aphelenchus avenae* (fungivorous), *Panagrolaimus rigidus, Poikilolaimus oxycerca, Acrobeloides* sp. (bacterivorous). Results showed that nematophagous fungi successfully formed adhesive traps and captured nematodes in the group of *P. penetrans*, *P. rigidus,* and *P. oxycerca* in 12 days. But didn't induce trapping structure against *A. avenae* and *Acrobeloides* sp. both belongs to c-p group 2. Number of *A. avenae* increased during the test period. The results of this study indicated that predacity of nematophagous fungi was variable among nematode species.

MOLECULAR APPROACHES FOR DIRECT DETECTION AND QUANTIFICATION OF SOYBEAN CYST NEMATODE, *HETERODERA GLYCINES* IN SOIL AND SIMULTANEOUS IDENTIFICATION OF CLOSELY RELATED *HETERODERA* SPECIES. **Baidoo, Richard and G. P. Yan.** North Dakota State University, Department of Plant Pathology, Fargo, ND 58108.

The soybean cyst nematode (SCN), *Heterodera glycines*, continues to threaten soybean production world-wide. Identifying and counting SCN by cysts, eggs or juveniles under microscope are a tedious task due to morphological similarities in species such as *H. schachtii*, *H. trifolii*, *H. ciceri*, and *H. avenae*. False positive or negative reports and over or under-estimation of numbers may occur especially where mixed populations of these species exist. Quantitative real-time PCR (qPCR) assays using SYBR Green I were developed to specifically detect and quantify SCN directly in DNA extracts of field soils, and to differentiate SCN from other *Heterodera* spp. DNA sequences of a putative parasitism gene, *CLAVATA3* were used to design SCN-specific qPCR primers which showed high specificity to SCN with a single amplicon in melt curve analysis. The specificity of the assay was evaluated using 30 isolates of SCN and 30 other nematode species. A standard curve relating threshold cycle and log values of nematode number was generated ($y = -3.566x + 29.73$; E = 90%; $R^2 = 0.99$) by inoculating SCN eggs or juveniles (1, 4, 16, 64, and 256) into 0.25 g sterilized soil from which soil DNA was extracted using the DNeasy® PowerSoil® Kit and amplified with SCN-primers. The sensitivity of the assay was evaluated and it could detect up to 1 SCN egg added to 20 g of soil, equivalent to 10 eggs in 200 g of soil. The assay was used to estimate SCN in artificially and naturally infested soils. Approximately, 400 g of soil samples from each of 32 fields naturally infested with SCN at varying population densities were divided in half for qPCR quantification, and traditional egg extraction and microscopic enumeration. There was a linear relationship between both methods of quantification in either artificially infested soils ($y = 1.39x – 2.43$; $R^2 = 0.99$) and naturally infested soils ($y = 1.2x + 246$; $R^2 = 0.91$). The identities of SCN in the field soils were confirmed by randomly sequencing two genomic regions of 15 populations. SCN detection and quantification efficiencies from soil were highest in sandy loam, followed by sandy clay loam and clay loam, and were significantly improved by grinding the field soil prior to DNA extraction. High detection specificity and sensitivity of the assay ensure that only SCN DNA are detected and quantified at even low densities (≥10 SCN eggs/200 g soil), essential for developing effective integrated pest control measures. A second qPCR assay was developed which simultaneously identified both SCN and sugar beet cyst nematode (SBCN) based on melt curve analysis. These assays will be useful for identification and quantification of SCN directly from soil, and to differentiate SCN from SBCN. Utility of these assays does not require expertise in nematode morphology, and the time-consuming steps involved in microscopic identification and quantification are obviated.

SURVIVAL AND REPRODUCTION OF BENIN ISOLATES OF ENTOMOPATHOGENIC NEMATODES UNDER VARIOUS TEMPERATURE, DESICCATION, AND HYPOXIA CONDITIONS. **Hugues Baimey, A. Fanou, L. Zadji, R. Elegbede, R. Kotchofa.** University of Parakou, Benin. BP 123, Route de l'Okpara.

Entomopathogenic nematodes (EPNs) are effective biocontrol agents of agricultural insect pests, especially when the infective juveniles of the nematodes (IJs) are tolerant to environmental stresses. The tolerance to heat (at 40°C for 2, 4, 6 or 8 h), to desiccation (in 50% v/v glycerol solution incubated at 25°C and 75-85% RH for 6, 8, 10 or 12 h) and to hypoxia (in Eppendorf tubes closed and kept in 25°C for 24 or 72 h) of 30 Benin isolates of EPNs was evaluated under laboratory conditions. In another study, five isolates of EPNs were used to inoculate third instar larvae of the greater wax moth, *Galleria mellonella* and larvae of the sweet potato weevil, *Cylas puncticollis* with 20 nematodes each under laboratory conditions. The larvae of both insects were checked for infection 72h post inoculation (PI) and then kept at 15°C or 30±2°C for eight weeks during which nematode survival inside the insects, nematode reproduction and dehydration of insect larvae were evaluated at weekly basis. The survival of IJs at 40°C, after desiccation and hypoxia treatments differed significantly among nematode isolates and exposure times. General responses of survival of IJs (Y) as function of exposition time (X) for heat, desiccation and hypoxia were expressed, respectively, as: $Y = 80.121–0.5235\ 9\ X$, $Y = 102.18–8.702\ 9\ X$ and $Y = 107.69 - 0.6571\ 9\ X$. In the second study, 72h post inoculation, mortality of larvae varied between 98.99% and 100.00% for *G. mellonella* and 92.22% and 98.99% for *C. puncticollis* according to nematode isolates. Nematode survival inside the tested insects decreased from 99.47% and 98.68%, respectively at 15°C and ambient temperature 10 days PI to 5.42% and 0.00%, respectively at 15°C and ambient temperature according to nematode isolate. Nematode reproduction rate inside insect cadavers varied with nematode isolate and insect host, increased during the first and second weeks of storage (maximum of 302,667 and 223,083 IJ/cadaver at 15°C and at ambient temperature, respectively) and decreased thereafter to 0 IJ/cadaver during the 8th week. Percentage weight loss of insect cadavers varied with nematode isolates from 14.51% to 88.15% at 15°C and from 18.73% to 85.61% at ambient temperature. These studies, though conducted under controlled conditions, provided baseline data that can be useful in selecting Benin EPN isolates for insect pest control.

THE RESURGENCE OF SPODOPTERA FRUGIPERDA IN MAIZE FIELDS IN NORTHERN BENIN: TOWARDS THE DEVELOPMENT OF A CONTROL INTEGRATING ENTOMOPATHOGENIC NEMATODES. **Hugues Baimey, L. Zadji, A. Fanou, R. Kotchofa, R. Dossou Agbèdè, H. Tella, A. M. Alia.** University of Parakou, Benin. BP 123, Route de l'Okpara.

Since 2016, maize (*Zea mays*) production in Africa has been affected by the resurgence of the fall armyworm, *Spodoptera frugiperda*. The incidence and damage severity of the pest in maize fields and also the efficacy of three entomopathogenic nematodes (one isolate of *Heterorhabditis sonorensis* = Ze4, one of *Steinernema* sp. = Bembereke and one of an un-identified species = Korobororou) to control its larvae under field and laboratory conditions were evaluated in the municipality of Djougou in northern Benin. The incidence of damage caused by the pest in maize fields was 87.00% and damage severity varied between 26.0% and 50.0%. The population density of the insect larvae observed on each infected plant varied between 1 and 15. The larvae were observed inside the tassel (91.0%), inside the ears (85.7%), on the leaves (43.0%) and on the stems (3.0%) of inspected plants. Under laboratory conditions, all three nematode isolates applied at the rate of 1000 infective juveniles/insect larva in 25 ml-plastic dishes containing each 13 ml sterilized soil were able to kill 100% of the insects. However, the percentages of nematodes penetrating each insect larva were 3.00% for the Korobororou isolate, 9.41% for Bembereke and 15.70% for Ze4. Data collected in the fields following application of the nematodes (10000 infective juveniles/plant) in the tassels, showed insect mortality ranging between 24.12% (Bembereke) and 47.35% (Ze4). The results of this study are promising and need to be confirmed in other agro-ecological zones of Benin for the development of *S. frugiperda* control methods integrating the use of entomopathogenic nematodes.

DIFFERENTIAL EXPRESSION ANALYSIS SUGGEST THE ROLE OF SALICYLIC ACID IN RESISTANCE MECHANISM AGAINST COLUMBIA ROOT-KNOT NEMATODE IN POTATO. **Bali, Sapinder[1], V. Kelly[2], G. Cynthia[3], M. Hassan[4], C. R. Brown[4], V. Sathuvalli[1, 5].** [1]Hermiston Agricultural Research and Extension Center, Oregon State University, Hermiston, OR 97838. [2]Dept. of Horticulture, Oregon State University, Corvallis, OR 97330. [3]Dept. of Plant Pathology, Washington State University, Pullman, WA 99164. [4]United States Department of Agriculture, Prosser, WA 99350. [5]Dept. of Crop and Soil Science, Oregon State University, Corvallis, Oregon 97331.

Columbia root-knot nematode (CRKN; *Meloidogyne chitwoodi*) is a microscopic, soil borne pest of potato prevalent in the Pacific Northwest region of the United States. It infects both potato roots and tubers. Nematode infected tubers develop both external as well as internal defects, thus reducing the market value of the crop. Germplasm screening identified race specific resistance to CRKN from wild, diploid potato species, *Solanum bulbocastanum*. This resistance was introgressed into a tetraploid potato clone, PA99N82-4 using protoplast fusion and subsequent back crossing. Histological evaluations in CRKN resistant PA99N82-4 and CRKN susceptible 'Russet Burbank' revealed that the nematode can successfully enter both resistant as well as susceptible plant but PA99N82-4 inhibits the feeding site formation. Comparative transcriptomic study revealed that the resistance response is triggered by R-gene(s) leading to Salicylic Acid mediated hypersensitive response. In addition, polyamines like, spermine and spermidine may play a critical role in the defense response mechanism, which warrants further validation.

A COOPERATIVE EXTENSION SPECIALIST IN NEMATOLOGY: A CALIFORNIA PERSPECTIVE. **Becker, J. Ole.** Department of Nematology, University of California, Riverside, CA 92521.

California's agriculture is vast with respect to its value and diverse in the number of crops, many of which grow almost exclusively in the Golden State. More than 400 commodities are produced, most of them classified as specialty crops. Those are defined as fruits, tree nuts, dried fruits, vegetables, horticulture crops and nursery plants, including floriculture. More than a third of the US's vegetables and two-thirds of the fruits and nuts derive from California's 76,500 farms. Their exports make California the world's 5th largest food supplier. Plant-parasitic nematodes are major production constraints that reduce attainable yields in CA by an estimated 5-8%. Regulatory restrictions, increasing application cost, and public perception have challenged the past reliance on soil fumigants and nematicides. Coincidentally, current University of California Cooperative Extension (CE) Nematology positions are quite different compared to those of our predecessors. Agriculture-relevant research has been directed toward integrated pest management with emphasis on more environmentally benign tactics. A significant change occurred with split appointments of CE Specialists that demanded not only effective outreach but successful scholarship as well. As most professorial (I&R) faculty shirked away from applied agricultural research, solutions for current and near-future nematode-caused problems primarily became the tasks of CE/OR Specialists. Increasing research costs along with stagnating commodity support and declining state and federal funding required CE Specialists to develop a competitive research program, competent grantsmanship as well as seeking alternative revenue sources. The multitude, diversity, and value of the state's crops and the wide-spread nematode problems provide California's CE Nematologists with many research and outreach opportunities as well as significant challenges.

THE DAUER JUVENILE AND LIFE HISTORY OBSERVATIONS OF *DISTOLABRELLUS VEECHI*, A FACULTATIVE INSECT-PARASITIC NEMATODE. **Bernard, Ernest C., Satyendra K. Pothula, Gary Phillips.** University of Tennessee, 2505 E. J. Chapman Drive, 370 Plant Biotechnology Building, Knoxville, TN 37996-4560 USA.

Distolabrellus veechi (Rhabditida: Mesorhabditidae), described in 1982 from Texas specimens, is now known from scattered localities around the world. Some experimental evidence exists that it is a facultative entomopathogen. During a nematode community study, distinctive dauer juveniles were collected from both agricultural and forest soils. Dauers (n = 30) placed on NGM agar with *E. coli* OP-50 developed into adults of *D. veechi*, constituting the first observation of dauers of this nematode. These dauers are distinctive in having three prominent oral pseudolabia, appearing under a stereo microscope as a dark knob. Females of this population are obligately amphimictic. Dauers typically develop in older cultures, and were easily spotted due to their uniform dark intestine interrupted only by the lighter genital primordium. In dense cultures, all stages migrate readily to the lid of the Petri dish, where they become congregated in water droplets. In isolation, mated females, identified by the presence of a copulatory plug, usually produced only female offspring. Unmated females in all-female cultures were larger than normal, lethargic and packed with oocytes; they never laid eggs. Introduction of a male to a mature unmated female usually resulted in mating and the production of many eggs (53–109) within the next 18 hours. Males may only be able to mate once, as virgin females paired with already mated males did not produce eggs. A single observed mating lasted five minutes. Of 14 individual females that produced eggs, males developed from eggs of only three of them, with female:male ratios of 40:1, 9:7 and 3:2. The proportion of males in this lab culture has progressively declined over the year, suggesting a narrow genetic base in the founder population.

WRKYS TRANSCRIPTION FACTORS REGULATING *SOLANUM LYCOPERSICUM* RESPONSE TO ROOT KNOT NEMATODES: TRANSCRIPTOMIC AND METABOLOMICS INSIGHTS. **Chinnapandi Bharathiraja[1], Patricia Bucki[1], Natalia Foitoussi[1,2], Michael Kolomiets[3], Eli Borrego[3], and Braun Miyara Sigal[1].** [1]Agricultural Research Organization (ARO), the Volcani Center, Bet Dagan, 50250, Israel. [2]Faculty of Agriculture Food & Environment, the Hebrew University of Jerusalem, Rehovot, 76100, Israel. [3]Texas A&M University, TAMU 2132, College Station, 77843-2132, U.S.A.

WRKY web of plant defense regulators is implicated in transcriptional reprogramming during plant immune responses. In this study the fluctuation of tomato's WRKYs during infection by the root knot nematode *Meloidogyne javanica* was analyzed, where several upregulated WRKYs genes, among them *SlWRKY3*, *SlWRKY35, SlWRKY45* and *SlWRKY72* were studied in-depth in the context of spatial and temporal expression upon nematode infection, responsive to phytohormone to wounding treatments and functional analysis. Promoter GUS analysis of these *WRKYs* genes indicate on their involvement during RKN infection with differential expression among the studied WRKYs along feeding site formation, maturation and galls development. Histological analysis of nematode-feeding sites indicated that expression of each studied *WRKY* TF is associated with feeding site development and formation. Studying the response of *SlWRKYs* promoter to several phytohormones illustrated, that while *SlWRKY45* is highly induced by specific phytohormones, including cytokinin (*N*[6]*-Benzyladenine*, BAP), auxin (Indole-3 acetic acid, IAA and Indole-3-butyric acid, IBA) and the defense signaling molecules salicylic acid (SA), both *SlWRKY3* and *SlWRKY35* are induced only by SA and IBA. To determine the biological function of *WRKY3* and *WRKY45*, overexpressing tomato lines were generated. Infection tests illustrate that significantly, in roots over expressing *SlWRKY45* substantially increased number of females was measured, indicating *WRKY45* overexpression support a faster nematode development. On the other hand, overexpressing *SlWRKY3* resulted in lower infection of the RKN *M. javanica,* indicating its function as defence signaling regulator. Hormone and oxylipins profile conducted by LC-MS analysis have shown that enhanced resistance observed in tomato roots overexpressing *SlWRKY3* is coupled with increased accumulation of defence molecules parts of the shikimate and oxylipins pathways. Altogether, this comprehensive study subject SlWRKYs as a potential transcription factor which its manipulation by the invading nematode might be critical for coordination of hormone signals genes generating favour condition for nematode development in root tissue.

WERE NEMATODE-INDUCED FEEDING SITES PRECURSORS OF NITROGEN-FIXING NODULES? **David Bird.** Department of Entomology and Plant Pathology, & the Bioinformatics Research Center, NC State University, Raleigh NC, 27608, USA.

Nematoda is an ancient phylum. Diversification into the current major clades occurred more than 500 million years ago (Mya), and parasitic forms likely appeared as new host niches became available. Nematode-plant associations observed in the fossil record have been dated to 420 Mya, which coincides with the evolution of roots. In contrast, the ability of plants to host rhizobial bacteria in an environment conducive to high efficiency nitrogen fixation (HiNiFix) was surprisingly late to evolve (about 60 Mya). Why does acquisition of a trait so eminently useful as HiNiFix occur so infrequently? The literature broadly champions two models of the invention of HiNiFix: 1) Conversion of rhizobial pathogens to N_2-fixing mutualists in partnership with legumes, by the rhizobia acquiring the ability to avoid host defenses. 2) Evolution of the necessary biochemical pathways, particularly the crucial nitrogenase. Both are probably correct, but neither model addresses the 360 million year time lag for plants to host gall-forming nematodes to the time they host nodule-forming rhizobia. Here I propose a third route. I present a hypothesis that in its simplest form proposes that HiNiFix was invented in a tritrophic interaction. More specifically I propose that the interacting organisms included a gall-forming, plant-parasitic nematode, a bacterium with some nitrogen fixation capacity, and of course, a vascular plant host. By its nature, this model is speculative. But nothing that does not occur in extant biological systems is required or proposed, including multi-trophic symbioses.

RELATIONSHIP BETWEEN POTATO EARLY-DIE AND SOIL HEALTH USING THERMAL IMAGERY. **Bird, George[1], B. Basso[2] and R. Price[2].** [1]Dept. of Entomology, [2]Dept. of Earth and Environmental Sciences. Michigan State University, East Lansing, Michigan, 48824.

Potato early-die (PED) is a key infectious disease caused by the interaction of *Pratylenchus penetrans* and *Verticillium dahliae*, resulting in tuber yield losses of 20-50%. Multi-year (2014-2017), field-scale, research was used to determine the relationship between 14 soil health indicators and tuber yield in two adjacent 50 acre fields with known histories of PED. The Defender field was managed as a conventional potato-corn rotation with metam applied before the 2015 potato crop and a proprietary biological nematicide applied prior to the 2017 potato crop. The Challenger field was divided in half and managed as a potato-cover crop rotation with pearl millet from different sources planted in the east and west halves in 2014, a seven-cultivar cover crop blend planted in the west half in 2016 and a four-cultivar blend in the east half in 2016. Fourteen soil indicators were used. These included the Cornell University Soil Health System, nematode community structure and thermo-stability. In 2017, nine high-resolution UAV and airborne thermal images of the fields and their associated thermo-stability maps were developed using the spatial-temporal changes between planting and harvest. The field maps were partitioned into four zones depending on their behavior in regards to canopy temperature (unstable, cold-stable, medium-stable, and hot- stable). Thirty-two geo-referenced points (12 for the Defender and 10 for the Challenger-W and 10 for the Challenger-E) were used for permanent location reference points for the non-aerial soil health indicators and tuber harvest digs. The 2015 Defender tuber yields were significantly greater than those of the Challenger. Marketable tuber yields in 2017 were 422, 300 and 462 cwt per acre for the Defender, Challenger-W and Challenger-E, respectively. The field with the highest tuber yield (Challenger-E) had the highest mid-season soil aggregate stability, protein index, active carbon (ppm), organic matter and overall Cornell soil health score. The sites with the highest tuber yields were associated with cold-stable thermo-stability; whereas, those with lower tuber yields were associated with unstable or hotter thermo-stability sites. High population densities of Dorylaimidae spp. were associated with low tuber yields. This is believed to be the first report of the use of thermo-stability as a soil health indicator and Dorylaimoid nematodes associated with low potato tuber yields.

MELOIDOGYNE JAVANICA INFECTING HOPS (HUMULUS LUPULUS) IN FLORIDA, USA: A STUDY CASE. **Brito, Janete Andrade,[1] S. A. Subbotin,[2] J. Desaeger,[3] F. Achinelly,[4] and S. Qiu[1].** [1]Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL 32614-7100. [2]Plant Pest Diagnostics Center, California Department of Food and Agriculture, 3294 Meadowview Road, Sacramento, CA 95832-1448. [3]Entomology and Nematology Department, University of Florida, Gulf Coast Research and Education Center, Wimauma, FL 33598. [4]Conicet, University of La Plata, La Plata, Argentina, 1900.

Humulus lupulus (Cannabaceae), commonly referred to as hops, are perennial, herbaceous climbing plants, native to temperate northern climates. Because of the high demand for hops from the micro-brewing industry in the Tampa-St. Petersburg area, it has recently been introduced in Florida. In October 2016, several hop plants that exhibited yellowing leaves and stunted growth were uprooted and showed severe root galling. Soil samples were collected for nematode extraction and showed high numbers of root-knot nematode second-stage juveniles (J2) (up to 1500 J2/ 200 cm^3 soil). Root samples were sent to the Florida Department of Agriculture and Consumer Services, Division of Plant Industry Nematology Laboratory in Gainesville, FL. Species identification was performed using both morphological and molecular analyses. Configuration of the perineal patterns, morphometrics of selected characters of second-stage juveniles, including body, stylet and tail length, and the esterase phenotype (EST=J3), which is species-specific and malate phenotype (MDH=N1), were consistent with those reported in the original description of *M. javanica*. For molecular analyses, DNA was extracted from individual females and mitochondrial DNA was amplified with MORF (5' - ATCGGGGTTTAATAATGG G - 3') and MTHIS (5' - AAATTC AATTGAAATTAATAG C - 3') primer set. A fragment of approximately 740 bp was produced, which has been reported for *M. incognita* and *M. javanica* found in Florida. To further confirm the nematode species identification, we used the species-specific SCAR primer set Fjav (5'- GGTGCGCGATTG AACTGAGC - 3') and Rjav (5' - CAGGCCCTTCAGTGGAACTATAC - 3'). This primer set yield a fragment of approximately 670 bp, which is identical to that previously reported for *M. javanica*. Additionally, NADH dehydrogenase subunit 5 gene was amplified using NAD5F2 (5'-TAT TTTTTGTTTGAGATATATTAG - 3') and NAD5R1 (5'- CGTGAATCTTGATTTTCCATTTTT-3') primer set. The obtained nad5 gene sequence (GenBank accession No. MH230176) was identical to the reference sequence of *M. javanica*.

EVIDENCE THAT PHORETIC BACTERIA REGULATE ENTOMOPATHOGENIC NEMATODES IN NATURE. **Campos-Herrera, Raquel[1], R. J. Stuart[2], F. E. El-Borai[3], and L. W. Duncan[3]**. [1]Instituto de Ciencias de la Vid y del Vino (CSIC, Universidad de La Rioja, Gobierno de La Rioja), Finca La Grajera, Carretera de Burgos km 6, 26007 Logroño, Spain. [2]Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Dundee FL 33838, USA. [3]Citrus Research and Education Center, University of Florida, 700 Experiment Station Road, FL 33850, USA.

A non-pathogenic *Paenibacillus* sp. in Florida produces endospores which adhere specifically to the cuticle of the entomopathogenic nematode (EPN) *Steinernema diaprepesi*. The bacterium reproduces inside the nematode-infected insect cadaver without apparent affect on nematode fecundity or development. However, spore encumbered EPN do not move through soil to infect insects as readily as do spore-free individuals. To study the question of whether these bacteria regulate EPNs in nature, we monitored the abundance of naturally occurring *S. diaprepesi* and *Paenibacillus* sp., along with that of other fungal, bacterial and nematode natural enemies of *S. diaprepesi* during two years in four Florida citrus orchards. Nematodes were extracted from two soil depths at ~ monthly intervals, DNA extracted, and target organisms were measured using qPCR. Potential regulation of the nematode by the bacterium was assessed in multiple ways. *Paenibacillus* sp. exhibited significant phase-space (predator-prey) dynamics at two of three sites with abundant *S. diaprepesi*. The initial abundance of both *S. diaprepesi* (positive effect) and *Paenibacillus* sp. (negative effect) explained significant variation in population changes of *S. diaprepesi* in a multiple regression model at a lag of three months. Soil pH in these surveys was directly related to the infestation rate (encumbrance) by *Paenibacillus* sp. and inversely related to the abundance of *S. diaprepesi*. Complementary laboratory experiments showed that pH is directly related to adherence of the bacterial endospores to the *S. diaprepesi* cuticle. These results suggest that soil pH management can be used by growers to conserve the demonstrated services of *S. diaprepesi*.

A NEW LITYLENCHUS SPECIES (ANGUINATA) FROM BEECH (FAGUS GRANDIFOLIA, F. SILVATICA) LEAVES IN OHIO. **Carta, Lynn K.[1], Z. A. Handoo[1], D. J. Chitwood[1], G. Bauchan[2], and C. K. Gabriel[3].** [1]Mycology and Nematology Genetic Diversity and Biology Laboratory, USDA, ARS, NEA, Beltsville, MD 20705. [2]Soybean Genomics and Improvement Laboratory, USDA-ARS, Electron Microscopy and Confocal Microscopy Unit, Beltsville, Maryland 20705. [3]Ohio Department of Agriculture, Reynoldsburg, OH 43068.

Large numbers of nematode females and a few males were extracted from leaves of American beech (*Fagus grandifolia*) and European beech (*Fagus silvatica*) in Perry, Ohio during the fall of 2017 and sent for identification to the Mycology and Nematology Genetic Diversity and Biology Laboratory, USDA, Beltsville, MD. Symptoms on the beech leaves included interveinal darkening, and puckered, crinkled, thickened leaves, which is distinct from the chlorotic symptoms caused by *Litylenchus coprosma* on *Coprosma repens* (Rubiaceae) leaves in New Zealand. Attempts to reproduce symptoms with the nematode are underway in other laboratories. Unlike *L. coprosma* this species lacks semi-obese females, males have a subterminal rather than terminal bursa, and both sexes have a shorter stylet and 6 vs. 4 incisures in the elevated lateral field. The females have a more slender, conical tail with pointed, often mucronate extension, more anterior vulva, and longer post uterine sac. Clustal W marker sequence alignments compared to *Litylenchus coprosma* showed 91.6% similarity for ITS 1,2 rDNA, 95% similarity for 28SrDNA, and 99.4% for 18S rDNA. A 699 nucleotide sequence for the COI marker was also generated. Low Temperature SEM images of nematodes showed extensive body undulations, an unusually soft and malleable cuticle, puckering of the vulval lips and lateral depression on either side of the vulval opening.

ASSISTING SMALLHOLDER FARMERS IN ADOPTING INTEGRATED NEMATODE-SOIL HEALTH MANAGEMENT: I - FUZZY COGNITIVE MAPPING TO UNDERSTAND GROWER PERCEPTIONS. **Chan, C.[1], P. LaPorte[1], J. Chan-Dentoni[1], B. S. Sipes[1], A. Sanchez[2], A. Sacbaja[2], and H. Melakeberhan[3].** [1]University of Hawaii (UH) at Manoa, Honolulu, HI 96822 USA. [2]Faculty of Agronomy, University of San Carlos (USAC), Guatemala City, Guatemala. [3]Dept. of Horticulture, Michigan State University (MSU), East Lansing, MI 48824 USA.

Alleviating the intertwined and grand challenges of food and nutritional insecurities have been a major focus of the USAID's Horticulture Innovation Laboratory. Plant-parasitic nematodes (PPN) and poor soil health negatively affect potato yield of smallholder farmers in the Highlands of Guatemala. These farmers have limited knowledge of the cause-and-effect relationships between agricultural practices, soil health, nematodes, and potato yield. In order to enhance the adoption of best practices to overcome the challenges we need to understand farmer's perceptions of the multifaceted relationships. An interdisciplinary team from UH (social science), MSU (soil health) and USAC (agronomy and soil science) conducted ground-truthing in 2017 and initiated experiments in the Xela and Huehuetenango regions of Guatemala. The field experiments will provide the science-based evidence needed for making recommendations to farmers, however, conventional wisdom tells us the adoption rate will be low. In order to understand the thought process of farmers and farmer perceptions on 'best' practices, we used a fuzzy cognitive mapping approach to mental model how farmers view these practices on potato productivity changes prior to demonstrating the results of the field experiments. Using a structured mental model protocol, we interviewed 45 potato farmers belonging to the Cooperativa Paquixeña in Paquix, representing over 10% of the members. We evaluated the farmers' perceptions on the relationships between various agronomic practices on PPN, soil health, potato yield, and the likelihood of the farmer adopting the practices. The smallholder farmers' mental maps showed they perceive the use of biocontrol, nematicides and compost to negatively impact PPN while the use of certified seeds, chicken litter and fertilizer positively impact PPN. The results of more weights given to the perceptions of agronomic practices toward soil health are indicative of better understanding of these practices on soil health than understanding of the impact on PPN. If reducing yield loss to PPN is the goal of the project, evidence-based training on the 'best' practices is needed by these smallholder farmers. The community mental model shows farmers are willing to adopt agronomic practices if farmers are provided training on 'how to' and if farmers actually visit demonstration plots.

APPLICATION OF PRINCIPAL COMPONENT ANALYSIS IN ECOLOGICAL NEMATOLOGY RESEARCH: A HANDS-ON DEMONSTRATION. **Cheng, Zhiqiang.** Department of Plant and Environmental Protection Sciences, CTAHR, University of Hawaii at Manoa, 3050 Maile Way, Honolulu HI 96822.

Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. It is a type of multivariate analysis that is widely used in ecology studies. PCA has seen progressively more applications in ecological nematology research in recent years. This hands-on demonstration workshop will provide a brief review on how to run PCA, how to generate PCA graphs, and how to interpret statistical outputs and summarize results. I will use nematode data from my previous studies in this demonstration workshop. Minitab 18 will be used to run the PCA. Participants are encouraged to bring their own computer and install Minitab 18 prior to the workshop. If participants do not have a subscription to Minitab 18, a 30-day free trial is available at www.minitab.com.

A DECADE OF NEMATODE ASSAY DATA TO INFORM EXTENSION EFFORTS. **Colantonio, Vincent, G. Alake, W. T. Crow, and P. DiGennaro.** Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.

Identifying the pests that affect agricultural fields is a vital first step to developing effective pest management strategies. Regional nematode assay laboratories are valued extension resources utilized by growers to determine which nematode pests are present in their systems. Here we present visual analyses of samples sent in to the Florida Nematode Assay Lab and their respective diagnoses over the course of a decade. From 2006 to 2015, growers and researchers sent in 26,894 samples from 34 states, with 71% of samples coming from Florida. The samples originated from Commercial (58%), Public (16%), Residential (23%), and University (3%) accounts. The top five genera of nematodes found were *Mesocriconema* (80%), *Hoplolaimus* (54%), *Helicotylenchus* (51%), *Belonolaimus* (50%), and *Meloidogyne* (43%). Within Florida, the majority of samples came from golf courses ~59% (15,782), which is understandable as the economic impact of golf courses in Florida is one of the highest in the nation. Furthermore, we found a correlation between the estimated economic impact of golf courses in Florida and the number of samples sent in from golf courses by county. These data can help inform extension efforts by presenting areas where the economic impact of a crop is high, yet sampling may be relatively low. Overall, by making aggregate nematode sampling data accessible, we will address under-sampled areas to help better serve growers and inform management decisions.

EVALUATING SOIL AMENDMENTS AND BIOCONTROL AGENTS FOR SUPPRESSION OF POTATO EARLY DIE COMPLEX IN MICHIGAN **Emilie Cole, K. Poley, J. Shoemaker, and M. Quintanilla.** Michigan State University, Department of Entomology, 288 Farm Lane, Rm 26, East Lansing, MI 48823.

Potato early die complex is caused by the plant pathogen *Verticillium dahliae* in conjunction with the plant parasitic nematode *Pratylenchus penetrans*. When infected with these pathogens, potatoes (*Solanum tuberosum*) exhibit symptoms such as severe wilting, leaf necrosis, and up to 50% reduced yields. Management has historically included soil fumigation, but this tactic is costly and detrimental to soil, human and environmental health. Finding alternatives to soil fumigants could provide Michigan growers with a cost-effective and sustainable solution to this disease complex. In this study, our objective was to first evaluate commercially available non-fumigant soil additives such as nematicides, manures, and composts in their ability to reduce *V. dahliae* and *P. penetrans* populations in a field setting. Our second objective was to understand the nematicidal properties of five composts as well as the biocontrol potential of two fungi in a laboratory setting. In the field trial, nine treatments were assessed in a randomized complete block design during the 2017 field season. Treatments included: control, Nimitz, BioA-Formula, Movento, Mocap, Velum Prime, chicken manure, cattle manure-based compost and a poultry/cattle manure-based compost with wood ash. We found that nematode populations were significantly lower in plots treated with the poultry/cattle manure compost with wood ash and Nimitz. Moreover, *V. dahliae* populations were the lowest amongst the chicken manure, Mocap, and control treatments. No significant differences in yield were observed between treatments. To determine the direct effect of compost on *P. penetrans*, five composts and a control were evaluated. Treatments included: cattle manure compost, poultry manure compost, vermicompost, cattle/poultry compost blend with wood ash, cattle manure compost with spelt hulls, and a coco coir/sand blend as the control. Petri dish arenas were set up, each with either autoclaved or not autoclaved media for a total of 12 treatments with 5 replicates. Each petri dish was inoculated with approximately 50 *P. penetrans* nematodes, incubated in a growth chamber for 4 weeks, and then processed to determine nematode mortality. The two fungi evaluated were *Paecilomyces lilacinus* and *Beauveria bassiana*. Each fungus was individually inoculated on five plates of water agar; five non-inoculated plates served as a control. Fugal experiments were set up in the same way as the compost experiments. Dishes were observed 2, 6, 18, 24, 48 and 72 hours after inoculation. From these experiments, we expect to determine whether compost provides control of *P. penetrans* as well as determine if *P. lilacinus* and *B. bassiana* are effective biocontrol agents against *P. penetrans*. From this research, we can provide insightful management suggestions to growers and potentially reduce fumigant use. Further research should be done, however, to understand interactions between the *P. penetrans* and treatments.

TWO BIOLOGICAL APPROACHES FOR MANAGEMENT OF PLANT PARASITIC NEMATODES. **Abdelfattah A. Dababat[1*], S. Ashrafi[1,3], G. Erginbas-Orakci[1], H-J. Braun[2], W. Maier[3], and R. A. Sikora[4].** [1]International Maize and Wheat Improvement Center (CIMMYT), Ankara, Turkey. [2]International Maize and Wheat Improvement Center (CIMMYT), Mexico. [3]Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Institute for Epidemiology and Pathogen Diagnostics, Braunschweig, Germany. [4]Consultant Int. Agr. Plant Health Management, Professor Emeritus, University of Bonn, Germany.

There are many different types of antagonists in the soil that naturally regulate nematode densities. An important group are the fungi and bacteria that colonize healthy plant tissue without causing disease and that are known as mutualistic endophytes. There are two types: obligate endophytes which require a host plant for survival and facultative endophytes which can also survive saprotrophically on organic matter. Biological control of plant parasitic nematodes has been defined as a reduction in nematode population density which is accomplished through the action of living organisms other than nematode resistant host plants. It occurs naturally, through the manipulation of the environment or following the introduction of antagonists. Biological control is mediated through mechanisms such as: predation, competition, antibiosis and parasitism. Our study using the mutualistic endophyte *F. oxysporum* showed additional modes of action e.g. repellency and induced systemic resistance. A study aiming at the isolation of fungi associated with *Heterodera filipjevi* at experimental wheat fields of CIMMYT in Turkey resulted in the identification of three new nematode egg-parasitic fungal species, *Polyphilus sieberi*, *Ijuhya vitellina* and *Monocillium gamsii*. *Polyphilus sieberi* is a helotialean dark septate endophyte (DSE) inhabiting different plant species and is the first DSE reported to colonize nematode eggs. *In vitro* studies showed that the fungus colonized cysts and eggs while developing moniliform hyphal cells resembling structures formed in colonized plant root cells. *Ijuhya vitellina* and *M. gamsii* colonized nematode eggs by formation of microsclerotia and they are currently being studied for their endophytic interactions with their plant hosts. Endophytic fungi probably have the greatest potential for effective nematode control because they are found in the endorhiza of all major crops. By targeting the endorhiza as the site for endophyte application with either seed or seedling treatment, efficacy is improved in the pathozone and overall costs to the farmer are reduced. The need for biological control is important, because: 1) many effective synthetic nematicides have been removed from the market, 2) crop rotation has become less attractive to growers for economic reasons, 3) resistant varieties are not available for many important crops and 4) resistence often breaks down due to newly emerging virulent nematode pathotypes. Biological control should be seen as a part of the overall nematode management program and not as a stand-alone solution.

GLOBODERA ALLIANCE (GLOBAL): RISK ASSESSMENT AND ERADICATION OF *GLOBODERA* SPP. IN U.S. PRODUCTION OF POTATO. **Dandurand, Louise-Marie[1], Glen Bryan[2], Vivian Block[2], Walter De Jong[3], Dee Denver[4], Pam Hutchinson[1], John Jones[2], Joe Kuhl[1], Christopher McIntosh[1], Benjamin Mimee[5], Rich Novy[6], Mike Thornton[1], Xiaohong Wang[6], Jonathan Whitworth[6], and Inga Zasada[6]**. [1]University of Idaho, Moscow, ID 83844. [2]James Hutton Institute, Dundee, Scotland. [3]Cornell University, Ithaca, NY 14853. [4]Oregon State University, Corvallis, OR 97331. [5]Agriculture and Agri-Food Canada, Saint-Jean-Sur-Richelieu, Quebec, Canada. [6]USDA ARS, various locations.

A transdisciplinary team of researchers including nematologists, plant breeders, extension specialists, and economists are working together to tackle the ongoing threat of *Globodera* spp. to U.S. potato production. This collaborative effort is known as GLOBAL (GLOBodera ALliance). The objective of this research will yield a model management approach to protect the U.S. potato industry from current and future introductions of these nematode pests, and will improve U.S. agriculture, food security, and stakeholders' economic interests, knowledge base, and participation in decision-making. Ongoing research is directed towards 1) Development and implementation of effective early warning tools for *Globodera*, including improved detection and diagnosis methods, 2) Use of genomic approaches to characterize pathogen virulence and host resistance for development of resistant cultivars, and for detection and identification of effector genes and broader genetic variability in *Globodera* across its geographic range, 3) Identification and deployment of potato germplasm conferring resistance to three species of *Globodera* in economically viable potato varieties, 4) Coordination with stakeholders and policymakers to co-develop science-based agricultural approaches to deal with the threat of *Globodera* and implement sustainable, environmentally sound agricultural practices for potato production in the context of *Globodera* risk management, and 5) Increased number of scientists, extension specialists, and educators with the skills and knowledge to effectively address the problem of invasive agricultural pests.

MANAGEMENT OF MELOIDOGYNE INCOGNITA WITH RESISTANT GENOTYPES IN A SWEET SORGHUM - SUGAR BEET - COTTON ROTATION. **Davis, Richard F.**, **K. Harris-Shultz**, **and J. Knoll**. USDA-ARS, P.O. Box 748, Tifton, GA 31793.

A crop rotation experiment was conducted in Tifton, GA to evaluate the effectiveness of resistant genotypes of sweet sorghum, sugar beet (SB), and cotton for suppression of *Meloidogyne incognita* when those crops were grown in that order. Sorghum treatments were a nematode-susceptible and a resistant genotype; sugar beet and cotton treatments were a resistant genotype, a susceptible genotype, and the susceptible genotype plus fumigant nematicide. Sorghum was planted in June 2016, and nematode levels were barely detectable at planting. At harvest (August 2016), nematode levels were greater under the susceptible than the resistant genotype. SB was planted (October 2016) in a 3×2 factorial arrangement of treatments (3 SB treatments and the 2 previous sorghum treatments). SB galling was greater following susceptible sorghum. Fumigation decreased galling in susceptible SB, but the lowest galling was on resistant SB. The previous sorghum treatment had less effect on galling on resistant SB than on susceptible SB regardless of fumigation (a sorghum × SB interaction). Nematode samples from SB at harvest in May 2017 were consistent with the levels of galling observed. Fumigation of susceptible SB increased sugar content (°Brix), but the previous sorghum treatment had no effect. Cotton was planted in early June 2017 in a 3×3×2 factorial arrangement of treatments (3 cotton treatments, the 3 previous SB treatments, and the 2 previous sorghum treatments). Neither the previous sorghum treatment nor SB treatment affected cotton root galling at harvest. Susceptible cotton had the greatest galling, susceptible cotton with fumigation was intermediate, and resistant cotton had the least. Nematode samples at harvest were generally consistent with observed levels of galling on cotton, although previous sorghum treatment, which did not affect galling, may have affected nematode counts ($P = 0.0601$). Cotton yield following resistant SB was greater than following susceptible SB regardless of fumigation, and fumigated susceptible cotton had the greatest yield. In general, fumigation and resistance were both effective in reducing galling and final nematode levels for each crop and significantly contributed to reducing galling and nematode levels in the subsequent crop. Although the effects of fumigation and resistance in sorghum were apparent in the SB crop, they were not apparent in the cotton crop.

A JOURNEY INTO THE LITTLE KNOWN WORMS. **Decraemer, Wilfrida.** Nematology Research Unit, Biology Dept., Ghent University, Ledeganckstraat 35, B9000 Ghent, Belgium.

Biological diversity is unevenly distributed globally varying from diversity hotspots to low diversity cold spots. Also the interest of taxonomists in animal taxa is diverse and unequally divided over the animal phyla or within a phylum over the different taxa. The main interest lies on parasitic taxa as is also reflected in the history of Nematology. Later, the focus widened to the beneficial aspects of nematodes such as the application of entomopathogenic nematodes as biocontrol agents of pest insects, the use of free-living nematode as indicators for environmental quality of soils and aquatic ecosystems or the study of nematodes as model organisms to understand human diseases. In general the applied aspects of nematology research receive more attention. Even among the plant-parasitic infraorder Tylenchomorpha, where the family Tylenchidae with representatives that feed mostly on fungi, algae, mosses and root surfaces, appears less attractive. The same applies for free-living species in general and more in particular those that are considered less informative or are rare. Free-living marine nematodes represent the most diverse and abundant animal group of the meiofauna, however, they still remain under-studied and poorly sampled in several habitats. Recent counting of the free-living marine nematode taxa (family/genera/species) based on Nemys (Bezerra et al., 2018), revealed that over a period of 50 years, only about a thousand new species descriptions have been added to the 4500 species known in the 1970s. Nematode taxonomy encountered many shortcomings and pitfalls on the interpretation of its unit, the species, also due to its originally morphology-based descriptive approach and the time-consuming aspect. Nowadays, molecular techniques and analyses based on different genes and mass collection of information continuously help to complete information on relationships and strengthened nematode systematics. However, only 30% of the known genera and 3% of the marine species described are represented in GenBank. This means that the reference database is insufficient to assign all OTUs to species/genus level; family level appears the best option (Holovachov *et al*., 2017). We will focus here on the Desmoscolecida, a peculiar group of mainly marine nematodes. They represent only a fraction (0.5–2%) of littoral and sublittoral nematofauna but in deep-sea their relative abundance is twice as high (about 4%). Together with the families Epsilonematidae and Draconematidae, the genus *Desmoscolex* is characteristic for deep-sea corals. At present about 25% of the more than 250 species described are from deep-sea (>200m depth). Some reflection will be included on how we can extend the diversity catalogue, what is the importance and how can we provide additional support.

QUANTIFYING SOIL SURFACE FEATURES FOR NEMATODE ECOLOGY WITH S.T.I.P.S.I.: SURFACE TOPOGRAPHY IMAGING BY POINT SOURCE ILLUMINATION. **De Ley, Paul.** Department of Nematology, University of California, Riverside CA 92521.

Too little is known about the factors driving nematode community composition in arid soils. Although Darby & Neher pioneered work on correlations of nematode faunas belowground with maturity of Biological Soil Crusts (BSCs) on the soil surface, most published studies focus only on subsurface soil properties and precipitation parameters among abiotic factors, along with vascular vegetation structure among biotic factors. BSCs contribute carbon and nitrogen fixation to dryland ecosystems, but their relevance to nutrient cycling is unclear, and we know nothing about belowground nutrient flows via their algal and fungal grazers (such as nematodes). In order to investigate the potential associations between nematodes and soil surface features including BSCs, methods must incorporate techniques of geomorphology with microbial metagenomics as well as accurate characterization of BSC types. One of the key parameters of interest for these studies is surface microtopology. Existing tools can quantify small-scale topology of soil surfaces, if they are highly portable and low cost then they lack millimeter-scale precision or analytical versatility, while others are mathematically powerful and highly precise but expensive and unsuitable for remote deployment or highly uneven ground. We are developing and testing a single-image photography method that aims to combine high precision, portability and adaptability, with moderate cost and open-source design of key software and hardware. The essential equipment consists of a four-legged camera stand assembled with 3D printed parts and covered with lightproof fabric, lit underneath by a powerful single-LED point source at 45 degree angle. Using optical principles derived from work with projected shadows by photography pioneers such as André Kertész, the stand provides standardized illumination and color balance regardless of weather, solar angle or time of day/night. Using attachments such as a horizontal crossbar, a linear shadow is cast onto the surface, generating projected light/shadow boundaries whose undulations closely match vertical dimensions of the intersected microtopology. The method avoids physical contact with the analysed surface, while allowing measurement of well-established microtopology parameters such as crossover length and random roughness. The angled point-source lighting also causes smaller shadows to be cast by adjacent gravel particles, thalli or leaf/stem microtopology within patches of soil biocrusts, as well as smaller or larger fissures in the surface soil material - again with dimensions corresponding to those of the height or depth of each illuminated surface feature. The resulting images allow digital data extraction for calculation of surface properties usually measured by 3D digitization, including more complex indices such as soil surface roughness, Moreno's shadow index, semivariograms and fractal methods. At this stage we are primarily focusing on generating a diverse set of example images from different environments, and on developing digital analysis algorithms for quantifying the shadow boundary microtopology of the horizontal crossbar's intersections. Longer-term developments will include algorithms for the more sophisticated parameters, adjustments to permit use of spherical distortion optics as typically found in cellphone cameras, as well as standardized photo documentation of surface microfeatures with homogeneously shadow-free illumination.

NEMATODES PARASITIZING HOPS IN FLORIDA. **Desaeger, Johan[1], Deng, Zhanao[2], Agehara, Shinsuke[3].** [1]Department of Entomology and Nematology, [2]Dept. of Environmental Horticulture, [3]Dept. of Horticultural Sciences, University of Florida, Gulf Coast Research and Education Center, Wimauma, FL 33598.

The rapid growth of Florida's craft beer industry has prompted a new research project at the University of Florida's Gulf Coast Research and Education Center (GCREC) to verify the feasibility of introducing and establishing commercial hop (*Humulus lupulus*) operations in Florida. This new industry would have the potential to provide new and high profitable markets for Florida growers. However, many challenges make the establishment of this industry difficult. They include limited knowledge of cultivars suitable to Florida's climatic conditions, and lack of information on potential pests and diseases that will affect adversely this crop in Florida. Greenhouse and field trials were conducted at the GCREC. A newly established hop yard provided with commercial trellis was used also for a multi-year evaluation experiment, which included the evaluation of ten to fourteen different hop cultivars for their growth potential and nematode host status. Ten hop cultivars were planted using rhizomes at the GCREC hop yard in spring 2016. By summer several stunted and chlorotic plants were observed, with all of the stunted plants showing a high degree of root galls. High levels of plant-parasitic nematodes were found to be associated with these plants, predominantly root-knot nematodes (*Meloidogyne javanica*), but also lesion (*Pratylenchus* spp.), stubby root (Trichodoridae), spiral (*Helicotylenchus* spp.), ring (*Mesocriconema* sp.) and sting nematodes (*Belonolaimus longicaudatus*) were found. Hop cultivars showed significant differences in their root-knot nematode host status, with Chinook, Fuggle and Centennial all showing the highest gall incidence (> 50% root galls). Magnum, Perle and Nugget showed lowest gall incidence (<20%), and Cascade, which was the best growing cultivar, showed about 28% root galls. Due to the high incidence of nematodes and additional virus problems, the vines were removed late fall, and the field was fumigated in winter to be used for a new multi-year evaluation experiment. The yard was replanted in spring 2017 with tissue-culture plants of 14 different cultivars (half the same, half different from the ones in 2016). The same cultivars that were replanted in the hop yard were also evaluated in a greenhouse pot trial. Pot trial results mostly confirmed data from the first year field trial, with Chinook showing a high degree of root galls (50% of roots). Also Comet, Cashmere and Zeus showed high degree of nematode infection (50% or more root galls). Centennial and Nugget showed about 30% root galls and Cascade, Triple Pearle and Magnum between 10 and

20%. Comet and Cashmere also produced the greatest number of nematode eggs (30-40,000 eggs per plant). Nematode management will be important if hops are to become an economically viable crop in Florida. For this, the right selection of cultivars will be essential. It also remains to be seen if cone yields can be competitive. We will continue to collect nematode data from the hop cultivar trial in the coming years, as well as growth and yield data, to further evaluate nematode host status and growth and productivity of the plants.

USE OF AGRALI (A LOW-CHLORIDE LIQUID FERTILIZER) TO INCREASE PLANT GROWTH AND REDUCE ROTYLENCHULUS RENIFORMIS POPULATION DENSITY ON COTTON. **Dyer, David R. and K. S. Lawrence.** Auburn University, 209 Rouse Life Science Building, Auburn University, AL 36849.

The overall objective of this study was to evaluate the effects of AgraLi on the population density of *Rotylenchulus reniformis* and subsequent effects on cotton yield. AgraLi is a by-product obtained from the process of making the chicken feed additive methionine and has a nutrient analysis of 2-0-13 (N-P-K). Tests included comparisons of the AgraLi with a commonly used fertilizer, nematicide, and fertilizer-nematicide combinations. Tests compared an untreated control, AgraLi, ammonium polyphosphate, fluopyram + imidacloprid (Velum Total), AgraLi + Velum Total, and ammonium polyphosphate + Velum Total. Evaluations were conducted in the greenhouse, microplot, and field settings using PhytoGen 487WRF cotton as a host plant. Greenhouse and field tests found that all treatments which included the nematicide Velum Total significantly ($P \leq 0.1$) reduced the number of *R. reniformis* eggs/g of root when compared to the standard fertilizer, ammonium polyphosphate. Treatments of AgraLi in a field setting reduced *R. reniformis* eggs/g of root by 78% when compared to the untreated control, indicating that the product may have an effect on *R. reniformis* population density. Field testing also indicated that the application of AgraLi + Velum Total resulted in significantly ($P \leq 0.1$) larger plants, measured by plant height and total plant biomass. This combination treatment of AgraLi + Velum Total also increased seed cotton yields over the untreated control and Velum Total alone. When AgraLi and Velum Total were applied in combination, a yield increase of 1,491 kg/ha was observed over the untreated control and a yield increase of 417 kg/ha was observed over Velum Total alone.

TEMPORAL EXPRESSION OF SPORULATION GENES IN *PASTEURIA* SPECIES **Dyrdahl-Young, Ruhiyyih[1], W. Hu [1], R. Giblin-Davis [1], L. Duncan [1], T. Mengistu[2], P. DiGennaro. [1]** [1]Department of Entomology and Nematology, University of Florida, Gainesville, FL, 32611, [2]National Institute of Food and Agriculture, Washington, DC, 20024.

Pasteuria spp., are obligate endoparasitic, spore-forming bacteria, some of which are antagonistic to phytoparasitic nematodes. Current methods of tracking the life cycle of different *Pasteuria* species rely on microscopic observations of its developmental stages. These observations are highly subjective, but suggest that *Pasteuria* follows the same highly conserved stages of sporulation as the model endospore-forming bacterium, *Bacillus subtilis*. A few homologs involved in the sporulation of *B. subtilis*, have been previously identified in *Pasteuria penetrans*. The current study examines the expression of these sporulation genes using qPCR in *P. penetrans* and *P. nishizawae* throughout their life cycles *in planta* with their respective nematode hosts, *Meloidogyne arenaria* and *Heterodera glycines*. To compare the temporal variation in the expression of the sporulation genes (*Spo0A, Spo0F, SpoIIAB*) and sigma factors (σE and σG), infested plant roots were sequentially harvested throughout the 30-day life cycles of *M. arenaria* and *H. glycines*, on *Vigna unguiculata* and *Glycines max*, respectively. Microscopic observations and pictures of vegetative structures and developing endospores were taken at five-day intervals for *P. penetrans* and seven-day intervals for *P. nishizawae*. Copy numbers of the sporulation genes and sigma factors were calculated using a standard curve. This approach of tracking gene expression to examine the life cycle of different *Pasteuria* species provides a degree of analytical precision that was lacking in previous attempts. These expression patterns are crucial to comparing the life cycle and virulence of other species and isolates in the genus. The temporal variations in the genes controlling sporulation are critical to understanding the reproduction of *Pasteuria*, and its disruption of the nematode life cycle, key pieces of information for exploring *Pasteuria* for biological control of plant-parasitic nematodes.

DEVELOPMENTAL DYNAMICS OF THE NORTHERN ROOT-KNOT NEMATODE (*MELOIDOGYNE HAPLA)* IN WASHINGTON STATE VINEYARDS. **East, Katherine[1], I. A. Zasada[2], R. P. Schreiner[2], and M. M. Moyer[1].** [1]Department of Horticulture, Irrigated Agriculture Research and Extension Center, Washington State University, Prosser, WA 99350. [2]USDA-ARS, 3420 NW Orchard Ave, Corvallis, OR 97330.

The northern root-knot nematode, *Meloidogyne hapla*, is the most prevalent plant-parasitic nematode found in Washington state winegrape (*Vitis vinifera*) vineyards. Due to the limited information available on the biology of this nematode, current management recommendations in Washington are based on other species of *Meloidogyne* in other grape-growing regions, the timing of which may not be appropriate in this system. The objective of this study was to determine when vulnerable life stages of *M. hapla* are present in Washington vineyards to improve the timing of management intervention. Three winegrape vineyards in Washington were intensively sampled from March 2015 to March 2017 to determine the life cycle of *M. hapla* by measuring the number of second-stage juveniles (J2) in soil, egg densities in roots, and quantity of fine root tips. This information was used to model *M. hapla* J2 development based on soil growing degree days using a base temperature (T_b) of 0°C (GDD_{soil}) and a start date of March 1. One vineyard was sampled over both years and used for model development. The other two vineyards were sampled one year each, one over the March 2015-2016 period and one over the March 2016-2017 period, and were used for model validation. Based on J2 and egg dynamics, *M. hapla* appears to have one generation per year. Juvenile populations initially declined in the spring, reaching their lowest density around 1,800 GDD_{soil} (late June to early August). They subsequently increased over the remaining summer and fall, reaching a maximum density in soil over the winter (October to March), from 4,200-4,800 GDD_{soil}. *Meloidogyne hapla* egg density in roots reached a maximum around 2,800-3,100 GDD_{soil} (T_b 0°C) in late July to early August when root tip density was also highest. Understanding the developmental dynamics of *M. hapla* will allow Washington winegrape growers to better time chemical or cultural management techniques.

A RADISH BIOASSAY AS QUALITY CONTROL MEASURE FOR NEMATODE SUPPRESSIVE POTENTIAL OF BIOGAS DIGESTATE. **Eberlein, Caroline[1*], A. Edalati[2], R. Zhang[2], and A. Westphal[1].** [1]Nematology Dept., University of California, Riverside, Parlier, CA, 93648. [2]Department of Biological and Agricultural Engineering, University of California, Davis, CA, 95616.

Land applications of biogas digestates can combine fertilizer value of recycled organic material with nematode suppression, thereby converting waste into a potentially valuable byproduct. To determine if biogas effluents are consistently efficacious against plant-parasitic nematodes, we standardized a quick, simple, and inexpensive radish bioassay with *Heterodera schachtii*. In factorial design, three different incubation environments, two different growth containers, and two different nematode life stages as inoculum were used. Containers with

50 g dry weight of a sandy loam soil, were inoculated with 500 second-stage juveniles (J2) of *H. schachtii* or with cysts with equivalent hatchable J2. After planting of one seed of radish *Raphanus sativus* per container, drench treatments were applied, and the containers closed with lids. The infested soils were treated with 1 ml drench of water, 1 ml of digestate or 1 ml of abamectin solution at 20 ppm. After 64 DD incubation (4-5 days), roots were washed and stained with acid fuchsin for nematode counting. In three replicated experiments, measuring root penetration by J2 was indicative for the nematode-suppression of the digestate. Cyst inoculation resulted in more marked differences between treatments than J2 inoculation. The digestate suppressed nematodes in all contexts, especially after inoculation with cysts. Results in the different contexts were similar, making this bioassay a useful and reliable quality control tool.

MOLECULAR AND FUNCTIONAL DISSECTION OF THE INSECT IMMUNE RESPONSE AGAINST NEMATODE-BACTERIA COMPLEXES. **Eleftherianos, Ioannis, J. Patrnogic, S. Yadav, E. Kenney, Y. Ozakman, D. Cooper, and C. Heryanto.** Biological Sciences Dept., The George Washington University, Washington, DC 20052.

Despite important advances in the field of insect innate immunity, our understanding of host immune responses to entomopathogenic nematode infections lags behind. Nematodes in the genus *Heterorhabditis* and *Steinernema* maintain mutualistic relationship with the bacteria *Photorhabdus* and *Xenorhabdus*, respectively. Unlike other animals associated with mutualistic bacteria, *Heterorhabditis* and *Steinernema* nematodes are viable in the absence of their associated bacteria. Consequently, each partner of this mutualistic/pathogenic relationship can be separated and studied in isolation and in combination, thus enabling the insect host immune reactions against each player of the interaction to be studied separately or together. Recent work to analyze the interactions between insects and entomopathogenic nematode-bacteria complexes has begun to take advantage of the powerful genetic and genomic tools of the fruit fly *Drosophila*. We have used this tripartite system to understand the molecular and mechanistic basis of insect immune defenses against these nematode parasites and their bacteria. We have generated fundamental information on the immune detection, the transcriptional regulation of signaling pathways in the fly, as well as the number and nature of the effector immune process that *Drosophila* activates in response to entomopathogenic nematode-bacteria complexes. Our findings provide novel insights on insect anti-nematode immune activities that could be considered when devising alternative strategies for the control of noxious insects of agricultural or medical importance.

EFFICACY OF TWO SEED-APPLIED BIOLOGICAL AGENTS FOR SUPPRESSION OF SOUTHERN ROOT-KNOT NEMAOTDE IN SOYBEAN **Travis R. Faske, M. Emerson, and K. Brown.** University of Arkansas, Division of Agriculture, Lonoke Extension Center, Lonoke, AR.

Two biological agents, *Bacillus amyloliquefaciens* (AVEO™ EZ Nematicide) and *Burkholderia rinojensis* (BioST® Nematicide 100) are being marketed as seed-applied nematicides to manage plant-parasitic nematodes in soybean. Though these biological agents were available in the 2018 cropping season, few studies have investigated their efficacy to suppress *Meloidogyne incognita*. These seed-applied biological agents were evaluated separately in one greenhouse and two field experiments. In a greenhouse pot assay, *M. incognita* eggs were used as inoculum at a population of 5.3 eggs/cm^3 soil in a 656 cm^3 Deepot. Numerically, nematode reproduction was lower on *B. amyloliquiefaciens* compared to *Bacillus firmus* (VOTiVO®) and abamectin (Avicta®). In the field, initial population of *M. incognita* was 65 and 47 J2/100 cm^3 soil, while final population were 350 and 700 J2/100 cm^3 soil in experiment one and two, respectively. Southern root-knot nematode susceptible soybean cultivars, Delta Grow DG 4970 was used in experiment one, while Stine 47RF32 was used in experiment two. Ten root systems from each treatment were sampled at 50 days after planting and nematode infection was rated based on the percent of root system galled. In the first experiment, seed treated with *B. amyloliquefaciens* had a similar gall rating to that of the seed treated with *Bacillus firmus* and both had a numerically lower gall rating than abamectin-treated seed and non-nematicide treated control. In the second experiment, root system galling was numerically lower than the first experiment and seed treated with *B. rinojensis* had a numerically more galling than the abamectin-treated seed and non-nematicide treated control. All treatments had a similar gall rating for both experiments with an average yield of 22 bu/A. Final root-knot nematode population densities were severe, which may have masked any yield benefit by these seed-applied biological agents. These seed-applied biologicals provided a similar degree of nematode suppression and yield protection to that of other commercially available seed-applied nematicides.

DYNAMICS OF THE IMPACTS OF *PRATYLENCHUS PENETRANS* ON GISELA® CHERRY ROOTSTOCKS. **Forge, Thomas[1], D. Neilsen[1], G. Neilsen[1], S. Blatt[2].** [1]Agriculture and Agri-Food Canada, 4200 Hwy 97, Summerland, BC V0H 1Z0. [2]Agriculture and Agri-Food Canada, 32 Main Street, Kentville, NS B4N 1J5.

Sweet cherry growers are increasingly using semi-dwarfing rootstocks, including the Gisela® series of rootstocks, when replanting orchards. The root-lesion nematode, *Pratylenchus penetrans*, is an important pest of orchard trees worldwide, but little is known of the susceptibility of these new cherry rootstocks to *P. penetrans*. Two identical field experiments were planted in 2010, one in the Okanagan Valley of British Columbia (BC) and one in the Annapolis Valley of Nova Scotia (NS). Each experiment was a factorial combination of three rootstocks (Gi-3, Gi-5 and Gi-6) x three training systems (tall spindle axe, upright fruiting offshoot, Kym Green bush), with six replicate 4-tree plots of each of the nine combinations, arranged in a randomized complete block design. Both sites were fumigated prior to planting. Beginning in 2013, composite samples of roots and root-zone soil were taken from each plot of the BC experiment in June and August of each year through 2017. The NS site was similarly sampled in October of 2015, 2016 and 2017. Root fragments were picked from each sample and quantified, nematodes were then extracted from soil and fine roots, and *P. penetrans* counted. None of the *P. penetrans* population parameters (nematodes per L soil, nematodes per g fine root, nematodes per L soil including roots) differed consistently among rootstocks or training systems at either site. Tree growth (trunk cross-sectional area, TCSA) data were subjected to Analysis of Covariance with rootstock and training system as categorical factors and *P. penetrans* population densities as covariate. Tree growth (TCSA) was in the order Gi-6>Gi-5>Gi-3 at both sites, as expected. At the BC site there was an inverse relationship between *P. penetrans* population densities and TCSA that differed among rootstocks (rootstock x *P. penetrans* interaction $p = 0.01$). For Gi-3 trees, the inverse relationship between *P. penetrans* population densities and TCSA was significant in all years except 2013; for Gi-5 trees the relationship was not significant in any year; and for Gi-6 trees there was a significant inverse relationship in 2017 only. Overall, the NS site had greater *P. penetrans* population densities and smaller trees than the BC site, and we speculate that inadequate sampling relative to greater variability may have been responsible for the lack of an observed inverse relationship between *P. penetrans* abundance and rootstock growth at the NS site. Our data provide field evidence of the impact of *P. penetrans* on cherry tree growth, and indicate that Gi-3 rootstock is more susceptible than Gi-5 and Gi-6 rootstocks and should be avoided when replanting into *P. penetrans*-infested sites.

CHEMOTAXIS OF PLANT-PARASITIC NEMATODES TO SOYBEAN AMINO ACID ROOT EXUDATES. **Frey, Timothy S., R. B. Kimmelfield and C. G. Taylor.** Department of Plant Pathology, Ohio State University, Ohio Agricultural Research and Development Center, Wooster, OH, 44691.

When plant-parasitic nematode juveniles hatch they must navigate through the complex soil environment in order to find a suitable plant root. Juveniles must accomplish this efficiently because they have limited energy reserves. Previous studies have shown that nematodes employ a chemotactic mechanism to move non-randomly through soil towards plant roots. Because plant-parasitic nematodes get their nitrogen from their hosts in the form of amino acids we investigated whether the amino acid component of root exudates could be a chemotactic signal. We hypothesized that plant-parasitic nematodes would be attracted to root-exuded amino acids and that those amino acids essential to nematode growth (i.e. those that cannot be made by the nematode) would act as the strongest chemotactic signals. We quantified the amino acid portion of soybean root exudates and found that soybean root exudates contain measureable amounts of most amino acids. Using nematode mazes we conducted choice experiments and found that the amino acid component of soybean root exudate is attractive to plant-parasitic nematodes, especially those that can use soybean as a host. We also found that some amino acids are highly attractive to root-knot nematodes while others are repellant. Additionally, root-knot nematodes respond chemotactically to the biologically available L-form and not the D-form stereoisomers of the amino acids. These findings are now being used to develop new ways of nematode control using chemotactic disruption strategies.

SYSTEMIC RESISTANCE TO *MELOIDOGYNE INCOGNITA* CAUSED BY *BACILLUS* SPECIES. **Gattoni, Kaitlin, N. Xiang, B. Lawaju, K. S. Lawrence, and J. W. Kloepper.** 209 Rouse Life Science Building, Auburn University, Auburn, AL., 36849.

Systemic resistance is the process by which a pathogen or non-pathogen can upregulate plant defense responses. Typically, systemic resistance occurs in the form of induced systemic resistance (ISR) or systemic acquired resistance (SAR). ISR can occur when jasmonic acid signaling in a plant is upregulated by introduction of a plant growth promoting rhizobacteria (PGPR). SAR can occur when salicylic acid is upregulated by other pathogenic and nonpathogenic microbes. However, there have been reports that PGPR strains induce salicylic acid signaling instead of jasmonic acid signaling, making it essential for both pathways to be investigated when looking at systemic resistance. The overall purpose of this study was to evaluate the ability five PGPR *Bacillus* strains to cause induced resistance to *Meloidogyne incognita* race 3. The tests performed were an *in vitro* assay with the bacteria and the metabolites, a basic greenhouse pot test, a split-root assay and qRT-PCR examining salicylic and jasmonic acid were utilized. Initial results found that *B. firmus* I-1582 was also the only *Bacillus* sp. to directly affect nematode mortality in vitro. It was also observed that *B. pumilus* GB34, *B. firmus* I-1582 and *B. subtilus* QST713 decreased *M. incognita* eggs similar to the chemical control of Fluopyram in the basic greenhouse test. *Bacillus firmus* I-1582 and *B. subtilus* QST713 can systemically reduce nematode population density systemically in a split root assay. The result of this study will determine whether each *Bacillus* sp. can induce defense against *M. incognita* and thereby help determine the most effective means these strains can be used in a commercial setting.

PHENOTYPIC AND GENOTYPIC EVALUATION OF WILD UPLAND COTTON ACCESSIONS IDENTIFIED IN THE LITERATURE AS RESISTANT TO ROOT-KNOT OR RENIFORM NEMATODE. **Gaudin, Amanda, M. J. Wubben, F. E. Callahan, D. D. Deng, J. C. McCarty, and J. N. Jenkins.** USDA-ARS, Crop Science Research Laboratory, Genetics and Sustainable Agriculture Research Unit, Mississippi State, MS, 39762, USA.

The root-knot nematode (RKN; *Meloidogyne incognita*) and reniform nematode (RN; *Rotylenchulus reniformis*) are important pests affecting Upland cotton production throughout the southeastern United States. Beginning in the early-1970s and continuing to the present day, direct screening of tetraploid and diploid cotton lines has identified many potential sources of nematode resistance that have been reported in the scientific literature. The objectives of the current study were to (i) phenotypically re-evaluate wild accessions previously identified as resistant to either RKN or RN and (ii) determine whether resistance was associated with molecular markers linked to known quantitative trait loci (QTL). In total, (26) putative RKN resistant wild accessions and (18) putative RN resistant wild accessions were evaluated in growth chamber experiments. In all assays, germinated seedlings were planted in Conetainers, inoculated with RKN or RN eggs, and the roots harvested six-weeks post inoculation. Approximately two-weeks after planting, leaf disc samples were taken from all plants for genomic DNA extraction. Nematode egg counts and fresh root weight were recorded and used to calculate eggs/g root and reproductive factor (RF). The susceptible checks M8 and DeltaPine61 (DPL61) were used in all trials. Of the putative RKN-resistant lines, TX-25, TX-28, TX-2076, and TX-26 showed RKN RF values similar to the highly resistant M240 germplasm line that carries the known chromosome 11 and chromosome 14 resistance QTLs. Accessions TX-70, TX-487, TX-27, TX-29, TX-1440, TX-2107, and TX-1174 showed RF values similar to an isoline control that carried only the chromosome 14 resistance QTL. The RF of accessions TX-177, TX-22, TX-247, TX-176, TX-2006, and TX-19 were comparable to an isoline control containing only the chromosome 11 resistance QTL. The following accessions were susceptible to RKN: TX-495, TX-188, TX-1860, TX-2105, TX-2103, TX-2102, and TX-78. Regarding evaluations of RN resistance, accessions TX-1414, TX-1568, and TX-1765 showed RN resistance comparable to the resistant checks MT2468 Ren1 and M713 Ren1. All other accessions were considered RN susceptible compared to the DPL61 control. All accessions evaluated were genotyped with molecular markers linked to known RKN resistance QTLs on chromosome 11 and 14 and with markers linked to known RN resistance QTLs on chromosomes 18 and 21. Our genotypic analysis showed that while most of the accessions likely express already known resistance QTL, a subset of lines, including TX-25 and TX-28, were negative for RKN resistance markers while showing a high level of RKN resistance.

POST CARD FROM ALBUQUERQUE: REVISITING MASSEY'S BOOK, "BIOLOGY AND TAXONOMY OF NEMATODE PARASITES AND ASSOCIATES OF BARK BEETLES IN THE UNITED STATES". **Giblin-Davis, Robin M.[1] and N. Kanzaki[1,2].** [1]Fort Lauderdale Research and Education Center, Department of Entomology and Nematology, University of Florida/IFAS, 3205 College Avenue, Davie, FL 33314-7799 and [2]Kansai Research Center, Forestry and Forest Products Research Institute, 68 Nagaikyutaroh, Momoyama, Fushimi, Kyoto, 612-0855, Japan.

Open almost any page of C. L. Massey's 1974 book, "Biology and taxonomy of nematode parasites and associates of bark beetles in the United States" and you will discover descriptions of diverse nematode phoretics and parasites from the Aphelenchoididae, Bunonematidae, Cephalobidae, Diplogastridae, Panogrolaimidae, Plectidae, Rhabditidae, and Tylenchidae listed with their bark beetle associate(s) and type location. Many of these nematodes were isolated from bark beetles collected from the Cibola National Forest in the Sandia Mountains overlooking Albuquerque, New Mexico, where Dr. Massey died in 1984, and the 57th annual meeting of the Society of Nematologists is being held in 2018. We have re-examined and re-described many of Massey's *Acrostichus* and *Bursaphelenchus* species using his type material to help inform the classification of other insect-associated members of these clades. However, we have not yet modernized the descriptions by re-isolating, culturing (where possible), and sequencing the many nematodes that he described. One aspect that is well-informed by modern molecular phylogenetic approaches not available to Massey involves the pervasive issue of convergence in nematode morphology and the presence of cryptic species that are often linked to different, but closely related, or sympatric species of insect hosts. Modern sequencing methods also allow the discovery of trophic polyphenism, and the assignment of unusual adult morphs and non-descript developmental stages (dauers) to the correct species epithet. We will discuss this updated starting point for viewing Massey's impressive early roadmap for elucidating the amazing diversity, biology and ecology of nematode associates of radiating assemblages of insects such as bark beetles, and a variety of other beetles, bees, and fig wasps.

PLANT PARASITIC NEMATODES ASSOCIATED WITH GRAPEVINES, *VITIS VINIFERA*, IN NEW MEXICO. **Giese, Gill[1], J. M. Beacham[2], S. Thomas[2], C. Sutherland[1], T. O. Powers[3], and L. Roberts[4]**. [1]Department of Extension Plant Sciences, P.O. Box 30003, MSC 3AE, New Mexico State University, Las Cruces, NM 88003. [2]Department of Entomology, Plant Pathology and Weed Science, P.O. 30003 MSC 3BE, New Mexico State University, Las Cruces, NM 88003. [3]Department of Plant Pathology, 406 Plant Science, University of Nebraska-Lincoln, Lincoln NE 68583. [4]Demand Forecasting Department, Amazon Inc., 7 West 34th Street New York, NY 10001.

High populations of *Meloidogyne incognita* and *Pratylenchus* spp. were recently recovered in areas of severe grapevine decline in two vineyards in southwestern and north-central New Mexico, respectively. As a result, a survey of thirty commercial vineyards from three American Viticultural Areas (AVAs) within New Mexico was initiated in 2018 to determine the association of plant–parasitic nematodes with vineyards and vine health. Whenever possible, three sampling "zones" were visually identified and designated as "healthy", "severely stunted/dead", or "moderately stunted/transitional" within a single variety/rootstock at each vineyard site. A composite sample consisting of ten 3.2 cm diam × 45 cm deep soil cores was collected from within 40 cm of the trunks of ten individual vines within each of the three zones per vineyard. Nematodes and soil insects were extracted from a 100 cm^3 subsample of soil from each zone by wet sieving and centrifugal flotation. Soil insects were collected on a 40 mesh (420 µm pore size) sieve and preserved in ETOH for future identification. Initial results showed most producing vineyards contain populations of *Pratylenchus* spp., *Meloidogyne* spp., *Mesocriconema* spp., or *Xiphinema americanum* which exceed levels reported to cause moderate to extensive damage to producing vineyards in California (UC Agriculture and Natural Resources Publication 3343, third ed.). DNA barcoding with the COI mitochondrial gene is underway for better taxonomic resolution of the *Pratylenchus*, *Meloidogyne* and *Mesocriconema* species. Highest populations of *Meloidogyne* and *Pratylenchus* were 40-fold and 21-fold greater, respectively, than those associated with extensive damage in California. Highest populations of *Xiphinema americanum* and *Mesocriconema* were 13-fold and 11-fold greater, respectively, than populations associated with moderate damage to producing grapevines in California. The long-term impact of these nematodes on New Mexico vineyards, especially own-rooted *V. vinifera* vineyards, has not been determined and merits further study.

WHAT DO WE KNOW ABOUT RESPONSE MECHANISMS TO ENVIRONMENTAL TRIGGERS IN ENTOMOPATHOGENIC NEMATODES? **Glazer, I.** Department of Entomology and Nematology, Agricultural Research Organization, the Volcani Center, Bet Dagan 50250, Israel.

Entomopathogenic nematodes (EPN) are use as commercial biocontrol agents for more than two decades. Even though intensive research has backed up their utilization, little is known about EPN's abilities to tolerate environmental stress such as heat and desiccation. These factors have been identified as restrictive elements reducing EPN persistence and efficacy. Therefore, there have been attempts to improve the tolerance of EPN to abiotic stresses. While in the past, most studies consisted of biological and behavioral characterization of various EPN species to heat and desiccation, in recent years, modern genetic and molecular tools such as RNA-seq, transcriptomics and proteomics were utilized to follow and understand the molecular basis of beneficial traits. Molecular markers and QTL can also help to develop new strategies for genetic improvement of EPNs. New techniques for genome editing (TALENs and CRISPR-Cas9) may facilitate modification of important traits. In this presentation, the past and future perspectives of EPN tolerance to environmental stress will be discussed.

SURVEY OF PLANT-PARASITIC NEMATODES IN PULSE CROP FIELDS OF THE CANADIAN PRAIRIES. **Gouvea Pereira, Fernanda[1], M. Tenuta[1], M. Harding[2], and D. Risula[3]**. [1]Department of Soil Science, University of Manitoba, Winnipeg, MB, Canada R3T 2N2. [2]Alberta Agriculture and Forestry, Brooks, AB T1R 1E6. [3]Saskatchewan Ministry of Agriculture, Regina, SK S4S 0B1.

The quarantine pest nematode, *Ditylenchus dipsaci* can hamper securing export markets for some crops. In Canada, we have reported that previous identification of *D. dipsaci* in yellow pea export shipments was likely the non-quarantine species *D. weischeri*, a parasite of creeping thistle and not crops. To further clarify, if the quarantine pest *D. dipsaci* is found on pulse plants and to address the gap in understanding of the distribution of plant-parasitic nematodes in the Canadian Prairies, a field survey was conducted on commercial yellow pea, lentil and chickpea fields in Alberta, Saskatchewan, and Manitoba. Samples of pulse and creeping thistle (a.k.a. Canada thistle, *Cirsium arvense*) plants (flowers or pods, stem and leaves) and soil were collected from 93 fields. Nematodes were extracted from plant materials using a modified Whitehead tray method and from soil using the Cobb sieving sugar/flotation method. The first 100 nematodes observed for each sample were identified to genus by morphological features and frequency, mean population densities and prominence values calculated. Molecular analysis by species-specific PCR, PCR-RFLP and/or sequencing of the ITS (ITS 1 + 5.8S + ITS2) of the rRNA gene were used to identify selected nematodes to species. Twenty genera of plant-parasitic nematodes were recovered from soil and (or) plants of pea, chickpea, lentil and creeping thistle, including *Anguina*, *Aphelenchoides*, *Ditylenchus*, *Helicotylenchus*, *Hoplolaimus*, *Longidorus*, *Merlinius*, *Paraphelenchus*, *Paratylenchus*, *Pratylenchus*, *Subanguina*, *Paratrichodorus*, *Tylenchorynchus* and *Xiphinema*. Plant-parasitic nematodes were, in general, less prominent in plant samples than in soil samples. In soil samples, *Paratylenchus* was the most prominent genus (241 prominence value) recovered from lentil soil followed by *Tylenchorhynchus* (78) and *Pratylenchus* (74), both recovered from thistle soil from pea fields. In above ground samples, *Ditylenchus* was the most predominant genus (38) recovered from chickpea and *Aphelenchoides* was the second most predominant genus (2) recovered from pea samples. Molecular analysis results to date indicate recovery of *D. weischeri, D. dipsaci*, *X. revesi and Paratylenchus nanus. D. weischeri* was recovered from 22 fields (1 to 300 nematodes/g) across Alberta, Saskatchewan, and Manitoba. *D. dipsaci* was recovered at very low density from pods of one yellow pea field (1.6 nematodes/g pods) but not from soil. Resampling of the field for soil the following year failed to obtain *D. dipsaci*. *D. dipsaci* has been reported in two garlic fields in southern Manitoba and *D. weischeri* is not considered an agricultural pest. *P. neglectus* was identified in six pea and chickpea fields. Four of those fields had density levels (104 to 176 nematodes/100g dry soil) potentially damaging to crops. *P. neglectus* host preference and possible crop damage remains to be determined. Our results confirm the high predominance of *D. weischeri* on creeping thistle in pulse fields and near absence of *D. dipsaci*. This is part of ongoing research and data from sampling of new fields in 2016 will be included in this presentation.

TARGET AND NON-TARGET EFFECTS OF FUMIGANT AND NON-FUMIGANT NEMATICIDES IN COTTON AND PEANUT PRODUCTION. **Grabau, Zane[1], E. T. Carter[2], and M.D. Mauldin[3]** [1]Entomology and Nematology Department, University of Florida, Gainesville, FL 32611. [2]Jackson County Extension, University of Florida, Marianna, FL 32448. [3]Washington County Extension, University of Florida, Chipley, FL 32428.

The number of non-fumigant nematicides available for cotton and peanut growers has increased in recent years with the introduction of new chemistries and the return of older ones. Fumigant nematicides are also available for growers and there is need to compare these nematicides for efficacy at managing plant-parasitic nematodes in commercial settings. Nematicides can also affect non-target, free-living nematodes and we hypothesize that effects on free-living nematodes vary by nematicide. Therefore, on-farm nematicide trials in were conducted in 2017 and 2018 in commercial cotton and peanut in Jackson County, Florida. Treatments were Telone II (1,3-Dichloropropene) applied at 3.5 gallons/acre in the row before planting, Velum Total (fluopyram) applied at 18 oz/acre in-furrow, AgLogic 15GG (aldicarb) applied at 7 lb/acre in-furrow, and control without nematicide application. Treatments were applied in randomized strips across the length of the field and replicated 4 times. In the 2017 cotton trial, none of the nematicides significantly increased cotton yield or decreased *Meloidogyne incognita* soil abundances or root galling compared to the untreated control ($P < 0.05$). Fluopyram and 1,3-D applications significantly decreased free-living nematode abundances compared to the untreated control. In the 2017 peanut trial, nematicide application did not significantly affect *Meloidogyne arenaria* or free-living nematode abundances, but all nematicides significantly increased peanut yields compared to the untreated control. In summary, nematicide impacts on target and non-target nematodes as well as crop damage by root-knot nematodes were inconsistent in the first year of this study.

NEMATODE MANAGEMENT IN FLORIDA POTATO PRODUCTION USING NON-FUMIGANT NEMATICIDES. **Grabau, Zane[1], and J. W. Noling[2].** [1]Entomology and Nematology Department, University of Florida, Gainesville, FL 32611. [2]Citrus Research and Education Center, University of Florida, Lake Alfred, FL 33850.

Potatoes are grown on about 25,000 acres in Florida and harvested potatoes are worth about $90 million. Florida potatoes face substantial pressure from a number of nematodes such as sting, root-knot, lesion, and stubby-root, the vector for Corky Ringspot disease (CRS). As costs and regulations for applying fumigant nematicides increase, so does the interest in use of non-fumigant nematicides. For this reason, field trials were conducted in Hastings, FL, a center for potato production in Northeast Florida, to determine the efficacy of different rates and formulations of non-fumigant nematicides for nematode and CRS management. In 2016, 2017, and 2018, preplant treatments of Nimitz (fluenosulfone) at 2.5, 3.5, 5.0, and 7.0 pints/treated acre (broadcast on soil surface and incorporated), Telone II (1,3-dichloropropene) at 6.5 gallons per bedded acre, and untreated control were compared. In 2016, high rates of fluenosulfone (5 and 7 pt/a) and 1,3-dichloropropene (1,3-D) increased tuber yield compared to untreated control. In 2017, low rates of fluenosulfone (2.5, 3.5, and 5.0 pt/ta) increased potato yield compared to untreated control, but yields were similar to untreated control for plots treated with 1,3-D or 7 pt/ta of fluenosulfone. In both 2016 and 2017, nematode pressure was relatively substantial and each nematicide treatment reduced sting nematode soil abundances compared to untreated control. Different formulations of fluenosulfone were tested in a separate trial conducted in 2017. Fluenosulfone emulsifiable concentrate (EC, the current commercial formulation) at 3.5 and 7.0 pt/ta, fluenosulfone capsule suspension (CS) at 9 pt/ta, 1,3-D at 6.5 gal/a, and untreated control were compared. Nematode abundances were not substantial in that trial, and tuber yield was generally similar among treatments. Symptoms of CRS were minimal in all 2016 and 2017 trials. In 2018, fumigant and nonfumigant nematicides were also compared including fluenosulfone at 5 pt/ta, Mocap EC (ethoprop) at 1.5 gal/ta, Velum Prime (fluopyram) at 6.8 fl oz/ta, Vydate C-LV (oxamyl) at 2 gal/ta, 1,3-D at 6.5 gal/a, and untreated control. For 2018 trials, yield and nematode abundances at harvest are forthcoming, but preplant nematode pressure was relatively moderate, which included sting, stunt, lesion, and stubby-root nematodes. Results suggest non-fumigant nematicides have some efficacy for nematode management in Florida potato production and optimizing rates and formulations is important for effective use of these products.

AN EVALUATION OF UNMANNED AERIAL SYSTEMS FOR NEMATODE DETECTION AND MANAGEMENT IN TURFGRASS FOR USE IN MODERN IPM SYSTEMS. **Groover, William and K. Lawrence.** 209 Rouse Life Science Building, Auburn University, Auburn, AL 36849.

Plant-parasitic nematodes are one of the most problematic and damaging pathogens of turfgrass in the southeastern United States, yet symptoms can often go misdiagnosed, causing detection to be delayed and nematode population density to reach critical levels. With early detection being one of the most important strategies for managing plant-parasitic nematodes, implementing scouting strategies in conjunction with soil sampling can help improve detection. Recently, the Federal Aviation Administration opened airspace to routine commercial drone use, causing the amount of permits and use in agricultural research to increase exponentially. While there is currently much research in drone use for turfgrass management, little to no research has been conducted for using this technology as a tool for nematode management. The goal of this project is to evaluate these Unmanned Aerial Systems (UAS) for their ability to detect plant-parasitic nematode populations in turfgrass. Research objectives for this project are, 1) conduct grid-based sampling of turf in east Alabama and the surrounding areas with a history of nematode problems to determine nematode species presence, distribution, and density; 2) evaluate UAS for the ability to detect symptoms as a result of plant-parasitic nematodes through RGB and multispectral cameras; and 3) evaluate current nematicides for turf in combination with UAS scouting to manage nematode problems. This project will provide data on the ability of this technology to detect and track plant-parasitic nematodes that has not been previously explored. The results will be used to improve plant-parasitic nematode management on turfgrass.

EFFECTS OF PLANT-PARASITIC NEMATODE INFESTED BERMUDAGRASS ROOTS ON MYCELIA GROWTH PATTERNS OF THREE PYTHIUM SPP. **Gu, Mengyi and W. T. Crow.** Entomology & Nematology Dept. University of Florida, Gainesville, FL 32611.

Pythium root rot is one of the most common bermudagrass diseases on Florida golf courses. A previous nematicide greenhouse experiment and a *Pythium* root rot disease survey indicated the infection of *Pythium* species on bermudagrass might be associated with plant-parasitic nematodes. In our greenhouse disease complex test, plant-parasitic nematodes (*Belonolaimus longicaudatus* and *Meloidogyne graminis*) increased root infection by two avirulent *Pythium* spp. (*P. catenulatum* and *P. middletonii*), but not virulent *P. aristosporum*; and *B. longi-*

caudatus reduced root infection by *P. aristosporum* when nematodes were inoculated 7 days ahead of *Pythium*. Results of this experiment indicate different nematode species and different *Pythium* spp. interact with each other differently. Based on those results, a lab assay was conducted to study the effects of nematode-infested (*B. longicaudatus* or *M. graminis*) bermudagrass roots on mycelia growth patterns of three *Pythium* spp. (*P. aristosporum*, *P. catenulatum* and *P. middletonii*). Surface sterilized diseased (*B. longicaudatus* or *M. graminis* infested) and healthy bermudagrass roots were placed on two ends of *Pythium* selective (PART) medium. One 5-mm, 5-day old *Pythium* mycelia plug was placed in the middle of each PART medium and cultured for 2 to 5 days. Growth pattern of *Pythium* mycelia (whether mycelia grow on bermudagrass roots or not) on each medium was recorded. Analysis of variance was conducted using least-squares means (LSMeans) to compare mycelia growth data of diseased roots to that of healthy roots. In this lab assay, *B. longicaudatus* infested roots significantly reduced the mycelia growth of *P. aristosporum* (P=0.0368) and *P. middletonii* (P=0.0811), while the mycelia growth of *P. catenulatum* (P=0.0368) was significantly slowed by *M. graminis*. These results indicate bermudagrass roots infested with plant-parasitic nematodes may have negative effects on growth of *Pythium* mycelia, regardless of virulence. From our research, bermudagrass root rot disease identification based only on *Pythium* isolation results can be inaccurate. Sometimes plant-parasitic nematodes are the primary causal agent of turf root damage, and the associated *Pythium* infection may be from avirulent strains.

BIOLOGICAL CONTROL OF SOYBEAN CYST NEMATODES (*HETERODERA GLYCINES*) USING NATURALLY OCCURRING FUNGAL ANTAGONISTS. **Haarith, Deepak[1], K. Bushley[2], and S. Chen[1]**. [1]Department of Plant Pathology, [2]Department of Plant and Microbial Biology, University of Minnesota, Saint Paul, MN 55108.

Soybean Cyst Nematode (SCN) is the most important pest of soybeans in the United States, which produces over 100 million tons annually. With conventional chemical control methods being banned for their toxicity to the environment, durable biological control agents are being sought after to manage the pest. This study aims at mining natural fungal antagonists of SCN and exploring possibilities of finding commercial biological control solutions. Long-term Soybean-Corn rotation plots in Waseca, Minnesota was sampled six times over three years for SCN cysts. Fungal organisms colonizing the eggs and cysts were isolated from the cysts post surface sterilization. All the fungi were grouped together based on colony morphology and representatives from each group similar looking colonies were identified by sequencing the fungal ITS1F barcode. The majority of fungi were found to be members of the fungal family Nectriaceae, with *Fusarium* and *Ilyonectria* being the most common genera. Analysis of the mycobiome was performed using statistical Nonparametric Multidimensional Scaling (NMDS), to identify changes in community structure across years and different crop rotation sequences. The changes in community structure were not highly significant, assuring continued persistence of applied biocontrol agents. These fungal isolates were tested *in vitro* for their ability to colonize fungal-free SCN cysts and eggs, as well as their ability to produce toxic compounds against SCN egg hatch. Fungi having both high parasitism and toxicity were further evaluated *in vivo* in a greenhouse study for their efficacy to control SCN on Soybeans. Successful isolates are under consideration for further *in vitro* and *in vivo* tests and field trials.

EXPLORING CULTURABLE MYCOBIOME OF SOYBEAN CYST NEMATODE CYSTS FOR BIOLOGICAL CONTROL AGENTS AND BIOPESTICIDES **Haarith, Deepak[1], Bushley, Kathryn[2], and Chen, Senyu[1]**.[1]Department of Plant Pathology, [2]Department of Plant and Microbial Biology, University of Minnesota, Saint Paul, MN 55108.

Soybean Cyst Nematode (SCN) is the most important pest of soybeans in the United States where 100 million tons of soybeans are produced annually. Conventional chemical control methods are often toxic to the environment, and many of them such as Methyl Bromide have been banned. Many fungal and bacterial organisms have been studied for their biocontrol potential, but there are no commercially successful biocontrol agents in the market that are effective against SCN. Inability of the applied biocontrol agent to establish itself in the introduced environment, and fungistasis or inhibition of the biocontrol agent by other inherent fungi and their metabolites are major contributors to the failure of many biocontrol agents. Hence, understanding phytobiomes of soybean-SCN pathosystem, and mining for naturally occurring fungal antagonists of SCN from such phytobiomes are important criteria while screening for biocontrol agents. Biopesticides, or chemicals derived from living organisms have the advantages of both being natural and are easy to use like their chemical counterparts. It has been reported that some fungal secondary metabolites have negative effects on nematode reproduction. Therefore, screening for such metabolite production from candidate biological control agents is a valuable strategy. In this study, fungal organisms colonizing the eggs and cysts of SCN were isolated from long-term soybean-corn rotation plots in Waseca, Minnesota, sampled six times over three years for SCN cysts. This community of natural antagonists were then clustered and analysed based on various soy-corn rotation sequences post their identification using ITS1 barcoding region. Representatives from each cluster were screened *in vitro* to select candidates that can withstand freeze-thaw, are good egg parasites and producers of metabolites that inhibit SCN egg hatching. Fungi having both high parasitism and toxicity are being evaluated *in vivo* in a greenhouse study for their ability to establish in native soils from two different geographical locations in Minnesota, and for their efficacy to control SCN on Soybeans. Metabolite supernatants that inhibited SCN egg hatch will be fractionated and examined for active compounds using chromatography and spectrometry.

NEMATODES ARE A HIDDEN THREAT TO TURFGRASS INDUSTRY: THE UF NEMATODE ASSAY LAB EXPERIENCE. **Habteweld, Alemayehu [1] and W. T. Crow [1,2].** [1]Nematode Assay Laboratory, Department of Entomology and Nematology, University of Florida. [2]Landscape Nematology Laboratory, Department of Entomology and Nematology, University of Florida.

Turfgrass is the fourth largest U.S. crop in acreage, covering 31 million acres with $40 to $60 billion estimated annual value. It beautifies home lawns, provides safe playing surfaces, outdoor recreation and provides economic opportunities for seed and sod producers, lawn care operators and landscapers. It also provides environmental protection and enhancement by purifying and protecting our water, soil and air. Plant parasitic nematodes (PPN) are one of the most important pathogens affecting the turfgrass industry in the U.S. though their damage is often mistaken for other issues such as drought, disease and nutrient deficiencies. Roots damaged by PPN are less capable of absorbing water and nutrients. As a result, turgrass requires frequent watering and fertilization, and also becomes susceptible to other disease complexes that cost the turf industry millions of dollars. Hence, it is important to accurately identify PPN risk level to alleviate damage to turfgrass's root system. The UF Nematode Assay Lab experience reaffirmed that PPN continue to be a hidden threat to the huge turfgrass industry. In 2017, we received >7,000 soil and root samples for nematode assays. Over 80% of the samples came from Florida, followed by Texas, North Carolina and other states altogether with 5.6, 2.3 and 11.8%, respectively. Turfgrass comprised 90.5% of the assay samples out of which bermudagrass represented 76.4%, followed by bentgrass, St. Augustinegrass, zoysia and other turfgrasses with 7.1, 6.6, 4.9 and 5%, respectively. Seventy-one percent (71%) of the sample sources were golf courses. Lawns, sports fields, landscaping and nurseries represented by 13.3, 11.4, 1.1 and 0.8% of the sample sources, respectively. We processed 76.4% of the samples for diagnosis of existing problems and 2.3% of the samples for advice for the future crops. Experimental samples represented 21.3% of the samples. The majority of the samples came from commercial settings representing 70.7%, followed by residential, public and private settings with 14.4, 14.3 and 0.6%, respectively. Out of the diagnostic samples, 70% of the samples were considered as having moderate or high risk of PPNs damage. Out of these, 47% of the samples were diagnosed with high risk of nematode damage and 23% of the samples had moderate risk level. Lance, sting and root-knot nematodes were responsible for 41.0, 34.0 and 13.6% of soil samples with moderate to high risk levels, respectively. Overall, the present analysis showed that PPN are a hidden threat to the turfgrass industry. Therefore, designing and implementing effective PPN management, especially for lance, sting and root-knot nematodes will continue to be a major area of focus.

MANAGEMENT OF *HETERODERA SCHACHTII* WITH SPIROTETRAMAT IN SNAKE RIVER PLAIN SUGARBEET PRODUCTION. **Hafez, Saad L.[1] and K. Luff [2].** [1]29603 U of I ln. Parma, ID 83660. [2]Bayer Crop Science 3554 East 4000 North Kimberly, ID 83341.

Several nematode species affect sugarbeet production along the Snake River Plain of southern Idaho and southeastern Oregon. Sugarbeet cyst nematode, northern rootknot nematode and stubby root nematode are the most troublesome. All three species can seriously limit sugarbeet yield and quality. Sugarbeet cyst nematode, the most detrimental, infests more than half of the production acres and is found in all counties where sugarbeets are grown. Until recently, Temik® (aldicarb) was the standard non-fumigant nematicide used to manage nematode damage. Aldicarb was an effective management tool when thresholds between five or six viable cysts/500 cc of soil were not exceeded. Over much of the past decade, foliar placement of spirotetramat was tested as an alternative to aldicarb. A broadcast equivalent rate of 85 g ai/ha was investigated both as banded and broadcast applications. Two to four sequential applications sprayed on a 14-day interval were studied with the first treatment beginning at various timings ranging between 7 and 28 days after sugarbeet emergence. Nematode densities ranged between 10 and 82 viable cysts per 500 cc of soil. Studies have shown that spirotetramat compares favorably to aldicarb in managing root damage and yield reduction caused by sugarbeet cyst nematode. Increasing the rate above 85 g ai/ha has not resulted in improved efficacy. Sequential treatments of spirotetramat beginning at 7 days after sugarbeet emergence were not as effective as treatments that began 14 to 28 days after emergence. This is most likely due to insufficient leaf area for uptake and translocation of the active ingredient within sugarbeet seedlings. Two and three sequential applications of spirotetramat were proven to be optimal and performed more consistently than treatments with up to four sequential applications. Spirotetramat has recently received EPA registration in sugarbeets under the tradename of Movento HL. Effective management of sugarbeet cysts nematode damage can be achieved when Movento HL is utilized in accordance with established non-fumigant nematode thresholds.

MANAGEMENT OF NEMATODE AND VERTICILLIUM WILT IN MINT GROWN IN EASTERN OREGON AND IDAHO. **Hafez, Saad L. and M. Murdock.** 29603 U of I ln. Parma, ID 83660.

The Pacific Northwest (PNW) produces a majority of the United States' total mint production, with approximately 69,000 acres of land dedicated to either spearmint or peppermint. Idaho is ranked 3rd in mint production in the U.S. Two major factors that can severely reduce mint output are nematode infestations and *Verticillium* wilt infections. Numerous studies have indicated that when combined these two pests have an augmented pathogenicity when considering root lesion nematode (*Pratylenchus* spp.) and *Verticillium dahliae*. Preliminary experiments at the University of Idaho Research and Extension Center – Parma have revealed that both *Pratylenchus penetrans* and *P. neglectus* cause significant damage to mint. An ongoing survey of mint fields throughout Idaho and Oregon reveal that of the 128 volunteered samples, 120 contain root lesion nematode, 44 contain root-knot nematode and 112 contain pin nematode with populations reaching over 50,000. Other preliminary research suggests that furrow irrigation is beneficial to nematode populations and can create management challenges for growers such as leaching of nutrients and pesticides. Surface irrigations can also limit pesticide selection and application timing throughout the season making it increasingly difficult to manage any type of pest. New chemicals and compounds were tested alongside existing treatments with the intention of finding new products or methods for nematode and *Verticillium* management. These products were tested in field, greenhouse and/or microplot conditions. Treatments consisted of Velum Prime (fluopyram) at 6.5 oz/a, Velum Prime followed by Movento 240 SC (spirotetramat), Vydate L (oxamyl) and Employ (harpin protein). Green manure crops were also tested in greenhouse conditions. Field data demonstrated a statistically significant reduction in pin nematode population as compared to untreated check, and greenhouse trials demonstrated successful chemical control of Northern root-knot nematode (NKRN) damage on mint. NRKN greenhouse work showed an average of 20% dry weight yield loss in mint due to nematodes. Lesion nematodes alone did not show significant yield reductions in either greenhouse or microplot trials. Pin nematode trials resulted in severe yield losses of up to 85% and 45% average yield loss in greenhouse and microplot trials, respectively. However, *Verticillium* was present and masked the direct impact of pin nematodes on yield. The results obtained from pin/vert trials did show a significant increase in dry weight yields for nematicide treatments, suggesting a complementary interaction between pin nematode and *Verticillium* on mint pathogenicity.

TYPE AND OTHER SPECIMENS DEPOSITED IN THE UNITED STATES DEPARTMENT OF AGRICULTURE NEMATODE COLLECTION, BELTSVILLE, MARYLAND. **Handoo, Zafar A., M. R. Kantor, L. K. Carta and D. J. Chitwood.** Mycology and Nematology Genetic Diversity and Biology Laboratory USDA, ARS, Northeast Area, Beltsville, MD 20705, USA.

The United States Department of Agriculture Nematode Collection (USDANC) is one of the largest and most valuable nematode repositories in existence and includes millions of specimens housed in over 40,000 permanent slides and over 9,400 vials. The USDANC was established in 1960 by A. Morgan Golden and currently contains more than 49,200 species entries. The USDANC Type Collection preserves type specimens of nematodes to serve as references for identifications and future taxonomic revisions. A list of the type specimens added to the USDANC since 1998 was recently published. Currently the Type Collection includes more than 7,600 slides and 600 vials. The other constituent divisions of the Collection are the General Collection with 21,875 slides and almost 7,700 vials from many different hosts and areas, the Thorne Collection with 6,602 slides with many original types, the Steiner Mermithid Collection with original types of 2,303 slides, the Mass Collection, a reservoir for undescribed taxa with 1,267 slides and 1,101 vials, the Gates Collection with 356 slides, and a Demonstration Collection of 88 museum jars showing symptoms and effects of nematodes on hosts. All depositions are entered in a computerized database which is available at: https://nt.ars-grin.gov/nematodes/. The online collection database is user friendly; typing the genus and the species name will reveal a list with all relevant entries and provide information about the host, the collector, the collection date, and the date when the sample was received. The database also provides a detailed list of specimens that are deposited in the USDANC and that are available to interested scientists throughout the world. Along with the publicly available database records, many specimens are available for loan for limited periods of time to scientists in trusted organizations. We encourage nematologists and private nematode collection owners throughout the world to enrich our collection by depositing valuable type and other specimens in the USDANC for taxonomic research and use by future generations.

ROOT EXUDATE TO ENHANCE ENTOMOPATHOGENIC NEMATODE ABIOTIC (AND BIOTIC) STRESS TOLERANCE. **Hiltpold Ivan**. Department of Entomology and Wildlife Ecology, College of Agriculture and Natural Resources, University of Delaware, Newark, DE.

The quality of entomopathogenic nematodes (EPN) used in integrated or biological management of insect pests highly depends on their storage conditions. Because nematodes are soil-borne organisms, storage and handling can be source of abiotic stress impairing their effectiveness as control agents. In addition, EPN infective juveniles rely only on their lipid reserves as they are not capable of feeing at this stage. Using pea (*Pisum sativum*) root exudate, we induced a reversible quiescence in *Heterorhabditis bacteriophora, H. megidis, Steinernema feltiae* and *S. carpocapsae*. The performance traits of EPNs were maintained over time after the induction of the reversible quiescence. Storing EPNs in root exudate resulted in a longer shelf-life and higher lipid content over time. It also improved their effectiveness at killing insect host after the quiescence was reversed. This dual benefit of increased storage time and infectiveness opens the door to the development of new application technologies. The example of capsules containing nematodes will be discussed to illustrate this purpose.

CROP AND SEASONAL SHIFT ON MICROBIAL COMMUNITIES OF SOYBEAN CYST NEMATODE. **Hu Weiming[1], S. Chen[2], K. E. Bushley[3].** [1]Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611. [2]Southern Research and Outreach Center, University of Minnesota, Waseca, MN 56093. [3]Department of Plant and Microbial Biology, University of Minnesota, St. Paul, MN 55108.

Soybean cyst nematode (SCN, *Heterodera glycines*) is the major pathogen of soybean, and there is great need for development of effective and environmentally sustainable management strategies such as biocontrol for the SCN. Development of effective biocontrol is hampered by a lack of knowledge of nematode control microorganisms. In this study, the bacteria community colonizing cysts was characterized under different crop rotation systems in a long-term crop rotation experiment of corn and soybean that includes annual rotation, 5-year rotation, and continuous monoculture. Fifty intact cysts of SCN from each plot were collected at planting, midseason and harvest in 2015 and 2016, and the bacterial communities were investigated by metabarcoding sequencing of the bacterial V4 region and shotgun metagenomics using high-throughput Illumina sequencing. The overall bacterial community at midseason was less diverse than at either planting or harvest. Crop rotation significantly affected community diversity only at planting and harvest in both years. However, the crop sequences changed bacterial community composition at all time points, and soybean shifted the bacterial community at midseason and harvest. Metabarcoding and shotgun metagenomics approaches yielded similar bacterial community composition, and both suggested that *Variovorax* sp. is a common and abundant bacteria colonizing the cysts of soybean cyst nematode.

MULTIVARIATE METHODS FOR ANALYZING CHANGES IN NEMATODE COMMUNITY STRUCTURE OVER TIME. **Hu Weiming, P. DiGennaro.** Entomology and Nematology Department, University of Florida USA.

For community data analyses—including nematode, microbial, or other communities, it is often desirable to detect shifts in community structure over time. This information can reveal seasonal fluctuations in community structure which may be tied to plant growth cycles or environmental conditions. It may also be used to test hypotheses about community formation. One way to analyze shifts in community structure over time is through ordination. Through ordination, the distribution of the community can be visualized using different shapes. By comparing the shape of the community at different time points, the effect of time on community structure at different time points can be tested. Participants in this workshop session will get hands-on experience testing for community shifts over time using R statistical software. In R, the function "procrustes" together with "protest" in the package "Vegan" can be used to visualize and test community similarity and/or differences among different time points or other treatments. The function "procrustes" rotates a community configuration relative to another community configuration from a different time point to show the similarity or difference, and "protest" tests the significance between two configurations. This is useful for tracking community evolution under given treatments.

PLANT-PARASITIC NEMATODES ASSOCIATED WITH SWEET GRANADILLA (*PASSIFLORA LIGULARIS*), BLACKBERRY (*RUBUS ULMIFOLIUS*) AND PLUM (*PRUNUS DOMESTICA*) IN THE REGION OF LOS SANTOS, SAN JOSÉ, COSTA RICA. **Humphreys-Pereira, Danny A[1], L. Flores-Chaves[1], R. Sandoval-Ruíz[1], J. M. Ávalos-Cerdas, L. Gómez-Alpízar[2].** [1]Laboratory of Nematology-CIPROC, University of Costa Rica, San Pedro, Costa Rica, 2060. [2]Laboratorio de Biotecnología de Plantas-CIA, Universidad de Costa Rica, 2060 San Pedro, Costa Rica.

Little is known about the plant-parasitic nematodes associated with temperate fruit crops in Costa Rica. Roots and the surrounding soil were sampled from sweet granadilla (*Passiflora ligularis*), blackberry (*Rubus ulmifolius*) and plum (*Prunus domestica*) in the region of Los Santos, in San José province. Samples were processed using the floatation-centrifugation method and extracted nematodes were quantified using an inverted microscope. Juveniles or females of *Meloidogyne* were selected from the solution for molecular identification. The *Meloidogyne* species were characterized using the mitochondrial marker between the *cox2* and *16SARNr* gene regions. PCR products were digested with the enzymes *HinfI* and *DraI*. In roots of plum, nematodes were identified in nine genera (*Tylenchus*, *Meloidogyne*, *Aphelenchus*, *Aphelenchoides*, *Helicotylenchus*, *Hemicycliophora*, *Paratylenchus*, *Xiphinema*, and *Pratylenchus*) and from the family Criconematidae and subfamily Heteroderinae. Similarly, these nematode species were also found in samples of the surrounding soil, apart from *Aphelenchoides*. Additionally, members of the Trichodoridae family, *Rotylenchulus* and *Ditylenchus,* were also found in soil samples of plum. Nematodes of the Criconematidae family were the most frequently recovered taxa fro m roots and soil (92.9% and 100%, respectively). Sampling from sweet granadilla roots yielded nine genera (*Aphelenchoides*, *Aphelenchus*, *Ditylenchus*, *Helicotylenchus*, *Meloidogyne*, *Pratylenchus*, *Rotylenchulus*, *Rotylenchus* and *Tylenchus*) and taxa from Criconematidae and Heteroderinae. Soil surrounding sweet granadilla roots had similar species composition with the exception of *Ditylenchus* and Heteroderinae, and in contrast to the roots *Ecphyadophora*, *Hemicycliophora* and Trichodoridae were found in soil samples. *Meloidogyne* (RF=69%) exhibited the highest population density with an average of 89801 nematodes/100g of roots with a maximum of 947595 nematodes. *Pratylenchus* (RF=48.3%) was found in sweet granadilla roots with an average population density of 9196 nematodes and a maximum of 48643 nematodes/100g of roots. Blackberry roots revealed nine genera (*Aphelenchoides*, *Ditylenchus*, *Tylenchus*, *Helicotylenchus*, *Meloidogyne*, *Pratylenchus*, *Aphelenchus*, *Hemicycliophora* and *Rotylenchus*) and taxa of the Criconematidae family.

These species and members of Trichodoridae, Heteroderinae, *Psilenchus* and *Xiphinema* were found in soil surrounding blackberry. *Meloidogyne* (RF=64%) had an average population density of 515 nematodes/100g of roots with a maximum of 2160/100g of roots. *Pratylenchus* (RF=41.2%) had an average population density of 252 nematodes/100g of roots with a maximum of 1090 nematodes/100g of roots. PCR-RFLP using mitochondrial DNA allowed for the identification of *M. incognita* and *M. javanica* in sweet granadilla and *M. hapla* in plum. Currently, the *Pratylenchus* species are being identified with the molecular 28S marker. The present study is the first survey of plant-parasitic nematodes associated with sweet granadilla, blackberry and plum in Costa Rica. Results suggest a wide diversity of plant-parasitic nematodes associated with the soils and roots of these hosts.

EVALUATION OF THE REPRODUCTIVE RATE OF THE CEREAL CYST NEMATODE (HETERODERA AVENAE) ON TWO WHEAT CULTIVARS UNDER OUTDOOR CONDITIONS**. Idris. Soliman, Saad, Hafez, and Mackade Murdock.** Parma Research and Extension Center, 29603, U of Lane, Parma, Idaho 83660, USA.

An outdoor trial was conducted to determine the reproduction of cereal cyst nematode (CCN) on two wheat cultivars (Stephens and Brundage) grown in Parma, ID. Five levels of inoculum (L1 = 0, L2 = 3000, L3 = 6000, L4 = 9000, and L5 = 12000 eggs) were inoculated to wheat seedlings planted in (1500 cm^3) pots filled with (50/50%) sterilized sand and clay soil. Experiment was laid out in completely randomized design (CRD) with six replicates in each treatment on an outdoor table protected from rain at the Parma R&E Center in Parma, ID. There were significant differences in the reproductive rate of CCN between the levels of inoculum and within the two cultivars. CCN reproduced on Brundage better than Stephens wheat at all levels tested. The highest number of cyst was counted on Brundage at L5 with a mean of 349 cyst/1500 cm^3 while Stephens at the same level had a mean of127 cyst/pot. The lowest number of cyst was at L2 with a mean of 101 and 55 cyst/1500 cm^3 on Brundage and Stephens, respectively. No J2 were found in soil or cyst and the majority of the cysts were white females. The reproduction factor (Pf/Pi) was calculated after the initial eggs densities were correlated to cysts. The reproduction factor (RF) was greater than 7 in Brundage wheat and at 4.2 in Stephens wheat. No above ground (yellowing or stunting) or below ground (knotting) symptoms were observed on plants from inoculation (02/26/2016) to harvest (07/12/2016). A yield reduction in weight of grain per pot was observed at L5 with a mean of 3.86g on Brundage compared to the control (L1) with a mean of 8.1g/pot at the same cultivar. None of the final eggs/1500 cm^3 reached to the damaging level (5 eggs/g soil) on the cultivar Stephens at all tested initial levels while that level was exceeded on the cultivar Brundage at the L4 and L5.

OCCURRENCE AND DISTRIBUTION OF PLANT-PARASITIC NEMATODES ASSOCIATED WITH PECAN IN GEORGIA. **Jagdale Ganpati B.[1], T. B. Brenneman[2] and D. Shapiro-Ilan[3].** [1]Dept. of Plant Pathology, University of Georgia, Athens, GA, 30602. [2]Dept. of Plant Pathology, University of Georgia, CAES Campus Tifton, 2360 Rainwater Road, Tifton, GA 31794 and [3]USDA-ARS Southeastern Fruit & Tree Nut Res. Lab. 21 Dunbar Road, Byron, GA 31008.

Pecan (Carya illinoinensis) is native to the United States but cultivated worldwide as a valuable tree-nut crop. Although United States pecan kernel production is usually high, about 136,000 MT in 2011, pecan trees are constantly attacked by a variety of diseases, insect pests, and nematodes that can cause serious damage to trees and reduce nut yields. Plant-parasitic nematodes (PPNs) including root-knot nematodes (RKN), Meloidogyne spp. and ring nematodes, *Mesocriconema xenoplax* are thought to reduce pecan yields in Georgia. Among the PPNs that occur in pecan orchards, the pecan RKN, M. partityla, is usually the dominant species associated with stressed trees exhibiting Nickel deficiencies, stunted growth, dead branches in the upper canopy and/or mouse-ear foliar symptoms of pecan in Georgia. However, there is little current information available on the occurrence and distribution of PPNs in Georgia pecan orchards. Since more research data are needed to establish the status of nematodes as parasites of pecan in Georgia, a preliminary PPN survey of 13 commercial pecan orchards in 11 counties was conducted August 2017 through April 2018. We found that ten genera including Meloidogyne, *Mesocriconema*, *Tylenchorhynchus*, *Helicotylenchus*, *Heterodera*, *Hoplolaimus*, *Paratrichodorus*, *Pratylenchus*, *Paratylenchus* and *Xiphinema* were present in pecan orchards in 13 counties. However, the frequency of occurrence of these PPN genera varied among the samples. *Mesocriconema* nematodes were present in the highest number of samples (86% samples) followed by *Helicotylenchus*, *Paratrichodorus*, Meloidogyne and *Xiphinema* genera in 55, 51, 42 and 33% samples, respectively. The other genera including *Heterodera*, *Tylenchorhynchus*, *Hoplolaimus*, *Pratylenchus* and *Paratylenchus* nematodes were present in less than 10% of soil samples. Although the most frequently detected PPNs were *Mesocriconema*, *Paratrichodorus*, *Helicotylenchus*, Meloidogyne and *Xiphinema*, found in 100, 92.28, 92.28, 84.59 and 84.59%, respectively of sampled pecan growing counties, their overall mean population density was varied. The highest mean population density was recorded for *Helicotylenchus* (27/100 cm^3 soil) followed by Meloidogyne (13/100 cm^3 soil), *Mesocriconema* (12/100 cm^3 soil), *Paratrichodorus* (3/100 cm^3 soil) and *Xiphinema* (1/100 cm^3 soil). The population densities of these nematodes are very low, but their damage threshold levels on pecan are unknown. However, the population densities of Meloidogyne, *Mesocriconema*, *Paratrichodorus* and *Xiphinema* nematodes could increase to damaging levels and could become a limiting factor for the production of pecans in Georgia.

CHALLENGES IN SUCCESSFUL APPLICATION OF MICROBIAL SOURCED NEMATICIDES FOR APPLICATION AS SEED TREATMENTS, IN-FURROW AND IN-SEASON FOR MANAGING NEMATODES IN HORTICULURAL AND LARGE ACREAGE CROPS. **Timothy Johnson, P. Pathak, A. Vasavada and P. Marrone**. Marrone Bio Innovations, 1540 Drew Avenue, Davis, CA 95618.

Various preparations of dead *Chromobacterium subtsugae* strain PRAA4-T[1] and heat-killed *Burkholderia rinojensis* strain A396 were evaluated from 2014-2017 as seed treatments and in-furrow for reducing damage from nematodes feeding on cotton, corn and soybeans and in-season for control of nematodes feeding on tobacco, sweet potatoes, cucurbits and fruiting vegetables. In-furrow studies included multiple rates applied either directly into the open seed furrow or applied as a T-band over the open seed furrow prior to the closing wheels. Trial locations on corn and soybeans were in Nebraska, Iowa, Minnesota, and Wisconsin whereas studies on additional crops were conducted in North Carolina, Mississippi, Alabama and Florida. Commercial formulations of both *B. rinojensis* strain A396 and *C. subtsugae* reduced nematode damage in corn and soybeans when applied in-furrow or as seed treatments. Applications to reduce nematode damage and to protect yield were also successful in fruiting vegetables, cucurbits, sweet potatoes and tobacco. A comprehensive review of trial data indicates the commercial potential for both active ingredients while also identifying possible knowledge gaps including accurate identification of active molecule(s), the rate of degradation of the active ingredients in different soil profiles, spectrum of activity against different nematodes species and the role of nematode biology in dictating the level of control achieved by the grower.

EFFICACY OF INCORPORATED ORGANIC AMENDMENTS ON TURFGRASS NEMATODES AND TURF HEALTH. **Jones, W. Brandon, and W. T. Crow.** University of Florida, 1881 Natural Area Dr., Gainesville, Florida 32611, USA.

Various chemistries are available for nematode control; however, applications can potentially be expensive rendering them inaccessible for many golf courses and athletic fields. In many instances, use of cultural methods for management may be the only option. The incorporation of organic amendments within soils has been shown to improve several physical properties of the soil environment including benefitting the microbial population. Some of these microbes may possess plant-parasitic antagonistic qualities and potentially reduce nematode population numbers. Incorporation of organic amendments has been shown to suppress plant-parasitic nematode population numbers; however, previous research on this subject has provided inconsistent results. Comand® compost is a commercially available product marketed as an amendment for several different types of crops. The manufacturing of Comand® involves a series of unique microbial inoculations resulting in a rich microbial community which may possess antagonistic qualities. Canadian sphagnum peat moss (CSPM) is a commonly used organic amendment. In 2015, a microplot experiment conducted at the University of Florida comparing the efficacy of Comand® to CSPM showed a 95% reduction of *Belonolaimus longicaudatus* in soils containing a 20% Comand® mixture. Significant differences in *Mesocrionema* spp. and 'Tifway' (*Cynodon dactylon*) roots lengths were also reported. Based on the results of the microplot study, a two year field experiment using a randomized block design with 3 replications was initiated in May 2016. The objective of the study was to compare the results of soils incorporated with Comand® or CSPM to an unamended control. Treatments were applied (2.54 cm) and rototilled (12.7 cm in depth) within the soil creating a 20% mixture. Plots were then sprigged with 'T-11' bermudagrass. Data collected included soil, root, percent green, and tensile strength. Root lengths between the treatments remained similar; however, the unamended treatment did have slightly lower values throughout the entire period ($P \leq 0.1$). Initially, a reduction of *B. longicaudatus* population numbers occurred, but variation among the three treatments leveled off throughout the second year. Percent green coverage significantly increased with the two amendment treatments ($P \leq 0.1$). Initially, CSPM treatments had the higher values, but Comand® treatments increased and remained at a higher value throughout most of the trial. Tensile strength had a significant increase with both the amendments throughout the first year ($P \leq 0.1$). However, a dramatic decline in the Comand® plots occurred over the winter months and plots never recovered. This decline resulted in a significant reduction in tensile strength for the Comand® plots. The inconsistency in results suggests organic amendments have variable effects on root health and nematode suppression. These results indicate further research on the use of organic amendments as a method to reduce plant-parasitic nematode populations needs to take place.

DIVERSE STRATEGIES EMPLOYED BY THE SOYBEAN CYST NEMATODE TO CIRCUMVENT HOST DEFENSE RESPONSES. **Parijat S. Juvale[1], G. Pogorelko[1], J. Wang[2], M. G. Mitchum[2], and T. J. Baum[1].** [1]Department of Plant Pathology and Microbiology, Iowa State University, Ames, IA, 50014. [2]Division of Plant Sciences, University of Missouri, Columbia, Missouri 65211-7310.

Heterodera glycines, the soybean cyst nematode (SCN), is a sedentary plant parasite that draws nutrition exclusively from a specialized feeding site, the syncytium. Thus, SCN's survival depends on maintaining viability of the syncytium. Plants on other hand, induce defense responses to trigger programmed cell death (PCD) at the sites of infection to affect syncytial viability and deter SCN infection. Successful SCN parasitism relies on suppressing these defenses responses. Similar to other pathogens, the SCN interacts with its host by secreting effectors, i.e., proteins that interact with host factors and modulate various cellular pathways in favor of parasitism. One of our research areas is to identify SCN effectors and conduct their in-depth functional characterization studies to discover their unique roles in parasitism. In the past few years, we have identified multiple effectors that play specific roles in host defense suppression. Our research findings show that SCN effectors achieve this goal by employing various strategies including interacting with and modulating functions of host proteins with critical roles in host defenses, as well as targeting the host genome and altering expression of genes located near the targeted region. In this presentation we will discuss our latest results, which includes a comprehensive screen of SCN effectors to identify those with roles in host defense suppression. We will also discuss the functional characterization studies of these defense-suppressing effectors, which reveal diverse strategies to achieve virulence.

ASSESSMENT OF THE BIOPHYSICOCHEMICAL CONDITIONS OF SELECTED FRUIT AND VEGETABLE SOILS FOR ESTABLISHING SUSTAINABLE VALUE CHAIN PRODUCTION IN MALAWI. **Kakaire, Stephen[1], K. Njira[2], L. Chilasa[2], D. Chipeta[3] and H. Melakeberhan[1].** [1]Michigan State University, Dept. of Horticulture, 1066 Bogue Street, East Lansing, MI 48824 USA. [2]Lilongwe University of Agriculture and Natural Resources, Dept. of Crop and Soil Sciences, P. O. Box 219 Lilongwe, Malawi. [3]Land O'Lakes Inc., Private Bag A148, Lilongwe, Malawi.

Current smallholder farming practices in Malawi involve intensive cultivation, insufficient fertilizer application, lack of composting and climate-smart soil fertility management practices. These practices coupled with insufficient fertilizer formulation for different soil nutrient requirements and plant-parasitic nematodes (PPN) exacerbate soil degradation and crop yield losses. The Malawi Strengthening Inclusive Markets for Agriculture (MSIKA) project, a USDA-FAS funded project led by Land O'Lakes Inc. (LOL) has been implementing integrated and sustainable soil health and PPN management measures aimed at addressing these challenges. Michigan State University (MSU) provides the technical expertise in developing healthy soils and grower-adoptable production technologies. In collaboration with local expertise at Lilongwe University of Agriculture and Natural Resources (LUANAR), 20 vegetable and 7 fruit value chain Yankho™ (Demonstration) Plots (YPs) were established in Mchinji, Lilongwe, Dedza, Ntcheu and Mangochi districts in 2017. The YPs ranged from 0.2 to 0.8 ha in area. The vegetables were chili (*Capsicum annuum*), onion (*Allium cepa*), potato (*Solanum tuberosum*) and tomato (*Solanum lycopersicum*), and mango (*Mangifera indica*), guava (*Psidium guajava*) and citrus (*Citrus* sp.), were the fruits. As part of ground-truthing and developing standardized field-specific amendment recommendations, nematode community structure (NCS) and soil physiochemistry were analyzed. Representative soil samples were taken from each YP prior to planting. Nematodes were extracted from 100 cm^3 of soil, fixed in double TAF at LUANAR and shipped to MSU for trophic group and corresponding colonizer-persister (c-p) value analyses. Herbivores constituted 17% of the nematode fauna. The most prevalent PPN species were the root-knot (*Meloidogyne* sp.), lesion (*Pratylenchus* sp.), and spiral (*Helicotylenchus* sp.) nematodes, respectively. Based on the Ferris *et al.* (2001) soil food web (SFW) model, the data for the vegetable YPs showed up in Quadrant D (depleted system) and those of fruit YPs in Quadrant C (needing biological activity for nutrients to be released). Soil physiochemistry analysis indicated variability in the major soil nutrients and pH across locations. All, but three YPs required liming to raise soil pH to normal, and most sites were low in nitrogen (N). Consequently, chicken compost-based soil amendment was recommended to deliver either the standard (1X, 92kg N ha^{-1}) rate or 1.5X (138 kg N ha^{-1}) the standard rate. A check with no added amendment served as control. Preliminary field observations showed that the 1X and 1.5X rates were beneficial for chili, potato and tomato in areas where there was enough moisture. Soil type is likely to be another factor responsible for the observed variations. Nematode Community Structure analysis is still underway to correlate these observations with yield at harvest.

ASSISTING SMALLHOLDER FARMERS IN ADOPTING INTEGRATED NEMATODE-SOIL HEALTH MANAGEMENT: III-CHANGES IN SOIL BIOPHYSIOCHEMISTRY. **Kakaire, Stephen[1], A. Sanchez[2], B. S. Sipes[3], C-L. Lee[4], A. Sacbaja[2], C. Chan[3], and H. Melakeberhan[1].** [1]Dept. of Horticulture and [4]CANR Statistical Consulting, Michigan State University (MSU), East Lansing, MI 48824 USA. [2]Faculty of Agronomy, University of San Carlos (USAC), Guatemala City, Guatemala. [3]University of Hawaii (UH) at Manoa, Honolulu, HI 96822 USA.

Alleviating the intertwined and grand challenges of food and nutritional insecurities have been a major focus of the USAID's Horticulture Innovation Laboratory. Plant-parasitic nematodes (PPN) and poor soil health negatively affect potato yield of smallholder farmers in the Highlands of Guatemala. These farmers have limited perception of the cause-and-effect relationships between agricultural practices, nematodes, and potato yield. In order to address these challenges, an interdisciplinary team from UH (social science), MSU (soil health) and USAC (agronomy and soil science) conducted a ground-truthing in 2017 and initiated experiments in the Huehuetenango and Xela regions of Guatemala. The regions lay over Mollisol and Andisol soil groups (classes), respectively. The Mollisols are at 3,200 m to 3,353 m and Andisols around 2,896 m altitude. The experiment in each region consisted of testing the effects of amending soils either with or without bio-mix and 0, 318, or 454 kg composted chicken manure at eight locations. The bio-mix (BioCopia) consisted of Guatemalan isolates of *Purpureum* and *Bacillus* applied at 1.8 kg/m^2 to suppress harmful nematodes. This presentation deals with the effects of these treatments on nematode community (NCS) and soil food web (SFW) structure and soil physiochemistry. Nematodes were extracted from 100 cm^3 of soil, fixed in double TAF solution at USAC and enumerated at MSU. Over the growing season, nematode abundance averaged about 300 to 600 individuals/100 cm^3 of soil. Herbivores accounted for 20–40% of the nematode fauna in both regions. No treatment effects were observed on NCS during the growing season at either location. Herbivores, predators and omnivores tended to increase with time in Andisols plots more so than in Mollisols plots. Soil pH in the Andisols averaged 5.5 and 5.0 in Mollisols. P was similar in both soils. While K was above recommended levels in both soils, K was higher in Andisols than in Mollisols. Percent soil organic matter and C:N ratio were significantly higher in Mollisols than in Andisols, suggesting nutritional imbalances between the soil groups. Yet, based on the Ferris SFW model, the agroecosystem suitability profile of the two soil groups fell into Quadrant C – needing biological activity for nutrients to be released. The combination of the biophysiochemical data suggest that neither soil group has suitable conditions, but the soil groups differ in the practices needed to achieve ideal agroecosystem conditions – profile outcomes falling into Quadrant B of the SFW model.

RESPONSES OF *HETERODERA SOJAE* TO HG TYPE RESISTANT SOYBEANS. **Kang, Heonil[1], N. Park[2], E. Yun[2], D. Kim[2], I. Choi[1,2].** [1]Department of Plant Bioscience, Pusan National University, Miryang, 50463, Korea. [2]Nematode Research Center, Life and Industry Convergence Research Institute, Pusan National University, Miryang, 50463, Korea.

Heterodera sojae is a new cyst nematode, found from soybean roots in Korea in 2016. About 111 samples 41.1% contained cysts among 270 soil samples collected from soybean field. Among them 77% were *H. glycines* and 23% were *H. sojae* indicating that *H. sojae* is widely distributed in soybean fields. Among the *H. sojae* populations, six populations were selected and tested for their genetic diversity using resistant cultivars. Six populations of *H. sojae* in Korea could reproduce on PI88788, PI209332 and PI548316 and could be designated as HG type 2.5.7. They could not reproduced (0-4%) on PI548402 (Peking), PI90763, PI89772 and PI437654.

DELINEATION OF TWO ACROSTICHUS CRYPTIC SPECIES ASSOCIATED WITH DIFFERENT NEW WORLD RHYNCHOPHORUS WEEVILS BY MOLECULAR SEQUENCES AND HYBRIDIZATION TESTS. **Kanzaki, Natsumi[1,2] and R. M. Giblin-Davis[2].** [1]Kansai Research Center, Forestry and Forest Products Research Institute, 68 Nagaikyutaroh, Momoyama, Fushimi, Kyoto, 612-0855, Japan. [2]Fort Lauderdale Research and Education Center, Department of Entomology and Nematology, University of Florida/IFAS, 3205 College Avenue, Davie, FL 33314-7799.

A new *Acrostichus* species was delineated based upon hybridization tests, re-examination of morphology, molecular sequences, and insect host associations. This new species had been circumscribed within the description of *A. rhynchophori* which had originally been described from morphologically identical host isolates from two geographically separated species of New World *Rhynchophorus* palm weevils, i.e., *R. cruentatus* from South Florida (culture code RGD193) and *R. palmarum* from Central and South America (culture codes RGD194-196). The newly delineated species is from *R. palmarum* host isolates from Central and South America (RGD194-196) versus the host isolate from *R. cruentatus* from South Florida (RGD193) which is being designated as the type strain of *A. rhynchophori*. Sequences from ribosomal DNA loci (near full-length of small subunit, full length of internal transcribed spacer and D2-D3 expansion segments of large subunit) and partial mitochondrial cytochrome oxidase subunit I gene and hybridization testing corroborated the independent species status of RGD194-196. In the hybridization test, a strain of the new cryptic species, RGD195, exhibited partial reproductive isolation from the other two strains, RGD194 and RGD196, i.e., the fecundity of F1 progeny was low, suggesting further geographical isolation within this widely-distributed amphimictic species.

INVESTIGATING THE BIOCONTROL CAPABILITIES OF SELECT NATURAL FUNGAL ISOLATES AGAINST SOYBEAN CYST NEMATODES. **Kim, Dong-gyu**[1], **D. Haarith**[2], **K. Bushley**[3], **S. Chen**[2]. [1]Biochemistry, Molecular Biology and Biophysics, University of Minnesota, Minneapolis 55455. [2]Department of Plant Pathology, University of Minnesota, Saint Paul 55108. [3]Plant and Microbial Biology, University of Minnesota, Saint Paul 55108.

The soybean cyst nematode (SCN; *Heterodera glycines*) is an economically consequential pathogen of soybean plants, capable of causing drastic yield losses in affected plots. Fungal biocontrol agents, for which numerous candidates may be found in fungal populations endowing soybean plots with natural antagonism against SCN, may provide an alternative to current environmentally detrimental or economically unfavorable SCN management practices. This study examined the biocontrol capabilities of twenty fungal isolates from distinct genera (*Fusarium*, *Ilyonectria, Chloridium, Exophiala, Purpureocillium, Mortierella, Pochonia, Trichoderma, Alternaria, Cladosporium, Clonostachys, and Mariannaea)*, selected based on their *in vitro* parasitic and nematotoxic capabilities, in realistic greenhouse assays to assess their potentials as biocontrol agents against SCN. SCN-susceptible soybean cultivar "Sturdy" was chosen to be challenged with fungi and SCN in this study. Fungal spores of each fungal candidate were inoculated alongside race 3 population of SCN eggs in fresh soil obtained from two distinct geographic locations (Crookston and Waseca, Minnesota). Suitable controls for biocontrol candidates, SCN, and native soil microbiomes were also factored in the Randomized Complete Block design. Soybean plants were destructively sampled 30 days post-infection for assessment of fungal isolate biocontrol capabilities. Native soil microbiomes were evaluated through metabarcoding analyses of bacterial 16S ribosomal RNA and fungal internal transcribed spacer 1 (ITS1) sequencing. The biocontrol capabilities of fungal isolates against SCN were quantified by evaluating SCN cyst counts and soil egg density. Analysis of Variance (ANOVA) on data acquired from aforementioned parameters suggest further screening of effective isolates in combinations, as well as implications of native soil microbiome composition on biocontrol efficacy.

EXTENSION NEMATOLOGY IN THE MID-SOUTH: WHERE DO WE GO FROM HERE? **T. L. Kirkpatrick[1] and Julie Robinson[2].** [1]University of Arkansas System Division of Agriculture, Department of Plant Pathology, Fayetteville, AR 72701 and [2]University of Arkansas Division of Agriculture, Cooperative Extension Service, Little Rock, AR 72204.

Although cotton and soybean are still the "king" in the Mid-South, crop production practices – and nematode dynamics have changed considerably in the last 30 years. The reniform nematode, *Rotylenchulus reniformis* has advanced from an occasional pathogen in cotton mainly encountered along the Gulf Coast to become the most widespread and significant nematode parasite of the crop throughout much of the region. In contrast, the soybean cyst nematode, *Heterodera glycines*, that was considered the most important nematode of soybean throughout the region during the 1980s, is not even considered a threat in much of the Mid-South. Even in Arkansas with about 3.5 million acres of soybeans, this nematode occurs in only about 30% of the fields. Nematode management strategies have also changed. Carbamate and organophosphate nematicides that were the first line of defense for many cotton growers are no longer available – replaced with softer, but many times less effective products. Unfortunately, high levels of genetic resistance to major nematodes of both cotton and soybean has not been forthcoming. Crop rotation systems, the use of cover crops, and strategic deployment of available nematicides and resistant cultivars will become increasingly important in nematode management. Timely, science-based information for growers is just as important as ever, but the mechanisms of information exchange have changed dramatically. Growers have access to information (correct, incorrect, and irrelevant) instantaneously, anytime day or night. As in the past, the responsibility for sorting and validating this information so that it can be effectively used will continue to fall on Extension specialists – as will much of the applied, problem-solving research that will be required to keep agriculture sound and profitable. Extension nematologists will be just as vital to the long-term health of Mid-South agriculture in the next 30 years as they were for the last 30 years. How well we meet these needs will to a large degree mirror the economic success or failure of row crop farming in the mid-southern U.S.

SUSCEPTIILITY AND YEILD LOSS RELATIONSHIPS OF *MELOIDOGYNE HAPLA* AND *M. INCOGNITA* INFECTING *CANNABIS SATIVA*. **Kotcon, James, K. Wheeler, R. Cline and S. Carter.** Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506.

Industrial hemp (*Cannabis sativa*) is re-emerging as an agricultural crop, however little is known regarding its interaction with root knot nematodes. Three greenhouse and lab bench trials were conducted to evaluate the impact of *Meloidogyne hapla* and *M. incognita* on *C. sativa*. In the first trial, *Cannabis* cultivars Canda, Delores, Futura, Fedora, and Felina 32 were grown in the greenhouse in 250 cm^3 plastic plots with a steamed 1:1 sand-soil mix, and inoculated with 2000 eggs of either *M. hapla* or *M. incognita*, or were uninoculated. Nematode gall production 40 days after inoculation was observed on inoculated plants of all cultivars with both nematode species, but no egg production was observed. *M. incognita* produced more galls on Canda than on Felina 32 or Futura, while *M. hapla* produced more galls on Felina 32 than all other varieties. A second experiment compared nematode reproduction on *Cannabis* cultivars Canda and Felina 32 and a susceptible tomato cultivar, Mountain Majesty, at 39 and 60 days after inoculation. Plants were grown on the lab bench at 22 C with a 14-hour photoperiod. Gall and egg production were observed with *M. hapla* and *M. incognita* on Canda and Mountain Majesty, but not with Felina 32 at 39 days after inoculation. Both nematode species produced eggs on all hosts at 60 days after inoculation. In the second experiment, gall and egg production by *M. hapla* at 60 days after inoculation were not significantly greater on Felina 32 than on Canda. Gall and egg production by *M. incognita* was greater at 60 days after inoculation on Canda than on Felina 32. Egg production on tomato cultivar Mountain Majesty was significantly greater than on either *Cannabis* cultivar with either nematode species. In the third trial, Canda and Felina 32 were inoculated with 0, 1, 10 and 100 eggs/cm^3 soil in 600-cm^3 pots, and grown for 60 days on a lab bench at 22 C. The photoperiod was initially set at 14 hours, but was adjusted to 17 hours when some plants exhibited premature flower induction. Shoot weight of Canda was reduced by 50% at the highest inoculum rate, whereas shoot weight of Felina 32 was not reduced, compared to uninoculated plants, however, differences were not statistically significant. The variety by nematode species interaction observed in the first two experiments was not significant in the third trial. We conclude that all five cultivars of *Cannabis* are moderately good hosts for root knot nematode, although some differences in nematode reproduction among varieties were observed. *Cannabis* cultivars exhibit high variability and sensitivity to minor changes in environmental conditions, and field trials will be needed to confirm yield differences.

ROTATION CROPS FOR MANAGEMENT OF *PRATYLENCHUS PENETRANS* IN CONNECTICUT. **LaMondia, James A.** The Connecticut Agricultural Experiment Station Valley Laboratory, PO Box 248, Windsor, CT 06095.

The lesion nematode *Pratylenchus penetrans*, can directly affect perennial strawberry plantings and is associated with fungal root rots in the strawberry black root rot complex. Management of the disease complex is currently achieved through reducing the number of lesion nematodes by crop rotation, but these rotations require multiple years out of strawberry. We evaluated 4 rotation regimes in replicated field microplots to determine whether 3 potentially nematode-antagonistic crops grown in sequence within one year could effectively manage lesion nematodes within a shorter 1-year time frame. Rotation crops were planted in spring (10 May 2016), summer (7 July 2016), and fall (21 September 2016). Rotation crop sequence treatments consisted of: 1) oats (*Avena sativa*) plus crimson clover (*Trifolium incarnatum*), followed by no-till soybeans (*Glycine max*), and a fall planting of no-till rye (*Secale cereal*) plus hairy vetch (*Vicia villosa*); 2) Hockett barley (*Hordeum vulgare*), followed by no-till buckwheat (*Fagopyrum esculentum*), and a fall planting of no-till wheat (*Triticum aestivum*); 3) Pacific Gold (*Brassica juncea*) tilled in prior to Trudan 8 sudangrass (*Sorghum bicolor*) tilled in prior to Tifgrain 102 millet *(Pennisetum glaucum*) plus Nitro daikon radish (*Raphanus sativus*); and 4) *Avena strigosa* black oats, followed by no-till millet plus *Rudbeckia hirta*, and a fall planting of Dwarf Essex (*Brassica napus*) tilled in spring 2017. Lesion nematode populations were monitored using a soybean bioassay. Roots and soil in plots were sampled and the number of lesions per g soybean root werer counted after 3 weeks. In microplots, lesion nematode populations were lower after a full year for rotation sequences 3 and 4 than for rotation treatments 1 and 2 ($P = 0.01$).

ASSISTING SMALLHOLDER FARMERS IN ADOPTING INTEGRATED NEMATODE-SOIL HEALTH MANAGEMENT: II-FUZZY COGNITIVE MAPPING IDENTIFYING GAPS BETWEEN EXPERTS AND FARMERS PERCEPTIONS. **LaPorte, P.[1], C. Chan[1], B. S. Sipes[1], A. Sanchez[2], A. Sacbaja[2], and H. Melakeberhan[3].** [1]University of Hawaii (UH) at Manoa, Honolulu, HI 96822 USA. [2]Faculty of

Agronomy, University of San Carlos (USAC), Guatemala City, Guatemala. [3]Dept. of Horticulture, Michigan State University (MSU), East Lansing, MI 48824 USA.

Alleviating the intertwined and grand challenges of food and nutritional insecurities have been a major focus of the USAID's Horticulture Innovation Laboratory. Plant-parasitic nematodes (PPN) and poor soil health negatively affect potato yield of smallholder farmers in the Highlands of Guatemala. Farmers' limited knowledge of the cause-and-effect relationships between agricultural practices, soil health, PPN, and potato yield may limit their adoption of best practices. To overcome these challenges, we need to better understand where farmers perceptions diverge from the perceptions of agricultural experts to design better extension programs. Fuzzy cognitive mapping was used to assess the perceptions of agricultural professionals (17) at USAC and smallholder potato farmers (45) in Paquix in the Western Highlands of Guatemala regarding the influence of agricultural practices on soil health and PPN. We compared the community maps of these two groups to identify differences in the signs (negative or positive influence) and the weights (low, moderate or high influence) in the relationship between agricultural practices, PPN, and soil health. The only difference in sign between experts and smallholder farmers was found on the perceived influence of certified seeds on PPN. Farmers perceived certified seeds will increase PPN. Major differences are found in the weights of the relationships of practices and PPN and soil health between experts and smallholder farmers. In the farmer community map, many weight values were close to zero because of the lack of consensus among farmers. Weights tended to be directionally stronger in the expert model. A squashing function was applied to run intervention scenarios for five agricultural practices: certified seeds, compost, biocontrol, chicken litter and nematicide. The output impact on yield, PPN and soil health are mostly similar directionally except for application of compost, certified seeds and pesticides. Experts map shows certified seeds and compost reduce PPN. Farmer's map showed using certified seeds increase yield. Understanding the knowledge gaps of farmers and experts helps taylor the development of extension activities to ameliorate knowledge gap and promote higher rates of adoption of 'best' practices that will lead to enhanced soil health, higher potato yield, lower PPN and improved farmer livelihoods.

NEMATICIDAL ACTIVITY OF SECONDARY METABOLITES PRODUCED BY SELECTED PLANT GROWTH PROMOTING RHIZOBACTERIA AGAINST HETERODERA GLYCINES. **Lawaju, Bisho Ram, N. Xiang, K. S. Lawrence, and J. W. Kloepper.** Department of Entomology and Plant Pathology, Auburn University, Auburn, AL 36849.

Plant Growth Promoting Rhizobacteria (PGPR) are rhizosphere bacteria known to promote plant growth and inhibit different plant pathogens including plant-parasitic nematodes through production of a range of secondary metabolites. Recently, there has been much interest in identifying these metabolites as a biological alternative to chemical nematicides. In total, 663 PGPR strains were assayed for their nematicidal activity by co-culturing them with 30-50 second stage juveniles (J2) of *Heterodera glycines.* Their nematicidal effect was determined by observing the response of juveniles to Na_2CO_3. The juveniles changed their body shape from straight to curled or hook-shaped and showed quick movements within 2 minutes of addition of 1 µl of 1 N Na_2CO_3 if alive while dead ones did not respond. Eight PGPR strains showing the highest effect on J2s after 48 hours of co-culture were grown in Tryptic Soy Agar (TSA) for 10 days. The cell biomass (≈100 mg) from these plates were collected in 1ml sterile water, and the cells were lysed by repeated exposure to boiling (in water bath) with intermittent cooling in ice for 15 minutes. The lysis was followed by removal of cell materials by centrifugation at 4,500 rpm for 5 minutes. The cell-free supernatants were collected as crude extracts, and their efficacy against the J2s was tested *in vitro* in 96 well plates. The *in vitro* results indicated that of the eight strains tested, five strains: *Bacillus altitudinis* (Bal13), *B. mojavensis* (Bmo3), *B. safensis* (Bsa27), *B. aryabhattai* (Bar46), and *B. subtilis* subsp. *subtilis (*Bsssu2*)* produced metabolites that were significantly more toxic to J2s of *H. glycines* compared to the control and other PGPR strains tested ($P \leq 0.05$). Future studies will attempt to purify, identify, and determine the lethal concentration of these metabolites for the management of plant-parasitic nematodes.

FIELD SURVEY IN NEMATOLOGY. **Kathy Lawrence.** Department of Entomology and Plant Pathology, Auburn University, Auburn, AL 36849.

The Field Survey class if offered to graduate students in Plant Pathology during the summer semester. This course focuses on the practical aspects of plant disease management. Our main objective of the course is to give students "real world" experiences with plant diseases and the agricultural industry. On site visits via field trips to producer's fields, greenhouses, and markets along with onsite visits with the agriculture industry corporations gives the students an understanding of the agriculture business as it relates to plant pathology from multiple perspectives. In each tour the students visit with university, extension, and USDA scientists as well as Ag industry representatives including scientists in research and development, technical support, and sales. We also visit the crop consultants of all types and grower families. Students have the opportunity to see a diversity of career opportunities and options in plant pathology, particularly in the applied field aspects as well as demonstration of the technical and soft skills needed to be effective in these careers.

THE ROLE OF THE CADAVER IN ENTOMOPATHOGENIC NEMATODE SURVIVAL: IT'S NOT JUST A BAG OF BACTERIA AFTER ALL. **Lewis, Edwin[1] and D. I. Shapiro-Ilan[2].** [1]Dept. Entomology, Plant Pathology and Nematology University of Idaho, Moscow, ID 83844. [2]USDA ARS, SEFTNRL, Byron, GA 31008.

Entomopathogenic nematodes (EPNs) survive in all sorts of soil conditions. They have been isolated from extreme environments that include desert conditions, freezing, high salinity, apparent absence of hosts and unpredictability. Often survival is measured only with the infective stage juvenile in mind because of this stage's importance in the biological control of insect pests. Infective juveniles search for hosts only; they do not search for food or mates, nor do they develop. Much of the published work on EPN survival exposes infective stage juveniles to environmental extremes and records outcomes. But, most stages of the life cycle of these nematodes reside inside their host cadavers. We have asked in many different ways what is the contribution of the infected cadaver to survival of EPN populations, beyond its role as an essential food source? We have recorded the direct impact of the cadaver on EPN survival in terms of protection from freezing and desiccation of the nematodes that are inside. We have also measured improved fitness and survival of infective juvenile nematodes when they emerge directly into soil as compared with infective juveniles harvested in the more traditional White trap. While for biological control purposes we focus on survival and infectivity of infective stage juvenile nematodes, their actual population biology and structure may be largely driven by conditions during the ongoing infection within their host cadaver.

FLUOPYRAM-TREATED CARROT SEED REDUCES SEEDLING DAMAGE BY THE SOUTHERN ROOT-KNOT NEMATODES. **Loffredo, Angelo, J. de Oliveira Silva, and J. O. Becker.** Department of Nematology, University of California, Riverside, CA 92521.

Fresh market carrots grown in California account for approximately 80% of the US production. Several species of root-knot nematodes (rkn, *Meloidogyne* spp.) are of major production concern. They may cause seedling stunting, root forking and galling, as well as limit the attainable yield. Presently, only fumigant nematicides are registered against rkn, but regulatory, environmental and economic issues drive the search for alternatives. Carrot cultivars resistant to rkn are under development but not yet commercially available. We have shown previously that in rkn-infested carrot fields a seed coating with abamectin mitigates rkn-caused root damage. Fluopyram has been known for nearly a decade as a broad-spectrum succinate dehydrogenase-inhibiting fungicide. More recently, it was registered as a soil nematicide and as a seed treatment for soybeans. The trial objective was to evaluate the efficacy of fluopyram seed treatments on carrots against the early attack of rkn in greenhouse trials. Plastic cups (850 cm^3) were filled with a pasteurized sandy loam soil that was infested with 200 eggs of *M. incognita*/100 cm^3. Each cup was sown with carrots seeds cv. Choctaw treated with thiram (1.87 g/kg seed), metalaxyl (0.153 g/kg seed) and fluopyram at various rates (0.006 mg/seed, 0.01 mg/seed, or 0.035 mg/seed). Soil treated with fluazaindolizine (1.2 µl/750 cm^3) served as a chemical control treatment. A non-treated check and the chemical control were sown with seed that was only treated with thiram and metalaxyl. The trial was set up as a randomized complete block with five replications, and it was repeated once. Gall ratings were arcsine transformed and subjected to ANOVA. All seeds sprouted evenly with no signs of phytotoxicity. The highest fluopyram rate reduced galling by three rating classes (Zeck's 0-10) compared to the control and was not different from the chemical check. These preliminary results confirm fluopyram's excellent efficacy at a low seed-delivered application rate.

DOMINUS®, A BROAD-SPECTRUM SOIL BIOFUMIGANT BY ISAGRO USA, INC. **Longland, Julie Miranda, and Allan, M. A**. Isagro USA, Inc., 430 Davis Drive, Suite 240, Morrisville, North Carolina, 27560.

Isagro USA focuses on developing an expanding bio-solutions portfolio designed to serve growers seeking to meet consumer demand for more natural and organic food production. Designed for use on both conventional and organic farms (pending USDA NOP approval, 2018), Dominus® is a biologically-based, USA EPA-registered, soil treatment that controls soil-borne fungi, nematodes, weeds, and insects in a wide range of crops including fruits, vegetables, turf, and ornamentals. Dominus® contains the active ingredient allyl isothiocyanate (AITC), a synthetically-produced biopesticide based upon a naturally-occurring, plant-derived chemical defense mechanism found in the Brassicaceae family. The liquid formulation (96% a.i.) can be applied using conventional soil injection methods and equipment at pre-plant rates of 10-40 gallons/acre (or 85-340 pounds/acre) and post-harvest crop termination rates of 3-20 gallons/acre (or 25.5-170 pounds/acre). Since 2009, Dominus® has undergone rigorous testing in the USA as well as Canada, Egypt, Italy, Lebanon, Morocco, Syria and Turkey. Current data will be presented.

CONSERVATION BIOLOICAL CONTROL OF COFFEE BERRY BORER IN HAWAI`I BY APPLYING NITROGEN FIXING TREE MULCH TO ENHANCE EFFICACY OF ENTOMOPATHOGENIC NEMATODES. **Martiney, Christina L. and K.-H. Wang.** University of Hawai'i at Mānoa, 3050 Maile Way, Honolulu, HI 96822.

Coffee berry borer (*Hypotehnemus hampei*) (CBB), is the world's primary pest for coffee production worldwide. In Hawai`i, current management strategies include field sanitation and repeated applications of an entomopathogenic fungus, *Beauveria bassiana*. Using indigenous soil-dwelling entomopathogenic nematodes (EPNs) as a biological control agent against CBB in infested coffee cherries that drop on the ground would offer an economically viable management approach. The objective of this research was to examine the use of nitrogen-fixing tree (*Leucaena leucocephala* var KX2) mulch under the coffee tree canopy to enhance infectivity of EPN on CBB. Two field trials were conducted at Poamoho Experiment Station at the University of Hawai`i. The first trial examined the effect of mulch (M) vs no mulch (NM) on CBB mortality and infection rate of EPN on CBB. Field cages made of 80-mesh (Kleen-Rite Corp) stainless steel spray strainer containing 3 CBB infected coffee cherries were buried in the soil under M and NM coffee canopies. Cherries retrieved 1 week after burial revealed 23% EPN infection in M vs 6% infection in NM, though the averages were not different ($P > 0.05$). The second field trial was conducted at the same site arranged in a 2 × 2 (Mulch × EPN inoculation) factorial design. Indigenous EPN, *Heterorhabditis* sp. H1 isolated from the same field, were introduced at 31,000 IJs /0.9 m^2 quadrant near the tree trunk through 1 L of water. Repeated measures over 6 sampling dates in 3 months after initiation of experiment showed that mulch enhanced EPN infection by 70% ($P > 0.05$). This could be partially attributed to higher soil moisture in M compared to NM plots ($P < 0.001$). However, CBB death or% CBB infected by EPN were not affected by EPN application vs no application. None-the-less,% CBB infected by EPN was 13% less than in the no EPN application. This indicated that the EPN application was not effective as a biocontrol agent. This could be due to low virulence of the EPN being applied. Research in progress is to identify a more virulent strain of indigenous EPN against CBB in Hawaii and to develop a more effective EPN inundative release method.

THE GENOME OF THE BURROWING NEMATODE, RADOPHOLUS SIMILIS. **Mathew, Reny and C. H.Opperman** Department of Entomology & Plant Pathology, North Carolina State University, Raleigh, NC 27695.

The burrowing nematode *Radopholus similis*, is a devastating pathogen of citrus, banana, anthurium, black pepper, and numerous other economically important crops and ornamentals. Our project is focused on characterizing and understanding the genomic makeup of *R. similis* and identifying key genes that distinguish it from its sedentary counterparts. We sequenced the *R. similis* genome utilizing two different platforms; Roche 454 and Illumina HiSeq. The genome size is ~65.5 Mb assembled into 8176 contigs (Roche 454) and 7357 contigs (HiSeq). Efforts are ongoing to merge these assemblies to gain a more complete coverage. The completeness of the genome assembly was assessed using Core Eukaryotic Gene Mapping Approach (CEGMA) and Benchmarking Universal Single Copy Orthologs (BUSCO). CEGMA analysis indicates approximately 93% completeness in terms of genome coverage while BUSCO analysis showed approximately 67% BUSCOs (complete & partial) in the *R. similis* genome. Additionally, CEGMA analysis revealed approximately 2 orthologs per CEG, implying that *R. similis* may have undergone a recent genome duplication event. Gene prediction using Augustus and SNAP revealed 13,211 and 15,315 genes, respectively. Additionally, we performed tblastx, utilizing 7,382 EST sequences downloaded from the public database, as query sequences against the *R. similis* assembly and obtained approximately 94% alignment of the transcripts with the genome. *In silico* functional annotation of the genome was performed using the Blast2Go platform and manual curation is being employed for deeper analysis of selected pathways. Automated functional annotation included GO analysis, InterPro Scan, KEGG analysis and PFAM. Sequences coding for five different classes of enzymes, namely, oxidoreductases, lyases, ligases, hydrolases and transferases were identified and compared with other plant-parasitic nematodes. Furthermore, we utilized OrthoMCL to uncover the various orthologous groups present in *R. similis*. Notably, using this approach, we found 31 nuclear hormone receptor genes (*NHR)*, 63 g protein-coupled receptor genes (*GPCR)* and 22 collagen genes among other families. Additionally, we examined the kinome of *R. similis* by coupling OrthoMCL and the Kinomer database. OrthoMCL predicted 411 kinases, which can be grouped into 249 orthologous groups. Utilizing this approach, we identified six different kinases in *R. similis* also occurring in *Brugia malayi* which were absent in *Caenorhabditis elegans* and *C. brigssae.* This might indicate a role for these kinases in parasitism. Furthermore, we examined several developmental and behavioral pathways, including dauer formation, sex determination, chemonsensory, and RNAi orthologs. Research is on-going to identify possible syntenic regions with other plant-parasitic nematodes and clarify the evolutionary position of this nematode in the phylogenetic tree.

RELATEDNESS AMONG SOIL NUTRIENT LEVELS, NEMATODE POPULATIONS, AND NEMATODE ECOSYSTEM FUNCTIONS IN WHEAT AGROECOSYSTEMS. **Matute, Martin. M[1], A. H. Carter[2], and J. Sherman[3]**. [1]Department of Natural Sciences, University of Arkansas-Pulaski Tech College, North Little Rock, AR 72118. [2]Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164. [3]Plant Sciences and Plant Pathology Department, Montana State University, Bozeman, MT 59717.

Organic and inorganic soil amendments meant to enhance plant growth and productivity are normally applied in composite forms. Effects of application of manure and phosphate fertilizers are normally interpreted simply as manure versus no-manure or fertilizer versus no-fertilizer effects. We were interested in determining the effects that individual soil elements have on soil ecosystem functions that might have a bearing on plant life. We used soil nematodes as indicators of changes in the environment because of their abundance, because they occupy all trophic levels of the soil food web, and they are in direct contact with their environment. We collected soil samples from three *Triticum aestivum* (winter wheat) fields in Washington, preplant, at mid-season, and at harvest. Ten rows were randomly selected from each field and a composite sample consisting of up to 10 cores was obtained with a foot-driven manual soil sampler. Nematode extraction, identification, and categorization, as well as nematode faunal analysis, were carried out according to standard methods. Soil analysis for mineral elements was carried out by the University of Arkansas Soil Laboratory (Mariana). Changes in nematode populations and ecosystem function levels as well as changes in the levels of soil elements were calculated using simple percentages, relative to pre-plant data. Soil nematodes of all trophic groups, herbivores, bacterivores, fungivores, predators/carnivores, and the omnivores, were recovered. Eleven elements were quantified from the soil analysis -N, P, K, S, Mg, Ca, Fe, B, Mn, Zn, and Cu. The elements N, Ca, Mn, Mg, Zn, and B were negatively related to the bacterivorous nematodes and positively related to the other soil nematode feeding groups. Likewise, the elements P, K, S, Cu, and Fe were positively related to the bacterivorous nematodes and negatively related to the other nematode feeding groups. Individual elements affected nematode population-derived ecological indices or functions the same way they related to nematode population levels. For example, the bacterivore metabolic footprint, the enrichment metabolic footprint, and the enrichment index, were all positively related with P, K, S, Cu, and Fe and negatively related to N, Ca, Mn, Mg, Zn, and B. This trend was generally the same across all three sampled sites, despite their physico-chemical soil differences. It is thus possible to characterize soil elements and soil nematode feeding groups into two main categories based on their interactions and effects on ecosystem functions.

BIOACTIVE METABOLITES: CAPITALIZING ON NATURALLY DERIVED NEMATODE-ANTAGONISTIC ACTIVITY. **Meyer, Susan L. F.** USDA, ARS, NEA, Mycology and Nematology Genetic Diversity and Biology Laboratory, Beltsville, MD 20705, USA.

Many plants, fungi and bacteria produce compounds that are active against plant-parasitic nematodes, and management strategies are enhanced by use of these organisms and their antagonistic metabolites. Management practices can include selection of cover crops that produce nematotoxic compounds and have potential to suppress phytoparasitic nematode populations on subsequent cash crops. Microbes with biological control activity are applied live, and are also used as sources of biologically based nematicides. Plants associated with endophytic fungi may have increased resistance to nematodes, and the association can result in the presence of metabolites not found in plants without the endophyte. As with all management strategies, a myriad of factors is involved in successful implementation. Several of these are selection of plant cultivars and cultivar/endophyte associations, variable activity of metabolites against different nematode taxa, and breakdown of active compounds in the soil. For example, the antibiotic diacetylphloroglucinol, produced by some isolates of the bacterium *Pseudomonas fluorescens*, has variable toxicity to nematodes from different genera. Winter rye (*Secale cereale*) produces glucosides of benzoxazinoids that break down to form nematotoxic compounds, but rapid degradation in the soil results in limited exposure to plant-parasitic nematodes. Associations between grasses and endophytic fungi, including tall fescue (*Schedonorus arundinaceus*) and *Neotyphodium coenophialum*, can contribute to host plant resistance and suppression of nematode populations. However, the nematode suppression varies with plant cultivar, endophyte strain and nematode taxon. These examples illustrate the intricacies and the potential of nematode management tools that incorporate bioactive metabolites.

SNAILS AND ROOT-KNOT NEMATODE DISPERAL. **Michaud, Amy and Caswell-Chen Edward.** Dept. of Entomology and Nematology, University of California Davis, 1 Shields Ave, Davis, CA 95616.

Dispersal is a fundamental life history phenomenon with fitness consequences for individuals, populations, and communities. Dispersal is particularly significant with respect to parasite dissemination among hosts. *Helix aspersa*, the brown garden snail, is common in California, especially in agricultural settings. As snails move and feed, they encounter and have the potential to consume a diverse array of meiofauna. If snails consume plant-parasitic nematode propagules (e.g., eggs or infective juveniles) present in their food, and the nematodes survive the passage through the digestive tract, viable nematodes may be moved from their natal location and deposited with snail feces some distance away. Because plant-parasitic nematodes are small, and have limited capacity to disperse independently, snails may represent a potential long-distance dispersal mechanism. Here we report our experimental results that egg masses of the root-knot nematode (*Meloidogyne javanica)* consumed by snails survived transit through the snail digestive tract. The eggs recovered from feces were viable, and the juveniles that hatched from those eggs infected host plants. Snails were allowed to feed for 5 days on carrot discs upon which had been placed intact *M. javanica* egg masses. Snail fecal pellets were collected daily and disrupted in water by bombardment with zirconia/silica beads. The resultant aqueous suspension was diluted, and a subsample of eggs, injective juveniles and other nematodes were enumerated using a dissecting microscope. A subsample of fecal pellets were placed on Baermann funnels and were sampled every 24 hours for up to 10 days to quantify egg viability by monitoring hatching. A subsample of the freshly-hatched infective juveniles were added to tomato seedlings and the roots were evaluated for galling after 6 weeks. We recovered eggs from fecal pellets within and up to 48 hours after ingestion of egg masses, and eggs hatched for at least 10 days. In the samples of eggs from which juveniles were recovered, those juveniles successfully infected and induced symptoms (gall formation) in 61% of host plants. Snails may act as dispersal, potentially phoretic, hosts of plant-parasitic nematodes and represent an underrecognized means of dispersal.

EFFECTS OF FLUOPYRAM ON RADOPHOLUS SIMILIS IN ANTHURIUM PRODUCTION. **Myers, Roxana[1], C. L. Mello[1], B. Bushe[2], J. Lichty[2], A. H. Hara[2], and B. S. Sipes[3]**. [1]USDA, ARS, DKI-PBARC, 64 Nowelo St., Hilo, HI 96720. [2]College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, 875 Komohana St., Hilo, HI 96720. [3]CTAHR, University of Hawaii at Manoa, 3190 Maile Way, Honolulu, HI 96822.

Radopholus similis causes a severe reduction in the size and yield of flowers of *Anthurium andraeanum*. An application of fluopyram every three months was evaluated in a commercial grower's field for its effect on populations of *R. similis*, plant health, and yield of cut flowers. After two applications, cut flower size and yield of *A. andraeanum* 'Starlight' began to increase among treated plants. One year after the initiation of the experiment the average yield increase was 26% compared to the untreated control. Monthly sampling of roots and surrounding cinder indicated nematode populations were lower in treated plants versus untreated controls following the first fluopyram application with an average population reduction of 55% in the first six months of the trial. Following the third application, the trend began to reverse as treated plots had increasing root masses and could support higher nematode populations. More robust roots were observed on the surface of cinder beds along with an increase in foliage production in the fluopyram treatment. Measurements of the canopy cover after one year showed an increase of 30% in leaf mass in fluopyram treated plots compared to untreated controls. Fluopyram applications appear to have potential in mitigating the damage caused by *Radopholus similis* in anthurium cut flower production.

NIMITZ®, A NON-FUMIGANT, CONTACT NEMATICIDE: UPDATE OF NEW REGISTRATIONS IN THE USA. **P. A. Navia Gine, D. J. Erasmus, S. R. Eskelsen**. ADAMA Agricultural Solutions, Raleigh, North Carolina.

NIMITZ® is an efficacious nematicide providing control of plant-parasitic nematodes with minimal impact on beneficial nematodes. In comparison to fumigants, application of NIMITZ is simple, and "*… represents a safer alternative for nematode control with a new mode of action and a much simpler and straightforward product label.*" (U.S. Environmental Protection Agency, Federal Docket, July 24, 2014). NIMITZ is labelled with a 'CAUTION' signal word. NIMITZ requires no Fumigant Management Plans, no 24-hour field monitoring, no buffer zones, has a 12 hr re-entry interval (REI) and minimal personal protective equipment (PPE). In addition to earlier registrations for fruiting vegetables and cucurbits in 2014, the following crops were added to the label in June 2016: Crop Group 4, Leafy vegetables (except Brassica vegetables), Crop Group 5, Brassica (Cole) leafy vegetables, Crop Group 13-07G, Low growing berries, including strawberry, and tobacco. More recently, in March and April of 2018, further crops were added to the NIMITZ 480 EC label. These are Crop group 1B, Root Vegetables (except sugar beet) subgroup, including carrot and radish; Crop groups 1C, Tuberous and Corm vegetables including potato and sweet potato; Crop Group 11-10, Pome Fruit; Crop Group 12-12, Stone Fruit; Crop Group 14-12, Tree Nuts; Crop Group 13-07D, fruit, small vine climbing subgroup including grapes and kiwi; and Sugarcane. The active ingredient, fluensulfone, has a unique mode of action which categorizes the product within a new chemical classification. NIMITZ causes irreversible nematicidal activity resulting in plant-parasitic nematode mortality within 24 to 48 hrs. NIMITZ provides competitive nematode control when compared to commercial available standard products. Application options include chemigation via drip-injection and sprinkler and soil-applied broadcast or banded spray followed by mechanical incorporation. And, depending on the crop, application is made at plant, 7-10 day pre-plant or at spring and fall root flush in perennial tree crops. NIMITZ is currently registered in 35 states and Puerto Rico. Two additional states are pending. The most recent Federal EPA labelled crops have been registered in these states with California state registrations in progress.

A NOVEL ROOT-KNOT NEMATODE RESISTANCE QTL IN COWPEA FROM SOUTHEASTERN AFRICA. **Ndeve, Arsenio[1], W. C. Matthews[1], J. R. P. Santos[1,2], B. L. Huynh[1], Y-N. Guo[3] S. Lo[3], M. Muñoz-Amatriaín[3], T. J. Close[3], and P. A. Roberts[1].** [1]Dept. Nematology, University of California, Riverside, CA 92521, USA. [2]Departamento de Fitopatologia, Universidade de Brasilia, Brasilia, DF, Brazil. [3]Dept. Botany and Plant Sciences, University of California, Riverside, CA 92521, USA.

The root-knot nematode (RKN) species *Meloidogyne incognita* and *M. javanica* cause substantial root system damage and suppress yield of susceptible cowpea cultivars. The narrow-based genetic resistance conferred by the *Rk* gene, present in some commercial cultivars, is not effective against *Rk*-virulent populations found in several cowpea production areas. The dynamics of virulence within RKN populations demand a broadening of the genetic base of resistance in elite cowpea cultivars. As part of this goal, F_1 and F_2 populations from the cross CB46-Null (susceptible) x FN-2-9-04 (resistant) were phenotyped for *M. javanica* induced root-galling (RG) and egg-mass production (EM) in controlled growth chamber and greenhouse infection assays. In addition, $F_{2:3}$ families of the same cross were phenotyped for RG on field sites infested with *Rk*-avirulent *M. incognita* and *M. javanica*. The response of F_1 to RG and EM indicated that resistance to RKN in FN-2-9-04 is partially dominant, as supported by the degree of dominance in the F_2 and $F_{2:3}$ populations (D/A = 0.4 – 0.5). Two resistance QTLs associated with RG and EM were detected on chromosomes Vu01 and Vu04 ($P<0.05$) of the SNP-based cowpea consensus genetic map. The QTL on Vu01 (PVE = 34% − 94%) was effective against the aggressive *M. javanica* isolate, whereas both QTLs (Vu01 − PVE = 27.9% and Vu04 − PVE = 73.4%) were effective against *Rk*-avirulent *M. incognita*. Allelism tests indicated that CB46 and FN-2-9-04 share the same RKN resistance locus on Vu04, but that the strong, broad-based resistance in FN-2-9-04 is conferred by the additive effect of a novel resistance locus on Vu01. This novel resistance in FN-2-9-04 is important for broadening RKN resistance in elite cowpea cultivars.

A 21ST CENTURY PHILOSOPHY OF APPLIED RESEARCH, EXTENSION OUTREACH AND CAREER PATHS IN EXTENSION NEMATOLOGY. **Noling, Joseph**. University of Florida, IFAS, Citrus Research & Education Center, Lake Alfred, FL 33850.

Nematology extensionists are agricultural educators who instruct students, growers and other members of the Ag community on a wide breadth of knowledge and skills, including nematode biology, ecology, environmental science, pest / crop management and agricultural technology. In addition to the educational component, the extensionist in nematology has a responsibility to communicate statistically relevant and needed information to agricultural producers regarding nematode population and cropping system responses to a diverse variety of physical, chemical, cultural and environmental factors. The extensionist generates the results and provides the technical expertise to evaluate the research, determine its effectiveness and of necessity to implement other corrective measures. Based on the outcomes of field and laboratory research, the extensionist develops recommendations and guides implementation of nematode management programs to be used by growers for plant and agricultural production. In addition to field oriented research, the nematology extensionist assumes responsibility for participating within and for developing educational programs which publish and disseminate useful research findings and ideas to growers in hopes of bringing about desirable changes in behavior and agricultural practices. It is an evolutionary process, which with each iterative cycle of research, improves the quality and impact of the extension program.

AERIAL IMAGING OF STRAWBERRY FIELDS USING DRONES TO ASSESS STING NEMATODE FIELD DISTRIBUTION, YIELD IMPACTS AND SOIL FUMIGANT PERFORMANCE. **J. W. Noling and S. M Buchanon.** University of Florida IFAS CREC, 700 Experiment Station Rd, Lake Alfred, FL 33850.

In Florida, the Sting nematode (*Belonolaimus longicaudatus*) is a very important yield limiting pest, infesting an estimated 40% of strawberry acreage. Yield losses and patchy field distributions of plant stunting are well correlated with soil population densities of the Sting nematode. For these studies, digital color imaging and end of season assessments of plant size were used to characterize the distribution and degrees of plant stunting, strawberry yield, and within row measures of green plant canopy cover. For relative yield determinations, the numbers of plants in four plant size categories were systematically recorded at 12 to 15 m intervals throughout the experimental areas within these fields. Plant size categories, measured as average canopy diameter, were dead (0), small (<20 cm), medium (>20 and <30 cm) and large (>30 cm). Relative yields were cumulatively derived for each plant size category from percentage contributions of maximum yield potential determined from previous research. Aerial imaging surveys of four commercial field locations were conducted on 28 November 2017, 13 December 2017, 22 January 2018 and 15 March 2018 using a DJI™ Phantom 4 Pro UAS drone carrying a DJI camera equipped with a 24mm 20MP Exmor R CMOS sensor. Image orthomosaics were created using DroneDeploy™ cloud software platform with an image resolution of 10 to 20 mm per pixel. Processed RGB and NDVI maps were analyzed using ESRI™ ArcGIS v10.33. Within these maps, green pixel counts were used to provide estimates of green canopy cover (% greenness) against a backdrop of black plastic mulch covering the raised bed. Strawberry canopy cover and relative yields derived from plant size assessments were compared using regression analysis and with commercial harvest yield information for some of the fields. Percent greenness (vegetative cover) computed from green pixels within plant rows was always highly correlated with relative strawberry yield and of commercially harvested strawberry yields expressed as flats per acre, explaining 77% to 92% of the variation between any two of the different response parameters. Accurate maps and assessments of fumigant treatment performance, GPS location, and sting nematode stunting severity of strawberry plants was well described by digital imaging using the DJI drones for field mapping. These results illustrate how digital imaging and greenness analysis can be used to provide quantitative measures of strawberry yield and to provide growers guidance on suitable alternatives to methyl bromide soil fumigation for nematode management. In addition to quantifying end of season strawberry production impacts, drone assisted aerial mapping will also enable assessment of strawberry transplant quality, disease incidence and severity, as well as to characterize end of season strawberry production impacts within disease impacted fields.

VERTICAL MANAGEMENT ZONES FOR STING NEMATODE CONTROL AND CROP RESPONSE IN FLORIDA STRAWBERRY. **Noling, Joseph[1] and J. Desaeger[2].** [1]University of Florida, IFAS, Citrus Research & Education Center, Lake Alfred, FL 33850, [2]Gulf Coast Research and Education Center, Wimauma, FL 33598.

For the second year in a row, field studies were conducted in 2017 to demonstrate the importance of deep fumigant placement and management of sting nematode, *Belonolaimus longicaudatus*, as a composite of vertical management zones located above and below a gas-impermeable traffic pan. To target deep soil profiles, new fumigant application systems were developed to shank inject fumigants 40 cm deep. The fumigant treatments included deep shank applications of 1,3-dichloropropene (Telone II™ at 18.4 L/ha) with or without fumigants applied in-the-bed (Telone C35 at 46 L/ha, PicClor60 at 38 L/ha, PicClor80 at 35.2 L/ha, and Pic100 at 33 L/ha). The differing formulations allowed evaluation of increasing chloropicrin use rates (21.4 to 45.9 kg/ha) for management of sting nematode and charcoal rot (*Macrophomina phaseolina*). Other fumigant treatments included bed shank and drip treatments of Paladin®-Pic (79/21% at 46 L/ha) with or without deep shank Paladin (76 L/ha), drip-applied metam potassium (KPAM® at 95 L/ha) and fluensulfone (Nimitz® at 1.66 L/ha). An untreated control with and without the deep shank Telone II ™ (18.4 L/ha) treatment was also included for comparison. Similar to 2016, strawberry yields in 2017 were unresponsive to application rates of chloropicrin greater than 21.4 kg/ha, with or without the deep shank Telone II treatment. This lack of response was not related to the level of sting nematode control achieved with the different rates and formulations of Telone or chloropicrin applied within the plant bed (vertical management zone 1). Strawberry yields were significantly ($P < 0.001$) increased for each Telone-Chloropicrin formulation applied to the plant bed when Telone II was deep shank applied (below the traffic pan) within vertical management zone 2. In an end of season assessment of relative yield in 10 other grower trials where deep shank Telone II treatments have been repeatedly applied for nematode control, average strawberry yield increased 5.1 percent. Strawberry yields increased 73% above that of the untreated control following only the deep shank Telone II treatment (18.4 L/ha). Additional yield increases of 30 to 41% were observed when the deep shank treatment was supplemented with an in-the-bed fumigant treatment. Additional chloropicrin in itself did not reduce sting nematode or disease-induced plant mortality at seasons end, but deep shanking Telone II numerically reduced plant mortality compared to the untreated control or in-the-bed only fumigant treatments. Nimitz® produced strawberry yields equivalent to the untreated control. Use of deep shank Telone II (18.4 L/ha) has greatly reduced sting nematode-induced yield losses in FL strawberry fields. We believe a primary cause of inconsistent nematode control using methyl bromide alternatives has been identified, and that supplemental fumigant applications, which consider the importance of vertical management zones, will be required to manage nematode pests in Florida strawberry.

ACTIVITY OF *CORYNESPORA CASSIICOLA* CULTURE FILTRATES ON MORTALITY OF *HETERODERA GLYCINES* J2S *IN VITRO*. **Nunes Rondon, Marina, B. Lawaju, and K. S. Lawrence.** Entomology and Plant Pathology Department, College of Agriculture, Auburn University, AL 36849.

The soybean cyst nematode (SCN, *Heterodera glycines*) is the most destructive plant-parasitic nematode in soybean-growing regions around the world. Different fungal genera have been associated with cysts of SCN and *Corynespora cassiicola* is one of them. The nematicidal activity of twelve culture filtrates obtained from *C. cassiicola* isolates was investigated *in vitro* against SCN J2s. Twelve *C. cassiicola* isolates were recovered from cotton and soybean symptomatic leaves sampled at different locations in Alabama. Then, isolates were grown for 21 days in potato dextrose agar broth (PDB), the cultures were filter-sterilized and stored at 4˚C prior to use. Ninety µL of each culture filtrate was placed into 96-well plates with 10 µL of SCN J2s suspended in sterile distilled water containing 20 to 50 SCN J2s, and incubated at room temperature for 48 hours. Sterile distilled water and PDB were the untreated controls. There were four replications for each culture filtrate and the experiment was repeated. Live SCN J2s were counted and recorded at the beginning of the experiment and 48 hours after exposure to the culture filtrates. The viability of SCN J2s was assessed applying 1 µl of 1N Na_2CO_3 at pH 10. Mortality percentage of SCN J2s was calculated and data were analyzed in SAS 9.4 using PROC GLIMMIX procedure, and LS-means were compared using the Tukey-Kramer method ($P \leq 0.05$). LS-means of SCN mortality ranged from 14.4 to 64.3% for the culture filtrates. Of 12 culture filtrates, three (PBU04, FHP22, and LIM13) were significantly more effective in killing SCN J2s, compared to other culture filtrates and untreated control ($P \leq 0.05$). Future investigation is needed to identify the compounds present in these bioactive culture filtrates from *C. cassiicola* with potential nematicidal activity against juveniles of *H. glycines*, as well as the potential of activity against other plant-parasitic nematodes species.

IDENTIFICATION OF APHELENCHOIDES SPP. ASSOCIATED WITH STRAWBERRIES IN FLORIDA. **Oliveira, Clemen[1,2], J. Desaeger[1], T. Watson[1], S. Vau[3], L. G. Freitas[2], R. N. Inserra[3].** [1]Entomology and Nematology Dept, University of Florida, Gulf Coast Research and Education Center, Wimauma, FL, 33568, USA. [2]Dept. Fitopatologia, Univ. Federal de Viçosa, Viçosa, Brazil. [3]Division of Plant Industry, DPI- FDACS, Gainesville, Florida 32614-7100, USA.

Florida is the second largest strawberry producer in the USA and supplies the eastern United States during late fall and winter months. The summer crimp nematode, *Aphelenchoides besseyi* is a foliar nematode that has damaged Florida strawberries in the past. After decades without any reports of foliar nematode infestations, *A. besseyi* has re-appeared in recent years in Central Florida strawberry farms. Nematode surveys have been conducted in these strawberry fields to monitor the populations of this nematode during the strawberry season. The results have shown that several unidentified foliar nematodes, morphologically different from *A. besseyi,* occur in leaves of both live and dead strawberry plants in these sites. Nematodes were extracted from strawberry leaves and cultured on the fungus *Monilinia fructicola* to obtain a sufficient number of specimens for morphological and molecular analyses. Comparisons of the morphological features of these populations with those of other species reported in the literature indicate that they belong to two species: *A. bicaudatus* and *A. fujanensis*. The detection of *A. bicaudatus* is a new record for Florida and that of *A. fujanensis*, is a new record for Florida and the United States. *Aphelenchoides fujanensis* was described in China and has been reported in Brazil. Molecular analyses of the cytochrome oxidase subunit I (COI), 18S rRNA, and 28S rRNA gene regions of these nematode species are still in progress.

LOST OPPORTUNITY: MUNGBEANS (*VIGNA RADIATA*) IN WHEAT CROPPING SYSTEMS FAVOUR *PRATYLENCHUS THORNEI*. **Owen, Kirsty[1], T. G. Clewett[1], K. L. Bell[2], and J. P. Thompson[1].** [1]University of Southern Queensland, Centre for Crop Health, Toowoomba, Queensland, Australia 4350. [2]Queensland Department of Agriculture and Fisheries, Toowoomba, QLD, Australia, 4350.

Due to their quick maturity, mungbeans (*Vigna radiata*) can be grown directly after wheat (*Triticum aestivum*) and are referred to as an opportunity crop in the sub-tropical rain-fed cropping systems of eastern Australia. Both crops are susceptible to the root-lesion nematode, *Pratylenchus thornei* which can result in high population densities when these crops are grown. *Pratylenchus thornei* is found in 75% of fields in this region of Australia and can cause up to 70% yield loss of intolerant wheat cultivars. We wanted to demonstrate the effects of a wheat/ mungbean/ wheat sequence on *P. thornei* populations and crop production. In Phase 1 of the field experiment, low or high *P. thornei* populations were established by growing moderately resistant (MR) or susceptible (S) wheat cultivars in a factorial design with three replicates. In Phase 2, one-month after harvest of Phase 1, treatments consisted of ten mungbean cultivars, one susceptible soybean cultivar and a clean fallow. In Phase 3, 2.5 months after harvest of the Phase 2 crops, intolerant wheat cv. Lincoln was grown. Soil was collected in four depth intervals to 90 cm (0–15, 15–30, 30–60 and 60–90 cm) at planting and after harvest of the Phase 2 treatments. Nematodes were extracted by the Whitehead tray method and enumerated under a microscope. After the Phase 1 wheat cultivars, there was a five-fold difference between *P. thornei* at 0–90 cm soil depth (970 *P. thornei*/kg soil and 4800/kg after the MR and S cultivars respectively). Growing mungbean cultivars exacerbated this effect with populations increasing 1.2–1.8 times after the Phase 1 S wheat and 2.5–6.1 times after the Phase 1 MR wheat (2440–8790 *P. thornei*/kg soil). After growing soybean there was a 7.6-fold increase after the MR Phase 1 wheat (7380/kg soil) and a 2.4-fold increase after the Phase 1 S wheat (11600/kg soil). Grain yield of the Phase 3 wheat ranged from 882 kg/ha (after soybean and Phase 1 S wheat) to 2023 kg/ha (after fallow and Phase 1 MR wheat). There was a negative, linear relationship between grain yield of the Phase 3 wheat and *P. thornei* sampled 1-month before planting (R^2=0.74, P<0.001). The decline in *P. thornei* populations after growing a moderately resistant wheat cultivar in Phase 1 of the experiment was counteracted by the susceptibility of the mungbean cultivars which increased *P. thornei* populations and caused poor yields of the next intolerant wheat cultivar in the sequence. The reproduction of *P. thornei* was not limited by the hot summer conditions during growth of the mungbeans. Growing mungbeans where *P. thornei* was present was a lost opportunity to manage the nematode populations by using a resistant crop.

DNA BARCODING OF *PRATYLENCHUS* FROM AGROECOSYSTEMS IN THE NORTHERN GREAT PLAINS OF NORTH AMERICA. **Ozbayrak, Mehmet[1], T. Todd[2], T. Harris[1], K. Powers[1], L. Sutton[1], R. Higgins[1], P. Mullin[1], and T. O. Powers[1].** [1]Department of Plant Pathology, University of Nebraska-Lincoln, Lincoln, NE 68583-0722. [2]Department of Plant Pathology, Kansas State University, Manhattan, KS 66502.

In the Great Plains region, *Pratylenchus* species are among the most prevalent plant-parasitic nematodes in soils cropped to corn and wheat. The objective of this study was to determine geographic distribution, host association, and identity of different mitochondrial COI haplotypes derived from *Pratylenchus* specimens from across the northern Great Plains of North America. Soil samples, primarily associated with six major crops, were collected from 86 counties representing 9 states, Kansas, Nebraska, Colorado, South Dakota, Wyoming, Montana, North Dakota, Washington, and Minnesota. The COI region of each individual was amplified by PCR followed by nucleotide sequencing that produced a 727-730 base pair region of COI DNA used for analysis. Maximum Likelihood and Neighbor-Joining trees were generated from a 482 specimen dataset. Phylogenetic and distance-based trees produced 10 Great Plains haplotype groups that were well-supported by boot-strap values and genetic distance. The most abundant haplotype group comprising 56% of all specimens, corresponded to *P. neglectus,* and was detected in 70 fields associated with wheat, corn, potatoes, dry beans, alfalfa, and barley. The second most frequent group corresponded to *P. scribneri*. It was identified from corn fields in four states; 12 in Nebraska, 12 in Kansas, two in South Dakota, and one in Montana. *Pratylenchus thornei* was primarily associated with wheat in Kansas, but was also recovered from corn, and alfalfa in Montana. *Pratylenchus penetrans* was relatively uncommon in field crops in the Northern Great Plains, collected from a single corn field in Nebraska, and potatoes in Wisconsin and Minnesota. All 10 of the Great Plains haplotype groups were collected from corn fields and wheat yielded 8 different groups. Despite the apparent broad host ranges of many of the haplotype groups, mixed field populations were rarely encountered. When coupled with an understanding of host reproduction preferences, it is expected that identity of haplotype groups should aid in designing management strategies that involve crop rotation and incorporation of cover crops in cropping sequences.

EVALUATION OF SOYBEAN PLANT INTRODUCTIONS WITH REPORTED RESISTANCE TO SOYBEAN CYST NEMATODE FOR RENIFORM NEMATODE RESISTANCE. **Robbins, Robert and D. Crippen.** Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

It is widely reported and accepted that Reniform Nematode (RN) (Rotylenchulus reniformis) of soybean is often related to Soybean Cyst Nematode (SCN) (*Heterodera glycines*) resistance. In 2017 greenhouse tests 214 SCN reported highly resistant Plant Introductions (PI) were evaluated for RN resistance and the following 45 PI's were not significantly different than the Resistant Check Hartwig: PI 303652, PI

339868 B, PI 399061, PI 404166, PI 404198A, PI 404198B, PI 407788A, PI 424298, PI 24595, PI 424608A, PI 437654, PI 437679, PI 437690, PI 437725, PI 438342, PI 438491, PI 438497, PI 438498, PI 464910, PI 467327, PI 468903, PI 468915, PI 494182, PI 507354, PI 507471, PI 507475. PI 507476, PI 533605, PI 543855, PI 548402, PI 548665, PI 548982, PI 567230, PI 567305, PI 567336A, PI 567336B, PI 567387, PI 567491A, PI 567516C, PI 594170B, PI 603445B, PI 612611, PI 84751, PI 89772, and PI 90763. In a companion test 204 SCN reported moderately resistant Plant Introductions (PI) were evaluated for RN resistance and the following five PI's were not significantly different than the Resistant Check Hartwig: PI 399058, PI 408269C, PI 424608B, PI 437846, and PI 567342. Several PIs could be considered to be moderately resistant to RN and include Forrest (PI 548655) which in earlier studies was reported to be RN resistant. In a companion test genotypes of the entire 418 PI's tested against RN are being normalized and will be used to show how the genotypes and phenotypes (resistance to susceptible) are related using Genome-Wide Association Study (GWAS). In addition, PIs resistant to SCN and RN are being evaluated for resistance to the Southern Root-Knot Nematode (SRKN) (*Meloidogyne incognita*). Identifying PI's with resistance to SCN, RN and SRKN should help soybean breeders in producing resistant lines with multi-nematode resistance.

CHARACTERIZATION OF SOIL NEMATODE COMMUNITIES IN A SONORAN DESERT STUDY SYSTEM. **Pagan, Christopher[1], SA Nadler[1], and JG Baldwin[2].** [1]Dept. of Entomology and Nematology, University of California, Davis, CA 95616. [2]Dept. of Nematology, University of California, Riverside, CA 92521.

A lack of taxonomic knowledge currently impedes the investigation of species-level ecology among nematodes. Rapid methods of species discovery, description, and identification will be vital in advancing our understanding of nematode ecology, but there is also a need for convenient natural study systems in which to conduct experiments. Desert soil study systems are particularly convenient because nematode species therein are depauperate enough to make a biodiversity inventory tractable, yet abundant enough to be reliably sampled. Desert soil mesofauna also tend to be anhydrobiotic, and therefore easy to collect, transport, and preserve. We are currently working to characterize soil nematode communities in the Philip L. Boyd Deep Canyon Research Center (Palm Desert, CA). We are also evaluating the utility of a 28S ribosomal rDNA barcoding locus (D1-D3) in rendering species-level identifications, as well as the utility of Sanger and Illumina sequencing-based approaches in estimating the relative abundance and richness of species. Additionally, we are constructing a reference sequence database, which consists of 28S data from nematode specimens that were collected in Deep Canyon and morphologically documented, using virtual microscopy, prior to molecular analysis. We hope that this work will enhance the value of Deep Canyon as a future location for the study of nematode ecology in below-ground ecosystems.

PATHOGENIC VARIABILITY OF *MELOIDOGYNE INCOGNITA* POPULATIONS OCCURRING IN PEPPER-PRODUCTION GREENHOUSES IN ISRAEL TOWARD *ME1*, *ME3* AND *N* PEPPER RESISTANCE GENES. **Bucki Patricia[1], I. Paran[2], R. Ozalvo[1], I. Iberkleid[1,3], L. Ganot[4], Qing Xue[1], and S. Braun Miyara[1#].** [1]Agricultural Research Organization (ARO), the Volcani Center, HaMaccabim Road, P.O. Box 15159, Israel. [2]Plant Sciences, ARO, the Volcani Center, [3]The Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, Israel. [4]Negev R & D Center, M.P.O 4, Negev 8544100, Israel.

Natural variation in the root-knot nematode *Meloidogyne incognita* is problematic for breeding programs: populations possessing similar morphological characteristics can produce different reactions on the same host. Through this study we collected 30 widely dispersed *M. incognita* populations from protected pepper-production systems in major pepper-growing regions of Israel and accurately identified their virulence characteristics by modified differential host test in a growth chamber on tomato, tobacco, cotton, melon, pepper and peanut. Galling indices and reproduction were determined on the different hosts. All populations fit the published scheme for *M. incognita* race 2, except for reproduction on cotton plants by 5 out of 25 tested *M. incognita* populations, indicating host-range variations. Reaction of three genes that confer resistance to *M. incognita*—*Me1*, *Me3* and *N*—to the collected populations was evaluated. Several *M. incognita* populations induced galling and reproduced successfully on pepper genotypes carrying *Me3* and *N*, whereas plant resistance conferred by *Me1* was more robust for all examined populations. Moreover, the effect of genetic background on *Me1* resistance demonstrated a relative advantage of several genotypes in nematode infestations. Efficiency of *Me3* under local nematode infestation was further studied with a homozygous line carrying two *Me3* alleles. Reproduction of virulent populations on the homozygotes (*Me3/Me3*) and heterozygotes (*Me3/ Me3*$^{+}$) was similar, suggesting a limited quantitative effect of *Me3*. Phylogenetic studies in which sequences of the ITS2.1 and ITS2.2 regions are compared indicate for some molecular variation that exist among collected *M. incognita* populations. These results present the first characterization of host range, reproduction and molecular aspects of *M. incognita* from Israel and highlight the importance of taking a multidimensional approach in pepper-breeding programs for resistance to *M. incognita.*

THE NEMATOFAUNA OF THE WORLD'S LARGEST DIPLOPOD, *ARCHISPIROSTREPTUS GIGAS.* **Phillips, Gary and E. C. Bernard.** University of Tennessee, 2505 E. J. Chapman Drive, 370 Plant Biotechnology Building, Knoxville, TN 37996-4560 USA.

The giant African millipede, *Archispirostreptus gigas*, is the world's largest extant diplopod, measuring up to 38 cm in length. *Archispirostreptus gigas* is primarily found in the lowlands of East Africa from Mozambique to Kenya. The nematode fauna from *Archispirostreptus* spp. is scant, with only *Brumptaemilius justini* (Rhigonematida: Ransomnematoidea) being sequenced from *A. gigas* and *Thelastoma gueyei* (Oxyurida: Thelastomatoidea) sequenced from *A. tumuliporus*, a millipede indigenous to Senegal. Otherwise, the nematode fauna of *A. gigas* is virtually unknown. Four adult Tanzanian *A. gigas* (two males, two females) were purchased from a biological supply company in January 2017. The millipedes were placed into a large enclosure consisting of a mixture of sand and sphagnum peat moss, which was maintained at 22˚C. Shortly after placing the millipedes into their enclosure, they mated on numerous occasions. Eggs were laid in tunnels dug by the females. Beginning in August 2017, *A. gigas* juveniles were observed in the enclosure. One adult specimen was dissected soon after purchase and two others were dissected when they appeared near death. Nematodes were removed from the intestine and characterized. Ten different species of nematodes were extracted from the intestines. Some specimens were processed to glycerin, while others were used for scanning electron microscopy and DNA analysis. Among the nematodes collected were two *Coronostoma* spp., two *Brumptaemilius* spp., two *Thelastoma* spp., *Golovatchinema* sp., and three unidentified taxa. Dissection of the three adult *A. gigas* produced a mean of 1,686 nematodes (range 853–2,327) from the hindgut. The *Brumptaemilius* spp. were most often encountered, while the *Coronostoma* spp. were least encountered. Ten juvenile millipedes were placed into a separate enclosure without adults and remaining juveniles were kept with the adults. Three dissected juveniles cumulatively had half the number of nematode species and lower numbers of nematodes (mean 98, range 42–195) than their adult parents. Juvenile millipedes retained with the adults were more heavily parasitized with nematodes. However, the presence of multiple species in all dissected juveniles indicated that immature *A. gigas* become infected early in their development.

OBSERVATIONS ON BREAKING OF RKN RESISTANCE IN CALIFORNIA TOMATO AND BELL PEPPER. **Ploeg, Antoon[1], G. Miyao[2], T. Turini[3], J. Aguiar[4], and F. Franco-Navarro[1]**. [1]Dept. Nematology, University of California Riverside, CA 92521. [2]UCCE Woodland, CA 95695. [3]UCCE Fresno, CA 95695. [4]UCCE Indio, CA 92201.

The vast majority of processing tomato varieties grown in California contain the nematode resistance gene Mi. This gene confers resistance to the common warm-climate root-knot nematode (RKN: *Meloidogyne*) species *M. incognita*, *M. javanica*, and *M. arenaria*. This resistance has been available since the 1960s, but did not become popular until the late 1970s. An initial report on the occurrence of RKN populations able to overcome this resistance was published in 1996. Since then, the number of field observations on the occurrence of resistance-breaking RKN in tomato has been increasing. The goal of this study was to determine if differences in resistance levels occur between different processing tomato varieties, and in virulence between different RKN populations. Furthermore, we challenged other RKN-resistant vegetable crops with these populations to assess nematode symptoms and reproduction on these crops. Over a period of two years, we collected 24 populations from fields where resistance breaking was observed. Five populations (4 *M. incognita*, 1 *M. javanica*) were used in greenhouse tests and inoculated onto 5 resistant processing tomato varieties. All these resistant varieties developed galling and allowed similar and high levels of nematode multiplication. Furthermore, no differences in virulence were observed between the 5 RKN populations. When RKN-resistant varieties of green bean (Nemasnap), bell pepper (Carolina Wonder), and sweet potato (Bonita) were challenged with these populations, the resistance was not compromised. Thus, the resistance in crop varieties other than tomato, may be useful in a rotation to prevent the build-up of RKN populations able to reproduce on resistant processing tomato. Resistance breaking was also observed in a bell pepper field trial with the RKN-resistant variety 'Carolina Wonder' in the Coachella Valley in the hot southern desert region of CA. In a parallel trial in Irvine CA, with a more moderate climate, resistance breaking did not occur. We are currently testing the hypothesis that high soil temperatures at the Coachella field are causing the resistance breakdown. If true, this would have important consequences for the potential use of resistance as a means to manage RKN damage in Coachella Valley bell pepper production.

ASSEMBLY AND FUNCTION OF NEMATODE COMMUNITIES IN AN EARLY SUCCESSIONAL ALPINE LANDSCAPE. **Porazinska Dorota L[1], EC Farrer[2], MJ Spasojevic[3], CP Bueno de Mequita[1,4], KN Suding[1,4], SK Schmidt[1].** [1]Department of Ecology and Evolutionary Biology, University of Colorado Boulder, Boulder, CO. 80309. [2]Department of Ecology and Evolutionary Biology, Tulane University, New Orleans, LA 70118. [3]Department of Evolution, Ecology, and Organismal Biology, University of California Riverside, Riverside, CA 92521. [4]Institute of Arctic & Alpine Research, University of Colorado Boulder, 450 UCB, Boulder, CO 80309.

Soil nematode communities exist in a complex matrix of interacting biotic and abiotic factors. How and to what extend these interacting factors are drivers of natural nematode communities and their functioning remains largely unknown. We used a natural gradient of plant community complexity (from bare to vegetated soils) across a high-elevation C-deficient landscape to examine how nematode communities assemble and how they affect soil C accumulation). We hypothesized that in this early successional landscape nematode communities would be influenced by biotic and abiotic factors, but that the effects would vary by nematode trophic groups. We also hypothesized that because of these interactions, nematode communities would be among the main drivers of accumulating soil C along this gradient, but again the effects would vary by nematode trophic groups. To test these hypotheses, we characterized plant species richness (PR) and density (PD), bacterial (BacR), fungal (FunR), eukaryotic (EukR), and nematode (NemR) richness, abiotic factors (snow cover, water holding capacity (WHC), pH, and elevation), and ecosystem functions (different forms of soil C). As predicted, nematode communities exhibited extensive shifts from a few individuals of a single species in bare soils to hundreds individuals and tens of species within every trophic group under complex plant communities. The first colonizers included predators/omnivores (e.g., *Nygolaimus* sp. and *Pungentus* sp.) and bacterial-feeders (e.g., *Plectus* sp. and *Tratocephalus lirellus*). Although arrival of new species was observed along the entire gradient for all trophic groups, plant-parasites were the last to arrive. Using general linear regression models, we determined that PR and PD, BacR and EukR, and WHC were the most predictive factors of NemR and NemD (densities) but that the best models involved a combination of these factors. With structural equation modelling we tested pathways by which nematodes assemble and function. As predicted, the effects of investigated soil factors were trophic-group specific. For instance, a positive direct effect of PR on NemR was observed for fungal and root-associated taxa, whereas PD had a positive direct effect on omnivorous and plant-parasitic taxa. In addition to direct effects, the richness and abundance of all trophic groups was positively affected by plants indirectly via their positive effects on BacR and EukR and/or WHC. Soil C pools were directly affected by both nematode abundance and richness. In summary, plants, microbes, and water were the main drivers of nematode assembly but their effects and strengths were specific to nematode trophic groups. Moreover, the role of nematodes in C dynamics was evident and as important as that of plants.

RESPONSE OF NEMATODE FOOD WEBS TO PHYSICAL AND TEMPERATURE STRESS. **Pothula, Satyendra K.[1], P. S. Grewal[3], M. A. Radosevich[2], S. M. Schaeffer[2], W. C. Wright[2], G. Phillips[1], E. C. Bernard[1].** [1]Department of Entomology and Plant Pathology, [2]Department of Biosystems Engineering and Soil Science, University of Tennessee, Knoxville TN 37996 USA. [3]School of Earth, Environmental, and Marine Sciences, University of Texas Rio Grande Valley, 1201 West University Drive, Edinburg, Texas 78539-2999 USA.

Human activities such as land transformation, pollution, over exploitation of resources and introduction of invasive species are accelerating biodiversity loss. In addition, human influence is rapidly changing the global climate by emission of greenhouse gases such as CO_2, methane and other trace gases. It is predicted that the mean global air temperature increases by 2–5 °C in the next 50–100 years. An increase in air temperature results in increased soil temperature. Soil is a dynamic system in which organisms interact with each other and form complex food webs. Nematodes are at the center of the soil food web because they represent multiple trophic groups. Nematodes are categorized to different trophic groups based on their feeding habits and different colonizer-persister (CP) classes based on life history characteristics. Bacterivores, fungivores, and herbivores are considered as lower trophic groups and predators and omnivores are considered as higher trophic groups. Nematode community structure provides good information on the condition of the soil food web and serves as an indicator of environmental disturbances. Two experiments near Knoxville, TN, USA, were conducted. In the first, the response of nematode food webs to increasing levels of physical disturbance in a forest ecosystem was determined. In the second experiment, soil was warmed to determine the response of nematode food webs to increasing temperatures in agricultural and forest ecosystems. The soil warming system maintained a temperature difference of 5° C between warming and control plots by use of heating cables and dataloggers. Thermocouples and watermarks were installed to measure and control soil temperature and moisture. Nematode richness and abundance were analyzed according to trophic groups and CP classes for both the experiments. Results from the physical disturbance experiment indicated that even a small disturbance such as continuous removal of vegetation and litter itself can affect the richness of nematodes, whereas nematode abundance decreased under more disturbed conditions. Nematodes belonging to higher trophic groups and higher CP classes were the most impacted with increasing levels of physical disturbance, compared to lower groups. Results from the warming experiment indicated that soil warming gradually decreased the richness and the abundance of higher trophic groups and higher CP class nematodes. On the other hand, it increased the abundance of lower trophic group and lower CP class nematodes. Soil warming may enhance microbial activity, resulting in increased abundance of lower trophic groups. Perturbations such as physical disturbance or soil warming negatively impacted both abundance and richness of higher trophic and CP classes, which are critical for the maintenance of a full suite of soil ecosystem services.

GLADES, BALDS, PRAIRIES AND THEIR SOIL NEMATODE COMMUNITIES. **Powers, Thomas[1], T. Quedensley[2] T. Harris[1], R. Higgins[1], P. Mullin[1], M. Olson[1], and K. Powers[1].** [1]Department of Plant Pathology, University of Nebraska-Lincoln, Lincoln, NE 68583-0722. [2]Botanical Research Institute of Texas, 1700 University Drive, Fort Worth, Texas 76107-3400.

In the Ozark Plateau of Missouri, there are approximately 400,000 acres of native plant communities referred to as glades. Glades typically occur on south facing slopes with shallow, rocky soil and exposed bedrock. Trees are absent, and with respect to the plant community assemblage, glades highly resemble the tallgrass prairies of central North America. With respect to geology, ecology and their harsh environmental conditions, the glades closely resemble Appalachian mountain-top balds. All three plant communities are a component of ecosystems with considerable landscape heterogeneity, existing as a mosaic of fragmented habitats. We have initiated a comparative study of the soil nematode communities of each of these three plant communities. Our sampling methods consist of establishing a 40 x40m plot, or equivalent area, and using a soil probe to extract a 250 cc sample. Nematodes are extracted from the sample by a flotation/sieving-sugar centrifugation method and 150 nematodes are identified by morphological characteristics using a Leica compound light microscope with differential interference optics. Twenty-five specimens of each sample are measured, photographed, and prepared for PCR. Specimens of Criconematoidea are DNA barcoded using the mitochondrial COI to provide a high-resolution taxonomic comparison within the superfamily. Preliminary DNA barcoding of criconematid specimens has literally produced mixed results for the three glades analyzed to date. *Mesocriconema nebraskense*, a common indicator species in remnant tallgrass prairies is found in all three glades. Also in these glades are specimens that belong to haplotype lineages indigenous to southern prairies and savannas of Georgia and Arkansas. In contrast, the comparison of Missouri glades with four balds sites from Great Smoky Mountains National Park, failed to identify a single shared criconematid species between the two habitats. Analyses are underway to attempt to explain nematode community assembly in these three distinct habitats. At this early stage of investigation, it appears that the plant community plays a proportionally large role in structuring the nematode communities of Ozark glades.

INTEGRATED MANAGEMENT OF ROOT-KNOT NEMATODES IN FLORIDA TOMATOES COMBINING HOST RESISTANCE AND NEMATICIDE. **Regmi, Homan[1], S. F. Hutton[2], and J. Desaeger[1]**. [1]Entomology and Nematology Department, University of Florida, Gulf Coast Research and Education Center (GCREC), 33598. [2]Horticultural Sciences Department, University of Florida, GCREC, 33598.

Root-knot nematode (RKN) is one of the most important biotic factors limiting tomato growth and production in the United States and the rest of the world. Host resistance, governed by the *Mi* gene, is the only available source of resistance against RKN in tomato. Although this gene provides good protection against the most common root-knot nematode species (*Meloidogyne incognita, M. javanica* and *M. arenaria*), *Mi* cultivars are not widely adopted in Florida. There are several reasons for this, including the limited availaility of locally-adapted, resistant cultivars, the possibility of yield drag, heat instability of the *Mi*-gene, the emergence of resistance-breaking nematode isolates, and the use of fumigants which control other soilborne pathogens in addition to root-knot nematodes. Also, even in resistant cultivars, RKN juveniles still puncture the root and make the plant more vulnerable to different soil-borne pathogens. To test the hypothesis that integration of tomato host resistance with fumigants and/or nematicides can improve control of nematodes (and soil pathogens) and increase tomato yields, we conducted a field experiment during Fall 2017 at the University of Florida's Gulf Coast Research and Education Center (GCREC). Three tomato cultivars with *Mi* gene (Sanibel, Skyway687, and an *Mi* isoline of Tasti Lee) and one without *Mi* (Florida 47) were planted in plastic-mulched raised beds where; 1) a fumigant (F) (chloropicrin) was applied, 2) a fumigant + nematicide (FN) (chloropicrin + fluensulfone) were applied, or 3) no fumigant/nematicide was applied. Root gall damage was significantly affected by pre-plant treatments, with highest root gall (%) incidence in untreated beds (28%) > F (16%) > FN (5%). *Mi* cultivars also reduced root galls, with highest gall incidence for FL 47 (45%) > Tasti Lee *Mi* (15%) > Skyway and Sanibel (5%). Fumigant+nematicide gave significantly higher tomato yield (9.75 kg/plant) compared to fumigant alone (9 kg/plant) and the control (7.2 kg/plant). Sanibel gave the highest tomato yield (10 kg/plant), followed by Skyway (8.8 kg/plant), Tasti Lee (8.0 kg/plant) and Florida 47 (7.9 kg/plant). RKN soil populations at the end of the trial were also significantly higher in beds with the RKN susceptible cultivar Florida 47 (526 J2 per 200 cc soil) as compared to Tasti Lee (94 J2/200 cc), Skyway (39 J2/200 cc) and Sanibel (25 J2/200 cc).

PLANT- PARASITIC NEMATODE HOST STATUS OF SUNN HEMP (*CROTALARIA JUNCEA*) AND POST-HARVEST BIOFUMIGATION. **Rodriguez, Lauren, K. Poley, M. Quintanilla**. 288 Farm Ln, Room 26, East Lansing, MI 48823.

The integration of certain cover crops can improve the overall soil health of a field and reduce plant-parasitic nematode populations. Sunn hemp (*Crotalaria juncea*), a tropical legume used as a cover crop in the Southern United States, produces a toxic nematicidal compound called monocrotaline, which acts as natural pest control. Monocrotaline, if in effect, will yield less parasitic nematodes in plants grown in sunn hemp-incorporated soil. Sunn hemp has not been shown to host Southern root knot nematodes but it may be a host for northern species; the host status of root lesion nematodes in sunn hemp is currently unknown. Root lesion nematodes are the most prominent plant-parasitic nematodes in Michigan, affecting many short-season vegetable crops, such as cucurbits. Pending host status with adverse nematode species, sunn hemp could be employed as a cover crop after harvest Michigan short-season crop. We expect sunn hemp to be a host for root lesion nematodes as preliminary field trials resulted in an increase in root lesion after sunn hemp. A replicated greenhouse experiment was conducted to test the host-capabilities of sunn hemp with temperate plant-parasitic nematodes. Soil was inoculated with a root lesion nematode, *Pratylenchus penetrans*, and Northern root knot nematode, *Meloidogyne incognita*, prior to planting at three concentrations (0, 100, 500). The experiment was conducted in SC10 Super Cone-tainers, each with a diameter of 3.8 cm and a depth of 21 cm. Treatments were replicated six times and allowed to grow for eight weeks. Plants were assessed weekly for growth and nematode damage, including discoloration and wilting. After the growing period, plants were removed from soil and nematodes were extracted from the roots by shaking for 48 hours in a 1% bleach solution. Nematodes were identified and counted to determine host status. Cereal rye (*Secale cereale*), a cover crop commonly grown in Michigan that has an established nonhost status for both root lesion nematodes and Northern root knot nematodes, was assessed under the same conditions as sunn hemp and used as a comparison. A secondary experiment was conducted under greenhouse conditions to determine the biofumigation potential of sunn hemp on both root lesion and root knot nematodes. Sunn hemp seeds were broadcast planted in soil infested with root-lesion and root knot nematodes, separately. After the initial eight weeks, sunn hemp plants were clipped and tilled into the soil. It has been suggested that soil temperature plays a key factor in the success of the biofumigation processes, therefore soil temperature was monitored daily for two weeks. Nematodes were then extracted from the soil, counted, and compared to baseline population densities to determine the success of Monocrotaline from sunn hemp. From these experiments, we can infer the host status of sunn hemp to two important plant-parasitic nematodes in Michigan, and determine the effect of this cover crop on control of nematodes through biofumigation.

DEVELOPMENT OF AN EFFICACIOUS METHOD FOR EXTRACTING NEMATODE DNA DIRECTLY FROM SOIL FOR AMPLICON SEQUENCING. **Rutter, William B. and C. S. Kousik.** United States Department of Agriculture, Agricultural Research Service, U.S. Vegetable Laboratory, Charleston, SC 29414.

Estimation of soil nematode community composition is important for farmers to make informed management decisions and research scientists to survey soil microbial communities. To be done accurately, it also requires a considerable amount of time, skill, and knowledge of nematode morphology. High throughput sequencing (HTS) technologies and the burgeoning field of soil metagenomics raise the possibility of using a sequence based approach to estimate soil nematode community structure. An effective method for sequencing of nematode communities directly from soil samples could reduce the time and skill necessary to perform soil surveys. Sequencing based nematode surveys could also provide valuable information about interactions with microbes form multiple kingdoms, more accurately identify nematodes beyond the genus level, and perhaps even provide information about acronymically important nematode genes of interest in a field context. To facilitate soil nematode metagenomics, we have developed an efficacious method for processing and extracting nematode DNA directly from field and greenhouse soil samples. We tested variations on soil sample preparation methods in conjunction with commercial DNA extraction kits using multiple published primer sets specific to several plant parasitic nematode genera including *Meloidogyne*, *Rotylenculus*, and *Pratylenchus*. Unsurprisingly, our results indicate that different soil preparation methods can have significant effects both positive and negative on species specific amplifications. This method is expected to be of interest to those using HTS approaches for soil nematode community profiling.

MODELING THE DAMAGE FUNCTION OF *PRATYLENCHUS PENETRANS* ON SOYBEAN USING A NESTED ERROR COMPONENT MODEL. **Saikai, Kanan, and A. E. MacGuidwin.** Plant Pathology Dept., University of Wisconsin-Madison, WI 53706.

The root-lesion nematode (RLN) is the most prevalent nematode pest associated with soybean in Wisconsin. Nearly every field is positive for *Pratylenchus* spp., and *P. penetrans* accounts for about the 20% of RLN infestations in the state. We studied the impact of *P. penetrans* on soybean yield in nine soybean fields in Wisconsin during 2016 and 2017. Research plots ($n = 288$) were established at randomly-selected locations in each field when the soybeans were at vegetative growth stage VE. Soil and plant samples were collected at growth stages VE and V2, and yield was estimated from pod and seed samples collected at harvest. Plots positive for soybean cyst nematode at VE were excluded from data analyses. A nested error component model (NECM) was used to describe the relationship between 6506 pair-wise differences in nematode population density in two plots with the corresponding proportional difference in response variables. The model included either the initial population density of *P. penetrans* in soil or roots as the explanatory variable, one of five plant growth or yield parameters as the response variable, and year, location nested within year, and cultivar nested within location and year as random effects. There was a positive ($P < 0.001$) relationship for the difference among initial nematode population densities and proportional loss in grain yield, seed mass, pod number, shoot dry weight and shoot to root ratio. The proportional loss in pod number and shoot to root ratio was also related ($P < 0.001$) to the difference in *P. penetrans* per gram of root at V2. The model estimated that each nematode present at VE was associated with a 0.016%, 0.019%, 0.009%, 0.014%, and 0.028% loss in grain yield, seed mass, pod number, shoot dry weight, and shoot to root ratio, respectively. Each nematode detected per gram of root at V2 was associated with a 0.015% loss in the shoot to root ratio at V2 and a 0.0097% loss in pod number at harvest. The largest variance component for all the models was the experimental error, although the random effects of year, location and soybean variety were also highly variable and did not contribute to the model. The mean initial population densities ranged from 43 to 200 per 100 cm^3 soil for the nine fields in the study, implying a yield loss of 0.7 to 3% attributable to *P. penetrans.* This study is in progress, and field data will be collected in 2018 to validate the NECM model.

ASSISTING SMALLHOLDER FARMERS IN ADOPTING INTEGRATED NEMATODE-SOIL HEALTH MANAGEMENT: IV - CHANGES IN CYST NEMATODE POPULATION DENSITY AND POTATO YIELD. **Sanchez, Amilcar[1], G. I. Alvarez[1], B. S. Sipes[2], S. Kakaire[3] C-L. Lee[4], A. Sacbaja[1], C. Chan[2], and H. Melakeberhan[3]**. [1]Faculty of Agronomy, University of San Carlos (USAC), Guatemala City, Guatemala. [2]University of Hawaii (UH) at Manoa, Honolulu, HI 96822 USA. [3]Dept. of Horticulture, and [4]CANR Statistical Consulting, Michigan State University (MSU), East Lansing, MI 48824 USA.

Alleviating the intertwined and grand challenges of food and nutritional insecurities have been a major focus of the USAID's Horticulture Innovation Laboratory. Plant-parasitic nematodes (PPN) and poor soil health negatively impact potato yield of smallholder farmers in the Highlands of Guatemala. These farmers have limited perception of the cause-and-effect relationships between agricultural practices, nematodes, and potato yield. In order to address these challenges, an interdisciplinary team from UH (social science), MSU (soil health) and USAC (agronomy and soil science) conducted ground-truthing in 2017 and initiated experiments in the Huehuetenango and Xela regions of Guatemala. The regions lay over Mollisol and Andisol soil groups (classes), respectively. The Mollisols are at 3,200 m to 3,353 m and Andisols around 2,896 m altitude. The experiment in each region consisted of testing the effects of amending soils either with or without bio-mix and 0, 318, or 454 kg composted chicken manure at eight locations. The bio-mix (BioCopia) consisted of Guatemalan isolates of *Purpureum* and *Bacillus* applied at 1.8 kg/m^2 to suppress PPN. This presentation deals with the effects of these treatments on potato cyst nematodes (*Globodera* spp.) and crop yield. Cysts were extracted from 100 cm^3 of soil at-planting, midseason and at-harvest using acetone flotation methods and quantified as white, yellow, brown or dark at USAC. At midseason, striking differences in plant growth between compost and non-compost amendment treatments existed in both regions. These differences were reflected in yield although not statistically significant ($P \geq 0.05$). Cyst population density trended similar to yield, with both parameters higher in Andisols than in Mollisols. Soil pH and percent organic matter (%OM) did not show significant correlation with either yield nor the number of cysts across amendments. However, yield, soil pH and %OM were positively and significantly correlated in Andisols, suggesting differences between the soil groups. As part of assessing integrated efficiency of the soil amendment treatments and potential sustainability of the outcomes, cyst (x-axis) and yield (y-axis) were expressed as a percent of control and fitted to the fertilizer use efficiency (FUE) model. Based on the FUE model, the data fell into Quadrant B – soil amendments are increasing cyst population density and yield in both soil groups. The data suggest the need for additional measures for managing potato cyst nematodes without compromising biological processes that increase %OM or yield response.

FIRST REPORT OF *MELOIDOGYNE GRAMINIS* INFECTING LIMPOGRASS (*HEMARTHRIA ALTISSIMA)*. **W. L. Sanchez, W. T. Crow, A. Habteweld, and M. L. Mendes.** University of Florida Entomology and Nematology Department, PO Box 110620, Gainesville, FL 32611.

The turfgrass root-knot nematode (*Meloidogyne graminis*) is one of the most common root-knot nematodes in Florida, where it is a common pathogen of turfgrasses in lawns, athletic fields, and golf courses. Limpograss (*Hemarthria altissima*) is a forage grass, primarily for feeding cattle. Because limpograss is very tolerant to standing water it commonly used in Florida in low-lying swampy areas. A field survey of poorly performing limpograss pastures in Osceola County in Central Florida found several species of plant-parasitic nematodes parasitizing limpograss including *M. graminis*. Diagnosis of *M. graminis* was confirmed by genomic DNA extraction from 5 nematodes. The ribosomal region spanning the internal transcribed spacer (ITS) 1, 5.8S gene, and ITS2 was amplified with forward primers AB28F (5`-GTTTCCGTAGGTGAACCTGC-3`) and reverse primer TW81R (5`-ATATGCTTAAGTTCAGCGGGT-3`). A 501bp-fragment was amplified and the PCR product was purified and sequenced. BLAST search results revealed a sequence similarity of 98% with *M. graminis* over 95% query cover. The isolate of *M. graminis* from limpograss was maintained and increased on rice (*Oryza sativa*) in the greenhouse. Nematode-free cuttings of 'Kenhy' limpograss were planted into 5 pots containing 1,400 cm^3 of sand. Nematode inoculum was collected by incubating infected rice roots in modified Baermann funnels in a mist chamber. After the limpograss started to produce roots, the plants were inoculated with 3800 *M. graminis* J2 per pot. After 98 days the plants were removed from the pots and soil was gently removed. Egg masses were stained according to Thies et al. (2002) and rated using a 0 to 5 scale (Taylor and Sasser, 1978). The egg mass indices ranged from 1 to 3, indicating that the nematodes were capable of reproduction on the limpograss. However, on certain other grass hosts it has been observed that most of the egg masses of *M. graminis* remain embedded within the roots and not exposed on the root surface. Therefore, counting egg masses may not be the most accurate method for quantifying infection by this nematode. In future studies we intend to macerate the roots and extract eggs rather than counting egg masses.

DISENTANGLING RELATIONSHIPS BETWEEN NEMATODES AND ENVIRONMENTAL OR EXPERIMENTAL FACTORS USING CANONICAL CORRESPONDENCE ANALYSIS. **Sánchez-Moreno, Sara.** National Institute for Agriculture and Food Research and Technology, 28040 Madrid, Spain.

Reliable assessment of the condition and ecological function of nematode assemblages requires large data matrices that include the abundances of dozens of nematode taxa and several nematode-based indicators. In ecological studies, relationships are determined between the nematode data and various environmental factors, including continuous and categorical descriptions of climatic, edaphic, and experimental factors. Canonical Correspondence Analysis (CCA) facilitates summary and analysis of enormous amounts of ecological interactions to extract ecologically-relevant information and hypotheses. CCA is an ordination technique that assumes a unimodal relation between the species studied and environmental factors; it arranges both species and sites along environmental gradients. Several assumptions need to be fulfilled before performing the analysis; they include normality and homoscedasticity. The obtained ordination maximizes the relation between dependent variables (species or ecological descriptors) and environmental factors (continuous or categorical environmental data). The sensitivity of the analysis to rare species should be considered to determine whether they are ecologically relevant. To date, CCA has been successfully used to assess the response of nematode communities to soil (pH, C, nutrients, moisture), biological (other organisms), and management (tillage, crop, rotation) factors. CCA can be performed using several types of statistical software. In this workshop, we will use the R software to explain basic concepts, limitations, execution, and interpretation of CCA results.

VERTICAL DISTRIBUTION AND POPULATION DYNAMICS OF *ROTYLENCHULUS RENIFORMIS* LIFE STAGES IN PEANUT-COTTON CROPPING SYSTEMS. **Schumacher, Lesley[1], Z. J. Grabau[1], H. L. Liao[2], D. L. Wright[2], I. M. Small[2].** [1]Department of Entomology and Nematology, University of Florida, Gainesville, FL, 32611. [2]North Florida Research and Education Center, University of Florida, Quincy, FL 32351.

Sod-based rotation uses two years of pasture bahiagrass (*Paspalum notatum*) followed by one year each of peanut (*Arachis hypogaea*) and cotton (*Gossypium hirsutum*) to improve cotton yield, soil fertility, and water infiltration versus a conventional crop rotation (peanut-cotton-cotton). Reniform nematode (*Rotylenchulus reniformis*, RN) is a pathogen of cotton, but not peanut or bahiagrass, so sod-based rotation may be an effective tool for its management. RN is known to infest roots deep in the soil profile, but little is known about ratios between females/juveniles and males at different depths. Therefore, RN population dynamics were investigated at different soil depths in sod-based and conventional rotations with or without irrigation at a long-term research site in Quincy, FL. Soil samples were collected to a depth of 120 cm before planting and after harvest in 2017 and during winter (January) in 2018 using a hydraulic probe. RN populations were analyzed in 30 cm-sections (females/juveniles counted separately from males). No irrigation effects were observed in any of the sampling dates ($P > 0.05$). All RN abundances decreased step-wise as soil depth increased in each sampling date. In pre-plant 2017, both female/juvenile and male RN abundances were greater following second-year cotton than any phase of the sod-based rotation. There were significant crop by depth interactions for both female/juvenile and male RN abundances in post-harvest 2017. At the 0-30 cm depth, male RN abundance was greater in the conventional rotation than any of the sod-based phases. At the 90-120 cm depth, male RN abundance was greater in conventional peanut than any other phase. At the 0-60 cm depths, female/juvenile abundance was greater in the conventional rotation than bahiagrass and sod-based peanut. In winter 2018, both female/juvenile and male RN abundances were greater in the conventional rotation than bahiagrass and sod-based peanut. In pre-plant 2017, the females/juveniles:males ratio was greater following conventional cotton than conventional peanut, sod-based cotton, and first-year bahiagrass. In post-harvest 2017, the ratio was greater in conventional cotton than peanut and bahiagrass. Furthermore, the ratio was greater at the 0-30 cm and 60-90 cm depths than the 90-120 cm depth ($P = 0.08$). There were significant crop by depth interactions for the ratio in winter 2018. At the 0-60 cm depths, the ratio was greater in sod-based cotton than bahiagrass and conventional peanut. At the 60-90 cm depth, the ratio was greatest in conventional cotton and least in bahiagrass. Finally, at the 90-120 cm depth, the ratio was greater in cotton than all other phases. Based on this research, all life stages of RN are present at least 120 cm deep in the soil profile in these cropping systems, but are more abundant closer to the surface. Sod-based rotation is influencing RN population dynamics at this site.

EXPLORING PARASITIC GENE DUPLICATION AND DIVERSIFICATION IN THE SOYBEAN CYST NEMATODE. **Severin, Andrew**. Iowa State University, Ames, Iowa, 50011.

The soybean cyst nematode (*Heterodera glycines*), an obligatory and sedentary plant parasite, causes over a billion-dollar yield loss to soybean production annually. The costs and environmental hazards of current nematicides only exacerbate the problem of managing this pest and the emergence of *H. glycines* populations that frequently overcome the limited sources of natural resistance is becoming a widespread issue. *H. glycines* relies on complex host-parasite interactions to successfully parasitize its host. Effectors, the proteins secreted by *H. glycines* into host root tissues, are critical to overcoming host defenses and in the reprogramming of root cells into elaborate feeding sites, syncytia. Improving genomic resources for SCN will aid in our understanding of the mechanisms of effector acquisition, diversification, and selection, which is critical for the development of more efficient *H. glycines* management practices. Toward this end, we have annotated draft genome assembly of *H. glycines*. Using PacBio long read technology, we assembled and annotated 738 contigs into 123Mb with 29,769 genes. The genome contains significant numbers of repeats (34%), tandem duplicates (18.7Mb) and horizontal gene transfer events (151 genes). This presentation will discuss the current state of genomic resources in SCN and how we can leverage this information to identify regions in the genome responsible for virulence. Finally, an experimental path forward will be outlined toward the goal of rapid diagnostic tests for pathotypes identification in field populations.

ORCHARD FLOOR MANAGEMENT EFFECT ON SOIL FREE-LIVING NEMATODE COMMUNITIES. **Shakartchy Efrat[1], Eshel Gil[2], Egozi Roey[2], Doniger Tirtza[1] Steinberger Yosef[1].** [1]The Mina & Everard Goodman Faculty of Life Sciences, Bar-Ilan University, Israel. [2]Soil Erosion Research Station, Ministry Of Agriculture & Rural Development, Rishon-Lezion. P.O.B. 30, Beit-Dagan, 50250, Israel.

The selection of a given practice in agriculture has key impacts on soil biota functioning. Moreover, an intensive agriculture with bare soil promotes soil degradation processes as a result of increased level of runoff and soil erosion, caused by the raindrop impact on the bare soil. In order to overcome this essential threat, is common to mulch the soil in Orchards and Vineyards by plant and plants residue. In previous study *Eshel G*. and Egozi R. sowed that 100% mulching soil surface reduced the runoff maximum discharge by 60-80%, reduced the cumulative runoff by 70-90%, and decreased soil erosion and runoff by 95%. Moreover, using native vegetation as alternative to cover crops between the rows increased both the herbs and arthropods biodiversity, and maintain the development and heath of the orchard trees. In this work we studied the effect of different soil cover affect soil free living nematodes community and soil abiotic condition, in a citrus orchards' floor with woodchips below trees and annual winter herbaceous between rows. The soil free-living nematode communities are one of the most important and numerous groups of soil biota that play important role in fundamental ecological processes. Furthermore they have been found to be sensitive bio-indicators of soil quality. In the present study, we examined the effect of different soil management on a soil abiotic components and the soil free-living nematode communities (e.g. density and diversity) in a citrus orchard floor with woodchips below trees and annual winter herbaceous between rows. Soil samples were collected at the end of Dec 2015 from a five years old citrus orchard were the treatments described later stated from day one in in the Sharon area in Israel. The samples were collected from the 0-10 cm from three replicates with following treatments between rows (br): (1) Wbr – wild annual native species; (2) AVbr - Avena stavia + Vicia; and (3) Bbr - bare soil (treated with herbicides) and two treatment under the tree rows (tr) (4) Mtr mulched with wood chips made from Pinus trees; and (5) Btr bare soil (treated with herbicides). The obtained results had indicated the following: (1) significant difference in soil moisture were soil cover by annual plants (Wbr& OVbr) and control site; (2) organic matter and Water Holding Capacity were found to be higher for all mulched samples (Wbr, AVbr and Mtr) than the control (Bbr & Btr).The pH between rows planted with Wbr in comparison to OVbr and control; (3) nematode communities and the trophic diversity were significantly affected by orchard floor management. The obtained results had been found to elucidate the strong relation between the orchard floor management and soil free living nematode community relationships.

VARIABLE BIOTIC AND ABIOTIC STRESS IN ENTOMOPATHOGENIC NEMATODES: IMPLICATIONS FOR BIOCONTROL. **Shapiro-Ilan, David[1] and E. E. Lewis[2].** [1]USDA ARS, SEFTNRL, Byron, GA 31008. [2]Dept. Entomology, Plant Pathology and Nematology, University of Idaho, Moscow, ID 83844.

Entomopathogenic nematodes in the genera *Steinernema* and *Heterorhabditis* are potent biocontrol agents. Their efficacy is influenced substantially by various biotic and abiotic stress factors. The ability of entomopathogenic nematodes to withstand environmental stress varies greatly among species and strains. This is evidenced in variable longevity in the soil. Stress factors that contribute to differential longevity include temperature, desiccation and UV radiation. Biotic factors in the soil also contribute to entomopathogenic nematode foraging and infection efficiency (which in turn impacts biocontrol success). Two biotic elements that contribute to nematode dispersal and foraging behavior are phoresy and group dynamics. With the knowledge that certain biotic and abiotic components impact biocontrol efficacy, several approaches can be used to enhance the potential for biocontrol success. Some of these approaches include improved formulation (such as with protective gels), leveraging phoretic or synergistic interactions with other organisms, application of nematodes in their infected hosts, and strain improvement such as hybridization and stabilization via homozygous inbred lines.

EVALUTION OF POTENTIAL COVER AND TRAP CROPS FOR MANAGEMENT OF HETERODERA GLYCINES IN MICHIGAN. **Jeff Shoemaker and G. Bird,** Department of Entomology, Michigan State University, East Lansing, Michigan, 48824.

Soybean cyst nematode (SCN), *Heterodera glycines,* is a key pest of soybeans in Michigan (MI). While management options such as resistant varieties, seed treatments, and crop rotations are used, there is a distinct need for additional control practices. This is particularly important for prevention of highly aggressive populations related to extensive use of cultivars derived from the PI88788 source of resistance. The use of cover crops in MI is increasing for weed management and soil health enhancement; however, very little is known about their impact on SCN. In MI, specific cultivars of *Raphanus sativus oleiferus* are successfully used as trap crops for management of sugar beet cyst nematode, *H. schachtii* and both *H. glycines* and *H. schachtii* are known to exist in the same fields. The objective of this research is to evaluate selected plant cultivars for their potential as cover or trap crops in soybean production. Experiments were conducted under greenhouse conditions and in three field locations in MI (Ingham, Monroe, and Cass counties) during 2016 and 2017. Eleven cultivars, representing two families (*Fabaceae* and *Brassicaceae)*, were evaluated in the greenhouse experiments. Six were selected from the results for field experiments. A cover crop blend with potential trap crop germplasm (*Glycines max*) was included in 2017. All field trials included a SCN susceptible and SCN resistant soybean cultivar, as well as a fallow treatment. After 45 days, all cultivars evaluated in the greenhouse experiments had egg and cyst population densities lower than the susceptible control. This was not always true in regards to the number of eggs/cyst, which was not significantly different from the susceptible control. During 2016, in Monroe and Cass counties, all cover crop cultivars resulted in fewer eggs, cysts, and eggs/cyst, compared to the susceptible soybean control. In Ingham country in 2016; however, there were significant differences between the cover crop cultivars and the susceptible control for three SCN population indicators. In 2017, only Cass county had population changes associated with the cover crops that were similar to 2016. This is an indication of the importance of both site and year specificity in regards to the relationship of cover crops to SCN population dynamics. While a three-species cover crop blend containing the potential SCN trap crop (*G. max*) is being evaluated under commercial soybean production systems in 2018, there is still no good evidence that any of the cultivars investigated functioned as trap crops for SCN. We believe, however, this is the first report of the possibility of using *G. max* as the trap crop part of a cover crop blend for management of SCN.

A NOVEL NEMATICIDE FOR THE CONTROL OF ROOT KNOT NEMATODES IN TOMATO: FLUAZAINDOLIZINE. **Marina G. Silva[1], L. B. Resende[2], R. H. Serikawa[3], C. Vassallo[4], T. C. Thoden[5], J. A. Wiles[6].** [1]Corteva Agriscience™, Agriculture Division of DowDuPont™, Dupont do Brasil S. A., Alameda Itapecuru 506, Alphaville, Barueri, SP, 06454080, Brazil. [2] Somar Services Agro., Brazil. [3]Corteva Agriscience™ - Agriculture Division of DowDuPont™, DuPont Pioneer, 7000 NW 62nd Ave, Johnston, IA 50131, USA. [4]Corteva Agriscience™, Agriculture Division of DowDuPont™, Dow AgroSciences Argentina SRL, Boulevard Cecilia Grierson 355, Dique IV, Piso 25, Puerto Madero (C1107CPG), Ciudad Autónoma de Buenos Aires, Argentina. [5]Corteva Agriscience™, Agriculture Division of DowDuPont™, DuPont de Nemours (Deutschland) GmbH, Hugenottenalle 175; 63263 Neu-Isenburg; Germany. [6]Corteva Agriscience™, Agriculture Division of DowDuPont™, DuPont (U.K.) Limited, 4th Floor, Kings Court, London Road, Stevenage, SG1 2NG, United Kingdom.

Tomato yields can be far below their genetic potential due to root infection by root-knot nematodes. Integrated nematode control approaches, including biological control agents, nematicide applications and resistant varieties, are being employed by growers to reduce nematode populations in the field. One root-knot nematode species increasing in importance is *Meloidogyne enterolobii*. This species appears to have the ability to overcome resistance mechanisms of some host plants, including tomato. In addition, some nematicides have been banned or are restricted in use in several countries because of their unfavorable toxicological and environmental profiles, which has reduced the control options available to growers. Fluazaindolizine is a novel sulfonamide nematicide active ingredient that is being developed and can become a new, effective, tool for nematode management in tomatoes and several other crops. The formulated product is Salibro™ 500SC. The objective of this study was to measure root damage and tomato yield after Salibro™ application for the control of *M. enterolobii*. The experiment was conducted in a commercial field area with high nematode pressure in São Paulo State, Brazil. Salibro™ was applied either by drip application or in furrow spray applications one day before tomato transplanting. A commercial biological product (containing *Bacillus subtilis* + *Bacillus licheniformis*) as well as an untreated control were included for comparison. At 30 and 60 days after treatment application (DAA), plants were collected at random from each treatment to determine nematode population development. The roots of each plant were evaluated for the presence of galls according to the standard gall index scale 0-10 (*Bridge* and Page, 1980) and also sent to an external laboratory for root extraction to obtain the number of nematodes per gram of root. No statistically significant differences amongst treatments were noted in root nematode counts, however Salibro™ treatments clearly reduced gall damage on tomato roots at 60 DAA. Salibro™ applied by drip application and in furrow application increased the yield by an average of 8.8 and 7.1 tons/ha respectively when compared with untreated check, and by 8.1 and 6.4 tons/ha respectively when compared with the biological product. This study demonstrated that Salibro™ increased tomato yield in a field area infested with *M. enterolobii* and will be a useful tool for management of this nematode species.

MOLECULAR AND MORPHOLOGICAL ANALYSIS OF AN UNUSUAL POPULATION OF ROOT-KNOT NEMATODE FROM GARLIC MUSTARD IN OREGON. **Skantar, Andrea M.[1], Z. A. Handoo[1], C. Aldassy[2], and W. L. Bruckart[3].** [1]USDA-ARS Mycology and Nematology Genetic Diversity and Biology Laboratory, Beltsville, MD. [2]East Multnomah Soil and Water Conservation District, Portland. [3]USDA-ARS Foreign Disease Weed Science Research Unit, Frederick, MD.

The weed garlic mustard (*Allaria petiolata*) was isolated from a field in Oregon, exhibiting galling symptoms that indicated possible infection with nematodes. Morphological species identification was consistent with *Meloidogyne arenaria*, although diagnosis was somewhat hampered by specimens that were not in optimal condition. Molecular analysis of ribosomal and mitochondrial markers indicated this isolate may be a new species, as there were no definitive matches to existing sequences in GenBank. Nuclear Hsp90 genomic sequences from this population were distinct from the closest matches, with 81% similarity to *M. hapla*, *M. arenaria*, *M. floridensis*, and *M. incognita*. Further evidence of diseased plants at the initial location has not been detected, but the site is being monitored. A definitive description of the population would benefit from analysis of additional sampling and host range tests.

TRYPSIN-LIKE ACTIVITY CORRELATED TO VIRULENCE OF *HYALORBILIA OVIPARASITICA* ON *HETERODERA SCHACHTII*. **Smith Becker, Jennifer[1], J. Borneman[2], and J. O. Becker[1].** [1]Departments of Nematology, [2]Microbiology and Plant Pathology, University of California, Riverside, CA 92521.

The fungus *Hyalorbilia oviparasitica* (basionym: *Dactylella oviparasitica*) is a hyperparasite of the sugarbeet cyst nematode *Heterodera schachtii*. It was discovered as the primary biological entity responsible for a long-term population suppression of *H. schachtii* in field 9E at the University of California Riverside's Agricultural Operations. Three genetically different but closely related strains of *H. oviparasitica* (DO50, ARF, DOSt) isolated from *H. schachtii, H. glycines* and *Meloidogyne incognita*, respectively, differ in their parasitism of *H. schachtii*. They were tested for their ability to reduce the egg hatch in 3-week old white females of *H. schachtii* in an in vitro assay. Although all three fungal strains colonized the white females of *H. schachtii*, only DO50 significantly reduced the number of J2, with close to 100% suppression of the egg hatch. Enzyme production by the three fungal strains grown on PDA agar or parasitized *H. schachtii* females was evaluated using API ZYM (bioMérieux) test strips. The API ZYM assay tests 19 hydrolytic activities that may contribute to parasitic virulence, including peptidases, esterases, lipases, glycosidases, and chitinase. The test is semi-quantitative, with the intensity of the color reaction correlating to the amount of enzyme present. Assay color intensity was rated on a scale of 1-5 for quantification of enzyme activity. Of particular interest were changes in enzyme activity associated with parasitism of *H. schachtii* females and enzymes uniquely expressed by DO50. All three fungal strains produced α-chymotrypsin-like activity on parasitized females but not in agar culture while DO50 and DOSt produced β-galactosidase on females but not in agar culture. Trypsin-like protease activity was uniquely detected in DO50 grown on PDA and on *H. schachtii* females, with the highest activity associated with the fungus grown on parasitized females. These results suggest that protease activity, and specifically trypsin-like activity, may be an essential component of virulence in *H. oviparasitica* parasitism of *H. schachtii*.

ROTYLENCHULUS RENIFORMIS RESISTANCE IN *GOSSYPIUM ARBOREUM* ACCESSIONS. **Stetina, Salliana R. and J. E. Erpelding.** USDA, Agricultural Research Service, Crop Genetics Research Unit, P.O. Box 345, Stoneville, MS 38776, USA.

Reniform nematode (*Rotylenchulus reniformis*) causes annual yield losses of 4 to 8% in upland cotton (*Gossypium hirsutum*) in the southeastern United States. Host plant resistance is a desirable management option, but no upland cotton cultivars have been identified with resistance. Resistance has been reported in related cotton species, and *Gossypium arboreum* germplasm may be an important source of genetic diversity for resistance. Thus, 226 *G. arboreum* accessions from the US germplasm collection were evaluated for their reaction to the nematode in growth chamber experiments. Due to growth chamber space constraints, accessions were divided into 3 sets of 74 to 76 entries for evaluation. Each set of accessions was tested twice, and data from both tests were combined for analysis. Each set included the resistant controls *Gossypium barbadense* TX110 and *G. arboreum* accession A_2-190 (PI 615699) and the susceptible controls *G. hirsutum* cv. Deltapine 16 and *G. arboreum* accession A_2-101 (PI 529729). Root infection was measured on 3 plants per accession 4 weeks after inoculation with 1,000 vermiform nematodes and data were expressed as females per g of fresh root tissue. Data were subjected to $\log_{10}(x+1)$ transformation prior to analysis of variance, and differences among genotypes were determined using differences of least squares means ($P \le 0.05$). Additionally, a nematode index calculated for each entry (percentage of the average number of females that developed on susceptible *G. hirsutum* cultivar Deltapine 16) was used to classify accessions as resistant (nematode index <10%), moderately resistant (10% to 30%), moderately susceptible (31% to 60%), or susceptible (>60%). In total, there were 16 resistant, 125 moderately resistant, 72 moderately susceptible, and 13 susceptible accessions identified. Six accessions supported significantly fewer reniform nematode infections than were observed on the resistant checks: A_2-690 (PI 616184), A_2-737 (PI 616231), A_2-814 (PI 616308), A_2-849 (PI 616434), A_2-860 (PI 616354), and A_2-995 (PI 629323). Cotton breeders would benefit from introgressing the resistance from these newly-identified resistant accessions into their upland cotton improvement programs.

ENHANCING OXIDATIVE STRESS TOLERANCE AND LONGEVITY OF THE ENTOMOPATHOGENIC NEMATODE HETERORHABDITIS BACTERIOPHORA DAUER JUVENILES THROUGH GENETIC SELECTION. **Sumaya, Nanette Hope[1,2,3], V. Doerfler[1], M. Barg[1], B. Vandenbossche[1], O. Strauch[1], C. Molina[1], and R-U. Ehlers[1, 2].** [1]e–nema, GmbH, Klausdorfer Str. 28-36, 24223 Schwentinental, Germany. [2]Faculty of Agricultural and Nutritional Sciences, Christian-Albrechts-University Kiel, Hermann-Rodewald-Str. 4, 24118 Kiel, Germany. [3]Dept. of Biological Sciences, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, A. Bonifacio Ave., Tibanga, Iligan City 9200, Philippines.

The entomopathogenic nematode–bacterium complex *Heterorhabditis bacteriophora Photorhabdus luminescens* is one of the most widely used biological control agents against several insect pests. The dauer juveniles (DJs) are third stage non-feeding and infective juveniles, which carry the symbiotic bacteria, survive in the soil to search for and penetrate insect hosts. For their industrial production, DJs are produced in large quantities (up to 40 m^3) in e-nema GmbH (Schwentinental, Germany). Subsequently, DJs are stored, formulated, transported and applied in the field. However, from production to application, DJs encounter environmental stresses (desiccation, hypoxia, UV radiation, heat, and oxidative stress) in each stage that influences longevity before they can actively kill the insect pests. Understanding therefore the genetic component of the stress responses in *H. bacteriophora* and improving DJ longevity are important research tasks. In this study, we combined approaches like classical breeding and next-generation genomics to acquire knowledge about and improve DJ oxidative stress tolerance and longevity. We first screen the oxidative stress tolerance in a wide collection of *H. bacteriophora* strains and inbred lines from different geographical locations under with and without oxidative stress inductions. We determined a high variability among strains of this species and a high heritability for oxidative stress ($h^2 > 0.9$). Oxidative stress was also found to have significant positive correlation with DJ longevity and persistence. Thus, oxidative stress can be used as a predictor for DJ longevity and persistence, permitting a selection process within a shorter testing period. In order to enhance tolerance to oxidative stress, longevity and persistence, several genetic crosses, EMS-mutants and homozygous inbred lines were generated. These genetic crosses, EMS-mutants and homozygous inbred lines were observed to have a higher tolerance to oxidative stress, extended longevity in water and higher infectivity against *Tenebrio molitor* compared to their respective parental (AU1 and HU2), donor (IL3) and commercial (EN01) lines. Furthermore, the oxidative stress-responsive transcriptome of two contrasting lines was analysed using Massive Amplification of cDNA Ends (MACE) and candidate genes were screened for polymorphisms. More than 500 SNPs have been detected between a high- and a low-surviving inbred line. PCR-based KASP markers were derived from relevant transcripts and were tested in natural *H. bacteriophora* materials. Significant correlation between genotype and phenotype was determined for a subset of KASP markers. This basic research sets the basis for marker assisted selection and further breeding activities to prolong shelf-life of the nematodes.

DEPTH STRATIFICATION OF NEMATODE COMMUNITIES ASSOCIATED WITH VERTEBRATE DECOMPOSITION. **Taylor, Lois S.[1], G. Phillips[2], E. C. Bernard[2], J. M. DeBruyn[1].** [1]Department of Biosystems Engineering & Soil Science, University of Tennessee, Knoxville, TN 37996. [2]Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37966.

Vertebrate decomposition is a dynamic process resulting in ephemeral soil nutrient enrichment hotspots. As decomposition products enter the soil, numerous changes occur in the soil environment over time, including: pH and soil oxygen levels, rates of nitrogen and carbon cycling, microbial biomass and successional patterns, and an extensively-documented insect succession. By comparison, microfaunal members of the soil decomposing community have received little attention. There are some reports of changes to nematode communities associated with vertebrate decomposition hotspots, however, to our knowledge no attempt has been made to assess candidacy for indicator taxa or to compare responses between nematodes within c-p classes to determine which favor hotspot nutrient enrichment and which are sensitive to it. The objective of this study was to determine temporal development and successional patterns of nematode communities in soils underneath decomposing vertebrate carcasses over the course of a year. Six adult beaver carcasses (*Castor canadensis*), 20-23 kg each, were placed in wire cages to allow contact with soil and access by insect scavengers, while eliminating animal and avian scavenging, and allowed to decompose naturally for one year. Soil temperature, moisture, electrical conductivity, and internal temperatures were measured. Soil interface and core samples were taken to assess nematode population dynamics: interface samples were collected by removing the top 1 cm of soil from underneath carcasses, and core samples consisted of composited 30-cm deep cores. It was found in all cases that nematode abundances, richness, diversity, and Maturity Index rank responded strongly to the onset of active decay and that these effects persisted well into skeletonization. Communities present during active through late decay were dominated by a sequence of B1 enrichment opportunists: Rhabditidae (*Pelodera),* and Diplogasteridae *(Pristionchus)*, the response of which varied between cores and interfaces by up to an order of magnitude. During late decay through early skeletonization, Filenchus (F2) dropped below detectable limits in interface samples. *Aphelenchoides* (F2), *Acrobeloides* (B2), Tylencholaimidae (F4), and *Prismatolaimus* (B3) were enriched during late skeletonization. By the conclusion of the study, all diversity indices had returned to original levels, however community membership was significantly altered. We propose that the successional pattern of enrichment opportunists in the interface could be used as markers of decomposition progress. *Aphelenchoides* may be useful to define a narrow period of time in late skeletonization. In cores, Diplogasteridae and Rhabditidae may differentiate early periods of active decay, and simultaneous peaks associated with *Aphelenchoides*, *Acrobeloides*, Tylencholaimidae and *Prismatolaimus* may serve to define a narrow period of time in later skeletonization. In addition to identifying successional patterns of nematodes, our study has revealed that the inclusion of interface sampling with traditional coring methods shows considerable promise for depth-based comparative community analysis, particularly with respect to hotspot enrichment events.

BEYOND *R* GENES: DEVELOPING PLANT RESISTANCE AGAINST ROOT-KNOT NEMATODES. **Teixeira, Marcella, D. Zhou, J. He, and I. Kaloshian**. Department of Nematology, University of California, Riverside, CA 92521.

Pathogen perception by plants is based on a two-tiered defense strategy. The pattern-triggered immunity (PTI) is the first level, which relies on membrane-localized pattern recognition receptors' (PRRs) ability to perceive conserved molecular patterns from pathogens. Effector-triggered immunity (ETI) is the second mode of defense, which relies on disease resistance (*R*) genes recognizing directly or indirectly cognate pathogen effectors. Although *R* genes and ETI against nematodes have been characterized, identification of PRRs and characterization of PTI is at its infancy. We have shown that root-knot nematodes (RKN; *Meloidogyne* spp.) are perceived by plants similar to microbial pathogens. This perception in both tomato (*Solanum lycopersicum*) and Arabidopsis *(Arabidopsis thaliana)* requires the well-known co-receptor BAK1/SERK3 (BRASSINOSTEROID INSENSITIVE1-ASSOCIATED KINASE1/SOMATIC EMRYOGENESIS RECEPTOR KINASE 3), involved in the perception of a number of pathogens and herbivores. To better understand the *BAK-1* dependent defense against RKN, we performed gene expression analysis using RNA-seq in roots of Arabidopsis *bak1-5* mutant and wild-type Col-0, mock-treated or infected with *Meloidogyne incognita* at 24 h post inoculation. Our results indicate that more genes were regulated in *bak1-5* than in Col-0 by *M. incognita*. However, immunity related genes were upregulated to higher levels in Col-0 than in the *bak1-5* mutant. Among the genes regulated by RKN infection were those encoding receptor like kinases. Screening Arabidopsis mutants of a subset of these genes, we identified a lectin receptor-like kinase (LecRK), null mutants of which displayed enhanced resistance to RKN infection measured by the number of galls per square centimeter root. Compared to wild-type plants, these mutants did not exhibit altered root or plant growth phenotypes. Characterization of this LecRK and its mutants and the potential use of such mutation in developing durable resistance in crops will be presented.

FLUAZAINDOLIZINE (FORMULATED AS SALIBRO™): A NOVEL ACTIVE INGREDIENT FOR THE CONTROL OF PLANT PARASITIC NEMATODES IN NORTH AMERICA. **Joshua Temple[1], Tim Thoden[2] and John A. Wiles[3].** [1]Corteva Agriscience™, Agriculture Division of DowDuPont™, Bradenton, FL, 34208, USA. [2]Corteva Agriscience™, Agriculture Division of DowDuPont™, DuPont de Nemours (Deutschland) GmbH, Hugenottenalle 175, 63263 Neu-Isenburg, Germany. [3]Corteva Agriscience™, Agriculture Division of DowDuPont™, DuPont (U.K.) Limited, 4th Floor, Kings Court, London Road, Stevenage, SG1 2NG, United Kingdom.

Plant-parasitic nematodes remain a significant threat and source of yield reduction in crop production around the world. Over the last two decades nematicidal products used for protection against these soil dwelling pests have come under significant regulatory pressure due to a range of toxicological and environmental issues. In response, the crop protection industry has initiated an intensive effort directed at the discovery and development of new biological and chemical nematode control products, as well as traits in plants. Fluazaindolizine is a new highly effective and selective active ingredient for the control of plant-parasitic nematodes. Specificity for nematodes coupled with absence of activity against the target sites of commercial nematicides suggests that fluazaindolizine has a novel mode of action. It is the first member from the novel chemical class of sulfonamide nematicides. Salibro™ has been extensively tested in laboratory, greenhouse, microplot and field trials in North America. In those trials Salibro™ was proven extremely effective against a range of important plant-parasitic nematode species. Salibro™ has a fit in nematode management programs in a range of crops in North America, including fruiting and cucurbit vegetables, root vegetables (carrot, sweet potato, potato), tree nuts, grapes, citrus, stone fruit, and tobacco. An introduction to the chemical and biological properties of this new nematicide will be presented.

SALIBRO™: A NOVEL NEMATICIDE FOR THE CONTROL OF MELOIDOGYNE SPP. IN FRUITING VEGETABLES AND CUCURBITS IN FLORIDA. **Joshua Temple[1], Tim Thoden[2], and John A. Wiles[3].** Corteva Agriscience™, Agriculture Division of DowDuPont™, Bradenton, FL 34208, USA. [2]Corteva Agriscience™, Agriculture Division of DowDuPont™, DuPont de Nemours (Deutschland) GmbH, Hugenottenalle 175, 63263 Neu-Isenburg, Germany. [3]Corteva Agriscience™, Agriculture Division of DowDuPont™, DuPont (U.K.) Limited, 4th Floor, Kings Court, London Road, Stevenage, SG1 2NG, United Kingdom.

Several different species of nematodes can be important to crop production in Florida. In general, a mixed population of plant parasitic nematodes is present in many Florida fields. The most widespread and economically important nematode species are the root-knot nematodes, *Meloidogyne* spp. In Florida, the most prevalent root-knot nematode species in vegetables and row crops include *Meloidogyne incognita*, *M. javanica*, and *M. arenaria*. Integrated nematode management, which may include resistant/tolerant varieties, cultural methods, as well as chemical and biological solutions, is required to maintain root-knot nematode populations at levels that do not significantly impact yields. Salibro™, which contains the novel sulfonamide active ingredient fluazaindolizine is a new nematicide that has high potency against a broad range of species of root-knot nematodes. In Florida Salibro™ has been extensively tested against root-knot nematode in efficacy studies in a range of fruiting vegetable and cucurbit crops over several seasons. Salibro™, applied by various application methods according to the crop type, has demonstrated consistent and significant gall reduction on roots and will offer a new effective tool for the management of root-knot nematode pests.

EPIDERMAL SEAM CELL LINEAGES ARE ASSOCIATED WITH PYRIFORM BODY SHAPE IN CYST AND ROOT-KNOT NEMATODES. **Thapa, Sita, M. K. Gates, U. Reuter-Carlson, and N. E. Schroeder.** Dept. of Crop Sciences. University of Illinois at Urbana-Champaign, Urbana, IL, 61801.

Cyst and root-knot nematodes develop from vermiform juveniles into pyriform adult females. The mechanisms regulating this unusual growth are unknown. In the nematode *Caenorhabditis elegans,* body size is correlated with stem cell-like divisions of laterally positioned 'seam' cells that contribute to an increase in the total number of epidermal nuclei. We hypothesize that this process has undergone extensive evolutionary changes to control the growth of the cyst nematode *Heterodera glycines* from a vermiform juvenile to a pyriform adult female. We examined both live and fixed *H. glycines* at regular time points following synchronized infection. In pre-infection J2s, we found a line of epidermal cells morphologically similar to *C. elegans* seam cells. Following infection, the *H. glycines* seam cells divide to produce four epidermal daughter cells, which fuse with the dorsal and epidermal syncytia, and two seam cells. Similar to *C. elegans,* subsequent molts in *H. glycines* are associated with additional seam cell divisions. However, unlike in *C. elegans*, each subsequent molt in *H. glycines* coincides with an exponential increase in the number of divisions and epidermal nuclei daughters. This exponential increase in epidermal nuclei during development results in more than 1000 epidermal nuclei in adult *H. glycines* females compared with 175 in adult *C. elegans* hermaphrodites. Similar to *C. elegans,* we found that *H. glycines* epidermal nuclei are polyploid. Preliminary examination of *H. glycines* with transmission electron microscopy confirms the presence of a seam cell bundle surrounded by a large epidermal syncytia. To examine if a similar cell division pattern occurs in other non-vermiform shaped parasitic nematodes, we examined the epidermal development of *Meloidogyne incognita* and *Rotylenchulus reniformis.* Using similar time-course analysis, we found that while *M. incognita* also shows an increased seam cell proliferative capacity, the pattern of division is very different from that found in *H. glycines.* Interestingly, *R. reniformis* does not show an increased seam cell proliferation compared with *C. elegans.* Rather it appears that growth of *R. reniformis* is associated with stretching by the growth of the adult female gonad. Our results suggest the evolution of distinct mechanisms to produce a similar phenotype from a common ancestor.

THE SOIL HEALTH COMPATIBILITY OF SALIBRO™ - A NOVEL SULFONAMIDE NEMATICIDE. **Tim C. Thoden[1], Joshua Temple[2], and John A. Wiles[3]**. [1]Corteva Agriscience™, Agriculture Division of DowDuPont™, DuPont de Nemours (Deutschland) GmbH, Hugenottenalle 175; 63263 Neu-Isenburg; Germany; tim.thoden@dupont.com. [2]Corteva Agriscience™, Agriculture Division of DowDuPont™, Bradenton, FL 34208, USA. [3]Corteva Agriscience™, Agriculture Division of DowDuPont™, DuPont (U.K.) Limited, 4th Floor, Kings Court, London Road, Stevenage, SG1 2NG, United Kingdom.

Healthy soils are widely regarded as an important factor in reducing soilborne plant diseases and supporting plant growth. This has been directly linked to well-developed soil food webs (e.g. different nematode feeding groups), the presence of natural antagonists (e.g. nematophagous fungi), as well as plant growth promoting microbial organisms such as arbuscular mycorrhizal fungi (AMF) or plant growth promoting bacteria (PGPR). The integrated and sustainable management of plant-parasitic nematode populations can highly benefit from these natural antagonists and plant symbionts. However, especially when nematode pressure is high, chemical nematicides are needed to support good crop yields. Consequently, it's important to understand how soil applied nematicides interact with the different organisms that contribute to the overall soil health network and to include both into an integrated nematode management approach. Salibro™ is a novel sulfonamide nematicide containing the active ingredient fluazaindolizine that has been developed by DowDuPont™ and which has shown excellent control of plant-parasitic nematodes in hundreds of field trials around the globe. During its development, we also thoroughly investigated its effects on various players within the soil health complex and evaluated its compatibility with commonly used antagonists of plant parasitic nematodes, plant diseases and insects. Results of those studies will be presented in this paper.

SPATIAL VARIABILITY OF *PASTEURIA PENETRANS* PATHOTYPES. **Timper, Patricia[1] and C. Liu[2].** [1]USDA ARS, P.O. Box 748, Tifton, GA 31793. [2]Plant Pathology Dept., University of Georgia, Tifton, GA 31793.

Pasteuria penetrans is an endospore-forming parasite of *Meloidogyne* spp. Over the last several years, we have been studying the adaptation of *P. penetrans* to its host *Meloidogyne arenaria* in a field site in Georgia, USA. The nematode population is comprised of multiple genotypes differing in susceptibility to *P. penetrans*. Using clonal lines of *M. arenaria* that acquire different subpopulations (pathotypes) of *P. penetrans* spores, we observed rapid changes over time in the dominant pathotype within each of eight plots. The dominant pathotype also varied among plots indicating that shifts in pathotype frequency were not due to large-scale environmental factors, but to local adaptation of *P. penetrans* to genotype shifts in the host population. Because pathotypes varied among plots, we suspected that they may also vary within locations in a single plot. Therefore, we sampled soil within a 30 cm radius at 1.5, 3.0, 4.5, and 6 m from the end of a single plant bed in each of four plots and used the clonal lines of *M. arenaria* to determine the frequency of different pathotypes of *P. penetrans* at each location. In 2016, the dominant spore pathotype was relatively uniform across the sampled beds; however, in 2017, the dominant pathotype varied across the bed in three of four plots. Therefore, homogenizing soil from a large area can blend dominant pathotypes. Even in a small area, we sometimes observed no dominant pathotype. The inability to statistically detect a dominant pathotype was often associated with very low spore densities (<1 spore/juvenile). In beds with moderate spore densities (≥1 spore/juvenile), 73% of locations within the plots had a dominant spore pathotype. There was also a change in the dominant pathotype from one year to the next suggesting rapid adaptation of the *P. penetrans* population over time.

EXTENSION EDUCATION IN THE HEARTLAND OF CORN AND SOYBEAN PRODUCTION IN THE UNITED STATES. **Tylka, Gregory L.** Department of Plant Pathology and Microbiology, Iowa State University, Ames, IA 50011.

The north central region of the United States is where a majority of the country's corn and soybean crops are grown. The corn-soybean cropping system has fewer plant pests and pathogens than more diverse cropping systems, but complexity and challenges still exist in educating corn and soybean farmers about disease and pest management. The most effective extension educators in the region are sound researchers. They also are great communicators who often have a creative flair. Furthermore, these educators put forth considerable and sustained efforts to understand the specific situations of their clientele – the farmers who grow the crops – in order to provide research-based information and guidance in a form and context that ensure the information will be used. This approach to extension education will be elaborated upon and examples will be given in this presentation.

RESIDUAL EFFECT OF ROOT-KNOT NEMATODE RESISTANT TOMATO CULTIVARS AND FUMIGANTS IN A DOUBLE-CROP SYSTEM IN FLORIDA, USA. **Vau, Silvia João[1], S. Qiu[1], and D. W. Dickson[2]**. [1]Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL 32614-7100. [2]Entomology and Nematology Department, PO. Box 110620, University of Florida, Gainesville, FL 32611-0620.

Double cropping systems can serve as a type of crop rotation where nonhost, resistant, or grafted crops provide a basis for reducing root-knot nematode population densities in soil. Some regions of Florida provide climatic conditions conductive to producing several crops per year in a sequential multiple cropping system. Our objective in two separate trials was to determine the efficacy of soil fumigants and a root-knot nematode resistant and susceptible tomato cultivar as the primary crop followed by carrot - *Daucus carota* subsp. *sativus* L. (fall 2013-winter seasons), or cucumber - *Cucumis sativus* L. (spring 2014 – summer season) as double crops. A split-plot design with five replicates was used. The main plots included chloropicrin (pic) 263 kg/ha; dimethyl disulfide (DMDS) 374 l/ha; 1,3-D 140 l/ha; 1,3-D

+ pic 325 l/ha; and metam potassium 561 l/ha), and a nontreated control, and the subplots included root-knot nematode resistant and susceptible tomato cultivars Crista and BHN602, respectively. In 2013 the fumigants were applied in July in preparation for transplanting tomato in mid-August, whereas in 2014 the fumigants were applied in February in preparation for transplanting tomato in early April. In both trials the only benefit from Crista was the reduction of root-knot nematode second-stage juvenile population densities in soil. However, there were residual effects of the soil fumigant treatments when compared with the nontreated plots. The highest carrot yields were obtained in plots treated with DMDS and 1,3-D + Pic, whereas in the cucumber trial highest yields were obtained in plots treated with metam K and 1,3-D + Pic.

TRANSIENT EXPRESSION OF *PRATYLENCHUS PENETRANS* EFFECTORS USING POTATO VIRUS X-BASED EXPRESSION VECTOR. **Vieira, Paulo[1,2], J. D. Eisenback[1] and L. G. Nemchinov[2]**. [1]Virginia Tech, Dept. of Plant Pathology, Physiology, and Weed Science, Blacksburg, Virginia. [2]USDA-ARS, Beltsville Agricultural Research Center, Molecular Plant Pathology Laboratory, Beltsville, Maryland.

The root lesion nematode (RLN) *Pratylenchus penetrans* is an economically important pathogen that inflict damage and yield loss to a wide range of crops, including alfalfa. Currently, there are no commercially certified alfalfa varieties with root lesion nematode resistance. Similar to other plant-parasitic nematodes (PPN), the successful infection of RLN relies on the secretion of a repertoire of proteins with diverse parasitism-related functions. Recently, we provided novel insights into the catalogue of candidate effector genes of *P. penetrans*, covering not only different functional categories of known PPN effector genes, but also a significant number of genes encoding proteins with unknown functions. Since effector proteins are shaping the broad interaction between the pathogen and the host, it is always challenging to assign a specific function to novel effector genes, especially when they show no sequence homology to known effector-encoding genes. In this work, we investigated biological roles of these pioneer effector genes by their transient expression in *Nicotiana benthamiana* plants using potato virus X (PVX)-based expression system. Several unique phenotypes, different from symptoms caused by wild type PVX, were observed. Transcriptome analysis is underway to decipher plant genes affected by expression of individual effector genes.

EFFECTS OF FLUOPYRAM ON BENEFICIAL AND PLANT-PARASITIC NEMATODES IN COMPARISON TO AZARACTIN AND SUNN HEMP COVER CROPPING. **Philip Waisen[1], S. Ching[2], and K.-H. Wang[1].** [1]Dept. Plant and Environmental Protection Sciences, University of Hawaii at Manoa. [2]Hawaii Department of Agriculture, Honolulu, HI.

Fluopyram is a succinate dehydrogenase inhibitor (SDHI) fungicide with labels for plant-parasitic nematode control on some crops. Its use in Hawaii on horticultural crops is currently under evaluation. The objectives of this research were to evaluate 1) the efficacy of Velum One (a.i. fluopyram) chemigation compared to integrating sunn hemp cover cropping with Velum One or Molt-X (a.i. azaractin) against root-knot (*Meloidogyne javanica*) and reniform (*Rotylenchulus reniformis*) nematodes; and 2) the effects of Velum One on free-living nematodes. Two field trials were conducted at Poamoho Experiment Station, Waialua, HI. The first trial was on 'Felix F1' zucchini (*Cucurbita pepo*) and the second trial was on 'Komohana' cherry tomato (*Solanum lycopersicum*). Treatments examined were 1) Velum One at crop transplant (Velum I), 2) Velum One at crop transplant and 4 weeks after transplanting (Velum II), 3) planting sunn hemp (SH), *Crotalaria juncea* followed by soil incorporation and Molt-X at 4-week intervals after transplanting (SH+Molt-X), 4) planting SH followed by Velum One application 4 weeks after transplanting (SH + Velum), and 5) an untreated control. The zucchini trial lasted for 2 months, whereas the cherry tomato trial lasted for 3 months. In the zucchini trial, planting SH or applying Velum resulted in greater survival of zucchini seedlings from heavy infestation of *M. javanica* compared to the control ($P \leq 0.05$). SH+Velum or SH+Molt-X suppressed reniform and root-knot nematodes most significantly, and produced highest zucchini fruit numbers ($P \leq 0.05$). In addition, SH+Velum provided an additional advantage of reducing the negative impact of Velum (Velum I and Velum II) on soil health. While Velum (I or II) reduced the abundance of bacterivorous and fungivorous nematodes, SH+Velum increased these nematodes compared to the control. However, in the tomato trial, while SH+Molt-X continued to improve tomato growth and yield, Velum alone out performed SH+Velum in terms of tomato yield ($P \leq 0.05$) despite SH+Velum suppressing root-knot and reniform nematodes the most among all treatments. The most interesting finding from this study was that integrating sunn hemp with Velum 1 month after transplanting provided a synergistic effect against plant-parasitic nematodes while providing a green manure effect that enhanced plant growth, and reduced the negative impact of Velum alone on free-living nematodes. None-the-less, SH+Molt-X provided the most promising effect in protecting soil health. On the other hand, SH+Velum would be less labor intensive than SH + Molt-X as only one Velum application is required, compared to the monthly injection of Molt-X. It is worth noting that the longer the crop production cycle, the less SH could remediate the negative effect of Velum on soil health.

MANAGING PLANT-PARASITIC NEMATODES AND SOIL HEALTH THROUGH ECOLOGICAL BASED BIOFUMIGATION USING BROWN MUSTARD AND OIL RADISH. **Waisen, Philip***, **K.-H. Wang, Z. Cheng** and **B. S. Sipes**. Department of Plant and Environmental Protection Sciences, University of Hawaii at Manoa, 3050 Maile Way, Honolulu, HI 96822.

Brown mustard (MS), *Brassica juncea*, and oil radish (OR), *Raphanus sativus,* contain glucosinolates that can be enzymatically broken down into isothiocyanates (ITC) and sulfate among other products. ITC are especially toxic to soil-borne pathogens including plant-parasitic nematodes (PPN) but results are inconsistent in the field conditions. This inconsistency could be due to the volatile nature of ITC and the host status of these cover crops on the targeted PPN. The objectives of this research were to 1) determine heat units required by *Meloidogyne incognita* to reach an egg-laying female on MS or OR, and 2) determine the best termination method of MS or OR for PPN suppression and soil health management. A greenhouse trial was conducted where 'Caliente 199' MS and 'Sodbuster' OR inoculated with *M. incognita* were compared to 'Orange Pixie' tomato, *Solanum lycopersicum*. Roots were stained using acid fucshin at 3-day intervals beginning 9 days after inoculation. *M. incognita* required 3.5 weeks, equivalent to 274.5 degree days (DD), to reach the egg-laying female stage on MS and OR. A field experiment at Poamoho Experiment Station, Waialua, HI was conducted to verify DD to egg-laying females where OR was terminated at 2, 4, 6 or 8 weeks after seeding. Terminating OR at 4 weeks, equivalent to 386 DD, after seeding reduced root-gall index on a subsequent pumpkin crop ($P \leq 0.05$). Another field experiment was conducted to determine the best termination method for biofumigation. MS was terminated after 5 weeks of growth by either maceration (M) using a line trimmer, tilling (T), not tilling (NT), maceration but no tilling (MNT), maceration and tilling (MT), or combining M, T and covering with black plastic mulch (MTBP). A bare ground was included as untreated control. Using sulfate as an indirect measure of ITC, MTBP provided the most effective biofumigation, with a higher concentration of sulfate than all the other methods ($P \leq 0.01$). A canonical analysis among myrosinase activities measured by glucose analysis and sulfate; abundance of *Meloidogyne* spp. and *R. reniformis*; and soil health indicators including enrichment index, structure index, and channel index; abundance of bacterivores, fungivores, omnivores and predatory nematodes, diversity; zucchini fruit weight, chlorophyll content and root weight explained 93.8% of the variance on the first two axes. This analysis showed that sulfate was negatively related to abundance of *Meloidogyne* spp. but not to *R. reniformis*. However, sulfate concentration was possitively related to bacterivorous nematodes, predatory nematodes and enrichment index. In conclusion, terminating MS or OR at 4 weeks after planting was most effective to trap the *Meloidogyne* spp. in the roots. Despite an effective kill of *Meloidogyne* spp., MTBP did not compromise soil health. Therefore, MTBP using MS is an effective ecological based biofumigation approach.

NEMATICIDE EFFECTS ON NON-TARGET NEMATODE POPULATIONS IN BERMUDAGRASS. **Waldo, Benjamin, W. T. Crow, Z. J. Grabau, and T. M. Mengistu.** Entomology and Nematology Department, University of Florida, Gainesville, FL 32611.

Turfgrass (*Cynodon* sp.) in an important groundcover and playing surface utilized in golf courses in the United States. Plant-parasitic nematodes can be a serious pathogen in turfgrass and cause unacceptable decline in turfgrass appearance in the absence of chemical control. Nematicides are commonly applied to putting greens to reduce densities of plant-parasitic nematodes. While nematicides have been shown to reduce plant-parasitic nematodes, few studies have evaluated effects on beneficial free-living nematodes in turfgrass. Free-living nematodes contribute to ecosystem services such as nutrient cycling and altering the abundance of beneficial nematodes could have negative impacts on soil health. Similar pesticide treatment studies demonstrated a reduction in high colonizer-persistor (cp) value predatory and omnivorous nematodes in soil after pesticide exposure. In our study, we evaluated the effects of four turfgrass nematicide formulations of abamectin (Divanem SC), fluopyram (Indemnify), furfural (MultiGuard Protect EC), and fluensulfone (Nimitz Pro G) on free-living nematodes in bermudagrass. A randomized block with five replications of four treatments and an untreated control was used in this study. Plots were 6 m^2 with 0.6 m untreated borders between adjacent plots. Data were collected from 1.5 m^2 subplots located in the center of the treatment plots. Nematicides were applied at labeled rates every four weeks as a summer treatment program from 24 April to 18 July, 2017 at the University of Florida Plant Science Research and Education Unit in Citra, Florida. Samples were collected before treatment and two days, two weeks, eight weeks, and thirty-four weeks after the final treatment for functional group analysis. Data from each nematicide treatment were compared to the untreated control at each sample date using analysis of covariance with initial population counts serving as the covariate. Abamectin treated plots had a significant increase of bacterivores at two-week and eight-week sampling dates, and a decrease in fungivores and predators at thirty-four weeks after final treatment. Fluopyram plots had a significant reduction in bacterivores at two weeks, eight weeks, and thirty-four weeks; reduction of fungivores at thirty-four weeks; reduction of omnivores at all sampling dates; and a decrease of predators at two weeks and thirty-four weeks. Fluensulfone had a significant reduction of fungivores at eight weeks. Our results suggest nematicides can significantly impact free-living nematode functional group composition in bermudagrass. The results of this study could better assist golf course superintendents to make informed nematicide application choices.

SPATIAL AND TEMPORAL GENETIC DIVERSITY OF A RECENT *GLOBODERA PALLIDA* INFESTATION IN IDAHO. **Wasala, Sulochana[1], D. K. Howe[1], I. A. Zasada[2], and D. R. Denver[1].** [1]Department of Integrative Biology, 3029 Cordley Hall, Oregon State University, Corvallis, OR 97331. [2]USDA-ARS Horticultural Crops Research Laboratory, 3420 NW Orchard Avenue, Corvallis, OR 97330.

Globodera pallida is widely distributed in potato-growing regions of Europe and was first discovered in the United States (Idaho) in April 2006. It is among the top three most significant plant-parasitic nematodes worldwide, causing major agriculture loss. Since 2007 efforts have been underway in Idaho to eradicate *G. pallida* primarily through use of the soil fumigants methyl bromide and 1,3-dicholopropane. Recent work in spatial analysis of *G. pallida* infestation in Idaho supported a single introduction. In our study we used genome-wide spatial patterns of genetic variation to address this question. We also explored temporal patterns of genome-wide polymorphisms to identify putative candidate loci under selection. *G. pallida* cyst populations were obtained from six different fields in Idaho in addition to a greenhouse population maintained at the University of Idaho, Moscow. Four of the field populations were collected before the nematode eradication process started in 2007 and two were collected from recently identified infested fields (2014 and 2015) before they underwent fumigation. Temporal sampling was done for three of the six fields, where cyst samples were collected before fumigation (pre-fumigation) and at different time points after fumigation (post-fumigation). For each sample four replicates (consisting of 50 cysts each) were collected for DNA extraction and library preparation. Whole genome sequencing was performed for 54 *G. pallida* samples (Illumina HiSeq 3000, paired-end, 150 bp). After initial quality trimming, raw reads were mapped to the *G. pallida* reference genome using Burrows-Wheeler Aligner (BWA) software. Popoolation2 software was used to evaluate differentiation between populations across space and time. According to the genome wide Fst (Fixation index) analysis across space, most of the genetic variation was shared between pre-fumigation samples indicating the infestation might have resulted from a single introduction. Based on allele frequency data and Fst analysis across time, some outlier loci were identified in comparing pre-fumigation and post-fumigation samples, indicating the presence of genomic regions putatively involved in nematode adaptation.

LOW-VOLUME IRRIGATION SYSTEMS INFLUENCE *PRATYLENCHUS PENETRANS* POPULATIONS IN A NEWLY ESTABLISHED SWEET CHERRY ORCHARD IN BRITISH COLUMBIA. **Tristan T. Watson[1,2*], L. M. Nelson[1], D. Neilsen[2], G. H. Neilsen[2], T. A. Forge[2].** [1]The University of British Columbia - Okanagan Campus, Biology Department, Kelowna, British Columbia, V1V 1V7, Canada. [2]Agriculture and Agri-Food Canada, Summerland Research and Development Centre, Summerland, British Columbia, V0H 1Z0, Canada.

The root-lesion nematode (*Pratylenchus penetrans*) is widespread and contributes to poor growth of fruit trees in the Okanagan Valley of British Columbia, Canada. The nematode has particularly strong effects on young trees replanted into old orchard soil where it is an important component of the broader orchard replant disease complex. A four-year study was conducted to determine the effects of drip and microsprinkler irrigation systems on population densities of *P. penetrans*, plant growth, and early fruit yield of sweet cherry trees planted into an old apple orchard site. Trees irrigated with drip emitters had larger trunk diameters throughout the first four years of establishment, and greater total fruit yield in the fourth growing season. Population densities of *P. penetrans* in soil and roots were smaller under drip irrigation than microsprinkler. Trees irrigated using drip emitters were more colonized by arbuscular mycorrhizal fungi than those irrigated by microsprinklers, and had a greater density of fine roots in soil. While the amount of water applied in the two irrigation systems was similar, drip irrigation resulted in greater volumetric water content in root zone soil than microsprinklers. Overall, drip irrigation shows potential as a component of an integrated replant management strategy for minimizing the early buildup of *P. penetrans* and enhancing early growth of sweet cherry in British Columbia.

HOST PREFERENCE OF *PRATYLENCHUS NEGLECTUS* TO MAJOR CROPS OF THE PRAIRIE PROVINCES OF CANADA. **Priscillar Wenyika, and Mario Tenuta.** University of Manitoba, Department of Soil Science, Winnipeg, Manitoba, Canada, R3T 2N2.

Root-lesion nematodes (RLN) of the genus *Pratylenchus* Filipjev 1936, are economically important plant-parasitic nematodes. *Pratylenchus neglectus* has been reported to reduce yields of wheat, canola, chickpea, lentil and oat. In a survey of plant-parasitic nematodes across the Prairie provinces of Canada, we observed *Pratylenchus neglectus* in 19% of 93 commercial fields examined. Potato cv. Russett Burbank was previously shown to not allow reproduction of *P. neglectus* from the Canadian Prairies, but other crops have not been examined. Thus a host screening study of major crops on the Canadian Prairies to *P. neglectus* was conducted under greenhouse conditions. Soils naturally infested with the root-lesion nematode were collected from Brooks, Alberta and used. Plants of seven crops (chickpea, yellow pea, lentil, soybean, pinto bean, wheat and canola) were planted in pots of the infested soil and grown for 8 weeks repeatedly for four growth cycles. The reproductive factor (Rf) was determined as the ratio of final soil plus root to initial soil densities. *P. neglectus* was found in roots of at least some or all replicates of the test crops. Preliminary results showed Rf values > 1 for only soybean and chickpea. *Pratylenchus neglectus* densities of 70 and 29/g root were obtained from roots of chickpea and soybean in the first growth cycles, respectively. The other five crops did not increase densities of the nematode in the first cycle and thus, likely are non-hosts. As naturally infested soil was used, we confirmed recovered nematodes from roots and soil were morphologically and genetically consistent to being *P. neglectus*. Reproduction factors for each of the grow cycles of the crops will be presented. For now, the results indicate soybean and chickpea are hosts of *P. neglectus* in the Canadian Prairies with soybean being a new reported host of the nematode.

USE OF ANAEROBIC SOIL DISINFESTATION TO PRODUCE NEMATODE-FREE PLANTING STOCK. **Westphal[1], Andreas, T. R. Buzo[1], Z. T. Z. Maung[1], S. Albu[2], S. Strauss[2], and D. Kluepfel[2].** [1]Nematology Dept., University of California Riverside, Parlier, CA 93648. [2]USDA-ARS, Crops Pathology and Genetics Research Unit Davis, CA 95616.

In California, nut tree production areas are often infested with *Pratylenchus vulnus*. These infestations are deep in the soil making remediation difficult when producing nematode-free nursery stock. Several effective soil fumigation materials are in the process of being phased-out due to human and environmental health concerns. In the preplant soil treatment alternative, anaerobic soil disinfestation (ASD), carbon-rich materials are incorporated, and decompose under impermeable film at saturated moisture levels for 30 days. On 15 August 2016, rice bran (RB), molasses (MO), tomato pomace (TP) or mustard seed meal (MSM) were added to soil at a rate of 20.2 ton per ha. The amended plots were then covered with a plastic film and 150 liter per m^2 of water was applied. Controls consisted of water or Telone EC (250 ppm a.i.) treated plots. After two days, the soil became anaerobic at depths of 15-cm and 46-cm in all carbon source-amended plots. On 9 November 2016, numbers of *P. vulnus* per 250 cm^3 of soil in the ASD treatments were similar as those in Telone EC-treated plots. Numbers in all ASD-treated plots were lower than in the water treated controls. Peach rootstock 'Nemaguard' seeds were planted in all plots. During 2017, seedlings were repeatedly examined for *P. vulnus* populations in the roots. At harvest in winter 2018, *P. vulnus* were close to detection levels in all ASD (RB: 0.2; MO: 0.5; TP: 0.3; MSM: 0.1) and Telone EC treated (0.1) plots while 87 *P. vulnus* per g of root were detected in the non-treated control plots. ASD is a promising preplant soil treatment to produce clean planting stock.

CHEMICAL SIGNALS MEDIATING HOST FINDING BY AND COMMUNICATION BETWEEN ROOT-KNOT NEMATODE JUVENILES. **Williamson, Valerie M., Bruening, G. E., Leung, J., Danquah, W. B., and Cepulyte, R.** Department of Plant Pathology, University of California, Davis, CA 95616.

Root-knot nematodes (RKN; *Meloidogyne* spp.) can parasitize over 2000 plant species and cause significant losses to a wide range of crops. Infective juveniles (J2) are non-feeding and must locate and invade a host before their reserves are depleted, but what attracts them to appropriate host entry sites is not known. We have used Pluronic gel, a highly transparent, thermos-reversible medium to investigate behaviors and responses of RKN to both chemical gradients and plant roots. RKN J2 move through Pluronic gel in 3 dimensions mimicking aspects of nematode behavior in soil. In this medium, J2 of *Meloidogyne hapla*, *M. incognita* and *M. javanica* are highly attracted to root tips of tomato and the model legume *Medicago truncatula.* Compared to wildtype seedlings of both hosts, mutants that are defective in ethylene signaling are more attractive to RKN. Cell-free exudates collected from tomato and *M. truncatula* seedling root tips are highly attractive to *M. javanica* J2. The attraction activity fractionates similarly for the two exudates, and size-exclusion chromatography indicates the major active component has a mass of ~400 for both plant species. These findings demonstrate that a potent attractant with the same or similar properties is released from root tips of these two disparate host species and may represent a universal host signal for this broad host-range nematode. RKN also release exudates that may function in inter-nematode chemical signaling. Among these exudates are ascarosides, a class of conserved pheromones shown to modulate behavior and development in a wide range of nematode species. The most abundant ascaroside emitted from RKN is Ascr18. Synthetic Ascr18 strongly alters the response of RKN to root exudates. Additionally, application of Ascr18 to RKN aggregates in Pluronic gel can cause a dispersal response. Identification of the chemical signals that attract RKN to roots, repel them or otherwise modify their behavior has the potential to provide insights for novel and safe control strategies, and Pluronic gel medium provides a useful tool for such studies.

MARKER-ASSISTED-SELECTION COUPLED WITH RECOMBINANT INBRED LINE GENOME SEQUENCING IDENTIFIES A ROOT-KNOT NEMATODE RESISTANCE GENE ON CHROMOSOME 14 IN UPLAND COTTON. **Wubben, Martin[1], G. N. Thyssen[2], P. Lee[2], D. Fang[2], F. E. Callahan[1], D. D. Deng[1], J. C. McCarty[1], and J. N. Jenkins[1].** [1]USDA-ARS, Crop Science Research Laboratory, Genetics and Sustainable Agriculture Research Unit, Mississippi State, MS, 39762, USA. [2]USDA-ARS, Southern Regional Research Center, Cotton Fiber Bioscience Research Unit, New Orleans, LA, 70124, USA.

The southern root-knot nematode (RKN; *Meloidogyne incognita*) remains the primary yield-limiting biotic stress to Upland cotton (*Gossypium hirsutum*) throughout the southeastern United States. Simple-sequence-repeat (SSR) markers linked to RKN resistance quantitative trait loci (QTLs) on chromosomes 11 and 14 have been used to incorporate a high level of resistance into agronomically superior Upland germplasm; however, the genes responsible for resistance remain unidentified. The identification of these resistance genes would improve molecular breeding efficiency and provide insights into the molecular signaling cascades that mediate RKN resistance in Upland cotton. A random mated Upland cotton population (RMUP) comprised of 11 parents, including one parent having the chromosome 11 and 14 resistance QTLs, was developed through five cycles of random mating and used to create ~ 550 recombinant inbred lines (RILs). All RILs were subjected to SSR genotyping and 3-5X coverage genome sequencing. Based on SSR genotype and genome sequence, RILs were identified that showed recombinations within the known mapping interval of the chromosome 14 RKN resistance QTL. RKN resistance phenotyping of these RILs delimited a mapping interval on chromosome 14 to approximately 30 kb, within which resided four predicted genes. SNP analysis, qRT-PCR, and VIGS (virus induced gene silencing) identified a single gene within the mapping interval that was responsible for RKN resistance mediated by the chromosome 14 QTL. Furthermore, a gene-specific marker developed for the resistance locus was able to identify RKN resistant germplasm from a collection of wild accessions and a National Cotton Variety Panel. The mapping approach implemented in this study, i.e., SSR genotyping plus RIL genome sequencing, shows tremendous promise in the identification of specific genes underlying complex traits including pathogen resistance.

MOLECULAR CHARACTERIZATION AND IDENTIFICATION OF STUBBY ROOT NEMATODE SPECIES FROM EIGHT STATES IN THE USA. **Yan, Guiping**[1], **D. Huang**[1], **N. Gudmestad**[1], **J. Whitworth**[2], **K. Frost**[3], **C. Brown**[4], **W. Ye**[5], **P. Agudelo**[6], **and W. Crow**[7]. [1]North Dakota State University, Department of Plant Pathology, Fargo, ND 58108. [2]USDA-ARS, Aberdeen, ID 83210. [3]Oregon State University, Hermiston Agricultural Research and Extension Center, Hermiston, OR 97838. [4]USDA-ARS, Prosser, WA 99350. [5]North Carolina Department of Agriculture and Consumer Services, Raleigh, NC 27607. [6]Clemson University, Plant and Environmental Sciences Department, Clemson, SC 29634. [7]University of Florida, Entomology and Nematology Department, Gainesville, FL 32611.

Stubby root nematodes (SRN) are important plant-parasitic nematodes infecting many crops and widely distributed in many regions in the USA. Certain SRN species have the ability to transmit *Tobacco rattle virus* which causes corky ringspot disease in potato, therefore having a significant economic impact on the potato industry. In 2015-2017, 184 soil samples and 16 nematode suspensions from eight states including North Dakota, Minnesota, Idaho, Oregon, Washington, South Carolina, North Carolina, and Florida were assayed for the presence of SRN. SRN were found in 106 soil samples with population densities ranging from 10 to 320 per 200 g of soil and also in eight nematode suspensions. Sequencing of ribosomal DNA and/or species-specific PCR assays revealed the presence of four SRN species; *Paratrichodorus allius* was detected in North Dakota, Minnesota, Idaho, Oregon, and Washington; *P. minor* in North Carolina; *P. porosus* in South Carolina and North Carolina; and *Trichodorus obtusus* in Florida and South Carolina. *P. allius* is the most prevalent species in the samples from North Dakota, Minnesota, Idaho, Oregon, and Washington analyzed in this study and it has been reported as the most prevalent vector of tobraviruses in potato fields. Accordingly, their rDNA sequences were characterized by analyzing D2-D3 of 28S rDNA, two segments of 18S rDNA, and ITS (ITS1 and ITS2) rDNA obtained in this study and retrieved from GenBank. Both intra- and inter-species variations were higher in ITS rDNA than 18S rDNA and D2-D3 of 28S rDNA. The D2-D3 of 28S rDNA was the most conserved region among and within species when compared to ITS rDNA and 18S rDNA. Phylogenetic analyses using rDNA sequences yielded four notable groups associated with these four species, supporting their species identity. Based on the phylogenetic analysis, the four SRN species formed a monophyletic group, with *P. allius* more closely related to *P. porosus* than *P. minor* and *T. obtusus*. Much variation in ITS2 rDNA derived from insertion/deletion was present in *P. allius* populations that were not only from different geographic regions but also from the same geographic regions. This study documented the occurrence of SRN species across multiple states in the USA. The genetic diversity of rDNA between and within species observed in this study provides more information for understanding the evolutionary relationships of SRN species and will be valuable for future studies of SRN species identification, virus and nematode vector association, and disease management.

FIRST DETECTION OF THE RING NEMATODE, *MESOCRICONEMA NEBRASKENSE* FROM A CORN FIELD IN NORTH DAKOTA, USA. **Yan, Guiping**[1], **A. Plaisance**[1], **D. Huang**, **R. Baidoo**[1], **and Z. A. Handoo**[2]. [1]North Dakota State University, Department of Plant Pathology, Fargo, ND 58108. [2]USDA-ARS, Mycology and Nematology Genetic Diversity and Biology Laboratory, Beltsville, MD 20705.

During 2016 and 2017, 14 soil samples were collected from a corn field in Sargent County, North Dakota (ND) for nematode extraction. Six of these soil samples contained ring nematodes at densities of 85-900 per kg of soil. One large, composite sample with 75 ring nematodes/kg of soil was obtained by mixing positive and negative soil samples and used to inoculate three corn cultivars DK 43-48-RIB, DKC 43-46, and DKC 44-13 each in four replicates. After 14 weeks of growth at 22°C in the greenhouse, the final population density for DK 43-48-RIB, DKC 43-46, and DKC 44-13 was 158 ± 151, 283 ± 154, and 156 ± 140 per kg of soil, respectively; the corresponding reproductive factor was 2.1, 3.8, and 2.1. Individual ring nematodes from field and greenhouse were examined morphologically and molecularly for species identification. Morphometric measurements of adult females (n = 10) included body length, stylet, tail length, maximum body width, anterior end to basal bulb, a, b, c, V, R, Rex, RV, Rvan, body diameter at vulva and at anus. The lip regions of ring nematodes in ND have two annules that are smaller and narrower than other body annules but are not set off. Body annules are retrorse with smooth margins, labial disc elevated surrounding the oral opening, stylet robust with well-developed knobs, submedian lobes present, vulva on 8-10th annule and anus on 5-6th annule from posterior end of body, and post-vulval body portion conical to more or less rounded, with single to multiple lobed terminus. The nematode species was identified as Mesocriconema nebraskense Olson et al., 2017 based on morphological characteristics. DNA was extracted from single nematodes (n = 10). Two ribosomal DNA regions (D2-D3 of 28S rDNA and ITS rDNA) and one mitochondrial DNA region (cox1 gene) were amplified, sequenced, and assigned with GenBank accession numbers of MH013430, MH013431, and MH023322, respectively. The comparative sequence analysis suggests that the closest species was Mesocriconema nebraskense, showing 99% identity in cox1 gene with KJ787973 and 14 other isolates of M. nebraskense, and 90% or less sequence similarity with other Mesocriconema spp. The BLASTn search also revealed that the ring nematode from North Dakota had 99% similarity in ITS rDNA with seven isolates of M. nebraskense, five isolates of Mesocriconema sp., and four isolates of M. curvatum. The sequence of D2-D3 of M. nebraskense was not available in GenBank, and was deposited in the database for the first time. This nematode population had less than or equal to 98% similarity in D2-D3 with other ring nematode species. The molecular identification in the cox1 gene supported that the North Dakota specimens are M. nebraskense. M. nebraskense is a recently described species from native grasslands but not found in cultivated agroecosystems. To our knowledge, this is the first report of the ring nematode M. nebraskense from a corn field in North Dakota.

MOLECULAR CHARACTERISATION AND DIAGNOSIS OF ROOT-KNOT NEMATODES (MELOIDOGYNIDAE: *MELOIDOGYNE*) FROM NORTH CAROLINA. **Ye, Weimin.** Nematode Assay Section, Agronomic Division, North Carolina Department of Agriculture & Consumer Services, Raleigh, NC 27607.

Root-knot nematodes (*Meloidogyne* spp.) are the most economically damaging genus of plant-parasitic nematodes on horticultural and field crops. They are distributed worldwide and are obligate parasites of the roots of thousands of plant species, including monocotyledonous and dicotyledonous, herbaceous and woody plants. The genus includes more than 100 species with some species having several races. From 2006 to 2018, a total of 1,032 root-knot nematode populations were collected from North Carolina field crops, ornamental plants and turfgrasses. Root systems showing galling symptoms were dissected under the microscope and females were obtained for DNA analysis.

Since some of these samples were submitted as soil only, the second-stage juveniles or males were used instead. Molecular characterisation was performed by PCR using species-specific primers and DNA sequencing on the ribosomal DNA 18S, ITS and 28S D2/D3, intergeneric spacer, RNA polymerase II large subunit, mitochondrial DNA cytochromas gene subunit II and histone gene H3. Eight species were identified, including *M. incognita* (prevalence 70.0%), *M. enterolobii* (11.5%), *M. hapla* (5.2%), *M. marylandi* (3.1%), *M. arenaria* (3.6%), *M. graminis* (2.2%), *M. javanica* (1.9%), and *M. naasi* (0.3%). ***M. carolinensis, M. megatyla,*** **and** ***M. spatiniae*** were previously described from North Carolina, but were not detected from these samplings. Species-specific primers were developed to identify some root-knot nematode through simplex or duplex PCR. Molecular diagnosis using PCR by species-specific primers provides a rapid, accurate and cheap species identification approach for root-knot nematodes and are beneficial for growers to make a management decision.

THE ROLE THAT USDA PLAYS IN EXTENSION NEMATOLOGY. **Zasada, Inga**. USDA ARS, Horticultural Crops Research Unit, Corvallis, OR 97330.

The Agricultural Research Service (ARS) is the USDA's chief scientific in-house research agency. The mission of the agency is to find solutions to agricultural problems that affect Americans every day from field to table. There are over 2,000 ARS scientists and, of these, approximately 15 are specifically focused on nematology research with several other scientists having a nematology component in their research program. This presentation will address several issues specific to extension activities as an ARS scientist. How does ARS extend research findings to stakeholders? What is the role that ARS plays in extension nematology? What are the obstacles that an ARS scientist encounters when conducting extension? An overview of what ARS nematologists perceive as their role in extension nematology will also be presented.

IN-FIELD EVALUATION OF GRAPE ROOTSTOCK PERFORMANCE AGAINST PLANT PARASITIC NEMATODES *MELOIDOGNE HAPLA* AND *XIPHINEMA* SPP. IN WASHINGTON STATE. **Zasada, Inga[1], Michelle Moyer[2], and Katherine East[2]**. [1]USDA ARS, Horticultural Crops Research Unit, Corvallis, OR 97330. [2]Department of Horticulture, Irrigated Agriculture Research and Extension Center, Washington State University, Prosser, WA 99350.

Management of plant-parasitic nematodes in Washington State vineyards has been dominated by pre-plant soil fumigation. One practice that may mitigate economic loss due to nematodes in Washington vineyards is the adoption of nematode-resistant rootstocks; unfortunately, own-rooted vines are preferred in Washington given their ease of retraining after damaging winter cold events. There is also limited information on the performance of most rootstocks against northern root-knot nematode (*Meloidogyne hapla*), the main plant-parasitic nematode species in the state. In 2014, we established a trial evaluating rootstocks in a commercial vineyard, planted into replicated plots of fumigated (metam sodium), nonfumigated, and 'nonfumigated + *M. hapla*' soils. Rootstocks evaluated were Harmony, 101-14 Mtg, Teleki 5C, and 1103P grafted with Chardonnay; own-rooted *Vitis vinifera* Chardonnay was included as the industry standard. Fumigation suppressed *M. hapla* for only the first 6 months after application, while it effectively suppressed *Xiphinema* sp. for over three growing seasons. Rootstocks were poor hosts for *M. hapla* relative to own-rooted *V. vinifera*, but all were acceptable hosts for *Xiphinema* sp. In terms of viticulture performance, several rootstocks (e.g., Harmony, 1103P) developed faster than own-rooted vines with higher pruning weights at the end of the second season. Additionally, pruning weights two and three years after planting were significantly lower in own-rooted vines grown in 'nonfumigated + *M. hapla*' soil compared to vines grown in fumigated and nonfumigated soil ($p < 0.01$). This evaluation will continue until 2025, with nematode populations and vine performance monitored annually. The goal of this project is to understand the long-term performance of rootstocks and the impacts of nematodes on vineyard lifespan in Washington State.

INSIGHTS INTO POTATO ROOT-KNOT NEMATODE EFFECTORS. **Zhang, Lei and Gleason, C. A.** Department of Plant Pathology, Washington State University, Pullman, WA 99164, USA.

Root-knot nematodes are one of the most economically important plant-parasitic nematodes. Most vascular plants can be infected by root-knot nematodes, including many important crop plants, such as potatoes. Washington, Oregon and Idaho produce over half of the nation's potatoes, and unfortunately, this region is plagued by two root-knot nematodes: *Meloidogyne hapla* and *M. chitwoodi*. Both nematodes can infect the roots and tubers. Tuber infection lead to galling that looks like bumps and pimples on the tuber skin, and these blemishes significantly reduce the market value of the tubers. Because *M. chitwoodi* eggs hatch at relatively low temperatures compared to *M. hapla*, *M. chitwoodi* populations can quickly grow within a growing season of potatoes. Therefore, *M. chitwoodi* is the predominant root-knot nematode species in the Pacific Northwest, and this nematode is the prime target of our research. To understand the *M. chitwoodi*-potato interaction, our lab focuses on nematode effectors. Nematode effectors are secreted molecules that facilitate nematode parasitism. Pathogen-associated molecular pattern (PAMP) triggered immunity (PTI) is a major contributor to basal plant defenses, and some nematode effectors can suppress PTI to help the nematode avoid plant detection and immune responses. We have identified an effector called Mh265 originally from *M. hapla*. We found that *Mh265* is a novel gene, and the transcript localizes to the sub-ventral esophageal glands, indicating that the protein is secreted by the nematode into the plant. Arabidopsis Columbia (Col-0) plants that express 35S::*Mh265* were more susceptible to both root-knot (*Meloidogyne*) and cyst (*Heterodera*) nematode infections. To study the role of Mh265 in defense suppression, the transgenic plants were treated with the PTI-elicitor flg22. Typically, flg22 treatment induces callose deposition. However, the Mh265 transgenic plants exhibited a suppressed flg22-callose response. This indicates that Mh265 has a role in the suppression of PTI. An identical gene to *Mh265* was found in the *M. chitwoodi* genome and is called *Mc265.* We measured *Mc265* expression in the nematodes at different life stages; the highest level of expression was in the pre-parasitic J2 and in nematodes early after potato root infection. The role of *Mc265* role during the early interaction in potato has been further investigated. In addition, we have performed a transcriptome analysis on *M. chitwoodi,* looking for genes upregulated early after the infection of susceptible potato roots, and we have identified potential new effectors for the *M. chitwoodi*-potato interaction. We hope to use the information about *M. chitwoodi* effectors to better understand the nematode's interaction with potato and develop new potato resistance strategies.

LOOP-MEDIATED ISOTHERMAL AMPLIFICATION FOR THE DIAGNOSTIC DETECTION OF *MELOIDOGYNE CHITWOODI AND M. FALLAX.* **Zhang, Lei and Gleason, C. A.** Department of Plant Pathology, Washington State University, Pullman, WA 99164, USA.

Meloidogyne chitwoodi is a root-knot nematode that parasitizes a broad range of plants. In the Pacific Northwest (PNW) of the United States, *M. chitwoodi* is a major potato pest. The nematodes infect roots and tubers; blemishes caused by the nematodes on the tubers significantly affects potato marketability. There is a critical need to develop fast and easy nematode identification techniques so that growers can detect if root-knot nematodes are present in the potato field and, thereby, aid their management decisions. We have developed a loop-mediated isothermal amplification (LAMP) assay to identify the potato-infecting root-knot nematode *M. chitwoodi* and its close relative *M. fallax*. The LAMP assay can be completed within 45 minutes, does not require expensive equipment, and is 100 times more sensitive in nematode detection than conventional PCR. There is no cross reaction of the LAMP primers with DNA from tropical nematodes, *M. incognita, M. arenaria* and *M. javanica*, or the Northern root-knot nematode *M. hapla*. Using the LAMP assay, we can detect *M. chitwoodi* directly from DNA extracts of infected soils. Overall, our LAMP assay can detect *M. chitwoodi* and *M. fallax*. Although *M. fallax* was reported to be in turfgrass in California, it is not endemic to the USA and not found in the Pacific Northwest (PNW) where a large percentage of potato production occurs. Because *M. chitwoodi* is found in the PNW, a positive LAMP reaction from PNW soils would suggest the presence of *M. chitwoodi*. Ultimately, knowing if *M. chitwoodi* is present will help potato growers in the region control this important potato pathogen.