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ABSTRACTS

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METHOD OF APPLICATION AND COST-BENEFIT OF VYDATE USE AGAINST *MELOIDOGYNE HAPLA* ON CARROTS. **Abawi, G. S., J. W. Ludwig, and J. Bossard.** Plant Pathology Department, Cornell Univ., Geneva, NY 14456.

The northern root-knot nematode (*Meloidogyne hapla*) is a major pathogen of carrots in New York, affecting both the quality and quantity of yield. Vydate (oxamyl) is registered and often used to control this nematode primarily as an in-furrow drench application at planting. In 1996, Vydate applied as a broadcast spray and incorporated into soil to a depth of 10 cm was highly effective against various population densities of *M. hapla* on carrots in field microplots at. However, Vydate applied as an in-furrow drench treatment in four tests in grower's fields was less effective, although it significantly increased marketable yield. In 1997, tests were conducted in fields of collaborating growers to evaluate the methods of application and the economics of Vydate on carrot production. Results obtained showed that Vydate L applied at 18.7 l/ha. as a broadcast incorporated treatment was most effective against *M. hapla* on carrots grown in organic soils. In one test, a total of 43.3, 18.8, 0.3, and 0.5% of roots were unmarketable in the untreated plots and the Vydate-treated plots receiving drench, broadcast, and drench + broadcast treatments, respectively. In this test, the investment of $292 in Vydate/ha resulted in a profit of $3,835/ha, suggesting that Vydate is most cost-effective when applied as a broadcast or band-incorporated treatment against *M. hapla* in organic soils.

DYSFUNCTIONAL SPECIES CONCEPTS CAN SCREW UP YOUR RESEARCH. **Adams, B. J.** University of Nebraska, 406 Plant Sciences Hall, Lincoln, NE 68583-0722.

Each time we look at a nematode, what we see is either a species, part of a species, or a mixture of two or more species. But which of the three possibilities best describes the nematode at hand? The question is not merely rhetorical, because research programs in nematology that utilize recovered evolutionary history (e.g., adaptation, biodiversity, biogeography, coevolution, cospeciation) can be confounded by inaccurate guesses as to what is or is not a species. Consequently, different species concepts can be evaluated based on the potential each has to adversely affect the outcome of evolution-based research. Operationally, all definitional species concepts are subject to failure, but the Biological and Linnean species concepts are more prone to serious error than lineage, or topology-based species concepts.

GENE TREES, SPECIES TREES, AND THE SPECIES PROBLEM: IS THERE A RATIONAL BASIS FOR USING MOLECULAR MARKERS TO DELIMIT SPECIES OF ENTOMOPATHOGENIC NEMATODES? **Adams, B. J., and T. O. Powers.** University of Nebraska, 406 Plant Sciences Hall, Lincoln, NE 68583-0722.

Conserved morphology and a dearth of taxonomic expertise have increasingly led to species diagnoses (how to tell them apart) and species delimitations (how to tell they are species) that incorporate molecular data. While it is often assumed that gene trees and species trees are congruent, this is not always the case. Gene and species tree discordance is irrelevant for species diagnosis, but poses serious problems for phylogeny reconstruction and species delimitation using lineage-based species concepts. Exploration of the evolutionary processes responsible for discordance has led to several operational solutions that attempt to mitigate this problem.

OIL RADISH AND RAPESEED GREEN MANURE CROPS FOR COLUMBIA ROOT-KNOT AND LESION NEMATODE MANAGEMENT ON POTATO. **Al-Rehiayani, S., and S. Hafez.** University of Idaho, Parma Research and Extension Center, 29603 U of I Lane, Parma, ID 83660.

The use of oil radish (*Raphanus sativus*) and rapeseed (*Sinapis alba*) as green manures in potato crop rotations to improve potato yield and reduce population densities of potato nematodes (*Meloidogyne chitwoodi* race 2 and *Pratylenchus neglectus*) was investigated. Green manure crops were planted after wheat in mid- August and potato was planted the following spring. Fall fallow treatments were included as a standard. After green manure incorporation and before potato planting, nematode population densities declined in all plots. However, those planted to oil radish had significantly lower populations than fallow. In all plots, nematode populations increased on potato, but *M. chitwoodi* populations in green manure treatments were significantly lower than in fallow treatments. Green manure treatments increased potato yield by 21-37%, and reduced *M. chitwoodi* tuber infection compared to fallow. Oil radish was more effective than green manure.

PHYLOGENETIC ANALYSIS OF *PASTEURIA PENETRANS* BY 16S rRNA GENE CLONING AND SEQUENCING. **Anderson, J. M.,[1] J. E. Maruniak,[1] J. F. Preston,[2] and D. W. Dickson.**[1] [1]Department of Entomology and Nematology and [2]Department of Microbiology and Cell Science, University of Florida, Gainesville, FL 32611-0620.

Pasteuria penetrans is a parasitic bacterium of root-knot nematodes, *Meloidogyne* spp. The 16S ribosomal genes from two isolates, P-100 from *Meloidogyne* spp. and P-20 from *M. arenaria*, were PCR-amplified from a purified endospore extraction with universal primers. The amplified products were cloned into *Escherichia coli* and the resulting clones were subject to analysis using restriction fragment length polymorphism with Alu I and Rsa I. Several clones were sequenced and 1,315 base pairs of the 16S rDNA were compared with 20 different bacterial ribosomal genes using PAUP. The phylogenetic analysis indicated a 93% similarity with *Pasteuria ramosa*, which supports the placement of *P. penetrans* isolates P-100 and P-20 in the genus *Pasteuria.*

FIELD PERFORMANCE OF TWO GENETICALLY TRANSFORMED GRAPE ROOTSTOCKS AGAINST TWO ROOT-KNOT NEMATODE POPULATIONS. **Anwar, S. A, and M. V. McKenry.** Department of Nematology, University of California, Riverside, CA. 92521.

'Freedom' grape rootstock was developed for its resistance to a mix of *Meloidogyne* spp. Root-knot nematodes penetrate, establish feeding sites and develop to adult females, but reproduction does not occur. The insertion of a *Bacillus thuringiensis* (Bt) gene or genes encoding the Snowdrop lectin (GNA) halted penetration and establishment by a mixture of *Meloidogyne* spp. In the presence of a pathotype of *M. arenaria* that specifically reproduces on Freedom, population levels of 27 females/g root were counted 90 days after inoculation. Freedom transformed with Bt and GNA genes reproduced 59 and 14 females/g root, respectively. Brown to black lesions of variable sizes occurred around the infection courts of females on both transformed plants compared to non-transformed plants. A nine-month field evaluation in the presence of *M. arenaria* pathotype Freedom revealed no resistance to any of the rootstocks tested.

ELECTRON MICROSCOPIC OBSERVATIONS ON *PASTEURIA* SP. PARASITIZING *HETERODERA GLYCINES*. **Atibalentja, N.,[1] G. R. Noel,[1,2] and B. P. Jakstys.**[3] [1]Department of Crop Sciences, University of Illinois, [2]USDA, ARS, and [3]Center for Microscopic Imaging, Department of Veterinary Biosciences, University of Illinois, Urbana, IL 61801.

The ultrastructure of an undescribed species of *Pasteuria*, first reported in 1994 as a parasite of *Heterodera glycines* in North America, was investigated by examining thin sections prepared from *Pasteuria*-infected cysts extracted from the rhizosphere of *H. glycines*-susceptible soybean 'Williams 82' grown in the greenhouse in naturally infested soil. The stages of endosporogenesis were typical of *Pasteuria* spp. The mature endospore was similar to that of *P. nishizawae*, with an epicortical layer surrounding the cortex, an outer spore coat tapering from 0.2 μm thick at the spore equator to 0.1 μm or less at the base of the central body, and a partial hirsute layer originating from the adhesion layer of the central body. However, the endospores of this *Pasteuria* were larger than those of *P. nishizawae*. The central body, initially spherical ($1.6 \pm 0.2 \times 1.7 \pm 0.2$ μm) before the formation of

the parasporal fibers, was elliptical in the mature endospore, and measured 1.9 ± 0.3 × 1.5 ± 0.2 µm compared to 1.6 ± 0.2 × 1.3 ± 0.1 µm for *P. nishizawae*.

RELATIVE HOST SUITABILITY OF SMALL GRAINS FOR *MELOIDOGYNE* SPECIES AND POTENTIAL PROBLEMS WITH THEIR USE AS GREEN MANURE CROPS. **Barker, K. R., S. R. Koenning, and K. M. Parker.** Department of Plant Pathology, N. C. State University, Raleigh, NC 27695-7616.

A greenhouse study focused on the relative host suitability of selected small grain cultivars for *Meloidogyne* species and the efficacy of incorporating their foliage in soil to suppress the development of *M. incognita* on cotton. Although root-galling differed only slightly on seven small grain cultivars, reproduction differed substantially. *Meloidogyne javanica, M. incognita* races 1 and 4, and *M. arenaria* race 2 reproduced at greater rates than *M. incognita* races 2 and 3 and *M. arenaria* race 1. Barley supported the highest nematode reproduction; wheat was intermediate; and rye and oats were generally poor hosts. Races 1, 2, and 4 of *M. incognita* and *M. javanica* reproduced on Abruzzi rye. The incorporation of 50 to 100 gm of green foliage of barley, rye, or wheat/1,500 cm^3 soil significantly suppressed root-gall development caused by *M. incognita* on cotton ; the foliage of oats was less effective. The observed increase of *M. incognita* on a rye cover crop appears to enhance root knot nematode symptoms in some cotton fields.

IDENTIFICATION OF CHITINASE GENES IN PLANT-PARASITIC NEMATODE SPECIES. **Baum, T. J., T. R. Maier, C. R. Womack, D. H. Byrne, and J. M. de Boer.** Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020

Chitin is a structural polysaccharide present in the eggshell of nematodes. Chitinase genes and activity have been documented for several animal-parasitic nematodes, frequently as having a function during egg hatch. Recently, a PCR-based cloning approach revealed the presence of a chitinase gene in *Caenorhabditis elegans*. We used this PCR strategy to successfully amplify single major bands from genomic DNA of *Heterodera glycines, H. schachtii, Globodera tabacum*, and *Meloidogyne javanica*. Sequence analyses of cloned PCR products revealed convincing similarities with known chitinase genes. Our results indicate the presence of at least two different chitinase genes in the examined *Heterodera* species. We currently are in the process of further characterizing these chitinase genes with particular emphasis on timing and site of transcription.

POLYMORPHISM INFERRED FROM NTS AMPLIFICATION OF RIBOSOMAL DNA AMONG SPECIES OF THE CEREAL CYST NEMATODE. **Bekal, S., S. Valette, and R. Rivoal.** INRA, Laboratory of Zoology, BP 29 35650 Le Rheu, Rennes, France.

One pair of oligonucleotide primers from *Caenorhabditis elegans* rDNA sequences seem to be universal in that they hybridize with ribosomal DNA sequences of several species of organisms. We tested the possibility of using these primers to differentiate among the major species of cereal cyst nematodes. The primers allowed the amplification of the non-transcribed spacer (NTS) and parts of the 28S and 18S genes of the ribosomal DNA of cereal cyst nematodes. The NTS were amplified by PCR from single females or cysts of eleven geographic isolates and one isolate of *C. elegans*. The amplification products had different sizes, which permitted distinction of *Heterodera latipons* (1660 bp), *H. avenae* (1390 bp), *H. mani* (760 bp), and *H. filipjevi* (1230 bp).

EFFECTS OF FLOODING AND FREEZING TEMPERATURES ON INFECTIVITY OF *MELOIDOGYNE HAPLA* IN ORGANIC SOIL. **Bélair, G.** Agriculture and Agri-Food Canada, 430 Gouin Blvd., Saint-Jean-sur-Richelieu, Quebec, Canada J3B 3E6.

Egg masses and juveniles of *Meloidogyne hapla* were exposed in organic soil (80% organic matter) to flooding and freezing temperatures. Both flooded (400% soil-water content) and non-flooded (175% soil-water content) infested soils were either exposed to continuous freezing (at -5, -9 and -18 °C) or a freezing (2 days at -5, -9 or -18 °C) and thawing cycle (2 days at 4 °C) for up to 64 days. No significant reduction in *M. hapla* infectivity was measured between the continuous freezing and the freezing and thawing cycle in both flooded and non-flooded soils. Infectivity of *M. hapla* was lower in flooded soil than in non-flooded soil exposed to freezing temperatures of -9 and

-18 °C after 8, 16, and 32-day exposure periods. Infectivity was observed after 64 days at -18 °C in both flooded and non-flooded soils. When *M. hapla* egg masses were placed at 4 °C in flooded and non-flooded soil for a 16-day period, infectivity in flooded soil was reduced by 90, 88, and 85% for egg masses isolated from field plantings of carrot, tomato, and celery respectively.

ACCELERATING PROGRESS TOWARD BELOW-GROUND BIO-INTENSIVE IPM: FQPA IMPACTS AND POLICY CHALLENGES. **Benbrook, C.** Benbrook Consulting Services, 5085 Upper Pack River Road, Sandpoint, Idaho 83864.

The Food Quality Protection Act (FQPA) was passed in July 1996. The U.S. EPA is making good progress in the implementation process. A number of high-risk soil insecticides and nematicides are bound to be regulated more stringently; by crop year 2000 or 2001, some will no longer be available. As a result, growers and IPM practitioners are accelerating their search for biointensive IPM alternatives. Promising new tactics and strategies include microbial biocontrol and the creation of disease- suppressive soils through the structured management of soil biodiversity. Critical research and IPM funding need to be addressed, along with a method for rigorous measurement of progress along the IPM continuum. There is need for measurement methods that allow analysts to link progress toward biointensive IPM with reductions in reliance on and use of high-risk pesticides. Indicators are being developed that may be useful to extension IPM specialists and others responsible for assessing progress and benefits associated with IPM.

ALTERNATIVE FARMING SYSTEMS: ANALYSIS OF NEMATODE COMMUNITIES. **Berney, M. F., and G. W. Bird.** Department of Entomology, Michigan State University, East Lansing, MI 48824-1115.

Four farming systems (conventional, integrated fertilizer, integrated compost, and organic, blocked for crop rotation or continuous corn) and three secondary successions (0, 7, and 30 years since cultivation) were studied in replicated plots. All sites were sampled three times per year for three years, with nematodes subsampled and identified to genus. Each genus was identified as a plant parasite, plant associate, fungal feeder, bacterial feeder, algal feeder, omnivore, or carnivore. Several indices of maturity, diversity and stability were applied to the data. In the farming systems, two of the four treatments (integrated fertilizer and organic) were different when comparing rotation with continuous corn and measuring ratios of bacterial to fungal feeders. All four farming systems could be separated by block for rotation/continuous corn with the ratio of non-plant parasites to plant parasites. Secondary successions were separated by several of the measures, including total number of nematodes and percentage of plant, bacterial, and fungal feeders.

NEMATODE AND *PYTHIUM* INTERRELATIONSHIPS IN LOUISIANA SUGARCANE ECOSYSTEMS. **Bond, J. P., E. C. McGawley, and J. W. Hoy.** Department of Plant Pathology and Crop Physiology, Louisiana State University Agricultural Center, Baton Rouge, LA 70803.

Sugarcane cultivars CP 70-321 and LCP 82-089 were grown in microplots for 180 days following infestation with 0, 1,200, or 12,000 nematodes (30% ring, 35% stubby-root, and 35% stunt). In 1995 and 1997, nematodes reduced shoot and root weights of LCP 82-089 but not CP 70-321. In greenhouse experiments the interrelationships between these nematodes and *Pythium arrhenomanes*, the agent that causes sugarcane root rot, were evaluated. Treatments consisted of steamed soil infested with 0, 500, or 5,000 nematodes (40% ring, 15% stubby-root, and 45% stunt) and(or) 0, 22, or 220 g of fungal culture (*P. arrhenomanes*-colonized oat seed on a vermiculite carrier) in all possible cominations. In 1996 and 1997, the nematodes and *Pythium* individually caused reductions in plant growth. Additionally, there were significant nematode × *Pythium* interactions that were antagonistic with respect to both sugarcane growth and nematode reproduction.

BIOCHEMICAL EVENTS IN THE DEVELOPMENT OF *PASTEURIA PENETRANS*. **Brito, J. A., J. F. Preston, D. W. Dickson, R. M. Giblin-Davis, and J. D. Rice.** University of Florida, Gainesville, FL 32611-0620.

The biochemical events that occur during the development of *Pasteuria penetrans* are poorly understood and may provide valuable insight to the bacterium's host-parasite relationship with

Meloidogyne spp. Our objective was to determine the sequence of events required for the formation of spore-associated proteins (adhesins) required for attachment of spores to the nematode cuticle. Isolate P-20 of *P. penetrans* was produced on *M. arenaria* race 1 on tomato. An IgM monoclonal antibody (Mab) directed against P-20 spores that specifically recognizes spore adhesions was used to probe their formation as a function of development. Twelve, 16, 24, and 38-day-old healthy and *P. penetrans*-infected females were extracted from roots. Proteins were extracted with SDS and separated by PAGE. Gels were electro-blotted on nitrocellulose membranes and proteins were probed with the Mab. Only proteins extracted from 24 and 38-day-old females with spores were recognized. The synthesis of adhesins therefore occurred at a certain developmental stage relative to the sporulation process. Further definition of this process is needed to understand and enhance virulence of *P. penetrans* toward its host.

TRIAGE FOR THE BIOSPHERE. **Brooks, D. R.** Centre for Comparative Biology and Biodiversity, Department of Zoology, University of Toronto, Toronto, Ontario M5S 3G5 CANADA.

Human beings preserve what they value, and replace or ignore what they do not. Developing tropical societies will conserve their biodiversity if it generates intellectual and economic benefits that pay for its maintenance and contributes to national economic growth. Some species provide marketable products or attract tourists; others are essential for maintaining the species that provide direct economic benefits. An All Taxa Biodiversity Inventory (ATBI) is an inventory of all species in a large, conserved wildland site. It is simultaneously a biodiversity development project and a conservation project. An ATBI uses a team of national human resources and members of the international scientific community to determine, for each species, what is it, where is it, how to capture or see it when desired, and what it does, and manage this information electronically in the public domain. An ATBI represents an unparalleled opportunity to study the health, reproductive, and nutritional requirements of a large number of exotic species in a fully natural, yet protected and defined environment. Potential user groups include industry, educational, and scientific institutions, public, livestock, and agricultural health experts, environmental monitoring and restoration programs, and economists and development agencies. The taxasphere (the world's taxonomists and systematists) is concerned that the loss of taxonomic expertise parallels the loss of biodiversity, and is thus highly motivated to participate in projects that demonstrate the value of systematics to the world in general.

TURNING A CONUNDRUM INTO A RESEARCH PROGRAM. **Brooks, D. R., and D. A. McLennan.** Centre for Comparative Biology and Biodiversity, Department of Zoology, University of Toronto, Toronto, Ontario M5S 3G5 CANADA.

Darwin despaired that taxonomic notions of species as units of classification would always correspond to evolutionary notions of species as units of phylogenetic diversification. His worries were prescient; no universally agreed-upon solution has yet emerged. Major research agendas, including those in biodiversity, require that we press onward even in the absence of consensus. From a historical ecological perspective, research on species falls into three general categories. First, what ARE species? If we regard species as internally cohesive information systems forming historical lineages that divide and branch from each other in a detectable pattern, the taxonomic and evolutionary notions of species can be unified. Second, how do we discover species? If species are historical systems, phylogenetic methods must be useful for discovering and identifying them. Phylogenetic trees comprise branches and apomorphies. Consequently, three ways of counting the number of species on a phylogenetic tree have emerged: i) count the branches, ii) count the apomorphies, and iii) count the branches that have apomorphies. Each provides an objective framework for designating units of study but can lead to different views of the number of species present. Third, once we have discovered a set of entities that we wish to call species, how do we evaluate them with respect to our theories about the functions of species? Two approaches exist: i) How did the species originate and ii) how do they maintain their "specieshood". The first approach corresponds to the research program pioneered by Wiley and Mayden in the early 1980s. The second encompasses all non-dimensional species concepts that have been proposed, including typological and cohesion concepts.

ISOLATION AND PARTIAL CHARACTERIZATION OF TWO cDNA CLONES FROM THIRD-STAGE JUVENILES OF *HETERODERA GLYCINES*. **Byrne, D. H., J. M. de Boer, and T. J. Baum**. Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020.

Esophageal gland secretions of *Heterodera glycines* change with development. To identify genes involved in the production of secretions, we sought to isolate cDNA clones from esophageal gland-specific mRNAs of third-stage juveniles (J3). By using paramagnetic beads and PCR, a plasmid cDNA library was constructed from anterior J3 halves harboring the esophageal glands. Two differential hybridization strategies were used to screen this library. One screen compared hybridization to cDNA probes prepared from anterior versus posterior J3 halves. The second approach used cDNA probes from preparasitic versus parasitic nematodes. Two clones of interest were identified. Corresponding mRNA levels of both cDNAs appeared to be elevated in parasitic nematodes. One cDNA was homologous to an excretory-secretory product of *Brugia malayi*. The other cDNA had no similarity to known sequences. Both clones need to be further characterized with emphasis on the sites of transcription in the nematode.

PHYLOGENETIC SURVEY OF BACTERIAL-FEEDING NEMATODES IN RELATION TO SELECTED BIOCONTROL BACTERIA AND THE *CAENORHABDITIS ELEGANS* DETOXIFICATION GENE, PGP-3. **Carta, L.** USDA ARS, PSI, Nematology Lab, Beltsville, MD 20705.

Longevity, fecundity and bacterial preference tests on agar plates have been reported for a phylogenetically diverse group of bacterial-feeding nematodes found in agricultural soils. The nematodes *Caenorhabditis elegans* N2, *Pristionchus pacificus* PS312, *Zeldia punctata* PS1153, *Panagrellus redivivus* PS1163, *Mesorhabditis* sp. PS1179, *Oscheius myriophila* DF5020, *Diploscapter* sp. PS2123, and *Operculorhabditis* sp. LKC 10 have been tested for their preference toward *E. coli* OP-50 or biocontrol bacteria (*Burkholderia cepacia* JED-2, M-35, Bc-F, Bc-2, *Pseudomonas fluorescens* PF5 and SE59, *Stenotrophomonas maltophila* 34S1, *S. corrugata* SB45, *Serratia marcescens* N4-5, *Bacillus thuringensis*, *Xenorhabdus* sp., and *Photorhabdus* sp.). Preference for toxic bacteria was not uncommon. Toxicity of *B. cepacia* strains was significant for all tested nematodes except for members of the Mesorhabditinae. Such patterns may have significant consequences in field situations with different soil bacteria and nematode communities. Each bacterium also was tested for ability to affect the PGP-3 toxin transporter with *C. elegans* N2 and *pgp-3* strains. The *pgp-3* gene from nematode strains especially sensitive to a bacterial toxin can be sequenced to determine functionally and phylogenetically important molecular sites in target (parasitic) and non-target (free-living) nematodes.

MINERALIZATION OF NITROGEN BY *APHELENCHOIDES COMPOSTICOLA*. **Chen, J., and H. Ferris.** Department of Nematology, University of California, Davis, CA 95616.

Nitrogen mineralization by *Aphelenchoides composticola* feeding on *Rhizoctonia solani* and *Trichoderma* sp. was measured in sand columns. The sand was incubated with fungus and organic matter, with or without nematodes. At 3-day intervals, N concentrations in leachate from the columns were determined with a diffusion-conductivity analyzer. Representative columns were sampled at 0, 7, 14, and 21 days for nematode and fungal population assessment. Phospholipid fatty acid analysis was used to quantify fungal biomass. For *R. solani*, but not *Trichoderma* sp., there was significantly more N in leachate from columns containing nematodes than from those with fungus alone. Nematode population levels were 33, 79, 38, and 11 on *R. solani*, and 8, 11, 13, and 7 on *Trichoderma* sp. at 0, 7, 14, and 21 days, respectively. Fungal fatty acid 18:2_6c concentrations were lower in columns containing both *A. composticola* and *R. solani* at the first two dates and higher at the last two dates than in columns without nematodes.

VIABILITY OF *HETERODERA GLYCINES* EXPOSED TO FUNGAL FILTRATES. **Chen, S. Y.,[1] D. W. Dickson,[2] and D. J. Mitchell.**[3] [1]University of Minnesota, 35838 120th Street, Waseca, MN 56093, [2]Entomology and Nematology Department, and [3]Plant Pathology Department, University of Florida, Gainesville, FL 32611.

Filtrates from nematode-parasitic fungi have been reported to be toxic to plant-parasitic nematodes. Our objective was to determine the effects of fungal filtrates on second-stage juveniles and eggs of *Heterodera glycines*. The fungi tested were isolated from cysts extracted from a soybean field in Florida. Toxic activity of filtrates from 11 fungal species each grown in malt extract broth and Czapek-Dox broth was tested in vitro. Filtrates from *Paecilomyces lilacinus*, *Stagonospora heteroderae*, *Neocosmospora vasinfecta*, and *Fusarium solani* grown in malt extract broth were toxic to second-stage juveniles (J2). No toxic activity to J2 was observed for filtrates from *Exophiala pisciphila*, *Fusarium oxysporum*, *Gliocladium catenulatum*, *Pyrenochaeta terrestris*, *Verticillium chlamydosporium*, and sterile fungi 1 and 2 grown in malt extract broth, or for filtrates from fungi grown in Czapek-Dox broth. Filtrates of *P. lilacinus*, *S. heteroderae*, and *N. vasinfecta* grown in malt extract broth reduced egg viability, whereas *F. oxysporum* and *P. terrestris* filtrates had no effect on egg viability.

CYTOLOGY AND SPOROGENESIS OF *PASTEURIA PENETRANS*. **Chen, Z. X., and D. W. Dickson**. Entomology and Nematology Department, University of Florida, Gainesville, FL 32611-0620.

Pasteuria penetrans is a mycelial, endospore-forming, bacterial parasite that has shown potential as a biological control agent for root-knot nematodes. Currently, artificial cultivation of *P. penetrans* is impossible. Little information is available on the biology and cytology of the bacterium. The objective of this study was to use transmission electron microscopy to investigate the cytology and sporogenesis of *P. penetrans* grown in females of *Meloidogyne arenaria* race 1 on tomato. *Pasteuria penetrans* is polymorphic. Sporogenesis of *P. penetrans* is similar to other endospore-forming bacteria, and may be classified into seven stages. In stage I, hyphal terminals elongate and form a septation at the base of the terminal. The terminal cells increase in size and become oval. A membrane forms about one-third the distance from the anterior end and separates the forespore from the parasporium (stage II). The forespore is engulfed by the parasporium (stage III). The endospore coat, cortex, and exosporium form at stages IV to VI, and endospores mature at stage VII. The vegetative cell is branched, and each branch has bifurcate terminals. The bacterium has multicellular hyphae and each individual cell has multiple nucleoids

PATHOGENICITY OF *BELONOLAIMUS LONGICAUDATUS* ON POTATO. **Crow, W. T.,[1] D. P. Weingartner,[2] and D. W. Dickson.**[1] [1]Entomology and Nematology Department, Gainesville, FL 32611 and [2]Hastings Research and Education Center, Hastings, FL 32145.

The sting nematode *Belonolaimus longicaudatus* has long been associated with yield losses of potato. Despite this association, the pathogenicity of this nematode on potato has never been demonstrated experimentally. Also, mechanisms whereby damage occurs, and population dynamics of sting nematode on potato are poorly understood. A 3-year field study is in progress to quantify damage caused by sting nematode and to study its population dynamics on potato. Greenhouse trials are being conducted to demonstrate pathogenicity, describe symptoms, and to identify how the nematode affects the potato plant. Results from the first 2 years of the field study and from the greenhouse experiments indicate that sting nematode causes significant reductions in potato tuber yield and size.

EVALUATION OF COTTON GENOTYPES FOR RESISTANCE TO *MELOIDOGYNE INCOGNITA* RACE 3. **Davis, R. F.** Department of Plant Pathology, University of Georgia, Athens, GA 30602-7274.

Resistance to *Meloidogyne incognita* race 3 in 18 cotton (*Gossypium hirsutum*) entries was evaluated in a greenhouse experiment with six replications. Fourteen University of Georgia advanced strains were evaluated: Delta and Pine Land 90, Georgia King, Stoneville LA 887, and Auburn 623A were included as susceptible and resistant standards. Plants were grown in 1,200 cm^3 of soil in 15-cm-diam. pots, and each pot was infested with 7,000 *M. incognita* eggs once seedlings were established. Fifty-four days after inoculation, juveniles were extracted from soil, and eggs and juveniles were extracted from roots to obtain a reproductive factor (Rf = total nematodes/7,000) for each pot. Root galling was rated on a 0-10 scale. Mean gall ratings ranged from 1.8 to 7.7. Mean

total nematode counts ranged from 631 to 166,013. Log_e-transformed egg, juvenile, and total nematode counts revealed significant differences among genotypes. Eleven genotypes had an Rf < 1, while seven advanced Georgia strains and Auburn 623A had Rf < 0.5, which could make them effective in *M. incognita* management.

DEVELOPMENTALLY-REGULATED TRANSCRIPTION OF SUBVENTRAL GLAND CELLULASE GENES IN *HETERODERA GLYCINES*. **De Boer, J. M.,[1] Y. Yan,[2] E. L. Davis,[2] and T. J. Baum.[1]** [1]Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020, and [2]Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

Transcription of the subventral gland secretory cellulase genes *HG-eng-1* and *HG-eng-2* was monitored during post-embryonic development of *Heterodera glycines* using in situ hybridization with digoxigenin-labeled riboprobes and alkaline phosphatase staining. Production of cellulase mRNAs commenced in unhatched second-stage juveniles (J2). The cellulase mRNAs remained present in the subventral glands of hatched preparasitic J2 and parasitic J2. In third-stage juveniles, however, cellulase mRNAs were found in only about 10% of the individuals. In female fourth-stage juveniles (J4) and adult females, cellulase mRNAs could no longer be detected in the subventral glands. However, in late male J4 and adult males, cellulase mRNAs reappeared. This pattern of transcriptional regulation suggests that the main function of *H. glycines* subventral gland cellulases is to assist J2 and males during their migration through roots..

A METHOD FOR IN SITU HYBRIDIZATION TO ESOPHAGEAL GLAND mRNA IN *HETERODERA GLYCINES*. **De Boer, J. M.,[1] Y. Yan,[2] E. L. Davis,[2] and T. J. Baum.[1]** [1]Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020, and [2]Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

A digoxigenin-labeled RNA probe transcribed from the subventral gland cellulase gene *Hg-eng-2* was used to develop a procedure for in situ hybridization to esophageal gland mRNA in *Heterodera glycines*. Nematodes were fixed in buffered 2% paraformaldehyde and cut into sections. After permeabilization with proteinase-K, methanol, and acetone, the nematode sections were incubated with the RNA probe at 55°C in hybridization buffer (50% formamide, 4x SSC, 2% SDS, 1% Boehringer blocking reagent, 1 mM EDTA, 1x Denhardt's, 200 µg/ml sperm DNA, 166 µg/ml tRNA), washed in 4x SSC, treated with RNAse A, and washed in 0.1x SSC, 0.1% SDS. The RNA probe was detected with an alkaline phosphatase-conjugated antibody to digoxigenin. This procedure resulted in a strong and highly specific staining of the cytoplasm of the subventral gland cells.

EFFECTS OF CONCOMITANT INFECTION OF *MELOIDOGYNE INCOGNITA* AND *ROTYLENCHULUS RENIFORMIS* ON COTTON. **Diaz, A., and G. W. Lawrence.** Department of Entomology and Plant Pathology, Mississippi State University, Mississippi State, MS 39762.

A *Meloidogyne incognita* (Mi) and *Rotylenchulus reniformis* (Rr) interaction on cotton was studied in the greenhouse. Pots containing 500 cm^3 of soil with cotton cv. Delta and Pine Land 20 seedlings were infested simultaneously with juveniles (J2) of Mi and vermiform Rr in the following rations (Mi:Rr): 0:0, 100:0, 75:25, 50:50, 25:75, and 0:100. Plant growth parameters and soil populations of Mi and Rr were recorded at 3, 6, 9, 14, 19, 25, 35, 45, and 60 days after inoculation (DAI). Concomitant inoculation of Mi and Rr produced a negative effect on all growth parameters except plant height at 60 DAI compared to the effects produced by each species alone. *M. incognita* populations were inhibited in the presence of *R. reniformis* at all inoculum ratios.

PHYLOGENETIC IMPLICATION OF BUCCAL CAPSULE DEVELOPMENT IN SOME BACTERIAL FEEDING NEMATODES. **Dolinski, C.,[1] G. Borgonie,[2] R. Schanabel,[3] and J. G. Baldwin.[1]** [1]Department of Nematology, University of California, Riverside, CA, 92521, [2]Vakgroep MSE, Universiteit Gent, Ledeganck- straat 35, B-9000, Belgium, [3]Institut für Genetik, TU Braunschweig, Spielmannstraße 7, D-38106, Germany.

Bacterial feeding nematodes including *Zeldia punctata* and *Caenorhabditis elegans* (Rhabditida) differ profoundly in the parts and associated cells lining the buccal capsule. A range of tests was carried out to determine which parts are evolutionarly homologous between the two species. Reconstruction of the buccal capsule and procorpus with TEM, nuclei morphology using DAPI

staining, and cell lineage of the cells in the buccal capsule using 4D microscopy were used. The lining of the buccal capsule of *Z. punctata* includes four sets of muscular radial cells (ma, mb, mc, md) in contrast to *C. elegans*, which has two sets of epithelial cells (e1, e3) and two sets of muscle cells (m1, m2). Lineage of these epithelial cells contradict all previous hypotheses of homology, and suggest instead that ma and mb in *Z. punctata* are homologous respectively with m1 and m2 in *C. elegans*. These muscle cells could be homologous to primary and secondary sets of muscles in the stylet of Tylenchida.

CHARACTERIZATION OF THE NEMATODE COMMUNITIES ASSOCIATED WITH VEGETABLE SPECIES PRODUCED IN LOUISIANA. **Dominguez, H. D., E. C. McGawley, and C. Overstreet**. Department of Plant Pathology and Crop Physiology, Louisiana State University Agricultural Center, Baton Rouge, LA 70803.

Initial field surveys of nematode communities associated with the most important vegetable crops produced in Louisiana were conducted. Ten to 15 soil samples were collected from each site and bulked. Nematodes were extracted with semi-automatic elutriation and centrifugation, then counted at ×40 with an inverted microscope. Eleven genera of nematodes (*Criconemella*, *Ditylenchus*, *Helicotylenchus*, *Hoplolaimus*, *Meloidogyne*, *Paratrichodorus*, *Pratylenchus*, *Rotylenchulus*, *Trichodorus*, *Tylenchorhynchus*, and *Xiphinema*) were detected in the survey. *Rotylenchulus* sp. was associated with all crops except broccoli, cabbage, and mustard. *Tylenchorhynchus* spp. were associated with 9 crops and *Helicotylenchus* spp. with 7. *Rotylenchulus* sp. was found in 60% of all samples at population densities that ranged from a low of 10 /500 cm^3 soil (onion, 3 parishes) to a high of 3,090 /500 cm^3 soil (green bean, Franklin Parish).

MAPPING *HETERODERA GLYCINES* DISTRIBUTION WITHIN A FIELD OVER FOUR YEARS. **Donald, P. A.,[1] W. W. Donald,[2] A. J. Keaster,[1] R. J. Kremer,[2] and J. A. Kendig[1]**. [1]Plant Science Unit, [2]USDA/ARS, University of Missouri, Columbia, MO 65211.

Geostatistical methods were used to examine the distribution of soybean cyst nematode, *Heterodera glycines*, over four years in a soybean field in southeastern Missouri. To determine whether soybean cyst nematode population density in a field was stable over time if no population reduction practices were implemented, each spring and fall, eight 2.5 cm-diam. by 25 cm-deep soil samples were collected from a 2-ha field divided into 12.2-m ×12.8-m sections and processed for extraction of eggs. *H. glycines* population density at Pf was poorly related to the following Pi because of overwinter mortality. Spatial distribution of *H. glycines* was patchy. The location of highest population density within the field changed from year to year, although it was often in the same general region of the field. Yield was not related to egg population density at planting, indicating that unmeasured variables also were reducing yield. Finally, more intense sampling than a grid size of 12.2 m × 12.8 m would be needed to measure spatial dependence, if it were present.

DEVELOPMENT OF SPECIES-SPECIFIC MOLECULAR MARKERS FOR IDENTIFICATION OF *MELOIDOGYNE JAVANICA*. **Dong, K., S. A. Lewis, R. A. Dean, and B. A. Fortnum.** Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.

Species-specific DNA probes for identification of *Meloidogyne arenaria* and *M. incognita* have been reported by different research groups previously. The objective of this project was to develop DNA probe(s) specific to *M. javanica*. The DNA samples were isolated from single-egg-mass-amplified nematode cultures. A small insert genomic library of *M. javanica* was been constructed using the pBluescript vector, and 7,500 clones from the library have been used for genomic differential screening against DNA samples from *M. arenaria*, *M. incognita* and *M. hapla*. Over 99% of these clones hybridized with DNA from the other three species, possibly due to the polyploid nature and close evolutionary relationships among species of *Meloidogyne*. Five clones interacted with the genomic DNA isolated from a North Carolina *M. javanica* culture. The specificity of these clones to *M. javanica* is being assessed using collections of *M. javanica* from North America.

EFFECT OF NUTRIENT SOLUTION AND pH ON EMBRYOGENESIS OF *MELOIDOGYNE INCOGNITA*. **Ehrlich, S. M., T. C. Smith, and H. Melakeberhan**. Department of Entomology,

Michigan State University, East Lansing, MI 48824-1115.

Meloidogyne incognita eggs were incubated in normal strength Hoagland solution (HS) or distilled water (DW) at pHs 5, 6, and 7. Each treatment had 500 eggs and four replications, and was maintained for 11 to 12 days at 23 to 26 °C under laboratory conditions. Stages of embryogenesis and hatching were determined at 0, 2, 5, 8, and 11 days after incubation. No eggs with less than 16 cells were found after 5 days at pH 7, or 8 days at pH 5 and pH 6. Eggs with undifferentiated cells decreased with time at all pHs but more so in DW than HS. The numbers of eggs with fully differentiated juveniles increased at the same rate in DW and HS at pH 7, but more in DW than in HS at pHs 5 and 6. When eggs were incubated at 0, 0.5, 1.0, 1.5, and 2.0 times the normal strength HS, hatching tended to decrease with increasing HS concentration. The data indicate that *M. incognita* hatches better at neutral than at below neutral pH, and better at low than at high salt concentrations.

EFFECT OF PLANT AGE ON HOST SUITABILITY TO *MELOIDOGYNE JAVANICA*. **El-Borai, F.,[1] M. E. Mahrous,[2] and A. A. Salem.**[2] [1]Entomology and Nematology Department, University of Florida, Gainesville, FL 32611-0620, and [2]Plant Protection Department, Zagazig University, Egypt.

Many factors influence the host-parasite relationship of *Meloidogyne* spp. and their host plants. Our objective was to determine the effect of plant age on plant susceptibility to nematode infection. Three cultivars of tomato, two cultivars of eggplant, and one cultivar of sunflower were inoculated with 1,000 second-stage juveniles of *Meloidogyne javanica*/plant at 10, 20, 30, 40, and 50 days after transplanting. Each treatment was replicated five times and five uninoculated plants served as the control. Plant age affected the host-parasite relationship of the nematode on each tested plant. The highest amount of root galling, nematode reproduction, and plant growth reduction occurred when plants were inoculated at 10, 20, or 30 days after transplanting. Plants that were inoculated at 40 and 50 days were relatively undamaged.

A NOVEL APPROACH TO THE BIOCONTROL OF *GLOBODERA ROSTOCHIENSIS*. **El-Sherif, M. A.,[1] and B. B. Brodie.**[2] [1]Cairo University, Giza, Egypt, and [2]USDA ARS, Department of Plant Pathology, Cornell University, Ithaca, NY 14853.

The population density of *Globodera rostochiensis* Ro1 drastically declined in a field that had been planted to potatoes for over 25 consecutive years. However, the nematode reproduced freely on plants grown in soil from this field that was inoculated with *G. rostochiensis* eggs. Water extracts of soil from this field stimulated hatching of *G. rostochiensis* eggs similar to that obtained with potato root diffusate. Diluting or heating the water extract to 125 °C for 10 min reduced and destroyed its hatch stimulating properties, respectively. Culture filtrates from three unidentified isolates of microorganisms from this soil exhibited some hatch stimulation of *G. rostochiensis* eggs. These results suggest that suppression of *G. rostochiensis* in this soil is due to biological factors that induce juveniles to hatch in the absence of a food source rather than to an antagonistic relationship. Hatching of *G. rostochiensis* in the absence of potato roots greatly reduces population density due to starvation of the nematodes.

PATHOGENICITY OF SOUTH CAROLINA *MELOIDOGYNE INCOGNITA* POPULATIONS ON RESISTANT COTTON GENOTYPES. **Elliott, C. L., J. D. Mueller, and S. A. Lewis.** Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634.

Thirty *Meloidogyne incognita* populations, collected throughout the cotton producing region of South Carolina, were tested for their pathogenicity on four resistant cotton genotypes and one susceptible genotype. Plants were inoculated with 10,000 eggs, and galls per root system were counted 42-48 days after inoculation. There were significant differences among the five cotton cultivars in the number of galls produced by the 30 *M. incognita* populations. As expected, Deltapine Acala 90 supported greater galling and Auburn 634 less galling than the other genotypes. NemX, Stoneville LA887, and M-315 were intermediate between Deltapine 90 and Auburn 634, but similar to each other in the levels of galling supported. Only one *M. incognita* population did not produce significant levels of galling on Deltapine 90. Six populations produced levels of galling on Auburn 634 that were greater than 10% of the levels produced on Deltapine 90. Only one population produced as many galls on a resistant genotype (LA887) as on susceptible Deltapine 90.

YIELD DATA FOR SOYBEAN LINES WITH HARTWIG RESISTANCE TO SOYBEAN CYST NEMATODE. **Faghihi, J.,[1] R. A. Vierling,[2] V. R. Ferris,[1] and J. M. Ferris.[1]** [1]Department of Entomology, Purdue University, West Lafayette, IN 47907-1158, and [2]Indiana Crop Improvement Association and Department of Agronomy, Purdue University, West Lafayette, IN 47907-1150.

A determinate, SCN-resistant F_8 line derived from a Williams 82 × Hartwig cross was backcrossed to Williams 82. The BC_1F_2 progenies were screened with a virulent race 4-phenotype true SCN inbred. The histogram of resistance data fit a normal distribution. In addition to SCN resistance, the population also segregated for determinate and indeterminate growth types. In 1997, seeds from an indeterminate, SCN-resistant BC_1F_3 plant were sown in a non-SCN-infested field. Each plant was harvested individually and screened with the same race 4 phenotype SCN inbred, producing a range of resistant and susceptible reactions. Most of the indeterminate plants had the Williams 82 growth type with Hartwig resistance. The yields from the backcross plants were significantly higher than Williams 82 in the non-infested field.

INSECTICIDAL PROTEIN TOXINS FROM THE GENUS *PHOTORHABDUS*, SYMBIOTES OF *HETERORHABDITIS*. **Fatig, R., G. Orr, L. Guo, B. Schafer, L. Alward, A. Woodsworth, L. Lu, K. Sukhapinda, D. Merlo, T. Hey, L. Wegrich, J. Strickland, A. O. Merlo, J. Hasler, S. Young, J. Roberts, J. Petell,[1] D. Bowen, T. Rocheleau, R. French-Constant,[2] and G. Ensign.[3]** [1]Dow AgroSciences, Indianapolis, Indiana 46268-1054; [2]University of Wisconsin, Departments of Entomology; and [3]Bacteriology, Madison, Wisconsin 53706-7365.

Cultures of *Photorhabdus luminescens* were identified via traditional microbiological methods. The diversity of the strain collection was examined by rep-PCR analyses of genomic DNA. High-molecular-weight proteins produced by the bacterial symbiotes were toxic against a variety of insects. A select set of genes encoding some of the toxin proteins were cloned and sequenced.

MICROBIAL ANTAGONISTS TO ROOT-KNOT NEMATODE INCREASED BY ADDING DITERA, A BIOLOGICAL NEMATICIDE. **Fernández, C.,[1] R. Rodríguez-Kábana,[1] J. W. Kloepper,[1] and P. Warrior.[2]** [1]Plant Pathology Department, Auburn University, Auburn, AL 36849-5409, and [2]Abbott Laboratories, 6131 RDF Oakwood Road, Long Grove, IL 60047.

DiTera (Abbott Laboratories, IL, USA) is a new biological nematicide based on the fermentation of a nematode-parasitic isolate of the fungus *Myrothecium* spp. The product kills nematodes on contact and the potential of DiTera to stimulate microorganisms antagonistic to nematodes was studied using an alginate film system. Autoclaved and non-autoclaved soils were treated with 0, 2.5, or 5.0 g of DiTera/kg soil. Ten, thirty and sixty days after treatment (DAT), alginate screens with root-knot nematode (*Meloidogyne incognita*) eggs were buried in the soil for 70 hours, removed, and incubated in water at 24 °C for 5 days. Ten DAT, the unautoclaved control soil had the highest number of antagonists while at 30 and 60 DAT the unautoclaved soil treated with DiTera had higher percentages of parasitized eggs and juveniles. Our results indicate an enhancement of antagonistic microflora to plant- parasitic nematodes on addition of DiTera in non-autoclaved soil.

NITROGEN FERTILITY AND SOIL FOOD WEB MANAGEMENT. **Ferris, H.,[1] R. C. Venette,[1] H. R. van der Meulen,[1] and K. M. Scow.[2]** [1]Department of Nematology and [2]Department of Land, Air and Water Resources, University of California, Davis, CA 95616.

In organic and low-input farming systems, availability of N and other minerals is determined by organic matter decomposition rates and by the structure and activity of the soil food web. In central California, soil biological activity in late summer and early fall, in the absence of irrigation, is constrained by low moisture levels. Through respiration of C, and due to body C:N ratio, bacterial-feeding nematodes (BFN) are net mineralizers of N. We conducted field experiments to enhance population levels of BFN. during the fall and into the following spring. The availability of soil N in spring, and yields of the summer crop, were increased by practices designed to enhance soil biological activity during the previous fall. Available N in the spring was related to the abundance of BFN although management effects on the nematodes were not always clear. Microbial biomass activity in spring, indicated by substrate-induced respiration, was greatest in plots that were biologically active

the previous fall.

TOWARD A PRESCRIPTIVE PHYTOPHARMACOGNOSY FOR MANAGEMENT OF PLANT-PARASITIC NEMATODES. **Ferris, H., and L. Zheng.** Department of Nematology, University of California, Davis, CA 95616.

Over 500 plant species, used alone or in combination, are documented in Chinese traditional medicine to have activity against helminth and micro-invertebrate pests of humans. We subjected 155 candidate medicines, or their plant sources, to multilevel screening for effectiveness against plant-parasitic nematodes. For the materials effective in preliminary screens (about 30% of those tested), determinations were made of concentration-response relationships, efficacy in soil and phytotoxicity to plants. Several of the materials have been effective in greenhouse trials. The objective is to develop prescriptions for management of nematode species in different farming systems. The prescriptions will include the nature, combination, and amounts of plant products, and time and method of application. Additionally, we have developed a testable schema for comprehensive management of the soil food web through organic matter decomposition products, suppressive plant residues, elevated biological antagonism, and enhanced root vigor.

DO SPECIES CONCEPTS MATTER IN NEMATOLOGY? **Ferris, V. R.** Department of Entomology, Purdue University, West Lafayette, IN 47907-1158.

The convention of assigning every living organism to a species has persisted since Linnaean times. Although traditionally, species have been defined by morphological criteria, the problem of how to delimit species boundaries has always existed. Does the existence of new molecular data change this? Are classical approaches still useful for nematologists? What part does persistence or loss of genetic compatibility between isolated populations play in resolving issues of species identity? Is the designation "species" just a taxonomic convenience as is occasionally claimed? Modern methods of phylogenetic analysis have re-shaped the arguments and issues concerning species identity and recognition. These new methods and ideas can impact our understanding of taxon relationships and of many attributes distributed across species, including morphological, behavioral and ecological characteristics. Testable phylogenetic relationships are essential to an understanding of the nature and history of geographic distribution of nematode species.

INTEGRATED PEST MANAGEMENT: NEWER, BETTER, STRONGER. **Fitzner, M. S.**, United States Department of Agriculture, 1400 Independence Avenue, S.W., Washington, D.C. 20250-2220.

Over the past two decades, the public and private sectors have worked together to develop and implement integrated pest management (IPM) methods that have succeeded in reducing risk, minimizing pesticide use, and increasing the use of "softer" pesticides. Now, many factors are converging to make IPM research and extension more essential than ever before. One of these factors, implementation of the Food Quality Protection Act of 1996, will present many challenges to nematologists and other agricultural scientists over the next several years. The challenge before public sector scientists will be to develop the knowledge the food production and processing system needs to emphasize environmental compatibility and ecosystem management, with no loss in production efficiency. This will require additional resources and a focus on adaptive research that helps move IPM systems along the continuum towards greater reliance on prevention based practices.

A MOLECULAR FRAMEWORK FOR THE PHYLUM NEMATODA USING 18S rRNA AND RNA POLYMERASE II. **Frisse, L. M., C. L. Franklin, J. T. Vida, and W. K. Thomas.** School of Biological Sciences, University of Missouri–Kansas City, Kansas City, MO 64110.

A lack of clearly homologous characters and the absence of an informative fossil record have previously prevented the derivation of a consistent evolutionary framework for the phylum Nematoda. In initial work, we constructed a molecular evolutionary framework for the Nematoda using 18S rRNA. This analysis allows us to compare animal-parasitic, plant-parasitic, and free-living taxa using a common measurement. Some species including *Bunonema sp., Pelodera strongyloides, Pelodera teres*, and *Pellioditis typica* were difficult to place in the 18S tree due to high rates of evolution within their 18S rRNA sequences. In order to confirm the 18S analysis and determine whether this rate

variation is gene-specific or a genome-wide phenomenon, we have sequenced two putative single copy protein-coding loci, the 3' end of RNA polymerase II and elongation factor 1α.

TILLAGE ALTERS SPATIAL DEPENDENCE OF *HETERODERA GLYCINES*. **Gavassoni, W. L., G. P. Munkvold, and G. L. Tylka**. Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020.

The spatial patterns of *Heterodera glycines* were studied in two naturally infested soybean fields in Iowa from 1994 to 1997. At each location, there were 4 plots of 15.25 × 30.5 m subjected to different tillage treatments in the fall and spring. Soil samples (98 three-core samples per plot) were taken from a 7 × 14 grid (98, 5.2-m^2 contiguous quadrats) in the fall of 1994, before any tillage was performed, and in the spring of the following years shortly after planting. Cysts were extracted from samples by elutriation and counted, then eggs were extracted from cysts and enumerated. The spatial patterns of cysts and eggs initially were aggregated, as indicated by Lloyd's index of patchiness and geostatistics. The range and sill for cyst densities, estimated from the spherical model, decreased in the plots after conventional tillage, but aggregation of the pathogen population did not change significantly in the absence of tillage.

NATURAL PRODUCTS FROM *AMBROSIA PSILOSTACHYA, SOLIDAGO MISSOURIENSIS* AND *LESPEDEZA STUEVEI* AGAINST *MELOIDOGYNE INCOGNITA* NEMATODES. **Gavilano, L.,[1] C. J. Li,[1] F. J. Schmitz,[2] and K. Schubert.**[1] [1]Department of Botany-Microbiology, and [2]Department of Chemistry, University of Oklahoma, Norman, OK 73019.

Aqueous extracts of *Solidago missouriensis*, *Ambrosia psilostachya*, and *Lespedeza stuevei*, native plants to the United States, were tested for activity against *M. incognita* juveniles. Extracts of *S. missouriensis* exerted a nematistatic effect and extracts of *Lespedeza stuevei* inhibited nematode motility temporarily. Only *A. psilostachya* total extract showed nematicidal activity, 100% at a concentration of 20 mg/ml. Bioactivity-directed TLC fractionation of *A. psilostachya* extract resulted in the isolation of three nematicidal compounds. The structures of these compounds were determined by NMR and mass spectrometry. Two of them, parthenin and coronopilin, are known and were reported previously to possess antitumor, antibacterial, antifungal, molluscicidal, and insect antifeedant activities. However, this is the first report of their nematicidal activity. The structure of the third nematicidal molecule is being elucidated. The nematicidal effect of parthenin was reduced 95% by mixing the compound with equimolar concentrations of cysteine. This suggests that the lethal effect of parthenin on nematodes is due to reaction with sulphydryl groups present in essential proteins.

PASTEURIA-INFESTED SOIL SUPPRESSES *BELONOLAIMUS LONGICAUDATUS* IN A BERMUDAGRASS GREEN. **Giblin-Davis, R. M., B. J. Center, T. E. Hewlett, and D. W. Dickson.** University of Florida, 3205 College Avenue, Ft. Lauderdale, FL 33314-7799.

Soil infested with an undescribed species of *Pasteuria* (S-1) that attacks *Belonolaimus longicaudatus* (about 5,000 endospores/soil) was collected and dried at 46 °C for 48 hours. One half of this soil was autoclaved for 90 minutes at 121 °C at 103 kPa to kill all organisms and the other half was left untreated. A 'Tifdwarf' bermudagrass green was divided into a grid of 1-m^2 plots with 15-cm borders and pre-sampled for *B. longicaudatus* and *Pasteuria* S-1. Plots with equal nematode counts were paired and each received 900 g of a soil treatment (10 replicates per treatment) at the center of each plot. A higher proportion of *B .longicaudatus* was encumbered with *Pasteuria* S-1 endospores in plots treated with dried soil than with autoclaved soil at 6 and 12 months after inoculation. At 12 and 18 months after inoculation, there was significant suppression of *B. longicaudatus* in plots treated with the untreated dried soil. There was a negative correlation of *Pasteuria* S-1 encumbrance levels and *B. longicaudatus* counts, suggesting a *Pasteuria*-induced epizootic.

MECHANISMS OF SUPPRESSION OF PLANT-PARASITIC NEMATODES WITH ENTOMOPATHOGENIC NEMATODES. **Grewal, P.,[1] and E. E. Lewis.**[2] [1]Department of Entomology, Ohio State University, OARDC, Wooster, OH 44691-4096, and [2]Department of Entomology, University of Maryland, College Park, MD 20742.

Applications of entomopathogenic nematodes in turf, citrus, and cotton demonstrate suppression of plant-parasitic nematode populations. We discovered allelochemical effects of the entomopathogenic nematodes, *Steinernema* spp., and their symbiotic bacteria, *Xenorhabdus* spp., to *Meloidogyne incognita*. We uncovered several mechanisms contributing to this suppression: i) strong repellence of *M. incognita* juveniles from the substrates treated with heat-killed *Steinernema* spp. and cell-free extracts of *Xenorhabdus* bacteria; ii) mortality of infective juvenile *M. incognita*; iii) reduction in egg hatch of *M. incognita*; iv) reduction in root penetration; and v) reduction in egg production by *M. incognita*. Progress was made in identifying the toxic metabolites.

MORPHOMETRIC AND BIOLOGICAL CHARACTERIZATION OF *BELONOLAIMUS LONGICAUDATUS*. **Han, H.-R.,[1] D. W. Dickson,[1] and D. P. Weingartner.[2]** [1]Entomology and Nematology Department, University of Florida, Gainesville, FL 32611-0620, and [2]Hastings Research and Education Center, Hastings, FL 32145-0728.

Belonolaimus longicaudatus is one of the most damaging soil pathogens of agronomic and horticultural crops in the southeastern United States. Our objective was to compare the behavior of isolates of *B. longicaudatus* collected from different locations and hosts. Three isolates of *B. longicaudatus* from Florida (Hastings-potato, Lake Alfred-citrus, Gainesville-bermudagrass), and one isolate from Georgia (Tifton-cotton) were collected. Nematodes from each isolate were washed with 1 liter of sterile water and inoculated on excised corn roots growing on Gamborg B-5 medium. Females from the Georgia isolate laid eggs (two at a time, one from each uterus) at 10 to 60-minute intervals. Usually 4 to 5 days were required for egg maturation to the second-stage juvenile (J2). The first molt occurred within the egg shell. The J2 of all isolates except the Lake Alfred isolate were aggressive in their mobility and their feeding behavior. The Lake Alfred isolate was not attracted to corn roots and there was no egg deposition. The excised root culture method is useful for determining behavioral differences among isolates of *B. longicaudatus*.

ISOLATION OF FIVE CATALASE cDNA CLONES FROM *HETERODERA GLYCINES*-INFECTED SOYBEAN ROOTS. **Hardy, K. A.,[1] H. Su,[2] D. Hermsmeier,[1] and T. J. Baum.[1,2]** [1]Department of Plant Pathology and [2]Interdepartmental Genetics Program, Iowa State University, Ames, Iowa 50011-1020.

Plant catalases are involved in protecting cells from oxygen radicals and may mediate systemic acquired resistance by binding salicylic acid. Catalase transcription has been reported to be elevated in cyst nematode-infected potato, suggesting a role for catalases also in nematode infection. To determine whether soybean catalases are involved in *Heterodera glycines* parasitism, a cDNA library was constructed from susceptible, *H. glycines*-infected soybean primary roots harvested at 24, 48, and 72 hours after inoculation. Hybridization of approximately 100,000 plaques of the amplified library with a mixture of three *Arabidopsis thaliana* catalase cDNAs produced twelve positive clones. Sequence analysis revealed five different soybean catalase cDNAs, including four novel sequences. RNA blot experiments can be used to determine the transcriptional regulation of catalase genes in response to *H. glycines* infection.

EARLY GENE EXPRESSION CHANGES IN SOYBEAN CYST NEMATODE-INFECTED SOYBEAN ROOTS. **Hermsmeier, D., M. Mazarei, and T. J. Baum.** Department of Plant Pathology, Iowa State University, Ames, IA 50011.

The formation of soybean cyst nematode (SCN, *Heterodera glycines*) feeding cells in susceptible soybean roots is thought to be the result of SCN-directed changes in soybean gene expression. Using mRNA differential display, we identified fifteen cDNA clones of soybean mRNA species whose levels were different in SCN-infected and uninfected soybean roots 24 hours after inoculation. Of these, five were up-regulated, i.e., their mRNA levels were higher in infected roots, whereas ten were down-regulated. RNA-blot analyses verified the differential display results for six clones that produced detectable hybridization signals. Sequence data allowed the identification of three down-regulated cDNA clones as a transcription factor, a small GTP-binding protein gene, and an auxin gene. RNA-blot experiments on other known auxin down-regulated genes revealed their down-regulation in SCN-infected roots, as well.

DEVELOPMENT OF A SOIL SUPPRESSIVE TO *MELOIDOGYNE ARENARIA* WITH *PASTEURIA PENETRANS*. **Hewlett, T. E.,[1] A. C. Schuerger,[2] and D. W. Dickson.[1]** [1]Entomology and Nematology Department, University of Florida, Gainesville, FL 32611-0620, and [2]Walt Disney World, Lake Buena Vista, FL 32830-1000.

Pasteuria penetrans, an endospore forming bacterium, is reported to cause soils to become suppressive to root-knot nematodes. Our objectives were to determine if a root-knot nematode infested soil would become suppressive following the addition of *P. penetrans* and the length of time required for the soil to become suppressive. A *M. arenaria*-infected planting of 'Scarlet' bean was chosen for the experiment at The Land Pavilion, EPCOT Center, Disney World. Each plant was removed and observed for root-knot nematode galling. *M. arenaria*-infested sites had 2,500 *P. penetrans* spores/g of soil added. The area (35 m^2) was divided into 24 plots for soil assay. Bean roots and stems were harvested and beans replanted at 90-day intervals over a 2-year period. A high of 55% of all plants were galled on the seventh 90-day sampling interval; however, this number dropped to 9% (mean rating of 1.4 galls per plant based on a 0 to 10 scale, 10 = 100% of root system galled) on the last sampling date. A mean of 30 J2/100 cm^3 of soil was detected in samples from 1% of the area on the last sampling date, and 66% the second-stage juveniles had spores attached (16 endospores/J2 [range 1-78]). Estimates of spore densities per plot ranged from 1,000 to 10,000 spores/g of soil. *P. penetrans* increased to suppressive levels within 2 years and caused a reduction in root-knot disease.

MESSENGER RNA DIFFERENTIAL DISPLAY ANALYSIS OF THE PINE WOOD NEMATODE, *BURSAPHELENCHUS XYLOPHILUS*. **Higgins, D., D. L. Jones, and M. A. Harmey.** Botany Department, University College, Belfield, Dublin 4, Ireland.

The pine wood nematode, *Bursaphelenchus xylophilus*, is a serious and growing threat to pine forests in several regions of the world. In recent years the pathogen has spread from Japan to China where it is on the increase. Although this pathogen is not present in Europe, its non-pathogenic relative, *Bursaphelenchus mucronatus*, has been detected. As part of a risk assessment funded by the European Commission we are studying the molecular biology of the pathogenicity of the pine wood nematode. We used mRNA differential display to generate gene expression profiles for both pathogenic and non-pathogenic *Bursaphelenchus* species. Profiles were obtained for eight *B. xylophilus* and three *B. mucronatus* strains using six different primer sets. The profiles were compared between species and strains. Seventy species-specific bands were selected and reamplified. Reverse northern analysis of these bands is in progress to identify those which are truly differential.

PUBLIC PERCEPTION OF BIOTECHNOLOGY. **Hoban, T. J.** Department of Sociology and Anthropology, North Carolina State University, Raleigh, NC 27695-8107.

Public acceptance of biotechnology is vital to long-term research success. This has not been an issue in the United States, but has been much more of a concern in certain European countries. Recent surveys provide valuable insights into international levels of consumer awareness and acceptance of biotechnology. Surveys were conducted with random samples of consumers from 16 European countries and Canada during the winter of 1996-1997. The same questions were asked of U. S. consumers in the fall of 1997. All total, these surveys represent approximately 18,000 interviews. Results were compared from the various countries, as well as the most recent U. S results with earlier U. S. surveys, especially with regard to consumer perceptions of insect-protected crops in terms of their usefulness, risk, and moral acceptability. Factors that influence acceptance include knowledge, trust in government, and demographic characteristics, such as education and gender. Results suggest future implications for research, product development, and education.

IDENTIFICATION OF PROTEINS WITH NEMATICIDAL ACTIVITY WITH AN AXENIC, CHEMICALLY-DEFINED NUTRIENT MEDIA ASSAY. **Hocker, J. R., and K. Schubert.** Department of Botany-Microbiology, University of Oklahoma, 770 Van Vleet Oval, Norman, OK 73069-9984.

An assay was developed to identify proteins with biological activity capable of reducing

nematode reproduction. An axenic, chemically-defined culture medium was used to test several isolated protein fractions from seeds of a tropical legume. The nematode *Caenorhabditis elegans* was cultured at 20 °C in 2.5 ml in replicated stationary cultures. Populations were observed and recorded every 3 to 4 days over a period of 2 to 3 weeks. Controls and non-active fractions contained comparable populations. An active fraction was identified after separation by gel-filtration chromatography. Maximum nematode populations containing the active fractions were 70% below the control populations. The reduction in population-active fractions was dependent on concentration. Haemagglutination activity of rabbit, pig, and human red blood cells and bioactivity were both observed in the protein fraction with an estimated molecular weight of 50,000 or greater.

THE NEMATICIDAL METABOLITES OF THE BACTERIAL SYMBIONTS OF ENTOMOPATHOGENIC NEMATODES. **Hu, K., J. Li, and J. M. Webster.** Department of Biological Sciences, Simon Fraser University, Burnaby, Vancouver, V5A 1S6, Canada.

Xenorhabdus and *Photorhabdus*, the bacterial symbionts of *Steinernema* spp. and *Heterorhabditis* spp., respectively, grow rapidly in the insect's hemocoel and provide nutrients in the dying and dead insect for nematode development. The integument-enclosed cadaver contains a highly nutritious medium that enables exceptional multiplication of the nematodes. Among the secondary metabolites of the bacteria in culture are three nematicidal substances: ammonia, 3,5-dihydroxy-4-isopropylstilbene (ST), and a heterocyclic substance (HD). ST, at 100 _g/ml in an immersion test, caused almost 100% mortality of *Aphelenchoides rhyntium*, *Bursaphelenchus xylophilus*, and *Caenorhabditis elegans* but had no effect on juveniles of *Meloidogyne incognita* and *H. megidis*. HD caused mortality of *B. xylophilus* and *M. incognita* at 250-500 _g/ml, but only paralysis at lower concentrations. ST was present after 24 hours in nematode-infected *Galleria mellonella* larval cadavers at concentrations as high as 3,000 _g/g wet larval tissue. However, HD was not detectable in nematode-infected *G. mellonella* larvae.

MULTIPLICATION AND DEVELOPMENT OF *LONGODORUS AFRICANUS* ON TOMATO IN LABORATORY AND GREENHOUSE STUDIES. **Huang, X., and A. Ploeg.** Department of Nematology, University of California, Riverside, CA 92521.

The needle nematode *Longidorus africanus* causes damage to several crops (e.g. lettuce, carrots) in desert agricultural areas of southern California. Little is known of its ecology and biology. In greenhouse studies, optimum soil temperatures for nematode multiplication were between 29 °C and 32 °C. Fewer nematodes than were inoculated were recovered at temperatures < 20 °C or > 32 °C. The time from egg deposition to egg-hatching, studied on agar plates, also was shortest at 29 °C and 32 °C, with no egg-hatching at 35 °C. The minimum temperature for egg development was calculated to be close to 14 °C. Initial inoculation densities (Pi) (range 10-2,000/ 1.2 kg soil) strongly affected final population densities (Pf) after 8 weeks on tomato. Pf/Pi ratios were highest (13) at low inoculation densities, whereas high initial inoculum levels resulted in a population decline (Pf/Pi = 0.7). At soil moisture levels between 7.5% and 15% in sandy soil, soil moisture did not significantly affect multiplication rates. However, survival of *L. africanus* in slowly drying field soil was strongly correlated with the soil moisture content.

THE HOST-FINDING ABILITY OF *STEINERNEMA FELTIAE* IN THE PRESENCE OF INSECT LARVAE AND PLANT ROOT CUES. **Hui, E., and J. M. Webster.** Department of Biological Sciences, Simon Fraser University, Burnaby-Vancouver, V5A 1S6, Canada

The chemotactic behavior of *Steinernema feltiae*, in the presence of *Galleria mellonella* larvae and roots of germinated seeds of tomato and radish (offered individually and concurrently), was investigated. Inconsistencies in field efficacy evaluations may be, in part, attributed to the simultaneous encounter of conflicting chemical information emanating from various sources. Consequently, a series of petri dish arena studies were performed using *S. feltiae* and its response to target stimuli. *S. feltiae* responded positively to unsterilized and sterilized (with 10% bleach), germinated tomato seeds and sterilized. germinated radish seeds, but negatively to unsterilized, germinated radish seeds when compared to the controls. However, *S. feltiae* responded negatively to sterilized and unsterilized, germinated radish seeds presented together with living *G. mellonella*

larvae when compared to the controls. Sterilized and unsterilized, germinated tomato seeds produced sometimes greater and sometimes no significantly different attractive host-finding responses in all the larvae-plant combinations tested.

EFFICACY OF METHYL IODIDE AGAINST PLANT PARASITIC NEMATODE SPECIES UNDER LABORATORY AND FIELD CONDITIONS. **Hutchinson, C. M.,[1] M. McGiffen,[1] H. D. Ohr,[2] J. J. Sims,[2] and J. O. Becker.[3]** Departments of [1]Botany and Plant Science, [2]Plant Pathology, and [3]Nematology, University of California, Riverside, CA 92521-0415.

Methyl iodide (MI) was investigated as a potential replacement for methyl bromide (MB) for control of plant-parasitic nematodes. In laboratory experiments, *Tylenchulus semipenetrans* second-stage juveniles (J2) and *Meloidogyne incognita* eggs were mixed with UC potting mix and fumigated for 48 hours with either MB or MI. The effective dose of MI required to kill 50% of the population (ED50) of *M. incognita* and *T. semipenetrans* was 231.8 and 254.0 mM, respectively. The ED50 dose for MB was 678.6 and 1040.6 mM, respectively. In field experiments, *T. semipenetrans* J2 and *Heterodera schachtii* cysts were fumigated in sandy loam soil with either MB or MI. The ED50 dose of MI for *T. semipenetrans* and *H. schachtii* was 3.8 and 6.3 kg/ha, respectively. The ED50 dose of MI was 8.5 and 9.9 kg/ha, respectively. In both laboratory and field experiments, MI was more effective than MB for controlling plant parasitic nematodes.

MANAGEMENT OF STUBBY-ROOT NEMATODE DAMAGE TO ONION IN THE COLUMBIA BASIN OF THE PACIFIC NORTHWEST. **Ingham, R. E.,[1] P. Hamm,[2] J. McMorran,[2] and G. Clough.[2]** [1]Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902, and [2]Hermiston Agriculture Research and Extension Center, Hermiston, OR 97838.

Storage and dehydration (dehy) onion production has increased in the Columbia Basin during the last 10 years. After use of aldicarb on potato was suspended, an increase in onion damage from stubby-root nematode (*Paratrichodorus allius*) was noted in fields grown in rotation with potato. Symptoms appeared as patches of stunted onions. Stunted dehy onions treated in June 1995 responded dramatically to a broadcast application of oxamyl at 2.2 kg a.i./ha, but yield in the center of treated patches was still only 70% of that in undamaged areas. Treatment with 1.8 kg a.i./ha on 2 June 1997 increased yield of dehy onions by 34%, which was significantly better than in plots treated 22 June. Yield in plots treated 2 and 22 June was not different from plots treated only on 2 June. Yield of the largest grade of storage onions in plots treated with 1.1 kg a.i./ha oxamyl on 9 June 1995 was increased by 37%. Four *P. allius*/250 g soil may warrant treatment in storage onions while yield was not reduced in dehy onions with less than 10 *P. allius*/250 g soil.

BROAD SPECTRUM ANTIMYCOTIC ACTIVITY FROM IN VITRO CULTURES OF THE BACTERIAL SYMBIONT OF *STEINERNEMA RIOBRAVE*. **Isaacson, P. J., and J. M. Webster.** Department of Biological Sciences, Simon Fraser University, Burnaby, Vancouver, B.C., Canada V5A 1S6

The symbiotic bacteria of entomopathogenic nematodes are known to produce a number of metabolites that prevent secondary invasion of the nematode-infected insect cadaver by microorganisms and allow the bacteria and nematodes to grow optimally. *Xenorhabdus* sp. from *Steinernema riobrave* produces such metabolites. When tested against a series of agriculturally important fungi on agar diffusion plate assays, the cell-free culture broth completely inhibited the growth of many plant pathogens including *Botrytis cinerea*, *Pythium ultimum* and *Rhizoctonia solani*. Further characterization of this activity involved separating the whole broth into a water-soluble fraction and an organic solvent-soluble fraction. The water-soluble fraction showed the greater antimicrobial activity of the two when tested in petri dishes seeded with either *Bacillus subtilis* or *Botrytis cinerea*. Further analysis of this aqueous fraction showed that much of this activity was a result of extracellular proteins produced by the bacterial symbiont and of these, two enzymes, chitinase and glucanase, show significant antimycotic activity.

PEANUT ROTATIONS WITH BAHIAGRASS, CORN, COTTON, AND CHEMICAL SOIL TREATMENT FOR MANAGING NEMATODES AND DISEASES. **Johnson, A. W., and N. A.**

Minton. USDA ARS, P. O. Box 748, Tifton, GA 31793.

Crop rotations including continuous peanut, peanut-bahiagrass, peanut-corn, and peanut-cotton with and without soil chemical treatments were conducted from 1991 to 1996. *Meloidogyne arenaria, Pratylenchus brachyurus, Sclerotium rolfsii, Rhizoctonia solani,* and *Cercosperidium personatum* damage to peanut was suppressed and yield increased in peanut after 2 years of bahiagrass, cotton, or corn compared with continuous peanut. Yield of peanut was not different following 2 years of bahiagrass, cotton, or corn but was 20% greater than yield of continuous peanut. Over the 6-year study period, aldicarb, flutolanil, and aldicarb plus flutolanil increased peanut yield 14%, 17%, and 39%, respectively over the untreated control.

CHARACTERIZATION OF RESISTANCE TO THE POTATO APHID MEDIATED BY THE *MI* GENE IN TOMATO. **Kaloshian, I.,[1] M. Rossi,[2] M. Kinsey,[3] D. Ullman,[3] and V. M. Williamson.[2]** [1]Department of Nematology, University of California, Riverside, CA 92521, and [2]Nematology and [3]Entomology Departments, UC Davis, CA 95616.

Resistance to the potato aphid, *Macrosiphum euphorbiae*, has been identified in tomato lines carrying the root-knot nematode gene, *Mi*. The resistance was thought to be mediated by a novel single dominant gene, *Meu1*. Recently, *Mi* was cloned and it showed structural similarity to the group of resistance genes that contain a nucleotide binding site and leucine-rich repeats. Because aphid resistance was always linked with the *Mi* gene, we tested the possibility that *Mi* could be the aphid resistance gene. Aphid screens indicated that in fact *Mi* and *Meu-1* are the same gene. We are investigating the mechanism by which *Mi* mediates resistance to the aphid. Although *Mi* -mediated resistance to root-knot nematodes is characterized by a hypersensitive response (HR), no HR can be seen in resistant leaves infested with the aphid. Our data indicate that *Mi*-mediated potato aphid resistance dramatically modifies the feeding behavior of the aphid. The resistance is induced within a few hours and seems to be associated with the phloem sieve element. The resistance conferred by *Mi* to the potato aphid is species-specific. In addition, an isolate of the potato aphid that can parasitize tomato with *Mi* has been identified.

THE EFFICACY OF *VERTICILLIUM CHLAMYDOSPORIUM* AS A BIOLOGICAL CONTROL AGENT OF ROOT-KNOT NEMATODES ON DIFFERENT HOST PLANTS. **Kerry, B. R., and J. M. Bourne.** Entomology and Nematology Department, IACR-Rothamsted, Harpenden, Herts., AL5 2JQ, UK.

Plant species differed in their ability to support growth of *Verticillium chlamydosporium* in their rhizospheres at different nematode densities; fungal density increased more with increased nematode density on the roots of maize and tomato plants than on kale. Increasing the broadcast application rate of chlamydospores ten-fold resulted in increases in the density of the fungus in soil but not necessarily in the rhizosphere. In general, > 90% eggs exposed in the rhizosphere were parasitized and application of the fungus caused significant reductions of three root-knot species, *M. incognita, M. javanica,* and *M. arenaria* on maize, kale and *Phaseolus*. However, reductions of nematode infestations were much smaller if significant numbers of eggs remained within roots, a characteristic of nematode-susceptible plants such as tomato, which develop large galls on infested roots. Knowledge of the plant's susceptibility to nematode attack and its ability to support growth of *V. chlamydosporium* in its rhizosphere is essential for the development of biomanagement strategies based on the use of this fungus.

VARIATION IN RESISTANCE LEVELS OF SOYBEAN GENOTYPES BETWEEN RACES OF SOYBEAN CYST NEMATODE. **Kim, D. G.,[1] R. D. Riggs,[2] and L. Rakes.[2]** [1]SongJu Fruit Vegetable Experiment Station, Songju, Daega-myon, Kyongbuk, Korea, and [2]University of Arkansas, Fayetteville, AR 72701.

To facilitate breeding programs, variation in resistance levels of 739 soybean lines were examined against eight races of *Heterodera glycines*. Frequency distribution patterns were skewed in favor of resistance, and some showed bimodality. The majority of the pairwise regressions and correlations between races over the resistance levels was highly significant. Cluster analysis based on the correlation matrix divided eight races into four groups at 76% of explained variation; they were

races 1 and 5, races 2, 9, and 14, races 3 and 6, and race 4. Race groups suggested in this study may have practical value in breeding programs against *H. glycines*.

SUSCEPTIBILITY OF SELECTED COTTON AND SOYBEAN CULTIVARS TO *ROTYLENCHULUS RENIFORMIS*. **King, P. S., R. Rodríguez-Kábana , and C. F. Weaver.** Department of Plant Pathology, Auburn University, Auburn, AL 36849.

Twenty-four lines of cotton (*Gossypium hirsutum*) and nine lines of soybean (*Glycine max*) were evaluated for resistance to *Rotylenchulus reniformis* in the greenhouse. Five seed of each cultivar were planted in 1-liter, 10-cm-diam. cylindrical pots filled 1:1 with naturally infested soil from a cotton field and washed siliceous fine river sand. There were eight replications per cultivar, and pots were arranged in a randomized complete block design. The experiment was allowed to grow for eight weeks, after which soil and root populations were determined. Only one cotton cultivar (H-1215) showed significant resistance to *R. reniformis*, supporting only 46 nematodes/100 cm^3 soil and 26/g root compared to most cotton cultivars supporting 200-600 nematodes/100 cm^3 soil and 50-150/g root. The most resistant soybean cultivar to *R. reniformis* was Stonewall, which supported only 27 nematodes/100 cm^3 soil and 36/g root compared to the most susceptible cultivar, Brim, which supported 770/100 cm^3 soil and 62/g root.

PREVALENCE OF PLANT-PARASITIC NEMATODES IN SOYBEAN AND RACES OF *HETERODERA GLYCINES* IN NORTH CAROLINA. **Koenning, S. R., and K. R. Barker.** Department of Plant Pathology, Box 7616, North Carolina State University, Raleigh, NC 27695-7616.

A survey of soybean-production areas in the Piedmont, Coastal Plain, and Tidewater regions of North Carolina was conducted from 1994 through 1996. *Heterodera glycines* (SCN) was detected in 55 of 77 fields sampled in 15 counties. The host race of SCN was determined for 39 populations collected. Of all populations collected, 4% were race 1, 40% race 2, 16% race 4, 7% race 5, and 4% race 9; the remaining 29% could not be accurately categorized. None of the populations evaluated had high levels of reproduction on the resistant cultivar Hartwig. The southern root-knot nematode *Meloidogyne incognita* occurred in 26% of the fields. *Helicotylenchus* spp. were detected in all fields sampled, *Tylenchorhynchus* spp. were found in 62%, *Paratrichodorus* spp. in 56%, and *Pratylenchus* spp. in 94% of fields sampled. *Criconemella* spp., *Xiphinema* spp., and *Hoplolaimus* spp. were detected in less than 20% of the fields sampled.

DIFFERENTIAL INDUCTION OF CHITINASE ISOZYMES IN SOYBEAN CULTIVARS RESISTANT OR SUSCEPTIBLE TO ROOT-KNOT NEMATODES. **Kokalis-Burelle, N.,[1] J. Qiu,[2] D. B. Weaver,[3] J. Hallmann,[4] R. Rodríguez-Kábana,[2] and S. Tuzun.[2]** [1]USDA ARS, Ft. Pierce, FL, 34945, [2]Department of Plant Pathology, [3]Agronomy and Soils Department, Auburn University, AL, 36849, and [4]Institut für Pflanzenkrankheiten, Bonn, Germany.

Induction and activity of chitinase isozymes in response to *Meloidogyne incognita* infestation were compared in a resistant and a susceptible soybean cultivar at 0, 1, 3, 10, 20, and 34 days after infestation (DAI). The resistant cultivar had higher chitinase activity than the susceptible cultivar at every sample time beginning at 3 DAI. Isoelectric focusing gel electrophoresis indicated that three acidic chitinase isozymes with isoelectric points (pIs) of 4.8, 4.4, and 4.2 accumulated to a greater extent in the resistant cultivar following nematode infestation. Three major protein bands (33, 22, and 20 kD) exhibited stronger chitinase activity in the resistant cultivar according to SDS-PA(+glycolchitin)GE. Ongoing studies of recombinant inbred lines of soybean support these results.

AN ESOPHAGEAL GLAND-SPECIFIC CHORISMATE MUTASE FROM *MELOIDOGYNE JAVANICA* IS DEVELOPMENTALLY REGULATED. **Lambert, K. N., and I. M. Sussex.** Department of Plant and Microbial Biology, University of California, Berkeley, CA 94720.

Root-knot nematodes drastically alter plant cell growth and development in order to form giant cells. It is thought that the nematodes inject secretions, originating from their esophageal glands, into the plant cells they feed upon to cause giant cell formation. In a previous study an esophageal gland-specific chorismate mutase (CM) was cloned. CM is a key regulatory enzyme in the biosynthesis of phenylalanine and tyrosine. The nematode CM is expressed specifically in dorsal and subventral

esophageal glands and is secreted into the plant tissue. The nematode CM is developmentally regulated in both gland cell types as the nematode penetrates the root. These results suggest nematodes may directly alter plant aromatic amino acid biosynthesis as they parasitize plants.

RESPONSE OF MID-SOUTH SOYBEAN VARIETIES TO THE RENIFORM NEMATODE. **Lawrence, G. W.,[1] and K. S. McLean.[2]** [1]Department of Entomology and Plant Pathology, Mississippi State University, Mississippi State, MS 39762, and [2]Department of Agriculture, Northeast Louisiana University, Monroe, LA 71209.

Greenhouse tests were conducted to evaluate 19 soybean cultivars in maturity groups (MG) IV through VI for resistance to *Rotylenchulus reniformis*. Included in the study were six MG IV, nine MG V, and four MG VI cultivars. Plants were inoculated with 2,000 *R. reniformis*/plant and allowed to grow for 60 days. At harvest plant growth parameters were measured and nematodes were counted. For each cultivar, resistance was calculated by dividing the number of nematodes on that cultivar at harvest by the number of nematodes used as inoculum. Although nematode reproduction varied, resistance to *R. reniformis* was found in only two cultivars, Hyperformer 574 (MG V) and Delta and PineLand 3640 (MG VI). None of the MG IV cultivars included in these tests showed resistance to this isolate of *R. reniformis*.

MEHDINEMA ALII: MORPHOLOGY AND SEX-BIASED INFECTION IN *GRYLLODES SIGILLATUS*. **Luong, L. T.,[1] and E. G. Platzer.[2]** Departments of [1]Biology and [2]Nematology, University of California, Riverside, CA 92521-0415.

The prevalence and intensity of *Mehdinema alii* (Diplogasterida) infection in the decorated cricket, *Gryllodes sigillatus*, was studied. Both male and female crickets were randomly sampled. None of the juvenile crickets sampled were infected with the nematode. Results showed a significant male bias in level of infection. Of the 84 adult males sampled, 70% were infected with nematodes. In comparison, only 12.7% of the 79 adult females sampled harbored nematodes. The intensity of infection, ranging from 1 to 112 nemas/cricket, was usually much higher in males than females. Both females and males have dense, thin, posteriorly-oriented spines from the head to mid-body. The adult nematodes are located primarily in the ileum and colon of the insect hindgut, whereas third-stage dauer juveniles are located mainly in the rectum.

A SYSTEM TO MICROINJECT PARASITIC STAGES OF *HETERODERA SCHACHTII*. **Maier, T. R., and T. J. Baum.** Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020.

Genetic transformation of cyst nematodes is an urgently needed tool. The problematic first step in the development of such a system is the delivery of genetic material into the nematode body while ensuring survival and reproduction. This problem is aggravated by the relative inaccessibility of sedentary endoparasitic nematodes during their life cycles. We have developed a microinjection protocol for parasitic stages of *Heterodera schachtii*. The use of *Arabidopsis thaliana* as a host plant in an in vitro system ensured easy access to parasitic nematodes. Beveling of injection needles allowed penetration of the rigid cyst nematode cuticle and minimized leakage of body fluids after needle withdrawal. The internal body pressure was overcome by the use of a hydraulic injection system. We are now able to routinely inject various gene constructs into parasitic nematodes beginning with the third juvenile stage and to collect viable progeny from injected females. This system bears promise to mediate transmission of injected genetic material to subsequent generations.

NOVEL BROAD-BASED RESISTANCE IN COWPEA TO *MELOIDOGYNE INCOGNITA* AND *M. JAVANICA* VIRULENT ON GENE *Rk*. **Matthews, W. C.,[1] J. D. Ehlers,[2] and P. A. Roberts.[1]** [1]Department of Nematology and [2]Department of Botany and Plant Sciences, University of California, Riverside, CA 92521.

A new, broad-based form of resistance that controls both *Rk*-virulent and avirulent isolates of *M. incognita* and *M. javanica* was identified in the high-yielding, large-seeded 'blackeye-type' breeding line UCR H8-8R developed at U.C. Riverside. One F_2 population (CB88 × H8-8R) tested with an *Rk*-avirulent isolate of *M. incognita* indicated that H8-8R was homozygous for the *Rk* gene. Analyses of F_1, F_2, and F_2-derived F_3 families tested with isolates virulent to gene *Rk* revealed the presence of a

single recessive gene unlinked to gene *Rk*, which modifies *Rk* to a higher resistance expression. A parental line, TVU 4552, which lacks gene *Rk* but carries moderate resistance, was identified as the putative recessive gene donor. The resistance found in H8-8R may be the result of an additive effect of the moderate resistance in the presence of gene *Rk*.

CAN WE PUT THE SPECIES PROBLEM TO REST? **Mayden, R. L.** Department of Biological Sciences, University of Alabama, Tuscaloosa, AL 35487

Numerous concepts exist for biological species. This diversity of ideas derives from a number of logical reasons ranging from investigative study of particular taxa to philosophical aptitude and world view to operationalism and nomenclatorial rules. While usually viewed as counterproductive, in reality these varied concepts can greatly enhance our efforts to discover and understand biological diversity. Moreover, this continued "turf war" and dilemma over species can be resolved if the various concepts are viewed in a hierarchical system. Here, a theoretically appropriate concept tolerant of the abundant types of species diversity provides the guidance necessary to develop and employ secondary operational concepts or tools for identifying diversity. Of all the concepts currently recognized, only the non-operational Evolutionary Species Concept corresponds to the requisite parameters and therefore, must serve as the theoretical concept appropriate for the category Species. As operational concepts, the remaining ideas can be notably incompatible with one another in their ability to encompass species diversity. However, these concepts do serve a vital role under the ESC as fundamental tools necessary for discovering diversity compatible with the primary theoretical concept. Thus, this system promises both the most productive framework of mutual respect for varied concepts and the most efficient unveiling of species diversity.

EFFICACY OF FIVE POSTPLANT NEMATICIDES APPLIED VIA DRIP IRRIGATION TO FIRST-YEAR *PRUNUS* SPP. **McKenry, M., T. Buzo, and S. Kaku.** Nematology Department, University of California, Kearney Ag Center, 9240 S. Riverbend, Parlier, CA 93648.

Prunus spp. were planted in a nursery setting involving sandy loam soil infested primarily with *Pratylenchus vulnus*. A dripper system delivering 4 liters/hour every 3.3 m in distance provided irrigation to each tree at 4-hour increments. At the end of one year the untreated check revealed 448 *P. vulnus*/250 cm^3 soil. Monthly applications of oxamyl at 1.12 kg/ha resulted in 12 *P. vulnus*/250 cm^3 soil. Methyl isothiocyanate at 10 ppm (w/v) applied three times before summer and twice at 20 ppm during summer resulted in visible tree damage. At sampling time this treatment averaged 102 *P. vulnus*/250 cm^3 soil. Three treatments that did not provide significant population reductions included sodium tetrathiocarbonate at 700 ppm in spring and 500 ppm in fall; three applications of DiTera at 22.4 kg a.i./ha; and 2,000 ppm peroxyacetic acid plus biological additives applied seven times per year. Even the best treatment cannot be considered as a "stand alone" replacement for a good preplant treatment.

NEMATODE COMMUNITIES CAN BE USED AS INDICATORS OF SUSTAINABLE AGRICULTURAL MANAGEMENT PRACTICES. **McSorley, R.,[1] D. L. Porazinska,[1] and L. W. Duncan.**[2] [1]Entomology and Nematology Department, University of Florida, Gainesville, FL 32611-0620, and [2]Citrus Research and Education Center, University of Florida, Lake Alfred, FL 33850-2299.

In a field experiment involving six different irrigation levels, we investigated relationships between nematode community measures (taxa and community indices) and indices of sustainability. Some of the nematode indices showed consistent patterns with components of sustainable citrus agroecosystems (yield, profitability, and water use efficiency). Because these measures reflect different aspects of sustainable agriculture, the management programs may differ significantly depending on priorities of a grower. However, the relationships revealed between omnivore nematodes, maturity index, and water use efficiency, and between irrigation level and profitability, suggest an optimum irrigation treatment (minimizing water use and maximizing profits), and establish omnivorous nematodes and maturity index as indicators of water management history.

EFFECTS OF HERBICIDE-RESISTANT SOYBEAN CULTIVARS ON *HETERODERA GLYCINES*. **Mero, H. E.,[1] M. D. K. Owen,[1] and G. L. Tylka.**[2] [1]Department of Agronomy and [2]Department of

Plant Pathology, Iowa State University, Ames, IA 50011-1020.

Research was conducted to assess the effects of herbicide-resistant soybean varieties, a new and increasingly popular weed management strategy, on *Heterodera glycines* reproduction. After 35 days in *H. glycines*-infested soil in the greenhouse, the numbers of *H. glycines* females on nematode-susceptible soybean cultivars resistant to either glufosinate, glyphosate, or sulfonylurea herbicides were less than on Kenwood 94 (herbicide-sensitive, nematode-susceptible), but greater than on Jack (herbicide-sensitive, *H. glycines*-resistant) and a glyphosate-resistant, *H. glycines*-resistant soybean cultivar. There were no differences in numbers of eggs per root or eggs per female among Kenwood 94 and the herbicide-resistant, nematode-susceptible cultivars. In 1996 and 1997, *H. glycines* reproduction was similar on Kenwood 94 and the herbicide-resistant, nematode-susceptible cultivars in field plots where *H. glycines* densities averaged 3,000 eggs/100 cm^3 of soil. However, these herbicide-resistant cultivars may suppress *H. glycines* reproduction in fields with lower egg densities.

SPATIAL AND TEMPORAL INTERACTIONS OF *VERTICILLIUM LECANII* WITH *HETERODERA GLYCINES* AND WITH SOYBEAN ROOTS. **Meyer, S. L. F.,[1] D. P. Roberts,[2] and W. P. Wergin.[1]** USDA ARS, [1]Nematology Laboratory and [2]Biocontrol of Plant Diseases Laboratory, Beltsville, MD 20705.

Light microscopy and SEM demonstrated that the fungus *Verticillium lecanii* colonized soybean roots and females and cysts of *Heterodera glycines* in root tip explant cultures. To study rhizosphere colonization in soil, plastic half-cylinders (7.5 cm diameter, 10.5 cm height) were each covered with a Plexiglas sheet. These root boxes were filled with sandy soil, soybean seeds were planted, and *H. glycines* eggs were added. The fungus was applied to 38 boxes; 12 were untreated controls. Roots grew appressed to the Plexiglas. Four weeks after planting, the Plexiglas was removed and the roots photographed. Semi-selective agar media were pressed to soil and roots in each box and incubated. Fungus colonies on the media were photographed. The experiment was repeated once. Image processing analysis of the spatial distribution of *V. lecanii* demonstrated random distribution in the soil and rhizosphere, and low numbers of colony-forming units. Poor rhizosphere colonization in the competitive environment of natural soil may account for some of the variable biocontrol results observed with this fungus in microplot studies.

CROP PLANTS AS POSSIBLE SOURCES OF TOBACCO RATTLE VIRUS FOR TRANSMISSION BY *PARATRICHODORUS ALLIUS*. **Mojtahedi, H.,[1] J. M. Crosslin,[2] G. S. Santo,[1] and P. E. Thomas.[2]** [1]Department of Plant Pathology, Washington State University, Prosser, [2]USDA-ARS, Prosser, WA, 99350.

Tobacco rattle virus (TRV) causes corky ringspot disease (CRS) in potato and is transmitted by *Paratrichodorus allius* (PA) in the Pacific Northwest. It is generally believed that weeds serve as a reservoir from which PA acquires the virus. Alfalfa, corn and wheat, commonly used in rotation with potato, were evaluated as possible sources for PA to acquire TRV. In greenhouse studies, TRV was detected by PCR in 'Stylpak' sweet corn, 'Stephens' wheat, and indicator 'Samsun NN' tobacco but not 'Vernema' alfalfa roots after they were exposed to viruliferous PA. Virus-free PA acquired TRV only from wheat and tobacco plants and transmitted it to indicator tobacco plants, confirmed by visual symptoms, ELISA, and PCR. In similar experiments, PA acquired TRV from 'Russet Burbank', 'Ranger Russet', and 'Norkotah' potato plants that were initially grown from CRS-symptomatic tubers. PA isolated from these potato cultivars transmitted TRV to indicator tobacco plants.

REASSESSMENT OF HOST RACE CONCEPT FOR COLUMBIA ROOT-KNOT NEMATODE, *MELOIDOGYNE CHITWOODI*. **Mojtahedi, H.,[1] J. G. Van der Beek,[2] G. S. Santo,[1] and C. R. Brown.[3]** [1]Department of Plant Pathology, Washington State University, Prosser, [2]DLO-Research Institute for Plant Protection, Wageningen, the Netherlands, [3]USDA-ARS, Prosser, WA 99350.

Differentiation of *Meloidogyne chitwoodi* (MC) to host races 1, 2, and 3 is based on their ability to reproduce on carrot, alfalfa, and clonal selection P1275187.10 of *Solanum bulbocastanum* (SB). Race 1 establishes on 'Chantenay' carrot and races 2 and 3 do not. Races 2 and 3 reproduce on alfalfa, whereas only race 3 colonizes the SB clone. The ability of certain isolates of MC to reproduce on carrot and selected SB clones prompted us to reexamine the host list and race concept in MC. We

exposed 19 isolates of MC from Europe, North America, and South America to 'Thor' alfalfa, 'Chantenay' carrot, and seven clonal selections of SB for 55 days, and counted number of eggs or egg masses on host roots. The data were subjected to discriminant functions analysis, and results showed that 1.7 and 14.7% risk were involved to separate races 1 and 2 on alfalfa and carrot, respectively. Increased risk associated with carrot is probably due to high genetic heterogeneity in carrot seed lots resulting from open pollination. Differential behavior of MC isolates on SB selections suggests that race 3 of MC may be viewed as a virulent pathotype of race 2.

MATERNAL INHERITANCE OF THE MITOCHONDRIAL GENOME IN *CAENORHABDITIS ELEGANS*. **Morris, K., T. Bader, and W. K. Thomas** University of Missouri-Kansas City, 5007 Rockhill Rd., Kansas City, MO 64110

The mitochondrial genomes of most metazoa are maternally inherited. The unusual morphology of the *Caenorhabditis elegans* sperm and the distribution of mitochondria within the sperm compared to other metazoan species suggests the possiblity that *C. elegans* might represent an exception to the general principle of maternal inheritance of mitochondrial genomes. We used strains of *C. elegans* with different mitochondrial DNA sequences in reciprocal crosses to test the inheritance in this nematode species. In each cross, progeny were compared to parents using a mismatch PCR approach coupled with RFLP analysis. In all cases, the progeny had the mitochondrial DNA from the female parent. No significant paternal contribution was detected. The resulting data indicates that inheritance is predominantly maternal. This observation establishes that evolutionary trees inferred from mitochondrial DNA sequences represent maternal phylogenies.

EFFECTS OF VESICULAR-ARBUSCULAR MYCORRHIZAL FUNGI AND *PRATYLENCHUS PENETRANS* ON GROWTH OF APPLE. **Muehlchen, A. M., T. A. Forge, C. Hackenberg, and T. C. Vrain.** Agriculture and Agri-Food Canada, Summerland, BC V0H 1Z0, Canada.

Four species of vesicular-arbuscular mycorrhizal fungi (VAM) were evaluated, in two greenhouse experiments, for their effects on reproduction of *Pratylenchus penetrans* and growth of apple trees. Plantlets from tissue culture were transplanted into steam-pasteurized field soil inoculated with a mixture of peat and chopped roots of VAM-infected sorghum. Control plants were inoculated with an equivalent amount of peat. After one month, 1,000 *Pratylenchus penetrans* were added to one-half of the pots of each VAM treatment. Plant dry weights, mycorrhizal colonization, and nematode populations were determined 4 months after nematode inoculation. *Glomus mosseae* increased dry weights of nematode-inoculated and non-inoculated plants in both experiments, and *G. intraradices* and *G. etunicatum* each increased dry weights in one of the two experiments. *Pratylenchus penetrans* reduced dry weights of VAM-inoculated and non-inoculated plants in one experiment. Inoculation with VAM had no effect on *P. penetrans*/pot. Plants inoculated with *Glomus etunicatum* and *G. clarum* supported significantly greater *P. penetrans* per g root than those with *G. mosseae* and *G. intraradices*, but were not different from controls. Colonization of roots by VAM was not affected by nematode inoculation.

EVALUATION OF BIOCONTROL ACTIVITY AND COLONIZATION POTENTIAL OF RHIZOBACTERIA EFFECTIVE AGAINST *HETERODERA SCHACHTII*. **Neipp, P., and J. O. Becker.** Department of Nematology, University of California, Riverside, CA 92521.

Based on in vitro inhibition against *Heterodera schachtii*, sugarbeet cyst nematode, 18 bacteria strains were selected for testing against *H. schachtii* in greenhouse experiments. Most of the bacteria strains investigated were *Bacillus* spp. but also included *Pseudomonas*, *Variovorax*, and *Arthrobacter*. Bacterial suspensions were drenched over seeds after planting. Nematode inoculum included either eggs or second-stage juveniles (J2) applied two to three days after seedling emergence. Four of eight strains reduced J2 infection of sugarbeet up to 65% when eggs were used as inoculum. Seven of eleven strains reduced J2 root infection up to 59% when J2 were used as inoculum. In a second experiment, colonization of sugarbeet roots by three selected bacterial strains (*Variovorax paradoxus* and two *Bacillus megaterium* strains) was examined over a 30-day period. *B. megaterium* populations (cfu per g root) were significantly higher at 30 days while *V. paradoxus* populations began to decline by 30 days.

EFFECTS OF TILLAGE AND DATE OF PLANTING ON *HETERODERA GLYCINES*-SOYBEAN INTERACTIONS IN MISSOURI. **Niblack, T. L., G. S. Smith, and J. A. Wrather.** Department of Plant Pathology, University of Missouri, Columbia, MO 65211.

Field trials were conducted from 1991 through 1997 at three sites in Missouri (south, central, north) in split-split plots. Main plots were planting dates: early, middle, and late, at ca. 1-month intervals beginning in May. Subplots were tillage treatments: no-, conventional-, and ridge-till. Sub-subplots were soybean cultivars differing in host suitability for *Heterodera glycines*. In overall analyses, variances in soybean yield, *H. glycines* final population densities (Pf), and reproduction (Pf/initial population densities [Pi]), were heterogeneous, with environment accounting for 86% of the variation in yield; thus, general recommendations for cultural control of *H. glycines* may not apply to specific fields. Planting date and cultivar had significant impacts on soybean yield in 15 of 17 and 14 of 17 environments, respectively; however, only cultivar consistently affected Pf and Pf/Pi (15 of 17 and 12 of 16 environments, respectively). Tillage had no consistent effect on *H. glycines* at these locations, thus, tillage practices should not be altered solely to manage *H. glycines*.

LACK OF PREDICTABLE RACE SHIFT IN *HETERODERA GLYCINES*-INFESTED FIELD PLOTS IN MISSOURI. **Niblack, T. L., G. S. Smith, J. A. Wrather, R. D. Heinz, and A. Colgrove.** Department of Plant Pathology, University of Missouri, Columbia, MO 65211.

Soybean cultivars with different sources of resistance to *Heterodera glycines* were grown at three locations initially infested with races 6, 3, and 3. Plots were paired field plots rotated annually with corn from 1991 through 1997. Plots were sampled each spring and fall to determine cultivar effects on *H. glycines* final population densities (Pf), reproduction (Pf/initial population densities [Pi]), and race. Cultivars at the northern and central sites were Williams 82 (susceptible to *H. glycines*), Jackson (Plant Introduction [PI] 88788 + Peking sources of resistance), Linford (PI 88788), and a Morsoy cultivar (PI 90763). Cultivars at the southern site were Essex or Hutcheson (susceptible), Hartwig (PI 437654), Forrest (Peking), and Rhodes (PI 88788). Resistant cultivars consistently had lower Pf and Pf/Pi than susceptible cultivars, but did not reduce Pi below damage thresholds at the northern or central locations. Race determinations were highly influenced by time of sampling. Race shifts were not predictable based on the source of resistance of the soybean cultivar.

FUNGAL METABOLITES TOXIC TO THE ROOT-KNOT NEMATODE, *MELOIDOGYNE INCOGNITA*. **Nitao, James K., S. L. F. Meyer, and D. J. Chitwood.** Nematology Laboratory, USDA ARS, BARC-West, Beltsville, MD 20705-2350.

Fungi isolated from soybean cyst nematode eggs collected in China were tested for nematicidal activity. In vitro bioassays of filtered culture broths from these fungi revealed several *Fusarium* species that appear to secrete metabolites capable of inhibiting *Meloidogyne incognita* egg hatch. Bioassay-directed isolation of these metabolites was undertaken for one of these fungi, *Fusarium equiseti*. Culture broth was extracted with XAD-16 gel adsorbent. The XAD gel was washed with water and eluted with methanol. The dried methanol eluate was redissolved in water, sterile- filtered, and assayed for its effects on *M. incognita* egg hatch. Fungal broth extract was found not only to inhibit egg hatch but also to immobilize second-stage juveniles that did hatch, confirming that the fungus secretes biologically active metabolites.

EFFECTS OF TILLAGE AND CROP ROTATION ON POPULATION DEVELOPMENT OF *HETERODERA GLYCINES*. **Noel, G. R., and L. M. Wax.** USDA ARS, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

An experiment was established in 1994 to investigate the effects of no-till and conventional tillage production systems on the population development of *Heterodera glycines*. Soybean, either resistant or susceptible to *H. glycines*, was planted in 1994 and 1996, and corn was planted in 1995 and 1997. When the experiment was initiated in 1994, the number of eggs per plot averaged 1,700/250 cm^3 soil (range = 75-24,000). In 1994, Pf/Pi was significantly lower in the no-till system. When corn was planted in 1995, Pf/Pi was lower in no-till plots. In 1996 soybean was planted, and Pf/Pi also was lower in no-till plots. However, in 1997 corn was planted and tillage did not affect Pf/Pi.

RESPONSES OF SUSCEPTIBLE AND RESISTANT TOMATO CULTIVARS TO *MELOIDOGYNE INCOGNITA*. **Noling, J. W.** University of Florida, IFAS, Citrus Research and Education Center, Lake Alfred, FL 33850.

Four field microplot experiments were performed to test the impact of initial inoculum level (Pi) of *M. incognita* (0, 100, 500, 1000/100 cm^3 soil) on fruit yield of susceptible (Agriset 761, Florida 47) and nematode resistant (Sanibel) tomato cultivars in central Florida. In fall studies, tomato yields decreased with *M. incognita* Pi for all cultivars. Sanibel was damaged less and was significantly more tolerant of *M. incognita* than the susceptible cultivars, particularly at the highest Pi. Although root gall severity was high and generally increased with Pi, root galling of Sanibel was generally less than that of susceptible cultivars. No differences in tomato yield or root gall severity were observed between cultivars or *M. incognita* Pi during a spring 1997 study. Final harvest soil population densities were always less on Sanibel than the susceptible cultivars. These experiments demonstrated that even with a resistant cultivar, some consideration of *M. incognita* Pi must be observed to minimize tomato yield losses, and that root galling severity is not necessarily indicative of the nematode's reproductive capacity.

ALTERNATIVES TO METHYL BROMIDE FOR NEMATODE CONTROL: A FLORIDA SYNOPSIS. **Noling, J. W.,[1] and J. P. Gilreath.**[2] University of Florida, IFAS, [1]CREC, Lake Alfred, FL 33850 and [2]GCREC, Bradenton, FL 34203.

Recent studies in Florida show that no single, equivalent replacement (chemical or nonchemical) currently exists that exactly matches the broad-spectrum efficacy of methyl bromide. For example, yield reductions upwards of 40% were observed in replicate studies with a resistant tomato cultivar. In other studies, soil solarization proved to be inadequate for nematode, weed, or disease control, or in related research demonstrated potentials for reduced efficacy with soil depth and development of heat- tolerant pest populations. Use of composted municipal solid wastes were shown to be non-nematicidal, and did not enhance the ability of tomato plants to tolerate root-infection by *Meloidogyne* spp. A summary of chemical alternatives research suggests that a chemical cocktail of different fumigants (i.e., 1,3-dichloropropene with chloropicrin) and a separate, but complementary herbicide treatment will be required to achieve satisfactory soilborne pest control and tomato yields. In the final analysis, the future success for development of effective soilborne pest and disease control in Florida will require an integrated approach involving combinations of multiple tactics.

PATHOGENICITY OF *MELOIDOGYNE* SP. (FL-ISOLATE) ON *PRUNUS* IN THE SOUTHEASTERN UNITED STATES AND FRANCE. **Nyczepir, A. P.,[1] D. Esmenjaud,[2] and J. D. Eisenback.**[3] [1]USDA ARS, SE Fruit & Tree Nut Research Laboratory, 21 Dunbar Rd., Byron, GA 31008, [2]Laboratoire de Biologie des Invertebres, INRA, B.P. 2078, 06606 Antibes Cedex, France, and [3]Plant Pathology, Physiology and Weed Science Department, Virginia Polytechnic Institute, Blacksburg, VA 24061.

In recent years, additional taxonomic tools have become available to help clarify the taxonomic status of *Meloidogyne* spp. While comparing the esterase patterns between *M. incognita* race 3 (GA-isolate) and a presumed *M. incognita* race 3 (FL-isolate), the protein bands were observed to be different. Moreover, similar results in France confirmed the possibility of misidentification of the FL-isolate. Upon further morphometric examination, the FL-isolate did not key out to *M. incognita*, *M. hapla*, *M. arenaria*, or *M. javanica*. Greenhouse studies indicate that the FL-isolate parasitizes and reproduces on roots of the newly released 'Guardian' peach rootstock. Studies in France confirm that this FL-isolate reproduces on *Prunus* material derived from 'Nemaguard' (i.e., 'Nemared' and almond -peach hybrid 'Garfi' × 'Nemared'). Studies are underway to identify the *Meloidogyne* sp. (FL-isolate).

FREQUENCY OF VIRULENCE TO COWPEA (*VIGNA UNGUICULATA)* GENE *Rk* IN ISOFEMALE LINES OF *MELOIDOGYNE INCOGNITA*. **Petrillo, M. D., and P. A. Roberts.** Department of Nematology, University of California, Riverside, CA 92521.

Virulence to the *Rk* gene in cowpea was found in the parthenogenetic root-knot nematode, *Meloidogyne incognita*. Isofemale lines were developed from cultures of two *M. incognita* isolates

originally collected from the same field site, with 6 years separating the collections. The isolates were characterized as having high virulence (average egg mass production of 120% of the susceptible check) and low virulence (5%), respectively, before isofemale lines were developed. Previous tests with the low virulence isolate showed a decline from 80% to 5% virulence over a 6-year interval on susceptible plants. Isofemale lines developed from this isolate had different virulence profiles. Some showed stable virulence or avirulence, while others shifted in virulence frequency over a seven-generation interval. Isofemale lines developed from the high virulence isolate showed no shift in virulence over the seven generation interval. These data indicate that the virulence trait appears to be in a dynamic state of change and adaptation in some isofemale lines developed from the same culture, while other lines showed no response in virulence over multiple generations on cowpea with or without gene *Rk*. Furthermore, these data indicate that isofemale lines developed from the same culture of a field isolate vary significantly in virulence to gene *Rk*.

THE REACTION OF GRAPE ROOTSTOCKS TO *CRICONEMELLA XENOPLAX*. **Pinkerton, J. N.,[1] K. L. Ivors,[1] and M. C. Candolfi-Vasconcelos.[2]** [1]USDA ARS Horticultural Crops Research Laboratory, Corvallis, OR 97330, and [2]Department of Horticulture, Oregon State University, Corvallis, OR 97331-3704.

Eight phylloxera-resistant grape rootstocks and four self-rooted grape cultivars were evaluated for resistance to *Criconemella xenoplax* in the greenhouse. Eight- week-old rooted cuttings were planted in pots containing sandy loam. One-half of the pots were infested with 1 nematode/g soil and the remaining pots were uninoculated controls. After 8 months, nematode densities in the soil were edetermined. Dry root weights and the percent root necrosis of paired vines, inoculated and uninoculated, in each of the 10 replications were compared to determine host tolerance. Rootstocks 420A and 101-14 were the most resistant with Pf /Pi of 0.06 and 2.5, respectively, while the cultivars Chardonnay and Pinot Noir were the most susceptible, with Pf /Pi = 50. Genotypes 420A, St George, and Riparia Glorie were the most tolerant; 5C, 5BB, 101-14, and SO4 were intermediate; and 3309C, Chardonnay, and Riesling were the least tolerant of *C. xenoplax* parasitism.

COMPARATIVE ASPECTS OF ARGININE KINASE IN NEMATODES. **Platzer, E. G.,[1] W. Wang,[1] and S. N. Thompson.[2]** Departments of [1]Nematology and [2]Entomology, University of California, Riverside, CA 92521.

The activity of arginine kinase in the reverse reaction was measured at pH 7.5 in the juvenile stages of seven nematode species. In addition, the enzyme was determined in the adults of two species. Arginine kinase was highest in third-stage juveniles (J3) of *Nippostrongylus brasiliensis* (Strongylida) and not measurable in J3 of *Romanomermis culicivorax* (Mermithida). In the adult stages, the highest enzyme activity was found in *Steinernema carpocapsae* (Rhabditida), about 1.9-fold greater than that found in *Nippostrongylus brasiliensis*. The pH optima of the enzyme from juvenile stages ranged from 7.68 to 8.34, whereas, the range for the adult enzymes was 7.90 to 8.48. Although the number of juvenile nematode species was limited, arginine kinase activity was significantly lower in species from the adenophorean orders Mermithida and Trichocephalida.

NEMATODE COMMUNITY DYNAMICS IN CONVENTIONAL VS. REDUCED-INPUT AGRICULTURAL SYSTEMS IN A MATURE FLORIDA CITRUS ORCHARD. **Porazinska, D. L.,[1] L. W. Duncan,[2] and R. McSorley.[1]** [1]Entomology and Nematology Department, University of Florida, Gainesville, FL 32611-0620, and [2]Citrus Research and Education Center, University of Florida, Lake Alfred, FL 33850-2299.

To validate nematodes as indicators of the soil ecosystem status and processes, nematode communities were monitored for three years in a citrus orchard under various agricultural regimes comparing standard vs. reduced-input practices. Differences in agricultural regimes resulted from manipulation of fertilization, irrigation, and herbicide vs. mulch use under trees. While fertilization and irrigation treatments affected some nematodes only sporadically, mulch had a consistent effect on many bacterivores, fungivores, herbivores, and omnivores. Rhabitidae, *Cephalobus,* and *Aphelenchus* had an immediate but temporary response to mulch additions. *Acrobeles, Acrobeloides, Eucephalobus, Criconemoides,* and Dorylaimida were always less abundant in mulch treatments, whereas *Plectus* and

Belonolaimus were always more abundant. Different responses within a trophic group indicate unique roles of nematode species in soil ecosystem processes on temporal and spatial scales.

MOLECULAR IDENTIFICATION OF ANGUINID SPECIES. **Powers, T. O,[1] J. A. Griesbach,[2] A. L. Szalanski,[1] and B. J. Adams.**[1] [1]Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583-0722, and [2]Oregon Department of Agriculture, 635 Capitol Street, Salem, OR 97310-0110.

PCR-RFLP and nucleotide sequencing of the ITS1 region have been used to evaluate isolates of *Anguina*, *Ditylenchus*, and related nematodes. Distinct restriction patterns have been recorded for each isolate associated with a unique plant host, supporting views of strong host-specificity among anguinid nematodes. *Anguina agrostis* isolated from bentgrass is readily discriminated from *A. funesta* isolated from annual ryegrass, as well as *Afrina wevelli* from weeping lovegrass. The latter two species have been considered in several taxonomic treatments as synonyms of *A. agrostis*. Other anguinids producing unique ITS1 restriction patterns include *Anguina tritici* from wheat, *A. agropyronifloris* from western wheatgrass, *A. graminis* from hard fescue, *A. pacificae* from annual bluegrass, and an undescribed species from orchardgrass. This method provides a rapid means to assess anguinid species identity in shipments of nematode-contaminated seed.

RESPONSE OF MALES OF TWO SPECIES OF *APHELENCHOIDES* TO FEMALE SEX PHEROMONES. **Rahimi, S., U. Twomey, and R. N. Perry.** IACR-Rothamsted, Harpenden, Herts AL5 2JQ, UK.

Laboratory cultures of *Aphelenchoides besseyi* and *A. paranechaleos* gave a ratio of adult females to males of 7:1 and 42:1, respectively. Electrophysiological and behavioral assays were used to determine if the males responded to secretory-excretory (S-E) products from females of the same species. No electrophysiological responses were obtained from *A. paranechaleos* males, whereas there was a marked increase in electrical activity of males of *A. besseyi* to S-E products. Agar plate bioassays demonstrated that there was no oriented movement by *A. paranechaleos* males towards S-E products, although there was increased activity indicating a kinetic response. In contrast, males of *A. besseyi* showed a positive taxis to homospecific S-E products, which, therefore, may contain sex pheromones. Preliminary fractionation with reverse phase HPLC of the S-E products from females of both species identified two main peaks in each but there were no differences in the profiles obtained, indicating that differences in response between the two species may be centered on differences in receptors.

USE OF CENTRIFUGATION TO EXAMINE EFFECTS OF CHITINASE AND PROTEASES ON EGGSHELL INTEGRITY OF *PRATYLENCHUS SCRIBNERI* AND *MELOIDOGYNE HAPLA*. **Reiss, J. H., E. C. Bernard, and K. D. Gwinn.** Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37901-1071.

Chitinase, a PR protein commonly produced during plant resistance responses, has been found to both enhance and inhibit hatch of nematode eggs. Possibly these effects are due to enzymatic alterations in eggshell integrity leading to premature hatch or embryonic death. Eggs of *Pratylenchus scribneri* and *Meloidogyne hapla* were incubated for 1.5 days at 24 °C in potassium phosphate-buffered solutions (pH 6.0) of fungal chitinase and concentrations ranging from 0.004 to 4.0 units/ml, and potassium phosphate buffered solutions (pH 7.5) of bacterial protease, and citrate buffered solutions (pH 2.8) of fungal protease with concentrations ranging from 0.00014 to 0.55 units/ml. Controls consisted of eggs in buffer solution and eggs in water. Following incubation, solutions were centrifuged at 20,000*g* for 60 minutes. Eggs submitted to enzymatic treatment appeared no different than control eggs and had no visible damage to eggshell integrity such as rupture, loss of embryo, or distortion of shape.

COMPONENTS OF SWINE MANURE AFFECT *HETERODERA GLYCINES* EGG HATCH AND JUVENILE BEHAVIOR. **Reynolds, D. A., G. L. Tylka, and C. A. Martinson.** Department of Plant Pathology, Iowa State University, Ames, Iowa. 50011-1020.

The composition of swine manure has been identified by numerous researchers, and there are indications that the manure may inhibit hatching of soybean cyst nematode, *Heterodera glycines*.

Based on the results of preliminary experiments, several swine manure components and breakdown products were evaluated for effects on *H. glycines* eggs and second-stage juveniles (J2). The six compounds evaluated were indole, 4-ethyl phenol, butylated hydroxytoluene, and 4-amino acetophenone at 1mM and 3-methyl indole and 4-methyl phenol at 2mM. In airtight containers, free eggs were immersed in trays containing a selected compound; eggs also were incubated in deionized water in an adjacent tray to assess volatile effects. Hatch was inhibited by contact with 3-methyl phenol and indole, but was stimulated by 4-ethyl phenol and 4-methyl phenol. Volatiles from indole, 4-ethyl phenol, and 4-methyl phenol stimulated egg hatch and J2 body movement after hatch; both 4-ethyl phenol and 4-methyl phenol stimulated stylet thrusting of J2. Other compounds had no effect on hatch or J2 behavior.

EFFICACY OF 1,3-DICHLOROPROPENE APPLIED PREPLANT AND AT PLANTING TO MANAGE PLANT-PARASITIC NEMATODES IN COTTON. **Rich, J. R.,[1] R. A. Kinloch,[2] and S. K. Barber.**[1] [1]University of Florida, Route 3, Box 4370, Quincy, FL 32351, and [2]University of Florida, 4253 Experiment Drive, Jay, FL 32565.

Two cotton field trials were conducted in northern Florida. One site was infested with *Rotylenchulus reniformis* and the other with *Meloidogyne incognita*. Pre-plant rates of 1,3-D at 14 or 28 l/ha were applied by chisel injection in the row to 25-cm-deep, two weeks prior to planting. At-plant applications were applied similarly but immediately before planting. No phytotoxicity or differences in stand were observed among the 1,3-D treatments or the control. At the reniform nematode site, yield in the preplant and at-plant treatments averaged 1,119 and 1,102 kg lint/ha, respectively, and were greater than the control yield of 895 kg lint/ha. Yields in the root-knot nematode site were 875 and 702 kg lint/ha and greater than the control yield of 486 kg lint/ha. Post-harvest root-knot nematode numbers were reduced by all 1,3-D treatments compared to the control. Reniform nematode populations were high, and treatments did not affect final numbers. Under optimum conditions of these tests, data indicated potential use of at-plant 1,3-D applications for nematode management in Florida cotton.

MANAGEMENT OF ROOT-KNOT NEMATODES IN SOIL ENHANCED FOR DEGRADING 1,3-DICHLOROPROPENE. **Riegel, C.,[1] D. W. Dickson,[1] L.-T. Ou,[1] and L. G. Peterson.**[2] [1]University of Florida, Gainesville, FL 32611, and [2]Dow AgroSciences, 1853 Capital Circle NE, Tallahassee, FL 32308.

1,3-dichloropropene, formulated with chloropicrin, is the most likely alternative fumigant to replace methyl bromide when its use is suspended. 1,3-D has been monitored in a site that degraded 1,3-D in 14, 7, and 5 days in 1994, 1995, and 1996, respectively. Our objective was to determine if this soil would reduce the efficacy of 1,3-D on *Meloidogyne* spp. Two sites infested with *Meloidogyne incognita* race 1 that were in close proximity were selected. Site 1 (enhanced) was fumigated for the past 12 years with 1,3-D and site 2 (unenhanced) had never been treated with 1,3-D. Treatments included 1,3-D applied broadcast at 112 l/ha and an untreated control, and were replicated 10 times in each site. Six tomato seedlings were transplanted 7 days after fumigation in each plot. Eleven days after transplanting, the roots were assayed for the number of juveniles per root system. The number of juveniles per root system was lower in the fumigated plots when compared to the untreated control both in the enhanced and nonenhanced sites. Juveniles per root system in the untreated controls from the enhanced and nonenhanced sites were not different. Juveniles per root system in the fumigated plots from the enhanced and nonenhanced sites were not different. The enhanced soil in this study did not reduce the efficacy of 1,3-D for control of root-knot nematodes.

MANAGEMENT OF ROOT-KNOT NEMATODES WITH ENTOMOPATHOGENIC NEMATODES. **Riegel, C., D. W. Dickson, K. B. Nguyen, and G. C. Smart, Jr.** Entomology and Nematology Department, University of Florida, Gainesville, FL 32611.

Entomopathogenic nematodes have been used successfully in the management of insect pests. Recently they were reported to suppress plant-parasitic nematodes. Our objective was to determine if soil application of *Steinernema riobrave* and *Heterorhabditis bacteriophora* would reduce root-knot nematodes on squash. Treatments (10 replicates) included microplots with *S. riobrave* or *H.*

bacteriophora at a rate of 4.5×10^5 nematodes/m^2, 1,3-dichloropropene at 84 liters/ha, and an untreated control. One week after the treatments were applied three zucchini squash cv. Marketeer seeds were planted in each microplot. Plant stand, number of fruit, and marketable yield were higher, and root-knot nematode galling indices were lower in fumigated plots when compared to the untreated control and *S. riobrave* and *H. bacteriophora*-amended plots. Mean shoot growth in the fumigated plots was twice that of the untreated and *S. riobrave* and *H. bacteriophora*-amended plots. *Steinernema riobrave* and *H. bacteriophora* were not effective in the management of root-knot nematodes on squash.

RESISTANCE TO THE RENIFORM NEMATODE IN SELECTED SOYBEAN GERMPLASM LINES. **Robbins, R. T., and L. Rakes.** Nematology Laboratory, University of Arkansas, Fayetteville, AR 72701.

In previous tests of soybean accessions PI 458024A through PI 540740 for resistance to races 3, 5, and 14 of the soybean cyst nematode (SCN), resistance to race 3 was found in 19 lines and to race 5 in 3 lines. These 22 lines were tested in a greenhouse for resistance to the reniform nematode (*Rotylenchulus reniformis*) because of previous reports linking SCN race 3 resistance to reniform resistance. Three lines (PI 461509, PI 464912, PI 518772) were found to be susceptible to the reniform nematode. All other lines were not significantly different than the standard resistant cv Forrest. The lines PI 458520, PI 467312, PI 467327, PI 467332, PI468903, PI 468915, PI 494182, PI 495017C, PI 506862, PI 507354, PI 507422, PI 507423, PI 507443, PI 507470, PI 507471, PI 507475, PI 507476, PI 509095, and PI 509100 were as resistant as Forrest soybean.

INTEGRATED MANAGEMENT OF ROOT-KNOT NEMATODES WITH HOST RESISTANCE IN CROP ROTATIONS. **Roberts, P. A.** Department of Nematology, University of California, Riverside CA 92521, USA.

Soil fumigation with nematicides has been the primary management tactic for root-knot nematodes in annual field and vegetable crops for 40 years. Alternatives to nematicide-based management will be required that can protect all crops in the common rotations. However, most biological or cultural tactics are specific in action, being restricted to a nematode species or population, or a particular crop. Although *Meloidogyne* spp. have extensive host ranges that limit nonhost rotation options, numerous host resistance genes in diverse crops could be used in annual cropping sequences to manage root-knot. Resistance genes to *Meloidogyne* in beans, cowpea, cotton, carrot, Lima bean, pepper, tomato, and wheat are being studied to determine their impact on plant tolerance and nematode population densities in various rotation sequences. Several genes are available in some crops, and they vary in the level and specificity of resistance. As resistance becomes incorporated into commercial cultivars, a planned framework for root-knot management is possible based on the sequence and frequency of resistance factors included in the crop rotation system.

EVALUATION OF TRANSGENIC COTTON (*GOSSYPIUM HIRSUTUM*) DESIGNED FOR RESISTANCE TO *MELOIDOGYNE INCOGNITA*. **Robinson, A. F.,[1] M. J. Oliver,[2] and J. P. Velten.[2]** [1]USDA ARS, College Station, TX 77845 and [2]USDA ARS, Lubbock, TX 79401.

Two gene constructs were inserted separately into cotton cv. Coker 12 via *Agrobacterium tumefaciens*. The first (construct A) combined the NRE (nematode response element) from the root-specific *TobRB7* tobacco gene with an attenuated barnase (cell toxin) coding region. The second (construct B) combined the NRE promoter with antisense of a cotton homologue of an abundant tobacco aquaporin regulating cell volume. The strategy for achieving nematode resistance with both constructs was dysfunction or autolysis of the giant cells in nematode feeding sites in roots. Plantlets were confirmed transgenic by PCR and tested for nematode resistance in growth chambers (26-30 °C) by transplanting to 500-cm^3 pots containing a 6:1 (v:v) mixture of sand and vermiculite, inoculating with 1,000 *Meloidogyne incognita* juveniles per pot, and extracting nematode eggs from roots 60 days later. GUS reporter gene indicated NRE was expressed in cotton roots. Several promising cell lines with construct A or B were identified and true seedlings are being tested against *M. incognita* and *Rotylenchulus reniformis*.

DETERMINATION OF THE WINTER VERTICAL MIGRATION PATTERN OF *HOPLOLAIMUS*

GALEATUS IN NEBRASKA. **Robinson, K., and G. Dappen.** Biology Department, Nebraska Wesleyan University, Lincoln, NE 68504-2796.

Hoplolaimus galeatus is commonly found on corn in sandy loam soils in Nebraska. They are both ectoparasites and endoparasites; severe damage occurs when the population is over 200/100 cm^3 soil. Samples were taken from a corn field near Columbus, Nebraska, on 7 October 1997, 22 November 1997, 31 January 1998, and 5 March 1998. Four different sites with varying levels of crop damage were selected and samples were taken at depths of 13, 25, 38, and 50 cm. Nematodes were extracted from 100 cm^3 soil with centrifugation-flotation. The three sites with high numbers of *H. galeatus* all displayed significant changes in vertical migration over the sampling time.

COMPARISON OF THE NEMATICIDAL ACTIVITIES OF METHYL IODIDE AND OTHER SYNTHETIC AND NATURAL FUMIGANTS. **Rodríguez-Kábana, R., C. F. Weaver, and P. S. King.** Department of Plant Pathology, Auburn University, Auburn, AL 36849.

A greenhouse experiment was conducted to compare the nematicidal efficacy of methyl iodide (MI) with those of EDB, DBCP, 1,3-D, metham sodium, benzaldehyde, and furfuraldehyde. Soil for the experiment was from a field naturally infested with *Meloidogyne arenaria* and *Pratylenchus* spp. The chemicals were applied at 100, 200, 300 or 400 µl/kg soil and every treatment was represented by eight pots, each containing one kg of soil. Ten days after application of the chemicals pots were planted with 'Summer Crookneck' squash (*Cucurbita pepo)*, which was allowed to grow for 6 weeks. At planting, all rates of benzaldehyde, DBCP, EDB, furfuraldehyde, and metham sodium practically eliminated *M. arenaria* juveniles from soil; 1,3-D did so at rates >200 ul and MI only at 400 ul. There were no nematodes in the roots of squash from pots treated with DBCP, EDB, or metham sodium nor in those from pots with the highest rates of benzaldehyde, furfuraldehyde and1,3-D. Roots from all MI-treated soil contained significant numbers of nematodes; these numbers were lower than those in roots from the untreated control pots.

PRATYLENCHOIDES TAXONOMY AND PHYLOGENY STUDIED WITH MOLECULAR METHODS. **Ryss A.,[1] L. Waeyenberge,[2] and M. Moens.[2]** [1]Zoological Institute RAS, Universitetskaya nab., St. Petersburg, 199034, Russia, and [2]Agricultural Research Centre, Burg. Van Gansberghelaan 96, B-9820 Merelbeke, Belgium.

The taxonomic position and species differences of three *Pratylenchoides* species and related species belonging to the families Belonolaimidae, Hoplolaimidae, Meloidogynidae, and Pratylenchidae were studied with ITS-RFLP. PCR amplification of the ITS yielded a fragment of 600 to 1,250 bp. Digestion with HinfI allowed differentiation of all species or genera examined with the exception of *Pratylenchoides crenicauda* and *Pararotylenchus* sp. AluI digestion could not differentiate among *P. crenicauda, Pratylenchoides laticauda* and *Pararotylenchus* sp. A combination of two or more of the enzymes Bsp143I, Bsh1236I, BsuRI, Csp6I, and Hin6I was necessary to differentiate among the *Pratylenchoides* spp., *Amplimerlinius dubius, Geocenamus brevidens*, and *Pararotylenchus* sp.. A dendrogram of phylogenetic relations was constructed based on similarity index values. The *Pratylenchoides* spp. formed a separate group closer to the Belonolaimidae than to the Pratylenchidae. *Meloidogyne hapla* showed a significant phylogenetic distance from the other taxa. The relatively low similarity index value between *Pratylenchus pratensis* and *Pratylenchus penetrans* suggests significant genetic diversity within the genus.

YIELD OF CABBAGE IN HAWAII FIELDS INFESTED WITH *HETERODERA SCHACHTII.* **Schmitt, D. P.,[1] B. S. Sipes,[1] E. P. Caswell-Chen,[2] H. Ferris,[2] and R. Shimabuku[1].** [1]Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822 and [2]Department of Nematology, University of California, Davis, CA 95616.

Our objective was to define the relationship between yield of cabbage and population densities of *Heterodera schachtii.* Four field sites were selected on Maui at elevations ranging from 600-1,000 m. In two sites, plots (5 plants/plot) provided population densities ranging from undetectable to about 2,000 eggs/250 cm^3 soil. At the other two sites, half of the plots were fumigated with 1, 3-D and the remainder were left untreated. Cabbage heads were harvested and weighed. In the first two sites, variability was too great to discern clear relationships. Soil fumigation increased yields by 0.1-0.3

kg/head. At site 3, plots were selected based on a range of nematode population densities. Greater yield increases with fumigation occurred in plots with highest initial numbers of nematodes. At site 4, all plots had low numbers of nematodes. Head weights were 0.3 kg/head greater in the fumigated plots. *H. schachtii*, at low population densities, reduces cabbage yields causing significant economic loss.

INFLUENCE OF 1,3-DICHLOROPROPENE FUMIGATION ON PURPLE AND YELLOW NUTSEDGE GERMINATION AND SURVIVAL OF *MELOIDOGYNE INCOGNITA*. **Schroeder, J.,[1] S.H. Thomas,[1] and L.W. Murray.**[2] [1] Department of Entomology, Plant Pathology, and Weed Science, and [2] University Statistics Center, New Mexico State University, Las Cruces, NM 88003-0003.

Purple and yellow nutsedges (NS), *Cyperus rotundus* (PNS) and *C. esculentus* (YNS), are weeds that were shown to host *M. incognita* (RKN) in 85% of 40 fields sampled in NM during 1996. Studies were conducted in 1997 and 1998 to determine the effects of 1,3-D on NS germination and survival of RKN in NS tubers and rhizomes. NS tubers (and rhizomes for PNS only) were collected from RKN-infested or uninfested microplots, packaged in mesh bags, and buried prior to treatment with 1,3-D at 56 l/ha. Tubers were retrieved, planted, and grown in the greenhouse at 28 °C alone or with seedling chile peppers (*Capsicum annuum*). Tuber germination and RKN reproduction on chile were assessed at 28 and 75 days after planting, respectively. In 1997, YNS tuber germination, number of shoots per tuber, and number of daughter tubers were greater following treatment with 1,3-D. Both fumigated and unfumigated PNS tubers were reservoirs of RKN for chile.

POPULATION RESPONSE OF *MELOIDOGYNE KONAENSIS* TO MOISTURE REGIMES IN A TROPICAL INCEPTISOL. **Serracin, M., D. P. Schmitt, and B. Sipes.** Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.

A field (Inceptisol-Thixotropic over fragmental isothermic) in the Kona district of Hawaii was established to determine the influence of moisture regimes on the population dynamics of *Meloidogyne konaensis* (Mk) and growth of coffee (*Coffea arabica*). Treatments replicated six times were 8-month-old and 14-month-old trees of cultivar 'Guatemala', 8-month-old 'Catuai', and 14-month-old 'Guatemala' grafted into *C. deweveri* Lebrun, two inoculum levels (0, 130 juveniles/250 ml of soil), and two moisture regimes (continuous irrigation and natural rainfall). Soil water potential was continuously monitored with tensiometers and gravimetry. Mean population densities of Mk obtained at 3-month intervals after transplanting were greater in the continuously irrigated treatment compared to natural rainfall. Plant growth was reduced only on the younger 'Guatemala' plants. Continuous soil moisture had a beneficial effect in reducing Mk damage and could be an effective tactic to maintain productivity of coffee trees.

MICROASPIRATION OF ESOPHAGEAL GLAND CELL CONTENTS FROM PLANT-PARASITIC NEMATODES. **Shields, J. P., X. Ding, and R. S. Hussey.** Department of Plant Pathology, University of Georgia, Athens, GA 30602-7274.

Parasitic stages of *Meloidogyne incognita* and *Heterodera glycines* were carefully dissected from tomato and soybean roots, respectively, and stabilized in 3% low melting point agarose. Aluminosilicate microinjection needles having a tip diameter of 3-4 µm were preloaded with RNA extraction buffer. The needle was micropositioned to enter a living nematode at the level of the nuclear region of the dorsal gland cell. Once the dorsal gland cell was penetrated, negative pressure was applied to allow aspiration of the cell contents. Needle content was then emptied into a separate microfuge tube by applying positive pressure and the tube was stored at -80 °C until further processing. Removal of discrete gland cell contents will allow gland-specific cDNA libraries to be developed for characterization of secretory proteins involved in nematode pathogenesis of plants.

MECHANISMS OF ACTION OF INDUCED SYSTEMIC RESISTANCE TO THE POTATO CYST NEMATODE *GLOBODERA PALLIDA* MEDIATED BY RHIZOBACTERIA. **Sikora, R. A., and M. Reitz.** Institut für Pflanzenkrankheiten, Universität Bonn, Nussallee 9, D-53115 Bonn, Germany.

The rhizobacteria *Bacillus sphaericus* and *Agrobacterium radiobacter*, applied to potato tubers,

caused reductions of over 40 percent in *Globodera pallida* root penetration. In split-root studies, the bacteria seemed to induce some form of signal in the treated part of the root that moved acropetally to the shoot and then basipetally back down into the untreated root system where nematode control occurred. Living and dead cells of both bacteria as well as *B. sphaericus* metabolites were able to induce control activity. The rhizobacteria did not significantly influence nematode hatch, attraction, development, fertility, or sex ratio. Studies were conducted with *A. radiobacter* to determine the role of exopolysaccharides (EPS) and lipopolysaccharides (LPS) as inducing agents of systemic resistance. The EPS extracts from the cells applied to the split-root system had no systemic effect on nematode penetration. Conversely, the LPS extracts induced systemic activity and cause a significant reduction in nematode penetration that was similar in degree to that obtained with live cells of *A. radiobacter*.

POSTPLANT APPLICATION OF 1,3-D FOR NEMATODE CONTROL IN PINEAPPLE. **Sipes, B.** Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.

The efficacy of post-plant applications of emulsifiable 1,3-dichloropropene (1,3-D SL) for reniform nematode control in pineapple was evaluated in the field. Treatments consist of: i) 192 kg 1,3-D SL/ha preplant (PP) and trimonthly postplant applications (TP) of 1,3-D SL at 64 kg/ha; ii) 256 kg 1,3-D SL/ha PP and 64 kg/ha TP; iii) 192 kg 1,3-D SL/ha PP and a single postharvest treatment of 1,3-D SL at 96 kg/ha (PH); iv) 1,3-D SL at 256 kg/ha PP and 96 kg/ha PH; v) 256 kg 1,3-D/ha VL PP followed by fenamiphos at 1.7 kg/ha TP; vi) untreated control. Preplant reniform nematode populations densities were low (92/250 cm^3 soil) and did not differ among treatments. Reniform nematode population densities increased to 1,000-4,000/250 cm^3 soil within 9 months after planting and were not different among treatments. Number of nematode eggs per g root was greatest in the 192 kg/ha PP: 1,3-D SL TP plots and lowest in the 256 kg/ha PP:1,3-D SL TP plots 9 months after planting. Dry-leaf weight and plant height at 9 months were lowest in the 1,3-D SL TP plots, suggesting phytotoxicity of the treatment. Plant growth parameters, however, did not differ among treatments.

IDENTIFICATION OF *HETERODERA GLYCINES* GENES INVOLVED IN ARRESTED DEVELOPMENT. **Skantar, A. M.,[1] D. M. Bird[2], and C. H. Opperman[2].** [1]Nematology Laboratory, Agricultural Research Service, USDA, Beltsville, MD 20705, and [2]Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695.

Developmentally arrested infective juveniles of plant-parasitic nematodes are functionally similar to *Caenorhabditis elegans* dauer larvae, and may use similar molecular mechanisms to maintain arrest and resume development. Several *C. elegans daf* genes controlling dauer formation have been identified, including TGF-beta (*daf-7*) and TGFB-receptor (*daf-4, daf-1*) signaling molecules. Degenerate primers corresponding to conserved domains of the *C. elegans daf-7* gene were used to PCR-amplify putative *daf-7* homologs from *Heterodera glycines* genomic DNA. One PCR clone contained a stretch of 17 amino acids with 29-47% identity to other members of the daf-7/BMP protein family. The predicted coding sequence was interrupted by a 5Õ splice junction and 41 nucleotides of intron sequence. This intron was located in a position similar to one found in the *C. elegans daf-7* gene.

CHANGES IN ESOPHAGEAL GLAND ACTIVITY DURING THE LIFE CYCLE OF *NACOBBUS ABERRANS* (NEMATA: PRATYLENCHIDAE). **Souza, R. M., and J. G. Baldwin.** University of California, Department of Nematology, Riverside, CA, 92521.

The dorsal gland (DG) and two subventral glands (SvG) of the following seven developmental phases of *N. aberrans* were studied by TEM and light microscopy: pre-parasitic second-stage juveniles (J2), parasitic J2, J3, J4, migratory females, young sedentary females, and mature sedentary females. Esophageal gland activity was estimated by the abundance of organelles as endoplasmic reticula, ribosomes, Golgi bodies, and secretory granules (SG). All esophageal glands were metabolically active in the J2 examined, although only in parasitic J2 were there large numbers of SG in the esophageal gland extensions and ampullae. No evidence of major esophageal gland activity was observed in J3 and J4, nor in migratory females, suggesting that these stages do not feed. We suggest that reserves stored by J2 sustain three ecdyses and the migratory female's search for a feeding site and induction of a syncytium. Feeding activity is resumed in young and mature sedentary females, in

which the DG is highly active and enlarged. The SvG are active, but with little synthesis of SG, suggesting that in sedentary females the SvG may have physiological roles other than digestion.

PCR-RFLP OF rDNA IN *HETERODERA* SPP. AND *H. GLYCINES* RACES. **Sui, D. D.,[1] G. R. Noel,[2] and L. L. Domier.**[2] [1]Department of Crop Sciences, and [2]USDA ARS, Crop Protection Unit, and Department of Crop Sciences, University of Illinois at Urbana-Champaign, Urbana, IL 61801.

The variability of the ribosomal DNA region of eight *Heterodera glycines* races and the species *H. lespedezae, H. schachtii,* and *H. trifolii* were assessed by digestion of PCR-amplified ribosomal DNA fragments with 14 restriction endonucleases. The pattern produced by PmaC I differentiated *H. schachtii* from *H. glycines, H. trifolii, and H. lespedezae.* Ban I separated *H. glycines* races 2, 3, and 4 from races 1, 5, 6, 9, and 14 by absence of a 750-bp band in races 2, 3, and 4. Within the group of races 2, 3, and 4, Hae III differentiated race 2 from races 3 and 4 by the presence of a 680-bp band and absence of two other bands (a 200-bp and a 480-bp band) in race 2. PmaC I further separated race 4 from race 3 by leaving an uncut 1,280-bp band in race 4, but not in races 3. Therefore, *H. glycines* races 2, 3, and 4 can be differentiated from races 1, 5, 6, 9, and 14 by digestion with Ban I, and from each other by digestion with Hae III and PmaC I. Juveniles from 10 different cysts within races 1, 2, and 3 demonstrated that the race diagnostic restriction patterns were highly stable.

THE VERTICAL MIGRATION PATTERN OF A STING NEMATODE IN NEBRASKA DURING THE NON-GROWING SEASON. **Svoboda, J., and G. Dappen.** Biology Department, Nebraska Wesleyan University, Lincoln, NE 68504-2796.

A sting nematode, *Belonolaimus* sp., is associated with sandy soils in flood plains and attains high population levels in sandy, irrigated soils. Corn grown in these soils frequently suffers lower yields due to seedling root damage caused by these nematodes. This study determined the vertical migration pattern of a *Belonolaimus* sp. during one winter non-growing season. Samples were collected at depths of 13, 25, 38, and 50 cm from four different sites within the field, each displaying a different level of crop damage. The first sample was taken 7 October 1997 before corn was harvested; additional collections were on 22 November 1997, 30 December 1997, 31 January 1998, and 5 March 1998. Centrifugation-flotation and sieving techniques were used to extract nematodes from each soil sample. Sting nematodes were consistently reported at two sites; at these sites, 49% were found in the uppermost 13 cm, 25% in the 13 to 25-cm depth, 17% in the 25 to 38-cm depth, and 9% from the 38 to 50-cm depth. No significant change in the vertical distribution of sting nematodes was observed over the sampling time.

ECONOMICS OF ROOT-KNOT NEMATODE (*MELOIDOGYNE ARENARIA*), SOUTHERN BLIGHT FUNGUS (*SCLEROTIUM ROLFSII*), AND MICROBIVOROUS NEMATODES IN A COTTON-PEANUT PRODUCTION SYSTEM. **Taylor, C. R., and R. Rodríguez-Kábana.** Departments of Agricultural Economics and Plant Pathology, 226 LAB, Auburn University, Auburn, Al 36849.

The costs of the root-knot nematode (*Meloidogyne arenaria*) and southern blight fungus (*Sclerotium rolfsii*), and the benefits of microbivorous nematodes in a cotton and peanut farming system were estimated with a stochastic dynamic programming decision model that maximized the expected present value of profit. Stochastic state variables in the decision model were levels of the three pathogens in the fall, and prices of the two crops before planting. Deterministic state variables were use of the field in each of the previous 2 years. Decision variables were the crop to plant, and use of a fungicide and nematicide in peanuts. Embedded in the economic decision model were stochastic dynamic population models for the pathogens, Markovian price relationships, and the relationship between crop and the pathogens.

STABILITY OF THE *N* ROOT-KNOT NEMATODE RESISTANCE GENE IN BELL PEPPER AT HIGH TEMPERATURES. **Thies, J. A., and R. L. Fery.** U.S. Vegetable Laboratory, ARS USDA, Charleston, SC 29414-5334

Stability of the *N* gene that confers resistance to the southern root-knot nematode (*Meloidogyne*

incognita) in bell pepper (*Capsicum annuum*) was determined in growth chambers at 24, 28, and 32 °C. Numbers of eggs per g fresh root, reproductive factor of *M. incognita*, and root galling increased as temperature increased for the resistant bell cultivars Charleston Belle and Carolina Wonder (homozygous for the *N* gene) and their respective susceptible recurrent backcross parents Keystone Resistant Giant and Yolo Wonder B. Both resistant cultivars exhibited a partial loss of resistance at 28 and 32 °C. At the highest temperature, however, nematode reproduction on the resistant cultivars was only 20% of that on the susceptible cultivars, root gall indices were still within the moderately resistant range, and shoot dry weights were not suppressed. Although a partial loss of resistance occurred in Charleston Belle and Carolina Wonder at high temperatures, root-knot nematode-resistant bell pepper cultivars may be a useful component of cropping systems designed to manage *M. incognita*.

INTERACTIONS AMONG *MELOIDOGYNE INCOGNITA*, NUTSEDGES, AND CHILE PEPPERS. **Thomas, S. H.,[1] J. Schroeder,[1] and L. W. Murray.[2]** [1]Department of Entomology, Plant Pathology and Weed Science and [2]University Statistics Center, New Mexico State University, Las Cruces, NM 88003-0003.

Microplot experiments conducted during 1996 and 1997 showed the effects of presence or absence of *M. incognita* (RKN) on competition between *Capsicum annuum* (chile) and *Cyperus esculentus* (yellow nutsedge = YNS) or *C. rotundus* (purple nutsedge = PNS). Overall, data were consistent and similar between years. YNS, PNS, and RKN had similar detrimental effects on chile growth parameters individually, but effects were not enhanced when both pests were present. RKN numbers per volume of soil were greatest when chile alone was present. PNS was a better host for RKN than YNS, and RKN reproduction on PNS was greater when chile was present. Chile reduced some nutsedge growth parameters, but RKN had no deleterious effects on nutsedges. In contrast, RKN increased YNS and PNS tuber numbers and tuber weights. The results indicate that the relationship between nutsedge species and RKN is mutually beneficial, and that integrated management strategies must be developed for these pests.

EFFECTS OF RHIZOBACTERIA ON EGG HATCH OF SOYBEAN CYST NEMATODE, *HETERODERA GLYCINES* ICHINOHE. **Tian, H., and R. D. Riggs.** Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

Among 201 bacterial isolates from the rhizoplane and rhizosphere of soybean plants from fields in Arkansas that were screened for their effects on the reproduction of the soybean cyst nematode (*Heterodera glycines*, SCN) in greenhouse studies using pasteurized soil, 20 isolates (positive isolates) reduced the population level of SCN and 5 isolates (negative isolates) promoted SCN reproduction. After in vitro incubation of eggs with bacterial suspensions at 24 °C for 10 days, 12 of the 20 positive isolates inhibited egg hatch significantly, 2 had no effect, and 6 gave variable results, whereas, four of the five negative isolates decreased egg hatch significantly and one gave variable results. However, when eggs were incubated with bacteria-free tryptic soy broth culture filtrates, all positive and negative isolate culture filtrates inhibited egg hatch significantly. The results indicate that rhizobacteria inhibiting egg hatch in vitro do not necessarily reduce SCN reproduction in the greenhouse.

INTERACTIONS BETWEEN RHIZOBACTERIA AND SECOND-STAGE JUVENILES OF SOYBEAN CYST NEMATODE, *HETERODERA GLYCINES*. **Tian, H. and R. D. Riggs.** Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

Of 25 bacterial isolates from the rhizoplane and rhizosphere of soybean plants from fields in Arkansas that were tested for their activity on second-stage juveniles (J2) of the soybean cyst nematode (*Heterodera glycines*, SCN), 20 isolates (+ isolates) inhibited and 5 isolates (- isolates) increased SCN reproduction significantly in greenhouse tests. When J2 were incubated in bacterial suspensions at room temperature (22-24 °C) for 48 hours, all isolates inhibited J2 mobility except for one + and one - isolate that gave variable results. No isolate killed the J2. When J2 and bacteria that were incubated for 48 hours were poured around the roots of 'Hutcheson' soybean, none of the 25 isolates affected the number of cysts formed. When J2 were incubated in bacteria-free tryptic soy broth culture filtrates for 48 hours, culture filtrates from all isolates significantly reduced J2 mobility, but none killed the J2.

When the bacteria-free filtrates and J2 that had been incubated for 48 hr were poured around Hutcheson soybean roots, five + and two - isolates reduced cyst numbers significantly, while the other isolates had no effect on numbers.

REGULATION OF TRANSGENIC PLANTS WITH ALTERED PESTICIDAL TRAITS - EPA'S PROPOSED RULE. **Tomimatsu, G. S.** U.S. Environmental Protection Agency, Washington, DC 20460

Genetic technologies (including plant breeding) for pest control and crop production have been the pillars for protection of U.S. agriculture for several decades. Sophisticated transgenic plant varieties developed through biotechnology (i.e., the processes associated with genetic transformations using recombinant DNA) are often more defined than plants developed from hybridization and selection of resistant or tolerant plants, and are increasingly important tools in precision agriculture. The safety of introduced traits into crops is the joint responsibility of USDA, FDA, and EPA. EPA has responsibility for registering pesticides, and regulates pesticides by analyzing data to determine that a reasonable certainty of no harm to humans or their environment will result from use of the pesticide. To date, EPA has registered 7 transgenic plants that have altered pesticidal properties. EPA has proposed regulations and potential data requirements for transgenic pesticidal plants.

EFFECTS OF DITERA, A BIOLOGICAL NEMATICIDE, ON ASPECTS OF THE LIFE CYCLE OF THE POTATO CYST NEMATODE *GLOBODERA PALLIDA*. **Twomey, U.,[1] P. Warrior,[2] B. R. Kerry,[1] and R. N. Perry.[1]** [1]IACR-Rothamsted, Harpenden, Herts AL5 2JQ, UK, and [2]Abbott Laboratories, Chemical and Agricultural Products Division, Long Grove, IL 60047.

DiTera (Abbott Laboratories), a novel biological nematicide, did not stimulate hatch of *Globodera pallida*, but exposing cysts to 1% and 10% DiTera in distilled water for five weeks irreversibly prevented hatch when the cysts were transferred to potato root diffusate (PRD). Tests on free eggs indicated that, when mixed with PRD, DiTera prevented eggshell permeability change, normally caused by PRD, in a majority of eggs. Movement of hatched juveniles through sand soaked in DiTera demonstrated that there was a concentration-dependent adverse effect on movement. In agar plate bioassays, with DiTera incorporated in the substrate, movement of adult males towards female sex pheromone was reduced. In separate tests, where males were pre-exposed to DiTera, there was a significant reduction in movement of males during the first hour after exposure; however, after 16 hours there was no difference between untreated and treated males.

A DIFFERENT PERSPECTIVE ON IPM: MULTIPLE PESTS, MULTIPLE TACTICS. **Tylka, G. L.** Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020.

Integrated pest management, or IPM, has evolved to be interpreted as many different things in agriculture. Most simply, IPM is the use of scouting to determine whether pest population densities exceed established threshold values before applying a pesticide. At a more complex level, IPM is the selective use of available chemical, cultural, and biological control tactics to manage one or a few targeted pest species. However, the maximum utility of IPM will not be realized until a system of coordinated tactics is developed to manage entire pest complexes (weeds, insects, nematodes, etc.) for each crop. Since 1990, a multidisciplinary research team at Iowa State University has evaluated a variety of pest management tactics, including altered planting dates, herbicides, and nematode- and herbicide-resistant soybean varieties, for effects on weed, insect, and soybean cyst nematode population densities. Many of the pest management practices evaluated to date have had significant effects on the nontarget pests studied. This type of research is needed to develop a system of pest management tactics that effectively minimizes pest damage and maximizes crop yields.

RELATIONSHIPS AMONG *HETERODERA GLYCINES* POPULATION DENSITIES, SOYBEAN YIELDS, AND SOIL pH. **Tylka, G. L., C. Sanogo, and S. K. Souhrada.** Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020.

A study area of 20.2 ha divided into 0.2-ha cells was established with global positioning system (GPS) technology in 1997 in an Iowa field infested with the soybean cyst nematode, *Heterodera glycines*. A 20-core soil sample was collected from each cell at a randomly selected site located with

a hand-held GPS unit prior to planting the field with a *H. glycines*-susceptible soybean variety. For each soil sample, pH was determined, cysts of *H. glycines* were extracted and counted, then eggs were extracted from the cysts and counted. Average yield of each 0.2-ha cell also was determined. Cyst population densities ranged from 2 to 463 per 100 cm^3 of soil; egg densities ranged from 200 to 35,800 per 100 cm^3 of soil. Soil pH ranged from 5.5 to 8.0. Soybean yields of 820 to 3,258 kg per hectare were obtained. Significant linear correlations between soybean yield and cyst and egg densities were detected, as well as significant linear correlations between soil pH and cyst and egg densities. The nature of the relationship between soil pH and *H. glycines* density is not known.

BIODIVERSITY OF HEAT-STABLE GENOTYPE SPECIFIC RESISTANCE TO *MELOIDOGYNE* IN MARANON RACES OF *LYCOPERSICON PERUVIANUM* COMPLEX. **Veremis, J. C., and P. A. Roberts.** Dept. Nematology, University of California, Riverside, CA 92521.

Accessions of the *Lycopersicon peruvianum* complex and their F_1 progenies were screened for genotype-specific resistance to *Mi*-avirulent *M. javanica* at 25 °C and 32 °C and to *Mi*-virulent *M. incognita*. All individuals of *L. peruvianum* Chotano-*humifusum* race accessions LA 2157 and LA 2334 were resistant to *Mi*-avirulent *M. javanica* at 25 °C and 32 °C, indicating that the accessions were inbred homozygous for the heat-stable resistance. The *L. peruvianum* Maranon race accessions LA 1626, LA 1708, LA 2172, LA 2185, LA 2326 and LA 2328 segregated for heat-stable resistance to *Mi*-avirulent *M. javanica* . The F_1 progeny from the Maranon race accessions LA 392 × LA 2157, LA 2334 × LA 2157, LA 2328 × LA 2326, LA 2328 × LA 2185, LA 1708 × LA 2328 and LA 1626 × LA 2172 were resistant to *Mi*-avirulent *M. javanica* at 32 °C. The *L. peruvianum* LA 392 and LA 2163 and *L. chilense* LA 1968, LA 1972, LA 2404, LA 2405, LA 2406, LA 2748, LA 2930, and the *L. peruvianum* × *L. chilense* crosses were homozygous susceptible with all individuals susceptible at 32 °C. Thus, a range of differences was found in accessions and crosses for expression of heat-unstable and heat-stable resistance to *Mi*-(a)virulent *Meloidogyne* spp.

ENGINEERING GENETIC RESISTANCE. **Vrain, T. C.** Agriculture and Agri-Food Canada, Pacific Agrifood Research Centre, Summerland, BC, Canada V0H 1Z0.

Resistance genes already identified in wild relatives of crop plants have been mapped, cloned, and transferred into nematode susceptible crops. Genes expressed in nematode feeding cells can be identified, specifically to manipulate their promoters and prevent the formation or the normal function of giant cells and syncytia of root-knot and cyst nematodes. A truncated promoter (TobRB7), isolated from a tobacco gene, appears tofunction as a root-knot nematode giant-cell-specific element. Digestive secretory proteins can be purified, and antibodies binding to these proteins may be expressed in transgenic plants for the same purpose. Plant proteinase inhibitors expressed in transgenic crops interfere with digestive processes and delay the development and multiplication of various nematodes. Various other plant or bacterial proteins, such as *Bacillus thuringiensis* toxins, lectins, and cholesterol oxidase, are candidates to suppress physiological processes of parasitic nematodes.

REPRODUCTION OF *HETERODERA GLYCINES* ON SOYBEAN CULTIVARS IN THE NORTH CENTRAL REGION. **Wang, J.,[1] P. Donald,[1] T. L. Niblack,[1] P. R. Sellers,[2] and G. L. Tylka.[3]** Departments of Plant Pathology, [1]University of Missouri, Columbia, MO 65211, [2]Purdue University, West Lafayette, IN 47907, and [3]Iowa State University, Ames, IA 50011.

Scientists from 10 north central states participated in a study to determine how soybean cultivars in maturity groups (MG) I-IV and geographic locations influence reproduction of *H. glycines*. Two resistant and two susceptible cultivars of each MG were grown at 21 and 19 sites in 1994 and 1995, respectively. Soil samples were collected from each plot at planting and harvest. All samples were processed at Iowa State University for extraction of eggs. Overall, reproduction rates were higher on MG III and IV than those on MG I and II cultivars. Resistant cultivars in MG I and II were more consistent and effective in reducing reproduction. Reproduction on susceptible cultivars of all maturity groups was similar. Reproduction on all cultivars was similar among locations within the same maturity zone, but was more heterogeneous in zones 3 and 4 than zones 1 and 2. More frequent monitoring of *H. glycines* population densities is recommended for infested fields in zones 3 and 4.

USING TROPICAL COVER CROPS TO SUPPRESS *ROTYLENCHULUS RENIFORMIS* POPULATIONS IN HAWAII. **Wang, K.-H., and B. S. Sipes.** Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.

Sunn hemp (*Crotalaria juncea*), yellow mustard (*Sinapis alba*), and marigold (*Tagetes erecta*) were grown as intercycle crops between pineapple crops for 3 months at Whitmore, HI. Two additional treatments were weed fallow and 1,3-dichloropropene (1,3-D). Reniform nematode, *Rotylenchulus reniformis*, population densities were determined before cover crop planting, 3 months after cover crop planting, 1 month after cover crop incorporation into the soil, and bimonthly after pineapple planting. The cover crops were poor hosts of *R. reniformis* and suppressed nematode population densities during the intercycle period. The nematode reproduction rate at 6 months after pineapple planting was lowest in plots previously planted with *C. juncea*. *Sinapis alba* reduced numbers of *R. reniformis* during the intercycle period. Cover crop incorporation increased bacterial- and fungal-feeding nematodes, with the highest number in *C. juncea* plots (100/250 cm^3 soil). D-leaf weight and plant height of pineapple were greatest in plots treated with *C. juncea* and 1, 3-D. *Crotalaria juncea* is a promising cover crop for suppressing *R. reniformis* population densities.

GENOMIC VARIABILITY AMONG POPULATIONS OF *HETERODERA TRIFOLII* USING AMPLIFIED FRAGMENT LENGTH POLYMORPHISMS. **Wang, S., R. D. Riggs, and E. J. Anderson.** Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

Amplified fragment length polymorphism techniques (AFLP) were employed to detect the genomic variability of the clover cyst nematode, *H. trifolii*. Seven populations from different geographic origins and with different host preferences were examined. Genomic DNA of each population was extracted from gravid females by DNAzol reagent, digested with Eco RI/Mse I, and ligated with adapters. The products of preamplication reaction of DNA were then selectively amplified with two primer pairs, Eco RI primer E-AA with Mse I primer M-CTA and E-AT with M-CAT. Amplified fragments were separated on a 1% agarose gel. Two populations showed the same AFLP pattern and all others differed, indicating significant genomic variability within the species. A population from Australia maintained on carnation, *Dianthus caryophyllus*, had different amplified fragment bands from those of its sub-population maintained on white clover, *Trifolium repens*, which supported the observation that the sub-population had significantly different host preferences from that of the original.

POPULATION DYNAMICS OF *HETERODERA GLYCINES* ON SOYBEAN IN THREE SOIL TEXTURES IN MICHIGAN. **Warner, F. W. and G. W. Bird.** Dept. of Entomology, Michigan State University, East Lansing, MI 48824.

The population dynamics of *Heterodera glycines* associated with two susceptible (Corsoy 79 and Kenwood 94) and two resistant (Jack and Newton) soybean cultivars were studied under microplot conditions in three soil textures (sand, sandy loam, sandy clay loam) from 1994 to 1997. The microplots were infested with *H. glycines* eggs in the spring of 1994 and soil samples were collected before planting and after harvest each year. In 1994, Pf/Pi ratios for the susceptible varieties ranged from 4.6 to 151.9 with the highest ratios observed in microplots filled with sand. In 1995, *H. glycines* population densities increased on the susceptible varieties regardless of soil type, but the largest increases were in the plots filled with sandy clay loam. By 1996, the Pf/Pi ratios declined or remained stable among all soil types. *Heterodera glycines* population densities on the resistant varieties were about 90% less than on the susceptible ones. Soybean yields were reduced most in microplots with sand.

LONG-TERM STUDY TO ASSESS THE VALUE OF HAIRY INDIGO FOR THE MANAGEMENT OF *MELOIDOGYNE ARENARIA* IN PEANUT. **Weaver, C. F., R. Rodríguez-Kábana, and P. S. King.** Department of Plant Pathology, Auburn University, Auburn, AL 36849.

The value of hairy indigo (*Indigofera hirsuta*) as a rotation crop for the management of *Meloidogyne arenaria* in 'Florunner' peanut (*Arachis hypogaea*) was assessed in a field study in southeast Alabama. Cropping systems included monoculture peanut untreated and treated with the nematicide aldicarb (3.4 kg a.i./ha at-plant), one and two years of hairy indigo followed by peanut

treated and untreated, untreated peanut preceded by one year of hairy indigo and one year of 'Kirby' soybean (*Glycine max*), and untreated peanut followed by one year of 'DPL-90' cotton (*Gossypium hirsutum*) and one year of hairy indigo. All of the above cropping systems were also with and without treatment of the fungicide Folicur 3.6F. Hairy indigo was a non-host for *M. arenaria*. Combining the hairy indigo rotation system with aldicarb did result in some suppression of the nematode. Yields of peanut with no Folicur following hairy indigo were equivalent to monoculture with aldicarb. In Folicur-treated peanut, yields following hairy indigo were significantly higher than monoculture but were not as high as those following soybean or cotton.

A BIOASSAY TO EVALUATE SOIL SUPPRESSIVENESS AGAINST *HETERODERA SCHACHTII*. **Westphal, A. and J. O. Becker.** Department of Nematology, University of California, Riverside, CA 92521.

The number of juveniles of *Heterodera schachtii* detected in 3-day-old radish seedlings, *Raphanus sativus*, grown at 28/23 °C and a 16/8 hour day/night cycle was proportional to the number of juveniles in a sandy loam soil substrate. A Latin square-designed microplot experiment with eight replications was conducted to determine whether the radish bioassay was useful to predict damage and population development of *H. schachtii*. One-half of the plots contained a *H. schachtii*-suppressive sandy loam soil with a population of 17 eggs/g soil. The other half was fumigated to make it conducive. Four inoculum levels were established by infesting both soils with 0, 30, 60 or 120 eggs/g soil. Two months later Swiss chard, *Beta vulgaris*, was planted and soil subsamples from each plot were assayed with radish. At the two highest inoculum levels significantly more juveniles were detected in roots from the conducive soil than in roots from the suppressive soil. At harvest, Swiss chard yields in suppressive plots were not different from yields in the fumigated, uninoculated check. In the conducive plots, yields were significantly lower at the highest inoculum level. Numbers of cysts were significantly higher than in the suppressive plots at the equivalent inoculum density at the two highest levels. The results of the microplot trial validated the predictions of the bioassay.

POPULATION DYNAMICS OF *HETERODERA SCHACHTII* IN A SUPPRESSIVE SOIL. **Westphal, A., and J. O. Becker.** Department of Nematology, University of California, Riverside, CA 92521.

The population dynamics of *Heterodera schachtii* was compared in nematode-conducive soil and soil suppressive against *H. schachtii*. Soil fumigation rendered suppressive field soil into conducive soil. Swiss chard, *Beta vulgaris*, was planted in a field trial one month after infestation of both soils with cysts. Plants were harvested every 150 degree-days (DD; basal temperature: 8 °C) starting at DD 600. Similar cyst population developments were observed in both soils until DD 1,200, when there were significantly more cysts in the conducive than in the suppressive soil. Chambers for the non-destructive observation of nematodes on roots were filled with either one of the soils in a greenhouse trial. Females developing on the roots of mustard, *Sinapis alba*, after inoculation with second-stage juveniles of *H. schachtii* were counted weekly. The populations were similar in both soils during weeks three through seven following inoculation. Female populations significantly increased in the conducive compared to the suppressive soil in subsequent weeks. At harvest, cysts and females were picked from roots, squashed on microscope slides and rated for fungal infestation. A high fungal infestation was detected in cysts from suppressive soil. Cysts from conducive soil and females from both soils were nearly free of fungal infestation.

MARKETABLE YIELD OF CARROTS IN *MELOIDOGYNE HAPLA*-INFESTED SOILS AS AFFECTED BY A GREEN MANURE OF SUDANGRASS. **Widmer, T. L., and G. S. Abawi.** NYSAES/Cornell University, Barton Laboratory, Department of Plant Pathology, Geneva, NY 14456.

Severe infections of carrot by the northern root-knot nematode, *Meloidogyne hapla*, result in forking and galling of roots, thus reducing the quality and percentage of marketable yield. A total of 72 field microplots (1.2-m diam.) were established in 1996 and filled with mineral or organic soil. Each soil was initially infested with three densities of *M. hapla* (0, 2, or 8 eggs/cm^3 soil). Half of the microplots (6 replications/treatment) were planted to sudangrass cv. Trudan 8, which was incorporated as a green manure in the fall (approx. 25 t/ha). Carrot seeds, cv. 'Oranza', were planted in three rows,

30-cm apart (1.1 m/row) in all microplots. Damage of *M. hapla* to carrots was greater in the mineral soil than in the organic soil. At the highest infestation density the percent marketable roots in the mineral soil was reduced by 28 and 44% in sudan-amended and unamended plots, respectively, compared to uninfested plots. In the organic soil, percent marketable roots was reduced by 13 and 35%, respectively, compared to uninfested plots. No differences were observed among the sudangrass-amended and unamended plots at the other nematode infestation densities. These data suggest that sudangrass, as a green manure, is effective in reducing the damage caused by *M. hapla* on carrots when populations are above the damaging level.

HETERODERA GLYCINES POPULATIONS SELECTED FOR REPRODUCTION ON 'HARTWIG' SOYBEAN. **Young, L. D.** USDA ARS, 605 Airways Blvd., Jackson, TN 38301-3201.

Two *Heterodera glycines* populations were selected for reproduction on the cultivar Hartwig. Both populations were race 4 when tested. The first population originated from a mass mating of race 2 females with race 5 males. Eggs resulting from the cross were cultured on Hartwig and then on cultivar Hutcheson in alternate generations for 14 cycles, followed by 13 continuous generations on Hartwig. Female index after 26 generations of selection on Hartwig was 34; on PI 437654 the index was 12. Index on Hartwig increased to 46 after two additional generations. The second population was cultured on Hutcheson in the greenhouse for two generations following extraction of the nematode from field soil where Hartwig had been planted for four consecutive years. Then the population was cultured alternately on Hartwig and Hutcheson for six cycles followed by seven continuous generations on Hartwig. Female index for Hartwig was 21 after this population was cultured 13 generations on Hartwig.

RESISTANCE IN COTTON TO ROOT-KNOT NEMATODES. **Zhou, E.,[1] J. L. Starr,[1] and T. A. Wheeler.[2]** [1]Department of Plant Pathology and Microbiology, Texas A&M University, College Station, TX 77843, and [2]Texas Agricultural Experiment Station, Lubbock, TX 79401.

Cotton genotypes with resistance to *Meloidogyne incognita* have been released recently. The relationship between yield of the resistant cultivars Acala NemX and Stoneville LA887 and nematode Pi was compared to that of susceptible cultivar Paymaster HS26 in microplots. Pi was found to have a greater effect on yield of HS26 than on yield of NemX and LA887, with a 13% decrease in seed cotton yield for HS26 compared with decreases of 5.5% and 9.3% for LA887 and NemX, respectively, for each increase of 1 unit of log (Pi + 1). The resistant cultivars supported less nematode reproduction than did HS26. In a separate study, the aggressiveness of 107 populations of *M. incognita* on cotton genotypes with different levels of resistance was examined in greenhouse tests. M-315 and Deltapine 90 consistently had the fewest and highest numbers of galls per root system, respectively, for each population tested. Numbers of galls on NemX and LA887 were intermediate and more variable.