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ABSTRACTS

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EFFECTS OF TREATED MUNICIPAL WASTE WATER ON *MELOIDOGYNE JAVANICA* EGG HATCH AND PENETRATION. **Al-Hazmi, A. S., M. A. El-Saedy, and A. T. Abdul-Rizig.** Department of Plant Protection, King Saud University, Riyadh 11451, Saudi Arabia.

Eggs of *Meloidogyne javanica* were exposed in vitro to increasing concentrations of treated municipal waste water (TMWW) over a period of 8 days. Hatched juveniles were extracted and counted every 2 days. Juveniles that hatched from day 6 to day 8 were used as inoculum to determine their infectivity of tomato roots. Treated municipal waste water suppressed egg hatch at all concentrations, at least 4 days after incubation. After day 4 the hatch suppression was proportional to TMWW concentrations or incubation period. Hatch suppressions (percentage of control) at day 8 were 11.3, 27.4, 34.4, and 51% at concentrations of 25, 50, 75, and 100% TMWW, respectively. Invasion of tomato roots by the hatched juveniles was not adversely affected.

RESISTANCE TO *HETERODERA GLYCINES* IN SOYBEAN PI 90763 AND PI 424595. **Anand, S. C.** Delta Center, University of Missouri, Portageville, MO 63873.

Soybean cyst nematode (SCN), *Heterodera glycines* race 5 is widespread in the mid-southern United States. Soybean PI 90763 and PI 424595 have been reported to be resistant to race 5. Crosses were made between these two lines and with susceptible 'Essex' to determine their genetic relationship. The F_2 and F_3 progenies were exposed to SCN race 5 using conventional screening techniques. The cross PI 424595 x Essex segregated 1(R):63(S), whereas the cross PI 90763 x Essex gave a ratio of 1(R):15(S) in the F_2 generation. The cross between the two resistant lines PI 90763 and PI 424595 segregated into 13(R):3(S). The F_3 data confirmed the results obtained in the F_2 generation. These results indicate that some resistance genes in PI 424595 are different from those in PI 90763. PI 424595 should provide additional germplasm to broaden genetic diversity for SCN resistance.

FINE STRUCTURE OF *ZELDIA PUNCTATA* FOR INTERPRETING EVOLUTION OF THE BUCCAL CAPSULE OF RHABDITINA AND TYLENCHIDA. **Baldwin, J. G., and C. D. Eddleman.** Department of Nematology, University of California, Riverside, CA 92521.

Previous hypotheses suggest a morphocline ranging from the buccal capsule of *Zeldia* (Cephalobidae) adapted for feeding on bacteria, to the Tylenchida stylet adapted for plant parasitism. Five rhabdions line the buccal capsule of *Zeldia*. Fine structural findings strengthen the hypothesis of homology of the anteriormost rhabdion (cheilo-rhabdion). The second rhabdion in *Zeldia* is associated anteriorly with two nonpharyngeal arcade syncytia and posteriorly with pharyngeal radial muscle and marginal epithelial cells. It can be argued that the second rhabdion is a homolog to the putative pro- and meso-rhabdions of Rhabditina and to the vestibule extension and stylet cone of Tylenchida. The third and fourth rhabdion in *Zeldia* could be homologs of the putative meta-rhabdion in Rhabditina and the stylet shaft and knobs in Tylenchida.

EFFECTS OF SOIL TYPE ON THE REPRODUCTIVE POTENTIAL OF *MELOIDOGYNE INCOGNITA* AND *ROTYLENCHULUS RENIFORMIS* ON COTTON AND RELATED EFFECTS

ON CROP MATURITY. **Barker, K. R., S. R. Koenning, and S. A. Walters.** Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

The effects of soil type and initial inoculum density (Pi) of *Meloidogyne incognita* and *Rotylenchulus reniformis* on cotton cv. Deltapine 50 were evaluated in microplot experiments in 1991 and 1992. Cotton yield was suppressed by *M. incognita* race 3 ($P \leq 0.01$), but not by *R. reniformis* in 1991. Neither *R. reniformis* nor *M. incognita* race 4 affected cotton yield in a factorial experiment with six soil types in 1992. Approximately 30% of the cotton was picked from nematode-infested plots 2 weeks before bolls matured on control plants. Final population densities (Pf) of *R. reniformis* were 4-20 fold higher ($P \leq 0.01$) than those of *M. incognita*. Reproductive factors (Rf = Pf/Pi) were inversely related to initial inoculum density. Reproduction of *M. incognita* was greater in coarse textured soils than in fine textured soils, whereas *R. reniformis* reproduction was greatest in a Portsmouth loamy sand.

APPLICATION OF AUTOMATED PAGE FOR DNA AMPLIFICATION FINGERPRINTING (DAF) AND PHYLOGENETIC ANALYSIS OF FOUR *MELOIDOGYNE* SPECIES. **Baum, T. J.[1], S. A. Lewis[1], P. M. Gresshoff[2], and R. A. Dean[1].** [1]Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377, and [2]Plant Molecular Genetics, University of Tennessee, Knoxville, TN 37901-1071.

An automated DAF technique was developed and used to characterize 20 *Meloidogyne arenaria*, 12 *M. incognita*, 2 *M. javanica*, and 2 *M. hapla* isolates. Single octamer primers of arbitrary sequence and low stringency PCR were used to amplify genomic DNA. Amplification products were separated on precast polyacrylamide minigels and silver stained using the PhastSystem automated electrophoresis and staining unit (Pharmacia). Most primers produced amplification patterns specific for the four species. Several primers discriminated populations within species. Presence or absence of amplification products from all primers was scored for all individual nematode isolates and this data matrix was used to generate phylogenetic trees. Cladograms agreed with trees based on other taxonomic criteria.

EFFECTS OF ZINC FERTILIZERS ON POPULATION DENSITIES OF *HETERODERA GLYCINES*. **Behm, J. E., and G. L. Tylka.** Department of Plant Pathology, Iowa State University, Ames, IA 50011.

Zinc cations stimulate hatch of eggs of soybean cyst nematode (SCN), *Heterodera glycines*, in vitro, and application of zinc fertilizer increases corn yield under some soil conditions. Effects of zinc fertilizers on hatch of SCN eggs in infested soil planted with corn was tested in the greenhouse. Eleven liter pots were filled with soil collected from a field infested with SCN race 1. Treatments were zinc chelate and zinc sulfate fertilizers applied at rates equivalent to 1.12, 11.2, and 112 kg zinc/ha and an unfertilized control. Egg and second-stage juvenile (J2) population densities were determined periodically for 60 days. Corn shoot dry weight was measured after 60 days. Egg densities for each treatment remained constant throughout the experiment. Densities of J2 increased or remained constant for each treatment through day 14, then gradually decreased through the remainder of the experiment. There were no significant differences in egg or J2 densities among treatments. The 112 kg/ha zinc chelate treatment resulted in a significant reduction in corn shoot dry weight. Results indicate that addition of zinc fertilizers to soil does not elicit increased SCN egg hatch, even when applied at phytotoxic rates.

EFFECTS OF SELECTED CROPS ON *HETERODERA GLYCINES* POPULATION DENSITIES. **Behm, J. E., and G. L. Tylka.** Department of Plant Pathology, Iowa State University, Ames, IA 50011.

The effects of selected crop species on population changes of soybean cyst nematode (SCN), *Heterodera glycines*, race 1 were determined in microplot and growth chamber experiments.

Treatments were SCN-susceptible 'Corsoy 79' soybean, SCN-resistant 'Jack' soybean, fallow, corn, oat, alfalfa, pea, and greenbean. In both experiments, egg densities decreased gradually over time in soils planted with resistant soybean, corn, oat, alfalfa, and pea, and in soil left fallow. Reproductive factor (RF) for these treatments was less than 2.3 in the microplot experiment and less than 0.9 in the growth chamber experiment. Egg densities increased in soils where greenbean was grown, with RF values of 6.9 and 1.8 in the microplot and growth chamber experiments, respectively. Egg densities increased greatly in soil planted with susceptible soybean; Rf values were 62.5 and 25.6 in the microplot and growth chamber experiments, respectively.

HOLLY CULTIVARS AS HOSTS OF THE ROOT-KNOT NEMATODES *MELOIDOGYNE HAPLA* AND *M. INCOGNITA*. **Bernard, E. C., W. T. Witte, M. M. Dee, and P. L. Jennings.** Departments of Entomology and Plant Pathology, and Ornamental Horticulture and Landscape Design, University of Tennessee, Knoxville, TN 37901-1071.

The ability of two *Meloidogyne hapla* isolates (MHTN, MHNC) and one *M. incognita* isolate (MI) to parasitize 17 holly cultivars was studied in terms of galling response and giant cell formation in greenhouse tests. All three isolates heavily galled *Ilex aquipernyi* 'Elegance' and three *I. crenata* cultivars. *Meloidogyne incognita* also heavily galled all other cultivars except *I. cassine* 'Lowei' and *Ilex* × 'Calina' (*aquifolium* × *cornuta*). Nine cultivars varied in their galling response to MHTN and MHNC. Histologically, galling response could be separated into three categories: compatible, with large giant cells and abundant cell wall ingrowths, weakly compatible, with functional but smooth-walled giant cells; and incompatible, with lignification around the nematode and little giant cell formation.

CROP ROTATIONS FOR THE MANAGEMENT OF POTATO EARLY DIE CAUSED BY *PRATYLENCHUS PENETRANS* AND *VERTICILLIUM DAHLIAE*. **Berney, M. F., and G. W. Bird.** Department of Entomology, Michigan State University, East Lansing, MI 48824.

Four field soils naturally infested with *Pratylenchus penetrans* and *Verticillium dahliae* were placed in the greenhouse to evaluate the efficacy of nine crop rotations in the suppression of potato early die. These rotations ranged from 3 to 60 weeks between potato crops. Red clover, alfalfa, and annual rye were the rotation crops. Potato was grown for 3 and 6 weeks following each rotation. The *P. penetrans* population density increased in subsequent potato crops in proportion to the number of weeks of alfalfa or clover growth. This trend was less pronounced where fumigation had been used in the past. The percentage of plant survival increased with the number of weeks of alfalfa and clover. Both tuber weight and number decreased at 3 and 6 weeks for treatments of more than 18 weeks of clover or alfalfa growth.

EFFECT OF INITIAL NEMATODE DENSITY ON MANAGING *GLOBODERA ROSTOCHIENSIS* WITH RESISTANT AND NONHOSTS. **Brodie, B. B.** USDA, ARS, Cornell University, Ithaca, NY 14853.

Resistant potato cultivars in rotation with susceptible cultivars and oat, a nonhost, were evaluated at four initial nematode densities for their ability to reduce and maintain *Globodera rostochiensis* at population levels (<0.2 eggs/cm^3 soil) that minimize its spread. At initial densities of <1 egg/cm^3 soil, a minimum of two successive years of a resistant cultivar for every 3 years of potato cultivation was necessary to reduce and maintain *G. rostochiensis* at <0.2 eggs/cm^3 soil. Initial densities of 1-4 eggs/cm^3 soil required 2 years of a resistant cultivar plus 1 year of oat in succession for every 4 years of production to reduce and manage *G. rostochiensis* at <0.2 eggs/cm^3 soil. At initial densities greater than four eggs/cm^3 soil, 2 years of a resistant cultivar plus 1 year of oat reduced *G. rostochiensis* densities but did not maintain them at <0.2 eggs/cm^3 soil. Numbers of eggs per cyst in the residual *G. rostochiensis* population was

correlated with frequency of a resistant and susceptible hosts in the rotation.

XIPHINEMA BRICOLENSIS - A NATURAL VECTOR OF THREE SEROLOGICALLY DISTINGUISHABLE STRAINS OF TOMATO RINGSPOT NEPOVIRUS. **Brown, D. J. F.[1], T. C. Vrain[2], A. T. Jones[1], W. M. Robertson[1], J. M. Halbrendt[3], and R. T. Robbins[4],** [1]Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, [2]Agriculture Canada Research Station, Vancouver, B.C. V6T 1X2, Canada, [3]Fruit Research Station, Pennsylvania State University, Biglerville, PA, 17307-0309, and [4]Nematology Laboratory, University of Arkansas, Fayetteville, AR 72701.

Xiphinema americanum, *X. californicum*, and *X. rivesi* previously have been reported as natural vectors of tomato ringspot nepovirus (TomRSV). *Xiphinema bricolensis* were identified in soil samples from the rhizosphere of raspberries naturally infected with TomRSV growing at Dobbins, Washington. The ability of individual nematodes recovered directly from these samples was examined in the laboratory. In two tests, with *Petunia hybrida* and *Nicotiana tabacum* cv. Xanthii bait plants, 3 of 21 and 6 of 24 adult *X. bricolensis* transmitted TomRSV, respectively. The transmitted virus isolates belonged to three distinct TomRSV serotypes. These results provide further evidence of an apparent lack of specificity of transmission of North American nepoviruses by their vector nematodes. However, existing data are insufficient to suggest differences in the sites of retention of these viruses in their vectors as compared to European viruses transmitted by *Xiphinema* spp.

AN ATYPICAL ISOLATE OF RASPBERRY RINGSPOT NEPOVIRUS INFECTING GRAPEVINES IN GERMANY APPARENTLY TRANSMITTED BY *PARALONGIDORUS MAXIMUS*. **Brown, D. J. F.[1], A. T. Jones[1], W. McGavin[1], M. Rudel[2], and B. Altmayer[2].** [1]Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, and [2]Staatliche Lehr und Forschunganstalt fur Landwirtschaft, Weinbau und Gartenbau, Abteilung Phytomedizin, Neustadt/Weinstrasse, Federal Republic of Germany.

Several nematode transmitted viruses are present in vineyards in the German Palatinate, including raspberry ringspot nepovirus (RRV) transmitted by *Longidorus macrosoma*. An unusual strain of RRV was identified from numerous vineyards but may be spreading only in vineyards associated with a particular soil type. Also, *Paralongidorus maximus* was the only longidorid nematode species consistently associated with this soil type and in vineyards where the virus was spreading between vines. Grapevines planted in fumigated soil, adjacent to a RRV infected area, became infected with the virus after 3 years and *P. maximus* also were recovered from the rhizosphere of these plants. In the laboratory *P. maximus* was shown to acquire and transmit the strain of RRV at a low level and only when grapevines were used as the host plants.

STEINERNEMA RIOBRAVIS N. SP: A NEW ENTOMOPATHOGENIC NEMATODE SPECIES FROM TEXAS. **Cabanillas, H. E.[1], G. O. Poinar, Jr[2], and J. R. Raulston[1].** [1]Crop Insects Research Unit, USDA, ARS, Weslaco, TX 78596, and [2]Division of Entomology and Parasitology, University of California, Berkeley, CA 94720.

Steinernema riobravis n. sp. is a new entomopathogenic nematode species discovered in the Lower Rio Grande Valley of Texas. Morphological, hybridization, and DNA examinations indicated the distinctness of *S. riobravis* from *S. carpocapsae*, *S. feltiae*, *S. glaseri*, and *S. intermedia*. Diagnostic characters include the length of the infective-stage juveniles, the color and shape of the spicules and gubernaculum, and lack of a tail projection in the male. *Steinernema riobravis* did not hybridize with other *Steinernema* species. DNA analysis showed that the 304 base pair region of the 26 S ribosomal subunit examined in *S. riobravis* is significantly divergent from the same region in *S. carpocapsae*, *S. feltiae*, *S. glaseri*, and *S. serratum*. It may be naturally selected for the subtropical semi-arid environment where it serves as a biological control

agent for corn earworm and fall armyworm at high temperatures.

AN UNDESCRIBED SPECIES OF ROOT-KNOT NEMATODE FOUND ON PETUNIA IN BRAZIL. **Charchar, J. M.[1], J. D. Eisenback[1], and H. Hirschmann[2].** [1]Department of Plant Pathology and Physiology and Weed Science, Virginia Tech University, Blacksburg, VA 24061, and [2]Department Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

An undescribed *Meloidogyne* species was found parasitizing petunia (*Petunia hybrida*) in Brasilia, Brazil. Characteristically this species produces small galls on petunia compared to large galls produced on tomato. The perineal pattern has a high, squarish arch and widely spaced coarse striae, which form various angles, especially in the lateral field. The female stylet is 14.3 μm long and the knobs are small and rounded. The excretory pore opens about 32.5 μm from the head end below the level of the stylet base. Males are 1,800 μm in length, have a long stylet, (23.2 μm) with big, rounded knobs set off from the shaft. The second-stage juveniles are 393 μm in length, stylet length is 10.2 μm, tail length is 48.2 μm, and the hyaline tail terminus is 11.7 μm long. This species also reproduces on tomato and tobacco, and reproduces lightly on pepper, watermelon, and sweet corn. No reproduction occurred on peanut or cotton.

A THREE-DIMENSIONAL STUDY OF *PRATYLENCHUS PENETRANS* AND *VERTICILLIUM DAHLIAE* ASSOCIATED WITH *SOLANUM TUBEROSUM*. **Chen, J, and G. W. Bird.** Department of Entomology, Michigan State University, East Lansing, MI 48824.

A three-dimensional study was conducted to investigate stereo effects and distribution patterns of *Pratylenchus penetrans* and *Verticillium dahliae* associated with *Solanum tuberosum* at the Potato Research Farm in Entrican, MI. A north-south field-row (0.4 m^2 x 0.8 m^2 x 0.3 m) representing a ladder-shaped polyhedron was used in this study. The ladder-shaped soil polyhedron was sampled first in two dimensions, and then in the third dimension. Sixty samples were from the 6 x 10 sectors of the upper zone (ca. 0.5 x 0.9 x 0.1 m), 80 from the 8 x 10 sectors of the middle zone (0.7 x 0.9 x 0.1 m), and 100 from the 10 x 10 sectors of the lower zone (0.9 x 0.9 x 0.1 m). *Pratylenchus penetrans* densities in the upper, middle, and lower zones were 1.8, 8.7, and 14.4/100 cm^3 soil, respectively. The *V. dahliae* densities in the upper, middle, and lower zones were 2.0, 0.6, and 0.7 cfu/g dry soil, respectively. The 3-D localization images of the soilborne organisms were computer-stereopercepted. Two-dimensional semivariogram models were used on the third dimension. *Pratylenchus penetrans* population densities were in an independent distribution in the upper and middle zones, but in a spatial dependency distribution in the lower soil cuboid zone. Independent observations of *V. dahliae* distributions were suggested at this ladder-shaped polyhedron field-row site.

PATHOGENICITY OF FUNGI FROM A FLORIDA SOYBEAN FIELD ON *HETERODERA GLYCINES*. **Chen, Senyu[1], D. W. Dickson[1], and D. J. Mitchell[2].** [1]Entomology and Nematology Department, and [2]Department of Plant Pathology, University of Florida, Gainesville, FL 32611-0620.

Seventeen isolates of 15 species of fungi and five isolates of unidentified fungi were tested for their pathogenicity to eggs within cysts of the soybean cyst nematode. The fungi were cultured on corn meal agar for 2-3 weeks and a small block (1 cm^2) of each colony was transferred to water agar in a petri dish. Cysts were surface sterilized and plated on water agar containing 100 ppm streptomycin and 50 ppm chlortetracycline. Only yellow-colored cysts that showed no signs of fungal growth after plating for 1 week were used. Twelve to 15 cysts were placed adjacent to the fungal blocks. Each treatment was replicated three times, and one group of cysts plated on water agar without fungi was included as a control. Parasitism was determined after 3 weeks of incubation at 24 C, and the hatching rate was determined within 14 days. *Verticillium chlamydosporium* parasitized 76% of the eggs and reduced hatching rate 78%. *Pyrenochaeta*

terrestris, *Fusarium oxysporum*, *Paecilomyces lilacinus*, *Arthrobotrys dactyloides*, *Neocosmospora vasinfecta*, and four unidentified fungal isolates, were moderately pathogenic on eggs (20-44% of eggs parasitized and hatching rate reduced 20-65%). *Beauveria bassiana*, *Exophiala pisciphila*, *Fusarium solani*, *Stagonospora heteroderae*, and *Hirsutella rhossiliensis* showed a low rate of pathogenicity to eggs. A low level of parasitism was observed by *Dictyochaeta heteroderae*, *Dictyochaeta* sp., *Gliocladium catenulatum* and one unidentified fungal isolate.

A GLYCOSPHINGOLIPID FROM *MELOIDOGYNE INCOGNITA*. **Chitwood, David J., and Michael A. McClure.** Nematology Laboratory, USDA, ARS, Building 011A, BARC-West, Beltsville, MD 20705, and Department of Plant Pathology, University of Arizona, Tucson, AZ 85721.

Eggs of *M. incognita* race 3 propagated on greenhouse-grown *Solanum melongena* cv. Black Beauty contained material that, during thin-layer chromatography, migrated identically to a series of glycosphingolipids previously identified in *Caenorhabditis elegans*. The material was purified by solid-phase extraction; quantification by HPLC revealed the material to comprise 0.17% of the egg dry weight. Methanolysis of the purified compounds indicated that they were a series of glycosphingolipids containing glucose and various hydroxylated fatty acids covalently bound to a 17-carbon *iso*-long chain sphingoid base. Although the sugar and sphingoid moieties of the *C. elegans* and *M. incognita* compounds were identical, fatty acids of the *M. incognita* glycosphingolipid were primarily unsaturated, in contrast to the saturated fatty acids of the *C. elegans* compound. Almost two-thirds of the fatty acid from the *M. incognita* glycosphingolipids was 2-hydroxy-*n*-tetracosenoic acid.

POPULATION DYNAMICS OF *XIPHINEMA DIVERSICAUDATUM* IN A *PASTEURIA PENETRANS* NATURALLY INFESTED SOIL. **Ciancio, A.** Instituto di Nematologia Agraria, C. N. R., Via Amendola 165/A, 70126 Bari, Italy.

Temporal changes of *Xiphinema diversicaudatum* parasitized by *Pasteuria penetrans* were studied in a naturally infested peach orchard in Italy for two years with replicated monthly samplings. The nematode densities displayed fluctuations with alternate peaks at 2-3 month intervals, varying from 32.4 ± 13.8 to 121.7 ± 26.5 nematodes/100 cm^3 soil. The percentage of parasitized nematodes varied between 0.7 ± 0.7 and 9.3 ± 1.6, showing a trend similar to the density fluctuations, although displaced by 2-3 months. The population changes of *X. diversicaudatum* and the time series of parasitism were density dependent, as revealed by Bulmer and Pollard's tests ($P \leq 0.01$). The highest rate of nematodes parasitized by *P. penetrans* was 22.3%. The *X. diversicaudatum* densities and the percentages of parasitism appeared stable, showing limited time variations with average increase ratios of 1.0 (0.5-2.6) and 1.8 (0.1-9.8), respectively.

SCANNING PROBE MICROSCOPY OF NEMATODES. **Ciancio, A., and F. Lamberti.** Instituto di Nematologia Agraria C. N. R., Via Amendola 165/A, 70126 Bari, Italy.

Atomic Force Microscopy was applied to plant-parasitic nematodes to obtain high resolution images of the cuticle external topography. Scanning nematodes in constant force mode showed annulations and anastomoses in *Xiphinema diversicaudatum*, lateral fields of *Meloidogyne incognita* juveniles, and perineal patterns details of *M. javanica*. The nematodes fixed in formalin or directly extracted from the water suspension were usually visualized after air drying on the stub at room temperature and pressure. Images of the nematode parasite, *Pasteuria penetrans*, adhering to juveniles of *M. incognita* were also obtained by this technique. Atomic Force Microscopy was also applied to glycerol dehydrated specimens of *Helicotylenchus lobus*, revealing details of tail and phasmids, cuticle annulations, and lateral fields. Atomic Force Microscopy proved to be useful in the study of nematodes and associated microorganisms, allowing the

examination of specimens with no previous manipulation and integrating the other microscopical techniques already applied.

IMPROVED NEMATODE CONTENT AND SHELF LIFE OF GRANULAR "PESTA" FORMULATIONS OF *STEINERNEMA CARPOCAPSAE*. **Connick, W. J., Jr.[1], W. R. Nickle[2], and K. A. Williams[1].** [1]SRRC, USDA, ARS, P.O. Box 19687, New Orleans, LA 70179-0687, and [2]Nematology Laboratory, USDA, ARS, BARC-W, Beltsville, MD 20705.

Granules ("Pesta II") made from a dough containing wheat flour, kaolin, bentonite, peat moss, and *Steinernema carpocapsae* strain All released nematodes when placed in a moist environment. Bentonite (2.7% w/w) increased the dough's capacity for nematode slurry by 40%. Granules contained about 400,000 nematodes/g, and 24-28% water (a_w = 0.95-0.97). Shelf life at 21 C was about 4 weeks. However, addition of 0.2-1.4% (w/w) formaldehyde prevented fungal growth on the granules and increased shelf life at 21 C to >20 weeks. Nematodes exhibited normal infectivity toward wax moth (*Galleria mellonella*) larvae. At an addition level of 0.2%, only 0.05% formaldehyde was detected in the final product.

RESPONSE OF *ACROBELOIDES TRICORNIS* TO THE NUTRIENT LIMITATIONS IMPOSED UNDER CHEMOSTAT CONDITIONS. **Courtright, E. M.[1], D. W. Freckman[1], D. E. Crowley[2], and J. J. Park[3].** [1]Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, CO 80523, and Departments of [2]Soil and Environmental Sciences and [3]Nematology, University of California, Riverside, CA 92521.

The effects of nutrient resources on body mass and fecundity of *Acrobeloides tricornis* were studied under steady-state bacterial conditions using the food source, *Escherichia coli*. The bacterium was grown in chemostats of 0.1%, 1.0%, and 5.0% tryptic soy broth. Within the chemostat, a constant input of nutrients and removal of wastes allowed bacterial densities to remain constant over time. Nematode biomass changed significantly in relation to nutrient supply over the 50 days of the experiment. At day 0, female body mass was 0.30 μg per individual compared with 0.05 μg per individual for the 0.1% nutrient concentration by day 50 of the experiment. There were no differences in body size at 1.0% and 5.0% nutrient concentration. Fecundity (eggs per female) increased with nutrient concentration. Limited nutrient conditions have significant effects on body size and population structure of *A. tricornis*.

THE BIOCHEMISTRY OF ATTACHMENT OF *PASTEURIA* ENDOSPORES TO THE CUTICLE OF ROOT-KNOT NEMATODES. **Davies, K. G.** AFRC-IACR, Rothamsted Experimental Station, Harpenden, Hertfordshire, AL5 2JQ, UK.

Standard attachment assays were performed in which either second-stage juveniles of root-knot nematodes or endospores of *Pasteuria penetrans* had been preincubated in a series of proteolytic, lipolytic, glycolytic enzymes, and denaturing reagents. Sugar moieties, namely N-acetylglucosamine, on the surface of the endospores appeared to recognize carbohydrate recognition domains on the nematode cuticle. SDS-PAGE of crude cuticle extracts from *Meloidogyne javanica* were electro-blotted onto nitrocellulose paper. Blots incubated in *P. penetrans* endospore extract and probed with a polyclonal antibody raised to *P. penetrans* endospores identified a putative receptor. Similar blots treated with s everal probes and blocking reagents showed the putative receptor to be a glycoprotein.

OPTIMIZATION OF AN ELISA FOR THE QUANTIFICATION OF ROOT-KNOT NEMATODES EXTRACTED FROM SOIL. **Davies, K. G., and B. Carter.** AFRC-IACR, Rothamsted Experimental Station, Harpenden, Hertfordshire, AL5 2JQ, UK.

Second-stage juveniles (J2) of root-knot nematodes were milled with Ballotini beads in 1.5 ml of buffer containing urea. The 0.6 g of Ballotini beads of 0.5 - 0.7 μm diameter produced

suspensions leading to the highest optical density, which were used in a standard procedure. A series of ELISAs were conducted using monoclonal (MC28.8) and polyclonal ($PC242^{HRP}$) antibodies. DAS-ELISAs were less sensitive than the antigen-coated plate assay irrespective of whether $PC242^{HRP}$ was used in a direct ELISA or a MC28.8 was used indirectly. The loss of sensitivity in the DAS-ELISA was probably due to the antibody coated onto the plate hindering the second antibody from recognizing the second epitope. The antibody coated plate assay could quantify J2s at levels of 156 J2/ml (156 J2s extracted from a 200-g soil sample is equivalent to 0.78 J2s/g of soil).

ACCELERATED DEGRADATION OF FENAMIPHOS AND ITS METABOLITES IN SOIL PREVIOUSLY TREATED WITH FENAMIPHOS. **Davis, R. F., A. W. Johnson, and R. D. Wauchope.** Coastal Plain Experiment Station, University of Georgia, USDA, ARS, Tifton, GA 31793.

The degradation of fenamiphos, fenamiphos sulfoxide, and fenamiphos sulfone was observed in greenhouse experiments with autoclaved (121 C and 103.4 kPa for 30 minutes) and nonautoclaved soil from field plots with and without a history of fenamiphos application. Fenamiphos degraded faster in nonautoclaved soil than in autoclaved soil. In autoclaved soil, previous exposure to fenamiphos did not affect the degradation of fenamiphos, fenamiphos sulfoxide, or fenamiphos sulfone. In nonautoclaved soil, previous exposure to fenamiphos did not affect the degradation rate of fenamiphos or fenamiphos sulfone but increased the degradation rate of fenamiphos sulfoxide. Fenamiphos total toxic residue degraded more rapidly in nonautoclaved soil previously exposed to fenamiphos than in nonautoclaved soil never exposed to fenamiphos. This accelerated degradation was due to more rapid degradation of fenamiphos sulfoxide and may be biologically mediated.

GEOSTATISTICAL ANALYSIS OF SOYBEAN CYST NEMATODE DISTRIBUTION. **Donald, P., W. Donald, A. Keaster, A. Kendig, and B. Sims.** 108 Waters Hall, University of Missouri, Columbia, MO 65211.

Geostatistical methods were used to describe the distribution and variation in soybean cyst nematode (SCN), *Heterodera glycines*, densities across two soybean fields in southeastern Missouri. Spatial variation in SCN density was related to variation in soybean yield and edaphic factors over the fields and over several years. Semivariograms and kriging were used to prepare isoarithmic contour maps and associated error maps for each variable based on a grid of measured control points. Mapped regions of greatest SCN density across fields were related to lowest soybean yield, and changes in edaphic factors. Maps of soybean yield as a function of SCN density across fields may be helpful in formulating hypotheses regarding how these variables are related at a field scale. Such maps should help nematologists better understand how SCN distribution changes over time over fields.

EFFECT OF BLACK POLYETHYLENE FILM MULCH ON NEMATODE AND FUNGAL PATHOGENS, WATER CONSERVATION, AND TREE GROWTH OF *PRUNUS* SPP. **Duncan, R. A., J. J. Stapleton, and M. V. McKenry.** Kearney Agricultural Center, University of California, Parlier, CA 93648.

Despite reductions in irrigation water of more than 75%, soil moisture was often higher in the rootzones of mulched, drip irrigated, first-leaf peach (*Prunus persica*) and almond (*Prunus dulcis*) trees on Lovell rootstock, although leaf moisture potential sometimes indicated higher stress levels. Mulching resulted in higher soil temperatures in the surface 60 cm, elimination of weeds, reduced numbers of *Pratylenchus hexincisus*, *Tylenchulus semipenetrans*, *Paratrichodorus minor*, and *Paratylenchus hamatus* in the soil and a tendency toward greater root mass. There was a greater abundance of *Meloidogyne incognita* second-stage juveniles in mulched soil and root tissue but

reduced severity of root galling. Reductions in *Pythium* spp. were not significant. Blossom and fruit numbers were increased by mulching in both tree species. Leaf petiole analysis indicated an increase in calcium in both tree species.

ULTRASTRUCTURE OF THE BUCCAL CAVITY AND ESOPHAGUS OF *HETERORHABDITIS BACTERIOPHORA*. **Endo, B. Y., and W. R. Nickle.** Nematology Laboratory, USDA, ARS, Beltsville, MD 20705.

The cheilostom of the buccal cavity of third-stage infective juveniles of the insect parasitic nematode, *Heterorhabditis bacteriophora*, is supported by an invaginated body cuticle. The buccal ring constitutes the junction between the cheilostom and the prostom, which is supported by arcade cells of hypodermal origin. The mesostom cuticle is surrounded by nonmuscular tissues comprising the anteriormost region of the esophagus. Posteriad, the metastom and telostom cuticle or rhabdions are underlain by two tiers of esophageal muscles designated as M1 and M2, respectively. Radial cells have broad to narrow strands of myofilaments that make hemidesmosomal contacts with the lumen cuticle and outer membranes. Radial and marginal cell muscles of the esophagus are apparently contractile. Myofilaments of marginal cells also provide a supportive function.

DIFFERENTIAL IMPACT OF ROTATIONAL CROPS ON POPULATION LEVELS OF SOYBEAN CYST NEMATODE. **Faghihi, J., J. M. Ferris, and V. R. Ferris.** Department of Entomology, Purdue University, West Lafayette, IN 47907-1158.

Following field observations of visual differences in soybean growth when a susceptible soybean followed either corn or red clover, a greenhouse study was conducted to investigate a possible differential impact of corn, red clover, or fallow on suppression of soybean cyst nematode (SCN), *Heterodera glycines*. Infested field soil from a northern Indiana population of SCN was used for this study, for which four successive 4 month periods simulated four growing seasons. At the end of the first period, the number of eggs was not significantly different among soils planted to red clover or corn or left fallow. However, at the end of the second and third periods a reduction ($P \leq 0.01$) in number of eggs was apparent in soils under red clover as compared with the number of eggs in soil under corn or left fallow. A separate comparative analysis for three simulated growing seasons showed a reduction ($P \leq 0.01$) in number of eggs in soils under red clover or corn or left fallow.

EFFECT OF TEMPERATURE AND RESISTANCE OF *PRUNUS* ROOTSTOCK TO *MELOIDOGYNE INCOGNITA*. **Fernández, C.[1], J. Pinochet[1], and R. Rodríguez-Kábana[2].** [1]Departamento de Patologia Vegetal, IRTA, Cabrils, Barcelona, Spain, and [2]Department of Plant Pathology, Auburn University, AL 36849.

The effect of two temperatures (23 and 31 C) on resistance of four *Prunus* rootstocks [two peach-almond hybrids (GXN 22, and GF-677), 'Nemared' peach, and 'Myrobalan 29C' plum] to *Meloidogyne incognita* was studied under greenhouse conditions. Rootstocks were evaluated for galling and population increase 90 days after inoculation with 4,000 juveniles/plant. The rootstock GF-677 showed extensive galling and high level of parasitism at both temperatures, whereas GXN 22 was resistant at 23 C, but had significant galling and numbers of juveniles in the roots at 31 C. Nemared maintained high levels of resistance at 23 and 31 C, and Myrobalan 29C was immune to the nematode at both temperatures.

SEQUENCE COMPARISONS OF 5.8S RIBOSOMAL GENES IN CYST NEMATODES. **FERRIS, V. R., J. M. Ferris, and J. Faghihi.** Department of Entomology, Purdue University, West Lafayette, IN 47907-1158.

As part of a larger study of the internal transcribed spacer regions (ITS) of ribosomal DNA

(rDNA) in plant parasitic cyst nematodes, the 5.8S gene was also sequenced for *Heterodera glycines*, *H. schachtii*, *H. trifolii*, and *H. carotae* from the U.S.; *H. avenae* and a Gotland strain of *H. avenae* from Sweden, and a *Globodera* species from Mexico. Although the ITS rDNA regions varied greatly between some species, the 5.8S sequence was nearly identical for all. Comparisons of our 5.8S gene sequence with sequences in the literature showed about 75% similarity of the 5.8S sequence of *H. schachtii* to that of *Xenopus laevis* (Amphibia) and sea urchin (Echinoidea), 68% similarity to house mouse (Mammalia), but only 61% similarity to *Caenorhabditis elegans*.

MODIFICATIONS OF AN IN VITRO HORMONAL ASSAY FOR GROWTH USING *ASCARIS SUUM* JUVENILES. **Fleming, Michael W.** Helminthic Diseases Laboratory, LPSI, USDA, ARS, Beltsville, MD 20705.

Previous work demonstrated that brief (24 hour) exposure to ecdysteroids increased the rate of molting and, eventually, the growth rate of third-to-fourth stage *A. suum* juveniles in 24-multiwell culture system. This experiment was designed to test the effects of different juvenile densities (100 vs 400/ml) and hormonal exposure period (0-7 day, 4-7 day, 7-14 day) on *A. suum*. Juveniles at the higher density and(or) in the presence of 20-hydroxyecdysone (20-OH) had the fastest growth rates. Both ecdysone and 20-OH decreased growth rates at specific concentrations when exposure was limited to the post-molting period (4-7 day). However, during the later 7-14 days of incubation, 20-OH did not affect growth rate, whereas plumbagin, a napthoquinone believed to inhibit molting, increased growth rates during this latest period when molting does not occur.

CHARACTERIZATION OF TWO POPULATIONS OF *PRATYLENCHUS PENETRANS* BASED ON DIFFERENTIAL REPRODUCTION ON POTATO AND DNA ANALYSIS. **France, R. A., and B. B. Brodie.** Department of Plant Pathology, and USDA, ARS, Cornell University, Ithaca, NY 14853.

The potato cultivar Hudson, previously shown to be resistant to the Cornell population of *Pratylenchus penetrans*, was susceptible when it was grown on Long Island, New York. To test the hypothesis that pathotypes of *P. penetrans* exist, we analyzed the DNA of the Cornell and Long Island populations and compared their reproduction on selected potato clones. The potato clones and cultivars NY85, L118-2, Hudson, Butte, Russet Burbank, and Superior were inoculated (2,000 *P. penetrans*/plant) with the Cornell and Long Island populations and maintained in a growth chamber for 30 days. Total DNA was extracted from both populations and analyzed using RAPD markers for genetic polymorphism. The bioassay showed that the potato clones (L118-2, Hudson, and Butte) that were resistant to the Cornell population were susceptible to the Long Island population. The DNA analysis showed polymorphisms with several arbitrary primers between both populations. These results suggest that different pathotypes of *P. penetrans* affecting potato may be present in New York.

THE MORPHOLOGY OF COASTAL ENOPLID NEMATODES (NEMATODA, ENOPLINA) FROM MARION ISLAND. **Furstenberg, J. P.** Department of Zoology, University of Port Elizabeth, Port Elizabeth 6000, South Africa.

A quantitative survey of sublittoral macrozoobenthos was carried out in 1989 using SCUBA on Marion Island, southern Indian Ocean. Water depth at the study sites ranged between 5 and 15 m. Enoplids include the largest species of nematodes (up to 10 mm long) and were frequently observed in the macrobenthic collections. Nematodes were extracted from volcanic sand samples and from detritus, kelp holdfasts and shell benthos scraped from rocky substrates. Four undescribed species representing three genera (*Metaphanoderma*, *Thoracostoma*, and *Enoplus*) and a known species of *Phanodermata* were collected. The head structure and the morphology of the male genital structure are important in distinguishing the undescribed species.

POPULATION DYNAMICS OF *HOPLOLAIMUS GALEATUS* ON 'FLORATAM' AND 'FX-313' ST. AUGUSTINEGRASSES. **Giblin-Davis, R. M., P. Busey, B. J. Center, and F. G. Bilz.** Fort Lauderdale Research and Education Center, University of Florida, Ft. Lauderdale, FL 33314.

The polyploid (2n ≈ 32) 'Floratam' and the diploid (2n = 18) 'FX-313' St. Augustinegrasses (*Stenotaphrum secundatum*) were compared in a time-course experiment for host suitability and host susceptibility to the lance nematode, *H. galeatus*. *Hoplolaimus galeatus* densities were estimated from the soil and from acid-fuchsin stained roots 42, 84, 126, 168, and 210 days after inoculating with 99 ± 9 nematodes per pot (250 ml of autoclaved native Margate fine sand) at 25 C in the laboratory. Root and shoot dry weights of inoculated grass were compared through time with uninoculated pots of grass for each genotype. 'FX-313' may be a more suitable host for *H. galeatus* with higher numbers of nematodes in the soil and roots starting at 84 days after inoculation. Root and shoot dry weights of both grasses were not significantly affected by *H. galeatus* through 168 days.

INTERACTIVE EFFECTS OF *STEINERNEMA CARPOCAPSAE* AND *SPODOPTERA EXIGUA* NUCLEAR POLYHEDROSIS VIRUS ON *SPODOPTERA EXIGUA* LARVAE. **Gothama, A. A.[1], G. W. Lawrence[2], and P. P. Sikorowski[1].** [1]Department of Entomology, and [2]Department of Plant Pathology and Weed Science, Mississippi State University, Mississippi State, MS 39762.

Laboratory and field experiments were conducted to assess the interactions between *Steinernema carpocapsae* (Sc) and *Spodoptera exigua* multinucleocapsid nuclear polyhedrosis virus (SeMNPV), and their effects on mortality of beet armyworm *Spodoptera exigua* larvae on soybean. The LC_{25} and LC_{50} for Sc and SeMNPV were predetermined and used as single and combination treatments. For Sc, the LC_{25} and LC_{50} were 117 and 263 nematodes/ml, respectively; and those for SeMNPV were 7.6×10^3 and 1.9×10^4 polyhedral inclusion bodies/ml, respectively. Soybean leaflets were treated with the pathogens, using a pesticide spray chamber in the laboratory and a CO_2-charged backpack sprayer in the field. Treated leaflets were collected and bioassayed with 5-day-old *S. exigua* larvae. The Sc and SeMNPV had additive effects on mortality of *S. exigua* in all combination treatments. Combination of Sc + SeMNPV at $LC_{50} + LC_{50}$ resulted in significantly higher mortality of *S. exigua* than treatment with either Sc or SeMnPV alone. Combinations of Sc or SeMNPV at $LC_{25} + LC_{50}$ and at $LC_{50} + LC_{25}$ resulted in significantly higher larval mortality than the LC_{25} of either pathogen alone. The reproductive ability of Sc in the infected host was not affected by SeMNPV in the combination treatments.

RELATIONSHIP OF *PRATYLENCHUS PENETRANS* TO SINGLE AND INTERPLANTINGS OF ALFALFA AND GRASSES. **Griffin, G. D.** Forage and Range Research Laboratory, USDA, ARS, Utah State University, Logan, UT 84322-6300.

Although grass is a nonhost, it is invaded by the root lesion nematode *Pratylenchus penetrans*. *Pratylenchus penetrans* reduced the growth of Lahontan alfalfa, an excellent host, and Hycrest, Fairway, and Nordan crested wheatgrasses in an interplanting of alfalfa and grass in a greenhouse study. Alfalfa growth suppression was greater in single than in interplantings. The growth of all grasses was suppressed by the nematode in interplanting, but not in single plantings. *Pratylenchus penetrans* did not reproduce on grass, and nematode reproduction on alfalfa was less in interplantings than in a single planting. Similar results were obtained in a growth chamber study; *P. penetrans* inhibited alfalfa growth in single and interplantings and grasses in interplantings. Nematode virulence and reproduction were greatest at 30 C.

RAPESEED AS A DAGGER NEMATODE SUPPRESSIVE ROTATION CROP. **Halbrendt, J. M.** Fruit Research Laboratory, Pennsylvania State University, Biglerville, PA 17307-0309.

The putative basis for nematode suppression by rapeseed is the production of toxic

isothiocyanate by hydrolysis of glucosinolate in the tissues. Accordingly, rapeseed green manure should reduce nematode population densities more effectively than cover cropping. Dagger nematode population densities were monitored over 2 years under eight treatments, five replicates each. Six treatments included rapeseed, cv. Westar, sudan grass, cv. Piper, and sunflower, cv. Jumbo each as a cover crop and as a green manure. The controls included tilled and untilled fallow (bare soil) corresponding to green manure and cover crop treatments. Nematode population densities declined steadily in all fallow and rapeseed plots with final reproductive indices (RI) ranging from 0.1 - 0.3. Population densities were significantly higher under both sudan grass and sunflower green manures, each with an RI of 0.6. Population levels under cover crops of sudan grass and sunflower were significantly higher than all other treatments with final RIs of 2.2 and 2.3, respectively.

IN VITRO AND IN VIVO CONTROL OF *MELOIDOGYNE INCOGNITA* WITH CULTURE FILTRATES FROM NONPATHOGENIC *FUSARIUM OXYSPORUM* ON TOMATO. **Hallmann, J., and R. A. Sikora.** Institut für Pflanzenkrankheiten, Abteilung Phytomedizin in Bodenökosystemen, 53115 Bonn, Federal Republic of Germany.

Nonpathogenic fungal endophytes are important in regulating the interaction between plant-parasitic nematodes and their host. A nonpathogenic *F. oxysporum* isolated from tomato reduced *M. incognita* infection and reproduction on tomato by 50% in pot experiments. In vitro experiments were conducted with culture filtrates produced by adding five 10-mm-d discs of *F. oxysporum* grown for 7 days on PDA to 50 ml Gliotoxin fermentation medium. The media with metabolites was separated from the endophyte by sterile filtration after specific intervals and 1,000 juveniles were added to the solutions. An LD100 for *M. incognita* was reached in extracts obtained after 4 days fermentation at 20 C, or 3 days fermentation at 25 C. The fungal dry weight was 0.03 g/50 ml medium in both fermentation systems. Complete inactivation of *M. incognita* occurred after 60 minutes exposure to the full strength culture filtrate. These juveniles were only paralysed with reactivation occurring after removal to tap water. Exposure for more than 8 hours caused death.

DESCRIPTION AND SEM OBSERVATIONS OF AN UNDESCRIBED ROOT-KNOT NEMATODE (*MELOIDOGYNE* SP.) ATTACKING BEACHGRASSES. **Handoo, Z. A.[1], R. N. Huettel[2], and A. M. Golden[1].** [1]Nematology Lab, USDA, ARS, Beltsville, MD 20705, and [2]APHIS, PPQ, USDA, ARS Hyattsville, MD 20782.

An undescribed root-knot nematode (*Meloidogyne* sp.), not producing galls on roots, was found on beachgrasses in Delaware, USA. Primary distinctive characters are: a) the perineal pattern that has a high to rounded arch with shoulders, b) the widely spaced lateral incisure with interrupting transverse striations, and c) the sunken vulva and anus with coarse broken striae around and near the anal area. The second-stage juvenile body length is 554 μm (470-650), stylet length is 14 μm (13-14.5), and tail length is 93 μm (83-115). Male stylet length is 20 μm (19-21.5), and the spicule length is 33 μm (30-36). SEM observations of perineal patterns and face views of the head of females, males, and juveniles provided additional supportive evidence that the nematode was a previously undescribed species. In host tests the following eight graminaceous species were hosts: wheat, rice, oat, *Ammophila* sp., *Panicum* sp., Bermuda, Zoysia, and St. Augustine grasses. Corn was a nonhost. Known distribution of this species is the coast of Delaware, Maryland, and apparently North Carolina. The common name, "beachgrass root-knot," is proposed.

USING RESISTANT OILRADISH FOR MANAGEMENT OF THE CYST NEMATODE *HETERODERA SCHACHTII*. **Heinicke, D., and U. Zuke.** Landwirtschaftskammer Hanover, Pflanzenschutzamt, Wunstorfer Landstr. 9, D-30428 Hannover, and Institut für Angewandte

Botanik, Marseillerstr. 7, D-20355 Hamburg, Federal Republic of Germany.

Over a period of 4 years the population density of the sugar beet cyst nematode *Heterodera schachtii* was monitored in plots where sugar beet followed resistant oilradish (*Raphanus sativus* var. oleiformis) and bare fallow. A 30 - 60% reduction in the population density of *H. schachtii* was obtained under the oilradish. When initial population densities (Pi) of more than 1,000 eggs and juveniles/100 g soil were found, the sugar beet yield increased between 5 - 10% following oilradish. However, when the Pi was less than 200 eggs and juveniles/100 g soil, the increase in population density was not significant. Under these conditions, it is more difficult to detect cysts by soil sampling. Also, the nematode may reproduce on oilradish plants that are not completely resistant. Population reduction in fallow soil was 0-20%. Oilradish may be used to decrease the first generation of *H. schachtii*, however the final population densities are similar to those of untreated plots.

OCCURRENCE AND IDENTIFICATION OF *MELOIDOGYNE* SPP. IN TOBACCO FIELDS IN WESTERN SPAIN. **Herrero, S., R. C. Rufty, K. R. Barker, and I. Bianco.** North Carolina State University, Raleigh, NC 27695, and CETARSA, Caceres, Spain.

In August 1992, a total of 55 tobacco fields in Caceres (western Spain) were systematically sampled for *Meloidogyne* spp. Root samples were collected and taken to Raleigh, NC. *Meloidogyne* spp. were detected in 51 of the 55 fields sampled. Specimens were maintained on tomato cv. Rutgers. Isozyme assays, perineal patterns, male heads, and host range tests were used for species identification. Malate dehydrogenase banding patterns did not differ among any of the nematodes tested, thus species were differentiated based on esterase patterns. When using a biochemical approach, 90.2% of the samples were identified as *M. arenaria* only, 3.9% as *M. javanica* only, and 5.9% as a mixture of these two species. These results were similar to those obtained when using male heads to discriminate between species. With the latter, 93% of the samples were identified as *M. arenaria* only, and 4.6% as *M. javanica*. The rest of the samples contained a mixture of these two species. About 4% of the samples were identified as *M. javanica* through host range test, and 96% showed a host range typical of *M. incognita* race 2. However, females isolated from pepper were identified as *M. arenaria* by esterase assays. The *M. arenaria* population reproduced on pepper, but not on peanut, thus differing from races 1 and 2 of this species. Results obtained from examining perineal patterns were highly variable and did not correlate to those obtained by other methods.

ENDOSPORE ATTACHMENT SPECIFICITY OF *PASTEURIA PENETRANS* FROM A PEANUT FIELD IN FLORIDA. **Hewlett, T. E., and D. W. Dickson.** Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611-0620.

Knowledge of the host range of *Pasteuria penetrans* isolates is important for their development as biocontrol agents of nematodes. Endospores of *P. penetrans* collected from *Meloidogyne arenaria* females on peanut roots were tested for attachment to other nematode genera collected from three field sites. Site 1 was a *M. arenaria* suppressive soil containing the *P. penetrans* isolate used in this study, whereas soil from sites 2 and 3 was conducive for *M. arenaria*. Ten specimens of each nematode genus from each field site were exposed to 10^4 endospores in a 0.25 ml microfuge tube (9,500*g*, 2 min.). At site 1, endospores attached only to a *Tylenchus* sp. (15 endospores per nematode) of 10 genera and 12 species tested, whereas at site 2, endospores attached readily to an *Aphelenchoides* sp. (76 endospores per nematode) and to *Criconemella ornata* (2 endospores per nematode), and a *Meloidogyne* sp. (10 endospores per nematode) of 8 genera and 10 species tested. At site 3, endospores attached to *C. ornata* (2 endospores per nematode) and a *Meloidogyne* sp. (5 endospores per nematode) of 10 genera and 11 species tested. Attachment on the control *M. arenaria* averaged 86 endospores per second-stage juvenile. Based on these endospore attachment studies, several genera of nematodes may be possible hosts for a

P. penetrans isolate.

CHEMICAL MANAGEMENT OF THE RENIFORM NEMATODE *ROTYLENCHULUS RENIFORMIS* ON SWEET POTATO. **Horton, H. W.[1], K. S. McLean[1], and G. W. Lawrence[2].** [1]Department of Agriculture, Northeast Louisiana University, Monroe, LA 71209, and [2]Department of Plant Pathology and Weed Science, Mississippi State University, Mississippi State, MS 39762.

The efficacy of fosthiazate to reduce reniform nematode (*Rotylenchulus reniformis*) population densities and to increase yields of sweet potato (*Ipomoea batatas*) cv. Beauregard were examined. The test was conducted in a field naturally infested with *R. reniformis* with an average initial nematode population density of 274 nematodes/250 cm^3 soil. Nematicide treatments consisted of fosthiazate applied at 4.1, 8.2, and 16.4 liters/ha before or after bed preparation. Nematode population development was followed monthly for 110 days. Fosthiazate applied at 8.2 and 16.4 liters/ha increased sweet potato yield 875 and 4,960 kg/ha, respectively. All treatments produced more US#1 grade roots per hectare compared to the control, however, all increases were not significant. *Rotylenchulus reniformis* population densities increased to a high of 18,386 nematodes/250cm^3 soil at 110 days after planting. No treatment significantly reduced *R. reniformis* population densities at harvest.

INFECTION OF *CAENORHABDITIS ELEGANS* MUTANTS BY CONIDIA OF THE NEMATOPHAGOUS FUNGUS *DRECHMERIA CONIOSPORA*. **Jansson, Hans-Börje.** Department of Microbial Ecology, Lund University, Helgonavägen 5, S-223 62 Lund, Sweden.

Conidia of the endoparasitic fungus *Drechmeria coniospora* adhere to the head region of most nematode species tested, although penetration and infection do not necessarily take place in all nematodes. The specific chemical signals involved were suggested to emanate from the cephalic sensillar exudates interacting with adhering conidia. Several mutants of *Caenorhabditis elegans* exist with defects in the amphids and other areas of the head region. Four such mutants (CB3332, CB3687, CB1066, CB648) were compared with the wild type for interactions with *D. coniospora*. Juveniles and adults of all mutants and the wild type were infected in the cephalic region, but some mutants could also be infected in other parts of the cuticle. Variations in the surface proteins of the different strains may cause these effects.

RELATIONSHIP OF GLUCOSINOLATE IN RAPESEED EXTRACTS TO TOXICITY AGAINST *CAENORHABDITIS ELEGANS*. **Jing, G. N., and J. M. Halbrendt.** Department of Plant Pathology, Fruit Research Laboratory, Pennsylvania State University, Biglerville, PA 17307.

Rapeseed contains secondary metabolites known as glucosinolates. Hydrolysis of these compounds by the enzyme thioglucosidase (myrosinase) produces degradative products, some of which are toxic to nematodes. Glucose released during hydrolysis is directly related to the concentration of glucosinolate and can be used to quantify total glucosinolates in the extracts. Methanolic-water extracts of these compounds treated with and without myrosinase were tested against first-stage juveniles of *C. elegans*. Results showed that enzyme treated extracts were toxic and the level of toxicity varied with the rapeseed cultivar and plant growth stage. A glucose oxidase test was used to correlate toxicity to the total glucosinolate content of the different extracts.

NEMATICIDE RUNOFF FROM LARGE-SCALE SIMULATED RAINFALL EXPERIMENTS. **Johnson, A. W., J. E. Hook, R. D. Wauchope, C. C. Dowler, H. R. Sumner, and C. C. Truman.** Coastal Plain Experiment Station, University of Georgia, USDA, ARS, Tifton, GA 31793.

A mesoplot (600 m^2) rainfall simulator system was developed to evaluate runoff and

agrichemicals from field-size plots. Fenamiphos (3 SC) was applied broadcast at 6.7 kg a.i./ha and incorporated into the top 10-cm layer of soil to two 15 m x 43 m mesoplots and four 1.8 m x 3 m microplots on a Tifton/Carnegie loamy sand (plinthic kandiudult) with a 3% slope. One day after application and at intervals of a few weeks a 5-cm rain was applied at 2.5 cm/hour intensity. Runoff, leachate water and soil water were measured and collected and analyzed for solids and fenamiphos. Losses of fenamiphos in runoff ranged from 0.7 to 2% of applied amounts under worst-case weather conditions.

EFFECTS OF HOST RESISTANCE AND FOSTHIAZATE ON CONTROL OF TOBACCO CYST NEMATODES ON FLUE-CURED TOBACCO IN VIRGINIA. **Johnson, C. S.** Southern Piedmont Agricultural Experiment Station, Virginia Polytechnic Institute and State University, Blackstone, VA 23824.

Population densities of tobacco cyst nematodes *Globodera tabacum solanacearum* (TCN) and development of TCN-susceptible cv. K-326 or TCN-resistant cv. NC-567 were monitored in untreated plots or plots sprayed with 7.5 liter/ha of fosthiazate before transplanting. Fosthiazate reduced TCN population densities 5 or more weeks after transplanting. TCN population densities developed similarly on K-326 and NC-567 early in the growing season, but were lower at the end of the season on NC-567. Fosthiazate significantly increased yield at all harvests. K-326 produced higher yields than NC-567, but differences were often not significant. Gross economic returns were higher for K-326 than for NC-567, but no differences were observed among cultivars in grade index or average price. Fosthiazate increased yield, gross economic returns, and average price, but not grade index.

DEVELOPMENT OF *VERTICILLIUM CHLAMYDOSPORIUM* AS A BIOLOGICAL CONTROL AGENT FOR SOME PLANT-PARASITIC NEMATODES - AN ECOLOGICAL APPROACH. **Kerry, B. R.** AFRC-IACR, Rothamsted Experimental Station, Harpenden, Hertfordshire, AL5 2JQ, England.

Verticillium chlamydosporium has been studied as a potential biological control agent for cyst and root-knot nematodes. Empirical studies on the application of organisms for the control of these nematodes have failed or given inconsistent results. Basic research on the biology and ecology of *V. chlamydosporium* has led to the identification of several key factors that affect the efficacy of the agent such as method of inoculum production, temperature, soil texture, nematode density, and plant host. Effective isolates developed in the rhizosphere and rapidly colonized nematode females and eggs. Simple laboratory and glasshouse studies have been used to develop a management strategy for the control of root-knot nematodes on vegetable crops and it is currently being tested in the field.

METHODS FOR THE STUDY OF *VERTICILLIUM CHLAMYDOSPORIUM* IN THE RHIZOSPHERE. **Kerry B. R., and J. M. Bourne.** AFRC-IACR, Rothamsted Experimental Station, Harpenden, Hertfordshire, AL5 2JQ, England.

Isolates of *Verticillium chlamydosporium* differ in their ability to colonize the rhizosphere, and plant species and cultivars differ in their ability to support the fungus. The control of root-knot nematode populations is dependent on the density of *V. chlamydosporium* in the rhizosphere and so it is important to develop methods for assessing the prevalence of the fungus on the root surface. Simple methods for screening different isolates of the fungus have been used to estimate the extent of rhizosphere colonization of barley seedlings from inoculum applied as a seed coating. A semi-selective medium has been used to estimate relative changes in the abundance of the fungus on the root surface of different host plants susceptible to root-knot nematodes. The relationship between direct observations on the extent of hyphal growth using stains and the number of colony forming units that develop on the selective medium has been studied.

NEMATICIDAL POTENTIAL OF SOME SEED EXTRACTS AGAINST *MELOIDOGYNE JAVANICA*. **Khurma, U. R., and S. Sharma.** Department of Zoology, Guru Nanak Dev. University, Amritsar, India.

Aqueous seed extracts of *Calotropis procera, Melia azedarach, Ricinus communis,* and *Sesbania sesbane* were evaluated in vitro for their nematicidal efficacy against *M. javanica.* All extracts were highly effective in causing juvenile mortality in 24 hours, *C. procera* being the most toxic even at lower concentrations. Both *C. procera* and *S. sesbane* showed significant activity within 8 hours.

SYNCYTIUM DEVELOPMENT IN SUSCEPTIBLE SOYBEAN CULTIVARS IN RELATION TO GROWTH AND REPRODUCTION OF SOYBEAN CYST NEMATODE. **Kim, Y. H., R. D. Riggs, and K. S. Kim.** Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

Studies were conducted with syncytia formed in root tissues of soybean cultivars Lee (moderately tolerant), Bragg (intolerant), Coker 237 (tolerant), and PI 97100 (tolerant), at 20 days after inoculation with race 3 (R3) or race 14 (R14) of soybean cyst nematode (SCN), *Heterodera glycines.* Syncytial areas near the nematode lip regions were measured in 20 root samples of each cultivar-race combination. R14 produced significantly larger (2.3 - 4.3 mm^2) syncytia than R3 (1.8 - 2.8 mm^2). Syncytia of Coker 237 were smaller (R3 = 1.8 mm^2, R14 = 2.3 mm^2) than those of other cultivars (Lee = 2.5 and 3.4, Bragg = 2.8 and 4.3, PI 97100 = 2.1 and 3.5 mm^2 for R3 and R14). The number of females formed in the soybean cultivars was similar with both nematode races, but the fecundity and female body width 20 days after inoculation were significantly less for R3 than for R14, and less in Coker 237 than the other cultivars. This suggests that growth and reproduction of SCN is directly related to the syncytial development. Percentages of the stelar region area occupied by syncytium were lower in Coker 237 and PI 97100 than in Lee and Bragg, but were not always related to the tolerance of the soybean cultivars tested.

EVALUATION OF ARF18 MIXED WITH THREE PREDATORY FUNGI, AGAINST *HETERODERA GLYCINES* AND *MELOIDOGYNE INCOGNITA* IN MICROPLOTS. **Kim, D. G., and R. D. Riggs.** Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

Two year microplot studies were conducted with mixtures of fungi, egg parasitic plus juvenile predatory fungi, against root-knot nematode, *M. incognita,* and soybean cyst nematode (SCN), *H. glycines.* Each fungus was cultured in liquid medium and formulated in alginate pellets. Plots with fungus treatment received 10 g pellets/100 cm^2 each year. Treatments included control, each fungus alone, and mixtures of fungi; ARF18 mixed (50:50) with one of three predatory fungi, *Arthrobotrys oligospora, Dactylaria brochopaga,* and *Hirsutella rhossiliensis.* Soybean cv. Hutcheson (1991-1992) was planted in SCN infested microplots, and tomato cv. Rutgers (1991) or pepper cv. BulAm (1992) was planted in root-knot nematode infested microplots. Each treatment was replicated five times. Numbers of nematodes were determined at planting and harvest. The fungus treatments did not reduce the number of nematodes nor increase yield except in the SCN test in 1992. In 1992, ARF18 or ARF18 + predatory fungi treatments ($P \leq 0.01$) reduced the number of juveniles, cysts, and eggs of SCN, but predatory fungi alone were not effective. ARF18 + *A. oligospora* had the fewest SCN eggs (83% reduction), but not significantly fewer than ARF18 alone. The mixtures of fungi were not considered advantageous.

FALL APPLICATION OF 1,3-D FOR CONTROL OF ROOT-KNOT NEMATODE. **King, P. S., R. Rodríguez-Kábana, D. G. Robertson, and L. W. Wells.** Department of Plant

Pathology, Auburn University, AL 36849.

The efficacy of a post-harvest fall application of 1,3-D for control of *Meloidogyne arenaria* and providing a yield response of 'Florunner' peanut (*Arachis hypogaea*) was compared with a preplant spring application of the fumigant. Fall in-row injection of the nematicide at 84 liters/ha resulted in an increased yield over the untreated control and a in higher yield than that obtained with spring application of the material at the same rate. Fall or spring applications of 1,3-D at 56 liters/ha did not affect yield. Combination of fall-injected 1,3-D at 84 liters/ha followed by an at-plant application of aldicarb at 30 g a.i./100 m row in a 20-cm-wide band with light incorporation (2-3 cm) did not improve yield over that obtained with the fall treatment singly. The use of aldicarb alone did not affect yield.

INCIDENCE OF ROOT-KNOT AND RENIFORM NEMATODES IN FLORIDA COTTON FIELDS. **Kinloch, R. A., and R. K. Sprenkel.** Agricultural Research and Education Center, University of Florida, Jay, FL 32565.

A randomly selected 15% of the cotton fields in Florida cotton producing counties were sampled for soil nematodes following the 1990 harvest. *Meloidogyne* sp. were recovered from 61% and *Rotylenchulus reniformis* from 15% of the 178 sampled fields. Santa Rosa County, with the longest history of cotton production in the state, had the highest frequency of the reniform nematode (23%). Root-knot and reniform nematodes averaged 15 and 124 juveniles/10 cm^3 soil, respectively. In mixed infestations, numbers of root-knot nematode juveniles (y) were related to that of the reniform nematode (x) by: $\log y = 1.56 - 0.49 \log x$, ($r = 0.56$; $P \leq 0.02$; df = 14). There were no apparent relationships between numbers of either nematode and soil particle components.

EFFECTS OF *MELOIDOGYNE INCOGNITA* ON WATER RELATIONS AND GROWTH OF COTTON. **T. L. Kirkpatrick, M. Van Iersel, and D. M. Oosterhuis.** Southwest Research and Extension Center, University of Arkansas, Hope, AR 71801.

The effects of *Meloidogyne incognita* infection on the growth, development, and water relations of cotton plants were studied in microplots. Microplots containing fumigated (methyl bromide) soil were infested with *M. incognita* at a rate of 5,000 eggs and juveniles/500 cm^3 soil. Treatments included nematodes alone, nematodes plus application of aldicarb (15 G) broadcast and incorporated at planting at 1.7 kg/ha, and a control were no nematodes were added. Nematode infection decreased plant height and the number of main stem nodes and the number of sympodial branches, total bolls produced and seedcotton yield. In addition, infected plants remained vegetative longer and stopped fruiting sooner than uninfected plants. The components of leaf water potential were not affected by nematode infection. However, stomatal resistance was increased and transpiration rates, leaf temperature, and water movement through intact plants were decreased in infectious plants.

PCR DIAGNOSIS OF POTATO CYST NEMATODES, *GLOBODERA PALLIDA* AND *G. ROSTOCHIENSIS*, USING PRIMERS SPECIFIC TO THE MAJOR SPERM PROTEIN GENES. **Kulka, W. E.[1], H. J. Atkinson[2], M. McPherson[2], and C. E. Novitski[1].** [1]Department of Biology, Central Michigan University, Mt. Pleasant, MI 48859, and [2]Centre for Plant Biochemistry and Biotechnology, University of Leeds, Leeds LS2 9JT, UK.

Oligonucleotide primers for polymerase chain reactions were designed based on the nucleotide sequences of major sperm protein genes from the potato cyst nematodes, *Globodera pallida* and *G. rostochiensis*. Single cysts DNA of *G. pallida* and *G. rostochiensis* pathotypes yielded the expected product. The DNA of the soybean cyst nematode, *Heterodera glycines*, the sugar beet cyst nematode, *Heterodera schachtii*, and the carrot cyst nematode, *Heterodera carotae* did not amplify. Therefore, PCR using genespecific primers showed potential value as a diagnostic tool

for rapidly determining the presence of potato cyst nematodes.

THE EFFECT OF ROTATION CROPS ON STRAWBERRY BLACK ROOT ROT PATHOGENS IN FIELD MICROPLOTS. **LaMondia, J. A.** Connecticut Agriculture Experiment Station, P.O. Box 248, Windsor, CT 06095.

Field microplots previously planted to strawberry and infested with the black root-rot pathogens, *Pratylenchus penetrans* and *Rhizoctonia fragariae* (binucleate AG, A, G, and I), were planted to strawberry or rotation crops such as rye, oat, sorghum-sudangrass, canola, or saia oat. Soil cores were removed after 20 weeks and pathogens recovered from 50 cm^3 soil. Nematodes were recovered using a pie pan technique. *Rhizoctonia fragariae* was recovered by baiting with 1-cm segments of surface sterilized greenhouse-grown Alpine strawberry roots for 72 hr at 10 C. *Pratylenchus penetrans* recovery was greater for oat (112/50 cm^3 soil) than for strawberry, canola, or rye (23-43), and least for plots planted to sorghum-sudangrass or saia oat (3-6 *Pratylenchus*/50 cm^3 soil). *Rhizoctonia fragariae* recovery from bait roots was greater for canola and strawberry (5.3 and 7.8 colonies/8 cm root) than for all other crops (3.0 to 4.6 colonies/8 cm root). These results demonstrate the potential for reducing black root by rotation.

PREDATION OF PHYTOPARASITIC, ENTOMOPATHOGENIC, AND FREE-LIVING NEMATODES BY A COPEPOD. **Lehman, P. S.** Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, FL 32614-7100.

A copepod, *Phyllognathopus viguieri* was collected from a Florida nursery and reared in the laboratory. Laboratory tests indicated that this copepod preys on at least seven phytoparasitic, two free-living, and one entomopathogenic nematode species. Predatory activity of this copepod on *Meloidogyne incognita* second-stage juveniles (J2) was tested on 2% water agar, in a sandy-loam soil, and an artificial soil mix (Metro 300). On agar after 1 hour, 130 copepods consumed 905 of 1,000 root-knot nematode J2s. After 3.5 days, 25 copepods reduced initial population densities of 1,000 root-knot nematode J2s 32% and 74% in soil and in the artificial soil mix, respectively. This copepod, which has a cosmopolitan distribution in moist soil, was not previously considered a predator of nematodes.

SURFACE COAT PROTEINS FROM THE NEMATODE *MELOIDOGYNE INCOGNITA*. **Lin, Hao-Jin, and Michael A. McClure.** Department of Plant Pathology, University of Arizona, Tucson, AZ 85721.

Surface coat proteins of *Meloidogyne incognita* race 3 infective juveniles were characterized by electrophoresis and Western blotting of extracts from radioiodine and biotin-labeled nematodes. Extraction of labeled nematodes with cetyltri-methylammonium bromide yielded a principal protein band with a molecular weight of approximately 300 kD and several faint bands of lower molecular weight. The pattern of labeling was similar for both labeling methods. Western blots of unlabeled proteins were probed with a panel of biotin-labeled lectins, but only Concanavalin A bound to the principal band. Nematodes labeled with radioiodine and incubated in water for 20 hours released I^{125} into the water, indicating that the surface coat proteins may be transitory. Antiserum to the principal protein reacted with the surface of live nematodes and with surface proteins separated by electrophoresis. Differential patterns of antibody labeling were obtained on Western blots of extracts from *M. incognita* races 1, 2, and 3, *Meloidogyne hapla* race 2, and *Meloidogyne arenaria* race B.

PLANETOR ANALYSIS OF SELECTED CROP ROTATION SCHEMES IN MICHIGAN POTATO PRODUCTION. **Mather, R. L., and G. W. Bird,** Department of Entomology, Michigan State University, East Lansing, MI 48824.

PLANETOR, an on-farm integrated decision support system, was used to evaluate various

corn and alfalfa rotation schemes and continuous potato in relation to their impacts on potato yields, *Pratylenchus penetrans* population densities, and economic feasibility. Eight different rotation schemes were evaluated under field conditions. These included 2 years continuous potato, 3 years continuous potato, corn-potato, corn-corn-potato, corn-potato-potato, alfalfa-potato, alfalfa-alfalfa-potato, and alfalfa-potato-potato. Two years of alfalfa followed by potato increased potato yields significantly. Both direct return over costs and system sustainability issues were considered. Return over direct costs ranged between $267/ha for corn-corn-potato to $976/ha for potato-potato. Three scenarios were employed: selling the rotation commodities, on-farm utilization with livestock, and resource regeneration.

RESISTANCE IN COWPEA TO *MELOIDOGYNE INCOGNITA* ISOLATES AND *M. JAVANICA* VIRULENT RK GENE. **Matthews, W. C., and P. A. Roberts.** Department of Nematology, University of California, Riverside, CA 92521.

A Nigerian source (UCR #430) of *Meloidogyne* resistance in cowpea (*Vigna unguiculata*) was found to be highly and partially effective against isolates of *M. incognita* and *M. javanica*, respectively, which are virulent to gene Rk, the basis of resistance in current cultivars. In growth-pouches fewer egg masses per root system, fewer eggs per egg mass, and little or no root galling were found on UCR#430 compared to susceptible and gene Rk cultivars. Analyses of F1, F2, and BC1 progenies from UCR#430 x susceptible CBE 3 indicated resistance to Rk-virulent *M. incognita* was dominant and conferred by a single nuclear gene. All F1 plants were resistant, six F2 families each segregated in a 3 resistant: 1 susceptible ratio, and two BC1 (CBE 3 x F1) families each segregated in a 1:1 ratio. The relationship to gene RK is being studied in test for allelism and linkage.

REPRODUCTIVE AND PARASITIC VARIATION IN POPULATIONS OF THE RENIFORM NEMATODE, *ROTYLENCHULUS RENIFORMIS*. **McGawley, E. C., and A. Sankaralingam.** Department of Plant Pathology and Crop Physiology, Louisiana State University Agriculture Center, Baton Rouge, LA 70803.

Reproduction and parasitism by four populations (Eavangeline, East Baton Rouge, Opelousas, and Avoyelles) of the reniform nematode, *Rotylenchulus reniformis*, were compared on three cotton (Deltapine 20, LA887, and Auburn 56), and three soybean (Forrest, Kirby, and Davis) cultivars in 60-day-duration greenhouse experiments. There were significant differences in reproduction among all four reniform nematode populations. Reproduction of Louisiana populations also differed significantly from that of an isolate from Mississippi. In 62-day-duration pathogenicity studies in which the three cotton and soybean cultivars were inoculated with four levels (0, 500, 1,000, and 5,000 individuals/pot) of reniform nematode, highly significant differences in the virulence among the four isolates were observed. The Opelousas isolate was the most destructive for both crop species. Soybean death occurred within 40-55 days following inoculation and cotton root weights were reduced significantly at 62 days.

DEVELOPMENT OF *HETERODERA GLYCINES* AS AFFECTED BY *FUSARIUM SOLANI*, THE CASUAL AGENT OF SUDDEN DEATH SYNDROME. **McLean, K. S., and G. W. Lawrence.** Department of Agriculture, Northeast Louisiana University, Monroe, LA 71209, and Department of Plant Pathology and Weed Science, Mississippi State University, Mississippi State, MS 39762.

A test was established to examine the association between the soybean cyst nematode, *Heterodera glycines* and the blue form of *Fusarium solani*, the casual agent of sudden death syndrome (SDS) of soybean. Soybean cv. Coker 156 plants were inoculated with either *H. glycines* alone or *F. solani* + *H. glycines* in combination. Plants were maintained in a controlled environmental growth chamber for 40 days. Plants were harvested, and roots stained using

NaOCl and acid fuchsin, then microscopically examined for *H. glycines* development at 3 day intervals. *Fusarium solani* did effect *H. glycines* life-stage development and rate of maturation. Similar significant linear regressions of population development over time were observed for both *H. glycines* alone and *F. solani* + *H. glycines* in combination. At 40 days, *Heterodera glycines* population levels were reduced by 47% in the presence of *F. solani*.

SAMPLING OF PESTS FOR QUARANTINE PROGRAMS. **McSorley, R.** Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611-0620.

In quarantine and certification programs, intensive sampling of large shipments of plants may be required to detect plants containing nematodes or other plant pathogens. Subject to certain assumptions, the hypergeometric distribution or an approximation from the binomial probability distribution can be used to quickly estimate the probability of detecting various infestation levels as increasing numbers of samples are collected. Using the binomial probability distribution, the probabilities of detecting infestations of 50%, 10%, 5%, and 1% in various shipment sizes are provided for selected numbers of samples. When 5% of plants are infested, 59 samples and 90 samples would be required to detect the infestation 95% and 99% of the time, respectively. When only 1% of plants are infested, sample sizes must be increase to 300 and 500 for 95% and 99% detection, respectively. It is critical that quarantine programs establish an acceptable tolerance limit for detection of each pest sampled, because zero tolerance requires sampling every plant in the shipment, which may be impractical.

UNCOMMON CROPS FOR MANAGEMENT OF *MELOIDOGYNE ARENARIA*. **McSorley, R., D. W. Dickson, T. E. Hewlett, and J. J. Frederick.** Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611-0620.

Uncommon crops are being introduced into cropping systems in some areas of the southeastern United States to suppress nematode numbers. In north Florida during the summers of 1991 and 1992, 11 crops and fallow were compared in microplots infested with *Meloidogyne arenaria* race 1. In both years, highest levels of galling and most egg masses were obtained on peanut (*Arachis hypogaea* cv. Florunner), with moderate levels on hairy indigo (*Indigofera hirsuta*), horse bean (*Canavalia ensiformis*) and sesame (*Sesamum indicum*). In contrast, few galls or egg masses were obtained on velvetbean (*Mucuna deeringiana*), castor (*Ricinus communis*), American jointvetch (*Aeschynomene americana*), soybean (*Glycine max* cv. Kirby), crotalaria (*Crotalaria spectabilis*), cotton (*Gossypium hirsutum* cv. Deltapine 90), or sorghum-sudangrass (*Sorghum bicolor* x *S. sudanense* cv. DeKalb SX-17). Highest densities of *M. arenaria* juveniles occurred after peanut, horse bean, and soybean. Yield of yellow squash (*Cucurbita pepo* cv. Lemondrop L) planted in spring of 1992 was greatest following castor and least following peanut. Several crops were effective in keeping numbers of *M. arenaria* low and increasing yield of a subsequent vegetable crop, and their response against a range of root-knot nematode species and races is being investigated.

BREEDING WHITE CLOVER FOR RESISTANCE TO *MELOIDOGYNE HAPLA* AND *HETERODERA TRIFOLII*. **Mercer, C. F., J. van den Bosch, and J. L. Grant.** AgResearch Grasslands, Private Bag 11008, Palmerston North, New Zealand.

Trifolium repens seedlings were raised individually in pots of sand-soil mix for 3 weeks then inoculated around the roots with a suspension of eggs of *M. hapla* or *H. trifolii*. At 4 weeks from inoculation *M. hapla* galls were counted, and at 6 weeks *H. trifolii* cysts were extracted and counted. Roots were dried and weighed and stolon tips kept. After two cycles of selection and crossing, lines selected for resistance to *H. trifolii* had a mean cyst number 33% of the susceptible lines; clones of two resistant genotypes had mean cyst counts of 5 and 19, whereas clones of two susceptible genotypes had counts of 360 and 520. The F3 lines resistant to *M. hapla* had a mean

gall number 50% of the susceptible lines, but the equivalent figure for the F4 lines was 67%. Reasons for the apparent lack of progress are discussed. Clones of two resistant (and two susceptible) genotypes from the F4 screening had mean gall numbers of 80 and 82 (118 and 182) and mean egg counts of 1,500 and 3,700 (13,900 and 17,000).

EFFECT OF SOIL pH ON PREDISPOSING SWEET CHERRY SEEDLINGS TO PLANT PATHOGENS. **Melakeberhan, H.[1], G. W. Bird[1], and A. L. Jones[2].** [1]Department of Entomology, and [2]Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824.

The role of *Pratylenchus penetrans*, *Pseudomonas syringae* pv *syringae*, and low soil pH (most commonly associated factors with declining Michigan sweet cherry trees) in the incidence of canker or the predisposition phenomena was investigated using 1-yr-old Emperor Francis-mazzard combination at pH 7.0 (experiment I) or on mazzard rootstock at a pH of 7.0, 4.7, or 3.9 (experiments II and III). *Pseudomonas syringae* was inoculated on petioles at 12 weeks and 1 year after 5,000 *P. penetrans*/plant (experiment I) or 22 days following 10,000 *P. penetrans*/plant (experiments II and III). Each experiment included untreated and buffer controls. Plants were kept in a mist chamber at 22 C for 96 hours before transferring to a 24-C greenhouse. The incidence of canker was not increased by presence of *P. penetrans* in experiment I, whereas it increased with decreasing soil pH and the presence of *P. penetrans* in experiments II and III. *Pratylenchus penetrans* may have an additive effect at low soil pH.

XIPHINEMA AMERICANUM DAMAGING PEACH TREES IN SOUTH AFRICA. **Meyer, A. J., and H. J. Hugo.** Entomology and Nematology, University of Stellenbosch, Stellenbosch.

Poor growing peach trees in an orchard in Citrusdal, South Africa, which showed various degrees of die-back and early leaf drop were examined. No known pathological microorganisms could be found in the leaves, twigs, or trunk but the roots were severely affected. In the damaged trees the total root system was stunted, darkly colored and with little functional feeder roots. Again, no primary plant pathogens could be isolated. However, the soil yielded enormous numbers of *Xiphinema americanum* in the rhizosphere of the peach trees. Samples from each tree in the affected area ($\pm$110) revealed lower numbers of *X. americanum* around the roots of severely damaged trees, but high numbers in the rhizosphere of trees showing slight symptoms and some apparently unaffected trees. In the orchard as a whole, the population of *X. americanum* had a patchy distribution, so often observed in many other plant-parasitic nematodes. Application of nematicides and seedling trials with the nematode pointed towards *X. americanum* as a possible cause of the abnormal symptoms.

VARIATION IN DEVELOPMENT OF FIVE ISOLATES OF *HETERODERA SCHACHTII* ON SIX SUGARBEET X *BETA PROCUMBENS* INTERSPECIFIC HYBRIDS. **Miller, L. I.** Department of Plant Pathology, Physiology and Weed Science, Virginia Tech, Blacksburg, VA 24061.

Five physiology races of *H. schachtii* (C1 from tomato and C2 from sugarbeet in California, N1 from cabbage in New York, M1 from sugarbeet in Michigan, and F2 from cabbage in Florida) were tested in the greenhouse to determine their ability to develop egg-bearing females in interaction with USH11 sugarbeet (susceptible control), *B. procumbens* (resistant control), Lewellen's *H. schachtii* resistant lines (USDA, ARS Salinas, CA) of N801-A, the highly resistant interspecific sugarbeet x *B. procumbens* Dutch B-883 hybrid, and five S4 progeny of sugarbeet lines x B-883 (N103, N203-1, N204, N205, N206). All races developed mature females on USH11 and N205. *Beta procumbens*, N203-1, and N204 were not hosts or were highly resistant to all of the races. N801-A, N103, and N206 were not hosts of the races, except that N801-A was an efficient host of the N1 race, N103 a poor host of C2 and N206 an efficient host of F2.

CROPPING-SYSTEMS EFFECTS ON NEMATODES AND DISEASES OF PEANUT AND ASSOCIATED YIELD. **Minton, N. A.[1], T. B. Brenneman[2], S. H. Baker[3], G. J. Gascho[3], G. W. Burton[1], A. K. Culbreath[2], and D. R. Sumner[2].** [1]USDA, ARS, Departments of [2]Plant Pathology, and [3]Crops and Soil Sciences, University of Georgia, Tifton, GA 31793.

The effects of bahiagrass, cotton, and corn on *Meloidogyne arenaria*, southern stem rot caused by *Sclerotium rolfsii*, and Rhizoctonia limb rot caused by *Rhizoctonia solani* AG-4 in peanut were evaluated. Peanut was grown following 1 year of peanut, bahiagrass, cotton, or corn as whole plots and aldicarb (3.4 kg ai/ha), flutolanil (1.7 kg ai/ha), aldicarb (3.4 kg ai/ha) + flutolanil (1.7 kg ai/ha), and control were subplots. Fewer *M. arenaria* second-stage juveniles (J2) were in peanut plots following bahiagrass, corn, and cotton than in continuous peanut. There was a nonsignificant reduction of stem rot and limb rot in peanut following bahiagrass, corn, and cotton compared to continuous peanut. Aldicarb reduced *M. arenaria* J2 and flutolanil reduced stem rot and limb rot in peanut. Yields of peanut following 1 year of bahiagrass, corn, or cotton without a nematicide or fungicide were 36% greater than following continuous peanut. Aldicarb, flutolanil, or aldicarb + flutolanil increased yields of continuous peanut 26%, 35%, or 56%, respectively. Aldicarb + flutolanil increased peanut yields 23% in plots rotated with bahiagrass, corn, or cotton. Rotations increased yields 7% in aldicarb + flutolanil treated plots.

INTEGRATED CONTROL OF ROOT-KNOT NEMATODE *MELOIDOGYNE JAVANICA*. **Mousa E. M., and M. E. Mahdy.** Department of Agricultural Botany, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt.

Polyethylene mulching was used to cover *M. javanica* infested microplots (1.5 x 1.5 m) to determine its effect on population densities of this nematode. Tomato seedlings were transplanted 15-days before the polyethylene was used to cover the microplots. The experiment was terminated 3 months after the mulch was applied. The amount of root-knot nematode galls and nematode population densities were reduced approximately 25% in the treated plots compared with the untreated control.

BIOLOGICAL CONTROL OF EGYPTIAN AGRICULTURAL INSECTS WITH ENTOMOPATHOGENIC NEMATODES. **Mousa, E. M.** Department of Agricultural Botany, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt.

In greenhouse experiments and laboratory tests, Egyptian locust *Anocridium agytiuro* and cotton leaf worm *Spodoptera littoralis* were exposed to the entomopathogenic nematode *Steineronema carpocapsae*. A 100% mortality of the locust occurred 9 and 17 days after nematode inoculation by either injection and/or spraying. Complete mortality of cotton leaf worm was obtained 9 and 15 days after the nematode was applied by the two different methods of inoculation.

EFFECTS OF *HOPLOLAIMUS COLUMBUS* ON PHOTOSYNTHESIS AND YIELD IN COTTON. **Nendick, D. K., and J. P. Noe.** Department of Plant Pathology, University of Georgia, Athens, GA 30602.

Two cultivars of cotton, *Gossypium hirsutum*, tolerant Deltapine 90 (DP90) and susceptible Coker 315 (CK315) were grown in field plots naturally infested with *Hoplolaimus columbus*. Photosynthetic rates, petiole nitrogen, yields, and nematode population dynamics were monitored. The reproductive factor (Rf) was higher and the photosynthetic rates were lower for CK315 than DP90. Responses of the cultivars to *H. columbus* were estimated by linear regression. Yield was negatively related to nematode counts and photosynthetic rates. Photosynthetic rates were negatively related to nematode counts, and soil nitrogen for CK315. Petiole nitrogen was negatively related to midseason nematode counts, also for CK315 only. Yields, petiole nitrogen, soil nitrogen, and photosynthetic rates were negatively correlated with nematode counts in both

cultivars. Tolerance in DP90 was related to differences in the responses of photosynthetic rates and petiole nitrogen levels to increasing population densities of *H. columbus*.

EFFECTS OF TILLAGE, DATE OF PLANTING, AND RESISTANCE TO *HETERODERA GLYCINES* ON THE SOYBEAN-CYST NEMATODE INTERACTION. **Niblack, T. L., G. S. Smith, and J. A. Wrather.** Plant Sciences Unit, University of Missouri, Columbia, MO 65211.

Two years have been completed of a study in three Missouri locations: Edina (north), Benton City (central), and Portageville (southeast). Tillage treatments were no-till, ridge-till, and conventional-till. Three planting dates were from May or June to early July. Adapted cultivars were selected based on their genetic sources of *H. glycines* resistance. Planting date or source of resistance had no consistent effect on *H. glycines* population densities. Soybean yields were highest for resistant cultivars planted earlier. Only at Portageville were soybean yields significantly affected by tillage. Resistance had a greater impact than tillage on soybean yield at all sites. Although relative yield losses due to *H. glycines* decreased at later planting dates, yields of all cultivars decreased and root infection by *H. glycines* increased at later planting dates.

EFFECTS OF PESTA-PELLETIZED STEINERNEMA CARPOCAPSAE ON WESTERN CORN ROOTWORMS AND COLORADO POTATO BEETLES. **Nickle, W. R.[1], W. J. Connick, Jr.[2], and W. W. Cantelo[1].** [1]Nematology Laboratory and Vegetable Laboratory, BARC-West, USDA, ARS, Beltsville, MD 20705, and [2]Southern Regional Research Center, USDA, ARS, New Orleans, LA 70179.

Pesta-pelletized *Steinernema carpocapsae* strain All nematodes were used in soil treatments in the greenhouse against larvae of Western corn rootworm and prepupae of Colorado potato beetle. The pesta-pellets were produced to deliver 100,000 living nematodes/g. Infective stage nematodes and their associated bacteria survived the pesta-pellet process, emerged from the pellets in large numbers in the soil, and killed these pest insects significantly as compared to the control. Over 90% of both pest insects were killed as determined by adult emergence. There is an indication that when nematodes are applied in pellet form into the soil only half as many nematodes would be necessary to induce the same amount of control as with a drench. This formulation worked well for the All and Mexican strains of *S. carpocapsae* and for *S. feltiae* (bibionis).

ROTYLENCHULUS RENIFORMIS POPULATION DYNAMICS AND DAMAGE FUNCTIONS ON COTTON. **Noe, J. P.** Department of Plant Pathology, University of Georgia, Athens, GA 30602-7274.

Deltapine 50 cotton yield and population densities of *Rotylenchulus reniformis* were monitored in greenhouse pots and in field plots. A reproductive factor (Rf = Pf/Pi) of 100 was observed at 95 days after planting in 15-cm-d pots inoculated with 750 nematodes/pot. Top weight and number of bolls of cotton decreased in a linear response to increasing inoculum rates from 0 to 6,000 *R. reniformis*/pot, with a 34% suppression of top weight and a decrease of 36% in boll numbers observed at the highest inoculum level. The average Rf observed in field plots was 5.5, with a mean Pi of 678 *R. reniformis*/100 cm^3 soil. An exponential population model best described the relationship of Pf to Pi with an estimated maximum density of $4,620 \pm 294$ *R. reniformis*/100 cm^3 soil. An inverse logistic model best represented the relationship of yield to Pi with estimated maximum and minimum yields of $1,388 \pm 118$ and 417 ± 119 kg/ha cotton lint, respectively, for an estimated maximum yield suppression of 70% due to *R. reniformis*. The economic threshold for a \$95/ha treatment was estimated to be 125 *R. reniformis*/100 cm^3 soil.

RACES OF SOYBEAN CYST NEMATODE IN BRAZIL. **Noel, G. R.[1], M. L. Mendes[2], and C. Machado[2].** [1]USDA, ARS, University of Illinois, Urbana, IL 61801, USA, and [2]EMBRAPA,

86001 Londrina, PA, Brazil.

Heterodera glycines was first reported in Brazil in February 1992 and occurs in the savannah of central Brazil in the states of Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, and São Paulo. Populations of *H. glycines* were collected from the five states during February 1993 and brought to the University of Illinois for race identification. Each population was cultured on Lee 68 soybean and races were identified using the differential lines Pickett 71, Peking, PI 88788, and PI 90763. Races 3, 10, and 14 were identified in collections from Goiás and race 4 was identified in a collection from Mato Grosso do Sul. The four populations identified thus far were collected within a 30-km radius of Chapadão do Sul, Mato Grosso do Sul in an area with a 10 to 15-year history of production. The diversity of races may be due to several importations of infested seed from different seed production farms in Minas Gerais ca. 600 km to the east. The source of infestations in Minas Gerais is not known, but importation of *H. glycines* from the USA is suspected.

EFFECT OF REDUCED METHYL BROMIDE APPLICATION RATE AND HIGH BARRIER PLASTIC MULCH COVERS ON TOMATO YIELD AND NEMATODE CONTROL. **Noling, J. W.** Citrus Research and Education Center, 700 Experiment Station Road, University of Florida, Lake Alfred, FL 33850.

Two broadcast application rates of methyl bromide (MBr) (206 and 103 kg a.i./ha) in combination with a high barrier plastic mulch cover was compared with MBr (412 kg a.i./ha) and metham sodium (306 liters a.i./ha) using a standard commercial low barrier plastic mulch film for control of *Meloidogyne incognita* and yield enhancement of 'Sunny' tomato (*Lycopersicon escuelentum*). All fumigant treatments reduced preplant soil population densities of *M. incognita* to undetectable levels. Regardless of mulch film, only the two highest rates of MBr and metham sodium reduced post-fumigation weed emergence. Final harvest soil population densities of *M. incognita* were reduced by all MBr treatments, whereas no differences were observed between metham sodium and the untreated control. Use of the high barrier MBr plastic mulch film combined with lower MBr rates (206 and 103 kg a.i./ha) significantly increased tomato yields above all other treatments. These results suggest that current rates of MBr can be reduced 50-75% without loss of tomato crop productivity or nematode control when combined with MBr high barrier plastic mulch row covers.

CULTURAL CONTROL OF *CRICONEMELLA XENOPLAX* ON PEACH WITH WHEAT. **Nyczepir, A. P., and P. F. Bertrand.** Southeastern Fruit and Tree Nut Research Laboratory, USDA, ARS, Byron, GA 31008, and University of Georgia Cooperative Extension Service, Tifton, GA 31793.

Stacy wheat as a preplant management tactic against *Criconemella xenoplax* on peach was assessed on land having a history of peach tree short life. The site was maintained in fallow, small grains (including 'Stacy' wheat), or two peach rootstocks from 1986 until replanting peaches in 1990. In October 1989, some plots received methyl bromide preplant fumigation. The population density of *C. xenoplax* after 2 years was still greater ($P \leq 0.05$) in nonfumigated peach plots than in fumigated peach, fallow, or Stacy wheat plots. By 1993, no differences in *C. xenoplax* population densities were detected among the treatments. Peach tree short life occurred in all treatments by 1993, however, greatest ($P \leq 0.01$) incidence occurred in the nonfumigated peach plots. No differences in tree mortality were detected among the fumigated peach, Stacy wheat, or fallow treatments.

A TEACHING AID VIDEO ON PLANT-PARASITIC NEMATODES. **Orion, D., and C. Zabludovski,** Department of Nematology, A.R.O., Volcani Center, Bet Dagan, and Department of Communication, Ministry of Agriculture, Tel-Aviv, Israel.

A 36 minute video film was produced as a teaching aid for university courses in nematology and pathology. The film is divided into four independent sections: 1) Structure and Function, 2) Migratory Nematodes, 3) Sedentary Nematodes, and 4) Management. Field and laboratory photographs, light micrographs, scanning electron micrographs, and animation are used throughout the video and are well integrated with either English or Spanish narration.

AN INDUCED RESISTANCE REACTION IN MONOXENIC CULTURE OF *MELOIDOGYNE INCOGNITA*. **D. Orion, W. P. Wergin, and D. J. Chitwood.** Nematology Laboratory, and Electron Microscopy Laboratory, USDA, ARS, Beltsville, MD 20705.

Urea and its derivatives are known to induce resistance reaction toward the root-knot nematode in tomato. In our experiments, the root-knot nematode, *Meloidogyne incognita* was monogenically cultured on excised soybean cv. Pickett, and tomato cv. Rutgers root on media enriched with increasing concentrations, from 0 to 400 ppm, of either ammonium nitrate or urea. Observations with scanning electron microscope showed that giant cell formation was inhibited on the nematode-infected soybean where nematode development was also inhibited. The nitrogenous compounds induced the formation of spherical structures within the parenchymal cells of the roots.

POPULATION DYNAMICS OF *HOPLOLAIMUS COLUMBUS* ON SOYBEAN. **Perez, E. E., J. D. Mueller, and S. A. Lewis.** Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.

Soil and root samples were collected 2-4, 6, 8, 12, 16, and 28 weeks after planting (WAP) in 1991 and 1992 from Braxton soybean in plots naturally infested with *Hoplolaimus columbus*. Nematodes were recovered from 250 cm^3 of soil using centrifugal flotation and from ca. 15 g fresh weight of root using a mist chamber. Maximum nematode recovery from roots occurred at 12 (160/g root) and 10 WAP (130/g root) in 1991 and 1992, respectively. Recovery from soil peaked at 20 and 16 WAP in 1991 and 1992 with 120 and 95/100 cm^3 soil, respectively. In 1992, soil samples were also separated into soil and root fractions. At least 50% of adult *H. columbus* were recovered from the soil fraction at each date and none were recovered from the root fraction at planting or 28 WAP. Approximately 70% of juvenile *H. columbus* were in the root fraction at 6 and 12 WAP, but 50% or less were in the root fraction at the other sample dates.

PRESENCE OF NEMATOPHAGOUS FUNGI IN THE RHIZOSPHERE OF AGRICULTURAL CROPS. **Persmark, Lotta, and Hans-Börje Jansson.** Department of Microbial Ecology, Lund University, Helgonavägen 5, S-223 62 Lund, Sweden.

The presence of nematophagous fungi was studied on roots from pea, white mustard, and barley grown in a sandy agricultural field soil. Root and soil sampling were performed 4, 9, 12, and 18 weeks after sowing. Pea roots harbored up to 270 propagules of predatory nematophagous fungi per gram root, which is 10 times higher than in the root-free soil. The rhizosphere effect was greatest 9 weeks after sowing (the time of flowering). The roots of white mustard and barley, and the bulk soil all harbored around 10 propagules of nematophagous fungi per gram. An average of 2.5 species of nematophagous fungi was found per 0.1 g root segment of pea. On white mustard and barley roots about 1.2 species, and in root-free soil 1.6 species/gram soil, were found. The most commonly isolated predatory species were *Arthrobotrys musiformis, A. oligospora, Monacrosporium cionopagum* and *M. megalosporum*, and the most frequent endoparasites were *Catenaria anguillulae*, followed by *Nematoctonus leiosporus* and *Harposporium anguillulae*. Three genera of plant-parasitic nematodes were found, *Trichodorus, Pratylenchus*, and *Tylenchorhynchus*.

POPULATION DYNAMICS AND SPREAD OF *ANGUINA AGROSTIS* ON COLONIAL BENTGRASS. **Pinkerton, J. N., and S. C. Alderman.** Horticultural Crops Research

Laboratory, and National Forage Seed Production and Research Center, USDA, ARS, Corvallis, OR 97330.

The epidemiology of *A. agrostis* was investigated in a bentgrass field near Corvallis, Oregon. Each October from 1990-1992, nylon mesh pouches, each containing 10 galls, were buried in the field or placed in microplots containing bentgrass cv. Highland. Pouches were collected monthly or bimonthly between December and June and nematodes per gall determined. Nematode egression from galls began in late March and was completed by mid-May, corresponding to the period of flora initiation in bentgrass. In 1991 and 1992, 0.9 m^2 plots were inoculated with 0, 1, 5, 15, 50, 120, or 200 galls/plot. The disease severity (number of galls) and disease incidence (percentage seed heads with galls) increased linearly at inoculum densities below 50 galls/plot. At higher inoculum densities, disease increase approached an asymptote. In 1991, plots were established to determine the characteristics of disease spread. Foci were established by placing 0, 5, 50, or 500 galls along a 30-cm section of row in the fall. In July 1992, seed heads were harvested at 30 and 60 cm from each focus within and across plant rows. Nearly all subsequent infestations were found within 30 cm of foci at all inoculum levels. These disease spread and incidence data explain stable distributions of *A. agrostis* observed in Oregon bentgrass fields.

SURVIVAL OF *SCOTTNEMA LINDSAYAE* UNDER EXTREME OSMOTIC CONDITIONS. **Powers, L. E.[1], D. W. Freckman[1], and R. A. Virginia[2].** [1]Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, CO 80523, and [2]Environmental Studies Program, Dartmouth College, Hanover, NH 03755.

Scottnema lindsayae is the dominant nematode species in the Antarctic Dry Valleys, and is distributed widely throughout this ice-free, polar desert region. Soil salinity in the Dry Valleys is highly variable, ranging from 0.01 to 17 (EC of 1:5 soil: water extract). This suggests that S lindsayae may be capable of survival under widely variable osmotic conditions. We compared survival under different osmotic conditions of *S. lindsayae* with *Aphelenchus avenae*, a nematode known to survive desiccation by entering a coiled anhydrobiotic state. All life cycle stages of *S. lindsayae* and *A. avenae* were placed into solutions ranging in molarity from 0.0 to >5.0 M. Under high osmotic concentrations, *S. lindsayae* quickly folded itself into an accordian-like form, rather than the typical coiled form of *A. avenae*, and stayed in this nonactive state until the osmotic concentration was decreased. The ability of *S. lindsayae* to enter this osmotically induced cryptobiotic form may contribute to its success under the harsh environmental conditions of Antarctica.

EFFECTS OF FOSTHIAZATE ON *MELOIDOGYNE* SPP. AND YIELD OF FLUE-CURED TOBACCO. **Pullen, Mark P., and Bruce A. Fortnum.** Clemson University, Florence, SC 29501-9603.

The nonfumigant nematicide fosthiazate was evaluated over 2 years for control of *Meloidogyne arenaria* and *M. incognita* on flue-cured tobacco cultivars 'NK326' and 'Coker 371 Gold', respectively. Two fields infested with either *M. incognita* (site 1) or *M. arenaria* (site 2) were selected for study. Fosthiazate (2.1, 3.2, 4.2, and 8.4 kg/ha) was compared with fenamiphos (6.7 kg/ha), 1,3-D (56.1 liter/ha), and an untreated control. Fosthiazate (8.4 kg/ha) treated plots had greater yields at site 1 (1991, 1992) and site 2 (1991) than plots treated with fenamiphos or the untreated control ($P \leq 0.05$). Fosthiazate (8.4 kg/ha) treated plots did not differ in yield from plots treated with 1,3-D. Fosthiazate (8.4 kg/ha) was superior to fenamiphos and 1,3-D in reducing root galling in 1992 at both sites. Fosthiazate increased yields from 15-339% over an untreated control.

VERTICAL DISTRIBUTION OF NEMATODES ON CULTIVATED ANDEPTS FROM MARTINIQUE. **Quénéhervé, P., V.Eschenbrenner, and J-L. Chotte.** Soil Biology Laboratory,

ORSTOM BP 8006, 97259 Fort de Frances Cedex, Martinique, F. W. I.

The investigations were undertaken on four different crops (banana, sugarcane, yam, and on a 4 year old weed fallow) growing in the same restricted geographical area (1 km²) on an Andept from Martinique. Samples were collected in a pedological pit from the surface every 20 cm up to 2 m deep and results were expressed as the total number of nematodes per weight of dry soil along the soil profile. Whatever the cultivated crops, the plant feeders were the most abundant group. Each site exhibited distinct patterns of vertical distribution of nematodes, in relation with the vertical root distribution and with the horizonation of the soil. This fact is especially important depending on the sampling objectives. In case of ecological or population dynamics studies, diagnostic soil samples collected from the surface to 20-30 cm deep would seriously underestimate the nematode population (e.g., on bananas from 11.4% up to 91.6% depending on the nematode species) on this particular type of soil.

MORPHOLOGICAL STUDIES OF SOME PREDACEOUS NEMATODES (MONONCHIDAE), FROM TEXAS. **Rahman, Fawzia H. A.** Biology Department, Texas Southern University, Houston, TX 77004.

Some soil samples were collected from different localities in Houston, Texas, found to contain different species of predaceous nematodes of genera *Mylenchulus, Mononchus*, and *Miconchus*. The *Mylenchulus sp.* is characterized by globular, funnel-shaped buccal cavity, with large dorsal tooth projecting anteriorly located in the anterior 1/3 of the stoma, six smaller ventral teeth, five or six rows of fine denticles, and two small basal ventral teeth, esophago-intestinal valve none tuberculate, spinnenet is terminal. *Mononchus sp.* with globular stoma, wider anteriorly than posteriorly, dorsal tooth located in the anterior 1/3 of the stoma, projecting forward, one or two small basal ventral teeth, esophago-intestinal valve none tuberculate, caudal glands, and spinnenet absent. *Miconchus sp.* with barrel-shaped buccal cavity, three equal sized teeth located dorsally, ventrally and subventerally, two smaller, ventral, basal teeth; esophago-intestinal valve tuberculate, caudal glands and spinnenet present.

CHARACTERIZATION OF A *MELOIDOGYNE INCOGNITA* GENE ENCODING A SUBVENTRAL ESOPHAGEAL GLAND SECRETORY GRANULE PROTEIN. **Ray, Celeste, and R. S. Hussey.** Department Plant Pathology, University of Georgia, Athens, GA 30602-7274.

Isolating genes that encode esophageal gland secretory proteins will facilitate characterization of the function and expression of nematode secretions involved in parasitism of plants. We have isolated a clone from a *M. incognita* female oligo d(T) cDNA expression library using a monoclonal antibody that binds an antigen in the subventral glands of females but not the subventral glands of preparasitic second-stage juveniles. Hybridization of the cDNA insert to Southern blots containing *M. incognita, M. arenaria, M. javanica, M. hapla, Heterodera glycines, Caenorhabditis elegans*, and tomato genomic DNA indicated that analogous sequences were present in all four *Meloidogyne* species, but not in *H. glycines, C. elegans*, or tomato. The corresponding genomic clone also has been isolated from a *M. incognita* genomic library and the gene named *mis-1* for *M. incognita* secretion. *Mis-1* contains at least five introns that are similar to *C. elegans* introns in size, AT content, and intron border sequences. Preliminary analyses of the predicted amino acid sequence of the *mis-1* protein indicated homologies with several myosin heavy chains.

REPRODUCTIVE INDICES OF THE RENIFORM NEMATODE ON FOUR SOYBEAN CULTIVARS IN ARKANSAS. **Robbins, R. T., L. Rakes, and C. R. Elkins.** Nematology Laboratory, University of Arkansas, Fayetteville, AR 72701.

An Arkansas River valley field near Pine Bluff, Arkansas known to be infested with the reniform nematode, (*Rotylenchulus reniformis*), was selected as a site to test the reproductive

indices Pf/Pi of the reniform nematode on four commonly grown soybean cultivars. At the time of planting (Pi) the plots averaged 950 vermiform nematodes/100 cm^3 of soil. The average nematode Pf/Pi ratio at harvest was 1.59 for 'Tracy-M', 1.46 for 'Lloyd', 1.02 for 'Bedford', and 0.48 for 'Forrest'. Significantly greater yields were obtained from the cultivars Lloyd and Bedford, less for Forrest, and least for Tracy-M. When all cultivars were calculated together, the at-planting nematode numbers were positively correlated ($P \leq 0.05$) with nematode numbers at-harvest (Pf). Neither at-plant nor at-harvest reniform nematode numbers were correlated with yield.

RENIFORM NEMATODE REPRODUCTION ON 30 SOYBEAN CULTIVARS. **Robbins, R. T., L. Rakes, and C. R. Elkins.** Nematology Laboratory, University of Arkansas, Fayetteville, AR 72701.

In 1991 and 1992 greenhouse tests 30 soybean cultivars were tested for resistance to *Rotylenchulus reniformis*, the reniform nematode (RN) by using the reproductive index Pf/Pi to test for reproduction (Pi = 2 vermiform nematodes/cm^3 soil). The most RN-resistant cultivar tested was Forrest (combined Pf/Pi = 4.2). The cultivars Coker 485 (5.8), Sharkey (7.6), Centennial (8.4), and Stonewall (8.9) were not significantly different from Forrest. Braxton (84.2), the most susceptible cultivar, was not significantly different from Lloyd (67.1), Lee 74 (54.3), Coker 6955 (63.1), Walters (53.9), Davis (52.7), Pioneer 9442 (44.2), and Narow (52.7). The remaining cultivars could not be separated by their RN reproduction indices because of overlap. The cultivars Leflore and Lloyd exhibited a high degree of variation in Pf/Pi. The variation may be due to multiple genes for resistance and(or) segregation for resistance among individual seedlings.

MOVEMENT OF FIVE NEMATODE SPECIES IN RESPONSE TO VERTICAL TEMPERATURE GRADIENT FLUCTUATIONS. **Robinson, A. F., and A. C. Bridges.** Rt. 5, Box 805, USDA, ARS, College Station, TX 77845.

Process controllers and 2,560 cm^3 plastic tubes (15 cm long) filled with sand were employed to subject *Meloidogyne incognita*, *Rotylenchulus reniformis*, *Ditylenchus phyllobius*, *Steinernema glaseri*, and *Heterorhabditis bacteriophora* to temperature gradient fluctuations that occur as a result of heating and cooling of the soil surface. Nematodes were adapted to fluctuating temperatures for 36 hours at a simulated depth of 15 cm before being injected into the centers of tubes at that depth. When heat waves were propagated horizontally to eliminate gravitational effects, *R. reniformis* consistently moved to the end of the tube away from the thermal source and *M. incognita* moved toward the thermal surface within 24 hours. The initial direction of movement 1.5 hours after introduction to tubes at five depths at five intervals within a 24-hour cycle indicated that *M. incognita* moved away from and *R. reniformis* moved toward the temperature to which last exposed. There also were pronounced differences among the five species tested in movement toward or away from the gravitational surface.

IDENTIFICATION OF *PRATYLENCHUS* SPECIES BY THE POLYMERASE CHAIN REACTION (PCR). **Samac, Deborah A., and David Linden.** Department of Plant Pathology, USDA, ARS, University of Minnesota, St. Paul, MN 55108.

A PCR-based technique is being developed to identify the species of individual nematodes in the genus *Pratylenchus*. A simple, rapid tool for identification is valuable because species in this genus are morphologically similar and taxonomic characters are highly variable. Nematodes for this work were grown aseptically on corn root cultures. DNA was isolated by grinding nematodes in liquid nitrogen, then incubating in a buffer containing 100 mM Tris pH 8.5, 5 mM EDTA, 200 mM NaCl, 1% SDS, and 1 mg/ml proteinase K at 65 C for 15 minutes followed by phenol extraction and ethanol precipitation. DNA from individual nematodes was extracted by crushing

single adults in sterile water and adding the suspension directly to the PCR mix. The PCR reaction conditions and mix components were varied to achieve clear and reproducible banding patterns. Single oligonucleotide primers (10-mers) were identified that gave distinct molecular fingerprints for *Pratylenchus penetrans*, *P. scribneri*, *P. hexincisus*, and *P. agilis*. This method will be useful for identification of nematodes, as well as in studies to assess variability within populations.

THE INTERRELATIONSHIPS OF *ROTYLENCHULUS RENIFORMIS* WITH *RHIZOCTONIA SOLANI* ON COTTON. **Sankaralingam, A.[1], E. C. McGawley[1], and C. Overstreet[2].** [1]Department of Plant Pathology and Crop Physiology, and [2]Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, Baton Rouge, LA 70803.

The interrelationships between reniform nematode (*Rotylenchulus reniformis*) and the cotton (*Gossypium hirsutum*) seedling blight fungus (*Rhizoctonia solani*) were studied in the greenhouse using three isolates of *R. solani*, two populations of *R. reniformis* at multiple inoculum levels and two cotton cultivars (Deltapine 41 and 90). Colonization of cotton hypocotyl tissue by *R. solani* resulted in significant increases in nematode population densities in soil and egg production on roots in 40 and 90-day-duration experiments. Enhanced reproduction of *R. reniformis* in the presence of *R. solani* was consistent across both cotton cultivars, three isolates (1, 2, and 3) of *R. solani*, two populations and four inoculum levels (0.5, 2, 4, and 8/g soil) of *R. reniformis*. Severity of seedling blight was not influenced by the nematode. The relationship between nematode inoculum levels and plant growth reductions was linear. At 90 days, when the nematode and fungus were together, combined effects caused by the pathogens were antagonistic to cotton growth.

INFLUENCE OF *RHIZOCTONIA SOLANI* ON EGG HATCHING AND INFECTIVITY OF *ROTYLENCHULUS RENIFORMIS*. **Sankaralingam, A., and E. C. McGawley.** Department of Plant Pathology and Crop Physiology, Louisiana State University Agriculture Center, Baton Rouge, LA 70803.

The effect of culture filtrates of *Rhizoctonia solani* and the influence of root exudates from *R. solani*-infected cotton seedlings on hatching of eggs of *R. reniformis* was evaluated in the laboratory. Infectivity of vermiform female reniform nematodes to *R. solani*-infected and noninfected cotton seedlings was also determined. Filtrates of *R. solani* obtained from potato dextrose broth inhibited egg hatching of *R. reniformis*. Filtrates of *R. solani* collected from sterile distilled water did not affect the egg hatching. Exudates from roots of cotton seedlings increased the hatching of eggs of *R. reniformis*. Root exudates from *R. solani*-infected and noninfected seedlings did not differ in their effect on egg hatching. Infectivity of vermiform females to cotton seedlings, however, was significantly enhanced by fungal infection and this probably accounts for most of the enhanced egg production and soil population densities observed in greenhouse studies.

BIOLOGY AND FINE STRUCTURE OF THE TURBELLARIAN, *ADENOPLEA* SP. THAT PREYS ON ROOT-KNOT NEMATODES. **Sayre, R. M.[1], and W. P. Wergin[2].** [1]Nematology Laboratory, Building O11A, BARC-West, USDA, ARS, Beltsville, MD 20705, and [2]Electron Microscopy Laboratory, Building 177B, BARC-EAST, USDA, ARS, Beltsville, MD 20705.

A soil turbellarian which was found in the greenhouse preying on *Meloidogyne incognita* juveniles was moved to the laboratory where it was cultured by using the free-living nematode, *Panagrellus redivivus*, and juvenile stages of plant-parasitic nematodes. Mature specimens of the turbellarian were collected and either chemically fixed, embedded and sectioned for observation in a transmission electron microscope, or frozen in a hydrated state and fractured for low temperature observation in a field-emission scanning electron microscope. The biology and fine structure of this nematophagous turbellarian were studied to determine the proper taxonomic

placement of the new species in the genus *Adenoplea* and to evaluate its potential as a possible biological control agent of plant-parasitic nematodes.

EFFECTS OF EARTHWORMS ON DISPERSAL OF *STEINERNEMA* SPP. **Shapiro, D. I.[1], G. L. Tylka[2], E. C. Berry[3], and L. C. Lewis[4].** [1]Department of Entomology, and [2]Department of Plant Pathology, Iowa State University, Ames, IA 50011, and [3]National Soil Tilth Laboratory, and [4]Corn Insects Research Unit, USDA, ARS, Ames, IA 50011.

Dispersal of the nematodes *S. carpocapsae*, *S. feltiae*, and *S. glaseri*, applied to the top or the bottom of soil columns, was tested in the presence or absence of two earthworm species, *Lumbricus terrestris* or *Octolasion tyrtaeum*. Nematode dispersal was estimated after a 2 week period by direct extraction followed by enumeration of nematodes and with a bioassay against the greater wax moth, *Galleria mellonella*. Because *L. terrestris* produces mostly vertical burrows, whereas *O. tyrtaeum* produces mostly horizontal burrows, the effects of these earthworms on nematode dispersal can vary. The potential of earthworms to enhance nematode dispersal directly by acting as phoretic hosts was examined.

GENES FOR RESISTANCE TO *HETERODERA CAJANI* IN *CAJANUS PLATYCARPUS*. **Sharma, S. B.** International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India.

Cajanus platycarpus, a promising wild relative of pigeonpea, is a reservoir of useful genes not available in pigeonpea (*Cajanus cajan*) germplasm. Pigeonpea is an important grain legume in subsistence farming systems in India and *Heterodera cajani* is an important nematode pest of pigeonpea in India. There are no pigeonpea cultivars with resistance to *H. cajani*. Therefore, germplasm accessions of *C. platycarpus* were evaluated for resistance to *H. cajani* in greenhouse tests. Scarified seeds of 12 accessions were sown in sandy soil infested with 6-10 eggs and juveniles of *H. cajani*/cm^3 soil in 15-cm-d pots. At 35 days after seedling emergence, plant roots were evaluated on a 1 (highly resistant) to 9 (highly susceptible) white cyst index based on number of white cysts (females) on each root: 1= no cyst, 3 = 1-5, 5 = 6-10, 7 = 11-30, and 9 = > 30 cysts. Three accessions, ICPWs 62, 69 and 70 were resistant with average cyst indices between 1.7 and 2.6. All other accessions ICPWs 60, 61, 63-65, 67, 68, 71, and 72 were susceptible. Resistance in the three accession was confirmed in repeat tests.

RESISTANCE AND TOLERANCE OF PINEAPPLE TO *ROTYLENCHULUS RENIFORMIS* AND *MELOIDOGYNE JAVANICA*. **Sipes, B.** Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.

Eighteen cultigens of *Ananas comosus* (pineapple) were evaluated for resistance (nematode Pi > Pf) and tolerance (reduction in root biomass) to reniform (*Rotylenchulus reniformis*) and root-knot nematodes (*Meloidogyne javanica*). Pineapple crowns were inoculated with 1,500 reniform eggs, or 5,000 root-knot nematode eggs. After 8 months, dry root weight, nematodes per 250 cm^3 soil, and number of eggs per root were recorded. All cultigens supported nematode reproduction. *Ananas bracteatus* allowed the greatest reproduction of root-knot nematode (Pf > 80 Pi). *Ananas ananassoides* supported the least root-knot nematode reproduction and showed little dry root weight reduction with root-knot nematode infection. Pernambuco and a Cayeene X *Psuedomonas* hybrid allowed the greatest reniform nematode reproduction (Pf > 30Pi). Smooth Cayenne supported one of the lowest levels of reniform nematode reproduction and exhibited less dry root weight reduction than other cultigens. *Ananas ananassoides* may be a source of root-knot nematode resistance or tolerance. Screening will continue for sources of reniform resistance (tolerance).

MOLECULAR VARIATION IN AUSTRALIAN POPULATIONS OF ROOT-KNOT

NEMATODES (*MELOIDOGYNE* SPP.). **Stanton, J. M.[1], A. F. Hugall[2], C. Moritz[2], and W. E. O'Donnell[1].** [1]Queensland Department of Primary Industries, Indooroopilly Q 4068, and [2]University of Queensland, St Lucia Q 4072.

We have characterized many Australian populations of *Meloidogyne* spp. by perineal pattern, standard host range, esterase phenotype, and mtDNA RFLP's. We have also sequenced several mtDNA genes ($tRNA^{His}$, l-rRNA, ND3, cytochrome b), which reveals mtDNA sequence divergence between *M. arenaria*, *M. javanica*, and *M. incognita* at $< 1\%$ to be far less than previously reported, but that the divergence between *M. hapla* and these species (23-25%) is much more than reported. For all, within-species divergence was low. Perineal pattern and standard host range did not correlate well with mtDNA haplotypes and esterase phenotypes, but these biochemical characters were perfectly correlated. We suggest that further studies of these nematodes focus on molecular groups, whether or not these coincide with existing taxonomic units.

VARIATION AMONG ISOLATES OF *HIRSUTELLA RHOSSILIENSIS*. **Tedford, E. C., B. A. Jaffee, and A. E. Muldoon.** Department of Nematology, University of California, Davis, CA 95616.

Twenty-nine isolates of the nematophagous fungus *Hirsutella rhossiliensis* were obtained from different hosts and geographical locations. All isolates infected *Meloidogyne javanica*, *Heterodera schachtii*, and *Steinernema glaseri* in vitro, but isolates from *Rotylenchus robustus*, and *Hoplolaimus galeatus* infected more slowly than did those from other nematode species or mites. In soil microcosms, *H. schachtii* acquired spores of all isolates, but the percentage of *H. schachtii* that acquired at least one spore in 66 hours at 20 C was $19.2 \pm 0.9\%$ with isolates from *R. robustus* and *H. galeatus* and $48.6 \pm 1.6\%$ with other isolates. Isolates from *R. robustus* and *H. galeatus* produced larger spores (9 x 6 μm vs 7 x 5 μm) and grew slower (0.5 vs. 0.9 mm/day at 20 C) on cornmeal agar than did other isolates. The hypothesis that isolates from *R. robustus* would infect *R. robustus* better than would those from *H. schachtii* was tested and rejected. RAPD analysis of genetic variability showed clustering based on host nematode but not on geographical location.

RELATIONSHIP OF BROADLEAF WEEDS AND NUTSEDGES TO *MELOIDOGYNE INCOGNITA* POPULATIONS IN CHILE PEPPERS. **Thomas, S. H.[1], J. Schroeder[1], B. Vezzani[1], and L. W. Murray[2].** [1]Department of Entomology, Plant Pathology and Weed Science, and [2]Department of Experimental Statistics, New Mexico State University, Las Cruces, NM 88003.

A field experiment was designed to determine host suitability of common weeds of chile pepper (*Capsicum annuum*) production systems to *M. incognita*. Weeds included yellow nutsedge (*Cyperus esculentus*), purple nutsedge (*C. rotundus*), Palmer amaranth (*Amaranthus palmeri*), spurred anoda (*Anoda cristata*), and Wright groundcherry (*Physalis wrightii*). All were hosts of *M. incognita* in the greenhouse except *A. cristata*, which was not evaluated. Roots of weeds were separated from intermingled chile roots, washed and nematode eggs extracted from both plants 4 weeks after chile emergence and at 2 week intervals during the growing season. Nematode eggs per gram dry root were compared between weed and chile combinations. Nematode inoculum from *C. rotundus* 4 weeks after chile emergence may enhance infection of developing peppers.

PRELIMINARY CHARACTERIZATION OF GENES CONTROLLING *MELOIDOGYNE INCOGNITA*-INDUCED FEEDING SITE DEVELOPMENT IN ALFALFA. **Thomas, S. H.[1], C. Sengupta-Gopalan[2], C. L. Potenza[2], and E. A. Higgins[1].** [1]Department of Entomology, Plant Pathology and Weed Science, and [2]Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003.

Meloidogyne incognita infests more than 25% of the alfalfa acreage in New Mexico, contributing to premature stand decline in this crop. Our ultimate goal is to understand how *M. incognita* induces giant cell formation in alfalfa, with the objective of genetically preventing this process. We have isolated total RNA from infected and uninfected roots of *M. incognita*-resistant and susceptible cultivars 72 hours after inoculation. Poly(A)-RNA was isolated from total RNA by chromatography and used to construct cDNA libraries. Clones chosen from subtractive hybridization libraries are being screened against genes expressed in other plant tissues, developmentally expressed genes, wound induced genes, and RKN-DNA contamination.

THE INTERACTION OF *HIRSUTELLA RHOSSILIENSIS* AND A BACTERIOPHAGOUS NEMATODE IN SOIL. **Timper, P., and B. B. Brodie.** Cornell University, USDA, ARS, Ithaca, NY 14853.

The influence of the bacteriophagous nematode *Teratorhabditis* sp. on the persistence of the nematode-pathogenic fungus *Hirsutella rhossiliensis* (Hr) was studied in a growth chamber. *Teratorhabditis* is susceptible to Hr and is found in high numbers around the roots of potato; consequently, we hypothesized that this nematode would increase the persistence of the fungus by serving as a host. To test this hypothesis, potato plants were grown in Hr-infested soil with and without *Teratorhabditis* for 70 days. The relative amount of Hr conidia in the soil was determined at 10, 30, 50, and 70 days from planting. The results showed that the rate of decline of Hr conidia was similar in pots with and without *Teratorhabditis*. However, a high percentage (82 and 80% at 50 and 70 days) of the nematodes were dauer juveniles. Conidia adhered to the dauer juveniles, but did not penetrate the nematode's ensheathing cuticle. We believe that *Teratorhabditis* has opposing effects on Hr persistence: normal juveniles and adults increase persistence by serving as hosts; however, dauer juveniles decrease persistence by depleting the supply of conidia.

CONTROL OF ROOT-KNOT NEMATODES BY INTEGRATING *PASTEURIA PENETRANS* WITH OXAMYL AND SOLARIZATION IN PROTECTED CROPS IN CRETE. **Tzortzakakis, E., and S. R. Gowen.** Department of Agriculture, University of Reading, RG6 2AT, UK, and Natural Resources Institute, Chatham, ME4 4TB, UK.

In treatments to control a mixed population of *Meloidogyne javanica* and *M. incognita* on tomato, *Pasteuria penetrans* (Pp) was applied at 2.5 x 10^4 endospores/g soil as a spot planting treatment in 6 liters soil and oxamyl was applied in three applications of 0.05 ml a.i./plant. After 20 weeks root galling and eggs/g of root were significantly less in treated plots, but fruit yields were not significantly different from the untreated. Seventeen to 25% of females in Pp treated plants were parasitized. A succeeding cucumber crop benefitted from incorporation of roots containing cadavers of Pp infected nematodes and the residual inoculum from the first crop; in Pp and Pp and oxamyl (3 x 0.1 ml a.i./plant) treatments, there were significant decreases in galling, eggs per gram root and juveniles in soil. Sixty five-75% of females were parasitized and 63-70% of juveniles were encumbered with endospores from soil in Pp treated plots. In a separate experiment Pp (at same concentration), oxamyl (3 x 0.18 ml a.i./plant), and 50 days solarization (maximum 44 C at 10 cm) alone and in combination significantly reduced galling, eggs per gram root, and juveniles in soil.

STUDY OF RHIZOSPHERE MICROFLORA OF VELVETBEAN (*MUCUNA DEERINGIANA*) IN A ROTATION SYSTEM. **Vargas, Roberto, and R. Rodríguez-Kábana.** Department of Plant Pathology, Auburn University, AL 36849.

A microplot trial was established to evaluate soil microflora and nematode populations in a rotation program using nematode-suppressive and nonsuppressive legumes. Nematode-susceptible cowpea (*Vigna unguiculata*) and velvetbean (suppressive crop) were planted in a randomized block

design with eight replications. Samples were collected from microplots with velvetbean and cowpea to evaluate bacterial, fungal and nematode populations. Rhizospheres of velvetbean sustained a more diverse microflora with a greater diversity of bacterial genera and higher population density of *Penicillium spp.* than cowpea. Populations of *Meloidogyne incognita* and *Heterodera glycines* decreased considerably in soil planted with velvetbean.

TRANSFER OF *MELOIDOGYNE INCOGNITA* HEAT STABLE RESISTANCE FROM *LYCOPERSICON PERUVIANUM* TO TOMATO VIA BRIDGE LINES. **Veremis, J. C., and P. A. Roberts.** Department of Nematology, University of California, Riverside, CA 92521.

Clones of *Lycopersicon peruvianum* and *L. peruvianum* var. *glandulosum* genotypes resistant to *Meloidogyne incognita* at high soil temperature (30 C) were crossed with *L. esculentum-L. peruvianum* bridge lines. The incongruity barrier between the two plant species was overcome: F1 progeny were obtained from crosses between four parental combinations. Hybridity was confirmed by differences in leaf and flower morphology and by resistant F1 seed production on homozygous susceptible female parent plants. In growth pouch and cone-tainer experiments F1 plants were highly resistant to *M. incognita* at 25 and 30 C. Mature fruits with seeds were produced in tomato cultivar x resistant F1 crosses for use in recurrent backcrossing to introgress resistance.

EFFECT OF COVER CROPS ON *MELOIDOGYNE HAPLA* ON LETTUCE GROWN IN ORGANIC SOIL. **Viaene, N. M. M., and G. S. Abawi.** Department of Plant Pathology, Cornell University, Geneva, NY 14456.

Host suitability of six cover crops and the influence of their incorporated green manures to *Meloidogyne hapla* were determined in the greenhouse. Phacelia, oilseed radish, oat, rye, and a sudangrass hybrid 'Trudan 8' were all poor hosts to M. hapla, but white mustard was as good a host as lettuce. Plants were grown for 9 weeks in 1 liter pots, filled with soil infested with 16,000 eggs of M. hapla. Plant materials were incorporated into the soil and planted to lettuce after 3 weeks. Egg production of M. hapla and root galling severity were determined after 2 months. Reproduction of M. hapla on lettuce grown after sudangrass and in the fallow control was around 700 eggs/root system, whereas reproduction after lettuce, rye and phacelia was 5 to 7.5 time greater. Root galling severity on lettuce (on a 1 to 9 scale) sown after fallow and sudangrass was 2.2 and 2.6 respectively, whereas root galling severity averaged about 7 after lettuce, rye, and phacelia. Radish, oat, and mustard gave intermediate results.

SUSCEPTIBILITY OF TWELVE GARDEN HERBS TO ROOT-KNOT NEMATODE, *MELOIDOGYNE INCOGNITA* RACE 3. **Walker, J. T., and J. B. Melin.** Department of Plant Pathology, Georgia Station, University of Georgia, Griffin, GA 30223-1797.

Interest in the culinary, medicinal, and aesthetic value of herbs continues unabated, yet their potential effects on plant-parasitic nematode populations or vice versa are frequently overlooked. Twelve commonly-grown garden herb species (balm, basil, coriander, dill, marjoram, oregano, peppermint, rosemary, sage, tansy, thyme, wormwood) were evaluated for their susceptibility to *M. incognita* race 3 under greenhouse conditions. Plants were thinned to 4 to 5 seedlings/360 cm^3 pot when 1 cm in height, then infested with 0, 2, 5,or 15 eggs/cm^3 harvested from eggplant (*Solanum melogena* cv Black Knight). The highest infestation level caused a decrease in plant dry weight of five herbs ($P \leq 0.01$). The highest gall index was recorded for wormwood (2.5); marjoram, oregano, and peppermint had no galls. No nematode infection occurred on these latter three herb species in repeated experiments, suggesting that they may be effective for reducing population densities of *M. incognita*.

THE DISTRIBUTION OF *HETERODERA GLYCINES* IN MICHIGAN. **Warner, F. W., B.**

Mather, G. W. Bird, and J. Davenport. Department of Entomology, Michigan State University, East Lansing, MI 48824-1115.

A detection survey was conducted in Michigan for *Heterodera glycines* in 1992. *Heterodera glycines* was positively identified in 11 of the 16 Michigan counties sampled and tentatively from a twelfth. The nematode was recovered from 53% of 149 samples collected. The infestations were located in the southeast, east central and southwest soybean producing regions of the state. Absolute frequencies of detection ranged from 6-100% and absolute densities from 0.5-127.5 cysts of *H. glycines*/100 cm^3 soil in the 11 positive counties. These 11 counties comprise ca. 47% of Michigan's acreage planted to soybean annually. Thirty-one percent of the variability in soybean yields from Midland and Saginaw counties was explained solely by the population density of *H. glycines* recovered during the survey. The total numbers of years fields were in soybean production over the past 20 years explained 19% of the variability. Race determinations were completed for 16 samples. Races 1, 3-6, and 14 of *H. glycines* were found to exist in Michigan.

VELVETBEAN FOR THE MANAGEMENT OF ROOT-KNOT IN PEANUT. **Weaver, C. F., R. Rodríguez-Kábana, D. G. Robertson, and L. W. Wells.** Department of Plant Pathology, Agricultural Experiment Station, Auburn University, AL 36849-5409.

The value of velvetbean (*Mucuna deeringiana*) as a rotation crop for control of root-knot nematode (*Meloidogyne arenaria*) in 'Florunner' peanut (*Arachis hypogaea*) was studied in a field experiment initiated in 1989. Treatments in the experiment were: peanut monoculture without nematicide [P(-)], peanut monoculture with the nematicide aldicarb [P(+)], and peanut without nematicide following 2 years of velvetbean (V-V-P). In 1991 and 1992 peanut yields obtained with the V-V-P rotation were respectively 47% and 18.4% higher than the yields obtained with P(-); the P(+) system resulted in a 23% (1991) and 13% (1992) increase in yields over those obtained with P(-). The soil densities of *M. arenaria* juveniles were not significant in the V-V-P system in the years (1989 and 1990) velvetbean was grown.

SUPPRESSION OF ROOT-KNOT DISEASE BY *PASTEURIA PENETRANS*. **Weibelzahl-Fulton, E.[1], D. W. Dickson[1], and E. B. Whitty[2].** [1]Entomology and Nematology Department, and [2]Agronomy Department, University of Florida, Gainesville, FL 32611-0620.

Root-knot disease became less severe over time in a 7-year monoculture of tobacco in a field infested with a mixed population of *Meloidogyne incognita* race 1, *M. javanica*, and a natural population of *Pasteuria penetrans*. Soil collected 0-20 cm deep in March 1993 was subjected to four treatments: autoclaving (AC), microwaving (MW), air drying (DR), or untreated. The suppressiveness of soil from each treatment was bioassayed with tobacco 'Northrop-King 326' (resistant to *M. incognita*), and 'Coker 371-Gold' (susceptible to *M. incognita*) in pots inoculated with 0 or 2,000 second-stage juveniles of *M. incognita* race 1. Endospores were killed by AC, but only slightly affected by microwaving. Root galls, egg masses, and individual eggs were less ($P \leq 0.1$) on Coker 371-Gold in MW, DR, and untreated soils than in AC-treated soil. Fewer ($P \leq 0.05$) egg masses than root galls were detected on both tobacco cultivars in MW, DR, and untreated soil. The reduction in root galling, egg masses, and individual eggs probably resulted from infection of both nematode species by *P. penetrans*.

GENETIC VARIABILITY OF *MELOIDOGYNE* POPULATIONS: SIZE VARIABLE MITOCHONDRIAL DNA ANALYSIS. **Whipple, Lawrence, Nghiem Le, Jean Woodbury, and Bradley C. Hyman.** Department of Biology, University of California, Riverside, CA 92521.

The mitochondrial genomes of *Meloidogyne* spp. contain variable number tandemly repeated sequences, or VNTRs. Primers designed to anneal with sequences that flank a 63 base pair (bp) VNTR were used in polymerase chain reactions (PCR) to assess size-variable alleles maintained within root-knot nematode populations. Unique mtDNA molecules carrying 5 or 8 copies of the

63 bp repeat were fixed in two separate *M. arenaria* strains. Multiple PCR products were generated from *M. javanica* and *M. incognita* DNAs indicating that several mtDNA forms differing by the precise 63 bp repeat copy number are propagated within these cultures. Similar results were obtained from individual *M. incognita* females, indicating that heteroplasmic nematodes comprise this particular isolate. We are now employing our PCR assay to further assess genetic variability within and among root-knot nematode populations.

PENETRATION AND DEVELOPMENT OF *MELOIDOGYNE INCOGNITA* ON ROOTS OF RESISTANT CORN GENOTYPES. **Windham, G. L., and W. P. Williams.** P.O. Box 5367, USDA, ARS, Mississippi State, MS 39762.

Rates of penetration and development of *Meloidogyne incognita* in roots of resistant (inbred Mp307, and S4 lines derived from the open pollinated varieties of 'Tebeau' and 'Old Raccoon') and susceptible ('Pioneer 3110') corn genotypes were determined. Seedlings grown in styrofoam containers were inoculated with 5,000 *M. incognita* eggs. Roots were harvested at 3 day intervals starting at 3 days after inoculation (DAI) to 27 DAI and stained with acid fuchsin. Penetration of roots by second-stage juveniles (J2) at 3 DAI was similar for the four corn genotypes. *Meloidogyne incognita* numbers in Tebeau, Old Raccoon, Mp307, and Pioneer 3110 peaked at 12, 12, 15, and 27 DAI, respectively. Nematode development in the resistant genotypes was greatly suppressed compared to Pioneer 3110. Resistance to *M. incognita* in these genotypes appears to be expressed primarily as slower nematode development rather than differences in J2 penetration.

THE EFFECTS OF SOYBEAN CULTIVAR AND VESICULAR-ARBUSCULAR MYCORRHIZAE ON HOST RESPONSE TO SOYBEAN CYST NEMATODES. **Winkler, H. E., T. C. Todd, and B. A. D. Hetrick.** Kansas State University, Manhattan, KS 66506-5502.

Native vesicular-arbuscular mycorrhizal (VAM) fungi were evaluated in two field locations to determine the effect of VAM on soybean growth and soybean cyst nematode (SCN) population dynamics and damage potential. Ten soybean cultivars differing in susceptibility to SCN were treated with the fungicide benomyl to suppress native VAM and compared to untreated controls. In the SCN-infested soil, VAM colonization increased from 4% in July to 30% in October, whereas in the non-SCN-infested field, VAM increased from 2% to 18%. Colonization was 28% lower on susceptible cultivars compared to resistant cultivars. Benomyl application resulted in a slight reduction in cyst densities. Yields for all cultivars were a function of cyst densities on roots and VAM colonization at harvest ($R^2 = 0.65$). Soybean shoot and root dry weights and VAM colonization were negatively correlated with cyst densities on roots.

THE EFFECT OF SOYBEAN PHENOLOGY ON DORMANCY OF *HETERODERA GLYCINES*. **Yen, J. H., T. L. Niblack, and W. J. Wiebold.** Plant Sciences Unit, University of Missouri, Columbia, MO 65211.

The soybean cv. Clark and three isolines differing for date of maturity were planted in microplots infested at a low (< 500 eggs/100 cm^3 soil) or high (> 10,000 eggs/100 cm^3 soil) initial population (Pi) density of *H. glycines*. Microplots were sampled for nematodes monthly from June 1991-June 1993. Soil temperatures and rainfall were monitored. Dormancy was assessed through measurements of egg hatching, juvenile infectivity, and cyst development: low rates (indicating dormancy) were observed October through May, followed by sharp increases June through July, followed by equally sharp decreases August through October. Dormancy induction was not related to soil temperature. The magnitude of the June-July increases were Pi density-dependent but did not differ consistently among isolines, however, the timing of dormancy induction suggests that it is related to the onset of soybean reproductive growth.

CHANGES IN *HETERODERA GLYCINES* REPRODUCTION OVER TIME WITH DIFFERENT SOYBEAN CROPPING SEQUENCES. **Young, Lawrence D.** 605 Airways Boulevard, USDA, ARS, Jackson, TN 38301.

Reproduction of *Heterodera glycines* on soybean (*Glycine max*) was measured in soil collected over a 10-year period from plots with different cropping sequences. The sequences included continuous 'Bedford', 'Nathan', and D75-10710 soybean (all resistant to races 3 and 14), a 70:30 blend of Bedford and 'Forrest' (resistant to race 3), and two rotations: one of Bedford and corn (*Zea mays*) and the other of Bedford, 'Essex' (susceptible), and Forrest. Each year, cysts developing on Bedford, PI 89772, and PI 90763, expressed as the percentage of cysts occurring on Essex, was measured at 30 days after planting in the greenhouse in soil collected from each cropping-sequence plot. Reproduction on PI 89772 (resistant to races 3 and 14) and PI 90763 (resistant to race 3) was low and declined over time in soil from continuous plots of Bedford, Nathan, and D75-10710 and from plots of the Bedford and corn rotation. Reproduction on Bedford generally increased in soil from plots of Bedford, Nathan, D75-10710, the blend, and the two rotations.