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ABSTRACTS

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ABDEL-RAHMAN, F. H. *Taxonomy and morphology of a new species of Gracilacus sp. parasitic on grapes, with SEM observations.*

A new species of *Gracilacus* sp. is described and illustrated. This new species was collected from roots and soil samples of grapes. LM and SEM studies revealed that this species possesses a long stylet, a vulva located at 85% of the body, a lateral field consisting of 4 lines, and 3 or 4 annuli in the lip region, which is not set off from the body. The mouth opening is located centrally in the cephalic plate; the amphidial openings are large and slit-like and surround the cephalic plate laterally; the lateral lips are reduced; fused subdorsal and subventral lips extend as large lobes to cover the first lip annulus next to the cephalic plate. The tail is pointed; phasmids are located in the same level as the anus, or slightly posterior. *Department of Biological Sciences, Texas Southern University, 3100 Cleburne Avenue, Houston, TX 77004.*

ABOU-SETTA, M. M., and L. W. DUNCAN. *Attraction of Tylenchulus semipenetrans to selected organic and inorganic salts in vitro.*

Attraction of the citrus nematode, *Tylenchulus semipenetrans*, to selected salts was assayed *in vitro*. Nematodes were placed in the center of a plastic petri dish filled with moist sand (150–350 μm, 10% final water content, i.e., 25% holding capacity). Nematodes were allowed to move radially to equidistant sources of water or salt solution over a 2-day period. The number of nematodes in sectors of the dish containing salts expressed as a proportion of nematodes in sectors containing either salt or water was calculated as an attraction index (AI). Thus, AI significantly greater or less than 0.50 indicate attraction or repulsion, respectively. Salts were used at the rate of 0.05 millimoles/ml of the assay unit water content. Potassium acetate, sodium acetate, and $CaCl_2$ were the most attractive salts (AI = 0.81–0.85), followed by NaCl, KCl, potassium formate, and sodium formate (AI = 0.61–0.68). $NaHCO_3$ was neutral (AI = 0.46), whereas Na_2CO_3, potassium citrate, and sodium citrate were repellent (AI = 0.21–0.31). Total radial movement was positively related to percent attraction ($R^2 = 0.44$). Most salts attractive to *T. semipenetrans* were repellent to the root-knot nematode *Meloidogyne incognita*. Cleopatra mandarin fibrous root segments were attractive to *T. semipenetrans* (AI = 0.84) using this assay. In competition studies, nematode attraction to Cleopatra mandarin fibrous root segments was reduced more than 85% by competing sodium acetate gradients. These results suggest the possibility of reducing citrus root infection by *T. semipenetrans* through the use of nontoxic chemical attractants. *University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850.*

ANAND, S. C., A. K. DWIVEDI, and J. A. WRATHER. *Histopathological response to soybean cyst nematode in tolerant soybean PI 97,100.*

PI 97,100 has been reported to have a high degree of tolerance to the soybean cyst nematode (SCN), *Heterodera glycines* Ichinohe; however, the nature of tolerance is not known. The objective of our research was to study the syncytial development in PI 97,100 and compare it with that in SCN-susceptible Essex. Both PI 97,100 and Essex soybeans were inoculated with SCN race 3. The root segments in both soybean lines were examined under the microscope in cross-sections 3, 8, and 18 days after inoculation (DAI). No major anatomical differences were noticed between the two soybean lines 3 DAI; in both, small syncytia were observed at the nematode feeding sites. Eight DAI, the syncytia in Essex had enlarged considerably, whereas the syncytia in PI 97,100 remained almost the same size as before. The syncytia in Essex were 3 to 4 times larger than syncytia in PI 97,100 at 18 DAI. No apparent differences were noticed in the development of SCN females in the two soybean

lines. It appears that the development of large syncytia in susceptible Essex, which retarded the growth of secondary xylem tissue, would result in a greater yield loss. The tolerance to SCN in PI 97,100 is probably due to the development of very small syncytia at the nematode-feeding sites, with no major reduction on yield. *Plant Science Unit, University of Missouri–Columbia, Portageville, MO 63873.*

ANAS, O., and A. K. WATSON. *In vitro mass rearing of the nematode Orrina phyllobia (Thorne, 1934) Brzeski, 1981 and its use as a biological control agent for Solanum elaeagnifolium Cav. (silverleaf nightshade).*

Solanum elaeagnifolium is a perennial noxious weed in many agricultural areas of the United States and Mexico. The potential of the nematode *O. phyllobia*, which forms galls on the aerial parts of the plant, has been documented as a potential biological control agent. A culture system for the in vitro mass rearing of the nematode was established. Shoot tip cultures of the weed were established; and once the plantlets were past the shoot multiplication stage (Stage II), they were subcultured into a different medium with different levels of hormones and inoculated with axenic nematodes. Callus cultures of silverleaf nightshade were also inoculated with the nematodes, as a comparison to determine the increase in the nematode populations. Nematode numbers in galled leaves increased 200–400-fold, whereas on callus tissue the increase was less than fivefold. Studies on the histopathogenesis of the galls induced on the leaves by the nematodes showed hypertrophy and hyperplasia in the leaf tissue. The mature galls contained a cavity lined with giant cells with granular cytoplasm, and the nematodes remained in the cavity. Virulence of the nematodes obtained from this method has been tested in tissue culture and under greenhouse conditions. *Department of Plant Science, Macdonald College of McGill University, Ste-Anne-de-Bellevue, Quebec H9X 1C0, Canada.*

AREVALO-GUERRA, M. A., and B. B. BRODIE. *Effect of selected potato clones on penetration and egression of Pratylenchus penetrans.*

The potato clone L118-2 is resistant to *Pratylenchus penetrans*; however, the mechanism of resistance is unknown. To determine whether root penetration and egression by *P. penetrans* are important resistance factors, a comparative time-course study was performed with the potato clones L118-2 and NY 85 (susceptible). Seedlings (10-day-old) growing in clay pots filled with autoclaved soil were inoculated with 3,000 *P. penetrans* consisting of 42%, 37% and 21% juveniles, males and females, respectively. Plants were arranged in a completely randomized design in a growth chamber at 24 C with 15 hours of light. Plants were harvested at 12-hour intervals for 10.5 days. Whole root systems were stained in acid fuchsin (0.05%)–lactoglycerol solution, and nematodes were extracted by maceration and sieving. Total number of vermiform stages in roots was counted. All *P. penetrans* developmental stages penetrated roots of L118-2 and NY 85 in equal numbers. In addition, there were no detectable differences in nematode egression from roots of the two potato clones. These results suggest that penetration and early egression are not factors in the resistance of the potato clone L118-2 to *P. penetrans*. *Department of Plant Pathology, and USDA, ARS, Cornell University, Ithaca, NY 14853.*

AZEVEDO, J. B., and B. C. HYMAN. *Genetic organization of the Romanomermis culicivorax mitochondrial DNA amplicon.*

Large, polymorphic mitochondrial DNAs (mtDNAs) derived from the mermithid nematode *Romanomermis culicivorax* contain a 3.0 kilobase (kb) locus amplified to different copy numbers within individual mtDNA molecules. The complete nucleotide sequences of several cloned 3.0 kb repeating units independently isolated from separate regions of the mitochondrial genome have been determined, indicating a high degree of sequence conservation between these reiterated mtDNA segments. Encoded within each amplified domain are several open reading frames (ORFs), two of which specify polypeptide subunits 3 and 6 of the NADH dehydrogenase complex. Unexpectedly, a third ORF capable of encoding a protein of 238 amino acids contains a 32 amino acid sequence that shares significant sequence identity with the highly conserved heme-binding domain of cytochrome P_{450}, a protein typically encoded by nuclear DNA. Our result is of particular interest in light

of recent evidence that cytochrome P_{450} activity appears to be absent in helminths, including nematodes. *Department of Biology, University of California, Riverside, CA 92521.*

BARILLAS, J. R.[1], G. W. LAWRENCE[1], K. S. MCLEAN[2], and C. HOVERMALE[3]. *Efficacy of nematicides for management of the southern root-knot nematode (Meloidogyne incognita) on kenaf (Hibiscus cannabinus) cv. Tainung 1.*

The efficacy of nematicides to reduce *M. incognita* populations and effects on growth of kenaf were examined. The test was conducted in a field naturally infested with *M. incognita* race 3 with an average initial nematode population density of 646 J2/250 cm^3 of soil. Nematicide treatments consisted of the fumigant 1,3-dichloropropene (1,3-D) (46.74 liters/ha) and the non-fumigants fenamiphos (8.98 kg/ha), aldicarb (7.86 kg/ha), terbufos (11.23 kg/ha), phorate (4.21 kg/ha), ethoprop (13.47 kg/ha), and basamid (298.6 kg/ha). Basamid and 1,3-D were applied 3 weeks before planting, whereas all other nematicides were applied at planting. Nematode populations were followed monthly for 120 days. At harvest, kenaf yields were significantly increased in the plots treated with basamid compared with the untreated control. Kenaf yield was increased 5.9 ton/ha. Yields were greater in all treated plots, except aldicarb, when compared with the control; however, increases were not significant. Yield in plots treated with aldicarb were significantly lower than the yields in all the other nematicide-treated plots. *Meloidogyne incognita* population densities increased to a high of 33,331 eggs and juveniles/250 cm^3 of soil at 90 days after planting. No treatment significantly suppressed *M. incognita* populations over the growing season. [1]*Department of Plant Pathology and Weed Science, Mississippi State University, Mississippi State, MS 39762,* [2]*Department of Agriculture, Northeast Louisiana University, Monroe, LA 71209, and* [3]*South Mississippi Branch Experiment Station, P.O. Box 193, Poplarville, MS 39470.*

BAUJARD, P., D. MOUNPORT, and B. MARTINY. *SEM observations on the morphology of two species of the genus Trichotylenchus Whitehead, 1960 (Nemata: Belonolaimidae).*

The morphology of two species of Trichotylenchus, *T. falciformis* and *T. palustris*, was studied under SEM. Eight characters appear to be constant within the two species: 1) head continuous with body contour; 2) four to six cephalic annules present; 3) labial disc oval, laterally elongated, fused with the second cephalic annule at amphid level; 4) absence of lateral cephalic sectors; 5) fusion of the submedian cephalic sectors dorsally and ventrally; 6) amphidial apertures slit-like, elongated, and parallel to longitudinal body axis; 7) lateral fields areolated with three lines; 8) spicules flanged with a distinct process on dorsal side. These results support the synonymization of *Uliginotylenchus* under *Trichotylenchus.* [1]*Laboratoire de Nématologie, ORSTOM, B.P. 1386, Dakar, Sénégal, and* [2]*Département de Biologie Animale, U.C.A.D., Dakar, Sénégal.*

BAUM, T. J., R. A. DEAN, and S. A. LEWIS. *Isolation and application of Meloidogyne species-specific oligonucleotides.*

A genomic library of *M. arenaria* race 2 (Ma2) was differentially screened with radiolabeled genomic DNA of Ma2 and *M. incognita* race 3 (Mi3). Eighteen clones that hybridized strongly to Ma2 showed little homology to DNA of Mi3. Southern blots prepared from restriction digests of these clones were probed with radiolabeled Ma2 and Mi3 genomic DNA, and five clones were chosen for further study. When used as hybridization probes against Southern blots of restriction-digested DNA of multiple *Meloidogyne* isolates, one of the five clones was specific to Ma and two others hybridized only to Ma and *M. javanica.* Restriction mapping of the Ma-specific clone and hybridization experiments identified the species-specific region to be within a 900-bp Sca I fragment. A rapid method for extraction and dot blotting DNA from single egg masses was developed. The species-specific probe was used to estimate *Meloidogyne* species proportions in mixed field populations. *Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.*

BAUM, T. J.[1], B. A. FORTNUM[2], R. A. DEAN[1], and S. A. LEWIS[1]. *Association of Meloidogyne incognita and M. arenaria in flue-cured tobacco.*

Field experiments were conducted at the Pee Dee Research and Education Center, Florence, South Carolina, to study concomitant populations of root-knot nematode species in different tobacco varieties. *Meloidogyne incognita*-resistant and susceptible tobacco cultivars

were inoculated with eggs of *M. incognita* and *M. arenaria* at different levels and combinations. Length measurements of second-stage juveniles from roots were used to estimate the proportion of each species. The tested *M. incognita* had greater reproduction in mixed populations than any *M. arenaria*. A few *M. incognita* were isolated from resistant plants when previously parasitized by *M. arenaria*. In the second year, species determinations were made with dot blotted DNA of single egg masses and radiolabeled species-specific oligonucleotides. [1]*Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377, and* [2]*Pee Dee Research and Education Center, P.O. Box 271, Florence, SC 29503.*

BECKENBACH, K., M. J. SMITH, and J. M. WEBSTER. *Comparative phylogenetic analysis of the pinewood nematode species complex, based upon a single copy protein-coding gene and spacers of the ribosomal cistron.*

The use of molecular tools in nematode taxonomy and phylogeny has become an established practice in recent years. As in any taxonomic study, the most sensitive methods must be used in order to demonstrate the taxonomic relationships accurately. In this study, 19 isolates of the pinewood nematode species complex (PWNSC) from North America, Japan, and Europe were analyzed with the 5′ end of the heat shock 70A gene (*hsp*70A) and the internal transcribed spacer (ITS) and the non-transcribed spacer (NTS) of the ribosomal gene cistron. The *hsp*70A gene segregated 19 isolates into 9 groups, each with 100% sequence homology. The ITS sequence resulted in fewer groups because of the combining of closely related groups. The NTS showed a high degree of variation within a population. By collating this data with that on the biology of the PWNSC, it would seem that the heat shock gene with its intron may be appropriate for identifying specific and subspecific forms. *Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada.*

BÉLAIR, G., and G. BOIVIN. *Evaluation of Steinernema carpocapsae for control of carrot weevil adults in muck-grown carrots.*

Under controlled environmental conditions, tests were conducted to determine the influence of application method (soil drench, baiting), rates (1×10^3, 1×10^4, and 1×10^5 infective juveniles per 18-cm-d pot), and relative humidity (95, 80, 60% RH) on the efficiency of *Steinernema carpocapsae* against carrot weevil adults (*Listronotus oregonensis*). Soil drench applications of 1×10^3, 1×10^4, and 1×10^5 *S. carpocapsae* significantly reduced by 35, 59, and 86%, respectively, the oviposition rate of carrot weevil (CW) adults at 95% RH. At 80 and 60% RH, the baiting method significantly reduced by 77 and 63%, respectively, the oviposition rate of CW adults, but all drench applications were ineffective. A significant rate effect was recorded from the drench applications at 95 and 80% RH. In two field microplot experiments, soil drench application at the rate of 2×10^5 infective juveniles per row meter provided a 44% mean reduction of CW damage the first year and no significant reduction the second year. The application of nematodes did not influence the level of CW egg parasitism by *Anaphes* spp. (Hymenoptera: Mymaridae). Under large field conditions, soil drench application at the same rate reduced CW damage by 30% when compared to the untreated controls, whereas the insecticide treatment with phosmet (Imidan) provides a 66% reduction. *Research Branch, Agriculture Canada, Research Station, Saint-Jean-sur-Richelieu J3B 3E6, Canada.*

BENT, A. F., B. N. KUNKEL, and B. J. STASKAWICZ. *Use of Arabidopsis and Pseudomonads for molecular genetic dissection of plant disease resistance.*

Race-specific ("gene-for-gene") resistance has been demonstrated for the interaction between *Arabidopsis* and *Pseudomonas syringae* pv. *tomato*. Pathogen genes that determine avirulence have been cloned and characterized. Specific soybean cultivars are also resistant to bacteria carrying avirulence genes *avrRpt2* and *avrB*, suggesting that extremely similar pathogen recognition mechanisms are present in *Arabidopsis* and soybean. Isogenic bacterial strains that differ by the presence or absence of single avirulence genes are being used to analyze plant resistance. Plant resistance genes have been identified in crosses between resistant and susceptible *Arabidopsis* ecotypes and through mutagenesis of resistant lines. The extensive map-based cloning tools available in *Arabidopsis* are being used to isolate the relevant plant genes. In a related project, ethylene-insensitive *Arabidopsis* mutants have been

used to study the role of ethylene in disease development. Ethylene apparently mediates symptom formation and is not required for resistance, suggesting a possible strategy for enhancement of disease tolerance in crops. *Department of Plant Pathology, University of California, Berkeley, CA 94720.*

BERNARD, E. C.[1], and D. P. SCHMITT[2]. *Nematodes of Hawaiian native plant communities.*

Nematodes were extracted from 320 soil samples collected from the islands of Hawaii, Kauai, Maui, Molokai, and Oahu. Most of the samples were collected from native forest with little or no exotic plant intrusion. Plant-parasitic nematode species richness was greatest on the oldest island, Kauai (15 species), lowest on the youngest island, Hawaii (five species), and intermediate on the other islands. *Xiphinema* spp. were particularly diverse, with species related to those of North America and the eastern Pacific region. Among putative fungivores, Aphelenchoidea were uncommon and *Aphelenchus avenae* was never found, but numerous *Tylenchus-Filenchus-Lelenchus* taxa were collected. Densities and richness of bacterivorous species were very low, with Cephalobidae predominating. An analysis of Molokai nematodes was undertaken. Nematodes from four plant community types (in descending altitude, montane bog [Community 1], *Metrosideros-Cibotium* rainforest [2], *Metrosideros-Pelea* wet mesic forest [3], and *Pelea-Cheirodendron-Metrosideros* wet mesic forest [4]) were identified and counted; 62 species-level taxa were recognized. Total nematodes per 100-cm^3 subsample rarely exceeded 200 individuals. In most samples, plant-parasitic nematodes were numerically the most abundant. Distributions of some species were sharply restricted. For example, of the two *Helicotylenchus* spp. collected, an amphimictic species was found only in community 1 and a parthenogenetic species only in community 2. All samples in communities 2–4 contained substantial numbers of a *Criconema* sp. similar to *C. longula.* Community 4 had high numbers of *Paratylenchus* sp., *Prismatolaimus* sp., and a *Xiphinema* sp. of the *X. americanum* group. There was no evidence that exotic species common in agricultural fields have dispersed into the remaining native vegetation. [1]*Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37901-1071, and* [2]*Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.*

BERNEY, M. F., and G. W. BIRD. *Effect of temperature on hatching of Heterodera carotae.*

Field-collected cysts of *Heterodera carotae* were submerged in root filtrates collected from greenhouse grown carrots. Cysts were held at 5, 10, 15, 20 and 25 C. Counts were made daily of the number of second-stage juveniles emerging. Root filtrates were replaced weekly. The treatments were followed for 25–32 weeks before emergence ended. No emergence occurred at 25 C, and the patterns of emergence at the other temperatures were distinctly different from each other. The largest number of juveniles emerged at 15 C, but the emergence was most discrete and sudden at 10 C. The temperature response and timing of emergence show a strong relationship to seasonal plant growth and field soil temperatures. *Department of Entomology, Michigan State University, East Lansing, MI 48824.*

BINDER[1], B. F., A. B. DEMILO[2], J. P. KOCHANSKY[3], and D. J. CHITWOOD[1]. *Inhibition of reproduction in Caenorhabditis elegans by a reduced aromatic Schiff base and related compounds.*

Caenorhabditis elegans was propagated sterilely in semidefined aqueous medium. Insect juvenile hormones, insect juvenile hormone mimics, and the anti-juvenile hormone precocene II were added and evaluated for biological activity. The compounds had no effect at concentrations ≤ 100 µg/ml. A reduced aromatic Schiff base, *N*-[4-(phenoxyphenyl)-methylene]-2,6-difluorobenzylamine, is known to act as a juvenile hormone mimic in insects. When added to *C. elegans* medium, it inhibited nematode reproduction, with an ED_{50} of approximately 100 µg/ml. Modification or simplification of the reduced Schiff base often increased biological activity, and 4-(phenoxy)benzyl alcohol had the highest activity, with an ED_{50} of 3.0 µg/ml. [1]*Nematology Laboratory,* [2]*Insect Chemical Ecology Laboratory, and* [3]*Insect Neurobiology and Hormone Laboratory, USDA, ARS, Building 011A, Beltsville, MD 20705.*

BIRD, G. W., F. W. WARNER, R. L. MATHER, M. K. UYGUNANCO, and A. J. DULAN. *Impact of Steinernema carpocapsae on specific life cycle stages of Leptinotarsa decemlineata.*

Leptinotarsa decemlineata (Colorado potato beetle) presents a unique challenge to potato growers because of resistance to both chemical insecticides and the biological control agent,

Bacillus thuringiensis. It is important, therefore, to explore other control alternatives. Four stages of *L. decemlineata* (2nd instar, 3rd instar, 4th instar and adult) were exposed to five population densities (0, 1, 10, 100, 1,000) of *Steinernema carpocapsae* applied directly to the surface of the insect or to potato foliage. Application of *S. carpocapsae* to leaves resulted in at least 80% mortality for densities of 10 nematodes or more at day 2 for 2nd instars, at day 3 for 3rd instars, and day 4 for 4th instars. Adult beetles were not affected. Application of *S. carpocapsae* to leaves was slightly more effective than direct application to the insect surface. Reproduction of *S. carpocapsae* occurred within *L. decemlineata*, and infective-stage juveniles exited beetle cadavers. They were introduced into sterilized soil and were able to penetrate *Galleria* sp. and reproduce in this alternative host. *Department of Entomology, Michigan State University, East Lansing, MI 48824.*

BLAXTER, M. L. *Cuticle surface proteins of wild-type and mutant Caenorhabditis elegans.*

The surface of *Caenorhabditis elegans* offers a model system in which to investigate the biochemistry and biophysics of the nematode cuticle. Surface-directed iodination specifically labels cuticular components, including the collagens. Two non-collagenous proteins are also labeled, a heterodimer of 15 kDa, found on all stage, and a dauer-specific 37-kDa molecule. The 15-kDa heterodimer is not glycosylated and is hydrophobic. It is resistant to extraction with organic solvents, indicating that it is not part of the surface coat or the lipid epicuticle. TLC analysis of the lipid from the surface reveals the presence of polar, apolar, and complex glycolipid classes. The *srf* mutants of *C. elegans* have altered surface reactivities to antibodies or lectins. Nematodes mutant at the *srf-2*, *-3*, *-4*, *-5*, *-8*, and *-9* loci lack the 15 kDa heterodimer, suggesting that they define pathways of transport or secretion for molecules destined for the surface. *Wellcome Centre, Department of Biology, Imperial College, London SW7 2BB, England.*

BLAXTER, M. L., S. TWEEDIE, L. INGRAM, A. WATSON, and R. LAWRENCE. *The hemoglobins of the gut-parasitic nematode Nippostrongylus brasiliensis.*

Hemoglobins have been reported in several animal-parasitic nematodes and have been shown to have unique biochemical properties compared to vertebrate globins. The rat parasite *N. brasiliensis* contains two distinct 14-kDa globins, one in the pseudocoelom (with a pI of 7) and another in fluid-filled interstices in the cuticle (pI of 9). The host is exposed to the cuticular globin as the fourth-stage juvenile molts in the gut, and the globin may thus be an important immunogen. Purification of the globins was obtained with preparative two-dimensional gel electrophoresis, and antibodies were raised against the two forms. cDNAs were selected from an expression library and sequenced. The globins are monomeric, myoglobin-type molecules with strong similarity to other nematode globins (*Ascaris*, *Pseudoterranova*, *Trichostrongylus*, and *Caenorhabditis*) but are only distantly related to other invertebrate or vertebrate globin superfamily proteins. *Wellcome Centre, Department of Biology, Imperial College, London SW7 2BB, England.*

BOWERS, J. H., R. M. RIEDEL, and R. C. ROWE. *Effect of Pratylenchus spp. on infection and colonization of potato roots by Verticillium dahliae.*

Factorial greenhouse experiments were initiated to test hypotheses concerning the nature of the interaction between *Verticillium dahliae* (Vd) and *Pratylenchus penetrans* (Pp) or *Pratylenchus crenatus* (Pc) in potato early dying. Soil was infested with known densities of Vd and/or Pp and Pc, and plants were destructively harvested over time. Root samples were excised using a grid method and stained using an immunoenzymatic procedure. Root length and percent colonization were estimated, and healthy and infected root tips were counted. Five weeks after planting, roots grown in soil infested with Vd alone had a very low percentage of infected root tips (1.2%), which was significantly less ($P < 0.05$) than roots growing in soil infested with Vd+Pp or Vd+Pc (2.3 and 2.5%, respectively). However, roots were colonized by Vd to a significantly greater extent ($P < 0.05$) when grown in soil infested with Vd+Pp (0.13 cm of colonized root/m of root) than in soil infested with Vd alone or with Vd+Pc (0.05 and 0.02 cm of colonized root/m of root, respectively). Low levels of initial infection and colonization resulted in high incidences of stem colonization in treatments with Vd+Pp (58%). Infection was not observed to be associated with nematode feeding and the effect of nematodes on initial infection may be non-specific; however, root colonization by

Vd was increased when Pp was present. The interaction between Vd and Pp in potato early dying may occur within the root as an altered or delayed host response to colonization by Vd. *Department of Plant Pathology, The Ohio State University, OARDC, Wooster, OH 44691.*

BRODIE, B. B.[1], and R. L. PLAISTED[2]. *Effect of H_1 gene dosage on the development of Globodera rostochiensis on potato.*

Resistance in potato to *Globodera rostochiensis* (Gn) is conditioned by the dominant gene H_1. Up to 5 cysts of Gn can develop on the root system of a potato plant that possesses this gene. No hypothesis has been advanced to explain why a few cells in resistant potato roots support Gn development whereas a majority of the root system does not. We measured the effects of H_1 gene dosage on development of Gn on potatoes. The resistant cultivar Hudson which has two copies (duplex) of the H_1 gene was self pollinated, and the resultant progenies were test crossed with a Gn-susceptible clone. The progenies of test crosses were evaluated for Gn resistance and from segregation ratios of resistant to susceptible plants, we identified parental clones that possessed 0 (nulliplex), 1 (simplex), 2 (duplex), and 3 or 4 (triplex or quadraplex) copies of the H_1 gene. Potato plants representing these 4 genotypes were evaluated for Gn development in both greenhouse pot tests and sterile root cultures. Numbers of developing cysts were equal on all genotypes, indicating that Gn development on potato is governed by the presence or absence of the H_1 gene and not the number of copies of this gene in the potato genome. [1]*USDA, ARS, Department of Plant Pathology, and* [2]*Department of Plant Breeding, Cornell University, Ithaca, NY 14853.*

BROWN, C. R.[1], H. MOJTAHEDI[2], and G. S. SANTO[2]. *Resistance in potato to Meloidogyne chitwoodi and M. hapla derived from wild Solanum species.*

Selected clones of *Solanum bulbocastanum* and *S. hougasii* were non- or poor hosts for *Meloidogyne chitwoodi* races 1 (Mc1) and 2 (Mc2) and *M. hapla* (Mh). Crosses of *S. tuberosum* with *S. hougasii* indicated single gene inheritance of resistance (non-host status) to Mc1 and complex inheritance of resistance to Mc2. Due to reproductive isolation, the *S. bulbocastanum* genome was introgressed into the cultivated potato gene pool by somatic fusion. Hexaploid protoplast fusions were non- to poor hosts for Mcl, Mc2, and Mh. Nematode reproduction was correlated with tuber damage in field microplot experiments. Protoplast fusions had acceptable tuber traits and were successfully crossed with tetraploid potato breeding clones. [1]*USDA, ARS, and* [2]*Department of Plant Pathology, Washington State University, IAREC, Prosser, WA 99350.*

BROWN, D. J. F.[1], and J. M. HALBRENDT[2]. *The virus vector potential of Xiphinema americanum and related species.*

Xiphinema americanum sensu lato nematodes have been reported as vectors of four nepoviruses indigenous to North America, cherry rasp leaf (CRLV), peach rosette mosaic (PRMV), tobacco ringspot (TobRSV) and tomato ringspot (TomRSV). In 1979 the description of 15 new species in the *X. americanum* group resulted in controversy both with species designation and the specific associations between vectors and viruses. In the early 1980s *X. rivesi* and *X. californicum* were reported as vectors of TomRSV. Researchers in California subsequently reported four of seven *X. americanum sensu lato* populations as vectors of TomRSV, with three of these populations also vectors of TobRSV. New methods for studying virus transmission using single nematodes has enabled the following virus and vector associations to be clearly identified: *X. americanum sensu stricto, X. californicum* and *X. rivesi* are each vectors of CRLV, TobRSV and TomRSV; and *X. bricolensis* is a vector of TomRSV. [1]*Zoology Department, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, and* [2]*Plant Pathology Department, Pennsylvania State Fruit Research Laboratory, Biglerville, PA 17307.*

BURLANDO, T. M., and H. K. KAYA. *Persistence of entomopathogenic nematodes and reduction of black vine weevil in soil.*

The entomopathogenic nematodes *Heterorhabditis bacteriophora* and *Steinernema feltiae* (=*bibionis*) were evaluated for persistence, reproduction, and black vine weevil (BVW) control in planters. *Heterorhabditis bacteriophora* at 3,150 or *S. feltiae* at 2,350 infective juveniles/cm^2 were applied to planters with and without the addition of the alternative non-phytophagous

host *Galleria mellonella*. Controls were planters without nematodes with or without the alternative host. The hypothesis was that an alternative host would bolster BVW control by increasing nematode persistence through reproduction. The two nematode species persisted in planters with or without the alternative host for 377 days, but population densities were higher in planters with the alternative host. Persistence in planters without the alternative host was attributed to the continual reinfestation of BVW. We observed no significant differences among the nematode treatments in the number of BVW recovered at the end of the year-long experiment. The controls had significantly higher levels of BVW than the nematode treatments. *Department of Nematology, University of California, Davis, CA 95616.*

CARES, J. E., and J. G. BALDWIN. *Fine structure of spermatozoa of Verutus volvingentis (Heteroderinae, Nematoda).*

TEM observations on the spermatogenesis of *Verutus volvingentis* indicate that sperm cell division ceases after the last molt. TEM and SEM studies show that the spermatozoa in this species are round to elongate and about 5.0 μm in diameter. They are amoeboid, with many pseudopodia/filopodia unevenly distributed on the body. The distribution of organelles in the cytoplasm is not polarized. Unlike other heteroderids and *Meloidogyne* spp., spermatozoa in *V. volvingentis* do not include a single layer of cortical microtubules lining the plasma membrane. Immature spermatozoa are rich in cytoplasmic fibrillar bodies, whereas mature spermatozoa in the adult male and inseminated female are devoid of these structures. Mitochondria seem to be more abundant in mature sperm. The nucleus lacks a membrane and the chromatin does not suffer drastic changes in the condensation state during development and after insemination. Spermatozoa of *V. volvingentis* are compared with spermatozoa of other genera to aid in phylogenetic analysis of Heteroderinae. *Department of Nematology, University of California, Riverside, CA 92521.*

CASWELL-CHEN, E. P.[1], and P. B. GOODELL[2]. *Potential cover crops for reduction of Meloidogyne incognita in California.*

We assessed the ability of several cover crops to reduce populations of root-knot nematodes (*Meloidogyne incognita*) (Mi) using field and greenhouse experiments. The treatments examined included marigold (*Tagetes erecta* and *T. tenuifolia*), sesame (*Sesamum indicum*), sunnhemp (*Crotalaria juncea*), rhodesgrass (*Chloris gayana*), lovegrass (*Eragrostis curvula*), okra (*Abelmoschus esculentus*), and fallow. The capacity of the cover crops to reduce numbers of Mi in the field was variable, but none of the cover crops supported significant nematode reproduction. Lovegrass did not support nematode reproduction but did not suppress populations of Mi either, even after incorporation of the foliage. Rhodesgrass did not reduce nematode numbers as well as fallow, possibly because rhodesgrass roots were penetrated at a low level and some root-knot nematode development was supported. Mist chamber extractions revealed a very low level of nematode reproduction on rhodesgrass. Sesame did not support reproduction of Mi and may act as a trap crop, as many juveniles penetrated the roots. Both marigold species effectively reduced nematode numbers during growth and after incorporation. Sunnhemp was penetrated by juveniles, and nematode development was supported. The numbers of bacteriophagous nematodes in the soil increased after incorporation of cover crop foliage. Neither the fallow nor the weedy fallow treatments resulted in an increase of bacteriophagous nematodes. [1]*Department of Nematology, University of California, Davis, CA 95616, and* [2]*Integrated Pest Management Program, Kearney Agricultural Station, 9240 S. Riverbend Avenue, Parlier, CA 93648.*

CASWELL-CHEN, E. P., V. M. WILLIAMSON, and F. F. WU. *RAPD analysis of Heterodera schachtii and H. cruciferae populations.*

DNA from multiple females of *Heterodera schachtii* (Hs) and *H. cruciferae* (Hc) was amplified by PCR using random primers. The 19 different random primers used yielded from two-to-twelve fragments ranging in size from 200 to 1,500 bp. Reproducible differences in fragment patterns allowed differentiation of the two species with each primer. Similarities and differences among these populations of Hs were detected. The relationships among six California populations of Hs was assessed using cluster analysis of 78 scorable RAPD markers from 10 different random primers. Jaccard's coefficients revealed that two Imperial Valley populations (approximately 5 km apart) had a similarity coefficient of only 0.45, and

the cluster analysis placed the two populations in the most distant clusters of the dendrogram. Two Clarksburg populations (approximately 8 km apart) had Jaccard similarities of 0.63. The cluster analysis grouped the Clarksburg populations with a Lodi population (34 km from Clarksburg) in the first and second clusters of the dendrogram. These analyses suggest that geographic proximity of populations does not necessarily correlate with relatedness as revealed by RAPDs. RAPD analysis may help define the relatedness among populations and the history of introductions. Comparing RAPD patterns of the six California populations with Hs populations from Florida and New York revealed similarities and differences. DNA from single cysts was successfully amplified, and variability within populations was observed. [1]*Department of Nematology, University of California, Davis, CA 95616.*

CHEN, G., and J. M. WEBSTER. *Effect of entomopathogenic nematodes and their symbiotic bacteria on soil microorganisms.*

Steinernematids and heterorhabditids are used as biological control agents in integrated pest management systems and are symbiotically associated with the bacteria *Xenorhabdus* spp. Although these nematodes naturally occur in the soil, the biotic interactions of the entomopathogenic nematodes and of their symbiotic bacteria with other soil microorganisms are not understood. A study was done on the use of this nematode-bacterium combination as an environmentally safe biological control agent. Experiments were done to investigate the persistence of *Xenorhabdus* spp. in sterile soil. Although both *X. nematophilis* and *X. luminescens* survived for more than one month after having been inoculated into the sterile soil with their culture broth, no antibiotic production was detected. The effect of *Xenorhabdus* spp. on a range of soil microorganisms was tested in petri dish cultures, and the data showed that the growth of many of the organisms was slowed or inhibited. The effect of nematode- and bacteria-killed cadavers of insects killed by *Xenorhabdus* and their nematode associates on natural soil bacterial and fungal populations was investigated. *Department of Biological Sciences, Simon Fraser University, Vancouver, British Columbia, V5A 1S6, Canada.*

CHEN, J., and G. W. BIRD. *Geostatistical studies of a geo-referenced Pratylenchus penetrans-Solanum tuberosum continuum.*

A geo-referenced biological data model from a 1990 experiment of a 100 × 100 agroecosystem grid with 10,000 *Solanum tuberosum* plants stressed by *Pratylenchus penetrans* was analyzed with geostatistical approaches. The univariate features of the data indicated that *P. penetrans* distribution had properties favoring the use of theoretical approaches to estimation. The bivariate features of the data showed similarities and differences in distributions between *P. penetrans* and *S. tuberosum*. The spatial features of the data suggested a predictable relationship in *P. penetrans* populations and *S. tuberosum* biomass in a moving window statistics. A series of six indicator maps were used to record the transition from high *P. penetrans* densities that tended to be aligned in a west to east direction, and then a southwestern to northeastern direction of low *P. penetrans* densities. A semivariance analysis resulted a best-fit ($r^2 = 0.902$) model providing a quantitative estimate of the degree to which *P. penetrans* or *S. tuberosum* sample points in space are correlated with one another by virtue of distance. A means of interpolating values for points not physically sampled were provided in kriging through the Spherical isotropic model. It appeared that the relationship between *P. penetrans* and *S. tuberosum* became progressively weaker over distances, resulting in almost no negative correlation at a distance of ca. 2.5 meters apart. *Department of Entomology, Michigan State University, East Lansing, MI 48824.*

CRAMER, C. L. *Regulation of defense-related gene expression during plant–pathogen interactions.*

Plants have evolved a broad array of defense mechanisms important for disease resistance. These include synthesis of phytoalexin antibiotics and proteinase inhibitors, deposition of cell wall materials, and accumulation of hydrolytic enzymes such as chitinases. Resistance appears to depend on the ability of the host to rapidly recognize the pathogen and induce these defense responses in order to limit pathogen spread. Application of molecular technologies has yielded significant new information on mechanisms involved in pathogen recognition, signal transduction, and defense gene activation, and has provided novel strategies for engineering enhanced disease resistance. We are using these approaches to

analyze regulation of HMG CoA reductase, a key enzyme mediating the production of terpenoid defense compounds. HMG CoA reductase is encoded by four genes in tomato; *HMG2* is induced in response to pathogens or defense elicitors. In order to monitor *HMG2*-specific gene expression, DNA constructs fusing the *HMG2* promoter to a reporter gene have been expressed in transgenic tobacco and tomato. In addition to localized wound- and pathogen-induced expression, *HMG2* is also expressed in hypocotyl tissues, trichomes, and pollen of unstressed plants. *Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.*

DAVIS, E. L., and R. S. HUSSEY. *Monoclonal antibodies that bind to stylet secretions of Meloidogyne incognita.*

Four monoclonal antibodies (MAb) that bound to secretory granules within the dorsal esophageal gland of females of *Meloidogyne* spp. also bound to stylet secretions from adult females of *M. incognita.* Globular secretions produced by living *M. incognita* females incubated in an antibiotic-saline solution for 72 hours were collected with a micromanipulator. The secretions were immobilized on dialysis membranes and processed for indirect immunofluorescence staining with MAb prior to viewing with a fluorescence microscope. Cryosections of 30 day-old *M. incognita* infection sites in tomato roots were tested with the four MAb for immunofluorescent localization of nematode secretory components within infected host tissue. Specific MAb binding was observed immediately outside the giant-cells adjacent to the nematode's head. Second-stage juveniles (J2) of *M. incognita* were incubated in resorcinol to stimulate the production of stylet secretions, and the collected secretions were processed for immunofluorescence microscopy as described above. Monoclonal antibodies that bound to the subventral esophageal glands in J2 also bound to the stylet tip and stylet secretions of J2. These results provide evidence that secretory components synthesized in the subventral glands in plant-parasitic nematodes can move anteriorly in the esophagus and be secreted through the stylet. *Department of Plant Pathology, University of Georgia, Athens, GA 30602.*

DAVIS, R. F.[1], G. R. NOEL[2], and H. T. WILKINSON[1]. *Pathogenicity of Tylenchorhynchus nudus to creeping bentgrass and annual bluegrass.*

Greenhouse and growth chamber experiments were conducted to determine the effect of *T. nudus* on the root growth of bentgrass and annual bluegrass, to compare the effect of *T. nudus* on bentgrass to the effect of *T. nudus* on annual bluegrass, and to examine the nature of the relationship between *T. nudus* population levels and root length on bentgrass and annual bluegrass. Root length and root mass were significantly reduced by *T. nudus* on both creeping bentgrass and annual bluegrass. Annual bluegrass produced longer roots and greater root mass than bentgrass both in the presence and in the absence of nematodes. Evidence suggests that *T. nudus* may decrease root length of annual bluegrass more than it decreases root length of bentgrass. Regression analysis demonstrated that root length is functionally related to *T. nudus* population levels on both annual bluegrass and bentgrass. *Tylenchorhynchus nudus* was clearly proven to be pathogenic to both bentgrass and annual bluegrass. [1]*University of Illinois, Department of Plant Pathology, Urbana, IL 61801, and* [2]*USDA, ARS, University of Illinois, Department of Plant Pathology, Urbana, IL 61801.*

DIAMOND, C. J.[1], D. C. RAMSDELL[2], and G. W. BIRD[1]. *Impact of plant-parasitic nematodes on Vitis labrusca in Michigan.*

A long-term microplot experiment was established in 1984 to investigate the impact of four plant-parasitic nematode species. Soil in the microplots was fumigated with methyl bromide and subsequently infested with specific population densities of *Criconemella xenoplax, Pratylenchus penetrans, Xiphinema americanum,* and *Meloidogyne hapla.* Each treatment was replicated five times in a completely randomized design. Following vine planting in 1984, some microplots were naturally infested with *C. xenoplax* and *P. neglectus.* The *P. penetrans* and *X. americanum* populations declined to undetectable levels. Nematode sampling started in 1985, whereas growth and yield data collection began in 1988. Comparing treatment yields in 1989, 1990 and 1991 indicated that initial yields in 1989 ranged from 1.0–1.4 kg and did not differ ($P = 0.951$). However, the 1990 yields (ranging from 17.4–22.0 kg) had a lower P-value ($P = 0.893$) and in 1991 the P-value decreased to 0.822 (with a yield range from

7.4–10.0 kg). Summing the yield data over the three year period, the *P*-value was 0.706, with a total yield ranging from 16.6–23.1 kg, showing a trend that steadily declined. As the vineyard continues to mature, this decrease should become more significant. The lowest fruit yields were associated with the highest population densities of *M. hapla*. *Criconemella xenoplax* and *P. neglectus* have not yet demonstrated yield reductions. [1]*Department of Entomology, Michigan State University, East Lansing, MI 48824, and* [2]*Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824.*

DONALD, P. A., A. J. KEASTER, and J. A. GRUNDLER. *Root-knot and soybean cyst nematodes on green beans.*

Green bean *(Phaseolus vulgaris)* plots were established in 1991 in southeastern Missouri to identify biological constraints to commercial production. Replicated field plots in four fields naturally infested with the root-knot nematode (RKN) *Meloidogyne incognita* or the soybean cyst nematode (SCN), *Heterodera glycines*, had fumigated strips and side-dressed nematicides applied to reduce nematode densities in experimental plots; control plots were not treated. Plots were sampled for nematodes preplant, at planting, and at harvest. RKN density was assessed by number of J2 per plot and SCN density by number of eggs per plot. Reproduction rates of RKN and SCN (final/initial population density) were less than 1.0, probably because the crop was planted in early April and harvested in mid-June. RKN galls were observed in localized areas, but RKN did not significantly affect green bean pod yields. Yields were significantly decreased by SCN at one location and potato leafhoppers *(Emposca fabae)* at two other locations. Early planting of green beans would allow double cropping, but SCN-susceptible crops should be avoided due to the potential for increase in SCN density and plant damage. *Plant Science Unit, University of Missouri, Columbia, MO 65211.*

DUNCAN, L. W., and J. H. GRAHAM. *Attractiveness of citrus root leachates to three species of plant-parasitic nematodes.*

The attractiveness of citrus root leachates to *Tylenchulus semipenetrans*, *Radopholus citrophilus*, and *Pratylenchus coffeae* was measured in petri plates containing 2.0% water agar. Leachates were obtained by placing citrus seedlings in flasks of aerated water. Leachate or water (control) was placed in wells cut in the agar on opposite sides of the plate, and the numbers of nematodes migrating into defined sectors encompassing the wells were determined after 4 and 24 hours. An attraction index (AI) was calculated as the number of nematodes migrating to the sector containing leachate as a proportion of the total nematodes migrating to the sectors containing leachate or water. Thus, AI significantly greater or less than 0.50 indicate attraction or repulsion, respectively. Leachates from all citrus cultivars tested repelled *T. semipenetrans*. Leachates of the cultivar Swingle citrumelo attracted *R. citrophilus* ($AI = 0.79$, $P < 0.01$) and *P. coffeae* ($AI = 0.78$, $P < 0.01$), but repelled *T. semipenetrans* ($AI = 0.08$, $P < 0.01$). Leachates of *Poncirus trifoliata* and the citrus cultivars Carrizo citrange and Swingle citrumelo, which are resistant to *T. semipenetrans*, were significantly more repellent ($AI = 0.13$, 0.22, and 0.20, respectively) than leachates of the susceptible cultivars Cleopatra mandarin, Volkamer lemon, and sour orange ($AI = 0.29$, 0.39, and 0.29, respectively). *University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850.*

EISENBACK, J. D. *Multimedia presentations for teaching nematology: Lecture one–An introduction to plant nematology.*

The lecture notes from lecture one of an introduction to plant nematology were converted into a multimedia format on a personal computer with an authoring program. The authoring program is analogous to a stack of cards. Each card is a computer screen. Cards contain fields of text and data, pictures, graphics, and buttons that invoke action. Text is typed, imported, or scanned with an optical scanner and converted to an ASCII file with character recognition software. Drawings and photographs are digitized and placed in an appropriate format for display within the lecture. Also, grayscale and color images are displayed within the stack. Animations are created and presented, sounds are digitized and utilized, and other data including short segments of video may be presented. The application of interactive multimedia presentations for teaching nematology promises to revolutionize teaching and change the role of the teacher from the source of information to that of

facilitator. The personal computer facilitates the management of a large volume of information, the integration of various media, and the interaction of the user with the subject matter. Interaction and visualization of phenomena and information are the keys to effective learning. Interactive multimedia incorporates text, pictures, graphics, video, animations, sounds, cartoons, voice, and responses by the student to make learning a stimulating and enjoyable experience. *Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.*

ENDO, B. Y. *Ultrastructure of cuticular exudates in juveniles of Heterodera glycines and related cuticular changes.*

Fibrillar exudates formed on the cuticle surface of parasitic J2 of *Heterodera glycines* during feeding on soybean roots. Accumulation of cuticular exudates was correlated with the fibrillar and porous nature of the epicuticle, exocuticle, and endocuticle. The apparent source of the exudates was the hypodermis, where coalesced secretory vesicles were assembled by the Golgi apparatus system and then were transferred to the inner surface of the apical membrane of the hypodermis. Products of the secretory vesicles were apparently released into a secretion accumulation zone at the base of the endocuticle by some mechanism such as exocytosis and then extruded through and onto the cuticle surface. Golgi bodies occurred in long expanded regions of the hypodermis, especially in the hypodermal cords, where prominent nuclei and other cellular components are located. During ecdysis of the J2 cuticle and during early stages of J3 cuticle formation, fluid-like material accumulated at the secretory-excretory pore. Concurrently, moderately electron-dense material occurred in the invaginated cephalic region and the space extending between the molted J2 cuticle and the entire body of the J3. *USDA, ARS, Nematology Laboratory, Bldg. 011A, BARC-West, Beltsville, MD 20705-2350.*

FERRIS, H. *NEMAPLEX: A menu-driven tutorial in plant nematology.*

A system based on Integra Computing's "Nifty" menu provides access to an interactive key to genera of plant-parasitic nematodes and to lecture notes on biology, host-range, bionomics and management of individual species. Further menu items include biographies of personnel, historical perspectives, principles of management, and recent literature citations for individual genera. The system also provides access to population simulators and sampling strategy optimizers. The system allows students to review lectures at any time and to explore areas in greater depth. A current limitation is lack of graphics and scanned images; that will be remedied by ongoing conversion to a hypermedia format. *Department of Nematology, University of California, Davis, CA 95616.*

FERRIS, H., and S. LAU. *Respiration rates of microbivorous nematodes.*

Temperature-dependent respiration rates were determined from CO_2 evolution of populations on pH-buffered gel in sealed chambers. Chambers were maintained at constant temperature and flushed with CO_2-free air before respiration measurements. The air above the gel surface in each chamber was circulated through an infrared gas analyzer before and after 30-minute respiration periods to measure change in gas concentration. Respiration of associated bacteria was adjusted using CO_2 evolution from nematode-free bacteria control flasks. Total nematode biomass in each chamber was estimated from length and width measurements of a representative sample. CO_2 evolution rates were standardized for age structure of the test population. Rates ranged from approximately 0.01 mg CO_2 per mg nematode per hour at 15 C to 0.031 at 25 C for *Cruznema tripartitum* and 0.036 at 30 C for *Acrobeloides bodenheimeri.* These two species, differing in thermal maxima for respiration rates, were obtained from the same field soil. Respiration rates for a laboratory population of *Caenorhabditis elegans* were comparable, with a maximum at 25 C. Because respiratory rates per unit biomass are similar, participation of these nematodes in energy flow in an ecosystem is a function of size of individuals and of individual and population growth rates. *Department of Nematology, University of California, Davis, CA 95616.*

FERRIS, V. R., J. M. FERRIS, and J. FAGHIHI. *Ribosomal DNA comparisons in Heterodera avenae.*

Partial sequences from internal transcribed spacer ribosomal DNA (ITS rDNA) were compared for six geographic isolates of *H. avenae* including two isolates each from Sweden, Australia, and the United States. The DNA sequence for *H. avenae* was only about 72% similar to comparable sequences for the *schachtii* group of *Heterodera* and 45% similar to that of *Caenorhabditis elegans.* Among the *H. avenae* isolates, the DNA regions sequenced were highly conserved, just as they were conserved among species or isolates of the *schachtii* group. A notable exception was the sequence for the Gotland strain of *H. avenae* from Sweden, which differed from the other *H. avenae* isolates more than *H. schachtii, H. trifolii,* or *H. glycines* differed from each other. *Department of Entomology, Purdue University, West Lafayette, IN 47907-1158.*

FORREST, J. M. S., D. STEWART, and S. M. MACINTOSH. *The effect of different immunization schedules on the specificity of antibodies to juveniles of Globodera rostochiensis and G. pallida.*

The greater the similarity between antigens, the more difficult it is to distinguish them with antibodies raised by standard methods. A protocol which reportedly led to the successful production of stage-specific monoclonals for the slime mold *Dictyostelium* was used in a modified form with potato-cyst nematode juveniles. Rabbits were immunized with juveniles of one species and antibodies to juveniles of the other species. Antibodies derived from this protocol differed from those obtained by immunizing only with whole nematodes in the extent to which they bound to the surface. *Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.*

FORTNUM, B. A.[1], D. R. DECOTEAU[2], and M. J. KASPERBAUER[3]. *Mulch surface color on simulated planting beds affects root-knot of tomato.*

Colored plastic mulches alter the light micro-environment and soil temperature, affecting plant growth and development. The light environment of the shoots can alter root growth and the development of *Meloidogyne* spp. The effects of upwardly reflected light on the development of root knot was studied in simulated planting beds in the greenhouse. Soil temperature was maintained constant among mulch treatments by placing an insulation barrier between the colored mulch and the soil surface. Biomass was recorded after tomato plants were inoculated with 0, 1, 10 or 50 ($\times 10^3$) *M. incognita* eggs per plant and grown for 50 days over three colors of polyethylene mulch. Tomatoes grown over white mulch had greater shoot weights (27%), root weights (33%), and leaf areas (20%) ($P < 0.05$) than similar plants grown over black mulch. Plants grown over red mulch were similar in size to plants grown over black mulch. The light environment of the shoots affected the final nematode populations per plant ($P = 0.04$). Roots of plants grown over red mulch contained 107% more second-stage juveniles/g dry root weight than similar plants grown over white mulch ($P = 0.01$). [1]*Department of Plant Pathology and Physiology and* [2]*Department of Horticulture, Clemson University, and* [3]*USDA, ARS, Route 1, Box 531, Florence, SC 29501-9603.*

FRANCE, R. A., and G. S. ABAWI. *Interaction between Fusarium oxysporum f. sp. phaseoli and Meloidogyne incognita in bean lines resistant or susceptible to both pathogens.*

Five bean *(Phaseolus vulgaris)* lines (Dark Red Kidney, Calima, IPA-1, A-107, and A-211) were each inoculated with three densities of *Fusarium oxysporum* f. sp. *phaseoli* (Fop) and race 3 of *Meloidogyne incognita* (Mi) arranged in a factorial design resulting in 9 treatments. Two bean seeds were planted in 10-cm clay pots filled with pasteurized soil and were immediately inoculated with 0, 1,500, or 3,000 eggs of Mi/pot. After 2 weeks, the seedlings in each treatment were removed and washed, the distal 1 cm of roots were cut, and the roots were then dipped for 5 minutes in sterile distilled water containing 0, 10^4, or 10^6 spores of Fop/ml. All seedlings were transplanted into 10-cm pots with pasteurized soil and maintained in the greenhouse for 4 weeks. Wilt severity was recorded weekly, whereas root galling, number of eggs per root system, root rot severity and plant weight were recorded 4 weeks after inoculation with Fop. On IPA-1 and A-211 (Fop-susceptible), infections by Mi resulted in an earlier onset of wilting symptoms and a significantly higher wilt severity. Calima and Dark Red Kidney (Fop-resistant) exhibited a susceptible reaction to Fop in the presence of Mi. In addition, A-107 (resistant to Fop and Mi) became susceptible to Fop when its

resistance to Mi was broken by incubation at 28 C. *Department of Plant Pathology, Cornell University, Geneva, NY 14456.*

FRANCL, L. J. *A hypertext glossary of nematological terms.*

Hypertext is a form of electronic word processing based on the concept of links. Links can join a word, phrase or picture with text or graphics in another location of the document, with replacement text, or with pop-up windows. Hypertext is particularly useful for producing reference materials, which are typically read in a nonlinear fashion. A hypertext authoring system, Black Magic version 2.0, was used to create a hypertext document from a newly edited glossary of nematological terms. In this glossary, links were formed between unfamiliar terms used in definitions and the definitions of those terms. Users thus can easily traverse links to cross-reference other definitions, much like paging through a book. *Department of Plant Pathology, North Dakota State University, Fargo, ND 58105.*

FRECKMAN, D. W.[1], and R. A. VIRGINIA[2]. *Nematodes in Antarctic Dry Valley soils: Extraction and distribution.*

Recovery of nematodes from cold desert soils was compared by two extraction methods at McMurdo and later at UCR following transit of soil at -10 C for 3 months. The sugar centrifugation method recovered a greater biodiversity of soil nematodes than did the Baermann funnel at 10 C or 15 C. Soil nematodes were related to the soil physical and chemical environment to determine factors that affect or limit Dry Valley soil fauna. Nematodes occurred in more than 65% of the samples and varied with site. Two-thirds of the samples at Taylor Valley contained nematodes. In the Dry Valleys, the maximum density for an individual sample was 4,242/kg dry soil. Bacterial feeders were the dominant trophic group, comprising 66 to 100% of the nematode community at all sites. Omnivores or predators ranged from 0 to 34% of the nematode community at Wright Valley. Tardigrades and rotifers were found in approximately 14% of the soil samples. Soil moistures varied from 0.3% (w/w) to saturated and were not correlated with nematode densities. The abundance of nematodes in the Dry Valleys was comparable to other deserts, but the frequency of samples lacking nematodes was much greater. Nematode species recovered were *Scottnema lindsayae, Plectus* spp., and *Eudorylaimus antarcticus. Scottnema lindsayae* dominated all samples. [1]*Department of Nematology, University of California, Riverside, CA 92521, and* [2]*Environmental Studies Program, Dartmouth College, Hanover, NH 03755.*

GARDNER, J.[1], E. P. CASWELL-CHEN[2], B. WESTERDAHL[2], C. ANDERSON[2], and T. LANINI[3]. *The influence of Raphanus sativus, Sinapis alba, and Phacelia tanacetifolia on California populations of Heterodera schachtii.*

Oilseed radish (*Raphanus sativus*), white mustard (*Sinapis alba*), and phacelia (*Phacelia tanacetifolia*) are grown in Europe to shorten the time required to reduce numbers of *Heterodera schachtii* below damage thresholds. We investigated whether different cultivars of these plants would be effective against California populations of *H. schachtii* (Hs). The ability to reduce numbers of Hs was assessed in field and greenhouse experiments using the oilseed radish cvs. Nemex, Pegletta, and Renova, the mustard cvs. Emergo, Maxi, Martigena, and Serval, and the phacelia cv. Angelia. These cultivars were grown for 168 days in a Brussels sprouts field naturally infested with Hs and, to a lesser degree, with *H. cruciferae.* Field populations were sampled at planting and at the end of the experiment. Pf/Pi ratios for Nemex, Renova, and Serval were lower than in the control fallow, and the next year's growth of Brussels sprouts were increased in plots where these plants were grown. In greenhouse experiments conducted for 38 days, Emergo, Renova, Pegletta, and Nemex supported significantly fewer numbers of cysts than did cabbage, Maxi, Martigena and Serval. [1]*Plant Protection and Pest Management Graduate Group, University of California, Davis, CA 95616,* [2]*Department of Nematology, University of California, Davis, CA 95616, and* [3]*Botany Department, University of California, Davis, CA 95616.*

GAZAWAY, W. S.[1], D. RUSH[2], and R. RODRÍGUEZ-KÁBANA[1]. *Effect of nematicides on cotton production in fields infested with the reniform nematode, Rotylenchulus reniformis.*

Nematicides were evaluated in three reniform nematode-infested cotton fields over a three-year period in south Alabama. All nematicides except fenamiphos increased yields

in six of seven field trials. Aldicarb (1.18 kg a.i./ha and 1.68 kg a.i./ha) incorporated in a 6-inch band on top of the row at planting and 1,3-dichloropropene (1,3-D) injected preplant at 28.8 kg/ha were the most cost-effective treatments. Aldicarb applied in a band maintained lower reniform nematode populations season-long than equal rates of aldicarb applied in the furrow, 1,3-D treatments, or no nematicide treatment. However, reniform nematode populations even in the aldicarb band treatments reached a sufficient level by the end of the season to require treatment or other control measures for reniform nematode on cotton the following season. [1]*Department of Plant Pathology, Auburn University, Auburn, AL 36849, and* [2]*County Extension Agent, Alabama Cooperative Extension Service, Brewton, AL.*

GIBLIN-DAVIS, R. M., P. BUSEY, and B. J. CENTER. *Population dynamics of Belonolaimus longicaudatus on FX-313 St. Augustinegrass.*

FX-313 St. Augustinegrass (*Stenotaphrum secundatum*) was used as a model laboratory host for monitoring population growth of the sting nematode, *Belonolaimus longicaudatus*, over time and for quantifying the effects of sting nematode parasitism on host performance in autoclaved native Margate fine sand at about 27 C. *Belonolaimus longicaudatus* peaked at a combined mean of 2,139 nematodes per pot (250 cm^3 volume) at 84 days after inoculation, remained stable through 168 days at about 2,064 nematodes per pot, and then declined at 210 days. Population census data on the relative numbers of juveniles and adults demonstrated population expansion from 0–84 days and senescence after 168 days. Root dry weight was progressively reduced in nematode-inoculated plants relative to uninoculated controls ($P < 0.01$), starting 84 days after inoculation and continuing through 210 days. FX-313 served as an excellent model laboratory host, and results from this study are being used as baseline data for controlled studies on host–plant resistance and for evaluating biological antagonists and pesticides for management of the sting nematode in turfgrass ecosystems. *Fort Lauderdale Research and Education Center, University of Florida, IFAS, 3205 College Avenue, Ft. Lauderdale, FL 33314.*

GIBLIN-DAVIS, R. M.[1], H. NADEL[2], and H. F. FRANK[2]. *New species of Schistonchus and Parasitodiplogaster parasitizing the fig wasp, Pegoscapus assuetes, in the syconia of Ficus citrifolia.*

Two new nematode species were discovered in the syconia of the indigenous fig, *Ficus citrifolia*, from Homestead, Dade Co., Florida. Mated immature females of *Schistonchus* sp. (Aphelenchoididae) and third-stage juveniles of *Parasitodiplogaster* (Diplogasteridae) parasitize adult females of the fig wasp, *Pegoscapus assuetes* (Agaonidae), which is the highly co-evolved pollinator of *F. citrifolia*. *Parasitodiplogaster* sp. molt from the J3 to the J4 stage and greatly increase in size in the hemocoel of the host. The J4s exit the wasp cadaver in the syconium and molt to adults which mate and lay eggs, giving rise to infective third-stage juveniles which infect the wasps as they emerge from their galls. *Schistonchus* sp. females are found in the hemocoel of the adult female and male wasps but are transported to the next fig syconium by the female. The nematodes exit the wasp in the fig and apparently parasitize the female florets of the syconium. There is at least one generation of *Schistonchus* sp. in the fig, and infective females are produced about the time that fig wasps eclose to adults from the pupal stage. [1]*University of Florida, IFAS, 3205 College Avenue, Ft. Lauderdale, FL 33314, and* [2]*Department of Entomology and Nematology, Building 970, Hull Road, Gainesville, FL 32611.*

GOTHAMA, A. A.[1], G. W. LAWRENCE[2], and P. P. SIKOROWSKI[1]. *Effect of Steinernema carpocapsae and Spodoptera exigua nuclear polyhedrosis virus on S. exigua larvae.*

The effect of *Steinernema carpocapsae* (Sc) and *Spodoptera exigua* nuclear polyhedrosis virus (NPV) combinations on mortality of *S. exigua* larvae on soybean was examined. Leaflets were treated with Sc at 169 and 338 nematodes/ml, NPV at 1.35 and 2.7×10^4 polyhedral inclusion bodies (PIB)/ml, and all possible combinations. The total volume of inoculum used was 198 ml per 11 meters of row for each treatment. Treated leaflets were collected immediately after treatment and at 12, 24, 48, 72, 96, and 120 hours after treatment and bioassayed with 5-day-old *S. exigua* larvae. The test was established in July, 1991 and repeated in August to determine the influence of planting dates on efficacy and persistence of Sc and NPV combinations on soybean ecosystems. The combination of Sc at 338 nematodes/ml and NPV at 2.7×10^4 PIB/ml significantly increased larval mortality compared to Sc or NPV alone. On leaflets collected immediately following inoculations in the first

experiment, Sc and NPV alone produced a mortality of 35–42% and 30–33%, respectively. The four combinations produced a 43–69% mortality. Field persistence of Sc was 12 hours and that of NPV was 120 hours. There was no significant difference between mortality in the July and August experiments. [1]*Department of Entomology, and* [2]*Department of Plant Pathology and Weed Science, Mississippi State University, Mississippi State, MS 39762.*

GRIFFIN, G. D.[1], and V. P. RASMUSSEN[2]. *Effect of tillage practices on population dynamics of plant-parasitic nematodes in wheat.*

Experimental plots established in northern Utah determined the effects of different tillage systems on population dynamics of nematodes associated with wheat, *Triticum aestivum* L. The greatest seasonal and final nematode populations (Pf) of *Pratylenchus neglectus* were found during the growing season in the fall-planted grain in chemical-fallowed plots. The smallest Pf of *P. neglectus* was observed in disc-fallowed spring-planted wheat. The greatest seasonal populations of the ectoparasitic nematodes *Quinisulcius acutoides* and *Merlinius brevidens* were found in the conventional fallow, fall-planted with deep furrow drill, but there were no differences in the Pf after the grain was harvested. *Pratylenchus neglectus* was less affected by environmental conditions than were *M. brevidens* and *Q. acutoides.* [1]*USDA, ARS, Forage and Range Research Laboratory, and* [2]*Department of Plants, Soils, and Biometeorology, Utah State University, Logan, UT 84322-6300.*

GRIFFIN, G. D., M. D. RUMBAUGH, and K. H. ASAY. *Effect of Meloidogyne hapla and M. chitwoodi on competitive growth of alfalfa and grasses.*

The effects of the root-knot nematodes *Meloidogyne hapla* and *M. chitwoodi* on the growth of alfalfa, crested wheatgrass, and Russian wildrye were studied in a controlled microplot study. Plots were planted to Lahontan alfalfa only, Hycrest crested wheatgrass only, Syn A Russian wildrye only, and combinations of alfalfa and grasses. Plants were inoculated with *M. hapla*, pathogenic only to alfalfa; *M. chitwoodi* race 2, pathogenic only to grasses; and *M. chitwoodi* race 1, pathogenic to both alfalfa and grasses. *Meloidogyne hapla* reduced the growth of Lahontan planted alone and in alfalfa-grass combinations. *Meloidogyne hapla* reduced the growth of Hycrest and Syn A in alfalfa–grass combinations. Growth of the grasses was not reduced by *M. hapla* when plantings did not include alfalfa. *Meloidogyne chitwoodi* race 1 reduced the growth of Hycrest and Syn A when grown alone and in combination with alfalfa. Similar trends were observed on grasses with *M. chitwoodi* race 2, but growth reduction was less. *Meloidogyne chitwoodi* race 1 had minimal effect, whereas race 2 did not affect the growth of single plantings of alfalfa. *Meloidogyne chitwoodi* race 1 reduced the growth of Lahontan less when planted alone than in alfalfa–grass combinations. *USDA, ARS, Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300.*

GRISI, E.[1,2], N. VON MENDE[2], P. BURROWS[2], and R. PERRY[2]. *Collagen genes of plant-parasitic nematodes.*

Collagen genes in animal-parasitic and free-living nematodes have been studied extensively, but no information is available on plant-parasitic nematodes. In comparison to mammalian collagen genes, nematode collagen units are smaller and there are many more members within this protein family. In this study collagen genes in *Globodera pallida* and *Meloidogyne incognita* were identified using two approaches–first, by Southern blotting using a cloned collagen gene, *dpy-13* of *Caenorhabditis elegans*, as a probe and, second, by PCR amplification with two primers homologous to the 5′ and 3′ region of the *dpy-13* gene and a collagen gene of *Haemonchus contortus.* In Southern blots only *Globodera pallida* genomic DNA showed homology with the *C. elegans* probe, but a similarly sized DNA fragment of 1 kb showing homology with the *dpy-13* probe was amplified from the DNA of *M. incognita.* [1]*Department of Molecular Biology, Federal University of Paraiba, Brazil, and* [2]*Entomology & Nematology Department, AFRC, IACR, Rothamsted Experimental Station, Harpenden, Herts., England.*

GRUNDER, J.[1], P. KUNZ[1], T. HASLER[1], A. BUSER[2], and D. J. F. BROWN[3]. *Nematode-transmitted nepovirus diseases of cherry trees in Switzerland.*

In Switzerland, pfeffinger disease is a serious problem in sweet cherry and was first observed in the Canton of Baselland last century. Subsequently, the disease was identified as being caused by raspberry ringspot nepovirus (RRV), which, in 1973–74, was

demonstrated to be associated with the occurrence of *Longidorus macrosoma*, the natural vector of the virus. Several other longidorids occur in Switzerland, and in 1990 a new *Longidorus* species was identified. This species was recovered from the rhizosphere of cherry trees growing in orchards in the region of Arth. These nematodes were associated with diseased cherry trees, most of the fruit of which is used for the production of kirsch. The disease was confirmed as being caused by a nepovirus serologically unrelated to RRV. Bait testing of soil samples and individual nematodes from two orchards revealed the new *Longidorus* species to be the natural vector of the nepovirus. Further investigations have identified other occurrences of the disease and the vector species in the region. [1]*Swiss Federal Research Station, CH-8820 Wadenswil, Switzerland,* [2]*Kanton Basel-Landschaft, Amt fur Landwirtschaft, 4402 Frenkendorf, Switzerland, and* [3]*Zoology Department, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.*

GUY, G. L., J. WOODWARD, and J. M. HINCH. *Globodera rostochiensis and possibly G. pallida in Australia.*

In early 1991, *Globodera rostochiensis* was detected in market gardens 45 km east of Melbourne. Victoria is Australia's premier potato state, producing some 370,000 tons annually, and this is the first record of potato cyst nematode (PCN) in Victoria. The level of cysts detected in the four initial outbreaks indicated that the infestations were well established (i.e., >100 eggs/g soil at focus). Previously, *G. rostochiensis* was recorded in Western Australia in 1986. Following this Victorian outbreak, properties with a history of intensive potato cropping were soil-surveyed for the presence of PCN. During these surveys, on commercial ware producing properties infestations were detected comprising apparent mixed populations of *G. rostochiensis* and *G. pallida*-like cysts within 20 km of the initial outbreaks. The two species were identified by taxonomic criteria and by comparison of protein banding patterns in isoelectric focussing gels of the Victorian cysts with those from defined English or European populations. The presence of *G. pallida* could not be confirmed. Pathotyping of the populations is not complete. Approximately 25% of Victoria's 13,000 ha of potatoes has been soil-surveyed during 1992. All certified seed growers' properties are tested prior to the crops being certified. *Institute of Plant Sciences, Department of Food and Agriculture, Burnley, 3121, Australia.*

HACKENBERG, C., and R. A. SIKORA. *Influence of cultivar, temperature and soil moisture on the antagonistic potential of Agrobacterium radiobacter against Globodera pallida.*

Rhizobacteria antagonistic to *G. pallida* were studied for their activity under different environmental conditions. An *A. radiobacter* strain reduced *G.pallida* hatch 75% ($P = 0.01$) and early root penetration 30% ($P = 0.05$) in laboratory and greenhouse studies. Variation in soil moisture or temperature did not significantly influence the level of biological control. Conversely, competing microorganisms and cultivar had major impacts on the control activity of the rhizobacterium. Even though *A. radiobacter* colonization averages only 2% of the total rhizoflora, it was able to reduce *G. pallida* penetration significantly ($P = 0.05$). Possible mechanisms of action include exudate alteration and production of metabolites with repellent action. *Institut für Pflanzenkrankheiten, Abteilung Phytopathologie in Bodenökosystemen, 5300 Bonn, Nussallee 9, Federal Republic of Germany.*

HAFEZ, S. L., F. RASHID, and K. HARA. *The effect of a sugarbeet tare dirt composting process on the viability of sugarbeet cyst nematode.*

The sugarbeet cyst nematode *(Heterodera schachtii)* has been recognized as one of the most serious problems for the sugarbeet industry. Returning tare dirt back to the field is the major means of nematode spread and reinfestation. The objective of this study was to control sugarbeet cyst nematode in the tare dirt through the composting process and thereby reduce the chances of its spread. During the composting process, organic matter breaks down and releases considerable heat (60 C) and high concentrations of CO_2 and other toxic gases which can be lethal to nematodes. Composting also enhances the activity of other nematode-destroying organisms such as bacteria and fungi which may parasitize nematode eggs and juveniles. Two experiments were conducted over two years during the fall of 1990 to spring of 1991 and fall 1991 to spring 1992. In the first experiment, wooden boxes (inside dimensions of 4 feet × 4 feet × 8 feet) with bottoms were filled with tare dirt infested with

high populations of cyst nematodes. Boxes were arranged in two rows 4 feet apart and replicated six times. Boxes were covered in fall and winter by black plastic for protection from snow and rain. Tare dirt samples were taken from boxes before composting and five months later to determine nematode populations. Tare dirt was thoroughly mixed, and a 500-ml subsample was processed by a wet sieve method. Nematodes were extracted by the sugar flotation–centrifugation technique. All eggs and juveniles were dead after the composting process. A bioassay conducted under greenhouse conditions to determine egg survival showed no reproduction. The results indicate that no stages of the sugarbeet cyst nematode survived the composting process. *University of Idaho, Parma Research and Extension Center, Parma, ID 83660.*

HAFEZ, S. L., F. RASHID, and K. HARA. *Seasonal decline of sugarbeet cyst juvenile and egg populations in Idaho.*

The sugarbeet cyst nematode *(Heterodera schachtii)* has been recognized as one of the most serious problems for the sugarbeet industry in Idaho and Eastern Oregon. The degree of loss caused by this nematode depends on the initial nematode population density at planting, which is influenced by various edaphic and climatic conditions that affect its survival. The objective of this study is to determine the survival of sugarbeet cyst nematodes over winter at different soil depths and to predict the spring population of viable eggs and juveniles from samples collected in the previous fall. The experiment was conducted under field conditions during the fall seasons of 1990 and 1991. Five pairs of 30-cm-deep and 30-cm-d plastic containers filled with sugarbeet cyst nematode-infested soils were buried, one on top of the other. The top container was at the 0–30 cm soil depth, and the bottom one was at the 31–60 cm depth. Soil samples were taken from each bucket in the fall and spring to determine population of sugarbeet cyst nematode eggs and juveniles. The number of juveniles was reduced by 47% and 12.7% at the 0–30 cm and 31–60 cm depths, respectively. The number of eggs was reduced by 39% and 29.4% at the upper and lower depths, respectively. The results suggest that the population reduction will be higher at the 0–30 cm soil depth compared to 31–60 cm depth. During the summer, these containers were kept in cold storage at 1.6 C, and samples from these were assayed in fall 1991. The number of juveniles was reduced by 28.4% at 0–30 cm and by 38.6% at 31–60 cm depth, and the numbers of eggs were reduced by 52% and 31%, respectively. *University of Idaho, Parma Research and Extension Center, Parma, ID 83660.*

HALBRENDT, J. M.[1], and D. J. F. BROWN[2]. *Aspects of biology and development of Xiphinema americanum and related species.*

Xiphinema americanum is notorious for being difficult to rear in culture, and most information on virus vector efficiency and morphometric variability has been gleaned from work with field populations. Morphometric variability within species is of particular interest to help resolve controversial questions of species designation. Seven *X. americanum*-group "families" were produced by rearing the offspring of single females on sudangrass cv. Piper. Six families were identified as *X. americanum* and the seventh tentatively as *X. californicum*. Standard de Man measurements and ratios were analyzed using stepwise discriminant analysis. Plots of the coordinates provided by the first and second canonical variables of individuals clearly separated *X. californicum* from *X. americanum*. All plots of *X. americanum* were in close proximity to each other, with considerable overlap between families. These data will be compared with similar analyses from field populations. [1]*Department of Plant Pathology, The Pennsylvania State University, Fruit Research Laboratory, P.O. Box 309, Biglerville, PA 17307-0309, and* [2]*Zoology Department, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.*

HALBRENDT, J. M.[1], and D. J. F. BROWN[2]. *Research on the life stages of Xiphinema americanum-group nematodes from disparate geographic locations.*

Recent studies have shown that *X. americanum*-group species differ in the number of juvenile stages they pass through. Several species from the western hemisphere have shown evidence of only three juvenile stages, whereas others from the eastern hemisphere have shown four. Data on the number of juvenile stages for species have been collected from relatively few populations and locations around the world. Additional data have now been collected from other locations. These data show that *X. americanum* from South Africa and

X. bricolense from British Columbia both have three juvenile stages. A population of *X. pactaicum* and an unidentified *X. americanum*-group species both from South Africa apparently have four juvenile stages, although first-stage juveniles were not found. These data may provide useful criteria to help resolve questions of relatedness within the *X. americanum*-group of species. [1]*Department of Plant Pathology, The Pennsylvania State University, Fruit Research Laboratory, P.O. Box 309, Biglerville, PA 17307-0309, and* [2]*Zoology Department, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.*

HAROON, S. A. *Effect of six grasses on the population levels of Meloidogyne incognita and Tylenchulus semipenetrans.*

Echinochloa colonum, Convolvulus arvensis, Sonchus oleraceus, Cyperus longus, C. rotundus and *Xanthium bragillicum* are common plants with widespread geographic distribution. All were antagonistic to *M. incognita* and *T. semipenetrans* in microplot tests. Juveniles of these two nematode species entered plant roots but did not develop past the second stage. In other microplot tests where tomato was interplanted with each plant species, the populations of *M. incognita* declined significantly. The same results occurred with *T. semipenetrans* when the plant species were planted in a heavily infested citrus orchard. In other studies, aqueous extracts were taken from each plant species. The active material extracted from each species appeared stable after heating for 7 to 10 hours at 90 C. A precipitate was collected from the concentrated aqueous extracts by adjusting to pH 10 with dilute NaOH. The dried precipitate was tested on nematodes in a suspension of 1.0 to 1.2 mg per ml water. About 50–70% in vitro mortality was encountered in both species. *Department of Plant Protection, University of Cairo, Fayoum Branch, Egypt.*

HARRIS, T. S.[1], C. H. OPPERMAN[2], J. P. NOE[3], and T. O. POWERS[1]. *A new PCR primer set for Meloidogyne species determinations.*

A single set of amplification primers has been designed to identify numerous species of *Meloidogyne*. To date, species-specific amplification patterns have been observed for *M. incognita, M. javanica, M. arenaria, M. hapla, M. chitwoodi, M. nataliei*, and *M. marylandi*. The primer set amplifies a region of mitochondrial DNA from the 3′ end of the COII gene to the large ribosomal subunit gene. A combination of size and restriction site polymorphism permits species identification. All identifications have been conducted on individual second-stage juveniles. [1]*Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583-0722,* [2]*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695, and* [3]*Department of Plant Pathology, University of Georgia, Athens, GA 30602.*

HASHMI, G.[1], F. A. HAMMERSCHLAG[2], L. R. KRUSBERG[1], and R. N. HUETTEL[3]. *Selection of somaclonal variants of peach for root-knot nematode resistance.*

The use of tissue culture-induced variability (somaclonal variation) for obtaining desirable genetic traits is a relatively new technique. In this study, somaclonal variation for resistance to *Meloidogyne incognita* was identified in peach plants regenerated from immature embryos. Regenerants 156-1, 156-7, 156-11, 156-12 and 30-1, 30-4, 30-6, 30-7 were obtained from immature embryo #156 from peach cv. Sunhigh and from immature embryo #30 from peach cv. Redhaven, respectively. Significantly higher numbers of nematodes developed on 156-7 compared with 156-1, 156-11 and 156-12, whereas no significant differences in nematode development were observed among Redhaven regenerants. Nematode development on these regenerants was then compared with in vitro propagated plantlets of Sunhigh, Redhaven and Nemaguard. Significantly higher numbers of nematodes were obtained on Sunhigh and 156-7 compared with 156-1, 156-11, 156-12 and Redhaven. No nematode development was observed on Nemaguard. To determine whether genetic differences between somaclones exist, random amplified polymorphic DNA markers were used. [1]*Department of Botany, University of Maryland, College Park, MD 20742,* [2]*USDA, ARS, Building 006, BARC-West, Beltsville, MD 20705, and* [3]*USDA, APHIS, Hyattsville, MD 20782.*

HASHMI, S., and L. R. KRUSBERG. *Some properties of a natural hatching factor for Heterodera zeae.*

Corn *(Zea mays)* rhizosphere leachates (CRL) contain at least one substance that stimulates hatch of eggs and emergence of J2 from cysts of *Heterodera zeae*. Fresh CRL

obtained from 25-day-old corn plants growing in 10-cm-d pots containing sandy soil retained its hatching activity after freezing, heating, and boiling. Percentage emergence of J2 from cysts immersed for 7 days in variously treated CRL at 30 C was: tap water control, 9%; fresh CRL, 20%; CRL heated at 60 C for 1 minute, 19%; CRL heated at 60 C for 10 minutes, 20%; CRL boiled for 1 minute, 20%; and CRL frozen for 2 hours at −14 C and then thawed, 20%. Both fresh CRL and fresh CRL sterilized by ultrafiltration began to lose hatching activity similarly, at some time between 5 and 10 days of storage at 25 C. Fresh leachates from massed, whole, 7-day-old corn seedlings grown in 15 cm × 15 mm petri dishes on moist filter paper at 25 C stimulated greater emergence of J2 from cysts (37%) than leachates from corn plants growing in soil (ca. 20%). All the hatching activity partitioned into diethyl ether upon extraction of fresh whole seedling leachate, but hatching activity remained in the aqueous phase when such leachate was partitioned against hexane or chloroform. Research is underway to isolate, purify, and identify this hatching factor or factors. *Department of Botany, University of Maryland, College Park, MD 20742.*

HATZ, B., and D. W. DICKSON. *Host-parasite interactions of Pasteuria penetrans on Meloidogyne arenaria race 1 as affected by temperature.*

The greatest rate of attachment of endospores on second-stage juveniles occurred at 30 C when tested in endospore-ladened field soil. The developmental rate of the bacterium was greater within its host at 30 and 35 C than at 25 C or below. *Pasteuria penetrans* development in *M. arenaria* females was divided into nine recognizable life stages. Mature sporangium was the predominant life stage observed after 35, 40, 81, and 116 days at 35, 30, 25, and 20 C, respectively. The body width and length of infected females were smaller than those of uninfected females during the early stages of infection, but the infected females became considerably larger than uninfected females over time at 25, 30, and 35 C. *Pasteuria penetrans* also parasitized and completed its life cycle in males of *M. arenaria. Department of Entomology and Nematology, P.O. Box 110620, University of Florida, Gainesville, FL 32611-0620.*

HERSHMAN, D. E., and P. R. BACHI. *Effect of wheat residue and tillage on Heterodera glycines cyst development in doublecrop soybeans in Kentucky.*

In 1990 and 1991, field experiments were established to determine the separate and combined effects of residue from a harvested wheat crop and tillage (no-till vs. minimum-till) on soybean cyst nematode cyst development in doublecrop soybeans. In both years, late season cyst counts in plots of soybeans, planted no-till into wheat residue, were 50–65% less than counts from identical plots but without wheat residue. In 1990, this effect was noted six weeks after planting. In 1991, the effect was not noted until just prior to harvest. In both 1990 and 1991, minimum-tillage (light disking) of wheat residue before planting soybeans resulted in significantly higher cyst counts than where soybeans were planted no-till into wheat residue. Minimum tillage had a similar effect in non-residue plots in 1990, but not 1991. In the latter year, cyst development in non-residue plots was not significantly different between the two tillage treatments. In both years, plots without wheat residue developed significantly more cysts than plots with residue, regardless of tillage. Thus, it appears that the main influence on cyst development is the result of wheat residue being present and not tillage per se. Tillage, however, is apparently important as it relates to disturbance of the wheat residue in a field, before planting doublecrop soybeans. *Department of Plant Pathology, University of Kentucky, P.O. Box 469, Princeton, KY 42445.*

HEWLETT, T. A., and D. W. DICKSON. *A centrifuge method for testing the attachment of Pasteuria spp. to nematodes.*

Rapid attachment of relatively small numbers of endospores to nematodes can be attained with this centrifuge method compared with the endospore–nematode suspension shaker method. Endospores in 0.1 ml water are placed in a 0.25-ml microfuge tube previously coated with a water repellant. The endospore–nematode mixture is centrifuged at 9,500*g* for 2 minutes. The nematodes are removed with a pipette and placed onto a slide for observation. In two tests the attachment rate of endospores from isolate P-100 to 200 second-stage juveniles (J2) of *Meloidogyne javanica* using 1,000, 10,000 and 100,000 spores/tube averaged 1, 6, and 28 endospores/J2, respectively. The attachment rate of endospores from *Hoplolaimus galeatus* to 100 mixed-life stages of this nematode using 1,000 endospores/tube was

0.9/nematode. In a host attachment study using 10,000 endospores/tube of P-100, the attachment rate to *M. javanica*, *M. arenaria* race 1, *M. arenaria* race 2, and *M. incognita* race 3 in two tests averaged 4, 0.2, 0, and 0.1 endospores/J2, respectively. *Department of Entomology and Nematology, P.O. Box 110620, University of Florida, Gainesville, FL 32611-0620.*

HIATT, E. E.[1], D. C. HARSHMAN[2], S. A. LEWIS[2], E. R. SHIPE[1], and A. G. ABBOTT[3]. *Molecular genetic analysis of single egg mass lines of Meloidogyne arenaria.*

The genetic homogeneity or heterogeneity of two populations (Pelion and Govan) of *M. arenaria* was examined using RFLP analysis of twelve clonal lines established from single egg mass isolates (six distinct clonal lines from each population). The Govan population is more aggressive than the Pelion population, producing larger galls and exhibiting greater reproductive capabilities on many soybean cultivars and experimental strains. Tandemly repeated, low-copy, and interspersed repeated probes were used to differentiate the clonal lines. The tandemly repeated and low-copy clones did not demonstrate any polymorphisms between the populations or within the populations. One of the interspersed repeated clones showed polymorphisms between the two populations and within the Pelion population. Polymorphisms were also seen in the Pelion population when PCR amplification experiments were conducted. [1]*Department of Agronomy,* [2]*Department of Plant Pathology, and* [3]*Department of Biological Sciences, Clemson University, Clemson, SC 29631.*

HIRUNSALEE, A., and K. R. BARKER. *Effects of peanut–tobacco rotations on population dynamics of Meloidogyne arenaria races.*

Microplots were infested with single populations of *Meloidogyne arenaria* races 1 (Ma1) and 2 (Ma2) and a 1:1 mixture of the two races. Plots were planted to Ma1-susceptible peanut (Florigiant), *M. incognita*-resistant tobacco (McNair 373), and susceptible tobacco (Coker 371-Gold) to characterize interactions of the two nematode races and to elucidate their population dynamics as affected by peanut–tobacco rotations. Penetration and reproduction of Ma2 on peanut and that of Ma1 on resistant tobacco were very limited. The two races reproduced similarly on susceptible tobacco. In mixed populations, Ma1 was dominant on peanut, and Ma2 was dominant on both tobacco cultivars. The degree of dominance of Ma2 on susceptible tobacco was less than that on resistant tobacco. Peanut root damage caused by Ma1 was limited by the presence of Ma2. Nematode survival after the first season was quite high, especially for the eggs of Ma1 on peanut. Crop rotation affected the population dynamics of different nematode races. Very low numbers of Ma1 and Ma2, resulting from a nonhost the previous year, increased rapidly on respective second-year, suitable hosts. Multiplication of Ma2 was greater on resistant tobacco than on susceptible tobacco when following peanut. *Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.*

HOFFMANN-HERGARTEN, S., and R. A. SIKORA. *Root-colonization behavior of rhizobacteria antagonistic to Heterodera schachtii and its relationship to nematode biological control.*

Application of the sugarbeet-specific rhizobacteria *Pseudomonas fluorescens* (strain T 58) to seed, in either liquid or as a solid-state dressing, caused 42% ($P = 0.05$) reductions in early root penetration of *H. schachtii*. Extensive root colonization occurred even in the absence of vertical movement of water, in sealed bioassay chambers. The density of the T 58 strain, measured 9 days after inoculation, was approximately 57% of the total rhizosphere microflora in sterilized sand and 20% in unsterile soil, respectively. Even though percentage root colonization of *P. fluorescens* in unsterile soil declined continuously during a 3-week period to 2% of the total microflora, nematode penetration was reduced. The incorporation of an additional layer of organic material onto the seed pellet was tested for promotion of rhizobacterial root colonization. The type of organic matter influenced total microflora density and colonization by the antagonistic strain. *Universität Bonn, Institut für Pflanzenkrankheiten, Nussallee 9, W-5300 Bonn 1, Federal Republic of Germany.*

HUETTEL, R. N.[1], S. A. HAROON[2], and A. ABDUL-BAKI[3]. *In vitro testing for resistance in temperature-sensitive tomatoes to Meloidogyne incognita.*

An in vitro root explant culture technique is described for determining susceptibility of tomato cultivars and heat-tolerant breeding lines to the root-knot nematode *Meloidogyne*

incognita. Root explants were excised from two-day-old seedlings and grown for 30 days at 28 C, 33 C, 37 C, and 40 C on Gamborg's B-5 medium with and without nematodes. In vitro root explants were evaluated for growth, and the number of nematode life stages was determined. Resistant heat-tolerant lines became susceptible to root-knot nematodes at temperatures above 30 C. The remaining portion of the root and stem from the excised root explants was transferred to soil in pots and grown to mature plants in the greenhouse. The regenerated plants were used to produce more seeds. The technique is simple, reliable, and adaptable to routine screening of large numbers of F_1 and F_2 crosses for resistance to *M. incognita* while preserving precious seed. [1]*Plant Protection and Quarantine, USDA, APHIS, Hyattsville, MD 20782,* [2]*University of Cairo, Cairo, Egypt, and* [3]*Vegetable Laboratory, USDA, ARS, Beltsville, MD 20705.*

HUSSEY, R. S.[1], C. W. MIMS[1], and S. W. WESTCOTT, III[2]. *Callose formation in root cells parasitized by the ring nematode Criconemella xenoplax.*

Polyclonal antibodies specific to (1→3)-β-glucans were used to locate callose around the stylet of *Criconemella xenoplax* in parasitized cortical cells in root explants of clover, carnation, and tomato. The stylet of *C. xenoplax* was inserted between epidermal cells to parasitize single cells in the first or second outer layer of the cortex. At the ultrastructural level, the nematode's stylet was inserted 5–6 µm through the wall of the parasitized cell without piercing the plasma membrane, which became invaginated around the stylet tip. A thick layer of electron-translucent callose was located by immunogold labeling between the invaginated plasma membrane and the inserted stylet, except at the stylet orifice. The callose formation was continuous with the inner wall surface of the parasitized cell. When the parasitized cell was in the second layer of the cortex, the nematode's stylet passed through a subepidermal cortical cell. The integrity of the plasma membrane of the transected cell was maintained and callose was deposited around the portion of the nematode's stylet that traversed the cell. We suggest that callose formation around a nematode's stylet in parasitized cells is a common wound response elicited when plant-parasitic nematodes feed from cells. [1]*Department of Plant Pathology, University of Georgia, Athens, GA 30602, and* [2]*Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.*

INGHAM, R. E.[1], K. J. MERRIFIELD[1], and M. A. MORRIS[2]. *Effect of ethoprop on Pratylenchus penetrans and yield of mint in Oregon.*

Fall 1989 applications of ethoprop at 6.6, 13.2, or 26.4 kg/ha significantly reduced midseason (June 1990) populations of *P. penetrans* in two Willamette Valley (WV) peppermint and one Central Oregon (CO) spearmint fields. All treatments, except the 6.6 kg/ha rate in spearmint, significantly increased yield of mint oil, but there was no difference between rates. One WV field was monitored for a second season without further treatment. In this field, midseason (June 1991) nematode densities in treated plots were greater than in 1990 but remained significantly less than the control in all treatments. By harvest (August 2, 1991), there was no difference in *P. penetrans* populations between untreated and ethoprop-treated plots. Yield in plots treated with 6.6 or 26.4 kg/ha were significantly greater than in the control, but the magnitude of the difference between treated and control plots was not as great as in 1990. Midseason nematode densities were negatively correlated with yield in both years. [1]*Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902, and* [2]*A. M. Todd Co., Jefferson, OR 97352.*

ISHIBASHI, N., and S. TAKII. *Movements, nictation, and infectivity of Steinernema carpocapsae as affected by insecticides.*

Movements, nictation, and infectivity of *S. carpocapsae* (strain All) were compared between ensheathed (EnJ) and desheathed (DeJ) infective juveniles in response to several insecticides. The movements of nematodes in the chemical solutions were characterized by sinusoidal (50 ppm oxamyl, 100 ppm acephate, 50 ppm permethrin), uncoordinated (50 ppm methomyl, 200 ppm oxamyl), twitching (200 ppm permethrin, 100 ppm methomyl), pretzel (>10 ppm DDVP), inactive S posture with fine twitching (200 ppm methomyl), or quiescence in straight posture (>800 ppm oxamyl) within 1 hour after incubation at 25 C. DeJ displayed the above characteristic movements at lower dosages for each insecticide than did EnJ. In the petri dish bioassay, infectivity of EnJ with chemicals against common cutworm larvae was

mostly lower than that of nematodes alone, but higher than insecticides alone at their sub-lethal dosages. Nictation reflected more clearly the relation with infectivity than did movement in solution. Insecticides that enhance the nictation rate at certain dosages (e.g., 50 ppm oxamyl, 100 ppm acephate, or 50 ppm permethrin) may be used for mixed application with nematodes. Nictation of DeJ was generally suppressed by the chemicals, even at lower concentrations. *Department of Applied Biological Sciences, Saga University, Saga 840, Japan.*

JAFFEE, B. A., A. E. MULDOON, and E. C. TEDFORD. *Growth of nematode-trapping fungi from parasitized nematodes.*

Many trapping fungi are considered facultative parasites that produce traps only under special conditions, i.e., traps are induced by nematodes, partially decomposed organic matter, and microbial competition. In contrast, endoparasitic fungi are considered obligate parasites that produce infective spores without need for induction. To clarify differences between endoparasitic and trapping fungi, we compared growth of these fungi from parasitized nematodes in soil solution (saturation extract) and in soil. The endoparasitic fungus *Hirsutella rhossiliensis* (Hr) and the trapping fungi *Arthrobotrys dactyloides* (Ad), *A. oligospora* (Ao), *Monacrosporium cionopagum* (Mc), and *M. ellipsosporum* (Me) produced abundant infective structures (adhesive spores for Hr and traps for Ad, Ao, Mc, and Me) when growing from parasitized nematodes in soil solution. Thus, trap induction may be typical in soil, and trapping fungi may be more dependent on parasitism than is generally recognized. The trapping fungi were similar to Hr in their sensitivity to soil disturbance but differed in their response to submergence: in soil solution, traps of Ad, Ao, Mc, and Me formed only in the solution, whereas spores of Hr formed only in the air above the solution. *Department of Nematology, University of California, Davis, CA 95616.*

JAGDALE, G. B., and R. GORDON. *Aminergic and peptidergic neurosecretory cells in Romanomermis culicivorax.*

A fluorescence histochemical method was used to visualize aminergic neurons in *R. culicivorax* at various stages of development. The tail region of mature adult male nematodes contained several aminergic ganglia, while that of females contained only two. There were no aminergic ganglia in the tails of juvenile stages of either sex. Both sexes had four aminergic ganglia in the nerve ring throughout development. The catecholamines in ganglia of the tail region may be involved in the process of reproduction. An FMRF-amide-like peptide was detected in adult nematodes, using an immunofluorescent technique. The strongest immunoreactivity was observed in cells of the nerve ring, cephalic ganglia, cephalic nerves, amphids and four nerve cords. Several FMRF-amide positive neurons were located throughout the nematode body posterior to the nerve ring and in between the four nerve cords. *Department of Biology, Memorial University of Newfoundland, St. John's A1B 3X9, Canada.*

JANSSON, H.-B. *Adhesion of Drechmeria coniospora conidia to nematodes.*

The conidia of the nematophagous fungus *Drechmeria coniospora* adhere to the head region of most nematodes tested, and sometimes also to other parts of the nematode surface. An adhering conidium may not necessarily lead to successful penetration of the cuticle and invasion of the host. Tests of the effects of electrical charges, hydrophobicity, ionic strength and pH on conidial adhesion, as well as enzymatic treatments of both nematodes and conidia, have been performed. The (glyco)-proteinaceous compounds exuded from the sensory structures of the nematodes and the (glyco)-proteins covering the adhesive bud of the conidia appear to be involved in the adhesion process. *Department of Microbial Ecology, Lund University, Helgonavagen 5, S-223 62 Lund, Sweden.*

JING, G. N., and J. M. HALBRENDT. *Evaluation of rapeseed extract toxicity using a Caenorhabditis elegans bioassay.*

A bioassay was used to evaluate the effect of rapeseed extract on growth and development of *C. elegans*. Extracts were prepared by a method for glucosinolate extraction using boiling methanol-water (70%) as solvent. Freshly hatched juveniles (0–12 hours old) were assayed in a liquid growth medium (99 ml buffer, 1 ml yeast suspension, 0.5 ml corn extract, and 0.1 ml cholesterol solution), to which plant extracts were added with and without

the enzyme myrosinase. This enzyme hydrolyzes glucosinolate to form volatile compounds which are reportedly toxic to nematodes. Nematode growth was determined by taking length measurements after 72 hours. Results showed that extracts were toxic when treated with myrosinase but not without the enzyme nor the growth medium with myrosinase alone. Toxicity varied with plant age and plant part. Furthermore, there was a differential response of nematodes to extracts from different rapeseed cultivars. *Department of Plant Pathology, The Pennsylvania State University, Fruit Research Laboratory, P.O. Box 309, Biglerville, PA 17307-0309.*

JOHNSON, A. W.[1], C. C. DOWLER[1], N. C. GLAZE[1], R. B. CHALFANT[2], and A. M. GOLDEN[3]. *Efficacy loss following multiple applications of fenamiphos.*

Meloidogyne incognita population densities and yield of sweet corn and sweet potato as affected by the nematicide, fenamiphos, in a sweet corn–sweet potato–vetch intensive cropping system were determined in a 5-year test (1981–85). Numbers of *M. incognita* increased on all crops in untreated plots each year to 3,635/150 cm^3 soil in plots of sweet potato. The nematicide fenamiphos incorporated into the soil before planting each crop increased yields of sweet corn in 1981 and 1982 and sweet potato number 1 grade in 1982 and 1983, but not thereafter. Yield of number 1 sweet potatoes was inversely related to numbers of *M. incognita* in the soil in July, August, September, and October 1982 and July, August, and September 1983. Numbers of nematodes in treated plots of sweet potato were lower at planting than those in untreated plots, but as numbers of nematodes increased the efficacy of fenamiphos diminished. [1]*Nematodes, Weeds, and Crops Research Unit, USDA, ARS, P.O. Box 748, Tifton, GA 31793,* [2]*Entomology Department, University of Georgia, P. O. Box 748, Tifton, GA 31793, and* [3]*Nematology Laboratory, USDA, ARS, Building 011A, BARC-West, Beltsville, MD 20705.*

KAPLAN, D. T. *Development of Pasteuria sp. in the citrus nematode, Tylenchulus semipenetrans.*

Juveniles and males of the citrus nematode, *Tylenchulus semipenetrans*, infected with *Pasteuria* sp. were detected in soil samples collected from a citrus grove in Central Florida. Spores released by mechanically rupturing spore-filled nematode cadavers in laboratory studies attached to citrus nematode juveniles and males suspended in distilled water. Three to 16 spores attached to nematode cuticles. Mature spores ("fried-egg" shaped) appeared within the nematode body eighteen days after spore attachment. Spore development was asynchronous and occurred throughout the bodies of juveniles and males. Infected second-stage juveniles each contained 320–400 spores 18 days post-infection. *USDA, ARS, U.S. Horticultural Research Laboratory, 2120 Camden Rd., Orlando, FL 32803.*

KENNEY, M. J.[1], J. SCHROEDER[1], L. W. MURRAY[2], and S. H. THOMAS[1]. *Effects of a herbicide on yellow nutsedge and chile pepper suitability as hosts of Meloidogyne incognita.*

Metolachlor is a chloroacetamide herbicide used to inhibit emergence of yellow nutsedge (YNS = *Cyperus esculentus* L.) in chile peppers (*Capsicum annuum* L.) in New Mexico. Previous research demonstrated that both plants are hosts of *M. incognita* race 3 (RKN). Greenhouse experiments were conducted in 1991–92 to determine the effects of metolachlor on the interaction of both pests with chile. Studies included factorial arrangements of all practical treatment combinations (chile, YNS, RKN, metolachlor) in a randomized complete block with 6 replications and a duration of 12 weeks postinoculation. RKN counteracted the tendency of both metolachlor and competing chile plants to reduce YNS shoot production. RKN also increased YNS tuber production in the absence of the herbicide. Metolachlor eliminated RKN reproduction on YNS alone but had no effect on reproduction on YNS when chile was also present. [1]*Department of Entomology, Plant Pathology and Weed Science, and* [2]*Department of Experimental Statistics, New Mexico State University, Las Cruces, NM 88003.*

KIM, D. G., and R. D. RIGGS. *Effects of sodium alginate-formulated filamentous fungus ARF18 on different soybean cultivars and races of soybean cyst nematode.*

Fungus ARF18 has been demonstrated to be a promising biocontrol agent of soybean cyst nematode (SCN), *Heterodera glycines*. The fungus cultured in a liquid medium and pelleted with sodium alginate was tested on 8 different races of SCN and on 9 soybean cultivars for its effectiveness. A soybean seedling was planted in 10-cm-d clay pots inoculated with fungus pellets (1% soil weight) and SCN eggs (18 eggs/g soil). Each test was replicated

5 times including controls without fungus. The juveniles, cysts, and eggs in each pot were examined 60 days after inoculation. To determine the role of host plants on SCN control by ARF18, the susceptible soybean cultivars, Davis, FFR561, Hutcheson, Lee74, Lee No-Nod, P9391, P9591, Sharkey, and Tracy, were inoculated with SCN race 14. Fungus-infested soil had 3–5 SCN eggs/g soil compared to 111–245 eggs/g soil in the controls, a reduction of 95–99%. To determine the effects of ARF18 on SCN races, races 2, 3, 4, 5, 6, 9, 12, and 14 were inoculated independently on Hutcheson soybean. Fungus-infested soil had 5–12 SCN eggs/g soil compared to 69–196 eggs/g soil in the controls, a reduction of 83–97%. This study indicates that the efficacy of the fungus ARF18 is not affected by soybean cultivar or SCN race. *Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.*

KO, M. P., and D. P. SCHMITT. *Effect of selected cover crops on subsequent growth of pineapple and multiplication of Rotylenchulus reniformis and Helicotylenchus dihystera.*

Soil from field plots at Kunia, Oahu, Hawaii previously planted with marigold, rhodesgrass, oat or soybean or covered with pineapple residue or left bare-fallow was collected and frozen to eliminate resident nematode populations. After re-infestation with 1,750 eggs of *R. reniformis* (Rr) and 750 eggs of *H. dihystera* (Hd), soil from individual plots was placed into 15-cm-d pots arranged in a randomized complete block design, with 5 replicates on a greenhouse bench. Frozen, noninfested (FNS) and non-frozen, naturally infested (NIS) soils from the mulched plots which contained 2,000 and 800 individuals of Rr and Hd, respectively, were used as controls. A single pineapple crown was transplanted into the center of each pot and allowed to grow for 7 months. Fresh shoot and root weights, D-leaf length and weight, and nematode population densities in the soil were determined. Population densities of Rr and Hd increased 10 and 50 fold, respectively, in NIS. Population densities of Rr in frozen and re-infested soil from the cover crop, mulched, or bare-fallow plots ranged from 10–42% of that in NIS. This range was 56–126% for Hd. Population densities of Rr and Hd in FNS were approximately 6% and 1% of the respective populations in NIS. Growth parameters of pineapple were lowest in NIS and highest in FNS; the parameters were intermediate for all other treatments with no significant differences ($P = 0.05$) among them. Pineapple growth was negatively correlated ($r = -0.5$) with numbers of Hd. *Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.*

KOENNING, S. R.[1], K. R. BARKER[1], S. C. HUBER[2], and W. LIU[3]. *Effects of Heterodera glycines on soybean growth, yield, photosynthesis, and carbohydrate metabolism in different environments.*

Greenhouse, microplot, and field experiments were conducted to evaluate the effects of *Heterodera glycines* (SCN) on selected physiological processes, growth, and yield of soybean. Growth and (or) yield of soybean were suppressed by SCN in a predictable manner, regardless of the type of experiment conducted. Photosynthetic rate and leaf sugar content of soybean were consistently related to the initial inoculum level (Pi) only in greenhouse experiments. Relatively crude measurements of plant photosynthetic area, such as plant height and canopy width, were closely related to Pi of SCN and soybean yield in field and microplot studies. Reproducible determinations of plant physiological responses to nematodes may be restricted to controlled environments for several reasons: 1) current technology places limitations on the size and number of samples that can be taken; 2) the lack of control over stresses which occur in field situations often confound results; 3) measurements of plant growth tend to integrate all stresses up to that point in time and thus may more accurately reflect the plant's potential; and 4) measurements of parameters such as photosynthetic rate, starch, or sugar accumulation may not reflect the alteration of the source–sink relationships which occur in nematode-infected plants. [1]*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695,* [2]*USDA, ARS and Crop Science Department, North Carolina State University, Raleigh, NC 27631, and* [3]*Plant Pathology Department, Shenyang Agricultural University, Dongling, Shenyang City, Liaoning Province 110161, People's Republic of China.*

KOENNING, S. R.[1], D. P. SCHMITT[2], and K. R. BARKER[1]. *Cropping-systems effects on Heterodera glycines population densities and associated soybean yield.*

Soybean planting date and maturity group effects on final population densities of *Heterodera glycines* and soybean yield were evaluated in soybean monoculture or rotations of

1 or 2 years of corn or sorghum. Population densities of *H. glycines* declined in the absence of a host to nearly undetectable levels after 2 years of nonhost culture. A soybean maturity-group-VII cultivar consistently resulted in greater ($P = 0.05$) population densities than a group-V cultivar. Planting date effects on *H. glycines* final population densities were frequently significant ($P = 0.05$) but not consistently so. Early planting resulted in highest numbers of *H. glycines* some years, whereas late planting resulted in higher population densities in other years. Plots with 1 or 2 years of nonhost had greater ($P = 0.01$) soybean yields than those with no rotation. Soybean yield of a group-V cultivar grown in succession with a group-V cultivar were greater than yields of a group-VII cultivar that followed a group-VII cultivar, in monoculture or in a 1-year rotation with a nonhost. Higher yields of the group-V cultivar were the result of low equilibrium densities of *H. glycines* associated with a shorter growing season. Late soybean planting (June) resulted in generally lower soybean yields than early (May) planting. A soybean maturity group-V cultivar planted late was equivalent in yield to a maturity group-VII cultivar planted in May when *H. glycines* was at damaging levels. [1]*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695, and* [2]*Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.*

KOTCON, J. B., and T. P. BATCHELOR. *Population dynamics of Xiphinema spp. on rotation crops.*

Various rotation crops were evaluated for their potential to reduce dagger nematode populations in orchard replant sites. Greenhouse beds, 0.6 × 0.9 m, were filled with 20 cm infested field soil, and an irrigation system was installed to maintain optimum soil moisture among fallow controls and five crops. After 8 months, population density of *Xiphinema americanum* was greatest on corn, followed by marigolds, canola, and 'Fawn' fescue. No significant change was observed in fallow beds or in 'Kentucky-31' fescue. In one field trial, population densities of *Xiphinema* spp. were greater ($P = 0.05$) after 6 months on corn than on the other crops; while in another field trial, extreme drought prevented normal crop growth and no significant differences were observed among canola, corn, marigolds, wheat, oats, ryegrass, and the two fescue cultivars. *Division of Plant and Soil Sciences, West Virginia University, P. O. Box 6057, Morgantown, WV 26506.*

LACKEY, B. A., B. A. JAFFEE, and A. E. MULDOON. *Sporulation of the nematophagous fungus Hirsutella rhossiliensis from hyphae added to soil.*

After assimilating host nematodes, *Hirsutella rhossiliensis* (Hr) produces external hyphae, phialides, and spores from assimilative hyphae within the cadaver; the spores adhere to and infect nematodes. The ability of Hr to produce external hyphae, phialides, and spores from hyphae (vegetative colonies) produced in shake culture (potato dextrose broth) was tested. Vegetative colonies were 1.7 mm in diameter and were rinsed free of broth before addition to 17 cm^3 soil in 25-ml vials. Sporulation from vegetative colonies in either unheated, heated (2 hours at 60 C), or autoclaved loamy sand at 20 C was measured by quantifying parasitism of *Heterodera schachtii* juveniles (J2) that were added to the soil 14 days after the colonies and extracted 66 hours later. Parasitism increased nonlinearly with increasing fungal inoculum and was not affected by soil treatment. In another experiment, four vegetative colonies per 17-cm^3 soil were required to obtain 50% parasitism of J2 in seven different untreated soils. Penetration of cabbage roots by J2 in untreated loamy sand declined with increasing number of vegetative colonies. No direct affect of Hr on plants in the absence of nematodes was observed. Our data suggest that hyphae may be a useful form of inoculum for biological control of nematodes by Hr. *Department of Nematology, University of California, Davis, CA 95616.*

LAMBERT, K. N., and V. M. WILLIAMSON. *Construction of a cDNA library of nematode-resistant tomato root tips infected with root-knot nematodes.*

Our research objective is to identify genes in root-knot nematode-resistant tomato that are potentially involved in the plant's resistance response. Nematode-induced tomato genes that are specific to resistant plants and expressed early in the response will be considered the best candidates. The first step in identifying these genes is to make a cDNA library from nematode-infested resistant root tips. Because root-knot nematodes infect the plant primarily at the root tip, the amount of tissue available for analysis is small. A

hydroponic nematode culture system and a mass seedling inoculation technique have been developed for generating hundreds of nematode-infested root tips. Even with improved techniques the amount of material is limited. The polymerase chain reaction (PCR) technique and superparamagnetic beads were used to amplify cDNA synthesized from nematode-infested root tip mRNA. The PCR-cDNA was used to construct several cDNA libraries in a plasmid vector. We are screening one library by differential hybridization to identify plant genes induced by nematodes. Each candidate clone will be tested to determine whether it is of tomato or nematode origin and if it is specifically induced in the resistant plant. *Department of Nematology, University of California, Davis, CA 95616-8668.*

LAMBERTI, F., and A. CIANCIO. *The diversity of Xiphinema americanum and related species in North America and the problems associated with taxonomic identifications.*

There are 39 species described within the *Xiphinema americanum* group, of which 14 have been originally described from North America and another four have been reported from this region. Close similarities exist among many species, which can be distinguished on the basis of various combinations of some morphometric characters, mainly shape of tail and lip region, length of the body and the odontostyle, position of vulva, and values of the ratios a, c and c′. Other useful characters include the distance of the basal guiding ring from the oral aperture and the length of the hyaline portion of the tail (J). A study on morphometrics of the type populations of the 39 species attributed to this group by means of principal component analysis and hierarchical cluster analysis revealed the occurrence of various phenotypes. *Istituto di Nematologia Agraria, C.N.R., Via G. Amendola 165/A, 70126 Bari, Italy.*

LAWRENCE, G. W.[1], G. L. WINDHAM[2], and K. S. MCLEAN[3]. *Corn as a nonhost for reniform nematode management in cotton production.*

Corn *(Zea mays)* was evaluated as a non-host crop for the reniform nematode in a sustainable cotton *(Gossypium hirsutum)* production system. Corn (Pioneer brand 3165) and cotton (DPL-20) were planted in a field naturally infested with *Rotylenchulus reniformis.* Cropping sequences include monoculture cotton and alternate year combinations of corn and cotton. Each treatment was planted with and without aldicarb at 1.18 kg a.i./ha. Population densities of *R. reniformis* were 14,935, 7,004, and 412 nematodes/500 cm^3 soil in monoculture cotton, cotton monocultured two years after corn, and alternate year combinations of corn, respectively. Cotton yields were significantly higher in plots with alternate year combinations compared with monoculture cotton plots. The inclusion of corn in a cotton production system reduced *R. reniformis* populations and improved cotton yields. [1]*Department of Plant Pathology and Weed Science,* [2]*USDA, ARS, Mississippi State University, Mississippi State, MS 39762, and* [3]*Department of Agriculture, Northeast Louisiana University, Monroe, LA 71209.*

LEWIS, S. A.[1], E. R. SHIPE[2], and J. D. MUELLER[3]. *Correlation of Heterodera glycines reproduction on soybean breeding lines in the field and in a greenhouse assay system.*

A greenhouse procedure for assessing soybean breeding lines for susceptibility to *Heterodera glycines* (SCN) is currently used to assay over 3,500 lines/year. This assay enables elimination of lines at an earlier stage of development compared to field tests. The ranking of varieties based on the numbers of mature SCN females visible on the roots is similar for both greenhouse and field tests. Varieties or lines having large numbers of females on the roots in the field reacted similarly in the greenhouse. Most importantly, no line or variety that was listed as susceptible in the greenhouse screening system was resistant in the field. One line was resistant in the greenhouse and susceptible in the field. These studies show that reliance can be placed on the greenhouse assay system for demonstrating susceptibility to SCN. [1]*Clemson University, Department of Plant Pathology and Physiology, and* [2]*Department of Agronomy and Soils, Clemson University, Clemson, South Carolina 29634-0377, and* [3]*Edisto Research and Education Center, P.O. Box 247, Blackville, SC 29817.*

LOLAS, M. A.[1,2], K. J. MERRIFIELD[1], J. K. PINKERTON[3], and R. E. INGHAM[1]. *Effect of fenamiphos on population dynamics of Pratylenchus penetrans and Xiphinema americanum in Oregon red raspberry fields.*

Population dynamics of *P. penetrans* (four sites) and *X. americanum* (one site) from untreated and fenamiphos-treated (9.9 kg/ha on November 15, 1989 and 13.2 kg/ha on December 31, 1990) plots were monitored in red raspberry fields in northwest Oregon. Soil and root samples were taken monthly from October 1989 to November 1991 from five replicate plots of each treatment. Populations of *P. penetrans* were low through the winter but increased to maximum densities during the late summer of 1990. Populations declined through the winter again but in 1991 increased rapidly in the early spring, declined during the late spring and summer, and then increased to maximum densities in the fall. In both years, *X. americanum* increased from October until February and then declined until June and remained at low levels through the summer. Populations of *P. penetrans* were significantly less in fenamiphos-treated plots on some sample dates, but there was no discernable effect of fenamiphos on *X. americanum* populations. [1]*Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902,* [2]*Agronomy School, University of Talca, Talca, Chile, and* [3]*Horticultural Crops Research Laboratory, USDA, ARS, Corvallis, OR 97330.*

MASHELA, P.[1], L. W. DUNCAN[1], J. P. SYVERTSEN[1], and R. MCSORLEY[2]. *Mechanical root pruning and Tylenchulus semipenetrans affect concentrations of osmoticum ions in citrus rootstock seedlings.*

Previously we proposed that increasing citrus root carbohydrates by *Tylenchulus semipenetrans* infection induced an alteration in partitioning of osmoticum ions (Cl, K, Na) as a means of regulating the reduced osmotic potential in roots. This was tested by comparing effects of root pruning and nematode infection on osmoticum ions in Cleopatra mandarin (*Citrus reticulata* Blanco) and sour orange (*C. aurantium* L.). Pruning increased starch (82%), ketone sugars (34%), and reducing sugars (42%) in remaining roots of Cleopatra mandarin. The nematode also increased starch (13%), but decreased reducing sugars (33%), and had no effect on ketone sugars in Cleopatra mandarin roots. Pruning decreased leaf K (38–49%), and root K (37–41%), Cl (28–32%), and Na (27–46%), but increased leaf Cl (33-130%) in both rootstocks and Na (38%) in Cleopatra mandarin. The nematode decreased leaf K (20–25%), and root K (18–31%), Cl (17–22%), and Na (18–39%), and increased leaf Cl (33–40%). Thus, the pruning data supported the hypothesis that increasing root carbohydrates changes the partitioning of osmoticum ions in citrus. However, the effect of nematodes on reducing sugars, which are part of osmotically active sugars, did not support the hypothesis. [1]*Citrus Research and Education Center, University of Florida, IFAS, 700 Experiment Station Road, Lake Alfred, FL 33850, and* [2]*University of Florida, IFAS, Department of Entomology and Nematology, Gainesville, FL 32611.*

MATHER, R. L., J. MAAN, and G. W. BIRD. *The potential role of Planetor as a decision support aid for root-knot nematode management in carrot production.*

Planetor is a whole farm planning system that is being validated by the Center for Farm Financial Management at the University of Minnesota as part of the Sustainable Agriculture Research and Education Program. Inputs into the system include farm data, environmental parameters and economic information. Outputs include projected income, potential losses and environmental impacts over a user-specified time period. This integrated decision support system has been used to analyze the impact of several rotation strategies for Michigan carrot growers with fields containing high, medium and low population densities of root-knot nematode. Rotation strategies include carrot–onion–carrot, carrot–carrot–onion–onion, and carrot–onion–fallow–carrot–onion. The purpose of this demonstration is to show nematologists how existing decision support systems can be modified to include impacts of plant-parasitic nematode management on the economics and environmental compatibility of specific agricultural production systems. *Department of Entomology, Michigan State University, East Lansing, MI 48824.*

MCKENRY, M. V., and T. BUZO. *Field performance of a soil drenching device.*

Many nematicidal agents that perform well in a laboratory setting may have little practical value in a field setting because of the inability to deliver appropriate concentrations for sufficient exposure time to the site of the pest. This is a common occurrence with water-transported nematicides, especially those having short half-lives. We have now field tested two portable soil drenching devices which were designed to correct this problem. To

visualize the device, consider the placement of one dripper emitter on each 0.9-m^2 of field surface area. The nematicidal agent is delivered as a solution in large volumes of water. We have used a 15-cm head of water to deliver nematicidal agents 1.3 m in depth. We have now obtained 99.99% reductions in nematode populations throughout the surface 1.3 m of a soil profile in ten of ten replicates using metham sodium. These soil drenching devices may also be used to deliver "alternative" nematicidal agents and, for example, have been shown to greatly enhance the nematicidal value of plant extracts and commercial fertilizers. Inability of many water-transported nematicides to penetrate old roots is the single limitation we have experienced. Soil drenching devices are simple to construct for small sites. Their use in larger field sites will be limited to high cash-value crops. *Department of Nematology, University of California, Riverside, CA 92521.*

MCLEAN, K. S.[1], and G. W. LAWRENCE[2]. *Effect of Heterodera glycines and delayed inoculation of Fusarium solani on sudden death syndrome of soybean.*

Tests were established to examine the association between the soybean cyst nematode (SCN) and delayed inoculation of the blue form of *Fusarium solani* (FSA), the causal organism of sudden death syndrome of soybean. Initial inoculum treatments consisted of SCN alone, FSA alone, the combination of SCN + FSA, an untreated control, and FSA alone and SCN + FSA where FSA was added two weeks after SCN. Foliar symptoms occurred more frequently and were significantly more severe on plants inoculated with the SCN + FSA combination compared to FSA alone, regardless of inoculation times. Foliar symptom development was not significantly increased by delaying FSA inoculations. Plant height, fresh and dry shoot and root weights of the SCN + FSA combination were not significantly different between FSA inoculation treatments. The SCN development was significantly reduced in the presence of FSA in all inoculations. [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.*

MELAKEBERHAN, H.[1], A. L. JONES[2], and G. W. BIRD[1]. *Abiotic factors affecting sweet cherry trees in Michigan.*

The level of soil pH, soil and leaf nutrient elements, and winter injury (abiotic) was studied in five selected orchards. In addition, the presence of nematodes and incidence of bacterial canker (biotic) were also determined. The orchards were 6 to 16 years old and consisted of nine cultivars on mazzard rootstock. Orchards 2 and 5 were the healthiest and Orchards 1 and 3 had the greatest number of dead and declining trees and the highest incidence of bacterial canker, followed by Orchard 4. While *Pratylenchus penetrans*, *Criconemella xenoplax*, *Xiphinema americanum*, and two pathovars of *Pseudomonas syringae* were isolated from these orchards, the intensity of each biotic factor varied with orchard. Winter injury was severe in Orchard 3 and slight in Orchard 4. Low soil pH was the most common factor in all orchards, requiring ca. 2.2–4.6 tons/ha of lime to raise the pH to the recommended level of 6.5. The relationship between soil and leaf nutrient concentrations showed that Ca and N were insufficient in leaves from all but Orchard 4; Mg in leaves from Orchards 1 and 2; K in Orchard 2; and P in Orchard 3. Leaves from Orchards 1, 3, and 4 had leaf Al concentrations of 110–392 ppm. Low soil pH appeared to increase available Al in the soil. Overall, it appears that the abiotic factors may play a significant role in the decline of sweet cherry trees in Michigan. [1]*Department of Entomology and* [2]*Department of Botany and Plant Pathology and the Pesticide Research Center, Michigan State University, East Lansing, MI 48824.*

MENDES, M. L.[1], and D. W. DICKSON[2]. *Heterodera glycines found on soybean in Brazil.*

The soybean cyst nematode (SCN) *Heterodera glycines* was collected and identified on soybean during site visits in three states in Brazil during March 1992. The infested sites are located near the municipalities of Campo Verde, Mato Grosso; Nova Ponte and Iraí de Minas, Minas Gerais; and Chapadão do Céu, Goiás. The large geographical region represented by these infested sites likely means that the SCN is firmly established in Brazil. Based on the severity of plant stunting and the number of cysts recovered from soil collected at each site, it is estimated that the infestations are at least 3–5 years old. [1]*EMBRAPA-Centro Nacional de Pesquisa de Soja, Cx. P. 1061, CEP.86.001 Londrina, PR, Brazil, and* [2]*Department of Entomology and Nematology, P.O. Box 110620, University of Florida, Gainesville, FL 32611-0620.*

MERCER, C. F., and J. L. GRANT. *Aggressiveness of populations of Meloidogyne hapla and Heterodera trifolii on white clover.*

Colonies of populations of *M. hapla* and *H. trifolii* were collected from sites around New Zealand and established on white clover. Seed of two lines of white clover showing some resistance and of two lines known to be susceptible were sown singly in 6.5-cm-d pots. The experimental design for each nematode species was eight populations × four white clover lines × 11 replications. A suspension of eggs from each colony was added to the root zone. After 50 days, *H. trifolii* cysts and females were washed from soil and roots by elutriation and counted. Mean counts of *H. trifolii* cysts were lower on resistant lines than on one or both susceptible lines at six sites. Overall, the counts on resistant lines were 46% of the counts on susceptible lines. The indication is that there is intraspecific variation among *H. trifolii* populations. The resistance screening program should test future, improved resistant lines against several populations. After 70 days, *M. hapla* galls were counted on washed roots. Mean gall counts were lower on the resistant lines than on susceptible ones at each site. Overall, the counts on resistant lines were 28% of the counts on susceptible lines. The indication is that there is no important intraspecific variation among *M. hapla* populations and that the breeding program can continue using one population as inoculum. *National Pastoral Research Institute, Private Bag, Palmerston North, New Zealand.*

MERRIFIELD, K. *Population dynamics of forest floor moss-dwelling nematodes and tardigrades.*

Between October 1990 and October 1991, 5-cm-d samples of the moss *Eurhynchium oreganum* (Sull.) Jaeg. were removed at four to six week intervals from ten stations, all between 1 and 1.5 meters apart, along rotting logs on Douglas fir forest floor on the northwest slope of Mary's Peak, Benton County, Oregon. Following Baermann funnel extraction, moss samples were dried and weighed. *Plectus* sp., a bacteria-feeder, averaged between 4 and 12 per dry gram of moss except in June, when the population peaked at 25 per gram. *Monhystera* sp., of unknown feeding habits, averaged one or less per gram throughout the winter and spring but increased in late summer, reaching a maximum of 35 per gram in September. Populations of *Tylenchus* sp., a probable plant- or fungal-feeder, were patchy and fluctuating. Population peaks of 35 and 25 per gram were reached in November and July, respectively. Densities of the predator *Prionchulus* sp. fluctuated throughout the year but reached maxima of 6 to 8 per gram during summer and winter. *Eudorylaimus* sp., a fungal feeder or predator, averaged 12 per gram or lower from fall through spring, with a population peak of 25 per gram in June. Other sporadically occurring nematode genera included *Acrobeles, Ecphyadophora, Teratocephalus, Cuticonema,* and *Aphelenchus.* Tardigrades averaged less than one per gram from November through March, increased to nearly 5 per gram during April through August, and increased again to 15 per gram in September and October. Mosses and their endemic faunal communities are potential indicators of environmental damage, but little about their composition and dynamics is known. *Department of Botany and Plant Pathology, Oregon State University, 2082 Cordley Hall, Corvallis, Oregon 97331-2902.*

MERRIFIELD, K. J., and R. E. INGHAM. *Effects of ethoprop on nematode population dynamics and root growth in Oregon peppermint.*

Peppermint root weights and parasitic nematodes were monitored from March through November 1991 in the Willamette Valley (WV) and Central Oregon (CO). In each location, five 5-cm-d × 15-cm-deep cores were taken biweekly from each of four ethoprop-treated (6.6 kg/ha in September, 1990) and untreated plots. Root weight in both locations peaked in April and again in July. Total (soil plus root) *Pratylenchus penetrans* populations in both locations peaked in early June, declined to a summer plateau, increased again in late summer, and declined through fall. Highest *P. penetrans* densities followed root weight peaks by 4–6 weeks. Root weights were higher and *P. penetrans* populations were lower in ethoprop-treated plots. WV *Paratylenchus* sp. populations were low in spring and increased to a maximum in late October, while CO populations peaked in late April, decreased to a summer plateau, and increased again in fall. Populations of *Criconemella xenoplax, Longidorus elongatus,* and *Paratrichodorus* sp., all present in WV only, each peaked in spring, decreased to a summer plateau, and increased again in fall. No ethoprop treatment effects were observed in the latter four species. *Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon 97331-2902.*

MILLER, L. I. *Second-stage juvenile dimensions of Globodera tabacum virginiae and G. t. solanacearum cultured on Solanum carolinense and Nicotiana tabacum.*

Comparisons were made of certain characters of second-stage juveniles of type locality isolates of *Globodera tabacum virginiae* (N1) and *G. t. solanacearum* (N2) when cultured on horsenettle (P1), *Solanum carolinense*, and tobacco (P2), *Nicotiana tabacum* cv. VA 312. P1 and P2 were efficient hosts for N1 and N2. Mean dimensions in µm of 115 specimens were as follows–DGO: N2P1 5.5, N2P2 5.8, N1P2 6.1, N1P1 6.1; tail terminus length (TER): N2P1 24.1, N2P2 25.7, N1P2 26.2, N1P1 27.1; length (LTH): N2P1 497, N1P1 503, N2P2 506, N1P2 514. Comparisons between the subspecies were significantly different ($P = 0.01$) for DGO dimensions of N1 and N2 on P1 and P2, the TER dimensions of N1 and N2 on P1, and the LTH dimensions of N1 and N2 on P2. DGO dimensions of N1 on P1 and P2 were not significantly different, but they were greater ($P = 0.01$) than dimensions of N2 on P1 and P2. TER dimensions of N1 and N2 were not significantly different on P2, but they were significantly different ($P = 0.01$) from N2P1 and N1P1. The LTH dimensions of N1P2 were greater ($P = 0.01$) than LTH dimensions of N2P1, N1P1 and N2P2. *Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.*

MINTON, N. A.[1], T. B. BRENNEMAN[2], and G. W. HARRISON[3]. *Nematicidal, fungicidal, and insecticidal activity of fosthiazate on peanut.*

Fosthiazate, a systemic compound, was evaluated during 1990 and 1991 against the peanut root-knot nematode (*Meloidogyne arenaria*), thrips (*Frankliniella spp.*) and southern stem rot (*Sclerotium rolfsii*) on peanut. Infestation levels of *M. arenaria* second-stage juveniles at time of planting (AP) averaged 3,000 and 150 per 150 cm^3 of soil in 1990 and 1991, respectively. Fosthiazate 10 G rates ranging from 2.2 kg a.i./ha to 6.7 kg a.i./ha were all applied AP or half AP and half at pegging (PEG). Root-gall indices were reduced significantly ($P = 0.05$) by all fosthiazate treatments in both years. In 1990, thrips damage was reduced significantly ($P = 0.05$) by 2.2, 3.3, 4.4, and 6.7 kg a.i./ha AP treatments, and also in 1991 by 1.5 and 1.0 kg a.i./ha AP treatments. In 1990, the incidence of southern stem rot was reduced significantly ($P = 0.05$) by the fosthiazate 6.7 kg a.i./ha AP treatment and by two split application treatments (1.5 lb a.i./ha AP + 1.5 lb a.i./ha PEG and 2.0 lb a.i./ha AP + 2.0 lb a.i./ha PEG). Peanut yields in 1990 were significantly ($P = 0.05$) greater in all treated plots than in controls. Yield increases ranged from 104% for 3.3 kg a.i./ha AP to 253% for 6.7 kg a.i./ha AP treatments. In 1991, yields were increased significantly by all treatments, except the 2.2 kg a.i./ha AP treatment. The maximum increase of 79% occurred in the 2.2 kg a.i./ha AP + 2.2 kg a.i./ha PEG treatment. *[1]USDA, ARS, and [2]Department of Plant Pathology, University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31793, and [3]ISK Biotech Corporation, P.O. Box 70665, Albany, GA 31707.*

MOJTAHEDI, H., G. S. SANTO, J. H. WILSON, and A. N. HANG. *Control of Meloidogyne chitwoodi with rapeseed as green manure.*

Jupiter rapeseed leaves and stems, chopped and incorporated into the soil, reduced *Meloidogyne chitwoodi* egg masses, freed eggs, or second-stage juvenile (J2) populations in the zone of incorporation and protected from nematode recolonization for 6 weeks. Root tissues were also effective, provided they were homogenized before amending. In the greenhouse, Jupiter accumulated more glucosinolates with age and was more effective against *M. chitwoodi* as a soil amendment. J2 were more sensitive than egg masses to rapeseed amendment, with respective ED_{50} of 10 and 23 mg green leaves of 4-month-old rapeseed/g of soil. For two consecutive years, planting Jupiter rapeseed in late summer and incorporating it in spring as green manure reduced *M. chitwoodi* impact on field-grown potato. Augmenting green manure amendment with ethoprop further reduced nematode damage, similar to 1,3-dichloropropene. *Department of Plant Pathology and Agronomy, Washington State University, IAREC, Prosser, WA 99350.*

MOUNPORT, D.[1], P. BAUJARD[2], and B. MARTINY.[2] *TEM observations on the cuticle of two species of the genus Trichotylenchus Whitehead, 1960 (Nemata: Belonolaimidae).*

The fine structure of the cuticle was studied in females of two species of *Trichotylenchus, T. falciformis* and *T. palustris.* Cuticle ultrastructure is similar in the two species

and consists of three zones: cortical, median, and basal. The cortical layer consists of a trilaminate external layer and a granular internal layer. The median zone is represented by an electron-lucent layer. The basal zone consists of a striated layer outside lateral fields. Striae are radial and their periodicity is greater in longitudinal than in cross sections. Beneath both outer incisures of the lateral fields, the striated layer is replaced by five layers: two outer granular layers; an intermediate electron-lucent layer, appearing only between incisures; and two inner fibrous layers. This pattern has been observed also in *Tylenchorhynchus vulgaris*, another genus of the family Belonolaimidae. [1]*Département de Biologie Animale, U.C.A.D., Dakar, Sénégal, and* [2]*Laboratoire de Nématologie, ORSTOM, B.P. 1386, Dakar, Sénégal.*

MOUSA, E. M. *Biological control of the root-knot nematodes Meloidogyne incognita and Meloidogyne javanica with Pasteuria penetrans.*

The root-knot nematodes *Meloidogyne incognita* and *Meloidogyne javanica* were exposed to the biocontrol agent *Pasteuria penetrans* in experiments with tomato and nightshade plants in two soil types (sandy and heavy soil) in microplot experiments. *Pasteuria penetrans* inoculum was introduced into the soil by adding spore-encumbered nematodes to tomato and nightshade plants and then subsequently incorporating root materials into the soil after plant senescence. Exposure of both nematode species to *P. penetrans* resulted in a highly significant reduction of nematode populations. The reduction was greater in *M incognita* than in *M. javanica.* The population decrease was greater and occurred sooner in sandy soil than in heavy soil. The number of galls on both tomato and nightshade plants in sandy soil was reduced as much as 50% of the amount in heavy soil. The growth of both tomato and nightshade plants was markedly enhanced during the experiments. *Department of Agricultural Botany, Faculty of Agriculture, Menoufiya University, Shebin El-Kom, Egypt.*

MYERS, R. F. *Chemical inventory program.*

A menu-driven program was developed for the IBM PC-2 to facilitate locating chemicals and to print inventories. Written in Microsoft's Basic (v. A3.10), it also functions on the Gateway 2000 486/33E using Microsoft's GW-basic (v. 3.23). The program manipulates interactive index and data files. Chemicals are assigned numbers when acquired, and when deleted from the database, numbers are reused. Chemicals are sorted alphabetically by name and prefix, and informational data may be retrieved and modified as necessary. A list of either chemical names, ID numbers, and places of storage; or chemical names, CAS numbers, toxicity classes, and residual quantities have been printed on an Epson MX100, NEC Pinwriter P5200, and Hewlett Packard LaserJet IIP+. To locate a chemical, the computer performs a Shell sort. Such sorts require excessive time for computers operating at 4 Mhz, and so database size should be limited to between 500 and 1000 chemicals. For computers operating at 33 Mhz, or when using printed lists, database size can be considerably larger. *Plant Pathology Department, Rutgers University, Cook College, New Brunswick, NJ 08903.*

NEWCOMB, G. B.[1], K. J. MERRIFIELD[1], K. A. RYKBOST[2], and R. E. INGHAM[1]. *Effect of fumigant and nonfumigant nematicides on Meloidogyne chitwoodi, Paratrichodorus teres and corky ringspot disease in potato at Klamath Basin, Oregon.*

Fumigant and nonfumigant nematicides were applied, alone and in combination, to fields with a history of *M. chitwoodi* and corky ringspot (CRS) disease. One set of 10 tubers from each plot was sliced once longitudinally to evaluate CRS, while another set of 25 tubers was peeled to evaluate *M. chitwoodi* infection and then sliced into 8–12 transverse slices to assess CRS symptoms. CRS measured with the two procedures was similar, but more statistical separation of treatments was obtained with transverse slicing. The lowest percentage of *M. chitwoodi* infection and CRS in 1990 were from treatments with 1,3-D at 140 liters/ha (fall or spring applied) plus broadcast preplant incorporation (bppi) of ethoprop at 6.6 kg/ha, 1,3-D plus 17% chloropicrin at 257 liters/ha, or bppi of ethoprop at 13.2 kg/ha. During the 1991 growing season, spring-applied 1,3-D at 186 liters/ha or bppi of ethoprop at 9.9 kg/ha plus a side dress of aldicarb at 3.3 kg/ha produced tubers free of CRS. Only treatments with 1,3-D plus ethoprop at 6.6 kg/ha or 1,3-D plus aldicarb at 3.3 kg/ha produced

tubers free of *M. chitwoodi* infection in 1991. [1]*Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902, and* [2]*Klamath Experiment Station, Klamath Falls, OR.*

NIBLACK, T. L.[1], W. J. WIEBOLD[2], and J. H. YEN[1]. *Interactions between Heterodera glycines and Glycine max isolines differing for maturity.*

In 1991, the first year of a study to identify the effects of host phenology on *H. glycines*–soybean interactions was conducted in field microplots (1 m × 1 m × 0.6 m deep). Natural infestations of *H. glycines* were augmented to obtain four initial population (Pi) classes, the lowest averaging 149 and the highest 12,147 eggs/100 cm^3 soil. Microplots were planted to cv. Clark or one of three isolines differing from Clark for maturity: e_2, 10 days earlier; E_1e_3, 10 days later; and E_1, 20 days later. Over 20 different soybean growth and yield components were measured; all differed among isolines, but no isoline × Pi interactions were observed. Highly significant linear effects due to Pi were detected over all isolines for number of days flowering, plant heights at R1 and R5, change in plant height from R1 to R5, plant growth rate, number of branches, number of barren nodes, seed yield, number of pods, and number of flowers. Seed yield decreased from 296 g/m^2 at the lowest *H. glycines* Pi to 156 g/m^2 at the highest. Microplots were sampled monthly for *H. glycines* eggs. Reproductive rate of *H. glycines* was dependent on Pi and unaffected by isoline. The hatching rate of eggs produced on e_2 declined to a lower level in August and September than eggs produced on the other three isolines. Infectivity of second-stage juveniles was affected by month of sampling but not by isoline. [1]*Department of Plant Pathology and* [2]*Department of Agronomy, University of Missouri, Columbia, MO 65211.*

NICKLE, W. R.[1], and M. SHAPIRO[2]. *Use of a Stilbene Brightener, Tinopal LPW, as a Radiation protectant for Steinernema carpocapsae.*

A stilbene fluorescent brightener, Tinopal LPW, was used as an ultraviolet (UV) protectant for the entomopathogenic nematode *Steinernema carpocapsae* (All strain). Irradiation of an aqueous suspension of nematodes produced a LT_{50} in 13 minutes under a sunlamp and in 40 minutes in direct sunlight. Irradiation by both sunlamp and sunlight of a suspension of nematodes in Tinopal LPW did not reduce their biological activity as measured by their ability to parasitize wax moth larvae after exposure of 8 hours and 4 hours, respectively. A standardized nematode infectivity test, original activity (OA), that regularly provides 90–100% wax moth larval mortality in 72 hours was used. A percentage of this standard, after UV light exposure, becomes the original activity remaining (OAR). Tinopal LPW appeared promising as a radiation protectant showing progress toward a practical formulation. [1]*Nematology Laboratory and* [2]*Insect Biocontrol Laboratory, Plant Sciences Institute, USDA, ARS, Building 011A, BARC-West, Beltsville, MD 20705.*

NILES, R. K., and D. W. FRECKMAN. *Distribution and activity of bacterivorous nematodes in the root zones of greenhouse-grown tomato and western wheatgrass.*

Bacterivorous nematodes constitute an important, and often a dominant, component of nematode communities in agricultural and natural habitats. To investigate bacterivorous nematodes and their effect on plant growth, a series of pot experiments was conducted in the greenhouse with tomato *(Lycopersicon esculentum)* and western wheatgrass *(Agropyron smithsii)*. Treatments of *Acrobeloides* sp. (suspended with *Escherichia coli)* or tap water were added to the resident nematode community of both plants. Also, *Meloidogyne javanica* + *Acrobeloides* sp. was added to tomato, and an *E. coli* suspension without *Acrobeloides* sp. was added to western wheatgrass. Shaking the soil from roots and sonicating the roots enabled nematodes to be assayed from bulk soil (soil furthest from roots), outer rhizosphere soil (a few cm from roots), inner rhizosphere soil (a few mm from roots), and the root surface (with soil absent). Plant growth was assessed as shoot and root dry weights. Microbial activity was measured as substrate-induced respiration. Preliminary analyses show bacterivorous nematodes were most abundant in the rhizosphere. Growth of western wheatgrass appeared greater with *Acrobeloides* sp. + *E. coli* suspension, rather than with other treatments. *Department of Nematology, University of California, Riverside, CA 92521.*

NOEL, G. R.[1], C. D. NICKELL[2], and R. L. BERNARD[2]. *Reaction of nine advanced breeding lines to Heterodera glycines races 1–5 and 14.*

Breeding lines evaluated previously in the field and greenhouse against *Heterodera glycines* race 3 and having PI88.788, Cloud, PI87.631-1, PI90.763, PI209.332, or PI89.772 as the source of resistance and 'Williams' as the susceptible parent were tested in the greenhouse against *H. glycines* races 1–5 and 14. The lines and their source of resistance were: LN89-5593 (PI88.788), LN89-5612 and LN89-5616 (Cloud), LN89-5642 and LN89-5649 (PI87.631-1), LN89-5680 (PI90.763), LN89-5698 and LN89-5699 (PI209.332), and LN89-5717 (PI89.772). An index of parasitism (I) based on the number of females that developed on the breeding line ÷ the number on 'Lee 68' × 100 was determined, and a ranking of resistance was assigned, where 0–9% = resistant (R), 10–30% = moderately resistant (MR), 31–60% = moderately susceptible (MS), and >60% = susceptible (S). Reaction of LN89-5698, LN89-5699, and LN89-5717 to races 3 and 14 was R and reaction to race 4 was MR. LN89-5717 also was designated R to race 5. Reaction of LN89-5593 was R and MR to races 3 and 14, respectively, and reaction of LN89-5612 was MR to races 3 and 14. All lines were designated either S or MS to race 1. LN89-5616, LN89-5642, LN89-5649, and LN89-5680 also were classified either as S or as MS to races 2, 3, 4, 5, and 14. No lines were designated R to race 2, but LN89-5593, LN89-5698, LN89-5699, and LN89-5717 were rated MR to race 2. Germplasm releases of the lines with high levels of resistance are planned. [1]*Crop Protection Research Unit, USDA, ARS, Department of Plant Pathology, and* [2]*Department of Agronomy, University of Illinois, Urbana, IL 61801.*

NOLING, J. W. *Use of root gall indices for prediction of tomato yield losses.*

Damage relationships between tomato (*Lycopersicon esculentum* Mill. cv. Sunny) yield and root galling induced by *Meloidogyne incognita* were evaluated in five experiments conducted in field microplots or bedded, plastic mulch-covered row plots. In all experiments, the relation between tomato yield and root gall severity was well described ($P = 0.01$) by negative linear and Seinhorst damage functions. Tolerance levels to *M. incognita* root galling were over 6 times higher in field microplots that had been methyl bromide fumigated prior to nematode inoculation and planting than in bedded row plots. Slope values from linear regression analysis were significant ($P = 0.01$) but variable and highly dependent on tomato production level. Use of root gall indices for crop loss assessment provided a practical, rapid feedback alternative to traditional preplant soil sampling methodology. *Department of Entomology and Nematology, University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850.*

NORDBRING-HERTZ, B., H.-B. JANSSON, E. FRIMAN, Y. PERSSON, C. DACKMAN, T. HARD, and E. POLOCZEK. *Mechanisms of capture in nematophagous fungi.*

Nematophagous fungi use different modes to capture, kill and digest nematodes: the endoparasites use their spores and the nematode-trapping fungi use special capture organs formed on the hyphae. In this film the endoparasitic fungi *Catenaria anguillulae* (zoospores) and *Drechmeria coniospora* (adhesive spores), and the nematode-trapping fungi *Dactylaria candida* (adhesive knobs), *Monacrosporium cionopagum* (adhesive branches), *Arthrobotrys oligospora* (adhesive networks) and *Arthrobotrys dactyloides/Dactylaria brochopaga* (constricting rings) are presented. The different modes of attacking nematodes, penetration of the nematode cuticle, digestion of the animals, formation of traps and sporulation are shown. *Department of Microbial Ecology, Lund University, S-223 62 Lund, Sweden, and Institut für den Wissenschaftlichen Film, Nonnenstieg 72, D-3400 Göttingen, Germany.*

NYCZEPIR, A. P.[1], M. B. RILEY[2], and R. R. SHARPE[3]. *Pathogenicity and interaction of Meloidogyne incognita and Criconemella xenoplax on peach.*

The effect of *Meloidogyne incognita* (Mi) and *Criconemella xenoplax* (Cx), singly and in combination, on growth and stress of peach was investigated. Twenty-four field microplots were established with 'Lovell' seedlings in August 1989 in soil that had been preplant-fumigated with methyl bromide in April. Individual nematode species, alone (10,000 nematodes per microplot) and in combination (10,000 Cx + 10,000 Mi), were established in November 1989. Population density of Cx was suppressed ($P \leq 0.05$) in the presence of Mi + Cx as compared to Cx alone 16 months after inoculation. No differences in Mi juvenile

population densities were detected between Mi alone and Mi + Cx treatments. Tree growth, as measured by trunk diameter, was stunted ($P \leq 0.05$) only in the Cx + Mi treatment 18 months after inoculation. A synergistic effect ($P \leq 0.05$) causing a reduction in tree growth was detected 26 months after inoculation. Tree growth in the presence of Mi alone was less ($P \leq 0.05$) than Cx alone and less than the control, but Cx alone did not differ from the control. Increased levels ($P \leq 0.05$) of malonyl-1-aminocyclopropane-1-carboxylic acid (a compound associated with ethylene production in plants) occurred only in leaves from treatment trees grown in the presence of Mi. Results after two years indicate that Mi affects tree growth more than Cx and that the interaction between Mi and Cx is significant. [1]*USDA, ARS, S.E. Fruit and Tree Nut Research Laboratory, Byron, GA 31008,* [2]*Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634, and* [3]*USDA, ARS, S. Piedmont Conservation Research Laboratory, Watkinsville, GA 30677.*

OLTHOF, Th. H. A., and A. B. BROADBENT. *Evaluation of steinernematid nematodes for control of a leafminer, Liriomyza trifolii, in greenhouse chrysanthemums.*

In laboratory and greenhouse tests, foliar sprays of *Steinernema carpocapsae* (Biosys All strain) in water containing 0.02% sticker (Agral 90), applied at 100,000 nematodes/10 ml/plant to 15-cm potted chrysanthemums (cv. Manatee Iceberg) 4 days after oviposition by *Liriomyza trifolii* were effective (>85% mortality) only when high humidity was maintained by covering plants with plastic cages or when the evaporation of moisture on the leaves was reduced by glycerin. In the first of two tests in a research greenhouse compartment (52 m^2), *S. carpocapsae* All provided only 52.7% leafminer mortality at 22 C and 95% R.H.; however, in a second test, >80% mortality was achieved with two applications (3 and 4 days after oviposition) of the All strain; one or two applications of the Scanmask strain; and one or two applications of Scanmask + 5% glycerin. To date, a single commercial greenhouse trial was unsuccessful (<30% mortality), possibly because 19 C was below the optimum for nematode activity. *Research Branch, Agriculture Canada, Research Station, Vineland Station, Ontario L0R 2E0, Canada.*

PEREZ, E. E.[1], J. D. MUELLER[2], and S. A. LEWIS[1]. *Relationship of soybean planting dates to Hoplolaimus columbus populations.*

'Braxton' soybean, susceptible and intolerant to *Hoplolaimus columbus*, was planted on May 10, May 17, May 31, June 14, and June 28 in a Dothan sandy loam naturally infested with a mean of 37 *H. columbus*/100 cm^3 soil. On each planting date, six replications of paired plots 15 m long, untreated or treated with 28 liters/ha of 1,3-dichloropropene, were established to determine the effect of planting date on infection and yield suppression by *H. columbus*. *Hoplolaimus columbus* was recovered at planting from soil, and from roots and soil at 6 weeks after planting and at harvest. Nematicide treatment significantly ($P \leq 0.05$) reduced recovery of *H. columbus* from roots (41 vs 276/g dry root weight) and soil (8 vs 32/100 cm^3) at 6 weeks after planting and from roots (10 vs 42/g dry root weight) and soil (18 vs 68/100 cm^3) at harvest for all planting dates. Infestation levels of *H. columbus* at planting did not differ for the different planting dates. Planting date had no effect on number of adults plus juveniles present 6 weeks after planting and harvest. Yield from soybean planted on June 28 was significantly lower than for the other four planting dates. [1]*Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377, and* [2]*Edisto Research and Education Center, P.O. Box 247, Blackville, SC 29817.*

PEREZ, E. E.[1], J. D. MUELLER[2], and S. A. LEWIS[1]. *Sampling strategies for predicting Hoplolaimus columbus-induced yield losses of soybean.*

Sixteen six-row plots (15 m long) of the soybean cultivar 'Braxton' were planted in a Dothan sandy loam on 17 May, 1991, in a field naturally infested with a mean of 48 *H. columbus*/100 cm^3 soil. Braxton soybean is susceptible to infection and intolerant of *H. columbus*. Significant ($P \leq 0.05$) correlations were observed between yield and number of *H. columbus* in soil for adults (A) at planting and at 3, 12 and 20 weeks after planting, for juveniles (J) at 2, 3, 4, 6, 12, 16 and 20 weeks, and A+J at planting and at 2, 3, 4, 6, 12, 16 and 20 weeks. Correlations of number of *H. columbus* with yield were highest for J at 3 ($r = -0.64$) and 20 ($r = -0.61$) weeks, A at 12 ($r = -0.59$) and 20 ($r = -0.57$) weeks, and A+J at 3 ($r = -0.61$) and 20 ($r = -0.65$) weeks. The number of *H. columbus* per g dry weight and per

g fresh weight of roots at 8 weeks was correlated with yield ($r = -0.49$, $r = -0.50$, respectively). [1]*Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377, and* [2]*Edisto Research and Education Center, P.O. Box 247, Blackville, SC 29817.*

POWERS, T. O., and T. S. HARRIS. *Mitochondrial DNA sequences indicate ancient divergence between Caenorhabditis and plant-parasitic nematodes.*

Nucleotide sequences from four mitochondrial genes have been compared among *C. elegans* and *Meloidogyne* species. Each of these genes, ND3, CytB, COII, and the large ribosomal subunit (lrRNA) are saturated with mutations, such that variable nucleotides have undergone multiple mutations since the two lineages split. The approximately 50% divergence calculated for the lrRNA subunit suggests a split more than 600 million years ago for *Caenorhabditis* and *Meloidogyne*. *Caenorhabditis* and *Ascaris* diverge only 25% for lrRNA. For the COII gene, divergence estimates for *Heterodera–Meloidogyne* exceed those of *Caenorhabditis–Ascaris*. This may be explained by ancient divergence within Heteroderidae or accelerated rate of evolution among plant parasites. *Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583-0722.*

PUNJA, Z. K., and Y. Y. ZHANG. *Chitinases in plants and their roles in resistance to fungal diseases.*

Our research is focussed on enhancing and characterizing chitinase expression in cucumber and carrot plants by induction and through foreign gene insertion using *Agrobacterium*. The subsequent challenge of these plants with obligate and facultative parasites that infect leaves and roots should provide interesting insights into the role and mechanisms through which chitinases could influence disease development. In general, chitinases are expressed in a range of plants both constitutively at a low level at various stages of development and at higher levels following induction. Exposure to ethylene, salicylic acid, salt solutions, or chitosan can enhance chitinase expression, whereas biotic stresses such as fungal, viral or bacterial infections enhance chitinase levels locally and systemically in the plant. Genes encoding chitinase expression have been cloned from several plants and code for acidic (extracellular) or basic (vacuolar) proteins. In many cases, several isoforms of chitinase are seen in plants. Inhibition of fungal spore germination and hyphal growth have been attributed to chitinase activity in vitro. In vivo, reduction in fungal development and disease expression have been attributed to chitinase activity in a number of host–pathogen systems. There are potential applications for reducing nematode development in plants using the approaches that have been developed for fungal pathogens. *Center for Pest Management, Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada.*

QIU, J.[1], B. B. WESTERDAHL[1], C. E. ANDERSON[1], and R. P. BUCHNER[2]. *Refinement of hot water treatment for management of Aphelenchoides fragariae in strawberries.*

The effects of hot water treatment (HWT) on the California "strain" of the foliar nematode, *Aphelenchoides fragariae*, and on five current California strawberry varieties, Chandler, Douglas, Fern, Pajaro and Selva, were tested in the laboratory and in the greenhouse, respectively. Exposure periods of 15, 5, 4, and 2 minutes were required to produce 100% mortality of extracted nematodes in water at 44.4, 46.1, 47.7, and 49.4 C, respectively. In a water bath, 4 minutes were required for crowns initially at 25 C to equilibrate with temperatures ranging from 44.4–54.4 C. The maximum exposure periods tested at 44.4, 46.1, and 47.7 C that did not significantly reduce plant growth and flower production were 30, 15, and 10 minutes, respectively. Differences were evident among the five varieties tested. Hot water treatment at 49.4 C for 5 minutes significantly reduced plant growth and flower production for all five varieties. The recommended minimum–maximum times of HWT for management of *A. fragariae* in strawberry runner crowns are 20–30, 10–15, and 8–10 minutes at 44.4, 46.1, and 47.7 C, respectively. [1]*Department of Nematology, University of California, Davis, CA 95616, and* [2]*University of California, Cooperative Extension, 3179 Bechelli Lane, Suite 206, Redding, CA 96002.*

ROBBINS, R. T. *The distribution of Xiphinema americanum and related species in North America.*

In the 1990 polytomous key of Loof and Luc, 34 species are identified as being in the *Xiphinema americanum* group. Of these, 20 have been reported from North America. The U.S. distribution of species by state (using U.S. Postal Service state abbreviations) is as follows: *Xiphinema americanum sensu stricto* (AR, CA, PA, RI, VA), *X. brevicolle* (CA, NV, UT), *X. bricolensis* (CA), *X. californicum* (AR, CA, NY), *X. citricolum* (AR, FL), *X. diffusum* (FL), *X. floridae* (FL), *X. georgianum* (GA, FL), *X. intermedium* (FL, MS), *X. laevistriatum* (FL), *X. luci* (FL), *X. pachtaicum* (CA, WA), *X. rivesi* (AR, KS, MD, NE, NJ, NY, PA, RI, SC, TN, VT, WV), *X. sheri* (FL), *X. tarjanense* (FL), *X. tenuicutis* (AR, TN), *X. thornei* (CO, ID, ND), and *X. utahense* (UT, OR). Three species have been reported from Canada: *X. bricolensis* (BC), *X. occiduum* (ALB, MAN, SAC), and *X. pacificum* (BC). The only species from this group reported from Mexico is *X. californicum. University of Arkansas, Nematology Lab, Fayetteville, AR 72701.*

ROBERTS, P. A. *Intraspecific characterization of Meloidogyne based on virulence and host range.*

A scheme is presented for characterizing and reporting virulence and host range profiles of isolates or populations within a species of *Meloidogyne.* The intraspecific groupings are designated as biotypes and are assigned a reference or identification code that summarizes ability or inability to parasitize (reproduce on) 1) a given plant species or crop and 2) plants of an accession, breeding line or cultivar carrying a specific gene or genes for resistance. The scheme is designed to facilitate modification, especially addition, as the existence and specificity of more host plant resistance factors are revealed. Justification for such a reporting system is presented based on the limitations of existing *Meloidogyne* species host race assignments, which do not account for numerous nematode virulence–avirulence profiles for resistance–susceptibility traits in most host crops. Common *Meloidogyne* spp. isolate responses to resistance in crops, including alfalfa, beans, carrot, cowpea, grape, potato, soybean, tomato, and wheat, are used to demonstrate requirements for and application of the proposed biotype scheme. *Department of Nematology, University of California, Riverside, CA 92521.*

ROBERTS, P. A., and W. C. MATTHEWS. *Alternatives to hotwater–formalin dip for disinfecting garlic seed cloves of Ditylenchus dipsaci.*

Different dip times of hotwater treatment without formalin, including different warmwater presoak times and different rates of several potential alternative hotwater dip additives were assessed for efficacy for control of *Ditylenchus dipsaci* in heavily infected garlic seed cloves. All treatments were compared to hotwater–formalin clove dip disinfection treatment and to untreated infected controls. Treatments that greatly reduced viable nematode numbers assessed in post-treatment mist chamber extractions were compared in small replicated field experiments. Hotwater dip treatments without additive were not effective in controlling *D. dipsaci*, even with prolonged presoaking to hydrate nematodes. Addition of an avermectin compound, abamectin, at concentrations of 10–50 ppm in the hotwater dip (20 minutes at 49 C) or in the final cooling dip (10 minutes at 18 C) reduced ($P < 0.05$) infection in field plots to trace levels and increased ($P < 0.05$) garlic yield. Hotwater–avermectin clove dip may be an acceptable disinfection treatment for commercial garlic seed cloves. *Department of Nematology, University of California, Riverside, CA 92521.*

ROBERTSON, W. M.[1], J. R. KUSEL[2], L. PROUDFOOT[3], and A. R. PRESCOTT[3]. *The use of fluorescent probes to study the surface characteristics of Longidorus elongatus, Globodera rostochiensis and Anguina tritici.*

Adult *Longidorus elongatus* and second-stage juveniles of *Globodera rostochiensis* and *Anguina tritici* were treated with a panel of lipid, amino reactive and membrane potential probes, which revealed specific internal and surface staining of the nematodes. Almost all stains tested showed internal and some external labeling of *L. elongatus.* However, internal labeling was so strong that surface labeling could be assessed by only confocal microscopy. Labeling of *G. rostochiensis* and *A. tritici* was reduced in comparison with *L. elongatus*, and several dyes differentiated between these two species. [1]*Zoology Department, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland,* [2]*Department of Biochemistry, University of Glasgow, Glasgow G12 8QQ, Scotland, and* [3]*Department of Biochemistry, University of Dundee, Dundee DD1 4HN, Scotland.*

RODRÍGUEZ-KÁBANA, R., P. S. KING, D. G. ROBERTSON, and L. W. WELLS. *Velvetbean for the management of root-knot and southern blight in peanut.*

The value of velvetbean (*Mucuna deeringiana*) as a rotation crop for the management of root-knot nematode (*Meloidogyne arenaria*) and southern blight (*Sclerotium rolfsii*) in Florunner peanut (*Arachis hypogaea*) was studied from 1989–91 in a field experiment at the Wiregrass Substation near Headland in southeast Alabama. The field had been in peanut with winter fallow for the preceding 10 years and was heavily infested with the nematode. In 1991 the yield of peanut following two years of velvetbean (V–V–P) was 47% higher than the yield of monoculture peanut without nematicide P(–) and 20% higher than that of monoculture with aldicarb P(+) applied at-plant (3.3 kg a.i./ha in a 20-cm-wide band). In contrast with peanut plots, plots with velvetbean in 1989 and 1990 did not have significant populations of *M. arenaria* juveniles in soil at peanut harvest. In 1991, *M. arenaria* juvenile populations in soil were lowest in plots with the V–V–P rotation and highest in those with P(–); numbers of juveniles in plots with P(+) were lower than in P(–) plots and equivalent to the numbers in plots with V–V–P. Neither the V–V–P rotation nor the application of nematicide to monoculture peanut had any effect on the incidence of southern blight in peanut. *Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama 36849.*

RODRÍGUEZ-KÁBANA, R., D. G. ROBERTSON, and L. W. WELLS. *Delayed planting for the management of root-knot in peanut.*

The value of delayed planting for increasing 'Florunner' peanut (*Arachis hypogaea*) yield and managing *Meloidogyne arenaria* was studied in 1990 and 1991 in a field at the Wiregrass substation in southeast Alabama. The field had been in peanut with winter fallow for the preceding 10 years. Peanut yields from plots planted one month (T1) after conventional planting time (T0) were 23% (1990) to 60% (1991) higher than the yield obtained with conventionally planted peanuts. Soil juvenile populations of *M. arenaria* at conventional harvest time were lower in T1 plots than those with T0 both years of the study. Juvenile population development in T1 plots followed the same exponential model observed in those with T0. Planting time application of aldicarb (3.3 kg a.i./ha in a 20-cm-wide band) to T0 peanut failed to increase yield or reduce juvenile populations significantly in the two years of the study. *Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama 36849.*

RODRÍGUEZ-KÁBANA, R., C. F. WEAVER, and D. G. ROBERTSON. *Furfural–A natural fumigant for control of plant-parasitic nematodes.*

The nematicidal properties of furfural (2-furaldehyde) were studied in greenhouse and microplot experiments. Furfural applied directly to soil at rates of 0.1–1.0 ml/kg soil suppressed populations of *Meloidogyne arenaria* and *Pratylenchus brachyurus* in greenhouse experiments with naturally infested soil. The number of root galls caused by *M. arenaria* in 'Summer Crookneck' squash (*Cucurbita pepo*) planted in the treated soil was reduced proportionately to rate of furfural applied. Furfural was equally effective against the two nematodes when applied directly into the soil or underneath a soil column with the vapor moving up through the column. Furfural was injected into soil at rates of 54–646 ml/m^2 in a microplot experiment with 'Clemson Spineless' okra (*Hibiscus esculentum*) and soil infested with *M. arenaria* and *Paratrichodorus minor.* The aldehyde effectively controlled the nematodes at all rates; okra yields increased proportionately to the furfural rate up to 150 ml/m^2, with no further yield increases obtained with higher rates. *Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama 36849.*

ROUSE, D. I. *The role of Verticillium dahliae in potato early dying.*

Verticillium dahliae causes potato early dying either alone or in combination with other pathogens such as nematodes. The disease cycle can be considered to have five stages; survival in soil as microsclerotia, infection of the root system, colonization of the xylem, expression of symptoms and production of microsclerotia in dying or dead plant tissue, after which microsclerotia are released into soil. Methods for determining inoculum density (ID) in soil have been developed. These methods have been used to determine the relationship between soil ID and xylem colonization. Relationships between soil ID and yield have also

been found. Mechanisms of symptom expression have been examined. Early symptoms include reduced photosynthesis caused by increased hydraulic conductivity. Visual symptoms occur after reduction in net photosynthesis is detected and include wilting and leaf senescence. Soil fumigants provide disease control. Management may also include modified cultural practices. *Department of Plant Pathology, University of Wisconsin, Madison, WI 53706.*

SANKARALINGAM, A., and E. C. MCGAWLEY. *Seedling disease complex involving Rotylenchulus reniformis and Rhizoctonia solani in cotton in Louisiana.*

Previous observations have suggested an association between *R. reniformis* and seedling blight caused by *R. solani* in Louisiana cotton fields. To examine this relationship, *R. reniformis* at an inoculum level of 4,000 vermiform stages/pot (typical field population level) and three isolates of *R. solani* were evaluated on cotton varieties DPL41 and DPL90 in a greenhouse. Previous experiments indicated that DPL90 supported levels of *R. reniformis* after 90 days that were nearly twice those on DPL41. After 40 days, colonization of plant hypocotyl regions by *R. solani* resulted in reductions in number of vermiform stages in soil (27%) and eggs on roots (23%) on DPL41 but increases in these parameters of 15% and 56%, respectively, on DPL90. Plant fresh weights were reduced by *R. solani* but not by *R. reniformis*. Severity of hypocotyl necrosis and root discoloration caused by *R. solani* was not affected by the nematode. *Department of Plant Pathology and Crop Physiology, Louisiana State University, Baton Rouge, LA 70803.*

SANTO, G. S., and J. HUAN. *Interrelationship of Pratylenchus neglectus, P. penetrans, Verticillium dahliae and Erwinia carotovora subsp. carotovora on potato early dying.*

The interrelationship of *Pratylenchus neglectus* and *P. penetrans* with *Verticillium dahliae* and *Erwinia carotovora* subsp. *carotovora* alone and in combination was studied on Russet Burbank potato in field microplots. The effect of soil type (loamy sand and loam) and soil moisture (moderate and high) was also evaluated. Tuber yield reduction was greatest whenever *P. neglectus* or *P. penetrans* occurred together with the fungus and bacteria as compared to any two in combination or any alone. Yields were reduced by 70, 36 and 12%, respectively. Early die disease expression was also most severe when all three organisms cohabited the same plant. Soil type and soil moisture did not appear to influence the interaction between these organisms. In eastern Washington the importance of *P. neglectus* and *P. penetrans* on potato appears to be in their interaction with the early die disease pathogens. *Department of Plant Pathology, Washington State University, IAREC, Prosser, WA 99350.*

SANTO, G. S.[1], H. MOJTAHEDI[1], R. E. INGHAM[2], and J. H. WILSON[1]. *Suppression of root-knot nematode populations with selected sudangrass hybrids as green manure.*

Meloidogyne chitwoodi races 1 and 2 reproduced on Piper, P855F and P877F but failed to reproduce efficiently on Trudan 8, Trudex 9 and Sordan 79 sudangrass or sorghum-sudangrass hybrids. *Meloidogyne hapla* failed to reproduce on any of the cultivars tested. Twenty gram shoots of all cultivars as green manure reduced *M. chitwoodi* population more than unamended or wheat green manure treatments. Although the effects of Trudan 8 were limited to the zone of incorporation, Trudan 8 protected this zone from colonization by upwardly migrating second-stage juveniles (J2) for up to 6 weeks. Shoots of Trudan 8 but not roots were effective against *M. chitwoodi,* and J2 appeared to be more sensitive than egg masses. The adverse effects of Trudan 8 and Sordan 79 as green manure on *M. chitwoodi* were verified in bucket microplots under field conditions. [1]*Department of Plant Pathology, Washington State University, IAREC, Prosser, WA 99350, and* [2]*Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97330.*

SAYRE, R. M. *What if? Considering some decisive moments in the life of N. A. Cobb.*

Nathan A. Cobb was founding father of plant nematology in the United States. This statement is accepted by most phytonematologists, but what if his career had gone in other directions? What were the events and decisions that shaped his career and ultimately our science? During childhood he was molded by skills learned in the mills of New England, by purchasing and sharing a microscope, by laboring as a farm manager and by teaching elementary school. Later, he married a tolerant women who reared his seven children while giving up precious household space for home laboratories. Cobb's insatiable spirit of

adventure both in traveling and in a myriad of science projects resulted in remarkable scientific diversity of study. In 1907, returning to the United States he was ready to assume a broad leadership role at the Bureau of Plant Industry with USDA. However, in 1915 a sudden redirection by the department sealed his commitment to nematology, where he spent his remaining 17 years. *Nematology Laboratory, USDA, ARS, Bldg. 011A, BARC-West, Beltsville, MD 20705.*

SCHENCK, S. *Reactions of coffee varieties to Rotylenchulus reniformis.*

A series of coffee varieties being considered for commercial planting in Hawaii were tested for their susceptibility to *Rotylenchulus reniformis.* Coffee seedlings, 6 to 10 cm in height, were planted in 8-cm-d clay pots containing field soil heavily infested with *R. reniformis* (1,000 to 5,000 nematodes per 50 cm^3 soil). The soil contained free-living nematodes but virtually no other parasitic species. Seedlings were grown for 60 days in the infested soil under artificial light at room temperature. Then the roots were removed, rinsed carefully, and examined under a dissecting microscope. The number of *R. reniformis* infecting each coffee root system and the number of egg masses were counted and recorded as number of nematodes per gram root tissue. At least 10 plants each of 13 coffee varieties were observed along with highly susceptible tomato (cv. Rutgers). Results showed that none of the coffee varieties were very susceptible to *R. reniformis* when compared to tomato, but that there were significant differences in resistance levels among the varieties. *Hawaiian Sugar Planters' Association, Aiea, HI 96701.*

SCHMIDT, K.[1], R. A. SIKORA[2], and O. RICHTER[1]. *Forecasting the population dynamics of the sugarbeet cyst nematode Heterodera schachtii–A practical model.*

The population dynamics of the sugarbeet cyst nematode, *Heterodera schachtii,* is modeled using a system of difference equations. This model allows examination of the affects of different crop rotations on *H. schachtii* population dynamics and forecasting the (Pi) density for the next sugarbeet crop. The influence of environment is expressed as number of generations per season. The model has been tested against different sets of field data and showed a high degree of predictive power without any parameter change within the model. It is programmed with a menu-based graphic interface for use by agriculturalists. The model has different inputs for variable crop systems, data management, and output alternatives. The simulated comparison of the interrelationship between crop rotation and nematode population dynamics allows optimum selection of crop production systems to minimize nematode population increase and yield loss. [1]*Institut für Geoökologie, Langer Kamp 19c, 3300 Braunschweig, and* [2] *Institut für Pflanzenkrankheiten, Abt. Phytomed. in Bodenökosystem, Nussallee 9, 5300 Bonn 1, Federal Republic of Germany.*

SCHMITT, D. P., S. A. FERREIRA, and D. MEYER. *Survey for plant-parasitic nematodes on fruits and vegetables in Hawaii.*

Systematic surveys of commercial vegetable and fruit production areas on the Hawaiian islands of Oahu, Kauai, Molokai, and Maui were conducted in 1990–91. Sites selected represented a wide diversity of crops; attempts were made to sample a crop common to most sites. *Rotylenchulus reniformis* and *Meloidogyne* spp. were the most common nematodes recovered. Large numbers (>7,500/250 cm^3 soil) of *R. reniformis* were recovered from papaya, long bean, and sweet potato. *Meloidogyne incognita* and *M. javanica* were common on many crops, but *M. arenaria* was recovered in three samples. *Meloidogyne javanica* was the only *Meloidogyne* species found in this survey on the island of Molokai. Several samples contained a *Meloidogyne* species with a perineal pattern and esterase phenotype which do not match published descriptions. *Heterodera* spp. was found on cabbage and cauliflower. *Helicotylenchus* spp. were commonly associated with vegetable and fruit crops. Some 70% of all crops were parasitized by *Rotylenchulus reniformis, Meloidogyne* spp. and (or) *Heterodera* spp. *Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.*

SCHNEIDER, S. M.[1], D. P. SCHMITT[2], and K. R. BARKER[3]. *SIMCYST, a simulator of the life cycle of the soybean cyst nematode.*

SIMCYST, a simulator of the life cycle of the soybean cyst nematode, *Heterodera glycines,* was written in PASCAL and runs under DOS. The life cycle of the nematode was

divided into four functional stages; egg, infective juvenile, parasitic juvenile, and adult. Passage of an individual from one life stage to the next is determined by a probability function. This function simulates the probability of an individual of a given age maturing to the next stage during the current time step. An Erlang function is used to describe the probability for the developmental stages of egg, parasitic juvenile, and adult. A negative exponential function is used to describe the probability of an infective juvenile successfully penetrating the root and establishing a feeding site. A survival function describes the probability of an individual surviving to the next time step. The life cycle parameters used in the model include developmental rate and survival for each stage. These were estimated from field data for soybean cyst nematode race 2 on soybean cultivar Deltapine 105. A user-friendly interface was developed to allow input into the model and to graphically view the output. [1]*Crops Research Laboratory, USDA ARS, P.O. Box 1168, Oxford, NC 27565,* [2]*Department of Plant Pathology, University of Hawaii, 3190 Maile Way, Room 305, Honolulu, HI 96822, and* [3]*Department of Plant Pathology, Box 7616, North Carolina State University, Raleigh, NC 27695.*

SIJMONS, P. C., and O. J. M. GODDIJN. *T-DNA tagging for analysis of gene activities in syncytia of transgenic Arabidopsis roots after infection with Heterodera schachtii.*

The formation of feeding structures after infection with cyst or root-knot nematodes must be accompanied by a severe change in gene regulation of the host cells. To identify promoters involved in these changes, *Arabidopsis* cells were transformed with *Agrobacterium* carrying a binary vector construct containing a selective marker and a promoterless GUS gene and were regenerated from tissue culture. The regenerants were then allowed to self and set seed. These seeds were germinated on agar medium and were infected with *Heterodera schachtii* under axenic conditions. Developing syncytia were then analyzed for the presence of active GUS enzyme using a histochemical staining. In several transformants, GUS activity was observed inside the feeding structure, indicating that endogenous promoters were tagged that were active in the syncytium. Using inverted PCR in combination with primers directed against GUS sequences, we are now isolating the tagged promoter sequences from the most promising plant lines for further analysis. *MOGEN, Einsteinweg 97, 2333 CB Leiden, The Netherlands.*

SIPES, B. S.[1], D. P. SCHMITT[1], and C. ODA[2]. *Population fluctuations of Rotylenchulus reniformis on pineapple as influenced by plantation nematicide treatments.*

A randomized complete block design experiment of four treatments was established in a pineapple field near Whitmore, HI in August 1990 to determine the effect of standard nematicide treatments on the numbers of *Rotylenchulus reniformis.* The treatments were as follows: untreated control, preplant treatment of 1,3-D (335 liters/ha), preplant 1,3-D plus postplant fenamiphos (1.7 kg a.i./ha) at 3-month intervals, and preplant 1,3-D plus fenamiphos rotated with oxamyl (2.2 kg a.i./ha) at 3-month intervals. The plots were sampled monthly for the first 5 months and bimonthly thereafter. Population densities of *R. reniformis* remained below 350/250 cm^3 soil for the first 8 months in all treatments. By 12 months after planting, their numbers had increased to 2,129/250 cm^3 soil in untreated plots. Population densities decreased in all treatments 14 months after planting but recovered by 16 months after planting. The nematode population increased to 5,773/250 cm^3 soil at 18 months in the fenamiphos–oxamyl treated plots. The least number of nematodes at 18 months was 3,583/250 cm^3 in untreated plots. Nematicide treatments provide limited protection to pineapple roots allowing these roots to continue to develop. These roots support greater numbers of nematodes as the plant cycle progresses, even though nematicide application continues. [1]*Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822, and* [2]*Del Monte Corp., P.O. Box 200, Kunia, HI 96759.*

SIPES, B. S.[1], D. P. SCHMITT[1], and C. ODA[2]. *Multiple nematicide applications for the control of Rotylenchulus reniformis on pineapple, Ananas comosus.*

An RCBD experiment of 4 replications was established in a Del Monte pineapple field near Kunia, HI in March 1991 to evaluate the efficacy of tetrathio(peroxocarbonic acid) and ethoprop compared to standard plantation practice for the control of *Rotylenchulus reniformis.* Preplant 1,3-D at 335 liters/ha and postplant fenamiphos treatments at 1.7 kg a.i./ha every 3 months simulated standard plantation practice. An untreated plot was

included as a control. Tetrathio(peroxocarbonic acid) was applied preplant at 747 or 343 liters/ha and then applied bimonthly at 249 liters/ha. Ethoprop was applied monthly at either 3.4 or 6.8 kg a.i./ha to plots fumigated with 1,3-D prior to planting. Nematode population densities were assayed by collecting 250-cm^3 soil samples every 3 months. Estimated plant weight, percentage #1 color, and D-leaf weight were recorded at 6-month intervals. Neither preplant rate of tetrathio(peroxocarbonic acid) reduced numbers of *R. reniformis* compared to the untreated control by the first 3-month sampling date. By the 12th month after planting, populations ranged from 1,085 *R. reniformis*/250 cm^3 soil in untreated controls to 2,223 in ethoprop-treated plots. Nematode numbers did not differ ($P = 0.05$) among treatments at this sampling, although plant parameters were different. D-leaf weight of tetrathio(peroxocarbonic acid)-treated plants was lower than the untreated control (296 and 318 vs 324 g/10 leaves; 343 and 747-liter rates of tetrathio(peroxocarbonic acid) and untreated controls, respectively). D-leaves from the high rate of ethoprop were heavier ($P = 0.02$) than the untreated control (478 vs. 324 g/10 leaves, respectively) but not the standard plantation practice (478 vs. 451 g/10 leaves). Ethoprop appeared to control *R. reniformis* as well as the standard plantation practice. Tetrathio(peroxocarbonic acid) treatments resulted in unsatisfactory nematode control and may have been phytotoxic to the pineapple. [1]*Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822, and* [2]*Del Monte Corp., P.O. Box 200, Kunia, HI 96759.*

SMART, G. C., JR., and K. B. NGUYEN. *Cryopreservation of Steinernema scapterisci.*

Infective juveniles of *Steinernema scapterisci* were incubated in 22%, 30%, 35%, or 40% glycerin for 2 to 7 days. Then they were subjected to one of six treatments before being placed in 0.5 ml solution in 1.8 ml round bottom cryogenic vials and frozen in liquid nitrogen (-196 C). After a minimum of 24 hours in liquid nitrogen, the vials were removed and 0.5 ml of 0.85% saline at 35 C was added. Then the vials were placed in a water bath at 35 C until the solution thawed (about 1 minute). Specimens survived best when they were incubated from 3 to 7 days (regardless of percent glycerin), placed in ice-cold 50% methanol or 50% ethanol for 10 minutes, and then frozen immediately in liquid nitrogen. Survival was least when specimens were placed at -70 C before being frozen in liquid nitrogen (regardless of other treatments). *Entomology and Nematology Department, University of Florida, Gainesville, FL 32611-0620.*

SMITH, G. S., T. L. NIBLACK, and R. D. HEINZ. *Recovery of Heterodera glycines from field-collected droppings of lesser snow geese (Chen caerulescens) in Missouri.*

Droppings from lesser snow geese were collected in February, 1990 from three fields located in Barton County, Missouri. Fields 1, 2, and 3 contained winter wheat, corn stubble, and soybean stubble, respectively, and composite soil samples collected from each field contained 35,280, 37,800, and 980 *H. glycines* eggs/250 cm^3 soil, respectively. Droppings were carefully collected to avoid any soil adhesion. Twenty individual droppings from each field were processed by wet sieving–sucrose centrifugation and the filtrate was collected on nested 250 µm and 25 µm sieves. The 250 µm filtrates were bioassayed individually on Essex soybean for 40 days in a greenhouse. A total of 51 gravid *H. glycines* females (18% bioassays positive) were recovered from the filtrate bioassays of fields 1 and 2. *Heterodera glycines* juveniles and nematode eggs were counted from the 25 µm filtrates, bulked into one sample per field, and bioassayed. A total of 116 *H. glycines* juveniles (20% samples positive) and 194 nematode eggs (32% samples positive) were counted from the filtrates. In the bioassays of bulked filtrates from fields 2 and 3, 0 and 25 gravid *H. glycines* females, respectively, were recovered. Twenty-two unprocessed droppings from fields 1 and 3 were individually bioassayed, from which only one gravid female was recovered. *Plant Sciences Unit, 108 Waters Hall, University of Missouri, Columbia, MO 65211.*

SMITH, K. A., and C. T. REDMOND. *Recent advances in entomopathogenic nematode-based products in North America.*

A number of entomopathogenic nematode-based products are currently available from Biosys in several markets, including BioVector for citrus, artichoke, mint, turf, and ornamentals, Exhibit (Ciba-Geigy) for turf and ornamentals (U.S.), BioSafe-N for cranberries, and BioSafe (Ortho/Chevron) for the homeowner. The active ingredient in each of these

products is the nematode *Steinernema carpocapsae* (Weiser). Production techniques have been refined so that large quantities of nematodes can be produced in liquid fermentation. Formulation research has significantly extended the shelf-life of existing Biosys products, and a new flowable formulation is currently in the field testing phase. At least three species of nematodes have shown promise in field trials and will likely be introduced in new commercial products in the near future. *Steinernema glaseri* is effective against white grubs (Coleoptera: Scarabaeidae) in turfgrass. *Steinernema scapterisci* is effective against mole crickets (Orthoptera: Gryllotalpidae) in turfgrass. *Steinernema feltiae* is effective against mushroom flies (Diptera: Sciaridae) in mushrooms. *Biosys, 1057 East Meadow Circle, Palo Alto, CA 94303.*

STARR, J. L. *Number of nuclei in giant cells induced by Meloidogyne incognita.*

The numbers of nuclei in giant cells (GC) of several host species were determined by germinating seeds of each species in rag dolls and inoculating root-tips with 50 freshly hatched juveniles of *M. incognita* race 3 when the radicles were ca. 3 to 6 cm long. Gall tissue was harvested from *Pisum sativum* at 4, 5, 7, 15, and 21 days after inoculation (DAI) and stained with Feulgen, and then individual giant cells were dissected from the galls and mounted on glass slides for microscopic examination. At 4 DAI these giant cells contained 13 nuclei/GC. This number increased to 50 nuclei/GC at 7 DAI with little further increase. At 16 DAI total numbers of nuclei (52/GC) in *Lycopersicon esculentum* were similar to those observed in *P. sativum*. *Lactuca sativa* and *Vicia faba*, respectively with 27 and 35 nuclei/GC, had fewer nuclei at 16 DAI than did *P. sativum*. At 16 and 21 DAI a few nuclei of each giant cell were linked by chromatin material. Nuclei were clumped together at 21 DAI and precise counts were not possible. These observations confirm previous reports of high mitotic activity in GC prior to the molt of the nematode to the third juvenile stage, with little such activity at latter stages of development. *Department of Plant Pathology and Microbiology, Texas Agricultural Experiment Station, College Station, TX 77843.*

STARR, J. L.[1], and C. W. SMITH[2]. *Incorporation of high levels of resistance to root-knot into agronomically superior cotton cultivars.*

Although many cotton cultivars have been released with improved levels of resistance to the Fusarium wilt–root-knot complex, these cultivars are still quite susceptible to root knot. High levels of resistance to root knot have been identified by R. L. Shepherd (Crop Sci. 22:692) and incorporated in high-quality cotton breeding lines. We have initiated a program to incorporate this resistance into superior cotton germplasm without extensive backcrossing. Resistant genotypes M-120 and M-240 were crossed with the agronomically superior breeding line 86TT-12. F2 individuals were screened for resistance to nematode reproduction in the greenhouse and grown to maturity to produce seed. F3 individuals from resistant F2 plants will be field-grown in the second year and screened for agronomic characteristics. F4 individuals will be again screened for nematode resistance in the greenhouse and grown to maturity to produce seed. Progeny rows will be planted in the third year with multi-location field trials for yield and fiber quality to begin in the fourth year. [1]*Department of Plant Pathology and Microbiology, and* [2]*Department of Soil and Crop Science, Texas Agricultural Experiment Station, College Station, TX 77843.*

STEINBERGER, Y., N. MAOR, and S. SARIG. *The effect of immediate wetting of soil on nematode population in the Negev desert.*

The relationship between biological activity and physical parameters of soil is mainly mediated by water availability. Because the amount, intensity and frequency of rainfall in desert areas vary greatly over time and space, the response of soil biota to such events is of great importance. A study was conducted in the northern Negev desert to evaluate the immediate response of nematode populations to different amounts of water imposed in a single event. Soil samples from the 0–5 cm depth were collected from four wetting treatments: 5, 10, 15 and 20 mm of water applied in a single pulse, as well as from a nonirrigated control. Diurnal change in nematode populations was observed and was correlated with the diurnal fluctuation in soil moisture. The greatest nematode abundance was in the 20-mm water-amended treatment (970 individuals/100 g dry soil), which was 2, 4, 5 and 14 times higher than 15-mm, 10-mm, 5-mm, and control treatments, respectively. Bacteriovores and fungivores accounted for approximately 95% of the numbers in all

treatments. The findings obtained in this study indicate that changes in nematode population are mainly triggered by diurnal fluctuation in soil moisture resulting from a certain threshold (15 mm) of water supply. *Department of Life Sciences, Bar-Ilan University, Ramat Gan, Israel, 52900.*

SUI, D., and T. O. POWERS. *Nucleotide sequence divergence in Heteroderidae.*

Intraspecific and interspecific comparisons have been made for the COII and large ribosomal subunit (lrRNA) mitochondrial genes in *Heterodera* and *Meloidogyne*. Interspecific nucleotide similarity in *Meloidogyne* and *Heterodera* range from 93–100% and 74–90%, respectively, for the COII gene. Inferred amino acid similarity among *Heterodera* species ranges from 80–100% for COII. *Meloidogyne* species display more than 99% sequence identity for the lrRNA gene. Within-species nucleotide sequence identity for *H. glycines* is approximately 98% for COII, similar to published estimates for the same gene in *Caenorhabditis elegans*. Extreme genetic divergence is observed between the two subfamilies in Heteroderidae. *Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583-0722.*

TAYLOR, C. G.[1], W. SONG[1], C. H. OPPERMAN[2], and M. A. CONKLING[1]. *Characterization of a nematode-responsive plant gene promoter.*

Infection by root-knot nematodes, *Meloidogyne* spp., results in developmental changes in root cells at the nematode feeding site. The changes induced by the nematode must be accompanied by alteration in plant gene expression at that site. We have identified a gene whose expression is enhanced in the developing nematode giant cells. This gene is normally expressed ephemerally in the developing vascular cylinder early in development. The promoter of this gene has been fused to the β-glucuronidase (GUS) reporter gene, and expression has been analyzed in transgenic plants by deletion mutagenesis. During nematode infection, the full-length promoter drives significant quantitative and temporal overexpression of GUS within the developing feeding site. The *cis*-acting sequences that respond to nematode-induction have been delineated sufficiently to allow them to be separated from those sequences required for root expression in uninfected plants. Constructs driven by this "Nematode Responsive Element" exhibit GUS expression limited solely to the giant cells. No expression is detectable in uninfected roots. [1]*Department of Genetics and* [2]*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695.*

TEDFORD, E. C., B. A. JAFFEE, and A. E. MULDOON. *Effect of soil moisture and texture on transmission of the nematophagous fungus Hirsutella rhossiliensis to cyst and root-knot nematodes.*

The spores of *Hirsutella rhossiliensis* (Hr) adhere to vermiform nematodes in soil; this process is called "transmission." Transmission is essential for infection of hosts and for spread of pathogens among hosts, and thus is a critical component of epidemiological models. Transmission of Hr spores to juveniles (J2) of *Heterodera schachtii* (Hs) and *Meloidogyne javanica* (Mj) was quantified at 20 C in vials containing 17–18 cm^3 of loam, loamy sand, or sand in the absence of a host plant. The fungus was added to each soil in the form of colonized nematodes. Healthy J2 of Hs and Mj were added after 14 days and recovered 66 hours later. Transmission in all three soils decreased as soil matric potentials increased from −80 KPa to near 0 KPa. We speculate that soil moisture influenced fungal sporulation rather than nematode motility, because 1) nematode motility was not affected by moisture levels that reduced transmission and 2) the fungus does not sporulate when submerged. At near optimum soil moisture levels, transmission to either Hs or Mj was greatest in loamy sand, intermediate in loam, and lowest in sand. Transmission to Mj was equal to or less than transmission to Hs. *Department of Nematology, University of California, Davis CA 95616.*

THIES, J. A.[1], D. K. BARNES[2], L. A. WANSCHURA[1], and C. R. JONES[1]. *Resistances of forage grasses and legumes to Pratylenchus penetrans.*

Seven forage legumes and four grasses were evaluated for resistance to *Pratylenchus penetrans*. Entries were planted in individual plastic tubes (32 tubes/entry) in a growth chamber (25 C). After two weeks, 8 tubes of each entry received 0, 200, 400, or 800 *P. penetrans*/tube. Fifteen weeks later, shoot and fibrous root dry weights were reduced by *P. penetrans* ($P < 0.01$). However, there were nematode treatment × entry interactions for shoot and root weights ($P < 0.01$). Total nematode populations in roots and soil were larger for

plants inoculated with 400 or 800 nematodes compared to 200 nematodes ($P < 0.01$). Reproductive factors for each entry (final population/initial population) inoculated with 200 nematodes were: 'Norcen' birdsfoot trefoil (57.6), common kura clover (39.4), 'Eski' sainfoin (27.0), 'Baker' alfalfa (22.5), 'MNGRN-4' alfalfa (14.6), 'MNGRN-14' alfalfa (13.8), common quackgrass (9.9), 'MNGRN-16' alfalfa (5.9), 'Palaton'(3.4) and 'Rise'(4.5) reed canarygrass, and 'NK-200' perennial ryegrass (5.0). At the 800-nematode inoculation rate, some of the more susceptible entries showed lower reproductive rates due to reduction in fibrous roots. [1]*USDA, ARS and Department of Plant Pathology, University of Minnesota, St. Paul, MN, 55108, and* [2]*USDA, ARS and Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.*

THURSTON, G. S., G. B. DUNPHY, and W. N. YULE. *Explanations for the low susceptibility of Leptinotarsa decemlineata to entomogenous nematodes.*

Laboratory bioassays indicated that the Colorado potato beetle (CPB), *Leptinotarsa decemlineata*, is less susceptible than other insect species to entomogenous nematodes. Factors that influence an insect's susceptibility to entomogenous nematodes include nematode host-finding ability, physical and behavioral barriers to nematode penetration, and physiological responses of the insect to the nematode. An agar-based arena was used to assess the chemotactic responses of *Steinernema carpocapsae* infective juveniles (IJs) to host-derived cues. IJs were attracted to CO_2, macerated whole *Galleria mellonella* larvae, and frass of *Tenebrio molitor* and *G. mellonella,* but were repelled by CPB feces. Examination of CPB larvae that survived exposure to nematodes revealed that IJs penetrating into the hemocoel were often enclosed in hemocytic capsules. The efficiency of this nonself response system was investigated. An individual CPB larva could encapsulate up to 23 *S. carpocapsae* IJs, but at loads above 9 IJs/larva at least one escaped encapsulation, resulting in the death of the larva. Thus, the low susceptibility of CPB larvae to *S. carpocapsae* is attributed, in part, to repellency by the host feces and to hemocytic encapsulation of invading nematodes. *Department of Entomology, Macdonald College of McGill University, Ste. Anne de Bellevue, QC H9X 1C0, Canada.*

THURSTON, G. S., and H. K. KAYA. *Enhanced susceptibility of white grubs to an entomopathogenic nematode.*

Cyclocephala hirta grub susceptibility to the entomopathogenic nematode *Heterorhabditis bacteriophora* was enhanced when the milky disease bacterium, *Bacillus popilliae* (Bp), was also present. In concentration–response assays with the nematode, LC_{50} values and 95% fiducial limits were 4.0 (0, 14.6) infective juveniles per grub for Bp-infected insects and 47.7 (32.0, 64.7) for non-Bp-infected insects. The enhanced susceptibility of Bp-infected insects was partially attributed to more rapid penetration of *H. bacteriophora* through the midgut wall. Total progeny production and infective juvenile emergence from the cadavers did not differ significantly between Bp-infected and non-Bp-infected grubs. These data indicate that coexistence of these two pathogens within a host can occur and that use of *H. bacteriophora* to control populations of *C. hirta* would be more successful in areas with existing *B. popilliae* infestations. *Department of Nematology, University of California, Davis, CA 95616-8668.*

TIMPER, P., and B. B. BRODIE. *Reduction in survival and root penetration of Pratylenchus penetrans by the fungus Hirsutella rhossiliensis.*

Little is known of the impact of nematode antagonists on *Pratylenchus* spp. Therefore, in two experiments we evaluated the nematode-pathogenic fungus *Hirsutella rhossiliensis* for its effectiveness in reducing survival and root penetration of *P. penetrans* in soil. The soil was infested with the fungus by mixing *Hirsutella*-infected nematodes (*Steinernema glaseri*) into soil. Soil without fungus was used as a control. Survival of *P. penetrans* in *Hirsutella*-infested soil without a host plant was 28–53% lower than in the control soil after 25 days. In the second experiment, penetration of pea roots by the nematodes was reduced by 25% after 6 days in *Hirsutella*-infested soil. Because *P. penetrans* spends much of its life cycle protected within roots, and its survival and root penetration was only moderately reduced by *H. rhossiliensis*, we believe that the fungus will be most effective in maintaining populations of this nematode below crop damaging levels when it is integrated with other nematode management tactics. *USDA, ARS, Federal Plant, Soil, & Nutrition Lab., Tower Rd., Cornell University, Ithaca, NY 14853-0331.*

TUDOR, M. E.[1], and T. R. FUKUTO[2]. *Increasing downward phloem translocation of the methylcarbamate oxamyl through N-sulfinylated and N-thiocarbamate derivatization.*

Oxamyl is one of the few insecticide–nematicides that has been shown to move downward to the roots through the phloem when applied to the plant's canopy. Derivatives using oxamyl as the parent molecule were synthesized in an attempt to achieve enhancement of the phloem translocability of the biologically active molecule. By using a series of moieties with increasing octanol–water partitioning coefficients, it was possible to increase the amount of downward translocated oxamyl by several fold. However, the biological response of a reduction in nematode infectivity was not correspondingly similar. [1]*DOLE, La Ceiba, Honduras, and* [2]*University of California, Riverside, CA 92521.*

TUDOR, M. E.[1], and M. V. MCKENRY[2]. *Management of cover crops and selected plants as nematode control agents.*

Three different management strategies were compared to see if plant-parasitic nematodes could be controlled to acceptable levels. The use of an aqueous extract performed better than the use of plant refuse as a mulch and the use of the plant grown in situ. In California, Cahaba Vetch performed well when considering nematode control and plant vigor. In bananas in Honduras, two herbaceous weeds commonly found in the field may have found a role in the control of nematodes. [1]*DOLE, La Cieba, Honduras, and* [2]*Department of Nematology, University of California, Riverside, CA 92521.*

TUDOR, M. E.[1], and M. V. MCKENRY[2]. *The decline of fenamiphos in soils under different nematicidal management strategies.*

Fenamiphos is a widely used postplant nematicide in perennial crops worldwide. An initial laboratory study was done to determine if some basic soil management strategies could influence the decline of fenamiphos. Two concentrations of fenamiphos, formulated under the trade name Nemacur, were incorporated into similar soil types under five different soil management practices. Results indicated that one management practice, the prior use of Telone II, showed a prolongation of fenamiphos. Also, field populations of nematodes living under constant nematicide pressure have no measurable acclimation to nematicides. [1]*DOLE, La Cieba, Honduras, and* [2]*Department of Nematology, University of California, Riverside, CA 92521.*

TYLKA, G. L.[1], G. A. KRAUS[2], J. M. APPLEGATE[2], and B. E. JOHNSTON[2]. *Evaluation of precursors and analogs of glycinoeclepin A, a natural hatching stimulus of Heterodera glycines.*

Glycinoeclepin A is a hatching stimulus of soybean cyst nematode, *Heterodera glycines,* that has been extracted from kidney bean roots. Research is currently focused on synthesizing glycinoeclepin A, because the natural compound is not present in kidney bean root tissues in quantities sufficient for agricultural use. Several analogs and precursors of glycinoeclepin A were synthesized and evaluated for effects on *H. glycines* egg hatch. Eggs were extracted from cysts, surface disinfested, and placed on 25-µm-pore microsieves. The microsieves were then incubated in aqueous solutions of the experimental compounds or two control solutions at 25 C in total darkness. Distilled water and zinc sulfate solution served as negative and positive control solutions, respectively. Microsieves were transferred to fresh solution and the number of hatched *H. glycines* second-stage juveniles was determined every other day for 30 days. One compound, GK1-1991, stimulated hatch of *H. glycines* eggs. Percent hatch of eggs incubated in a solution of 10.0 µg/ml GK1-1991 was significantly greater than hatch in distilled water, but not significantly different from hatch in zinc sulfate. Other analogs and precursors tested at concentrations of 0.001 to 85.0 µg/ml had no effect on *H. glycines* egg hatch. The percentage of hatch in solutions of these compounds was significantly less than hatch in zinc sulfate and not significantly different from hatch in distilled water. [1]*Department of Plant Pathology, and* [2]*Department of Chemistry, Iowa State University, Ames, IA 50011.*

UMESH, K. C., and H. FERRIS. *Interspecific competition between Meloidogyne chitwoodi and Pratylenchus neglectus on barley.*

Interaction between *Meloidogyne chitwoodi* (Mc) and *Pratylenchus neglectus* (Pn) on barley was investigated in four experiments. The effect of interaction on total numbers of each species was examined at soil temperatures of 15, 20, and 25 C. Barley plants were inoculated

with Mc, Pn, Mc+Pn, or neither species; and total numbers were determined after 62 days. Numbers of Mc and Pn increased with increasing temperature. The presence of Mc resulted in reduced numbers of Pn, and the influence of Mc increased with higher temperature. The presence of Pn did not reduce the numbers of Mc significantly. In a similar experiment, root penetration by nematodes were observed at 2, 4, 8, and 15 days after inoculation. Root penetration by Mc or Pn increased with time at all the temperatures; the numbers did not differ between single and concomitant inoculations. The nematodes did not compete for feeding site, as both species colonized distinctly different root zones. Effect of Pn on the fecundity of Mc at 20 C was determined 48 days after inoculation. The number of eggs per egg mass of Mc was reduced in the presence of Pn. In a fourth study, addition of Mc 5 days earlier than Pn, or vice-versa, reduced root penetration by the species inoculated later. *Department of Nematology, University of California, Davis, CA 95616.*

VANDERSPOOL, M. C., and D. T. KAPLAN. *Superoxide dismutase in root-knot nematodes and the plant tissue they infect.*

Superoxide dismutase (SOD) was identified in the root-knot nematodes *Meloidogyne incognita* and *M. javanica* by gel electrophoresis. An SOD isozyme present in the nematodes is common to both the nematode and soybean (*Glycines max*), but a second isozyme was unique to the *Meloidogyne* species studied. The SOD isozyme profile, as determined in native gels stained with nitroblue tetrazolium chloride, indicated that SOD content of root-knot nematodes changed qualitatively and quantitatively as the nematodes matured. This suggests that SOD in plant root tissue parasitized by root-knot nematodes may be of nematode and (or) plant origin. *USDA, ARS, U.S. Horticultural Research Laboratory, 2120 Camden Rd., Orlando, FL 32803.*

VRAIN, T. C. *Intraspecific rDNA restriction fragment length polymorphism in the Xiphinema americanum group.*

Sixteen populations of the *X. americanum* group were separated using restriction fragment length differences in the 5.8S gene and the internal transcribed spacers (ITS) of ribosomal DNA. Two plasmid clones from *Xiphinema bricolensis* (Xb) 18S and 26S ribosomal genes were isolated from a genomic library using a complete repeat of the ribosomal cistron of *Caenorhabditis elegans* (Ce) as a probe. Oligonucleotides primers were designed to amplify the ITS region using the polymerase chain reaction (PCR). The 1.5-kb amplified product from the ITS region of each of 16 populations of the *X. americanum* group was analyzed for restriction length polymorphisms (RFLPs). The RFLPs were recorded, dissimilarity coefficients were calculated, and a cluster analysis was generated arranging the 16 populations as a dendrogram with five clusters. Two populations of *X. rivesi* were well separated from other *X. americanum* populations. *Xiphinema bricolensis* and two populations from the state of Washington were grouped together, while *X. pacificum* and an undescribed population from California were in another cluster. Mixed populations of *X. rivesi* and *X. americanum* from Pennsylvania could not be resolved. *Agriculture Canada Research Station, 6660 N.W. Marine Drive, Vancouver, British Columbia V6T 1X2, Canada.*

VRAIN, T. C., T. A. FORGE, and R. M. DEYOUNG. *Seasonal changes in Pratylenchus penetrans populations in relation to root growth of raspberry.*

Root biomass and population densities of *Pratylenchus penetrans* in roots and soil at four depths were determined at 14-day intervals during two years in a raspberry plantation in the Fraser Valley of British Columbia. The root and soil populations were expressed as the number of nematodes per 100 ml soil. Eighty percent or more of the population was in soil at most sample dates. Root biomass was greater at the 0 to 10 cm depth than at 10–30 cm. Root biomass was greatest from November to March of each year and dropped to approximately one-third of winter levels during summer. *Pratylenchus penetrans* densities and magnitude of seasonal fluctuation were both greatest at the 5 to 10 cm depth. Population densities peaked from September to October in the first year and June to July in the second year, indicating that seasonal population growth is controlled primarily by climatic conditions rather than the availability of roots. Low soil temperatures may have prevented the nematodes from fully exploiting the increased availability of roots during winter. *Agriculture Canada Research Station, 6660 N.W. Marine Dr., Vancouver, British Columbia V6T 1X2, Canada.*

WALLACE, M. K.[1], W. C. STIENSTRA[1], and J. H. ORF[2]. *Field population dynamics of Heterodera glycines on blends of resistant and susceptible soybeans.*

Field plots of Latham 550 (race 3-resistant soybean with PI 88788 as source of resistance), Latham 650 (susceptible soybean) and blends of Latham 550/650 (25%/75%, 50%/50%, 75%/25%) were established in soybean cyst nematode (SCN) infested soil at two locations in southern Minnesota and sampled monthly during the 1991 growing season. Cysts, second-stage juveniles (J2), and males were extracted by sieving–sugar centrifugation and counted. Males and young females were detected 25 days after planting. J2 populations peaked in August at site 1 and declined steadily throughout the growing season at site 2. Cysts produced at site 1 by season's end ranged from an average of 61 cysts/250 cm^3 soil on Latham 550 to 191 cysts/250 cm^3 soil on Latham 650, with cyst index (CI) for Latham 550 of 32 (moderately susceptible). Cysts produced at site 2 averaged 14 cysts/250 cm^3 soil on Latham 550 and 137 cysts/250 cm^3 soil on Latham 650, with CI for Latham 550 of 10 (moderately resistant). The SCN population at site 2 is race 3, with an index on PI 88788 of 3. The race of the SCN population at site 1 is being determined. We predict that it will be race 1, with an index on PI 88788 of 10–20. Production of cysts at each site was intermediate for the blends, compared with resistant and susceptible soybean cultivars. [1]*Department of Plant Pathology, and* [2]*Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.*

WARNER, F. W., and G. W. BIRD. *Disruption of root penetration by Pratylenchus penetrans with beet sugar and spices.*

Beet sugar, five spices, activated charcoal and aldicarb were evaluated for their abilities to disrupt root penetration of potato, *Solanum tuberosum* cv. Superior, by *Pratylenchus penetrans* in a greenhouse study. The materials were uniformly mixed into ca. 600 g of sandy loam soil inoculated with 400 *P. penetrans* at the following levels: beet sugar, 60.0 g, 6.0 g, 0.6 g, 0.06 g; activated charcoal, 6.0 g, 0.6 g, 0.06 g; ground mustard, 6.0 g, 0.6 g; ground black pepper, 6.0 g, 0.6 g; garlic powder, 0.6 g; non-iodized table salt, 0.6 g; parsley, 0.6 g; and aldicarb, 0.03 g. The potato plants were destructively sampled 10 days after planting, growth was measured and roots were stained. Beet sugar at 60.0 g and 6.0 g, ground mustard at 6.0 g and 0.6 g, and table salt were phytotoxic. No *P. penetrans* were found in roots of aldicarb-treated plants. Mean numbers of *P. penetrans* were lower in 0.5 g root tissue of plants treated with ground mustard at 0.6 g, activated charcoal at 6.0 g and 0.6 g, beet sugar at 0.06 g and garlic powder than in roots of untreated plants. *Department of Entomology, Michigan State University, East Lansing, MI 48824.*

WENDT, K. R., and J. M. WEBSTER. *Variation in the ribosomal DNA of species and races of Ditylenchus.*

The genus *Ditylenchus* is complicated by plasticity of morphological characters and the presence of biological races within *D. dipsaci.* The ribosomal DNA of populations of *D. dipsaci, D. destructor,* and *D. myceliophagus* was examined for sequence and length polymorphisms. Southern blot analysis using the ribosomal cistron as a probe differentiated the three species and generated unique patterns for each of the races of *D. dipsaci.* The polymerase chain reaction (PCR) was employed to amplify the internal transcribed spacer (ITS) region of the rDNA of all *Ditylenchus* populations. Digesting the PCR products with restriction enzymes consistently discriminated between the three species and clearly differentiated one biologically distinct population of *D. destructor* from the other *D. destructor* isolates. Restriction enzyme analysis of the ITS was a powerful assay for distinguishing between species of *Ditylenchus,* but not between races. Host races of *D. dipsaci* were differentiated by probing Southern blots with the complete ribosomal cistron. *Department of Biological Sciences, Simon Fraser University, Vancouver, British Columbia V5A 1S6, Canada.*

WERGIN, W. P.[1], R. M. SAYRE[2], and E. F. ERBE[1]. *Use of low temperature field emission scanning electron microscopy to observe frozen, fractured, hydrated nematodes.*

To observe biological specimens with a scanning electron microscope (SEM), samples generally must be chemically fixed, dehydrated, critical point dried (CPD) and coated. Unfortunately, these procedures are frequently associated with artifacts or physical changes in tissues. For example, chemical fixation and dehydration are identified with the extrusion

of materials; critical point drying can shrink and distort tissues; and sputter coating with 20–30 nm of metal obliterates fine-structural details. Our laboratory has recently acquired a Hitachi S-4000 field emission scanning electron microscope (FESEM) that is equipped with an Oxford CT 1500 Cryotrans System. This combination of instrumentation allows us to quickly freeze, fracture, sputter coat and examine a frozen hydrated specimen. Preliminary results indicate that the cuticle and the fractured surfaces of frozen hydrated nematodes can be easily observed at magnifications up to 25,000×. This technique avoids the artifacts associated with the preparation procedures normally used in conventional SEM and offers the potential to observe nematode fine structure at magnifications greater than 100,000× with an FESEM. [1]*Electron Microscopy Laboratory, USDA, ARS, Building 177B, BARC-East, Beltsville, MD 20705, and* [2]*Nematology Laboratory, USDA, ARS, Building 011A, BARC-West, Beltsville, MD 20705.*

WESTERDAHL, B. B.[1], H. L. CARLSON[2], and J. D. RADEWALD[3]. *Influence of various nematicide application methods on control.*

Effectiveness of a nematicide is influenced by method of application and consequent distribution in the soil profile. Various methods were used to demonstrate this principle in field trials and to improve nematode control on carrots and potatoes in California. Artificially placed nematode indicators demonstrated distribution patterns of metham sodium applied via sprinklers, flood and shank injection, and untarped shank-injected methyl bromide. Increased effectiveness over traditional single-depth soil injection of metham sodium was obtained with implements containing various configurations of multiple spray nozzles and orifices. Flood applications of metham sodium and sodium tetrathiocarbonate applied in different volumes of water showed greater effectiveness with increased water. Deep incorporation improved control with ethoprop and oxamyl. This was demonstrated using implements providing 2.5–5 (rolling cultivator), 7–10 (rotary harrow), and 15–20 (rototiller) cm maximum depth. In some trials shallow incorporation of ethoprop resulted in greater potato tuber blemish from *Meloidogyne chitwoodi* infestation than no treatment at all. [1]*Department of Nematology, University of California, Davis, CA 95616,* [2]*University of California Intermountain Research and Extension Center, P.O. Box 447, Tulelake, CA 96134, and* [3]*Department of Nematology, University of California, Riverside, CA 92521.*

WESTCOTT, S. W., III, and D. A. KLUEPFEL. *Inhibition of Criconemella xenoplax egg hatch by a strain of Pseudomonas aureofaciens.*

Pseudomonas aureofaciens isolates derived from roots of peach trees grown on an orchard site with a history of relatively low population densities of *Criconemella xenoplax* (Raski) Luc & Raski were screened for their nematicidal activity. Gravid females (10–20 per dish) of *C. xenoplax* were incubated for 1 day in glass or plastic dishes containing 1 ml of distilled water at 26 C. Females then were removed and the remaining eggs (20–70 eggs per dish) were exposed to either 50 µl of distilled water or a bacterial suspension of *P. aureofaciens.* In dishes without added bacteria, 65–85% of eggs hatched. One strain of *P. aureofaciens* completely inhibited egg hatch at initial concentrations above 8×10^7 CFU/ml. This strain had inhibited *C. xenoplax* multiplication in greenhouse tests. Over the course of embryogenesis and egg hatch, which required 9–12 days at 26 C, bacterial population densities declined from 2×10^8 to ca. 4×10^6 CFU/ml. Below initial concentrations of 4×10^7 CFU/ml, the ability of this strain to inhibit egg hatch decreased substantially. Several other strains of *P. aureofaciens*, inhibitory to *C. xenoplax* multiplication in greenhouse tests, did not inhibit egg hatch at concentrations of 2×10^8 CFU/ml. *Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.*

WHEELER, T. A., R. M. RIEDEL, and R. C. ROWE. *Interactions between Verticillium dahliae and mixed species of Pratylenchus in the potato early dying syndrome.*

In microplot studies in potato (cv. Superior) with mixtures of *Verticillium dahliae*, *Pratylenchus penetrans*, and *P. scribneri*, a significant yield loss occurred with *V. dahliae* alone over a 3-year period, *P. penetrans* alone in 1986 and 1988, and *P. scribneri* alone in 1988. A synergistic interaction between *P. penetrans* and *V. dahliae* was significant in 1986 and 1988, but no interaction occurred between *P. scribneri* and *V. dahliae.* When *V. dahliae* was present, the final population density (Pf) of both nematodes was reduced. The Pf of *P. penetrans* was

higher when *P. scribneri* also was present. In mixed populations, Pf of *P. scribneri* declined as the initial population density of *P. penetrans* increased. In ten studies in commercial potato fields with mixed species, yield losses were associated with an interaction between *V. dahliae* and *P. penetrans* in five fields and *P. crenatus* in one field. In two fields, a synergistic increase in yield was related to an interaction between *V. dahliae* and *Meloidogyne hapla*. The spatial aggregation of each of these species was examined with Taylor's power law and only *P. crenatus* was found to be randomly distributed ($P = 0.05$). *O.A.R.D.C., The Ohio State University, Department of Plant Pathology, Wooster, OH 44691.*

WILLIAMSON, V. M., J. N. MILLER, Y. WEN, and J. -Y. HO. *A new root-knot nematode resistance gene that maps near Mi in tomato.*

Root-knot nematode resistance in modern tomato, *Lycopersicon esculentum*, is due to the single introduction of a resistance gene, *Mi*, from the wild species *L. peruvianum*. The presence of *Mi* confers effective field resistance to most populations of *M. incognita*, *M. javanica*, and *M. arenaria*; but biotypes of *M. incognita* capable of infecting plants with the *Mi* gene have been obtained. *Lycopersicon peruvianum* is a highly polymorphic species, and some accessions carry nematode resistance with different properties than *Mi*. MSK93, a complex hybrid between *L. esculentum* and *L. peruvianum*, was found to be resistant to *M. javanica*. MSK93 is self-compatible and resistance segregates as a dominant locus linked to the acid phosphatase-1 gene, which is genetically linked to *Mi*. Analysis of DNA polymorphisms indicates that the new resistance gene is distinct from *Mi*. The resistance response appears to be similar to that conferred by *Mi* in that a localized necrosis is associated with infecting juveniles. Because MSK93, unlike *L. peruvianum*, produces fertile progeny with *L. esculentum*, this new source of resistance can be rapidly incorporated into modern cultivars. *Department of Nematology, University of California, Davis, CA 95616.*

WINDHAM, G. L., and G. A. PEDERSON. *Effect of Meloidogyne incognita and irrigation on forage production of white clover.*

Meloidogyne incognita is a major parasite of white clover (*Trifolium repens*) and is particularly damaging following the hot, dry summer months of July and August in the southeastern United States. The effect of *M. incognita* and irrigation on white clover yield was examined in a field study. Plots (2 × 2 m) were infested with 9,000 *M. incognita* eggs per 500 cm^3 of soil and seeded with 'Regal' white clover in September 1990. Irrigated plots received 1.25-cm of water twice weekly from July to October 1991. Forage was harvested in April, June, July, and September 1991. *Meloidogyne incognita* suppressed forage growth in June, July, and September. In July, forage yields in nematode-infested plots were significantly less in nonirrigated plots (389 kg/ha) than in irrigated plots (1,052 kg/ha). However, by September, forage yields in nematode-infested plots were significantly greater in nonirrigated than irrigated plots. Over all treatments, irrigation increased total yields by 7.5% and *M. incognita* decreased total yields by 22.5%. *Forage Research Unit, USDA, ARS, P.O. Box 5367, Mississippi State, MS 39762.*

WONG, A. T., and G. L. TYLKA. *Effects of selected herbicides on hatching of Heterodera glycines eggs.*

Laboratory experiments were conducted to assess the effects of selected corn and soybean herbicides on hatching of eggs of the soybean cyst nematode, *Heterodera glycines*. Eggs were extracted from cysts, surface disinfested, dispensed onto 25-µm-pore microsieves, and incubated in aqueous solutions of selected herbicides or two control solutions. Distilled water and 3.14 mM zinc sulfate solution were used as negative and positive control solutions, respectively. The herbicides acifluorfen, alachlor, atrazine, ethalfluralin, and trifluralin were evaluated at two concentrations each. Microsieves with eggs were incubated at 25 C in total darkness, and the number of hatched juveniles was determined every other day for a minimum of 30 days. Alachlor, atrazine, ethalfluralin, and trifluralin had no effect on the hatch of *H. glycines* eggs. There were no significant differences in the percentage of hatched juveniles in these herbicide treatments compared to distilled water, but hatch in all herbicide solutions was significantly less than in zinc sulfate. Acifluorfen had a negative effect on *H. glycines* egg hatch. The percentage of hatched juveniles observed in 50 and 500 µg/ml solutions of acifluorfen was significantly less than in distilled water and zinc sulfate.

Consequently, acifluorfen, a postemergence herbicide for soybeans, may be useful in inhibiting egg hatch of *H. glycines* for management purposes. The effect of acifluorfen on eggs contained within intact cysts is currently being determined. *Department of Plant Pathology, Iowa State University, Ames, IA 50011.*

XUE, B., and J. M. WEBSTER. *Screening and characterization of a transposable element in Meloidogyne incognita.*

Genomic library of *Meloidogyne incognita* race 3 was probed with the transposable element of *Caenorhabditis elegans*, Tc1, by plaque hybridization and was cloned into BlueScript SK plasmid. Four fragments at 2.0 kb, 3.2 kb, 4.6 kb and 4.8 kb were isolated from the library, and a 4.6-kb fragment had the strongest hybridized signal with the Tc1 probe at high hybridization stringency. The screened fragment was confirmed by hybridizing back to genomic DNA of *M. incognita* digested with Eco RI, and the resulting hybridization pattern was very similar to Tc1. The fragment was digested and a B–B fragment of 0.8 kb was homologous with Tc1. The homologous fragment was subcloned into the Bam HI site of plasmid PVZ 1 and sequenced. DNA sequence analysis and hybridization patterns show that this screened fragment Tmi belongs to the transposable element group for *M. incognita* and is partially identical to *C. elegans* Tc1. *Department of Biological Sciences, Simon Fraser University, Burnaby, Vancouver, British Columbia V5A 1S6, Canada.*

YEATES, G. W.[1], D. W. FRECKMAN[2], and T. BONGERS[3]. *A guide to nematode feeding habits for soil ecologists.*

Soil ecologists concerned with the role of nematodes in soil processes need a sound basis for allocating nematodes to trophic groups. This paper describes problems of interpretation and defines eight essential feeding types: plant feeding, hyphal feeding, bacterial feeding, substrate ingestion, predation on animals, unicellular eucaryote feeding, dispersal-infective stages of parasites of animals, omnivory. Under a scheme of nominal orders and families the feeding habits of representative genera are given. There are major gaps in information for Dorylaimidae, Belondiridae, etc. While we believe that identification to these nominal families can lead to standard interpretation of trophic habits, it is still important for authors to indicate the overall generic composition of their nematode faunas to allow for subsequent advances in knowledge. [1]*DSIR Land Resources, Private Bag, Lower Hutt, New Zealand,* [2]*Department of Nematology, University of California, Riverside, CA 92521, and* [3]*Department of Nematology, Agricultural University, Postbus 8123, 6700 ES Wageningen, The Netherlands.*

YEATES, G. W.[1], and P. C. D. NEWTON[2]. *Response of pasture nematode populations to elevated carbon dioxide and temperature–A climate chamber experiment.*

To simulate climate change scenarios turves 1 × 0.5 × 0.4 m were collected from a grazed ryegrass–clover pasture and subjected to i) ambient CO_2 (350 ppm) and basal C, ii) 700 ppm CO_2 and basal C, iii) 700 ppm CO_2 and basal + 6 C in climate chambers; six replicate turves were used and after 4-week acclimation periods there were 6-week "winter", "spring" and "summer" periods. Interpretation of results must acknowledge the sudden impact of the conditions and the lack of possible immigration; the results show changes in competitive advantage under experimental conditions. Preliminary results on an areal basis show significant (t-test) increases in total vermiform nematodes to treatment iii in winter and to ii and iii in spring; at the genus level *Cephalenchus, Cephalobus*, and *Heterocephalobus* showed changes; root infestations of *Meloidogyne hapla* and *Heterodera trifolii* differed between treatments but interpretation of such differences is dependent on completion of the whole "annual cycle". [1]*DSIR Land Resources, Private Bag, Lower Hutt, New Zealand, and* [2]*MAF Technology, Flock House Agricultural Centre, Private Bag, Bulls, New Zealand.*

ZHANG, F. R., and D. P. SCHMITT. *Embryonic development of a new species of Meloidogyne on coffee from Hawaii.*

A new species of *Meloidogyne* has been recorded from four coffee (*Coffea arabica*) growing sites on the island of Hawaii. Embryonic development of this nematode was examined at 5, 10, 16, 20, 24, 31, 35, and 40 C. Twenty eggs in the 2-cell stage were placed at each temperature. The phases of embryonic development were categorized as 2-cell, 4-cell,

8-cell, multi-cell, J1, J2 in the egg, hatched J2, or dead. Development from the 2-cell through the multi-cell stages were observed at 2-hour intervals for 48 hours, then daily until all eggs hatched or development ceased. Rate of development increased with temperature from 10 to 31 C. Development was slower at 35 than at 31 C. No development occurred at 5 C and all eggs died within 24 hours at 40 C. At 31 C, eggs began to hatch at 8 days and 25% hatched. At 24 C, the first egg hatched at 12 days; 90% ultimately hatched. Development was slow at 20 and 16 C; hatching began at 20 and 36 days, respectively. At 10 C, embryonic development stopped at the multi-cell stage. The high percentage hatching at 24 C is likely related to adaptation to the environment in which coffee is grown, where the soil temperatures average 25 C at elevations of 450 m or higher on the island of Hawaii. *Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.*

ZUNKE, U. *The feeding behavior of plant-parasitic nematodes in relation to the evolution of sedentary endoparasitism.*

The use of high resolution video-enhanced contrast microscopy enabled detailed analysis at high magnification of the feeding behavior of different plant-parasitic nematodes on fungi, root hairs and roots of higher plants. The use of this system complements and extends studies using transmission electron microscopy; it enabled observations on the feeding on root hairs and endoparasitic migration and feeding behavior inside roots of very small nematodes, such as the root lesion nematode *Pratylenchus penetrans*, and the migration and feeding site initiation of second-stage juveniles and feeding behavior of sedentary larval and adult stages of cyst nematodes such as *Heterodera schachtii*. Behavioral sequences analyzed by time lapse evaluation clarified the feeding behavior of rapidly moving ectoparasitic nematodes, such as the fungivorous nematode *Aphelenchoides hamatus*. The different feeding strategies of these three species illustrates that the evolution of sedentary endoparasitism has been accompanied by the development of a specialized and complex feeding behavior linked to a more extensive involvement of the salivary secretions. *Institut fuer Angewandte Botanik, Marseillerstr. 7, D-2000 Hamburg-36, Germany.*