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ABAWI, G. S., and W. F. MAI. Effect of *Heterodera schachtii* on maturity and yield of cabbage.

Four initial population densities (P_i) of *H. schachtii* (Hs) were established in field microplots (unglazed clay tiles, 25 cm diam. and 30 cm deep) in 1986 and 1987. One cabbage seedling (*Brassica oleracea* var. *capitata* cv. Roundup) was planted per tile. A set of treatments for each of 3 harvest dates were arranged according to a randomized block design with 10 replications. Harvests were made at 75, 90 and 105 days after transplanting. Total and marketable weights were proportionally reduced by the P_i of Hs. Yield loss at all P_i was reduced by delaying harvest. However, delaying harvest by up to 30 days did not result in complete recovery of infected plants especially at the highest P_i of Hs. In 1987; 10, 20, and 40 eggs of Hs/cm³ soil reduced marketable yield by 34, 51, and 62%, respectively in the first harvest and by only 15, 23, and 36% at the last harvest. Departments of Plant Pathology, Cornell University, Geneva (14456) and Ithaca (14853), NY.

AHMAD, IRFAN, and M. SHAMIM JAIRAJPURI. Some observations on the copulatory behaviour of *Cruzinema lambdiensis*.

Observations were made to determine the sensory mechanisms involved in the initiation of copulation in *Cruzinema lambdiensis*. Males were allowed to make fifty contacts with small pieces of glasswool and freshly killed females and the number of copulations attempted was recorded separately. Three groups of males, viz. one day old virgins, two day old virgins and two day old copulating males were observed on 1% water agar and on agar with a sex attractant gradient. In both sets of experiments the differences between the number of attempts on glasswool and dead females by one and two day old virgins was significant but was insignificant for the copulating males. Both exogenous and endogenous stimuli may be responsible for the initiation of copulation. Sex attractants apparently do not influence copulation. Department of Zoology, Aligarh Muslim University, Aligarh - 202001, India.

ALPHEY, T. J. W., W. M. ROBERTSON, AND G. D. LYON. The nematocidal potential of natural plant products.

Recent results have shown that the sesquiterpenoid phytoalexin, rishitin has nematode repellent and nematocidal properties. Rishitin, produced in potato tissue challenged by the bacterium *Erwinia carotovora*, repelled *Xiphinema diversicaudatum* from point sources of 20 μ g or more of the compound on agar plates. During *in vitro* studies nematodes in 200 μ g/ml solutions became immobile within 10 minutes and died within 2 hours. In 100 μ g/ml solutions 90% of nematodes regained mobility if transferred into clean water within 3 hours. In a "split-pot" experiment rishitin at 1.5 mg/74 cm³ soil inactivated ca. 80% of *X. diversicaudatum* preventing migration from their inoculation site and feeding on seedling roots in the surrounding soil. Additional studies have been undertaken examining the nematocidal potential of other naturally occurring compounds. Some of these compounds exhibit nematocidal activity, similar to that of rishitin against *X. diversicaudatum*, and greater than that of rishitin against *Globodera* spp. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

ALSTON, D. G., AND D. P. SCHMITT. The impact of soybean cyst nematode on soybean canopy development and its subsequent influence on establishment of corn earworm populations.

Soybean growth alterations caused by different preplant densities of the soybean cyst nematode (SCN), *Heterodera glycines*, influenced establishment of corn earworm (CEW), *Heliothis zea*, populations in North Carolina field experiments in 1986 and 1987. Population densities of CEW larvae found on soybean in August were greatest with moderate (2,000-6,000 eggs/500 cm³ soil) SCN preplant densities, where soybean plants had an open canopy, but were not severely stunted and chlorotic. Closed canopy soybeans with zero to low (400-1,000 eggs/500 cm³ soil) SCN populations had fewer CEW larvae. Low and moderate SCN preplant densities increased yield loss due to CEW pod and foliage damage. Soybeans defoliated by CEW larvae remained green and vegetatively active longer into the season as compared to plants without CEW, which underwent normal senescence several weeks earlier. This enabled SCN populations to continue egg production later into the season, resulting in greater SCN densities in plots with CEW at harvest. North Carolina State University, Box 7631, Raleigh, NC 27695.

BARKER, K. R. Developing and utilizing nematode-damage thresholds on tobacco. Damage thresholds or hazard levels for given taxa may be derived through specialized nematicide experiments (often including resistant and susceptible cultivars), rotation, and cropping systems, and by artificially infesting field plots and/or microplots. Nematode taxa vary greatly in their aggressiveness on tobacco cultivars. Certain populations of Meloidogyne incognita, M. javanica, and M. arenaria cause severe yield losses, whereas M. hapla and most Pratylenchus spp. have only slight effects. Environmental parameters, including soil texture, nutrient and moisture levels, alter tobacco responses to nematodes. Although damage thresholds, as characterized from these experiments are useful, they have limitations because of associated sampling precision and environmental factors. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

BARKER, K. R., S. R. KOENNING, and P. R. ESBENSHADE. Interaction of Meloidogyne hapla and M. arenaria on peanut. Effects of Meloidogyne hapla (MH) alone and M. arenaria (MA) alone and in combinations up to 2800 eggs/500 cm³ soil of each nematode species were included in concomitant treatments and up to 5600 eggs/500 cm³ soil in single nematode plots. Relationship between mean plant yield and inoculum density (Pi) were described adequately by quadratic models $y=335-0.054 Pi + 0.00000062 Pi^2$ ($R^2=0.95$); and $y=341 - 0.036 Pi + 0.000004 Pi^2$ ($R^2=0.97$) for MA and MH, respectively. Galling of peanut pods was more severe with MA than with MH ($P=0.01$). Females were identified to species by esterase patterns after electrophoresis. MH failed to compete with MA ($P=0.01$). Reproductive factors (Pi/final nematode numbers) for MH and MA alone at $Pi=175/500$ cm³ soil were 12.7 and 263, respectively. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

BECK, J. L., and B. C. HYMAN. Molecular basis of size polymorphisms within Romanomermis culicivorax mitochondrial DNAs. Romanomermis culicivorax, a parasitic nematode of mosquitos, possesses unusually large mitochondrial (mt) genomes (25-30 kilobase pairs; kbp). Individual nematodes are monomorphic for one of three size variants. We have demonstrated that the mitochondrial genome size differential in three isofemale lineages is due to the presence of mtDNA sequences amplified to different copy numbers in each genome. The size of the repeating unit created by the amplification event differs by 100 bp in individual mtDNAs. We hypothesize separate amplification events within a progenitor genome to generate different-sized repeat units. The reiterated DNA sequences are present as direct, tandem repeats and as portions of the same sequence located elsewhere in the genome. Evidence suggests that genome rearrangements generating the dispersed repeated regions may also have been involved in separating the genes for cytochrome oxidase subunits by approximately 8 kb in each genome. Department of Biology, University of California, Riverside, CA 92521.

BECKER, J. O., M. MONSON, and S. D. VAN GUNDY. The use of a drip irrigation system for the infestation of field plots with nematodes. Field sites uniformly infested with plant parasitic nematodes for scientific trials are often hard to find. A method was developed using passive injection through a drip irrigation system to infest artificially field plots with plant parasitic nematodes. The system permitted the application of selected treatments in a randomized block design. The delivery method allowed pre- and postplant applications with no disturbance to the growing crop. At the UC South Coast Field Station, Irvine, CA, second-stage juveniles and eggs of Meloidogyne incognita were successfully transported through separate irrigation lines without plugging of the emitters. Trials with juveniles and adults of Acrobeloides sp. and Dedalenus sp. demonstrated that even larger nematodes can be delivered through the system. Three days after application, root-knot juveniles were recovered from previously uninfested soil 20-30 cm below the irrigation lines. Uniform heavy galling on tomato roots (Lycopersicon esculentum cv. UC 82) and very small variability between replicates indicated that passage through the system did not significantly affect viability or infectivity of M. incognita. Department of Nematology, University of California, Riverside, CA 92521.

BERNARD, E. C., and M. E. MONTGOMERY. Composition of plant-parasitic nematode communities in Great Smoky Mountains National Park. Multiple soil samples were taken at eleven sites within Great Smoky Mountains National Park (GSMNP). Sites were classified by the National Park Service as "areas with many big trees and only diffuse activity," or "areas high in virgin attributes." Elevations varied from

915-1830 m. Dominant, understory, and groundcover plant species were recorded. Bakernema inaequale, Criconema sphagni, Crossonema sp., Gracilacus straeleni, Helicotylenchus clarkei, Hoplotylus silvaticus, and Trichodorus sp. were found most frequently. Species of Criconemella, Heterodera, Merlinius, Pratylenchus, and Tylenchorhynchus, all common in adjacent agricultural areas, were seldom or never collected. Of 30 species found, seven often have been reported from agricultural soils, but only one (G. straeleni) was frequently (more than four sites) collected in GSMNP. Some species were collected only around certain tree species (Hemicycliophora sp. - red maple; Dolichodorus sp. - mountain ash). Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37901-1071.

BERNARD, E. C., L. H. SELF, and D. D. TYLER. Fungal parasitism of Heterodera glycines in two soybean cropping systems.

Fungal parasitism of Heterodera glycines was determined on a monthly basis, beginning December 1986, in two soybean cropping systems maintained for the previous six years: conventionally tilled, monocropped; and no-till, doublecropped with winter wheat. White females (July-September) or eggs from cysts (other months) were surface-disinfested and placed on antibiotic-amended water agar. Emergent fungi were identified. Parasitism of females was low in both systems in July and August (2-6%), but increased dramatically in September (28-33%). Egg parasitism was similar in the two systems from December 1986 to May 1987 and October-December 1987, with highest infection rates occurring in February (8-9%). Fusarium oxysporum and F. solani were isolated most often from females. Paecilomyces lilacinus and F. solani were the most frequent parasites of eggs in winter; Exophiala pisciphila and P. lilacinus in spring; and Gliocladium catenulatum, P. lilacinus, and Verticillium chlamyosporium in autumn. Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37901-1071.

BERNEY, M. F., and G. W. BIRD. Distribution of Heterodera carotae in Michigan. During the summer of 1986, a nematode survey of carrot fields was conducted to determine the distribution of Heterodera carotae, Jones 1950 (carrot cyst nematode) in Michigan. The survey was limited to 4 carrot growing counties in western Michigan, since H. carotae was already known to be widely distributed in Montcalm and Lapeer, the other major carrot production counties. A total of 327 soil and root samples were taken and analyzed by both a modified sugar floatation/centrifugation technique and a greenhouse carrot bioassay. Carrot cyst nematodes were recovered from 50% of the fields and 19% of the samples. Populations of Meloidogyne hapla, Chitwood 1949, were recovered from all carrot fields infested with H. carotae, but not from all samples containing H. carotae. H. carotae was detected in 3 of the 4 counties (Kent, Allegan, and Newaygo) included in the survey. Based on the presence of deformed carrots, the occurrence of H. carotae was associated with fields considered to be nematode problem sites. Department of Entomology, Michigan State University, East Lansing, MI 48824.

BIRD, DAVID MCK., MARK A. WILSON, and DONALD L. RIDDLE. Molecular analysis of Caenorhabditis elegans RNA polymerase II.

We have sequenced approximately 8.7 kb of genomic DNA, implicated by transcript mapping experiments as spanning ama-1. Removal of sequences resembling introns leaves a sequence which translates to a continuous open reading frame of 1795 amino acids. Alignment of this deduced sequence with that encoding the large subunit of yeast RNA polymerase II indicates that ama-1 encodes the analogous protein in C. elegans, and that our sequence begins approximately at the codon for amino acid 20. Currently we are completing the sequence. We have, however, made some preliminary observations. ama-1 is broken, by introns of approximately 300 bp. into 11 exons, ranging in size from 109-1589 bp. The 3' untranslated region appears extremely short. The AAUAAA motif overlaps the stop codon; there is a TGTGT box 34 bp further 3'. The carboxy terminus of ama-1 is composed of a "tail" of 31 tandem repeats of an heptapeptide with consensus: tyr, ser, pro, thr, ser, pro, ser. A similar tail is present on the yeast (26 repeats) and mouse (52 repeats) polypeptides. We also have begun to sequence selected ama-1 mutants, including m118, an allele that confers resistance to amanitin. A single C to T, resulting in a cys to tyr, has been observed. We plan to test this functionally. Department of Nematology, University of California, Riverside, CA, 92521.

BIRD, G. W., J. DAVENPORT, and J. CHEN, Potential role of Heterodera glycines in dry bean

production in Michigan.

Heterodera glycines was first discovered in Michigan in Gratiot Co. (Section 17 of Elba Township) in April of 1987. The site was first planted with soybeans in 1955, and was planted with soybeans during approximately 24 of the next 31 years. The first sample processed for this site contained 188 H. glycines cysts per 100 cm³ soil. Soybean yield losses in 1985 and 1986 were 100% since the grower did not bother to harvest the crop because of inadequate productivity. In 1987, this site was used to evaluate the comparative susceptibility of selected soybean and dry bean cultivars grown in Michigan. Initial population densities of H. glycines in the test area ranged from 1,700 - 8,840 viable units (eggs and second-stage juveniles) per 100 cm³ soil. H. glycines reproduced on current commercial dry bean cultivars; however, completion of the first generation took longer than on soybeans. H. glycines was pathogenic to dry beans, but bean losses were less severe than with soybeans. Final population densities of H. glycines associated with dry beans were less than those associated with soybeans. Michigan State University, East Lansing, MI 48824.

BIRD, G. W., and D. WOLFSON. Evaluation of MICROPOTATOPEST: A computer simulation of Pratylenchus penetrans - Solanum tuberosum.

From 1985-87, a multistate research project collected biological information from sites in MI, WI, MN and ND for evaluation of three potato models, POTATO (WI), SPUDGRO (MN) AND MICROPOTATOPEST (MI). MICROPOTATOPEST was developed in 1975 to simulate the growth and development of Solanum tuberosum and associated population dynamics of Pratylenchus penetrans using a mainframe computer. In 1987 this model was converted for use on a PC microcomputer, and calibrated for simulation of Russet Burbank using 1985 crop data from the Montcalm, MI Potato Research Farm. The new simulation contains graphics and is called MICROPOTATOPEST. Using 1987 environmental information, this model was able to simulate S. tuberosum growth and P. penetrans population dynamics for the Montcalm research site! Similar simulations for the WI, MN and ND sites were less accurate. Databases for the influence of plant spacing, and occurrence of P. penetrans in potato stolon tissue were developed as part of this project. Department of Entomology, Michigan State University, East Lansing, MI 48824.

BOAG, B., and W. M. ROBERTSON. The specificity of nematophagous fungi for plant-parasitic nematodes.

The ability of the adhesive knobs of the nematophagous fungus Arthrobotrys dasguptae to become attached to plant parasitic nematodes differed between species. While large numbers of adhesive knobs were recorded from both Rotylenchus and criconematid species very few were found on virus-vector nematodes belonging to the genera Xiphinema, Longidorus, Trichodorus and Paratrichodorus. Although screening with fluorescent lectins indicated that several carbohydrate moieties were present on the cuticle of R. robustus but not on X. diversicaudatum tests showed that these lectin/carbohydrates were not involved in the attachment of A. dasguptae to R. robustus. However, electrophoresis of the surface proteins of R. robustus and X. diversicaudatum have shown several differences exist between these species and may be involved in the process of attachment. Scottish Crop Research Institute, Invergowrie, Dundee, Scotland, DD2 5DA.

BOAG, B., P. SMITH, and P. R. BURROWS. Computer identification of cyst nematodes.

Computer identification programs have been written for migratory plant-parasitic nematodes belonging to the genera Helicotylenchus, Longidorus and Tylenchorhynchus but none for the economically important group of cyst nematodes. The identification of Heterodera and Globodera utilizes the characters of both cyst and juvenile whereas only characters from adult nematodes are required for migratory nematodes. The present program, which is written for a desk top microcomputer, allows a digitizing tablet to measure specimens directly. The program initially required basic information about the cyst, which determines the subset of cyst characters on which further information is required. Additional data is then requested on the juveniles of that cyst. The process is repeated for a given number of cysts and juveniles. The identification procedure depends upon matching the data from the specimen species to that on all species of cyst nematodes held on a reference file. A ranked list of the most likely to least likely species is then produced. Scottish Crop Research Institute, Invergowrie, Dundee, Scotland, DD2 5DA.

BOLLA, R. I., and M. C. HUBER. Heavy metal effects on pine susceptibility to pinewood

nematode.

Pinewood nematode is important to U. S. forestry because of embargoes enacted against import of infested pine wood products into Scandinavia and Korea. There are species and regional variations in symptom onset and development of pine wilt in the U. S. and there are host specific pathotypes of pinewood nematode. Environmental stress may have a role in this infection. We investigated the effect of heavy metals on the susceptibility of pines to pinewood nematode. Heavy metal-stressed Scots and Austrian pine lose tolerance and resistance, respectively, to pathotypes VPSt-1. Classic wilt symptoms occur in these pines, and wilting is rapid. Heavy metal-stressed, VPSt-1-infected Scots and Austrian pines have decreased concentration of carbohydrate and produce phytotoxic oleoresins. This suggests that introduction of pinewood nematode into Northern Europe, where pines often grow under conditions of environmental stress, may lead to establishment of the nematode and seriously alter forest productivity. Department of Biology, University of Missouri-St. Louis, St. Louis, MO 63121-4499.

BRODIE, B. B., and R. S. SPIVEY. Aseptic culture of *Globodera rostochiensis*.

Cysts of *Globodera rostochiensis* were soaked in sterile potato root diffusate for 8-10 days. Hatched second stage juveniles (J2) were collected on a 25 μ m sieve, flushed with sterile distilled water, layered in 20% sucrose (w/v), and centrifuged at 2500 rpm for 5 minutes. The J2, settled at the interphase, were then pipetted to a solution of penicillin (0.025 mg/ml) and streptomycin sulfate (0.025mg/ml) and centrifuged at 2500 rpm for 2 minutes. The J2 in the pellet were resuspended in the antibiotic solution and placed in a sterile separatory column filled with glass beads (6 mm) and the antibiotic solution. After 3 hours, 2-3 ml of solution containing sterile J2 were collected. These J2 were then inoculated to *G. rostochiensis* resistant and susceptible potato plantlets, roots, or callus tissue growing on sterile Gamborg B5 medium. For callus culture, the medium was supplemented with 2,4-D (2 mg/l), BAP (0.5 mg/l) and NAA (0.1 mg/l). The J2 penetrated the tissues and developed normally in cultures of susceptible but not in those of resistant potatoes. USDA, ARS, Department of Plant Pathology, Cornell University, Ithaca, NY 14853.

BROWN, D. J. F. Standardization of requirements by nematology journals for taxonomic descriptions including deposition of specimens in internationally agreed collections.

Several authors have complained of deteriorating standards in taxonomic descriptions in nematology. Criticism has been levelled at the "taxonomists," but, equally there is a lack of scientific leadership and discrimination from the editorial boards of journals. A remedy to this situation is journals agreeing to a common code of practice for taxonomic articles i.e. vigorous application of the Regles Internationales de la Nomenclature Zoologique; type specimens submitted with manuscript; names of the independent referees published in the description; use of standard vocabulary definitions; use of photographs to supplement drawings; morphometric data to include mean, range and standard deviation and morphometric differences used to differentiate species shown to be statistically significant. Only a few centers of excellence for taxonomy and systematics in nematology exist worldwide and type specimens received by the journals could be placed in a minimum of one center in each continent. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

BROWN, D. J. F., A. T. PLOEG, and D. J. ROBINSON. Preliminary studies on the transmission of tobacco rattle virus by trichodorid nematodes.

Thirty years have elapsed since the first report of a plant parasitic nematode transmitting a plant virus, namely *Xiphinema index* vectoring grapevine fanleaf virus. While much is known of the specificity between longidorid nematodes and their associated nepoviruses it is not known whether there is specificity for transmission between different isolates of tobacco rattle virus (TRV) and different species or populations of trichodorid nematodes. Methods and techniques have now been developed to study the acquisition retention, and transmission of TRV by individual nematodes. Using these techniques two trichodorid species each transmitted a different serotype of TRV at one field site whereas at a second site one species transmitted two serotypes of TRV. The field efficiency of trichodorid species transmitting their naturally associated viruses was 10-15% but in the laboratory this efficiency could be increased to 46-69%. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

BROWN, D. J. F., D. L. TRUDGILL, and A. F. MURANT. Serological variability in nepoviruses

and its effect on specificity of transmission of nematodes.

Many nepoviruses exist as several serologically distinct strains (serotypes). In Europe, many such strains, e.g. of raspberry ringspot and tomato black ring (TBRV) viruses, have different vector nematode species, and vector specificity is known to be determined by the virus particle protein. Conversely, some populations of Xiphinema diversicaudatum may differ in ability to transmit individual strains of arabis mosaic or strawberry latent ringspot viruses, and these nematode population differences are inherited. Some serologically similar isolates of TBRV can be transmitted differentially by a single population of Longidorus attenuatus. In North America, evidence is accumulating of differential transmissibility of strains of tobacco and tomato ringspot viruses by populations and/or species in the X. americanum group. In Europe, the distribution of serotypes is correlated with that of their specific vectors, and the same may be found true in North America. In all studies of virus vector relations it is essential to determine the virus serotype and the taxonomic status of the vector. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

BUECHER, E. J., and I. POPIEL. Growth of *Steinernema feltiae* Strain 42 in liquid culture. Our objective was to investigate the possibility of growing *Steinernema feltiae* in resuspended or growing cells of its symbiont *Xenorhabdus nematophilus*, both in thin liquid layers and in large volume, using various aeration methods. Basal salts medium plus cholesterol and resuspended bacterial cells supported nematode growth. Nematode populations were significantly increased when the medium was supplemented with tryptic soy and yeast extract to support bacterial growth. Aeration was required for nematode development in cultures with a depth of 4mm. Nematode population densities of 25,000/ml were obtained in 14 day 60 ml cultures. The incidence of infective juveniles in the population was 90%. These findings demonstrate the feasibility of nematode production in liquid culture and provide the basis for scale up studies in larger volumes. BIOSIS, 1657 East Meadow Circle, Palo Alto, CA 94303.

CARPENTER, A. S., and S. A. LEWIS. Variation in *Meloidogyne arenaria* virulence on soybean. Virulence and reproduction of four *Meloidogyne arenaria* isolates on six soybean selections were evaluated in microplots for 3 years. Three race 2 isolates were collected from South Carolina and one race 1 from Florida. The Govan, SC isolate had significantly higher reproduction and virulence than the Florence and Pelion, SC isolates as well as the Florida isolate. The Florida isolate had significantly lower reproduction and virulence than the three SC race 2 isolates. An additional microplot study conducted over 2 years has shown virulence and reproduction to be greatly influenced by soil structure effects. Considerable variation in virulence on soybean exists between different *M. arenaria* populations. Such variation is influenced by environmental factors. The relative virulence between populations, however, remains stable. Species purity of all isolates was continually evaluated utilizing perineal patterns, differential hosts, and esterase phenotypes on polyacrylamide gels. Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.

CHALFIE, MARTIN. Genetic analysis of mechanosensory receptor differentiation in *Caenorhabditis elegans*.

The reception of a gentle touch stimulus in *Caenorhabditis elegans* is mediated by six receptor neurons. Over 380 mutations that disrupt touch sensitivity have been identified. The genes identified by these mutations help to define various features of the developmental pathway by which the touch cells differentiate. Mutations in two genes result in animals in which the lineages that normally generate the touch cells are altered so that the cells do not arise. Mutations in a third gene, *mec-3*, result in animals with apparently normal touch-cell lineages but the cells produced have none of the distinguishing characteristics of the touch cells. Thus, *mec-3* appears to be required for touch cell specification. The remainder of the genes (at least sixteen), when defective, result in identifiable touch cells that do not function. Molecular analysis of the *mec-3* gene reveals that its putative product has a homeodomain, a structure found in a number of developmentally important genes in *Drosophila* where it is thought to serve as a DNA-binding domain. We hypothesize that the *mec-3* product also binds to DNA, and, thus regulates the expression of the differentiated features of the touch cells. Department of Biological Sciences, Columbia University, New York, NY 10027.

CHITWOOD, D. J. Sterol composition of *Pratylenchus agilis*.

Pratylenchus agilis was propagated monoxenically on root cultures of *Zea mays* in Gamborg's B5 agar. Nematodes were homogenized in chloroform/methanol to produce a lipid extract, which was subsequently saponified. Sterols were purified from the saponification products by silica gel column chromatography and were identified and quantified by gas-liquid chromatography on DB-1 and OV-17 liquid phases. Sixteen sterols were identified in extracts of *P. agilis*, including cholesterol (3.2% of total sterol), 24-methylcholesterol (2.3%), 24-methylcholestanol (10.7%), 24-ethylcholesta-5,22-dienol (19.9%), 24-ethylcholest-22-enol (36.0%), 24-ethylcholesterol (3.6%), 24-ethylcholestanol (7.1%), 24Z-ethylidenecholesterol (10.5%), and 24Z-ethylidenecholestanol (6.3%). Because the sterols of corn roots consist predominantly of 24-ethylcholesta-5,22-dienol, 24-ethylcholesterol and 24-methylcholesterol the results indicate the major metabolic transformation performed by *P. agilis* upon sterols of its host is saturation of the sterol nucleus. USDA ARS, Insect and Nematode Hormone Laboratory, Building 467, BARC-E, Beltsville, MD 20705.

CHO, M. R., and R. T. ROBBINS. Morphological studies on stylets of *Xiphinema*, *Longidorus* and *Californidorus* by scanning electron microscopy.

Stylet ultrastructure of 5 *Xiphinema* spp., 4 *Longidorus* spp., and 3 *Californidorus* spp. was compared by SEM. Differences in the morphology of the odontophores and base of the odontostyles were seen among the genera. All *Xiphinema* spp. studied had odontophores with well-developed flanges, *Longidorus* spp. had either tube-shaped odontophores with no flanges or flanges which were similar in shape but less-sclerotized than those of *Xiphinema*. All *Californidorus* spp. had odontophores with no flanges and a horn-shaped posterior terminus. All odontophores examined had 3 sinuses; one longer ventral and two shorter dorsolateral. The base of odontostyles of *Xiphinema* and *Californidorus* had similar collars, while bases of those of *Longidorus* were blunt. Odontostyle and odontophore junctions appeared as a rough horizontal line in most specimens when viewed laterally. A "V" shaped junction and longitudinal indentations were observed in some species of *Xiphinema* and *Californidorus* when viewed dorsally. Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

COOMANS, A. How to distinguish between plesiomorphic and apomorphic characters in nematodes.

To trace and reconstruct the phylogeny of a group we have to discriminate between what is primitive or plesiomorphic and what is derived or apomorphic. What methods can be used to make the distinction? In comparison with most other Metazoa, nematodes have a rather uniform and structurally simple body plan; the use of complex characters is therefore limited. Nematodes generally lack specialized larvae and hence ontogenetic clues are not evident. Through outgroup comparisons and functional interpretations we can nevertheless arrive at safe conclusions, as will be illustrated with a number of examples. Laboratorium voor Morfologie en Systematiek der Dieren, Ledeganckstraat 35, 9000 Gent, Belgium.

CULBREATH, A. K., and M. K. BEUTE. Effect of root-knot nematodes on *Cylindrocladium black rot* severity in resistant and susceptible peanut genotypes.

Four peanut (*Arachis hypogaea* L.) genotypes, *Cylindrocladium black rot* (CBR) susceptible cultivar, Florigiant; two new moderately resistant genotypes, NC 18416 and NC 18417; and highly resistant breeder line, NC 18016, were combined in a factorial microplot experiment with inoculum of the fungus, *Cylindrocladium crotalariae* and two root-knot nematode species, *Meloidogyne arenaria* and *Meloidogyne hapla*, to determine the effects of root-knot nematodes on CBR severity across a range of CBR resistance levels. Addition of either root-knot species enhanced root-rot severity in all four genotypes. *M. arenaria* caused greater increase in root rot severity ratings in the moderately resistant genotypes than did *M. hapla*. Addition of *M. arenaria* increased CBR severity in NC 18417 to a level equal to that observed in susceptible Florigiant. Little difference in the effects of the two species was observed in NC 18016 or Florigiant. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

DAVIS, E. L., D. T. KAPLAN, D. W. DICKSON, and D. J. MITCHELL. Root tissue response of two near-isogenic soybean cultivars to infection by lectin-treated *Meloidogyne* spp.

Treatment of second-stage juveniles (J2) of *Meloidogyne incognita* race 1(M:1) and *M. javanica* (Mj) with soybean agglutinin, Concanavalin A, wheat germ agglutinin, *Lotus tetragonolobus* agglutinin, or *Limax flavus* agglutinin (LFA) did not influence root tissue

response of 'Centennial' and 'Pickett 71' soybean cultivars to infection by Mi1 or Mj. Giant cells were usually associated with untreated M. incognita race 3 (Mi3) in Centennial root tissue 5 days after inoculation. Treatment of J2 of Mi3 with lectins or carbohydrates caused Centennial root tissue to respond to infection by treated Mi3 in a hypersensitive manner. Nematodes could not be detected within soybean roots 5 days after inoculation of root tips with J2 suspended in solutions of LFA or sialic acid. Sialic acid also impaired reproduction of Meloidogyne spp. in soybean roots. U.S. Department of Agriculture, ARS, 2120 Camden Road, Orlando, FL 32803.

DAVIS, E. L., D. T. KAPLAN, D. W. DICKSON, D. J. MITCHELL, and T. A. PERMAR. Characterization of surface carbohydrates of second-stage juveniles of Meloidogyne using lectin probes.

Fluorescent (rhodamine) conjugates of the lectins, soybean agglutinin, Concanavalin A, wheat germ agglutinin, Lotus tetragonolobus agglutinin, and Limulus polyphemus agglutinin bound exclusively to amphidial openings and secretions of viable, preinfective second-stage juveniles (J2) of Meloidogyne incognita races 1 and 3 (Mi1, Mi3), and M. javanica (Mj). No substantial difference in lectin labeling was observed among preinfective J2 of Mi1, Mi3, and Mj. Differences in configuration of surface carbohydrate complexes among populations of Meloidogyne spp. were revealed by glycohydrolase treatment of preinfective J2 and subsequent labeling with fluorescent lectins. Quantitative differences in binding of each lectin to J2 of Mi1, Mi3, and Mj were determined by a modified microfiltration enzyme immunoassay. U.S. Department of Agriculture, ARS, 2120 Camden Road, Orlando, FL 32803.

DUNCAN, L. W. Citrus fibrous root and Tylenchulus semipenetrans sample optimization in Florida flatwoods citrus orchards.

Single core (2.5 cm diam x 30 cm deep) soil samples were obtained from 2-ha areas in four Florida citrus groves. Optimum nematode sample sizes estimated from parameters of the negative binomial distribution fit to data from each orchard were significantly different from sample sizes predicted by Taylor's Power Law. Repeated sampling of the groves suggest that the nematode variance to mean relationships were better measured by the negative binomial distribution than by the power law. Fibrous root sample sizes estimated from the power law agreed closely with sample sizes assuming random distribution. Standard error to mean ratios were predicted to be less than 0.2 for both soil and root stages of the nematode and less than 0.1 for fibrous roots for samples of 60 cores procured beneath the tree canopy in three of the orchards. The fourth orchard differed from the others in that trees were sporadically and randomly infested and should be considered a special case for sampling purposes. Systematic sampling of nematodes and roots beneath individual trees reduced optimum sample sizes by half compared to random sampling. University of Florida, IFAS, Citrus Reserch and Education Center, Lake Alfred, FL 33850.

EISENBACK, J. D., and E. C. MCGAWLEY. Preparation of nematode stylets for scanning electron microscopy.

Stylets of female root-knot nematodes were extracted for observation with the scanning electron microscope. Whole females were placed in a drop of 45% lactic acid within a ring of nail polish on a 10-mm-diameter coverslip. The head was cut off and the stylet was pushed out through the cut opening with a sharpened dental pulp canal file. The lactic acid was removed by pipetting 2% formalin onto the preparation until the lactic acid was completely replaced. The formalin was drained and the stylet was air dried. The coverslip was mounted onto a stub, coated with gold, and viewed with a scanning electron microscope at a viewing angle perpendicular to the beam. The details of this technique were recorded with a video camera attached to a dissecting microscope and the results of the scanned images were recorded from a scanning electron microscope. Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

EISENBACK, J. D., and V. W. SPAULL. Additional notes on the morphology of males of Meloidogyne kikuyensis.

Males of Meloidogyne kikuyensis, parasitic on sugarcane from the Republic of South Africa, were examined by light and scanning electron microscopy. The head of the male is characterized by a distinct labial disc that is deeply concave. The medial lips are divided into pairs and each lip contains a cephalic sensilla. The head region is smooth. The stylet knobs are large and slope posteriorly. Three distinct esophageal gland lobes

are separated from each other by a prominent membrane. The dorsal lobe is smaller than the two subventral lobes. The nucleus and the nucleolus of each subventral gland is very large compared to that of the dorsal gland lobe. The morphology of *M. kikuyensis* is very different from the four most common species of root-knot nematodes. Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

ENDO, B. Y. and W. P. WERGIN. Fine-structure of the second-stage juveniles of the root-knot nematode, *Meloidogyne incognita*.

Juveniles of the root-knot nematode were examined to elucidate the fine structural details and interrelationships of the feeding, digestive, excretory and nervous system. This study follows the continuity of the lumens of the stylet, esophageal canal, intestine and excretory pore. Passage of material through these systems is controlled by the triradiate metacarpus pump and the esophageal-intestinal valve while secretory activities of accessory glands, namely a dorsal and two subventrals, are mediated by tetraradiate valves. A muscle system is attached to the stylet knobs, cephalic framework and median valve via hemidesmosomes. The nervous system of the juvenile consists of six inner labial and two lateral amphidial sensory receptors, which have openings through the cuticle, and four outer labial, four cephalic and several accessory receptors that lie beneath the cuticle within the cephalic framework. The receptors can be traced posteriorly to the nerve ring, which is slightly anterior to the ventral region. A ventral ganglion extends from the nerve ring posteriorly toward the tail of the juvenile. Nematology Laboratory, USDA-ARS, Beltsville, MD 20705.

ENDO, B. Y. Ultrastructure of the second and third juvenile stages of the soybean cyst nematode, *Heterodera glycines*.

The intestine of juvenile stages *Heterodera glycines* consists of large epithelial cells filled with lipid droplets, glycogen rosettes, mitochondria, endoplasmic reticulum, and ribosomes. The esophageo-intestinal valve consists of cells that are laterally attached with distinct junctional complexes. Apical boundaries of the cells have apposed membranes that separate during food ingestion. Cell surfaces of the intestinal epithelium which line the lumen have membrane folds, many of which resemble microvilli; however, they lack central actin filament cores. Sculpturing the surface membrane of the intestinal lumen membrane folds is an enteric coating. The membrane folds are sparse in the intestine of infective juveniles but extensive in parasitic juveniles. The intestino-rectal valve is similar to the structure of the esophageo-intestinal valve in that junctional complexes attach the lateral membranes of the opposing cells that comprise the valve. USDA, Agricultural Research Service, Nematology Laboratory, Beltsville, MD 20705.

FAGBENLE, H. H., and A. B. FILONOW. Endogenous cytokinins in roots of peanuts infected with *Meloidogyne hapla*.

Cytokinins from roots of nine-week-old peanuts (*Arachis hypogaea* L. cv Pronto) inoculated with 4000 *Meloidogyne hapla* eggs at plant were compared with noninoculated roots. Cytokinins extracted in 80% methanol were purified by solvent partitioning and by column chromatography. Samples were treated with β -glucosidase and compared with nontreated samples. Cytokinins were separated by thin-layer chromatography on silica gel in butanol:acetic acid:water (12:3:5 v/v). Samples eluted from thin-layer plates were analyzed by reversed phase HPLC on a column of Hypersil ODS; absorbance was recorded at 265 nm. Differences in profiles of peaks occurred between nematode-inoculated and noninoculated roots. Nematode-inoculated roots contained more of a compound which co-eluted with isopentenyladenine than did noninoculated roots. Compounds which could be hydrolyzed by β -glucosidase were more prevalent in noninoculated roots, suggesting the presence of greater amounts of cytokinin-O-glucosides. Department of Plant Pathology, Oklahoma State University, Stillwater, OK 74078-0285.

FERRIS, V. R., and J. M. FERRIS. Why ecologists need systematists: Importance of systematics to ecological research.

Ecologists are concerned with population dynamics of organisms and with the spacial patterns of single or multiple populations. The goal is usually to explain the observed patterns in terms of processes. Field samples of nematodes from different habitats may contain similar but not identical specimens of a nominal taxon and the systematist can help the ecologist decide whether the specimens are ecophenotypes of a single taxon or represent

distinct species. A correct decision may be important or trivial, depending on the parameters and goals of the study. When a correct decision is crucial, new methodologies of systematists may provide rapid and accurate diagnoses. Systematists can provide additional help in the assignment of taxa to trophic groups. For sorting out host-parasite associations, often a goal in ecological investigations, modern analytical methods of systematists can facilitate the ordering of systematic relationships. Department of Entomology, Purdue University, West Lafayette, IN 47907.

FORGE, T. A., and A. E. MACGUIDWIN. A rapid cold hardening response exhibited by second stage juveniles of *Meloidogyne hapla*.

Freshly hatched second-stage juveniles of *Meloidogyne hapla* suspended in 5% polyethylene glycol (20,000 m.w.) were placed at temperatures ranging from 4 to 24 C for 24, 48, and 96 hours, and then frozen to -4 C for 24 hours (controls were not frozen). After thawing, survival was assessed on the basis of mobility. There was an inverse relationship between the temperature of incubation and percent survival after freezing, for all inoculation times tested. The percent survival for juveniles incubated at 4 C was four times higher than for juveniles incubated at 24 C. Department of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

FORREST, J. M. S., E. W. MILNE, and W. M. ROBERTSON. Studies on the nature of the cuticle surface of the potato cyst nematode *Globodera rostochiensis* Ro1.

Examination of sections through the head region of freshly hatched juveniles of *G. rostochiensis* revealed that regions of the outermost layer of cuticle on the anterior end and the entire length of the guiding sheath had a periodic structure. The periodicity was perpendicular to the surface of the cuticle. Longitudinal sections were also cut through juveniles 5 days after inoculation on resistant and susceptible potatoes. These juveniles had grown but not yet moulted to third stage. Masses of fibrils were associated with the outside surface of the annular rings. These appeared to have been secreted from the basal layer of cuticle. Their function is unknown, but they could be involved in anchorage of the nematode, or perhaps be a response to the defense mechanisms of the plant. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

FORTNUM, B. A., M. J. KASPERBAUER, and P. G. HUNT. Biomass partitioning in tomato plants infected with *Meloidogyne incognita*.

Changes in plant biomass were recorded after tomato plants were inoculated with *Meloidogyne incognita* at an initial population (P_i) of 1, 10, 50, 100, and 200 ($\times 1000$) eggs per plant and maintained in a controlled environment chamber. Total fresh biomass remained constant with nematode P_i as high as 1×10^7 eggs. Reductions in top weights were matched by corresponding increases in root weights. P_i levels above 1×10^4 decreased fresh plant biomass. Total dry biomass declined at P_i above 1×10^4 eggs. The greatest reduction in fresh and dry biomass following nematode inoculation occurred in the stem tissue followed by the petioles. The least weight loss occurred in the leaflets. *M. incognita*-infected plants had thinner leaves (leaf area/leaf weight) than noninfected plants. Reductions in petiole weight, internode length, and leaf area at each node following nematode inoculations occurred uniformly over the height of the plant. Clemson University, Department of Plant Pathology and Physiology, Pee Dee Research and Education Center, and USDA-ARS, Box 271, Florence, SC 29503.

FORTNUM, B. A., and E. J. SADLER. Evidence against root-knot nematode induced moisture stress in flue-cured tobacco.

Root-knot nematodes alter root morphology potentially modifying the capacity of a plant to absorb and translocate water. Leaf temperature is altered by transpiration and reflects the water status of the plant. The effect of root-knot nematodes on leaf temperature in irrigated and nonirrigated microplots was evaluated under field conditions using an Everest Interscience infrared thermometer. Tobacco seedlings were pulled from methyl bromide (MBR) treated beds and transplanted into microplots which had been previously fumigated with MBR and covered with a black plastic tarp. Seedling roots were inoculated with *Meloidogyne incognita* at an initial population of 0, 10, 25, 50, 100 ($\times 1000$) eggs per plant. Leaf temperatures were determined three times daily from 30 to 60 days following inoculation. Leaf temperature minus air temperature (ΔT) was significantly reduced by irrigation over the duration of the study. Root-knot nematode infection did not increase ΔT in moisture stressed or irrigated plants. Root-knot nematode infected plants remained turgid

throughout the study. Clemson University, Department of Plant Pathology and Physiology, Pee Dee Research and Education Center, and USDA-ARS, Box 271, Florence, SC 29501.

FORTUNER, R. Demonstration of computer software NEMAID and NOMEN.

NEMAID is a computerized program for the identification of nematode species. A new, improved version is demonstrated. NOMEN is a database with published information on nematode nomenclature, taxonomy and morphology. Both pieces of software are available on IBM PCs and compatible equipment. California Department of Food and Agriculture, Analysis & Identification, Room 340, 1220 N Street, Sacramento, CA 95814.

FORTUNER, R. Morphological identification of plant-parasitic nematodes.

The conclusions of a NATO Advanced Research Workshop held in Raleigh on June 7-10, 1988, are reported. Over thirty nematode taxonomists and a computer scientist worked together to review the current state of the "LAUREL Project" for the use of artificial intelligence techniques in identification. The participants discussed the process of practical identification; the context of plant nematode identification; the problems attached to identification in specific groups. They also made plans for the continuation of the project with the publication of a manual for graphical characterization of plant-parasitic nematode genera, and the creation of NEMISYS, a nematode identification system. California Department of Food and Agriculture, Analysis & Identification, Room 340, 1220 N Street, Sacramento, CA 95814.

FRANCL, L. J., L. V. MADDEN, R. C. ROWE, and R. M. RIEDEL. Temperature trends correlated with amount of yield reduction caused by *Verticillium dahliae* and *Pratylenchus penetrans*. Yield data of 'Superior' potato from 8 yr of microplot experiments in silt loam with factorial levels of *V. dahliae* (V.d.) and *P. penetrans* (P.p.), causative agents of potato early dying, were regressed on log transformed initial pathogen densities. Residuals (i.e., variation left unexplained by regression model) for controls, V.d., P.p., and V.d. + P.p. were correlated with number of days with average temperature >24 C (NDY) and cumulative degree days (CDD) over various intervals after planting. Significant ($p < 0.05$) negative correlations were found between all treatments and NDY from 50-67 days after planting inclusive and all treatments but P.p. with CDD 53-70 days after planting. Residuals of yields relative to controls for V.d. and V.d. + P.p., but not P.p. alone, were significantly and negatively correlated with CDD 68-85 days after planting. Models usually underpredicted independent yield data from microplots in muck soil but predicted responses to CDD or NDY were accurate. Nematology Lab., USDA, ARS, Beltsville, MD 20705.

FRANSEN, J. C., and L. W. BONE. Prostanoids in *Trichostrongylus colubriformis* and *Turbatrix acetii*.

HPLC was used to demonstrate the presence of prostaglandins A_2 , E_1 , E_2 , 6-keto- F_{1a} and F_{2a} and thromboxane B_2 in extracts from *T. colubriformis*. These same prostanoids plus prostaglandins B_2 and D_2 were recovered from *T. acetii*. There were great variations from extract in the amounts of prostanoids per wet weight of tissue, and some prostanoids were present in one batch of extract, but absent from another. Prostaglandins B_2 , D_2 , 6-keto- F_{1a} and F_{2a} were consistently present in *T. acetii* extracts; prostaglandins 6-keto- F_{1a} and F_{2a} were found in all extracts from *T. colubriformis*. USDA Animal Parasite Research Laboratory, ARS, Box 952, Auburn, AL 36831-0952.

FRECKMAN, D. W., M. A. ACRA, K. R. BARKER, J. D. GOESCHL, and G. M. WANG. Effect of *Meloidogyne javanica* on carbon allocation patterns of *Panicum* grasses.

Carbon allocation was examined in intact plant utilizing the short-lived ^{11}C isotope tracer technique. This technique employs carbon-11 (half life 20.3 min) which approximates photosynthate transport rates and hence allows for real time dynamic measurements. The Serengeti savannah grass *Panicum coloratum* was used in the experiment. Eight plants (4 treatment and 4 control) in split root pots were inoculated on one side of the treatment plants with 200,000 eggs of *Meloidogyne javanica* 37 days before measurements were taken. While ^{11}C transport rate was slower to the *M. javanica* infected roots (1.312 cm/min) than to the *M. javanica* control side of the roots (3.632 cm/min), the export pool was significantly higher. However, there were no significant differences in other C-allocation patterns such as phloem activity, storage rate, or sink activity. The carbon-11 technique has proven to be a valuable method for assessing the effects of host-parasite interactions. Department of Nematology, University of California, Riverside, CA 92521.

GEORGI, L., P. S. ALBERT, and D. L. RIDDLE. Molecular cloning of a gene involved in dauer larva development in *Caenorhabditis elegans*. Juveniles of *Caenorhabditis elegans* may develop into dauer larvae when crowded or starved. Twenty-five genes involved in this developmental pathway have been characterized genetically. To understand the specific functions of these genes, we have begun to clone and characterize some of them on a molecular level. We have isolated mutant alleles of the dauer formation (*daf*) genes in strains where the mobile genetic element Tc1 causes mutations at high frequency. Insertion of Tc1 in a gene causes a mutation that may subsequently revert by excision of the transposon. We have isolated two mutant alleles of *daf-1*. A 2.5 kilobase-pair, Tc1-containing BamHI restriction fragment, is present in both mutants, but absent in three revertants examined. This DNA fragment has been cloned. Sequence analysis of the DNA flanking the Tc1 insert has revealed an open reading frame containing a putative intron of about 50 base pairs. An initial search of the DNA sequence database has not revealed similarities with known genes. The flanking sequences have been used as a probe to screen a *C. elegans* genomic library for clones that contain the entire wild-type gene. Division of Biological Sciences, University of Missouri, Columbia, MO 65211.

GERAERT, E. Evolutionary changes in nematodes.

Some morphological differences have been noticed between particular nematode groups of which representatives are found in South America and Africa. The excellent work of Ferris *et al.* (1976) on leptonchids will be compared with recent work on actinolaims by Vinciguerra (1988) and on *Peltamigratus* by Rashid *et al.* (1987). Laboratorium voor Morfologie en Systematiek der Dieren, Ledeganckstraat 35, Gent, Belgium.

GIBLIN-DAVIS, R. M., S. W. T. BATRA, and B. B. NORDEN. A *Koerneria* sp. (Diplogasterida: Diplogasteridae) associated in the abdominal glands of the bee, *Andrena allegheniensis*. Adult females of *Andrena allegheniensis* were collected from Saranac Lake, New York in May 1986 and June 1987. Bees were dissected and examined internally for nematodes. Eighty-one percent of the bees from 1986 (n=31) and 55% of the bees from 1987 (n=11) had abdominal glands which were infested with dauer juveniles of a diplogasterid nematode. Each infested bee had an average of 22±25 dauers (range=1-93) for 1986 and 12±19 (range=1-50) for 1987. Seventy-one and 42% of the 6 abdominal glands per infested bee contained dauers and each infested gland contained a mean of 6±6 (range=1-28) and 5±6 (range=1-21) for 1986 and 1987, respectively. Dauer juveniles from the abdominal glands were successfully established in xenic culture on nutrient agar and adults appear to be a newly discovered species of *Koerneria*. IFAS, University of Florida, 3205 College Avenue, Ft. Lauderdale, FL 33314.

GIBLIN-DAVIS, R. M., L. MCDANIEL, and F. BILZ. Survey for the occurrence of different *Pasteuria penetrans* isolates on nematodes in bermudagrass fairways in South Florida. Bermudagrass fairways in South Florida were sampled monthly for 16 months for seasonal changes in phytoparasitic nematode densities, grass performance, and encumbrance by *Pasteuria penetrans*. Significantly different sized spore isolates of *P. penetrans* (P<0.001) were associated with different species of nematodes. Sporangium and endospore diameter means and standard deviations were 7.26±0.36 and 3.54±0.24 (n=80) and 4.03±0.34 and 2.13±0.17 (n=42) for two co-occurring isolates on *Hoplolaimus galeatus*, 6.18±0.35 and 2.97±0.23 (n=308) for *Belonolaimus longicaudatus*, and 4.55±0.33 and 2.53±0.17 (n=41) for *Tylenchorhynchus* sp., respectively. Sporangium and endospore diameter differences were statistically consistent for different sites and sampling times. Spore filled specimens were rare. IFAS, University of Florida, 3205 College Avenue, Ft. Lauderdale, FL 33314.

GOURD, T. R., and D. P. SCHMITT. Penetration of second-stage juveniles of *Meloidogyne* spp. and *Heterodera glycines* in aldicarb, ethoprop, and fenamiphos treated soil. Sensitivity of *Meloidogyne arenaria*, *M. hapla*, *M. incognita*, *M. javanica* and *Heterodera glycines* races 1 and 5 to aldicarb, ethoprop, and fenamiphos was tested in the greenhouse. Treatments of 1, 2, and 4 ppm aldicarb, 1, 4, and 8 ppm ethoprop, and 1, 4, and 8 ppm fenamiphos were applied as a drench to soil in 413 cm³ Styrofoam cups. Juveniles in the roots were counted at two days after treatment. *Meloidogyne hapla* and *H. glycines* race 1 were most tolerant to aldicarb and ethoprop, respectively. *Meloidogyne incognita* was the most sensitive to all chemicals tested. All nematodes tested were most sensitive to aldicarb, followed by fenamiphos, and then ethoprop. Department of Plant Pathology, North

Carolina State University, Raleigh, NC 27695.

GRIFFIN, G. D. Effect of nematicidal activity and plant growth on seasonal population trends of *Heterodera schachtii* on sugarbeet.

Population dynamics of *Heterodera schachtii* on sugarbeet was affected by differences in 1,3-dichloropropene (1,3-D) and aldicarb control, and plant growth. The 1,3-D, at 168 kg/ha, reduced nematode Pi of 344, 766, and 1126 eggs and J2/100 cm³ soil by 90, 92, and 93%. There were 1, 3, and 3%, and 6, 6, and 7% of the Pi recovered from the 1,3-D treated plots, 5 and 15 cm from the center of the row, 28 days after planting. This compared to 31, 34, and 36%, and 52, 53, and 56% for aldicarb (5.6 kg a.i./ha), and 34, 37, and 38%, and 66, 67, and 69% for nontreated plots. Nematode population densities were significantly less in the 1,3-D treated than in the aldicarb treated plots until after 3 nematode generations (1212 degree-days). The greatest sugarbeet yield and nematode Pf₃ after 1364 degree-days were recovered from 1,3-D plots at a Pi of 344 eggs and J2/100 cm³ soil. The lowest sugarbeet yield and Pf were recovered from nontreated control plots at a Pi of 1126 eggs and J2/100 cm³ soil. USDA-ARS, Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300.

GRIFFIN, G. D., K. H. ASAY, D. L. CREBS, and W. H. HORTON. Population trends of plant parasitic nematodes on crested wheatgrass.

Soil moisture affected the population dynamics of *Xiphinema americanum* and *Quinisulcius acutoides*, on crested wheatgrasses 'Fairway' (*Agropyron desertorum* X *A. cristatum*), 'Rosana' (*Pascopyrum smithii*), 'OAHE' (*Thinopyrum intermedium*), and 'RSI' (*Elytrigia repens* X *E. spicata*), over a three year field study (1984-86). High soil moisture resulted in maximum population density peaks of *X. americanum* and *Q. acutoides* in the spring and fall of 1984, while low soil moisture resulted in reduced population densities of the two nematode species in 1985 and 1986. *Pratylenchus neglectus* was affected less by soil moisture, but population densities were significantly less in 1985 and 1986 than in 1984. Nematode populations differed between wheatgrasses. Maximum population densities of *Q. acutoides* and *P. neglectus* were observed on 'RSI,' and *X. americanum* on 'Fairway.' USDA-ARS, Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300.

HAFEZ, S. L., K. W. DORSCHNER, and K. HARA. The effect of *Heterodera humuli* Filipjev on hops, *Humulus lupulus* cv. Cascade.

The pathogenic effect and economic damage of the hop cyst nematode *Heterodera humuli* is not well documented. The objective of this study is to determine the effect of hop cyst nematode infection on hop plant growth and productivity. Cascade has been grown in Idaho since early 1970's, and cyst nematode populations were usually higher where this cultivar was grown. We observed that where aldicarb was used experimentally for insect control the hop yields were significantly increased only where Cascade was grown. In this experiment 40 rooted hop plants were transplanted singly into an autoclaved mixture of soil and sand (1:2) in 15-cm-d clay pots. Half of these plants were inoculated with 24,000 eggs/plant and the other half were noninoculated for comparison. Shoot heights, fresh and dry weight were measured 48, 114, and 164 days after inoculation. Hop cyst nematode significantly reduced plant height, shoot fresh and dry weight. Infected plants showed more severe nutrient deficiency symptoms and 20% of the inoculated plants died 146 days after inoculation. Department of Plant, Soil, and Entomological Science, University of Idaho, Parma, ID.

HAJDUKIEWICZ, P. T., and R. F. MYERS. Reciprocal interbreeding of selected isolates of *Bursaphelenchus xylophilus* and *B. mucronatus*.

Bursaphelenchus xylophilus obtained from France (F-1), the United States (US-1), Canada (C-2), and Japan (J-2) and *B. mucronatus* from Japan (J-14) were cultured on nonsporulating *Botrytis cinerea* growing on potato dextrose agar. Segregated larvae were individually reared to adults and the sexes reciprocally paired to determine if viable progeny were produced. Reciprocal intrabreeding of nematodes resulted in high frequencies of sexual encounters among nematodes accompanied by high rates of reproduction. Reciprocal crosses of F-1 collected from *Pinus pinaster* with US-1, J-2, C-2, and J-14 resulted in a reduced number of progeny after 2 weeks. In addition, *B. mucronatus* (J-14) interbred with C-2 from *Abies balsamea* produced many offspring as did crosses of C-2 with either US-1 or J-2. An occasional reciprocal cross of *B. xylophilus* (US-1 or J-2) with *B. mucronatus* produced progeny. Reciprocal crosses of males and females of specific isolates did not always

produce equal numbers of offspring. Department of Plant Pathology, Rutgers University, Cook College, New Brunswick, NJ 08903.

HALBRENDT, J. M. Developmental patterns of Heterodera glycines selected on soybean PI 209332.

Heterodera glycines populations developed from single females on soybean PI 209332 were examined for developmental patterns in 'Essex,' 'Pickett 71,' and PI 209332. Seedlings (roots ca. 5 cm) were infected during a 12-hr exposure to infested sand (500 eggs/cm³), then washed, and transferred to hydroponics. Cotyledons were cut to ca 0.25 cm and new growth was kept pruned to 1 cm above the cotyledonary node. After 20 days at 27 C all nematodes were counted; data on immature stages were obtained from stained and cleared roots. The number of adults from Pickett 71 was lower than from Essex or PI 209332 although male/female ratios were 1:1 in all combinations. Chi-square analysis showed that developmental patterns were the same in Essex and PI 209332 and that the difference in Pickett 71 was due primarily to a larger number of undeveloped second stage juveniles. Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.

HARRIS, A. R., and H. FERRIS. Interaction of Meloidogyne spp. and Fusarium oxysporum on cowpea (Vigna unguiculata).

Methods were developed for inoculating cowpeas with F. oxysporum f. sp. tracheiphilum (Fot) chlamydospores with minimal root disturbance. Increasing initial populations of M. javanica on the wilt-resistant cowpea 'California Blackeye No. 3' (CB3) increased Fusarium wilt. In one experiment, 1000 Meloidogyne eggs were added to CB3 just after sowing. The galled seedlings were transplanted into sand infested with Fot [20,000 colony forming units (CFU)/cm³] 23 to 25 days later. M. javanica from two greenhouse cultures reduced resistance to Fot race 3. Three populations of M. incognita did not significantly increase wilt compared to controls which received Fot but no Meloidogyne. In another experiment, 1000 M. javanica J2 were injected near CB3 roots either at sowing or after 2, 4, or 6 weeks. Fot chlamydospores were injected into the soil (20,000 CFU/cm³) of all treatments 6 weeks after sowing. Plants to which nematodes were added 4 weeks before Fot had the highest wilt rating. Nematode treatments had more wilt than controls with no nematodes, whether or not roots were cut immediately before Fot injection. Department of Nematology, University of California, Davis, CA 95616.

HARTMAN, K. M. and K. R. BARKER. Temporal and spatial patterns of Sphaeronema sasserii and Pratylenchus macrostylus in spruce-fir ecosystems, Black Mountains, NC.

Plots in mixed Fraser fir and red spruce stands at three elevation ranges in the Black Mountains, NC were sampled for Sphaeronema sasserii and Pratylenchus macrostylus from May 26 through October 20, 1987. Feeder-root biomass and overstory-crown condition also were assessed. Greatest feeder-root biomass occurred during May, July, and October. Highest total numbers of S. sasserii and P. macrostylus were detected in July and October, and were primarily on moderate-to severe-decline trees at higher elevations (<2,000 M). The fewest of both nematode species were extracted from healthy trees at low elevation (1,880 M). Combined feeder-root biomass and nematode levels were greater in the A vs. the O horizon. In some instances, feeder-root biomass and crown health were inversely correlated with nematode numbers, with R² ranges (P=0.05) of -0.16 to -0.45 and -0.12 to -0.67, respectively. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

HERMAN, M., R. S. HUSSEY, and H. R. BOERMA. Interactions between Meloidogyne incognita and Pratylenchus brachyurus on soybean.

Interactions among Meloidogyne incognita (Mi), Pratylenchus brachyurus (Pb), and soybean genotype on plant growth and nematode reproduction were studied in a greenhouse. 'Coker 317' (susceptible to both) and 'Gordon' (Mi resistant, Pb susceptible) were inoculated with increasing inoculum levels of both nematodes singly and combined. Mi and Pb suppressed shoot growth of both cultivars, but only root growth on Coker 317 was influenced by a Mi X Pb interaction. Mi and Pb reproduction was mutually suppressed on Coker 317. Pb reproduced better on Gordon than on Coker 317 but did not affect the resistance of Gordon to Mi. Split root systems of Coker 317 were inoculated singly or combined with Mi and Pb. Mi suppressed reproduction of Pb either when co-inhabiting a half-root system or infecting opposing half-root systems; however, Pb affected Mi only if both nematodes infected the same half-root system. In penetration studies, more Mi penetrated Coker 317 roots than

Gordon roots whereas Pb more readily penetrated Gordon roots. In dually inoculated plants, 40% fewer Pb were present in Coker 317 roots only at 16 days after inoculation than in roots of singly infected plants. Departments of Plant Pathology and Agronomy, University of Georgia, Athens, GA 30602.

HEWLETT, T. E., and D. W. DICKSON. Control of Meloidogyne arenaria on peanut using fumigant and nonfumigant nematicides.

Three separate tests evaluating fumigant and nonfumigant nematicides were conducted to determine their efficacy in the control of Meloidogyne arenaria on 'Florunner' peanut (Arachis hypogaea). Methyl bromide, 1,3-D, methyl isothiocyanate, and methyl isothiocyanate mixtures were applied 7 days preplant either broadcast or in-the-row. Aldicarb, fenamiphos, ethoprop, and F5145 (FMC Corp., Philadelphia, PA) were applied at different rates and by different methods of application at-plant or at early bloom. Of the 32 treatments evaluated in the three tests only seven treatments resulted in significant yield increases ($P=0.05$). Visual growth differences between treated and untreated plots from early season to past midseason indicated excellent nematode control in most treated plots. During the latter one-third of the growing season, however, the nematode control apparently broke down in most treatments resulting in heavy peg and pod infection by M. arenaria. Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.

HEYNS, J., ANTOINETTE SWART, and E. CHAVES. A SEM study of Xiphidorus balcarceanus Chaves & Coomans.

SEM micrographs are presented showing mouth opening, labial and cephalic papillae, amphid aperture, vulva, anus and caudal pores of adult female. Odontostyle base of all stages from J1 to adult and junction between odontostyle and odontophore and flanged base of odontophore are shown. Although labial and cephalic papillae, junction between odontostyle and odontophore and basal flanges are all similar to those commonly found in Xiphinema, the amphid aperture is pore-like as in Longidorus. Department of Zoology, Rand Afrikaans University, P.O. Box 524, Johannesburg, 2000, South Africa.

HOOPER, D.J. Dimorphic females in Hexatyclus.

Hexatyclus specimens from Rothamsted soil readily reproduce on agar plate cultures of Botrytis cinerea. Reproduction seems to be parthenogenetic, cultures are readily obtained from individual juveniles and the females produced lack sperm; they have the characteristic short stylet with bifid basal knobs. However, in aging fungal cultures occasional males and ensheathed preadult females occur; the latter have a longer, stouter, stylet with asymmetrical basal thickenings and a different oesophageal morphology, and the reproductive tract is not fully developed but contains sperm presumably from the accompanying males. These females do not reproduce on fungi. They have a superficial resemblance to infective females of Tripius sciarae but the stylet has conspicuous basal thickenings. They probably represent the infective stage of an insect parasitic nematode, possibly with a life history similar to Deladenus spp. Entomology & Nematology Department, Rothamsted Experimental Station, Harpenden, Herts AL5 2JQ, England.

HOOPER, D. J., and J. A. COWLAND. Courgette marrows (squash) for the mass culture of some nematodes.

Large numbers of Ditylenchus dipsaci (oat and giant races) and Aphelenchoides ritzemabosi reproduce in the fruit (courgettes) of courgette marrow (Cucurbita pepo cv. Zucchini, Green Bush). Healthy, turgid, fresh courgettes should be of a moderate to large size (20 cm long, 5 cm diameter). Clean, active nematodes for inoculation were suspended in a solution of 0.1% aretan and 0.1% streptomycin sulphate for 20 min, concentrated by centrifugation, the sterilant removed, and resuspended in sterile water. Two to four inoculations (ca. 1000 nematodes in 0.5 ml) are made into the central axis of each courgette using a 1-ml hypodermic syringe with a coarse needle. Courgettes are then stored, unwrapped, for 6-10 wk at 16-18 C and, although they may shrivel, the tissue becomes very heavily infested yielding 18000 to 25000 nematodes per g. Nematodes are recovered from infested tissue by blending, sieving, and filtering. Entomology & Nematology Department, Rothamsted Experimental Station, Harpenden, Herts AL5 2JQ, England.

HUAN, J., G. S. SANTO, and H. MOJTAREDI. Effect of Pratylenchus penetrans, Erwinia carotovora subsp. carotovora and Verticillium dahliae on potato yield in microplots.

The effects of Pratylenchus penetrans (PP), Erwinia carotovora subsp. carotovora (ECC) and

Verticillium dahliae (VD) alone and in all combinations on yield of 'Russet Burbank' potato were studied in field microplots. The PP (0 and 500/250 cm²), ECC (0, 1 X 10⁵, and 1 X 10⁸ cfu/ml) and VD (0, 5, and 25 microsclerotia/g of dry soil) levels were arranged in a factorial design with five replications. PP and VD were mixed in the top 15 cm of each bucket containing methyl-bromide fumigated sandy loam soil prior to planting potato seed-pieces. ECC inoculations were made 30 days after planting by drenching in a 1-liter suspension. All three organisms together in all combinations, and VD5+ECC10⁵ and VD25-ECC10⁵ reduced (P=0.05) tuber weight compared to the noninoculated. Pooled data showed that PP+VD+ECC reduced (P=0.05) tuber weight compared to VD+ECC, PP+ECC and PP+VD. However, a positive interaction in terms of tuber weight was only observed when VD and ECC occurred together. Washington State University, IAREC, Prosser, WA 99350.

HUAN, J., W. Z. RONG, and G. R. SHENTU. Biological study of cotton disease caused by *Meloidogyne incognita* in Zhejiang Province China.

The cotton disease caused by *Meloidogyne* spp. is rarely reported in China. During 1982-84 the root-knot nematode disease which occurred in a cotton field in the Jin Hua area, Zhejiang Province, was investigated and the biology of the pathogen was studied in the greenhouse and field. The investigation identified the root-knot nematode disease of cotton in the Jin Qu Basin, 6 counties, and Xias Shan County in Zhejiang Province as *Meloidogyne incognita*, race 4. *M. incognita*, race 4 can complete 5 generations in one year and attack root systems of cotton from the first ten days of April to the last ten days of October in Jin Hua County. One generation of *M. incognita* takes 25-30 days under natural field conditions. The main factor affecting the course of nematode development is temperature. In the sandy loam soil, the population density of juveniles is very great, causing serious damage on the cotton seedlings. Department of Plant Protection, Zhejiang Agricultural University, Hangzhou, Zhejiang, People's Republic of China.

HUETTEL, R. N., H. JAFFE, and A. DE MILO. In vitro screening of analogs of a sex attractant of soybean cyst nematode.

Three concentrations (10 mM, 5 mM and 10 μM) of 29 analogs of the soybean cyst nematode sex attractant were tested in vitro to determine phytotoxicity to root-explants of *Glycine max* cv. Kent. Root-explants (replicated 5x) were grown on Gamborgs B-5 medium +/- analogs. After three weeks, roots were removed from agar plates by microwaving for 20 seconds to allow for complete removal of the entire root system. Wet and dry root weights were then determined. Fifteen compounds were phytotoxic at 10 mM while three were phytotoxic at all levels. One compound caused callus formation of roots. At all concentrations, 20 analogs showed no reduction in root growth when compared to controls. This technique may provide a preliminary screen for phytotoxic effects of compounds that could be used as bioregulators for plant parasitic nematodes. Nematology Laboratory, USDA, ARS, Beltsville, MD 20705.

HUSSEY, R. S. Production of monoclonal antibodies specific for secretory granules formed in esophageal glands of *Meloidogyne* species.

Production of monoclonal antibodies to secretory components synthesized in esophageal glands is the most promising approach for characterizing disease-inducing secretions of plant-parasitic nematodes. Mice (BALB/c) were injected with immunogens from parasitic second-stage juveniles of *Meloidogyne incognita*. Hybridomas producing antibodies to secretory granules were selected by immunofluorescence microscopy of paraformaldehyde fixed sections of second-stage juveniles. Monoclonal antibodies were produced that reacted specifically with secretory granules formed in the subventral glands or the dorsal gland of second-stage juveniles. Only antibodies specific for granules in the dorsal gland reacted with the esophageal gland lobe of adult females of *M. incognita*. The antibodies also reacted with granules in both types of esophageal glands in second-stage juveniles of *M. javanica* and *M. arenaria* but not with granules in the glands of second-stage juveniles of *Heterodera glycines*. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

HUSSEY, R. S., and P. JANSMA. Immunogold localization of collagen in the cuticle of different life stages of *Meloidogyne incognita*.

Rabbit polyclonal antiserum was prepared against the major collagen present in cuticles of adult females of *Meloidogyne incognita*. The distribution of this collagen in the cuticle of preparasitic second-stage juveniles, parasitic (6 days after root penetration) second-stage juveniles, adult males, adult females, and the chitin layer of egg shells was

determined by immunogold labeling. This collagen was evenly distributed throughout the cuticle of adult females and parasitic second-stage juveniles, but was present only in the cortical and medium zones of preparasitic second-stage juveniles and adult males. The cuticle of second-stage juveniles changed morphologically with the onset of parasitism. The striated basal and medium zones disappeared and the cuticle became homogenous in appearance, similar to the cuticle of adult females. Colloidal gold also bound to the chitin layer of the egg shell indicating the presence of this collagen in the egg shell. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

HYMAN, B. C., K. C. WEISS, and J. L. BECK. Sequence analysis of gene rearrangement within the *Romanomermis culicivorax* mitochondrial genome.

Romanomermis culicivorax, an obligate mosquito parasite, possesses unusually large mitochondrial genomes of 25-30 kilobase pairs. A specific region of the mitochondrial DNA encompassing approximately 3000 base pairs has been differentially amplified within each mitochondrial genome. This accounts for the unexpectedly large size of these DNAs as well as their length polymorphisms (J. L. Beck and B. C. Hyman, abstracts of this meeting). Copies of this reiterated DNA are present as tandem, direct repeats and unlinked inverted copies within the mitochondrial DNA. To determine the genetic content of the repeated DNA and the precise endpoints delimiting the amplified region, nucleotide sequencing studies have been initiated. We shall report on the DNA sequence of the repeating unit and suggest possible mechanisms as to the amplification and dispersal of this interesting locus within the nematode mitochondrial genome. Department of Biology, University of California, Riverside, CA 92521.

INGHAM, R. E. Demonstration of nematode ecology literature data bases.

Literature on nematode ecology is published in a diverse array of sources throughout the world. With current on-line computer-based literature search systems, complete compilations of references in nematode ecology are difficult to retrieve without using numerous keywords or obtaining many irrelevant citations. Depending upon the system available to the individual, exhaustive searches on a wide range of ecological topics can be expensive. In 1983, the Ecology Committee for the Society of Nematologists published a bibliography of nematode ecology containing 1758 citations from 11 different subject areas. A second volume of the bibliography has now been completed and contains nearly 1800 additional references covering 20 topics. The new volume is also for microcomputers. This data base can be rapidly searched for titles of interest at virtually no cost. Details can be obtained by contacting Russell E. Ingham at the address below. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97311.

INGHAM, R. E., J. I. ORLOWSKY, and M. L. POWELSON. Influence of moisture addition on population development and potato tuber infection by *Meloidogyne chitwoodi*.

Field microplots were infested with 0, 0.001, 0.01, 0.1 or 1 *Meloidogyne chitwoodi* egg/g soil at planting and placed at each of four distances from a fixed line irrigation source. Microplots at increasing distance from the line source received 50, 42, 25 or 18 cm water and were ranked as very wet, wet, medium or dry, respectively. Densities of J2 in soil at harvest were greater in the drier treatments but were generally not different between inoculum levels within a moisture regime. Percent tuber infection for the four inoculum levels, averaged over all moisture regimes, averaged 19, 25, 66, and 78% and infection intensity, based on a scale of 0-6, averaged 0.4, 0.6, 2.1, and 3.7. Tuber infection was greatest in the driest treatments. Percent infection and intensity averaged over all inoculum levels were 66% and 2.8 in the dry treatment and 35% and 1.0 in the very wet treatment. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331.

JAFFEE, B. A., and T. M. MCINNIS. Importance of the phialide in inoculation of nematodes with spores of the nematophagous fungus *Hirsutiella rhossiliensis*.

Spores of *Hirsutiella rhossiliensis* adhere to passing nematodes. Spores are produced on flask-shaped phialides, and we hypothesize that spores detached from phialides cannot adhere to nematodes. Soil naturally infested with *H. rhossiliensis* was mixed, placed in vials (27 cm³), and periodically infested with an assay nematode, *Heterorhabditis heliothidis*. After 18 h, the *H. heliothidis* were recovered, and the percentage with adhering *H. rhossiliensis* spores was determined. The percentage of *H. heliothidis* with spores was always 0 in freshly mixed soil, but increased to 11% and 18% in soil incubated

undisturbed for 1 wk and 2 wks, respectively. Because soil disturbance removes spores from phialides and undisturbed incubation permits new spores on phialides to develop, the results indicate that spores must be on phialides to adhere to nematodes. Consequently, use of *H. rhossiliensis* spores as soil inoculum will probably be unsuccessful. Department of Nematology, University of California, Davis, CA 95616.

JENSEN, PREBEN. Tube-construction and its consequences for the sediment-water interface. The nematode *Ptycholaimellus ponticus* (Filipjev, 1922) occurs in European estuaries where it is the most dominant species in muddy sediments with abundances up to 400 individuals per cm³ down to about 1 cm depth. A 5 min. video sequence shows that a so-called "Interstitial nematode" (P.p., 0.8 mm long and 0.05 mm thick) in fact builds its own tube. The tube is sinusoid, about 7 mm long with an internal diameter of 0.07 mm, and is situated ventrally in the sediment with the opening at level of the sediment-water interface. The tube consists of fine detritus which is caught from the surroundings by mucus released through a pore opening near the lips. The mucus is produced by a large ventral gland cell situated behind the oesophagus. It takes about 3 hours to build such a tube under artificial laboratory conditions. The tube secures its living and may stabilize resuspension of detritus in an otherwise unstable estuarine environment. The tubes may expand the oxygenated sediment-water interface by a factor of 5, hence partially explaining the rate of mineralization of organic matter in the sediment. Sonderforschungsbereich 313 der Universität Kiel, Olshausenstrasse, D-2300 Kiel, Federal Republic of Germany.

JOHNSON, A. W., C. C. DOWLER, N. C. GLAZE, D. R. SUMNER, R. B. CHALFANT, A. M. GOLDEN, and J. E. EPPERSON. Effect of intensive cropping systems on population densities of *Meloidogyne* spp.

The effect of intensive cropping systems including sweet corn (SC)-soybean (SB)-wheat(W)-SB-spinach(S); turnip(T)-peanut(P)-cucumber(CU)-T-CU-SB; and T-field corn(FC)-southern pea(SP) on population densities of *Meloidogyne* spp. were studied for 6 years on a Tifton loamy sand. Numbers of root-knot nematode juveniles were lowest in the SC-SB-W-SB-S cropping system, intermediate in the T-P-CU-T-CU-SB system, and highest in the T-FC-SP system. Root-knot nematodes increased more on soybean than on other crops in the SC-SB-W-SB-S system. Generally, numbers of nematodes were highest on peanut in August or September, but declined on cucumber following turnip. Numbers of *M. incognita* increased on corn in August and Pinkeye Purple Hull southern pea in October or November in the T-FC-SP system. Turnip, wheat, sweet corn, and spinach were poor hosts for *M. incognita* and *M. hapla*. USDA ARS, Coastal Plain Experiment Station, Tifton, GA 31793.

KALINSKI, A., and R. N. HUETTEL. Use of DNA restriction fragment length polymorphism in detection of races of the soybean cyst nematode.

The nematode genome was analyzed by using restriction enzyme digestion of DNA from races 3, 4, and 5 of the soybean cyst nematode, *H. glycines*. Cellular DNA was purified from 10-12 day old virgin females isolated from established root-explant culture plates. DNA fragment patterns of race 4 generated by all eight tested enzymes (Ava I, Bcl I, Cfo I, Hha I, Hpa II, Msp I, Tag I) were different from those patterns obtained for races 3 and 5. The Msp I and Hpa II digestion profiles of DNA from races 3 and 5 differed in long and short respective fragments. The rapid method of nematode DNA isolation following its digestion with either Msp I or Hpa II enzymes and ethidium bromide visualization of DNA fragments in agarose gels is useful in discrimination of races 3, 4, and 5 of *H. glycines*. The nematode repetitive DNA fragment length polymorphism allows for construction of a library of nematode repetitive probes thus providing a molecular base in studies of genetic variability of *H. glycines* races. USDA, ARS, Nematology Laboratory BARC-West, Beltsville, MD 20705.

KALOSHIAN, I., P. A. ROBERTS, and I. J. THOMASON. Inheritance of *Meloidogyne javanica* resistance in *Aegilops squarrosa* L.

The inheritance of resistance in *Ae. squarrosa* to *M. javanica* was studied. F₁ and F₂ generations were produced by crossing 2 accessions of *Ae. squarrosa*, G 3489 and G1279, used as resistant and susceptible parents, respectively. Parental plants, F₁ and F₂ were tested for reaction to *M. javanica*. Fifteen day-old seedlings, in 500 cm³ sandy soil, were inoculated with 5000 eggs and maintained at 23-26 C soil temperature for 70 days. Plants were evaluated on the basis of egg count per g of fresh root. All tested F₁ plants were resistant to the nematode and a segregation of 3:1 resistant to susceptible was observed in

the F₂ generation. This indicated a single dominant gene determining resistance to M. javanica. Similar tests were conducted with M. incognita. Department of Nematology, University of California, Riverside, CA 92521.

KAPLAN, D. T. Improvement of excised carrot disk culture technique.

Nematodes have been cultured for research purposes on surface sterilized excised carrot disks for several years. As previously described, the technique provides a means to produce large numbers of nematodes, but it is inefficient because only nematodes which migrate out of carrot disks are collected. Furthermore, only late life cycle stages and/or adults migrated from disks so that early life cycle stages were not collected in quantity. Approximately 50% of the population within a culture tube was discarded. Our laboratory routinely cultures several populations of Radopholus citrophilus, R. similis and Pratylenchus coffeae on excised carrot disks. Use of tissue macerating enzymes and/or appropriate buffers in nematode extraction from carrot disk has improved culture efficiency. Furthermore, large quantities of eggs and juvenile life cycle stages may now be collected from cultures. United States Horticultural Research Laboratory, U.S. Department of Agriculture, ARS, 2120 Camden Road, Orlando, FL 32803.

KHAN, MUJEEBUR RAHMAN, and M. WAJID KHAN. Development of Meloidogyne incognita race 1 and growth of okra under ambient air pollution stress.

The impact of air pollutants from a coal-powered generator on development of M. incognita race 1 on okra and plant growth was studied. Concentrations of SO₂ and NO₂ were greater at 2 km than at 1 km but particulate pollutants per cm² leaf area were greater at 1 km than 2 km. Pollutants caused marginal and interveinal chlorosis on okra leaves with or without nematodes. Pollutants and nematodes equally reduced plant growth and biomass. Greater reduction occurred in pollution stressed plants inoculated with the nematode (2000 J2/plant). There was 19%, 47%, 59% and 50% more reduction at 1 km and 48%, 70%, 82% and 83% more reduction at 2 km in pod length, fresh weight and dry weights of okra and number of fruits, respectively in nematode inoculated plants in comparison to nematode-inoculated ones grown 15 km away from the power plant. In the same set of treatments, 10% and 52% reduction in leaf chlorophyll content was also recorded. No difference in root galling on okra was observed, however, egg mass production was greater at 2 km than at 1 km. Plant Pathology and Plant Nematology Laboratories, Department of Botany, Aligarh Muslim University, Aligarh - 202002, INDIA.

KIM, D. G., K. S. KIM, and R. D. RIGGS. Ultrastructure of soybean-cyst nematode, Heterodera glycines parasitized by a fungus strain.

Ultrastructure of Heterodera glycines cysts, eggs and juveniles parasitized by an isolate of an unidentified fungus was studied using transmission (TEM) and scanning (SEM) electron microscopy. In TEM, sections of infected cysts had abundant hyphae inside eggs and in unhatched juveniles. The cuticles of cysts, egg shells and juveniles were penetrated directly by hyphae. Internal hyphae often reemerged through the cuticle. The electron-dense substance evident at the site of hyphal penetration of the cyst cuticle was suggestive of localized enzymatic dissolution of the cutin layer. In SEM, the surface of infected eggs undulated greatly, creating a large number of furrows suggesting the entire contents of invaded eggs were replaced with mycelium. Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

KING, P. S., R. RODRIGUEZ-KABANA, D. G. ROBERTSON, and H. IVEY. Field study on cotton, peanut, and crops uncommon to Alabama and root-knot nematode.

The effect of 'Florunner' peanut (Arachis hypogaea L.), 'Deltapine 90' cotton (Gossypium hirsutum) and several crops not commonly grown in Alabama on soil populations of juveniles of Meloidogyne arenaria (Neal) Chitwood was studied in a peanut field near Headland, Alabama. Juvenile populations of the nematode determined at peanut harvest time were nil in plots with castor bean (Ricinus communis L.), cotton, joint vetch (Aeschynomene indica L.), partridge pea (Cassia fasciculata Michx.), and sesame (Sesamum indicum L.). Average juvenile population density in peanut plots was 120 juveniles per 100 cm³ soil. The use of aldicarb (12 kg a.i./ha broadcast equivalent) in peanut resulted in a population density of 27 juveniles/100 cm³ soil. Results showed that several crops were as effective as the aldicarb treatment for reducing soil juvenile populations of the nematode. Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, Auburn, AL 36849.

KO, M. P., and E. LODER. Culturing of plant parasitic nematodes and plant tissues in Pluronic polyol media.

Culture media incorporated in polyol Pluronic F127 were used to culture selected plant tissues and plant parasitic nematodes. Root explants or callus tissues of cucumber, cabbage, and alfalfa were grown in Gamborg's B-5 or White's media and inoculated with Meloidogyne incognita, Heterodera schachtii, and Pratylenchus penetrans, respectively. Only Pratylenchus penetrans in alfalfa callus was found to be maintained better in the polyol medium than in the agar medium. Rate of increase of P. penetrans in the former medium was much sharper and persisted longer, even after 5 months. Infectivity and female/male ratio of P. penetrans in the polyol media were similar to those in the agar media during the same period. Efficiencies of recovery of the nematodes from both media were similar. However, extraction from the polyol media was easier, quicker and cleaner. Department of Plant Pathology, Cornell University, Ithaca, NY 14853.

KOENNING, S. R., and K. R. BARKER. Effects of variable moisture stress on Meloidogyne incognita and soybean yield.

A microplot study focused on potential effects of moisture stress imposed at different phenological stages on Meloidogyne incognita (MI) and soybean yields. Nematode treatments were 0 or 5000 eggs/500 cm² soil. Plots were covered with plastic shields to deflect rain. Moisture treatments included full-season irrigation (twice weekly), no irrigation, and switching from irrigation to no irrigation and vice-versa at "R3" or "R5." Both low moisture and MI suppressed soybean yield (P=0.05). Highest soybean yield developed with season-long irrigation in the absence of MI. Yields were not affected by discontinuing irrigation after R3. High moisture treatments resulted in greatest (P=0.05) MI population densities at midseason. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

KOMM, D. A., P. J. DUDASH, and K. R. BARKER. Incidence and chemical control of Meloidogyne incognita on asparagus in North Carolina.

Root-knot nematodes were found in established commercial fields of asparagus in North Carolina. Meloidogyne incognita (MI) reproduced readily and induced small galls and typical giant cells in the feeder roots of 3- to 5-year-old asparagus plants. Plots in a MI-infested field of 5-year-old asparagus 'Martha Washington Princeville' were treated with fenamiphos at 0, 4.5, and 6.7 kg a.i./ha. Mid-season egg numbers in the control plots were up to 2800/500 cm² of soil. Reproductive factors (number of eggs and juveniles/initial numbers) at 10 weeks after treatment were 0.9 for 6.7 kg, 1.5 for 4.5 kg, and 3.8 for the control. The damage potential of MI on asparagus remains to be determined. Mobay Corporation, 8313 Bells Lake Rd., Apex, NC, 27502; Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

KOTCON, JAMES B. Influence of drip irrigation and fenamiphos on population dynamics of Pratylenchus, Xiphinema and Mononchus spp. on peach.

Population densities (pd) of plant parasitic and predaceous nematodes were monitored in a newly planted peach orchard. Two drip emitters applied 30 liters of irrigation water per tree daily from 5 June to 10 September. Fenamiphos at 20 kg a.i./ha was applied by three methods: a broadcast application applied in a 2-m band over the row, a drip application on 5 June, and a drip application applied at 10 kg/ha on 5 June and 25 September. Controls received water only. Soil samples were collected from irrigated and nonwetted regions of the root zone on 4 June, 15 July, 24 September, and 20 November. Irrigation alone reduced pd of Pratylenchus and Xiphinema by 56 and 58% on 15 July, and by 19 and 52% on 25 September, respectively, but had no effect on 20 November. Fenamiphos applied broadcast reduced pd of Pratylenchus and Xiphinema in both wetted and nonwetted soil, but only in wetted soil when applied via drip irrigation. Fenamiphos applications reduced pd of Mononchus papillatus by up to 50%. Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506.

LAIRO, D. W., J. -S. HUANG, and K. R. BARKER. Iron uptake and partitioning in Heterodera glycines-infected soybean.

The potential role of iron uptake in soybean cyst nematode-induced suppression of nodulation of soybean was studied utilizing ⁵⁵Fe. Plants were either labeled continuously for 4 weeks or pulsed with label for 2 hr at specific times. Dry weights and ⁵⁵Fe contents

of leaf, stem, root and nodule tissues decreased with increasing nematode inoculum density. ^{55}Fe content of nodules was reduced at very low levels of nematode inoculum density. Autoradiography of selected plants indicated peculiar partitioning of ^{55}Fe within leaf tissue. Pulse-labeled nematode-parasitized roots had dramatically higher ^{55}Fe content than those of controls 3 days after inoculation. No effect on ^{55}Fe content was observed 7 days after nematode inoculation. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

LAMONDIA, J. A. Tobacco resistance to *Globodera tabacum*.

Two flue-cured tobacco cultivars (VA-81 and Clemson PD-4) resistant to *Globodera solanacearum* were tested for resistance to *G. tabacum* in field and greenhouse experiments. A *G. tabacum*-susceptible Connecticut broad-leaf cultivar CT86-4 was used for comparison. In a greenhouse screening procedure the cultivars VA-81 and PD-4 had only 1 of 24 plants and 0 of 24 plants with cysts visible on the root system, respectively. All 24 plants of CT86-4 had at least 4 *G. tabacum* cysts visible per plant. Encysted juveniles inoculated to tobacco in the greenhouse hatched in response to all tobacco cultivars but reproduction was much less on VA-81 and PD-4 than on CT86-4. Fewer *G. tabacum* juveniles were present in stained roots of VA-81 and PD-4 than in CT86-4 5 weeks after inoculation. Naturally infested *G. tabacum* populations in field soil declined up to 80% under VA-81 and PD-4 but increased by 143% under CT86-4. This is the first report of tobacco resistance to *G. tabacum* in Connecticut. The Connecticut Agricultural Experiment Station, P.O. Box 248, Windsor, CT 06095.

MACGOWAN, J. B. Methods for sealing specimen bottles.

Techniques have been developed to eliminate the labor intensive ritual of semiannual inspections necessary to maintain the fluid levels in 2000 screw cap vials of preserved specimens. Preserved nematodes can be stored maintenance-free indefinitely in hermetically sealed glass ampoules or in screw cap vials which have been stoppered with silicone rubber adhesive. Other comparative studies which have led to the selection of certain materials and methodologies used by the developing Florida Nematode Collection will be addressed. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, P.O. Box 1269, Gainesville, FL 32602.

MACGUIDWIN, A. E. Population dynamics of *Pratylenchus* spp. on corn and potato: Distribution of nematodes between root and soil habitats.

The population dynamics of *Pratylenchus* spp. associated with irrigated corn and potato in a Plainfield loamy sand was monitored bi-weekly or monthly during 1985-1987. Nematodes were assayed from 100 cm³ soil and the roots therein by centrifugation and incubation methods, respectively. In samples taken during the growing season, nematodes recovered from soil represented 15% - 50% of the population. In 1987, ca. 20% of the nematode population was recovered from the soil in both potato and corn plots at planting. This proportion increased after planting, decreased in late spring, remained unchanged for the remainder of the 1987 growing season, and then increased again in the fall for both crops. The age structure of the nematode population recovered from soil was similar to that recovered from roots. These studies demonstrate the importance of assaying both soil and root habitats when estimating population densities of *Pratylenchus* spp. Department of Plant Pathology, University of Wisconsin, Madison, WI 53706.

MAGGENTI, A. R. What are the criteria for a genus, what are the criteria for a family?

A genus is defined as a category for a taxon including one species or a group of species, presumably of common phylogenetic origin and separated from related similar units by a decided gap. The size of the gap is in inverse ratio to the size of the unit. A family is a category including one genus or a group of genera or tribes of common phylogenetic origin and separated from related or similar units by a decided gap. The size of the gap is in inverse ratio to the size of the unit. The differences between these two concepts are examined relative to the amount of biologic, and phylogenetic information each generates. The role of the logic of classes is also discussed. Department of Nematology, University of California, Davis, CA 95616.

MANGAT, B. P. S., and D. S. BHATTI. Studies on the interactions of *Fusarium solani* (isolates-I and II) and *F. oxysporum* with *Tylenchulus semipenetrans* Cobb, 1913 on *Citrus jambhiri*.

Studies on the interaction of Fusarium solani (isolate-I) and Tylenchulus semipenetrans on Citrus jambhiri seedlings revealed that the maximum reduction of seedling growth was recorded when fungus was used 6 weeks after the inoculation of the nematode (N+F₆ wks). Interaction of F. solani (isolate-II) and T. semipenetrans showed that the maximum reduction of seedling growth was observed when nematode and fungus were inoculated simultaneously. The nematode population (in soil and root) was significantly reduced when fungal inoculations preceded nematode by 6 weeks (F+N₆ wks) for both the isolates of the fungus as compared to nematode alone. The interaction studies on F. oxysporum and T. semipenetrans on C. jambhiri showed that the effects of the fungus and the nematode on plant growth characters were independent. Department of Nematology, H.A.U., Hisar, 125004, India.

MANGAT, B. P. S., and D. S. BHATTI. Influence of Glomus mosseae singly and in combination with Tylenchulus semipenetrans Cobb, 1913 on the growth of Citrus jambhiri and the effect of carbofuran on the establishment of G. mosseae.

Studies on the interaction between Glomus mosseae and Tylenchulus semipenetrans on Citrus jambhiri revealed significant increase in seedling growth (number of leaves, girth, fresh and dry shoot weight, and fresh root weight) when mycorrhiza alone or in association with nematode was added as compared to noninoculated check. G. mosseae has shown to moderate the impact of nematode infection on plant growth. G. mosseae did not affect the penetration and development of citrus nematode on C. jambhiri. No significant effect of carbofuran (3G) was found on the establishment of G. mosseae on C. jambhiri even at 360g/tree (double the normal dose. Department of Nematology, Haryana Agricultural University, Hisar, Haryana, 125004, India.

MANNION, C. M., D. P. SCHMITT, and G. J. HOUSE. The effect of tillage and crop rotation on nematode population dynamics.

Population dynamics of selected nematodes was determined under different corn, wheat and soybean combinations as influenced by continuous conventional till (CT) and no-till (NT). Heterodera glycines egg counts were lower in NT than in CT. Populations of Rhabditoidea over all crops were similar in both tillage systems but were lower in NT than CT soybean and lower in corn than soybean. Rhabditoidea populations were similar in corn-soybean and 2 year corn-1 year soybean rotations and smallest in continuous soybean. Heterodera glycines eggs and Rhabditoidea populations were lower in rotations including wheat as a winter cover crop regardless of tillage. North Carolina State University, Department of Entomology and Department of Plant Pathology, Raleigh, NC 27695.

MAYASICH, S. A., and G. R. NOEL. Kinetics of Heterodera glycines esterase inhibition by organophosphate and carbamate compounds.

The active sites of soybean cyst nematode (Heterodera glycines) esterases were examined by probing partially purified enzymes with organophosphate and carbamate compounds with p-nitrophenyl butyrate as substrate. The carbamate aldicarb was a competitive inhibitor. The organophosphate paraoxon was a very strong-binding, irreversible inhibitor which bound very slowly. The presence of substrate appeared partially to protect the enzymes from inhibition. The kinetics of inhibition of the nematode esterases by these compounds are typical of the serine hydrolases. USDA-ARS Department of Plant Pathology, University of Illinois, Urbana, IL 61801.

MCINNIS, T. M., and B. A. JAFFEE. Effects of the fungicide carbendazim on the nematophagous fungus Hirsutella rhossiliensis.

Hirsutella rhossiliensis was sensitive to carbendazim in laboratory tests. Carbendazim at <2ppm inhibited radial growth, spore germination, sporulation from colonized Criconebella xenoplax, and infection of inoculated C. xenoplax. It was fungistatic at low concentrations and fungicidal at high concentrations. Applied in combination with GAFAC RA600 detergent as a soil drench to 0.05 m² peach orchard sites at rates of 60 and 300 g/m², carbendazim could be detected from samples taken at 10-55 cm depths 3 and 60 days later by spectrophotometry and bioassay. The results suggest that carbendazim can be used as a tool to assess the impact of H. rhossiliensis on C. xenoplax in peach orchards. Department of Biological Sciences, Clemson University, Clemson, SC 29634.

MCKENRY, M. V., and S. KAKU. Water extracts of green manures produce oxygen depleted and sometimes nematocidal solutions.

Various green manure crops were individually harvested, ground, placed into vats and soaked with water for 48 hours. Placement through a 200 mesh filter results in a crude extract at concentrations calculated from fresh weight of plant material/liter of final extract. The extracts have varying color, odor, fermentability and toxicity to nematodes. Also, most extracts at 3 g/l or more when added to tap water at 15 ppm dissolved oxygen quickly reduced the dissolved oxygen levels by at least half. At concentrations of 18 g/l, dissolved oxygen levels of 1 to 3 ppm were maintained for as long as 7 days. After 7 days, addition of equal parts of tap water to the solution did not appreciably raise the dissolved oxygen levels of the solution. Placement of Tylenchulus semipenetrans or Meloidogyne incognita into crude extracts at 18 g/l resulted in 95% nematode immotility in the population. Nematodes slowly regain motility after 72 hours; however, extracts of Tagetes tenuifolia and Eschscholtzia californica at 18 g/l were lethal to 95% of the nematode population. Department of Nematology, University of California, Riverside, CA 92521.

MEADOWS, J. R., S. S. GILL, and L. W. BONE. Lethality of Bacillus thuringiensis toxins for Turbatrrix acetii.

Thirty strains of Bacillus thuringiensis are lethal to various animal-parasitic worms and the free-living nematode Caenorhabditis elegans. A toxin from B. thuringiensis israelensis reduced the number of viable juveniles in cultures of Turbatrix acetii during a 13-day period. However, increased viability of juveniles over the test period indicated probable loss of toxicity. Adult nematodes were not affected by the microbial toxin. B. thuringiensis kurstaki and B. thuringiensis morrisoni were examined also for their effect on T. acetii populations. Animal Parasite Research Laboratory, P.O. Box 952, Auburn, AL 36831-0952.

MELAKEBERHAN, H., and H. FERRIS. Consumption by Meloidogyne incognita and its impact on energy partitioning in grape.

The impact of Meloidogyne incognita-stress-dosage, a product of number of nematodes and the total calories consumed per nematode, on growth, the rates of photosynthesis, transpiration and stomatal conductance, and on internal leaf CO₂ concentration of Vitis vinifera L. cv. French Colombard was measured over 1,000 degree days (base 10 C). Rates of the physiological processes were not related to the nematode-stress-dosage. However, total plant weight, total plant photosynthesis and plant biomass partitioning were significantly affected by increasing nematode-stress-dosage. The energy demand of M. incognita for respiration and production resulted in less energy available for partitioning into leaf area expansion, and in decreased total productivity. Department of Nematology, University of California, Davis, CA 95616.

MEYER, S. L. F., R. N. HUETTEL, and R. M. SAYRE. Benomyl tolerance of fungal antagonists to the soybean cyst nematode, Heterodera glycines.

Fungi that are used as biocontrol agents of soybean cyst nematode must be able to proliferate in field soil. Substances that may inhibit growth of these fungi include fungicides that are applied to soybeans. A number of fungi that have demonstrated antagonism to soybean cyst nematode in laboratory studies were examined for levels of tolerance to the fungicide benomyl. Benomyl in the form of 50% WP (E. I. duPont de Nemours & Co., Wilmington, DE) was suspended in sterile distilled water, and then added in various concentrations to potato dextrose agar. The fungi were then inoculated onto the agar surface. Benomyl tolerance varied from growth on approximately 0.1 µg benomyl/ml medium or less (one strain of Verticillium chlamydosporium) to growth on over 100 µg benomyl/ml (Verticillium chlamydosporium, Fusarium sp., and Verticillium lecanii). These results not only indicate the level of benomyl tolerance exhibited by each fungus, but also provide a basis for determining when biotypes with increased benomyl tolerance have been induced. Nematology Laboratory, USDA, ARS, Beltsville, MD 20705.

MILLER, L. I. Morphological comparisons of cyst cone structures of one isolate each of Heterodera schachtii, H. glycines and one of their hybrids.

Comparisons were made of cyst cone structures of 21 specimens of one isolate of Heterodera schachtii (C) cultured on 'US75' sugarbeet and of one isolate of H. glycines (M) and of one of their hybrids (CM) cultured on 'Lee' soybean. Dimensions in µm were as follows: vulval slit length: C 39-53 (mean 44.9, standard deviation ±3.4), M 47-57 (53.3±2.5), CM 39-54 (47.9±4.0); fenestral length: C 30-48 (37.4±5.1), M 47-65 (56.4±5.7), CM 39-64 (52.1±6.7);

fenestral width: C 22-36 (28.2±3.6), M 35-47 (42.9±3.6), CM 31-46 (39.7±4.2). C, M, and CM dimensions were significantly different ($P < 0.01$) for all characters compared. The CM hybrid was able to reproduce on both sugarbeet and soybean, whereas C was able to reproduce on sugarbeet but not on soybean and M was able to reproduce on soybean but not on sugarbeet. Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

MINTON, E. B., and J. C. BAILEY. Performance of cotton cultivars grown with and without Aldicarb-Terraclor Super X.

Aldicarb-Terraclor Super X applied in the seed furrow at planting followed by a side-dressing with additional aldicarb 5 weeks later increased seedling survival, plant height, flowering rate, and lint yields over no early season pesticide treatments. These pesticides reduced populations of root-knot nematodes and thrips and root gall indices. Lint yield was increased 46% by the pesticide treatments. A significant cultivar and cultivar X pesticide interaction for various plant and pest characteristics indicated that more than one cultivar should be used to evaluate pesticides. USDA ARS, Stoneville, MS 38776.

MINTON, N. A., A. S. CSINOS, and R. E. LYNCH. Effects of winter wheat, tillage, aldicarb and flutolanil on peanut pests.

Aldicarb 15G applied (3.4 kg a.i./ha) at planting and flutolanil 50WP applied (2.2 kg a.i./ha) 63 days after planting were evaluated for pest control on peanuts. 'Florunner' was planted in wheat stubble or fallow soil prepared by the subsoil-plant (SP) method or in moldboard plowed (MBP) soil. Wheat had no effect on pests or yield. Meloidogyne arenaria and Sclerotium rolfsii damage were less, but thrips (Franklinella fusca) damage was greater in MBP than in SP treatments. Damage by M. arenaria, F. fusca and potato leafhopper, (Empoasca fabae) was less in aldicarb-treated than in untreated plots. Three-cornered alfalfa leafhoppers (Spissistilus festinus) and velvetbean caterpillars (Anticarsia gemmatilis) were more numerous in aldicarb-treated than in untreated plots. S. rolfsii damage was less in flutolanil plots than in controls. Yields were 16% greater in MBP than in SP plots. Pesticide related increases were aldicarb, 14%; flutolanil, 52%; and aldicarb + flutolanil, 81%. USDA, ARS and Department of Plant Pathology, University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31793.

MOJTAHEDI, H., G. S. SANTO, J. N. PINKERTON, and J. H. WILSON. Effect of ethoprop on Meloidogyne chitwoodi and M. hapla.

Meloidogyne chitwoodi and M. hapla behaved similarly when exposed to ethoprop EC (0-ethyl S, S-dipropyl phosphorodithioate) in water for 4 days at 18 C. The concentration of ethoprop that produced irreversible effects on 50 percent (ED 50) of eggs in egg masses, free eggs and second stage juveniles (J2) were 160, 40-80, and 5-6 µl/ml, respectively. In 10-cm-d columns filled with soil and ethoprop at 6.67 kg a.i./ha, incorporated in the upper 5 cm, tomato roots were protected from upward migrating M. chitwoodi J2 for 5 weeks. The zone of protection was extended 20 cm below the root zone by applying 7.5 cm of water in 8 days. In the greenhouses, ethoprop at 6.67 kg a.i./ha incorporated in soil heavily infested with M. chitwoodi eggs similarly provided tomato roots with complete protection for 5 weeks. In the field, four monthly postplant applications of ethoprop 10G (broadcasted and followed with 2.5 cm of water) provided adequate protection of potato tubers against M. chitwoodi infection. Washington State University, College of Agriculture and Home Economics, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.

MONTGOMERY, M. E., and E. C. BERNARD. Reproduction of selected nematode species on oilseed rape, Brassica napus.

Oilseed rape has potential in the U.S.A. as a specialty contract crop. Reproduction of Helicotylenchus pseudorobustus (HP), Heterodera glycines (HG), and Meloidogyne hapla (MH) was determined on five rape cultivars: Bridger, Gorzanski, H-47, Lindoora, and Viking. All experiments were replicated and conducted in a greenhouse. Eggs were used for HG and MH inocula. All stages were used for HP inoculum. After 6-8 weeks, reproduction was determined as number of white females (HG), egg mass production (MH), or nematodes/100 cm³ soil (HP). At two weeks, roots from one replication of each experiment were stained to determine degree of penetration. At two weeks some HP had entered roots partially or completely. HP reproduced equally well on all cultivars but did significantly better on a sunflower control. HG juveniles penetrated roots of all cultivars, except Gorzanski and

Viking, but failed to develop to maturity on any cultivar. MH produced numerous galls and egg masses on all cultivars, all of which were equally suitable hosts. Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37901-1071.

MUCHENA, P. K., and G. W. BIRD. Distribution and impact of *Pratylenchus zeae* and *P. brachyurus* on maize production in communal farms in Manicaland Province, Zimbabwe. In the 1985-86 December-May growing season, a survey of 49 communal farms in Manicaland, Zimbabwe was used to determine the distribution, population density and impact of *Pratylenchus zeae* and *P. brachyurus* on maize. This was part of a 1985-86 nationwide survey of 116 communal farms. *P. zeae* and *P. brachyurus* were identified as the most common species associated with maize. In Manicaland, root-lesion nematodes were recovered from 96% of the farms. The mean population density was 166 (0-1,521)/1.0 g of root tissue. Population densities greater than 100 per 1.0 g of root tissue were recovered from 52% of the sites. Grain yields ranged from 0.09-6.75 t/ha. *P. zeae* and *P. brachyurus* did not appear to be major problems in red clay, red loam or sandy loam sites. They appeared to be a major limiting factor in maize production in at least 53% of the sites with sandy soils. This was based on root-lesion nematode population densities greater than 100 per 1.0 g of root tissue and yields less than 2.0/ha that could not be attributed to other limiting factors. Plant Protection Research Institute, Ministry of Agriculture, P.O. Box 8100, Causeway, Zimbabwe.

MUELLER, J. D., and G. C. WEISER. Yield reduction of tolerant and susceptible soybean by *Hoplolaimus columbus*. Tolerant 'Foster' and susceptible 'Braxton' soybean cultivars were planted on 15 May 1987 in a field near Blackville, SC infested with an average of 32 *Hoplolaimus columbus* (HC)/100 cm² of soil. Seventy 1 row X 1.8 m long plots were selected to give a gradient of at-planting counts (Pi) from 0-400 HC. Plant height at harvest was not affected by Pi. Relationship between yield reduction, and Pi was greater for Braxton ($Y=454-29.4x$, $r^2=0.26$, $P=0.01$) than for Foster ($Y=491-0.10x^4$, $r^2=0.14$, $P=0.01$). Relationship between recovery from soil at harvest, and Pi was lower for Braxton ($Y=21.6+2.33x^2$, $r^2=0.28$, $P=0.01$) than Foster ($Y=6.43+0.11x^4$, $r^2=0.39$, $P=0.01$). Relationship between recovery from roots at harvest and Pi was greater for Braxton ($Y=9.34+9.56x$, $r^2=0.21$, $P=0.01$) than Foster ($Y=11.47+0.02x^4$, $r^2=0.12$, $P=0.01$). Clemson University, P.O. Box 247, Blackville, SC 29817.

MYERS, R. F. Separation of pinewood nematode isolates by utilization of isozymes visualized by starch gel electrophoresis. *Bursaphelenchus xylophilus* were obtained from France, the United States, Canada, and Japan and *B. mucronatus* was additionally collected from Japan. All nematodes were reared on nonsporulating *Botrytis cinerea* growing on potato dextrose agar or moistened millet seed. Adults and juveniles (0.4-0.8 g wet weight) disrupted in buffer by sonication were centrifuged (13,000 x g) to separate cuticular and cellular sediments and the surface layer of lipids from the aqueous layer containing the enzymes. Starch gel electrophoresis was used to visualize isozyme patterns. Isozyme comparisons indicated that the French nematode (F-1) collected from *Pinus pinaster* and the Canadian nematode (C-2) from *Abies balsamea* were dissimilar and also different from other pine wood nematodes (US-1, US-7, C-1, and J-6). *B. mucronatus* (J-14) was also differentiated with isozyme patterns. Most isozyme patterns of *B. xylophilus* were remarkably similar in the numbers and location of the bands or spots. Department of Plant Pathology, Rutgers University, Cook College, New Brunswick, NJ 08903.

NADERMAN, G. C. The importance of soil properties to plant growth and nematode activities. Soil properties interact with climatic and man-made influences to provide the growing medium for plants. Within the same climatic region soils vary greatly in crop yield potential. This attests to the importance of factors including soil texture, water-holding capacity, horizon properties, fertility and drainage status of soils. Recent soil research has shown that soil compaction sharply influences the distribution and effectiveness of crop root systems. The spatial distribution of soil properties can often be predicted by soil classification and mapping. Since parasitic nematodes are intimately associated with host root systems this paper will review the role of soil influences important in nematology. Department of Soil Science, 3403 Williams Hall, Box 7619, North Carolina State University, Raleigh, NC 27695-7619.

NELSON, S. C., J. L. STARR, and E. SIMPSON. Resistance to *Meloidogyne arenaria* in exotic germplasm of the genus *Arachis*.

Resistance to *Meloidogyne arenaria* reproduction in wild *Arachis* spp. germplasm was identified in greenhouse and field studies. Nematode development on two resistant wild species germplasm lines was examined in two replications in 28 C growth chambers. Roots of the susceptible *A. hypogaea* cultivar 'Tannut 74' and the resistant wild species germplasm lines *A. batizocoi* 9484 and *A. cardenasii* 10017 were penetrated equally by juveniles seven days after inoculation. Juvenile development to adult females with characteristic giant cell development was observed in germplasm line 9484, but at reduced rates relative to Tannut 74. At 30 days after inoculation with 2,500 juveniles, 117 egg-laying females were observed on Tannut 74, while no egg-laying female was observed on 9484. In germplasm line 10017 only two individual nematodes were observed to develop past the unswollen J2 stage, and no giant cell development was observed. Resistance mechanisms in 9484 and 10017 appear to differ. Texas Agricultural Experiment Station, College Station, TX 77843.

NGUYEN, K. B., and G. C. SMART, JR. A new steinernematid nematode from Uruguay.

A steinernematid nematode collected from Uruguay is being investigated as a biological control agent for the control of mole crickets. The nematode has both morphological and biological characteristics that do not fit described species of *Neoaplectana* (=Steinernema). These characteristics are: a very limited host range; it does not develop in wax-moth larvae; the cheilorhabdions are thickened; spicules and gubernaculum are unlike those of described species; an epiptygma is present in females of the first generation; the protein patterns are different from those of described species; it does not hybridize with the Breton strain of *Neoaplectana carpocapsae*. The nematode is being described as a new species. Department of Entomology and Nematology, University of Florida, Gainesville, Florida 32611.

NIBLACK, T.L. Applications of community structure research to agricultural production and habitat disturbance.

Community structure refers to the patterns of interrelationships among the members of a community; the degree of structure of a community is dependent on the degree of interaction among its members. In agricultural studies, the interaction of interest is usually that of host-parasite and the factors affecting that relationship, but plant parasitic species are only part of an abundant nematode fauna that has effects in agroecosystems other than direct parasitism. Nematode communities have characteristics similar to those of populations of single species. For instance, limiting factors, genetic variation, and spatial distribution can apply as much to communities as to populations. Study of a community, compared with a population, only requires a different classification component. University of Missouri, Department of Plant Pathology, 108 Waters Hall, Columbia, MO 65211.

NICKLE, W. R., and M. J. COBURN. Pinewood nematode control, in wood chips, using hot water treatment.

The presence of living pinewood nematodes (PWN) in wood chips from trees grown in areas or states that are known to have PWN has resulted in a ban of these North American products normally shipped to Scandinavia and Europe. Experiments were conducted to control this organism before shipment. A treatment of hot water and a wetting agent was applied to the chips at the end of the conveyor belt. Eight wood chip samples were taken, four treated and four untreated, randomly from logs normally used for wood chips. Two samples contained PWN and all contained thousands of other nematodes. A treatment of 2.5-4.0 minutes at 60-77 C. was successful in killing all the nematodes in the chips. After two weeks at room temperature, these samples were processed again and no nematodes were found in the hot water treated samples, though PWN and other nematodes were still found to occur in the untreated samples. Systematic Botany, Mycology and Nematology Laboratory, USDA, ARS, Beltsville, MD 20705.

NIGH, E. L., JR. Chemical control of stem nematode infecting nondormant irrigated alfalfa.

The stem nematode attacks Arizona alfalfa in the desert valleys where damage occurs during the cooler months of fall and spring. Efforts to introduce and retain resistant alfalfa has had limited success. As temperatures decrease in the fall, humidity increases through dew, irrigations, and increased rainfall. From October until temperatures decrease 10±1 C, the nematode continues to reproduce and feed. In warmer years, damage may be sustained from October until spring temperatures exceed 29 C. Chemical controls are warranted during

these periods of feeding activity. Field trials were made to establish efficacy of pesticides, influence on yields and their economics. Temik, Vydate, Furdan, Disyston, Thimet and Dasanit applied in fall and spring as populations are first detected following dormancy are equally effective. Best control is obtained when pesticides are applied immediately after harvest and prior to irrigation. Yield increases of 15-25% were obtained compared to nontreated fields with decreased yields of 40-85%. Stand decline was reduced 50-95% when treatments were correctly applied. Yuma Valley Agricultural Center, College of Agriculture, University of Arizona, 6425 West 8th Street, Yuma, AZ 85364.

NILES, R. K., J. M. FERRIS, and V. R. FERRIS. The relationship between agronomic perturbation and nematode community structure.

Integrated strategies for crop production in the eastern U.S. cornbelt region were investigated in long-term field plots to determine the effect of tillage and rotation on nematode community structure. Tillage practices of either conventional moldboard plowing or no-tillage were combined with seven rotation schedules that included corn, soybean and wheat. Each management regime was replicated four times in plots managed for a moderate level of weed infestation. Nematode samples were collected within rows to a uniform soil depth at 837 DD (base 10 C) and at 3051 DD during the sixth and seventh management years. All nematode species present in each sample were identified and the number of specimens of each was counted utilizing an aliquoting procedure. Preliminary results indicate nematode abundance and trophic distribution differed among management regimes. Communities formed in plots of a given regime appeared more similar to one another than to the communities of other regimes. A more diverse and less dense community appeared to be formed under no-tillage than under conventional tillage. Department of Entomology, Purdue University, West Lafayette, IN 47907.

NOE, J. P. Characterizing nematode-soil environment relationships.

Plant-parasitic nematodes are primarily soil-inhabiting organisms, and interact with host plants within the soil environment. Differences in soil characteristics within and among fields impact the distribution, population dynamics, and host relationships of plant-parasitic nematodes. Soil environment effects on the within-field diversity of nematode abundances have been investigated through the use of computer mapping, frequency distributions, and multivariate statistics. Measures of soil texture and structure were found to be critical variables in accounting for diversity in nematode population densities. Levels of selected cations, including sodium and copper, and indices of soil fertility were also important indicators of nematode abundance. Differences in soil characteristics also affect the expression of nematode-induced stress on crop yields. Soil environment effects on nematode damage functions have been determined by simple multiple regression, and canonical analyses. Important edaphic factors affecting yield loss relationships included soil texture, and indices of soil fertility. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

NOE, J. P. Maximizing the potential of cropping systems for nematode management.

A quantitative approach to analyzing cropping systems includes the use of mathematical models to describe nematode induced crop stress and nematode population dynamics. These models then are assembled into a simulation of the cropping system, and quantitative decision-making tools are applied to maximize the potential productivity of the system with respect to nematode-induced stress. This approach was applied to a system of cotton 'Coker 315', soybean 'Centennial', and corn 'Pioneer 3265', with Hoplolaimus columbus as the primary nematode parasite. Data were collected from on-farm field plots in Scotland County, North Carolina. Nonlinear least squares methods were used to fit crop loss functions, and to fit functions which represented changes in nematode abundance under each crop. Calculated maximum crop losses were 14% in cotton, 29% in soybean, and 30% in corn. Calculated maximum nematode densities at harvest were 950, 450, and 1250 H. columbus/500 cm³ soil for cotton, soybean, and corn, respectively. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

NOEL, G. R., and S. A. MAYASICH. Partial characterization of Heterodera glycines esterases.

The esterase enzymes of the soybean cyst nematode, Heterodera glycines, were classified using specific substrates and inhibitors. Enzyme velocity and Vmax increased with carbon chain length (2,3,4 and 6 carbons) of p-nitrophenyl-ester substrates, but Km decreased

markedly. Paraoxon inhibition was greater with p-nitrophenyl butyrate as substrate than with p-nitrophenyl acetate, but in both cases less than 20% of the activity remained when the enzyme was preincubated with 10^{-8} M paraoxon. Inhibition by p-hydroxymercuribenzoate was greater with acetate than butyrate, but more than 90% of the activity remained even at 10^{-5} M. The intensity of staining on isoelectric focusing gels with various naphthyl-ester substances was: α -naphthyl propionate = α -naphthyl butyrate > α -naphthyl acetate > β -naphthyl acetate. Banding patterns were identical with all substrates. Ten bands of activity with isoelectric points from 4.56 to 5.60 were resolved on the gels. These results indicate that most (at least 90%) of the activity detected toward these substrates is due to carboxyl (B-) esterase activity. USDA-ARS Department of Plant Pathology, University of Illinois, Urbana, IL 61801.

NOLING, J. W., and L. W. DUNCAN. Estimation of citrus nematode stress and yield losses in a mature citrus grove.

Tylenchulus semipenetrans population growth was studied in an east Florida coastal flatwoods valencia orange grove from July 1985 to July 1987. Phenamiphos (22.2 kg/ha) was annually applied to 20 of 100 trees for nematode control. Citrus trees were separated into thirteen tree size and vigor categories based on canopy measurement and visual rating of tree health. The relation between citrus yield and tree size and vigor were adequately described in separate linear regression analysis for phenamiphos-treated and nontreated trees, each explaining 55% of yield variation. Citrus yield losses were inversely related to tree size and vigor. Citrus nematode population levels and nematode control with phenamiphos decreased with increasing tree size and vigor. In small, less vigorous trees, nematode control was excellent with a 93% reduction from nontreated trees. Average seasonal abundance of citrus nematode females and total number of second stage juveniles were strongly correlated with proportional yield losses when covariate effects of tree size and vigor were considered. Department of Entomology and Nematology, IFAS, University of Florida, Lake Alfred, FL 33850.

NOLING, J. W., and A. J. OVERMAN. Movement, dissipation, and efficacy of ethoprop for citrus in a deep, well drained sandy soil.

The dissipation, mobility, and efficacy of ethoprop 6EC was evaluated in a southcentral Florida orange grove. Ethoprop was applied in 1.73 m bands (6.0 kg a.i./ha) to a 1.7 ha plot. Tylenchulus semipenetrans population levels were monitored bimonthly on 45 randomly selected trees in both treated and untreated areas. Soil and groundwater ethoprop residue samples were collected at 0, .5, 1, 2, 4, 6, 8, 10, and 12 months following application. Ethoprop soil residues were generally contained in the upper 2 m of soil and degraded with a half life of approximately 13 days. Trace residues of ethoprop at concentrations between 0.2 and 1.6 g/L were recovered from 4 groundwater samples within three months of application. Ethoprop did not reduce either soil juvenile or female citrus nematode infestation levels. Neither fruit size nor citrus yields were significantly affected in the first year following treatment. Department of Entomology and Nematology, IFAS, University of Florida, Lake Alfred and Bradenton, FL 33850.

NORTON, D. C. Nematode community interactions under various soil physical and chemical environments.

A natural community of plant-parasitic nematodes is nearly always polyspecific. The host plant is the most important driving force in nematode populations but abiotic factors are important in maintaining the steady state. In any continuous habitat, including crop plants, generally there is a consistency of the most abundant species and they are largely predictable. Nematode communities often separate out by abiotic soil factors. Data on single species might be indicators of certain environments, it is only when we discuss such aspects as diversity and ordination that we relate to communities irrespective of any interactions among component species. If plant-parasitic nematodes act independently of each other, then autecological studies have validity in polyspecific communities. Department of Plant Pathology, Iowa State University, Ames, IA 50011-1020.

NYCZEPIR, A. P. Interaction between Criconeermella xenoplax and pruning as related to peach tree short life.

Twenty-four field microplots were established with 'Nemaguard' peach cuttings in the presence or absence of Criconeermella xenoplax (Cx) (5000 Cx/plot) to determine if a PTSL interaction exists between pruning and Cx. Soil in plots was not previously planted to

peaches, but fumigated with methyl bromide. Cuttings and associated soil were transplanted into plots in May 1984. Half the Cx and check trees (6 reps) were December-pruned (DP) and the other half March-pruned (MP) commencing in 1985. In 1986 and 1987 one DP Cx-inoculated tree died from PTSL. In 1987 one DP and one MP Cx-inoculated tree died from water-logging. The three remaining DP Cx-inoculated trees developed PTSL symptoms in March 1988 and are currently dying. Two MP Cx-inoculated trees developed PTSL symptoms in April 1988 and will probably die. None of the check trees developed PTSL symptoms. Results of this study show that the harmful effect of DP in the presence of Cx and that 'old peach soil' is not always a prerequisite for PTSL. USDA, ARS, S.E. Fruit and Tree Nut Research Laboratory, Byron, GA 31008.

NYCZEPIR, A. P., J. A. PAYNE, J. J. HAMM, and W. L. TEDDERS. *Heterorhabditis heliothidis* (Nematoda: Heterorhabditidae) a parasite of pecan weevil, *Curculio caryae* (Coleoptera: Curculionidae).

The entomogenous nematode, tentatively identified as *Heterorhabditis heliothidis* Georgia strain (Hh), was isolated from dead reddish color pecan weevil larvae [*Curculio caryae* (Cc)] at Byron, GA, in October 1986. Hh were increased on corn earworm (*Heliothis zea*) and fall armyworm (*Spodoptera frugiperda*) larvae and reinoculated into steam pasteurized soil in 4.2-cm-deep cups (2187 Hh/cup). Control cups received only water. One surface disinfested Cc was placed in each of 11 cups and incubated at 23.5 C for 6 days. One (9%) Cc in both the Hh and check died, but only the Hh-treated Cc turned red and liberated Hh juveniles after 13 days. The above procedure was repeated using 5 reps/treatment with three Cc/cup and 247 Hh/cup, since the number Hh recovered was lower. Mortality was 80% and 40% in Cc-inoculated and checks, respectively; with one red Cc cadaver yielding 137,500 Hh infective juveniles after 21 days. Hh is a pathogen of Cc. Its capability as a successful biological control agent needs further investigation. USDA, ARS, S. E. Fruit & Tree Nut Research Laboratory, Byron, GA 31008.

OMWEGA, C. O., I. J. THOMASON, and P. A. ROBERTS. *A nondestructive technique for screening bean germplasm for resistance to the nematode Meloidogyne incognita utilizing a nontoxic egg mass stain.*

A technique was developed for screening bean germplasm for resistance to root-knot nematodes based on egg mass counts. Bean plants were grown in seedling growth pouches (Northup King Co.). One week after germination the plants were inoculated with 2000 second stage juveniles of *M. incognita* race 1. Three weeks later the plants were irrigated daily for one week with 50 ppm of the dye erioglaucine (Aldrich Chemical Co.). This dye stains egg masses without staining female nematodes. Stained egg masses were counted four weeks after initial inoculation and evaluated plants were planted into UC mix soil and were grown to maturity. Evaluations were made four weeks after inoculation because this was a critical time in nematode development, plant growth in the pouches, and survival of the plants after transplanting into soil. Egg mass counts were more highly correlated to nematode reproduction ($r=0.85$) than either gall index or egg index. Department of Nematology, University of California, Riverside, CA 92521.

OOSTENDORP, M., D. W. DICKSON, and D. J. MITCHELL. *Soil bioassay and host specificity of populations of Pasteuria penetrans.*

A bioassay for the number of spores of a known *Pasteuria penetrans* population in soil was developed. The bioassay entails incubating spore-free juveniles of a known host nematode in *P. penetrans*-infested soil for three days. The number of nematodes with spores attached was counted. The sensitivity of the bioassay increased with an increase in nematode inoculum up to 100 juveniles/cm² soil. The attachment of spores to the nematodes was not altered over a wide range (25-75% of field capacity) of soil moistures. The host specificity of different populations of *P. penetrans* was tested in an *in-vitro* bioassay. *Pasteuria penetrans* populations obtained from different phytoparasitic nematodes showed marked differences in their host affinity. Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.

OPPERMAN, C. H. *Neurological control of molting in Caenorhabditis elegans.*

Molting in nematodes is thought to be initiated by the secretion of norepinephrine, but the evidence is largely histochemical. *Caenorhabditis elegans* was exposed to a variety of neuroactive drugs which are known to interact in the alpha and beta adrenergic systems. Compounds known to block the beta adrenergic receptor appeared to interfere with normal nematode development. Early stage juveniles often failed to develop past the second stage,

and no dauer larvae were observed. Other behavioral effects were associated with exposure to norepinephrine. Using affinity chromatography a putative adrenergic receptor has been isolated from C. elegans. Initial characterizations indicate that this receptor is similar to those found in other animal systems. It appears that a functional adrenergic system is present in C. elegans and is involved in molting. Department of Plant Pathology, North Carolina State University, Box 7616, Raleigh, NC 27695-7616.

OPPERMAN, C. H., and S. CHANG. Induced systemic resistance of soybean to Heterodera glycines.

A split-root technique was used to determine if prior infection of soybean roots with an incompatible race of Heterodera glycines would induce resistance to a race normally compatible. In one experiment 'Forrest' soybean was inoculated with H. glycines race 1 (incompatible), race 2 (compatible), or one race on each root-half. Race 2 produced approximately equal numbers of adult males and females on each root-half, while race 1 produced a 3:1 ratio of males to females. When race 1 was inoculated on one root-half and race 2 on the other, they each produced a 7:3 ratio of males to females. Another experiment demonstrated that excising the root-half with the incompatible race 1 at five or ten days after infection and then inoculating with race 2 allowed the normal compatible reaction to occur. Department of Plant Pathology, North Carolina State University, Box 7616, Raleigh, NC 27695-7616.

ORELLANA, C. F., M. E. AZIZ, K. E. CRAMER, and P. M. TEFFT. Determination of egg permeability in Heterodera glycines.

Egg permeability in Heterodera glycines was determined using fluorometry and fluorescence microscopy. Fluorescent dye efflux was greater from eggs pretreated in zinc or soybean root diffusate than eggs pretreated in water, calcium or magnesium. Parallel experiments were conducted by observing uptake of fluorescent dye by unhatched juveniles. Exposure of eggs to soybean root diffusate with ethylenediaminetetraacetic acid (EDTA) and zinc chloride followed by incubation in dye increased the percentage of unhatched juveniles fluorescing. Except for EDTA, agents that increased permeability also promoted hatching. Biology Department, St. Joseph's University, Philadelphia, PA 19131.

OVERMAN, A. J., and J. W. NOLING. Movement, dissipation, and efficacy of ethoprop for tomato in a shallow, poorly drained sandy soil.

Ethoprop 10G (13.4 kg/ha) was broadcast incorporated to a 20-cm-depth on Eau-Gallie fine sand prior to construction of fully mulched beds. The field was irrigated from a constant water table perched at a depth of 45 cm from the bed surface. 'Sunny' tomato was set on the day of treatment. Soil and ground water samples were collected 0, 0.5, 1, 2, 4, 6, 8, 10 and 12 months after treatment. Immediately after treatment, 10.5 µg/liter of ethoprop was detected in ditch water due to aerial drift. Movement in soil was limited to 0.3 m depth during the study; half-life of ethoprop was calculated as 40 days beneath the mulch (20% remained in the soil at 3 months), and as 15 days after mulch removal (0.023 µg/g soil). The chemical was detected in ground water test wells during the 4th and 5th months at 0.2 to 3.0 µg/l levels. Soil assays 0, 40, and 80 days after planting indicated ethoprop reduced populations of Dolichodorus, Hemicycliophora, Paratrachodorus, and Tylenchorhynchus at 40 days. Root galling by Meloidogyne was moderately severe on primary roots of control plants and light on secondary roots only of the treated plots. At first tomato harvest, yield was reduced 34%; at second and third harvest, yield of treated plants increased 25 and 20%, respectively. University of Florida, IFAS, Bradenton and Lake Alfred.

PAYAN, L. A., and D. W. DICKSON. Host specificity of four populations of Pratylenchus brachyurus.

Each population was tested under greenhouse conditions on seven selected plant types to determine host suitability and usefulness in identifying physiological races of this nematode. The differential plants were: 'Florida 77' alfalfa, 'Harvester' bean, 'Rough Lemon' citrus, 'Pioneer 304C' corn, 'Florunner' peanut, 'Braxton' soybean, and 'Rutgers' tomato. Each plant was inoculated with 300 nematodes, per 15-cm pot, set-up in a split-plot design with a factorial arrangement, and harvested 64 days later. No differences were detected between treatments in fresh shoot or root weights. There was a significant difference ($p=0.05$) in reproductive rate only in treatments with 'Harvester' bean. The two populations that originated from peanut had a significantly higher population density than

the other two; however, there were no differences in population densities between them or the other two which came from soybean and corn. Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.

PHILLIPS, M. S., and D. L. TRUDGILL. The interactions between plant growth and reproduction of *Globodera pallida* on potato genotypes with differing levels of tolerance and resistance.

Potato clones with different levels of resistance showed differences in tolerance when grown in field plots with different densities of *Globodera pallida*. Yield losses at the highest initial density (165 eggs/g soil) were 97% on the least tolerant clone but only 20% on the most tolerant. The relationship between initial density and yield was well described by existing empirical models of Seinhorst (1965) and Oostenbrink (1966). Rates of nematode reproduction were least on the most resistant clone and decreased as initial population densities increased. Multiplication rates were not only affected by the resistance of the clones but also by their tolerance. On the most tolerant clone, which was also partially resistant, the final population density increased over the whole range of initial densities and, at the highest densities, the final population exceeded that on a nonresistant but intolerant cultivar. Adequate modelling of population dynamics was possible only when the effects of plant growth were taken into account. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

POPIEL, I., D. GROVE, and M. J. FRIEDMAN. Infective juvenile formation in *Steinernema feltiae* Strain A11.

Steinernematid and heterorhabditid nematodes form a developmentally arrested infective juvenile (IJ) stage at the 2nd molt when conditions inside the insect host are no longer suitable for further rounds of reproduction. In a liquid culture micro-assay 2 environmental cues were shown to influence the formation of *Steinernema feltiae* IJ. High nematode population density induced IJ formation. Bacterial food and soluble nutrients acted competitively to reduce the frequency of IJ formation. The optimum temperature for the IJ induction response was 25 C. Frequency of IJ formation was greatest when 1st stage juveniles were subjected to IJ-inducing conditions. These findings suggest that maximal IJ production in large scale liquid culture will depend on the correct balance of nematode density and nutrient availability at the peak of egg hatching. Biosis, 1057 East Meadow Circle, Palo Alto, CA 94303.

PORTER, L. L., and B. B. BRODIE. A method for studying the behavior of *Globodera rostochiensis* juveniles in resistant and susceptible potato cultivars.

The resistant 'Rosa' and susceptible 'Katahdin' cultivars were planted in a 5:2:2 sand:soil:silt mixture in punctured styrofoam cups. The cups were placed in Petri dishes containing vermiculite to allow root development and to facilitate inoculation. Rosa and Katahdin were inoculated with 2000 and 3000 freshly hatched second-stage juveniles (J2) of *Globodera rostochiensis*, Race R₁A per plant. Twenty-four hours after inoculations, the Petri dishes were replaced with ones containing distilled water. Exiting juveniles from the roots of both cultivars were collected 48 hours later. Examination of the plates revealed an average of 57.5 (± 8.9) J2/plant exiting from the resistant host; 41.3 (± 14.8) from the susceptible host. This technique is being utilized to study the effects of host resistance on J2 of *G. rostochiensis*. Department of Plant Pathology, Cornell University and USDA, ARS, Ithaca, NY 14853.

POWERS, T. O., A. D. RADICE, and L. J. SANDALL. Mitochondrial genome evolution in *Meloidogyne* and *Heterodera*.

The nature and frequency of structural changes in the mitochondrial genomes of *Heterodera* and *Meloidogyne* species have been investigated by endonuclease restriction analysis and DNA hybridization. Estimates of interspecific genetic divergence appears much greater in *Heterodera* than *Meloidogyne*. The mitochondrial genome of *H. glycines* and *H. schachtii* have approximately 15% nucleotide sequence divergence. The greatest estimate of divergence in *Meloidogyne* was 3.3% between *M. arenaria* and *M. javanica*. Comparisons of mitochondrial genome divergence among *M. javanica*, *M. incognita*, and *M. hapla* ranged from 0.8 - 2.2%, and overlapped intraspecific comparisons. Both genera exhibit intraspecific mitochondrial genome size polymorphism. *Heterodera* is further characterized by heteroplasmy, where an individual has more than one mitochondrial genotype. Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583; Department of Molecular Biology, Albert Einstein

College of Medicine, Bronx, NY 10461.

PROCTER, D. L. C. Global overview of nematode communities and diversities.

The role of soil-living nematodes in different ecosystems can be largely predicted on the intensity of nonbiotic stresses imposed by different temperature and moisture regimes. Assuming that tropical lowland rain forest experiences the most biologically equitable climate, increasing climate-related stress occurs as one proceeds through intervening biomes to low latitude lowland desert, high latitude desert, and alpine desert, respectively. Soil nematodes, mostly being relative generalists, show only moderate diversity and low densities in tropical lowland rain forests because of competition from many other more specialized organisms. On the other hand, nematode diversity and densities increase and remain relatively high as one proceeds into the most extreme ecosystems because nematodes show greater adaptability than do many other taxa to climate-induced stress. However, cold allows nematodes greater "ecological release" than does drought because nematodes, being essentially aquatic organisms, require moisture for activity. Thus, cold ecosystems have the greatest nematode diversities and densities. Department of Biological Sciences, University of Calgary, Calgary, Alta., Canada. T2N 1N4.

REISE, R. W., K. J. HACKETT, R. M. SAYRE, and R. N. HUETTEL. Factors affecting cultivation of three isolates of Pasteuria spp.

Grace's Insect Medium, M199, Schneider's Drosophila Medium, Iscove's Modified Dulbecco's Medium and H2 Medium were tested for their ability to support the growth of Pasteuria spp. isolates. Standard media formulations were then modified by adding undefined organic, defined organic and mineral supplements, which resulted in improved growth. Pasteuria spp. isolates from Pratylenchus brachyurus, Heterodera glycines and Meloidogyne incognita were studied. Diseased nematodes were surface sterilized and then crushed in the various media. Visual observations were made at regular intervals. Increases in mature spores, sporangia, and vegetative cells were observed. Growth, closely resembling bacterial structures found in diseased nematodes, gradually decreased to marginal growth, ceasing after 3-5 transfers. Efforts to identify growth factors are continuing at this time.

USDA, ARS, Nematology Laboratory, BARC-West, Beltsville, MD 20705.

ROBERTSON, W. M., and J. M. S. FORREST. Lectin labelling of Longidorus elongatus.

Lectins conjugated with tetramethylrhodamine isothiocyanate (TRITC) were used to screen L. elongatus for carbohydrates on the nematode surface. Although labelling with lectin from Arachis hypogaea was found in the anterior part of the body no labelling was found on the head papillae or in positions corresponding to the amphidial openings. Lectin from Triticum vulgare (WGA) was found to label the openings of the body pores and large areas of the cuticle. Blocking the WGA-TRITC conjugate with the complementary sugar showed that only the body pores were specifically labelled. Treatment of whole nematodes with the cationic detergent cetyltrimethylammonium bromide removed surface proteins which were subsequently separated by SDS polyacrylamide electrophoresis. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

ROBINSON, A. F. Comparison of thermotaxis in two foliar and two root parasitic nematodes from southwestern North America.

Thermotactic preferences were reported previously in only four nematodes: Terranova decipiens (cod and seal parasite), Caenorhabditis elegans, Globodera rostochiensis, and Ditylenchus dipsaci (from narcissus). In the present study, behavioral responses to gradients of 1 and 0.1 C/cm at 12 temperatures (10-33 C) were compared among two foliar parasites, Ditylenchus dipsaci (alfalfa race) and Orrina phyllobia, and two root parasites, Rotylenchulus reniformis and Tylenchulus semipenetrans. All species exhibited a similar overall pattern of response that was characterized by movement toward a preferred temperature when within a relatively low range of temperature. The low range was separated by an avoided temperature from a high range within which nematodes moved toward heat. The preferred and avoided temperatures differed appreciably among species and were modified differently by thermal history. Foliar parasites were attracted to and avoided lower temperatures than did root parasites. Optimum temperatures for random movement were higher than preferred temperatures and were shifted less by physiological experience. Subtropical Agricultural Research Laboratory, USDA ARS, P.O. Box 267, Weslaco, TX 78596.

ROBINSON, A. F., and G. SALDANA. Characterization of host-specific attractants for the

silverleaf nightshade nematode, *Orrina phyllobia*.

An unknown attractant for the nematode *Orrina phyllobia* was extracted with water from foliage of *Solanum elaeagnifolium*. Stability, solubility, ionic character, and chromatographic purification were investigated using a bioassay based on nematode aggregation in agar. Activity was nonvolatile, dialyzable, heat stable below 60 C and partly lost within 30 minutes at 100 C. Activity was unchanged from pH 5 to 12 but was entirely lost at pH 2. Loss of activity at low pH did not appear to result from direct effects of pH on nematode behavior and was partially recovered by readjustment to pH 7. The attractive factor was most soluble in water and appeared to be cationically but not anionically exchangeable. Activity appeared to chromatograph as several compounds by high-performance liquid chromatography employing reverse phase C₁₈ and amine-bonded columns. Various known compounds which are common to *Solanum* spp. or which attract other nematodes were unattractive. Extraction of *S. elaeagnifolium* foliage specifically for Solanaceous glycoalkaloids using methods developed for *S. tuberosum* did not yield an attractive product. Subtropical Agricultural Research Laboratory, USDA ARS, P.O. Box 267, Weslaco, TX 78596.

RODRIGUEZ-KABANA, R., D. G. ROBERTSON, C. F. WEAVER, and D. BOUDE. Soybean meal and urea for control of plant-parasitic nematodes.

The value of soybean meal (SBM) amendments for the management of root-knot nematodes (*Meloidogyne* spp.) in horticultural crops was studied for 2 years in greenhouse and microplot experiments. Pre-plant applications of SBM at rates of 0.2-0.5 g/kg soil reduced root-knot (*M. arenaria*) in greenhouse Summer Crookneck squash (*Cucurbita pepo*) and in a subsequent crop of Rutgers tomato (*Lycopersicon esculentum*) grown in the same soil; treatments with SBM were most effective in controlling the nematode when applied together with urea (0.5 g/kg soil). Microplot experiments showed that SBM + urea mixtures were as effective as aldicarb (Temik 15G) treatments (11 kg a.i./ha. broadcast basis) for increasing yield and controlling root-knot nematodes (*Meloidogyne arenaria*, *M. incognita*) in Black Beauty eggplant (*Solanum melongena*), Purple Hull cowpea (*Vigna unguiculata*), Culbro 918 tobacco (*Nicotiana tabacum*), and Henderson lima bean (*Phaseolus lunatus*). Microplot experiments showed that SBM + urea mixtures resulted in control of *M. arenaria* and improved appearance of gardenia (*Gardenia jasminoides*) equal or better than that obtained with aldicarb treatment. Department of Plant Pathology, Auburn University, Auburn, AL 36849.

RODRIGUEZ-KABANA, R., D. G. ROBERTSON, H. IVEY, and C. F. WEAVER. Evaluation of a soybean cultivar tolerant to root-knot nematode for management of *Meloidogyne arenaria* in a peanut-soybean rotation.

The value of rotations of 'Kirby' soybean (*Glycine max* Merr.) with 'Florunner' peanut (*Arachis hypogaea* L.) for the management of *Meloidogyne arenaria* (Neal) Chitwood was studied for 3 years (1985, 1986, 1987) in a field near Headland, Alabama. Each year plots with soybean had the lowest soil population of *M. arenaria* juveniles determined at peanut-harvest time. Plots in peanut monoculture had the highest numbers of juveniles. Peanut following either one or two years of soybean resulted in ca. 50% reduction in juvenile soil population and a 14 (1-year soybean) or 20% (2-year soybean) increase in yields compared with continuous peanut. The soybean-peanut rotation resulted in increased peanut yield equal or higher than those obtained with aldicarb treatment at recommended use rate in continuous peanut. Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, Auburn, AL 36849.

SANDALL, L. J., and T. O. POWERS. Estimates of nucleotide sequence divergence among mitochondrial genomes of the soybean cyst nematode.

Nucleotide differences in mitochondrial DNA (mtDNA) have been used to estimate genetic divergence between mitochondrial genomes of soybean cyst nematode (SCN). These estimates can be used to derive phylogenetic relations among mitochondrial genomes from geographically diverse SCN populations. MtDNA from 19 populations representing seven states and five countries have been examined by restriction endonuclease analysis. Restriction fragments, end-labelled by (α -³²P) dNTP and the large fragment (Klenow) of DNA Polymerase I, were electrophoretically separated on 20-cm agarose gels. To date, estimates of percent nucleotide sequence divergence range from 0.0%, or complete identity of mitochondrial genomes, to 2.1%. The greatest sequence divergence was found between mitochondrial genomes from Virginia and Kansas populations. Phylogenetic analyses are

being conducted to assess congruence between genome relationships and geographic distribution. Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583.

SAYRE, R. M., W. P. WERGIN, T. NISHIZAWA, and M. P. STARR. Comparison of the fine structure of *Pasteuria penetrans* from *Meloidogyne incognita* with a related bacterium parasitizing *Heterodera glycines*.

On the basis of host ranges and morphometric differences, the bacterial parasite of the soybean cyst nematode (BSCN) was readily distinguished from a closely related species, *Pasteuria penetrans* parasitizing root-knot nematodes (PR-KN). When the two nematodes were cross-inoculated with endospores of the two bacteria, reattachments occurred only on the original host nematode. Electron micrographs of both bacteria showed similar cup-shaped sporangia, their measurements different. Mature sporangia of BSCN averaged $3.83 \pm 0.34 \mu\text{m}$ in diameter and $1.89 \pm 0.39 \mu\text{m}$ in height; the central elliptical endospore had an axial measurement of $1.64 \pm 0.15 \mu\text{m}$ by $1.30 \pm 0.12 \mu\text{m}$. Sporangia of PR-KN averaged $3.31 \pm 0.21 \mu\text{m}$ in diameter and $2.48 \pm 0.22 \mu\text{m}$ in height; the central elliptical endospore measured $1.10 \pm 0.11 \mu\text{m}$ by $1.42 \pm 0.12 \mu\text{m}$. These differences suggest BSCN might be assigned to a new species within the genus *Pasteuria*. Nematology Laboratory, USDA, ARS, Beltsville, MD 20705.

SCHENCK, S. Spacial and temporal distribution of *Rotylenchulus reniformis* in pineapple soils.

Nematode surveys are carried out as part of the integrated pest management strategy for Hawaiian pineapple plantations. These ongoing surveys revealed a pattern of distribution of *Rotylenchulus reniformis*. On one of the plantations, about 10% of the acreage contained severe infestations and the rest had none or very few. Areas without *R. reniformis* tended to have *Meloidogyne javanica* and vice versa. When present, the *R. reniformis* populations varied in a typical pattern over the four-year pineapple crop cycle. Between crops, populations were brought to undetectable levels by soil fumigation. They began to reappear about five months after planting and reached peak levels at about one year. They then declined gradually to the end of the crop cycle with further decrease to low numbers during intercycle fallow. Although plowing and other field activities dispersed the nematodes plantation-wide, they reappeared cycle after cycle in about the same areas which were not correlated with soil type, elevation, rainfall, temperature, soil pH, organic matter or any other identifiable physical parameter. Dole Pineapple Company, Wahiawa, HI 96786.

SCHMITT, D. P. Population dynamics of races of *Heterodera glycines* as influenced by crop management systems.

Management of *Heterodera glycines* by crop rotation focused on races attacking resistant cultivars. Two years nonhost alternated with 1 year soybean and a corn-wheat-soybean rotation kept populations of *H. glycines* low. The index of parasitism (IP) [(number of females developing on the host differentials/number of females developing on Lee1 X 100) increased on the host differentials 'Peking' and 'PI 88788' from plots with six years of continuous race 1 and 3 resistant soybeans and on 'Pickett' for soybean-corn rotations. On PI 88788, IP decreased on susceptible soybean and did not change on 'PI 90763'. Maximizing nonhost periods between soybean crops suppresses population levels of *H. glycines*, and its adaptation to the differentials. Department of Plant Pathology, Box 7631, North Carolina State University, Raleigh, NC 27695-7631.

SCHNEIDER, R. C., R. E. GREEN, W. J. APT, D. P. Bartholomew, and E. P. CASWELL. Movement and persistence of fenamiphos in soil with drip irrigation.

The mobility and persistence of fenamiphos in Hawaii soils under pineapple cultivation was studied at two sites as a function of irrigation variables and pre-plant fumigation with 1,3-dichloropropene (336 L/ha). Fenamiphos was applied post-plant at a rate of 3.4 kg/ha at two and three month intervals. Fenamiphos residues in the soil profile, nematode populations (*Rotylenchulus reniformis*), plant and root development, and yield were monitored over one crop cycle. Fenamiphos residues were found at depths of 30-40 cm one month after the first application, and to 150 cm after six months. Soil residues were influenced by both irrigation and rainfall as well as by degradation, with deeper penetration at the higher rainfall site. Weekly irrigation of 1.6 cm/ha caused fenamiphos to leach below the root zone (0-30 cm depth). Higher nematicide concentrations were maintained in the root zone by restricting irrigation after fenamiphos application. Pre-plant fumigation did not affect the fenamiphos degradation rate. Nematode populations were reduced to near zero after fumigation, compared with the moderate populations present in

the non-fumigated fenamiphos treatments. Detailed fenamiphos soil profiles taken one year after planting are presented. Department of Agronomy and Soil Science, and Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.

SCHNEIDER, S. M. Penetration of Tobacco Roots by *Meloidogyne incognita*, *M. arenaria*, and *M. javanica*.

Roots of two commercial tobacco varieties and a breeding line were examined for penetration by *M. incognita* (Mi), *M. arenaria* (Ma), and *M. javanica* (Mj). The varieties included Mi-susceptible NC2326 and Mi-resistant K399. All were grown in a greenhouse at 23-30 C. Soil temperature was maintained at 27 C using heating mats. Roots were harvested, washed, and stained at 1, 4, 7, and 14 days. Juveniles penetrating the roots were counted. Numbers of Mi and Ma increased over time, while Mj fluctuated in NC2326. Mi and Ma in K399 rose rapidly, then declined. Final numbers in K399 were 55-70% less than in NC2326. Final populations of Mj were similar in NC2326 and K399. Therefore, K399 appears to be as resistant to penetration by Ma as it is to Mi, but not to Mj. Penetration of the breeding line was inconsistent. Determining the nature of resistance in these plants will require more extensive studies. USDA-ARS Tobacco Research Laboratory, P. O. Box 1555, Oxford, NC 27565.

SCHNEIDER, S. M. Development of *Meloidogyne* spp. in susceptible and resistant tobacco cultivars.

Tobacco cvs 'K-399' and 'Sp G-28' are resistant and 'NC 2326' is susceptible to *M. incognita* (Mi). Seedlings of each cv were inoculated with second stage juveniles and placed in a greenhouse. Soil temperature was maintained at 27 C with heating mats. After 4 days, roots were rinsed and plants transplanted to steamed, nematode-free soil. Roots were sampled, stained, and cleared at transplanting and 13 days later for microscopic observation of nematodes. Numbers of nematodes in each developmental stage were recorded for each sample. Mi in both K-399 and Sp G-28 showed reduced development compared to MC 2326. Initially more nematodes penetrated, but fewer remained in the root in Sp G-28 than in NC 2326 or K-399. These preliminary results suggest different mechanisms of resistance may be active in K-399 and Sp G-28. Sp G-28 may allow more penetration, but less development than K-399. Additional experiments will be done to test this hypothesis. USDA, ARS, Oxford, NC 27565.

SIPES, B. S., and D. P. SCHMITT. Influence of planting date, alachlor, and fenamiphos on postinfection development of *Heterodera glycines*.

The rates of postinfection development of *Heterodera glycines* in the field on *Glycine max* cv. Deltapine 105 planted 29 April, 29 May and 29 June 1986 and 15 May, 15 June and 15 July 1987 were determined in response to alachlor (2.25 kg a.i./ha), fenamiphos (2.25 kg a.i./ha) or both. Fenamiphos allowed little nematode development except during the second planting in 1986 and when applied simultaneously with alachlor during the first planting in 1987. Alachlor did not alter *H. glycines* development as compared to the control on any of the planting dates. Development in the final planting of 1987 was three-fold faster than in 1986. Environmental conditions significantly impacted the interaction between alachlor and fenamiphos. Department of Plant Pathology, Box 7616, North Carolina State University, Raleigh, NC 27695-7616.

SMALLEY, V. K., and E. C. BERNARD. Colonization of *Meloidogyne incognita* females and eggs by nematophagous fungi.

Root-knot nematodes, especially *Meloidogyne incognita*, are destructive pathogens of commercial tomatoes in east Tennessee. Females were extracted from heavily infested, field-collected tomato roots with no further treatment; rinsed 3x or 20x with sterile water; or surface-sterilized with 0.5% NaOCl. All females were placed on antibiotic-amended PDA. Female viability was determined by observation of stylet thrusting and metacarpus movement. Eggs were extracted from field-collected egg masses with 0.5% NaOCl and spread on antibiotic-amended water agar. Eggs from greenhouse cultures were suspended in agar on slides and buried in the field. Fungi, primarily *Paecilomyces lilacinus*, grew from most females (70%) removed from roots and placed on agar. Females rinsed 20x with sterile water showed less evidence of colonization (24%) than those rinsed three times (44%). Fungi did not grow from NaOCl-treated females. Parasitism of eggs from egg masses was negligible, but up to 30% of free eggs on buried agar slides were parasitized. Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37901-

1071.

STERN S., H. JAFFE, A. DE MILO, and R. N. HUETTEL. Disruption of mate finding in soybean cyst nematodes with analogs of the nematode sex attractant.

Heterodera glycines, race 3, was screened in vitro to 15 analogs of its sex attractant. Nematodes were grown on root-explants of Glycine max cv. Kent with 10 mM and 10 μ M of each analog added to Gamborgs B-5 medium (replicated 5x). The number of females observed were recorded at 10, 11, and 12 and at 5 weeks postinfection. No significant differences ($P < 0.05$) were observed in first generation counts among all but one analog. However, significantly fewer females were observed on treated plates at 5 weeks when compared to controls. Addition of the nematode's sex attractant to agar reduced second generation females ca. 25%. Some analogs, however, caused a 100% reduction of second generation females. The use of analogs of natural bioregulators, such as sex attractants, may aid in reducing nematode population by interfering with mate finding. Nematology Laboratory, USDA, ARS, Beltsville, MD 20705.

THOMAS, S. H., C. SENGUPTA-GOPALAN, M. E. ALVAREZ, G. D. KUEHN, and J. D. KEMP. Effects of collagenase from a nematode-trapping fungus on *Pratylenchus scribneri*.

A fungal collagenase enzyme that hydrolyzes nematode collagen was isolated and purified from a cultural filtrate of the nematode-trapping fungus Arthrobotrys amerospora. The enzyme was precipitated with ammonium sulfate and purified using DEAE cellulose ion exchange chromatography and FPLC. When evaluated for activity against bovine collagen and nematode cuticular collagen from Pratylenchus scribneri, the purified enzyme (molecular weight, 28,000) more actively hydrolyzed the nematode collagen. Subsequent experiments conducted to date have demonstrated inhibition of movement and increased mortality of P. scribneri treated with FPLC-purified enzyme in vitro. Department of Entomology, Plant Pathology and Weed Science, Box 3BE, New Mexico State University, Las Cruces, NM 88003.

TIMPER, P., and H. K. KAYA. Role of the second-stage cuticle in determining the susceptibility of entomopathogenic nematodes to the endoparasitic fungus *Hirsutiella rhossiliensis*.

The second-stage (J2) cuticle of various species and strains of Steinernema and Heterorhabditis were removed either by allowing the dauers to move through moist sand or by treating the dauers with 0.05% sodium hypochlorite. Dauers with and without the J2 cuticle were placed in cultures of H. rhossiliensis for 3-4 hours, transferred to water agar plates or to saturated soil extract, and observed for infection and death daily for four days. Steinernema spp. lost 100% and Heterorhabditis spp. lost 0-22% of their J2 cuticles as they moved through moist sand. All nematodes without their J2 cuticle, regardless of genus or species, became infected and died when H. rhossiliensis spores adhered to their third-stage (J3) cuticle; although H. rhossiliensis spores adhered to nematodes with J2 cuticles, less than 1% of these nematodes became infected. The method of J2 cuticle removal did not influence spore adhesion or infection through the J3 cuticle. Department of Nematology, University of California, Davis, CA 95616.

TINIUS, C. N., D. P. SCHMITT, and T. E. CARTER, JR. Response of a resistant/susceptible soybean blend to *Heterodera glycines*.

In North Carolina, a yield advantage was observed with a 50:50 blend of 'Centennial' and 'Young' soybeans compared to pure stands of the component cultivars. The impact of resistance in Centennial to Heterodera glycines on blend performance was studied in the greenhouse. Steamed soil in 20-cm-d pots was infested with 10,000 eggs of H. glycines race 1. Root penetration was determined at seven days. Root and shoot dry weights, and numbers of cysts/pot were determined at 32 and 60 days. Root penetration was similar in all treatments at seven days. Fewer ($P=0.07$) cysts were recovered from the blend than the mean of the components at 32 days; however, by 60 days this relationship was reversed ($P<0.01$). Inoculated plants from all treatments had less root dry weight but similar shoot dry weight compared to controls at 32 days. By 60 days the susceptible Young had the greatest suppression in root and shoot growth. Average blend root and shoot growth was similar to the resistant Centennial, even though the nematode population was large on the blend. Departments of Crop Science and Plant Pathology, North Carolina State University, Raleigh, NC 27695-7631.

TSAI, B. Y., and S. D. VAN GUNDY. Effect of DL-methionine on host response to root-knot

nematodes.

The antimetabolite, DL-methionine at concentrations ranging from 200 to 800 ppm. effectively controlled Meloidogyne incognita on tomatoes (89.8 to 97.5% reduction in galling) in sterilized blow sand. In field soil the compound significantly increased the fruit yield by two to three fold. DL-methionine also controlled root-knot nematodes on cucumber, sugar beet, and potatoes. There was a differential dosage response in different plants. No contact toxicity to the nematode juvenile was found in vitro. However, 93% of the nematodes were immobilized within 24 hours in the presence of cucumber seedlings grown in a transparent seed pouch treated with DL-methionine, suggesting an interaction with root exudates or the effect of breakdown products of DL-methionine after host metabolism. DL-methionine also alters the host response to the nematodes by reducing the size of the galls. A test with the split-root system indicated that the effect of DL-methionine was translocatable between roots. Department of Nematology, University of California, Riverside, CA 92521.

TYLKA, G. L., R. S. HUSSEY, and R. W. RONCADORI. Interaction of soybean and Heterodera glycines as affected by vesicular-arbuscular mycorrhizal fungi and phosphorus fertility. The effects of vesicular-arbuscular mycorrhizal (VAM) fungi and phosphorus (P) fertility on Wright soybean growth and H. glycines (SCN) reproduction and development were determined in greenhouse experiments. Treatments were the presence or absence of a combination of four VAM fungi, 31.5 kg/ha (low) or 49.4 kg/ha (high) P, and four SCN inoculum levels (0, 7, 42, and 252 eggs/100 cm³ soil). Growth of mycorrhizal and nonmycorrhizal soybean was similar at 7 weeks. However, mycorrhizal plants had greater shoot and root growth than nonmycorrhizal plants across all SCN inoculum levels at 14 weeks. Soil population densities of second-stage juveniles and eggs and nematode penetration and development in roots were greater for nonmycorrhizal plants at the highest SCN inoculum level after 7 weeks. The largest numbers of cysts were on high P, nonmycorrhizal plants with the highest SCN inoculum level after 7 weeks, but by 14 weeks greater numbers of cysts were present on mycorrhizal plants across all treatments. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

VON MENDE, N., D. MCK. BIRD, P. S. ALBERT, and D. L. RIDDLE. A collagen gene in Caenorhabditis elegans affects body shape. In C. elegans, more than 30 genes affecting body shape have been identified by genetic work in several laboratories. Mutations in dpy (dumpy) genes result in short, fat adults. We have cloned and sequenced one such gene, dpy-13, and found that it encodes collagen, a structural component of the cuticle. To identify DNA clones corresponding to dpy-13, three mutants resulting from transposon insertion were isolated and studied. The gene lies within a 1.25 kilobase pair (kb) HindIII/EcoRI fragment that detects a 1.1 kb messenger RNA. The DNA sequence reveals homology to two collagen genes of known sequence in C. elegans. There is a close relationship to col-1, as both genes encode five short helical regions with glycine as every third amino acid. When hybridized to restriction digests of genomic DNA, both dpy-13 and col-1 detect the same range of 12 to 20 fragments (bands) which represent a subset of the collagen gene family. Although the dpy-13 gene is similar in structure to other collagen genes, it must have a unique function because it is essential for development of a normal body shape. When the C. elegans gene is hybridized to the DNA of Ascaris a few bands are detected, whereas hybridization to Heterodera glycines DNA detects only one band. These related Ascaris and Heterodera sequences may encode similar cuticle collagens. Division of Biological Sciences, University of Missouri, Columbia, MO 65211.

VRAIN, T. C., M. B. GRAHAM, and B. A. EBSARY. Two new species of Xiphinema in British Columbia vineyards.

In a preliminary survey, 80% of 280 soil samples taken from 79 vineyards contained one of two species of Xiphinema. These nematodes were found in a wide range of soil types, with every grape variety from which soil was taken. The first species is closely related to X. occiduum and X. thornei. It differs from X. occiduum by the larger stylet, shorter spicules, more supplements and larger tail. It differs from X. thornei by larger c' value, longer tail length, greater tail width and amphid size. The second species is closely related to X. californicum, but differs by the larger tail, larger c' value, longer odontophore, more posterior vulva and differences in the position of the caudal papillae. Agriculture Canada, Research Station, Vancouver, B.C. Canada V6T 1X2, Biological Sciences

Department, Simon Fraser University, Burnaby, B.C., and Biosystematics Research Center, Ottawa, Ontario, Canada.

WALTER, D. E., and E. K. IKONEN. Species, guilds, and functional groups: Using taxonomy to predict trophic behavior in nematophagous arthropods.

Phylogenetic relationship is an indication of shared abilities, or at least of shared constraints on morphology, physiology, and behavior, but is phylogenetic relationship a sufficient criterion for predicting ecological function? In predatory soil arthropods, phylogeny is often a good predictor of ecologically important characteristics such as developmental time or prey capture strategies (e.g., pursuit vs. ambush); however, because of divergence in resource use by related taxa and convergence in resource use by unrelated taxa, guilds or functional groups based on broad taxonomic affinity have little ecological meaning. Since morphology is more strongly conserved than behavior, divergence in resource use among related animals cannot always be predicted by the structure of the feeding apparatus. Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523.

WARNER, F. W., J. F. DAVENPORT, and G. W. BIRD. Soil chemigation for *Pratylenchus penetrans* and *Verticillium dahliae* control in Michigan potato production.

To determine the effectiveness of sodium methylthiocarbamate (metham) applied in irrigation water for control of *Pratylenchus penetrans* and *Verticillium dahliae*, extensive sampling of 1300 acres of potatoes (cv. 'Superior') was completed from 1985-1987 in Antrim County, Michigan. Metham applied in the fall of 1984 (0, 27, 53, and 103 gal/A) through a 40 -A center pivot irrigation system, resulted in 182, 14, 8 and 0 *P. penetrans*/1.0 g root (24 July 85), respectively. The treatment also controlled *V. dahliae* (20, 19, 0 and 0 colonies per 1.0 g soil) and increased tuber yields (300, 417, 490 and 485 cwt/A) in 1985. Control of *P. penetrans* was maintained through 20 August 1987, by the high rate of metham (78, 196, 129 and 0 *P. penetrans*/1.0 g alfalfa root. Yield increases were not obtained when metham was applied to virgin potato ground. Spring application (1986-87) of metham was not as effective for nematode control as fall application. Departments of Botany and Plant Pathology and Entomology, Michigan State University, E. Lansing, MI 48824.

WEAVER, C. F., R. RODRIGUEZ-KABANA, D. G. ROBERTSON, and H. IVEY. Bahiagrass-peanut rotation for the management of root-knot nematodes.

The effect of 'Pensacola' Bahiagrass (*Paspalum notatum* Flugge) in rotation with peanut (*Arachis hypogaea* L.) on populations of *Meloidogyne arenaria* (Neal) Chitwood at peanut for 2 years (1986, 1987). Each year soil populations of juveniles of *M. arenaria* at peanut harvest time were 96-98% lower in plots with bahiagrass than in plots with peanut. Peanut yields in 1987 in plots that had bahiagrass the previous year were 27% higher than in plots under peanut monoculture. Juvenile populations in bahiagrass-peanut plots were 41% lower than in plots with continuous peanut. The use of bahiagrass for reducing populations of *M. arenaria* and increasing yields of a succeeding peanut crop was as effective as the use of aldicarb at recommended use rate for peanut. Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, Auburn, AL 36859.

WERGIN, W. P., and R. M. SAYRE. Applications of low voltage field emission SEM in nematology.

A new generation of scanning electron microscopes (SEMs) known as low voltage field emission (LVFE) SEMs have distinct advantages to nematologists. The instruments have a ten-fold increase in resolution, require little or no specimen coating, operate at 1 or 2 kV, and have an electron density nearly 1000 X brighter than that of conventional SEM. As a result, fine-structure topography of uncoated specimens is greatly improved. The LVFESEM was used to observe, at magnifications of 500 to 100,000 X, juveniles and males of *Heterodera glycines*, some of which were infected with the bacterial parasite of cyst nematodes (BPCN). The results clearly illustrate spicules with two lateral openings, 0.1 to 0.2 μm in diameter, near the bidentate tip; distinct labial pores around the stoma in the labial disc which is surrounded by irregular lip annules and discontinuous annulations; and fine fibers and the reticulate pattern on the surface of the infective spores of BPCN. These observations indicate that LVFESEM will greatly enhance our knowledge and understanding about the structure-function relationships of nematode structures. Plant Stress Laboratory, USDA-ARS, Beltsville, MD 20705.

WESTCOTT, S. W., III. In vitro culture of *Criconemella xenoplax*.

Adults and juveniles of *Criconemella xenoplax* (Raski) Luc and Raski have been disinfested and grown on slices of disinfested carrot, *Daucus carota* L., on water agar in petri dishes. Periodic observations of behavior and development could be made since many of the nematodes remained on the upper surface of the carrot. Frequently nematodes became quiescent for several days after being placed on carrots, while similar nematodes kept in water or placed on water agar remained active. Nematodes could be observed with their heads pressed against carrot cells, and in some cases pulsing of the esophagus could be observed. Frequently a nematode's head or entire body was buried in a crack or hole in the surface of the carrot, and it was presumed that feeding was occurring. Some nematodes have remained in a feeding position at a single site for up to 45 days. Eggs were laid by some adults without moving from a feeding position. In these cases 5-10 eggs were laid during a 5-day period after which no further laying was observed during a 4-week period of observation. Cultures initiated with 20-50 adults increased in population density by 5-10 fold in 12 weeks. All stages of the nematode were observed in these cultures. Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29631.

WESTERDAHL, B. B., H. C. CARLSON, and J. D. RADEWALD. Fumigant dispersal in a silty clay loam soil containing 10-12 percent stable organic matter.

Dispersal of 1,3-dichloropropene (Telone II), shank injected at a depth of 40 cm, was monitored with biological indicators in five studies in two locations in the Tulare Basin of California. The nematicide was applied at 0, 140, 234, and 327 liters/ha of Telone II on 9 October and 4 November 1986 and 30 April 1987 (one application per site). Soil temperature at the injection depth was 9-12 C and soil moisture 46-86%. Field populations of *Pratylenchus neglectus* were sampled at depths of 0-8, 8-30 and 30-60 cm before and 15-50 days after fumigation. *Tylenchulus semipenetrans* and red annelid worms were buried at increments before fumigation and removed and assessed for viability after fumigation. In all studies, the assays demonstrated that dispersion at nematicidal levels was limited to 0-15 cm from the point of injection. Department of Nematology, University of California, Davis, CA 95616.

WHEELER, T. A., K. R. BARKER, and S. M. SCHNEIDER. Interaction of soil moisture and *Meloidogyne* spp. on tobacco.

Interactions of *Meloidogyne* spp. population density and soil moisture were examined in a split-plot design with nematode density as the main plot and soil moisture as the subplot. Microplots were infested with *Meloidogyne incognita* (MI) or *M. arenaria* (MA) at densities between 0 and 5000 eggs per 500 cm³ soil. High soil moisture was maintained by frequent watering with a drip irrigation system, and low moisture plots received limited irrigation. Moisture was monitored with a neutron probe. Rainfall was deflected from plots by plastic covers. Yield (dried leaf weight and dollar value/plant) was affected by the interaction of nematode density and water level for MI and MA (P=0.05). Main effects for both nematode species were not significant (P=0.05). Population density of MI at midseason was higher in wet soil treatments than in dry soil treatments (P=0.05). Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

WINDHAM, G. L., M. T. WINDHAM, and W. P. WILLIAMS. Effects of *Trichoderma* spp. on *Meloidogyne arenaria*-infected maize.

The interaction of *Trichoderma koningii* (TK), *T. harzianum* (TH), and *Meloidogyne arenaria* (MA) on maize hybrids 'Northrup King 508' (MA resistant) and 'Pioneer Brand 3110' (MA susceptible) were studied in the greenhouse. A peat-wheat bran inoculum of TK and TH was added at planting, and 3000 MA eggs were added 7 days after planting. Data on plant growth and nematode reproduction were recorded 50 days after infestation with MA. All TK and TH treatments, both with and without nematodes, significantly increased plant height, shoot dry weight, and root fresh weight of both maize hybrids. Reproduction of MA on Northrup King 508 was not affected by TK or TH. However, TK and TH reduced (P=0.05) the number of eggs per gram on Pioneer Brand 3110. Crop Science Research Laboratory, P.O. Box 5367, Mississippi State, MS 39762.

YOUNG, L. D., and L. G. HEATHERLY. Soil texture and water potential effects on soybean and *Heterodera glycines*.

Soil texture and water potential effects on soybean seed yield and population dynamics of *Heterodera glycines* (Hg) were evaluated in a greenhouse environment. 'Tracy M' soybean

[Glycine max (L.) Merr.] was grown at optimum (-30±5 kPa) and dry (0.5 times the water added to optimum) soil water potentials established in clay and silt loam soils that were either not infested with Hg or infested with 700 Hg cysts/L. Hg cysts were six times greater in the silt loam than in clay soil at harvest. In the clay soil, there were approximately equal Hg at both water potentials at harvest, but in silt loam soil Hg was significantly greater at the optimum water level. Seed yields of the noninfested dry and the infested optimum treatments were equal regardless of soil type. For each soil type, highest yields were obtained from the noninfested, optimum water treatment. Seed yield in noninfested clay soil at optimum water potential was significantly greater than all other treatments. USDA-ARS, Nematology Research, 605 Airways Boulevard, Jackson, TN 38301.

YOUNG, R. W., R. RODRIGUEZ-KABANA, H. IVEY, and P. S. KING. Hairy indigo for the management of *Meloidogyne arenaria* in peanut.

Rotation of hairy indigo (*Indigofera hirsuta* L.) with 'Florunner' peanut (*Arachis hypogaea* L.) was evaluated for the management of *Meloidogyne arenaria* (Neal) Chitwood in a 2-year (1986, 1987) field experiment at the Wiregrass Substation near Headland, Alabama. Juvenile populations of the nematode in soil, determined at peanut harvest time, were nil in plots with indigo both years; average juvenile numbers in plots with untreated continuous peanut were 147 and 217/100 cm³ soil in 1986 and 1987, respectively. Juvenile populations in plots with peanut in 1987 that had indigo the previous year were as high as those of plots planted with peanut both years; however, peanut yields in the indigo-peanut rotation were 18% higher than the yield for plots in peanut monoculture. The indigo-peanut rotation did not result in as high a yield response as the recommended aldicarb treatment (11 kg a.i./ha, broadcast basis) for peanut monoculture. Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, Auburn, AL 36849.

ZHENG, LIANG, and HOWARD FERRIS. Factors affecting hatch of *Heterodera schachtii* eggs.

Cysts of *Heterodera schachtii* were cultured on sugar beet plants grown in the greenhouse or lathhouse and used directly, or after pretreatment by storage in wet or dry soil for 3 to 6 months, for hatching studies. Treatments designed to stimulate hatch included exposure for different times to different temperatures, to different concentrations of sugar beet root diffusate, and to root diffusates from other host and nonhost plants. The studies indicate that there are at least three categories of hatch delay in *H. schachtii* eggs: 1) eggs that will not hatch in water, but that are stimulated by host-root diffusate (host-mediated delay); 2) eggs that will not hatch when moved from low winter soil temperatures to favorable temperatures (temperature-mediated delay); and 3) eggs that are not stimulated to hatch by either root diffusate or chilling, but that hatch at a very slow rate with passage of time (time-mediated delay). These mechanisms all have survival value and adaptive significance for the species in agriculture. Department of Nematology, University of California, Davis, CA 95616.