ABSTRACTS OF PAPERS

presented at the

Twenty-Eighth Annual Meeting of the

SOCIETY OF NEMATOLOGISTS

University of California

Davis, California

13–17 August 1989

AMES, L. M., and G. C. SMART, JR. Migration of an entomogenous nematode, Steinernema n.sp., through selected Florida soils.
Infective juveniles (IJs) were released on the soil surface of four soils 8 cm above the house cricket (Acheta domesticus). At the initiation of the experiment, all soils had a moisture equivalent of 1/10 bar (= approximately field capacity). After 5-7 days the host insects were removed and examined for nematode infections. The IJs migrated successfully through all soil types tested. There was little difference in infection after migration through 98% sand, 90% sand or organic (muck) soil; however, infection was less after migration through soil with a clay content greater than 20%. Nematode reproduction in the host cadaver was observed 5 days after release in all soils except that with a greater than 20% clay content. Nematology Laboratory, Bldg. 78, University of Florida, Gaineville, FL 32611 0611.

AREVALO, M., and M. P. KO. Differential effects of marigold cultivars on Pratylenchus penetrans reproduction.
Forty-eight commercial marigold cultivars (27 Tagetes patula and 21 T. erecta) were compared for their susceptibility to penetration and degrees of suppressiveness to P. penetrans. Pea (cv. Wando) was used as a susceptible host control. Pea or marigold seedlings (10-day-old) growing in pasteurized soil were inoculated with 5,000 P. penetrans (Pi) and arranged in a randomized complete block design with eight replications in a growth chamber. The plants were grown at 25 C with 16 hours light and 8 hours dark. Numbers of nematodes that penetrated the roots were determined after 1 week from root samples stained with acid fuchsin. Final population (Pf) in the roots and soil were estimated at 6 weeks from nematodes extracted by the pie-pan or shaker method, respectively. Pf/Pi ratios of P. penetrans on different Tagetes cultivars relative to that on peas were used as an indication of degree of nematode suspension. All marigold cultivars allowed P. penetrans penetration. However, nearly all of them suppressed subsequent nematode reproduction. A few cultivars, such as the Crush series of T. erecta, supported 10-20 times as much P. penetrans reproduction as did other marigold cultivars. These cultivars may possibly be used as controls for studying the development of nematodes in marigold roots. Department of Plant Pathology, Cornell University, Ithaca, NY 14853.

BARBERCHECK, M. E., and H. K. KAYA. Detection of suitable hosts by entomogenous nematodes.
The nematodes, Heterorhabditis heliothidis (Hh) and Steinernema feltiae (Sf), and the fungus, Beauveria bassiana (Bb) are insect pathogens which possess wide and overlapping host ranges. Sf and Hh only reproduce in Bb-infected Galleria mellonella larvae if the nematodes infect at the same time or within 2 days after the fungus. The ability to distinguish between a healthy and Bb-infected host may greatly affect the establishment and persistence of Hh and Sf in areas where Bb exists naturally. Attractiveness of healthy, cold-killed, and Bb-infected G. mellonella larvae to Hh and Sf was assayed. Healthy hosts were more attractive than cold-killed or Bb-infected hosts to Hh. Sf was equally attracted to Bb-infected, cold-killed, and healthy hosts. Department of Nematology, University of California, Davis, CA 95616.

BARKER, K. R., and S. R. KOENNING. Influence of soil moisture and texture on Heterodera glycines/Glycine max interactions.
A factorial experiment with six soil textures, two moisture levels, and four inoculum levels (0, 100, 800 and 6400 eggs/500 cm^3 soil) (Pi) was conducted in microplots to characterize Heterodera glycines-damage functions on soybean. Pi, soil moisture, and soil texture had significant effects on soybean yield ($P = 0.01$). All first order interactions were significant ($P = 0.01$), but the second order interaction was not. Soil moisture impacted soybean yield more than soil texture or Pi. Plants under moisture-deficit stress yielded 40% less than those with adequate moisture. As few as 100 eggs of H. glycines resulted in soybean yield suppression of 30 and 37% for high and low moisture, respectively. Soybean yield suppression was greater in coarse-textured than in fine-textured soils. Soil texture effects on final population densities and all first order interactions were significant ($P = 0.01$). Numbers of H. glycines eggs, second-stage juveniles, and cysts at midseason were affected by soil texture ($P = 0.01$), but not by soil moisture. Low moisture favored late season reproduction of this pest. Final population densities for all treatments were inversely related to initial nematode levels. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

BARKER, K. R., S. C. HUBER, S. R. KOENNING, W. LIU, and D. P. SCHMITT. Suppression of photosynthesis in soybean by Heterodera glycines.
Photosynthesis of soybean, as affected by initial population levels of Heterodera glycines in greenhouse, microplot and field tests, was determined with Li-Cor 6000 and 6200 systems. In addition, the effects of nematode numbers on specific carbohydrate levels were assessed after ethanol-extraction of leaf tissue and enzymatic determination of starch, sucrose, and hexose sugars (fructose and glucose). Photosynthetic rates were inversely related to ini-

tial nematode numbers (0, 312, 1,250, 5,000, 20,000 eggs per plant). Nematode damage also was reflected in restricted hexoses and sucrose. In contrast, the basal leaf-starch content (per unit area) increased with greater levels of H. glycines, indicating induced starch mobilization in darkness. H. glycines had little impact on photosynthesis per unit leaf area (Pcm^2) in a fine-textured Cecil clay soil in microplots. There was a negative relationship, however, between Pcm^2 in a Fuquay sand and level of initial inoculum (Pi). Moisture-deficit stress also resulted in a suppressed photosynthetic rate ($P = 0.01$) but did not interact with Pi. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

BECK, J. L. and B. C. HYMAN. Real-time sequence amplification and gene rearrangement within nematode mitochondrial DNA.
Romanomermis culicivorax, an obligate mosquito parasite, contains unusually large mitochondrial (mt) genomes of 26-32 kilobase pairs (kb). The mtDNA size variation is due to the differential amplification of a specific 3 kb locus within individual mitochondrial genomes. This reiterated mtDNA is present in tandem, direct repeats, and as unlinked inverted copies elsewhere in the genome. The rearrangements that dispersed the amplified mtDNA segments may also have been involved in separating the genes for cytochrome oxidase subunits by approximately 8 kb. We prepared mtDNA from a second R. culicivorax culture reproductively isolated from our population by approximately 160 generations. These molecules contain similar 3 kb repeating units, unexpectedly amplified to a different extent relative to previously characterized mtDNAs. These rearrangements are therefore occurring within "real time." Nucleotide analysis of the 3.0 kb repeating unit and its endpoints has generated a model for mtDNA rearrangement requiring amplification followed by sequence inversion in the evolution of this unique mitochondrial genome. Department of Biology, University of California, Riverside, CA 92521.

BECKENBACH, K., B. XUE, B. KACHINKA, and D. BAILLIE. Use of Tc-1 related sequences to identify races in the Phyla Nematoda.
Some species of economically important plant-parasitic nematodes are difficult to tell apart. Quick and accurate identification of these species, races, or pathotypes is necessary for informed decisions to be made on crop management. Two genera with which we have worked are Meloidogyne (root-knot nematode) and Bursaphelenchus (pine wilt nematode). We have developed species-specific probes for some of the species in these genera; but, these probes are not sufficiently sensitive to distinguish races or pathotypes. To facilitate subspecific identification we isolated a 0.9 kb EcoRV/XhoI fragment from the C. elegans transposable element Tc-1. This clone contains most of the coding region for the transposase gene which is conserved for Tc-1 like transposons. This clone was used to probe genomic DNA from each species. This DNA had been digested with a restriction enzyme EcoRI. We established that the various intraspecific races have different patterns of hybridization. This will allow for the quick and reliable identification of the races we have tested. The procedure should be useful with other species of nematodes where accurate identification is necessary, and it will significantly decrease the long, labor intensive process of nematode diagnosis. Simon Fraser University, Burnaby, British Columbia Canada, V5A 1S6.

BERNARD, E. C. Host-parasite relationships of a new root-knot nematode on legumes.
An undescribed Meloidogyne sp. of the graminis-group, but parasitic on white clover, was collected from soil in a mixed clover-fescue pasture in southwest Tennessee in 1987. In experimental host range studies, this nematode galled roots and reproduced on all tested Trifolium spp. and cultivars, 21 soybean cultivars, and four cultivars of Vicia sativa. Nine birdsfoot trefoil, five sericea lespedeza, and six alfalfa cultivars were highly resistant or immune. On alfalfa, small galls were produced but nematode development did not proceed past the J2 stage. On susceptible hosts, galls were spherical to fusiform and usually contained several nematodes each. Egg masses characteristically were retained within the root cortex and were not exposed on the root surface. Hatched juveniles often migrated through the cortex longitudinally before emerging. Males were produced abundantly and usually coiled within the egg masses. The nematode produced typical giant cell complexes on susceptible hosts. Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37901-1071.

BERNEY, M. F., and G. W. BIRD. Comparative hatching of two populations of Heterodera carotae Jones 1950.
Field (FP) and greenhouse (GP) isolates of Heterodera carotae from Michigan were used to test the impact of temperature and root exudates on nematode hatching--emergence. Experiments were conducted in controlled environment chambers. Cysts were subjected to root filtrates from greenhouse grown carrots. Numbers of emerging second-stage juveniles were recorded daily. Treatments included filtrates from healthy carrot roots, carrot roots infected with H. carotae and (or) Meloidogyne hapla, and several temperatures. FP had the

greatest hatching response to root filtrate from noninfected carrots, and the least to filtrate from M. hapla-infected carrots. Response to filtrate from H. carotae-infected carrots was intermediate. GP had a similar hatching pattern to filtrate from M. hapla-infected carrots; however, responses from H. carotae-infected carrot filtrate exceeded the response to filtrate from noninfected carrots. FP and GP also differed in their hatching response to temperature. Department of Entomology, Michigan State University, East Lansing, MI 48824.

BIRD, G. W., R. BLACK, and B. MARSHALL. Nematicide impact assessment in potato production. A survey representing 4,143 hectares of potato production area, indicated that 70% of the soil associated with Michigan's 20,250 hectares potato crop was treated with a nematicide in 1988. Nonfumigant organocarbamate and organophosphate nematicides represented 52% of the total cost of materials used, while chemigants and soil fumigants were 31% and 17%, respectively. Farms producing more than 101 hectares of potatoes used considerably more nematicides on a per-acre basis than 20-101 hectare (medium) or < 20 hectares (small) farms. The average nematicide treatment cost was $170.50/ha with a range of $36.50 to $555.75/ha. The cost of nematicides for 1988 potato production in Michigan represented 36% of the total pesticide cost (42%, 13% and 8% for insecticides, fungicides and herbicides, respectively). State-wide potato nematode surveys conducted in 1975 and 1982, and 1973-1988 pesticide evaluation research data were used as a base for estimation of the impacts of nematicides on potato productivity and tuber quality. Department of Entomology, Michigan State University, East Lansing, MI 48824.

BIRD, D. McK., and M. A. WILSON. DNA sequence-analysis of ama-1 IV, the gene encoding the largest subunit of Caenorhabditis elegans RNA polymerase II.
We are interested in understanding mechanisms by which gene expression is regulated during animal differentiation and development, and are exploiting the free-living nematode Caenorhabditis elegans as a model metazoan. Several lines of evidence implicate the largest subunit of RNA polymerase II (RNAP II) as being a site of crucial interactions between transacting gene regulators and the transcription machinery. In C. elegans, this RNAP II subunit is encoded by the gene ama-1. Here we report a DNA sequence analysis of ama-1. Beginning approximately 3.5 kb upstream from the ATG, we have sequenced through the transcribed region of the genomic clone (~9.3 kb) and past the AAUAAA. We have used a near full length cDNA clone to confirm splice junctions and the 3'-end. The gene is broken into thirteen exons. Our previous inference of the 3'-end processing signals (an AAUAAA which overlapped the stop codon, and a TGTGT motif 34 bp downstream) was found to be incorrect. The 3' untranslated region is, in fact, 393 bp to the first A of the tail, and is interrupted by a large intron (>900 bp). The mature transcript is, not counting the poly-A tail, 5,720 bp, which is consistent with the 5.9 kb seen on northerns. Currently, we are using two approaches to sequence ama-1 lethal alleles. Guided by the fine structure map, a PCR approach is being followed for those which can be maintained as homozygotes (at 15C). For the majority of the lethals, however, cloning seems necessary. In each case, an 11 kb Mlu I fragment is cloned into an ama-1 promoter vector (DB#10). The balancer allele is distinguished by its lack of the m118 (amanitin-resistance) mutation. We plan to examine promoter function of ama-1 by introducing a series of promoter (DB#10) deletions, fused to m118, into wild type animals. We hope soon to switch from micro-injection to particle gun technology. Department of Nematology, University of California, Riverside, CA 92521.

BOAG, B., and R. NEILSON. Spatial distribution of cereal cyst nematode, Heterodera avenae.
Plant-parasitic nematodes are known to have an aggregated distribution but the amount of aggregation is unknown for most species. To ascertain the spatial distribution of cereal cyst nematode in fields in eastern Scotland, two approaches were investigated. The first entailed sampling a 15 x 15 grid with 7 m between sampling points. Results indicated that the aggregated distribution observed in total cyst numbers was very highly correlated with that of viable cysts and number of eggs and juveniles. The second nested sampling procedure entailed the sampling intervals of 7 cm, 20 cm, 60 cm, 1.8 m, 5.4 m, 16.6 m and 50 m. The results of nine such sets of samples in five fields were analyzed using semivariograms. Results indicated an increase in aggregation with increasing distance. The results of this study are being used to produce an optimum sampling procedure for cereal cyst nematodes. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

BRODIE, B. B., and M. L. BRUCATO. Relation of cyst age and egg density to establishment of Globodera rostochiensis populations.
Cysts of Globodera rostochiensis were extracted from naturally infested field soil, individually crushed, and divided into 4 cyst classes according to numbers of viable eggs/cyst. These classes were: I = > 100; II = 50-100; III = 10-50; and IV = 2-10 viable eggs/cyst. Twenty 12-cm tall potato plants in 7.6-cm-d clay pots were inoculated with the eggs from each of 20 cysts from each cyst class. Plants were inoculated by washing the contents of a cyst into a depression in the soil of each pot. The same number of plants

were inoculated with a comparable number of viable eggs from 4-month-old-cysts. Plants were grown in the greenhouse (23-25 C) until they senesced. Afterwards, cysts were extracted from the soil by flotation. The probability of G. rostochiensis population establishment was determined from the number of cysts with viable eggs recovered per pot. The probability of establishment with 40% at an average inoculum density of 7 viable eggs/pot and 100% at an average of 75 or more eggs/pot. Age or source of cysts did not influence the probability of population establishment. Juveniles emerged, infected the roots, and reproduced equally as well from field cysts ≥ 1 yr old, as they did from 4-month-old cysts. USDA, Agricultural Research Service, Department of Plant Pathology, Cornell University, Ithaca, NY 14853.

BROSSARD, J. P., G. B. DUNPHY, and S. B. HILL. Effectiveness of two Heterorhabditis spp. and two Steinernema spp. against the plum curculio Conotrachelus nenuphar Herbst (F. Curculionidae).
Plum curculio (PC) is one of the most important insects attacking apple fruit in Canada and in USA. However, due to the lack of known biological control agents, chemical insecticides are still the only way to control PC populations. Potential control agents tested against PC include the entomophilic nematodes Steinernema feltiae, S. bibionis, Heterorhabditis heliothidis, and H. bacteriophora. The LD50's and LT50's of these nematodes were determined for larvae and adults in Petri dishes as well as on PC larvae in the soil. In addition, mortality results showed that only S. feltiae was effective against PC adults with an 80% mortality. However, S. feltiae, and S. bibionis tested against larvae resulted in an 80-90% mortality in Petri dishes, and with a slightly lower percentage against larvae in soil. Both PC adults and larvae were not affected by Heterorhabditis spp. These results show for the first time that potential of these nematodes as biological agents against PC is excellent. Department of Entomology, MacDonald College, 21,111 Lakeshore Road, Ste-Anne de-Bellevue, Quebec, Canada H9X 1C0.

BROWN, D. J. F., A. T. PLOEG, and D. J. ROBINSON. Specificity of transmission of tobravirus variants by their vector (Para)Trichodorus nematodes.
Many variants of tobacco rattle (TRV) and pea early browning (PEBV) tobraviruses occur in nature, including particle protein variants that are recognized as multiple serotypes. More than one serotype may be present in association with (Para)Trichodorus nematodes at the same field site and until recently it had been assumed that all vector nematodes present transmitted all the viruses. A study of the transmission of tobraviruses by populations of (Para)Trichodorus from Britain, The Netherlands, and Scandinavia revealed that each serotype identified was transmitted by one species of nematode; e.g., serotype PA was transmitted by P. anemones, PRN by P. pachydermus, Oregon by P. teres, B28 by T. cylindricus and RQ by T. primitivus. The virus transmitted by P. teres reacted in serological tests in a similar way to strains from Oregon, USA, and this is the first record of serologically similar isolates occurring in North America and Europe. Results from this study suggest that specificity of transmission occurs between (Para)Trichodorus vector nematodes and serological variants of tobraviruses. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

BROWN, D. J. F., C. E. TAYLOR, and D. L. TRUDGILL. Variation in virus transmission among longidorid vector nematode populations.
Populations of vector species in the genera Xiphinema and Longidorus from widely separated areas differ in their ability to transmit the viruses with which they are naturally associated. Further, some strains of a virus may be transmitted more efficiently than other strains of the same virus. There is increasing evidence that several variants of a virus may be present in association with a particular population of the vector e.g. mild and severe symptomatological variants of arabis mosaic virus with X. diversicaudatum and serological variants of raspberry ringspot virus with L. elongatus. The combination of virus variants that are present in a particular situation is dependent on the specific association with the vector and interactions with the hosts and other biotopic factors that influence the biology of the vector. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

BURROWS, P. R. The identification of plant-parasitic nematodes using biotin labelled DNA probes.
This work demonstrates the first effective use of a nonradioactive biotinylated DNA probe to detect the presence of a plant-parasitic nematode Globodera pallida in dot blots. The sensitivity of the technique in this application has been improved, facilitating the detection of a single G. pallida-infective second-stage juvenile. The rapid preparation of crude nematode DNA samples coupled with a high concentration of biotinylated probe during hybridization makes the detection process very quick. Nonspecific staining of the sample dots is not a problem even when probing impure DNA samples. This research is significant for the development of simple diagnostic kits for the routine identification of agricul-

turally important species, races, and pathotypes of plant-parasitic nematodes. Entomology & Nematology Department, AFRC Institute of Arable Crops Research, Rothamsted Experimental Station, Harpenden, Herts., AL5 2JQ, England.

CAMPBELL, J. F., A. BEDNAREK, and R. GAUGLER. Effect of medium range (302 nm) ultraviolet light on the pathogenicity of entomopathogenic nematodes.
The medium wavelengths of uv in natural sunlight are potentially the most significant environmental factors affecting entomopathogenic nematodes on exposed surfaces. Steinernema feltiae and Heterorhabditis bacteriophora infective stages with (ensheathed) and without (exsheathed and desheathed) the retained second stage cuticle were exposed to 70 $\mu W/cm^2$ of uv light (peaking at 302 nm). Five days after irradiation, sheathed and exsheathed S. feltiae and sheathed and desheathed H. bacteriophora had LD50's of 6.1, 6.0, 3.4, and 3.1 min. of exposure, respectively. Thus, the presence of a sheath did not significantly affect nematode tolerance to uv. Sheathed H. bacteriophora were significantly more susceptible than sheathed S. feltiae. Nematode reproduction was rarely observed after a uv exposure of 5 min with S. feltiae and 3 min with H. bacteriophora. These results indicate that heterorhabditid nematodes are even less tolerant of uv than steinernematids. Department of Entomology, Rutgers University, New Brunswick, NJ 08903.

CARPENTER, A. S., and S. A. LEWIS. DAPI fluorescent staining of Meloidogyne spp. chromosomes.
DAPI (4'-6-diamidine-2-phenylindol-dihydrochlorid, Boehringer Mannheim Biochemicals, Indianapolis, IN) fluoresces upon exposure to ultraviolet light when bound to DNA allowing detection at nanogram levels. Meloidogyne arenaria populations were cultured for 45-50 days at 25-30 C on 'Rutgers' tomato seedlings. Prior to staining, the number of metaphase plates were increased in the ovary germinal zone and immature oocytes by incubating individual root galls in a 0.05% colchicine solution at 25 C for 2-3 hrs. After dissection, smears were dried overnight, hydrolyzed in 1N HCL for 10 minutes, and placed in fixative (1:3, glacial acetic acid:absolute ethyl alcohol) for 30 minutes. DAPI chromosome staining was more rapid and selective than propionic-orcein and chromosomes could be viewed for up to 1 week if protected from ultraviolet light. Karyotyping of Meloidogyne populations may elucidate taxonomic and host-pathogen relationships. Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29634-0377.

CARTA, D. G., and L. K. CARTA. The Kalman Filter as a worthy alternative to ordinary least squares parameter estimation.
Ordinary least squares attempts to estimate parameters $p=(p_1,\ldots,p_n)$ by minimizing the sum of squares residuals by which a function $f(x_i,p)$ misses observed values f_i. This approach is burdened by many pitfalls in biological problems for which the fitting function frequently has domains where function values are close to some limiting constant. This is the case for the logistic function and the cumulative probability distribution function which approach constants at both the left and right hand limits. The Kalman Filter avoids many of the ordinary least squares problems by indirectly minimizing the sum of squares residuals in the parameters themselves. Both the mathematical and computer implementation of the filter are extremely simple. In a language like True Basic that directly implements matrix operations like Mat A=B*C the code is dramatically compact. The Kalman Filter was applied to estimate the mean and standard deviation of the specific gravity of a nematode population based on observations of its cumulative probability distribution. The procedure had no trouble dealing with the zero and one left and right hand asymptotes. P .O. Box 541, Sierra Madre, CA 91025.

CASTRO, C. E. The chemotactic response of Meloidogyne incognita to inorganic salts. A new approach to plant protection?
Infective second stage juveniles of M. incognita are strongly repelled by certain simple inorganic salts. Utilizing a new bioassay technique the response of the juveniles to defined gradients of a variety of ions has been ascertained. The same salts can be beneficial to plant growth. Initial greenhouse experiments confirm that the salts can shield tomato roots from infection by this parasite. The new assay technique will be briefly described, and a summary of the data will be presented. Department of Nematology, University of California, Riverside, CA 92521.

CASWELL, E. P., and W. J. APT. The reniform nematode in Hawaii and its effect on agricultural production.
The reniform nematode, Rotylenchulus reniformis Linford & Oliveira, was first observed in Hawaii in 1936. The nematode was not widespread at the time and was not considered an important pathogen. During the next 20 years the incidence of reniform nematode in pineapple fields increased, and it became the premier pathogen of pineapple in Hawaii. Today, the reniform nematode is still one of the primary limiting factors in pineapple production. Factors that have contributed to the reniform nematode problem include: continuous

monoculture of a single cultivar of pineapple; decreased duration of intercycle fallow periods; low soil pH in pineapple fields due to the use of ammonium sulfate fertilizers; and the extensive use of soil fumigation. Current research in Hawaii addresses integrated management for reniform nematode in pineapple. Although the reniform nematode is most important in pineapple, it has also been observed associated with banana, papaya, and tomato. Department of Nematology, University of California, Davis, CA 95616, and Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.

CASWELL, E. P., W. J. APT, J. DEFRANK, and C. S. TANG. The influence of nonhost plants on soil populations of Rotylenchulus reniformis.
The effect of rhodes grass (Chloris gayana cv. Katambora - RG), pangola grass (Digitaria decumbens-PG), marigold (Tagetes patula - M), and sun hemp (Crotalaria juncea cv. Tropic Sun - SH) on soil populations of Rotylenchulus reniformis was investigated in greenhouse and field experiments in Hawaii. Nematode populations were lower when these non-hosts were grown compared to clean fallow (CF) or growing a host plant (Lycopersicon esculentum cv. Tropic - T). Values for nematode population change (P_f/P_i) X 100) in the greenhouse after 102 days were for T, 108 (M), 25.8; RG, 3.8; T with M 35.2, T with RG, 27.9; and CF, 76.2. M and RG did not consistently reduce soil nematode populations when planted in the same pot with T. Values for nematode population change in the field after 187 days were on SH, 11.4; RG, 39.7; PG, 25.8; and CF, 61.7. A root penetration index (RI= ([numbers of vermiform and swollen nematodes per g root]/P_i X 100) was used to estimate host status. After 26 days in the greenhouse RI values were for T, 933; SH, 158; M, 29; and RG, <1. Department of Nematology, University of California, Davis, CA 95616; Department of Plant Pathology, Department of Horticulture, Department of Agricultural Biochemistry, respectively, University of Hawaii, Honolulu, HI 96822.

CHEN, J., and G. W. BIRD. Influence of Heterodera glycines on the concomitant growth of Glycines max and Chenopodium alba.
Controlled temperature growth chamber experiments were used to evaluate the influence of Heterodera glycines (soybean cyst nematode) on the concomitant growth and water utilization efficiency of Glycines max (soybean) and Chenopodium alba (lambsquarter). Under the research conditions, C. alba was more competitive than G. max in biomass production per unit of water consumed. In the presence of H. glycines, soybean water utilization efficiency was less than in the absence of this nematode. The growth (plant dry weight) of C. alba was more rapid in the presence of both G. max and H. glycines than in the absence of the soybean cyst nematode. The growth of G. max was slower in the presence of both H. glycines and C. alba than with any other combination of the three organisms. Similar developmental responses were observed for impacts of H. glycines and C. alba on G. max reproductive growth (pod development) and plant height. Department of Entomology, Michigan State University, East Lansing, MI 48824.

CHITWOOD, D. J., and W. R. LUSBY. Glycosphingolipids from Caenorhabditis elegans.
C. elegans was propagated axenically in an aqueous medium containing soy peptone, yeast extract, glucose, hemoglobin, sitosterol, and Tween 80. During our attempted isolation of ecdysteroids (hormonal compounds in insects), we discovered in C. elegans a substance migrating identically to ecdysone during thin-layer chromatography and comprising 0.1% of the nematode dry weight. The substance was fractionated by reversed phase high-performance liquid chromatography (HPLC) into 13 components, none of them ecdysone. Mass spectrometry revealed that the major component had a molecular weight of 785. Subsequent methanolysis of the major component yielded three products, the first of which was identified as d-methylgluco-side by gas-liquid chromatography-mass spectrometry (GC-MS) of the trimethylsilyl (TMS) ether derivatives. GC-MS revealed that the second product was the methyl ester of 2-hydroxy-n-docosanoic acid. The mass spectrum of the last methanolysis product and GC of its TMS derivative were consistent with results expected for 15-methyl-2-amino-4-hexadecene-1,3-diol. Consequently, the parent compound was a glycosphingolipid consisting of glucose and 2-hydroxy-n-docosanoic acid covalently bound to a 17-carbon iso-branched long chain sphingoid base. Analysis of methanolysis products of the remaining HPLC-purified components revealed differences only in the fatty acid moieties, which varied in chain length from C_{20} to C_{26} and in chain branching. Similar compounds were not detected in the culture medium. Nematology Laboratory and Insect Hormone Laboratory, USDA, ARS, Building 467, BARC-East, Beltsville, MD 20705.

CHO, M. R., K. S. KIM, and R. T. ROBBINS. Ultrastructure of the female genital tract and Z organ in Xiphinema coxi.
Ultrastructure of Z organ and apophyses in X. coxi was studied to determine their origin and structural relationship with other parts of the genital tract. The Z organ is oval-shaped, ca. 30 µm long, and 16 µm wide. It is clearly distinguished from the other parts of the female genital tract by its thick outer muscular layer, epithelial lining, and at least 4 apophyses near its center. Apophyses appear as amorphous masses of thickened and

densely wound epithelial lining forming numerous membrane bound chambers containing electron dense materials. These chambers open into the Z organ lumen. Each apophysis is continuous with the epithelial lining of the Z organ indicating that it originated from epithelial lining. Muscular layer thickness of oviduct and uterus varies with position. The vaginal wall is formed by invagination of the adjacent cuticular layers which become thicker around the vulva. Several ventral body pores ca. 100 nm wide and connected to the ventral nerve chord were observed. Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

CHOO, HO YUL, and H. K. KAYA. Agamermis unka (Mermithidae), a nematode parasite of Nilaparvata lugens (Delphacidae: Homoptera).
The Korean hosts of Agamermis unka were confirmed to be Nilaparvata lugens, the brown plant hopper (BPH) and Sogatella furcifera, the white-backed plant hopper (WBPH). No nematodes were discovered from BPH and WBPH emigrated from southern China, but a hymenopteran parasite was recorded. The nematode parasitism in BPH between plowed 39.0% and unplowed 78.0% sites was significantly different. The parasitism of 1st to 3rd instars of BPH was 15.5%, 4th 6.6%, 5th 12.3%, and adult 64.1% (total n=1,461), respectively. The range of nematodes per BPH host was from 1 to 14, but 1 was most common. Multiple parasitism with hymenopteran parasites was 1.4% (n=635). The BPHs parasitized by nematodes rarely had eggs (n=405), that is, only 8 of 405 BPH females had their eggs. The BPHs having over 4 nematodes did not have eggs. The nematode parasitism of female BPH was 56.1 ± 0.02 (n=545) as compared with none in the males. Department of Agricultural Biology, College of Agriculture, Gyeongsang National University, Chinju 660-701, Gyeongnam, South Korea, and Department of Nematology, University of California, Davis, CA 95616.

CIANCIO, A., and R. MANKAU. The occurrence of Pasteuria penetrans-like parasites in several Cephalobidae species.
Pasteuria penetrans-like parasites have been found in an Acrobeloides sp. and a Eucephalobus sp. from streambank soil at about 2,200 m altitude in the Sierra Nevada near Big Pine, CA. Spores on the cuticle and within these nematodes appear similar morphologically, have an average diameter of 3.4 µm with an endospore of 1.7 µm diameter and appear like those described from Meloidogyne spp. The parasite could complete its life cycle with juveniles, males and females of both species on agar Petri dishes. This is the first report of this parasite within microbivorous nematodes and affords the possibility of in vitro study under a variety of parameters and conditions. When the nematodes from this site were examined originally, only a small dorylaimid was observed to be infected with the parasite. Infected cephalobids appeared later among fauna plated and observed on water agar. It is possible that the infection originated from the dorylaimid; however, spores obtained from infected cephalobids did not attach to various stages of Caenorhabditis elegans. Another Pasteuria-like parasite of distinctly different shape and dimension and undoubtably a different species has been observed in a cephalobid nematode from turf grass in Riverside, CA. Department of Nematology, University of California, Riverside, CA 92521.

CID DEL PRADO, V. I. Meloidodera population present in different varieties of chile in Puebla, Mexico.
A population of Meloidodera sp. was detected in Tecamachalco, Puebla parasitizing different varieties of chile. Adult females were found mainly in the central part of the root system; the body is white, spherical to ovoid, cuticle lacks subcrystalline layer and has fine annulation, hypodermis thick; neck slightly elongated, sometimes with yellowish material around it. Vulva postequatorial, with vulval lips slightly protruding, separated from the anus 160-280 µm. Eggs are retained in the body and inside some females second-stage hatched juveniles were observed. Males are small, 0.48-0.70 mm; the head is separated from the body by a constriction; cephalic region with four annules and labial disc elevated. Spicules slightly curved and gubernaculum delicate. Lateral field with four incisures, aerolation absent. Tail short and clocal tubus absent. Second-stage juveniles small in size from 0.29-0.40 mm; the cephalic region is separated from the body by a slight constriction and with four annules; labial disc not prominent; the esophageal glands do not fill the body width. Phasmid with lens-like structure. Lateral field with four incisures, external aerolation present. Tail short 27-38 µm long and hyaline portion less than 50% of the tail length. Giant cells with giant nuclei were observed in the parenchyma cells of the vascular cylinder. Colegio de Postgraduados, Centro de Fitopatologia, Montecillo 56230. Mexico.

COOMANS, A., and M. C. VAN DE VELDE. Intrauterine Differentiations in Xiphinema.
The intrauterine differentiations of Xiphinema species are either restricted to a well-defined area, the Z-differentiation, or distributed throughout the greater length of the uterus. In the latter case, they vary from randomly arranged crystalloids to more or less orderly arranged spines. Both kinds of differentiations can occur together or separately. Spines can have several shapes, e.g., spindle- or bullet-shaped and with or without a stel-

late base. The inclusions of the Z-differentiation are variable in shape, e.g., from globular and smooth to irregular and denticulate; in refractivity reflecting the degree of sclerotization; and in number. Since crystalloids occur either freely in the uterus or inside Z-inclusions, these structures are probably produced by the same mechanism. Instituut voor Dierkunde, Rijksuniversiteit Gent, Gent, Belgium.

CORDERO, D. A., and J. G. BALDWIN. Fine structure of the cone of females of Heterodera schachtii.
Cone development of fine structure of H. schachtii was investigated in monoxenically grown females. At the final molt, the posterior end is round. Cone growth occurs after rupture of the fourth-stage juvenile cuticle. The body wall cuticle of the cone consists of A, B, and C layers, similar to that of the midbody. However, in maturing females the cuticle of the cone is modified by a fibrous layer internal to the C layer. The fibrous layer becomes irregular forming bullae in senescent females; this layer does not extend to the fenestrae. The fenestral C layer degrades to a reticulate pattern, which ruptures as a result of juveniles escaping from cysts. The vulva, vagina, and underbridge lining is continuous with A and C layers of the body wall; the C layer is predominant in the underbridge. Dilatores vaginae muscles radiate to the body wall but do not attach to bullae; sphincter vaginae muscles occur near the underbridge and encircle the vagina. The terminus of H. schachtii is compared with additional genera to aid in phylogenetic analysis of Heteroderinae. Department of Nematology, University of California, Riverside, CA 92521.

DAVIS, E. L. Molecular recognition in plant-nematode interactions.
Lectin, carbohydrate, and glycosidase treatments are employed in a model system that includes soybean cultivars compatible or incompatible with populations of Meloidogyne incognita races 1 and 3 (Mi3) and Meloidogyne javanica. Glycosidase treatments and an enzyme-linked lectin assay have revealed differences in binding of Concanavalin A, soybean, wheat germ, Limulus polyphemus, and Lotus tetragonolobus agglutinins to second-stage juveniles (J2) of the populations studied. Treatment of J2 of Mi3 with any of the lectins or carbohydrates tested promoted hypersensitivity in soybean root tissue compared to giant cells observed with untreated Mi3. The molecular basis of Meloidogyne sp. induction of the soybean phytoalexin, glyceollin, is being investigated utilizing the system described above. Nonlethal treatment of J2 of Meloidogyne sp. with sialic acid and sialic acid-binding lectins strongly inhibits nematode infection of soybean roots. The influence of lectins and carbohydrates on nematode attraction to and penetration of roots is being studied in several plant-nematode systems. USDA-ARS, Horticultural Research Laboratory, Orlando, FL 32803.

DE BOER, J. M., and H. A. OVERMARS. Electrophoretic analysis of the development of Globodera rostochiensis.
Two-dimensional polyacrylamide gel electrophoresis in combination with a silver stain was used to examine protein homogenates from four developmental stages of Globodera rostochiensis. Development of G. rostochiensis is characterized by a degeneration of the body wall musculature in the sedentary stages, and an extensive growth of the ovaries in adult females. In second-stage juveniles and males the muscle proteins paramyosin, tropomyosin, and three isoforms of actin are abundantly present, whereas in fourth-stage females and females these proteins are either decreased or absent. Females possess a number of abundant proteins of Mr 77,000, which are likely to be yolk proteins. In the stages examined, 463 reproducible protein spots were distinguished. High similarity indices were found for the protein patterns of second-stage juveniles and males (0.693), and for fourth-stage females and females (0.756). All other pairwise comparisons resulted in lower index vales (<= 0.602). No less than 342 spots (74%) showed modulations in presence or size between the different stages. From these results, it is concluded that G. rostochiensis has a very dynamic protein metabolism. Department of Nematology, Wageningen Agricultural University, P. O. Box 8123, 6700 ES Wageningen, The Netherlands.

DIEDERICH, J., R. FORTUNER, and J. MILTON. Nemisys, a nematode identification system: Update and extensions.
The current status of the Nemisys International Project (N.I.P.) is discussed. N.I.P. is an effort to create an expert workstation for nematode identification. An important planned subproject is the Terminator project, a full online data and knowledge base for plant-parasitic nematodes. University of California, Davis, CA 95616.

DIEDERICH, J., R. FORTUNER, and J. MILTON. Nemisys: the prototype. A video demonstration.
A fifteen minute video tape is presented to demonstrate the current capabilities of the Nemisys (Nematode Identification System) prototype and preview future extensions. University of California, Davis, CA 95616.

DI VITO, M., and N. SASANELLI. The response of fig cyst nematode (Heterodera fici) to natural and artificial hatching agents.
The effect of natural and artificial hatching agents on the emergence of juveniles from cysts of Heterodera fici was investigated at 23 C in a growing cabinet over a 7-week period. Cysts were collected from soil and batches of 100 were incubated in commercial or ornamental fig leachates, and in picrolonic acid, sodium metavanadate, zinc chloride, zinc sulphate, or distilled water. More juveniles emerged from cysts incubated in commercial fig leachate (97%) than in ornamental fig leachate (44%). The emergence of juveniles incubated in sodium metavanadate was 64%. Zinc chloride and zinc sulphate had less effect on the nematode and only 36% and 26% of the eggs hatched, respectively. Emergence of juveniles from cysts incubated in picrolonic acid (4%) was significantly less than that in distilled water (11%). Istituto di Nematologia Agraria, C.N.R., 70126 Bari, Italy.

DUBE, B. N. Biological control of Meloidogyne javanica using Paecilomyces lilacinus and an organic amendment.
The potential of Paecilomyces lilacinus to control Meloidogyne javanica was tested for 3 seasons (1985/6, 1986/7, 1987/8) under field microplot conditions in Zimbabwe. Twenty (12 x 6 m) concrete-bordered microplots were used. P. lilacinus inoculum was initially applied at a rate of 5 gm/kg soil (1 gm = 10^6 conidia) and M. javanica inoculated at a rate of 150 eggs/100 cm^3 soil. In the 1985/6 season soybeans Glycine max cv. Sable was used as a nematode host and field beans Phaseolus vulgaris cv. Natal Sugar was used in subsequent years. In the 1986/7 season fungus inoculum was not added but re-applied in 1987/8. Organic amendment (cattle manure) was applied to some plots in the 1987/8 season. Nematode population densities (Pi, Pm and Pf), root galling (RGI) and yield were recorded. Results of the first season (1985/6) showed that fungus-treated microplots had significantly lower nematode population counts (Pm and Pf) than the nontreated plots (nematodes only). Root galling also was reduced. Yield was 2% higher than in nontreated plots. In subsequent seasons (1986/7, 1987/8) results followed the same trend with even higher yield increases of 9% and 31%, respectively. Microplots in which both cattle manure and P. lilacinus were added, had significantly lower nematode population densities with a 52% yield increase. Department of Biological Sciences, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Harare, Zimbabwe.

DUDASH, P. J., and K. R. BARKER. Host suitability and response of selected asparagus cultivars to Meloidogyne spp.
The host-parasite relationships of asparagus and Meloidogyne spp. were investigated in greenhouse studies. In screenings on 'Pedigreed Washington', M. incognita race 1 (MI 1) and M. incognita race 4 (MI 4) reproduced very well (Pf/Pi > 1). M. arenaria race 2 (MA 2), MI 1, and MI 4 reproduced well on 'Mary Washington'. M. hapla, M. javanica, M. arenaria race 1, and M. incognita race 3 reproduced poorly (Pf/Pi < 1) on both cultivars. Host suitability of 9 cultivars, including 'Pedigreed Washington' and 'Mary Washington', for MI 1, MI 4, and MA 2 was further evaluated in a factorial experiment. No cultivar x nematode interaction was found. All cultivars were equally suitable hosts (Pf/Pi > 1) for the nematode populations tested. In other studies, growth of 'Mary Washington' was shown, by regression analysis, to be affected by a range of initial inoculum levels of MI 1, MI 4, or MA 2. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695 7616.

DUNCAN, L. W. Nematode management in citrus.
Nematode management in citrus is in a transitional state. Previous methods of managing nematode levels have been replaced by practices that pose less environmental risk but which are of undetermined economic value. With the exception of rootstock resistance, current methods of controlling nematodes are less effective than previous ones. Reduced efficacy results in more variable control, depending on environmental conditions, further complicating economic evaluation of new management practices. Models of seasonal population change of Tylenchulus semipenetrans based on temperature, population density, and root growth have been validated at two locations in Florida. The models are used in an algorithm in combination with crop-loss functions and models of pesticide movement in soil to estimate long-term effects of current and proposed nematode management strategies prior to costly field testing. Information necessary to improve forecasting includes tree growth models and effects of soil hydrology and rootstock cultivar on nematode populations. Compared to annual cropping systems, the use of quantitative methods in the furtherance of nematode management in a perennial crop requires special consideration of factors such as host quality, units of stress measurement, applicability of various population models, and unique sampling requirements. University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850.

DUNN, R. A., J. D. EISENBACK, J. D. RADEWALD, and B. B. WESTERDAHL. Extension nematology: taxonomy and the dilemma of diagnosis.

Diagnosis of economic problems of plants caused by phytoparasitic nematodes and recommendation of appropriate management practices depend heavily on accurately identifying nematodes involved. Incorrect or insufficiently precise identification may result in planting inappropriate crop species or cultivars in infested sites, inadequate chemical control through choice of unsuitable nematicides or rates, or unnecessary use of nematicides or other controls because the nematode(s) present do not actually affect the crop to be planted. Review and discussion of taxonomic procedures and standards currently employed in most nematode advisory laboratories will be followed by analysis of more advanced and/or precise methods employed in those few laboratories that provide species or race identifications. We will conclude by describing and discussing new technologies that, although not yet generally adopted by advisory nematologists, may provide more accurate, precise, faster, and(or) less expensive nematode identifications than do methods that are currently in use. University of Florida, Gainesville, FL 32611-0611.

DUSENBERY, D. B. Meloidogyne incognita responses to nonspecific stimuli and exudate of tomato roots.
Infective juveniles of the root-knot nematode Meloidogyne incognita are extremely sensitive to temperature gradients. However, it is unlikely this cue could be useful for locating a host because of the much larger gradients produced by other causes. They probably can use thermotaxis to move toward a favorable depth in the soil. The juveniles are also very sensitive to carbon dioxide. They can respond to CO_2 concentrations below atmospheric levels. How steep gradients must be for chemotaxis to be effective is not known, but calculations indicate this influence could, in principle, reach more than a meter from a host plant. A search for other volatile stimuli given off by host roots failed to reveal any. Testing nonvolatile fractions of tomato root exudate, revealed a strong repellent response. Chemical fractionation indicated that the repellents were highly polar and had apparent sizes of about 500 and 1,000 daltons. School of Applied Biology, Georgia Institute of Technology, Atlanta, GA 30332.

DWINELL, L. D. Colonization of conifer logs by pine sawyers and Bursaphelenchus xylophilus.
The pinewood nematode (B. xylophilus) is transmitted during oviposition of pine sawyers (Monochamus spp.) into freshly felled logs. In late May 1988, 88 91-cm-long freshly felled logs of red spruce, Fraser fir, and nine species of pine were set out in Clarke County, Georgia, to determine the colonization by pine sawyers and species of Bursaphelenchus. In addition, 16 logs of red spruce, Fraser fir, loblolly pine and slash pine were placed on Roan Mt. in North Carolina. After 2 months, oviposition pits were counted. Nematodes were extracted from wood samples by the Baermann funnel method. At both locations, pine sawyers did not successfully breed in red spruce and Fraser fir logs and no Bursaphelenchus was recovered. At Roan Mt., slash and loblolly pine logs were not colonized by pine sawyers and Bursaphelenchus was not detected. At the Georgia site, however, the pine logs were colonized by pine sawyers (M. titillator and M. carolinensis). B. xylophilus was the only species of this genus recovered. The density of B. xylophilus ranged from 124/g dry wood wt. for loblolly pine to 17/g for Table Mountain pine. For slash, eastern white, sand, Virginia, pitch, shortleaf, and longleaf pines, B. xylophilus densities averaged 41/g. USDA For. Serv., Southeast. For. Expt. Sta., Athens, GA 30602.

ENDO, B. Y. Fine structure of initial responses of soybean cultivars to the soybean cyst nematode, Heterodera glycines.
Soybean cultivars respond to infection by the soybean cyst nematode, Heterodera glycines, by the accumulation of smooth (ER) and rough (RER) endoplasmic reticulum within a thick walled initial syncytial cell (ISC). The ISC and adjacent cells showed slight enlargement 18 hours after inoculation but had definite disruptions in their interconnecting cell walls. The ER closest to the stylet and associated secretions was not associated with mitochondria but the surrounding cytoplasm had RER interspersed with many organelles. In most resistant cultivars, the syncytial RER had extensive dilated cisternae but these were less prevalent in syncytia of susceptible cultivars. Nematode secretions were surrounded by perimeters of ER that outwardly merged with syncytial RER. Wide ranges in electron dense patterns of nematode secretions occurred in 18-hour to 2-day-infections. The secretions nearest the nematode stylet appeared uniform in distribution whereas others extending into the syncytium had darkened peripheral cylindrical boundaries with clear to partially occluded centers. Syncytia formed in susceptible and resistant cultivars from 18 hours to 4 days after inoculation involved tissue hypertrophy, hyperplasia, cell wall dissolutions, membrane proliferations, and callose deposits. USDA, ARS, Nematology Laboratory, Beltsville, MD 20705.

ESBENSHADE, P. R., and A. C. TRIANTAPHYLLOU. Multiple mating in the soybean cyst nematode, Heterodera glycines.
Controlled crosses were carried out by placing one or more virgin females of known esterase

phenotypes on an agar plate and adding, at various time intervals, one or more males of different esterase phenotypes. Progeny (juveniles) of such crosses were propagated for one generation on soybeans and 30 days later young females were electrophoresed to determine their esterase phenotypes and, thus identify their male parent. When 74 females were given the opportunity to mate successively with two males of different esterase phenotypes, 43 mated with a single male (either the first or the second) and 31 mated with both males. One female mated with three males i.e. with a male of its own population (accidental sib-mating) and the two males provided for the cross. Inseminated females could mate for a second time soon after, or as late as 24 hours following their mating. When single males were given the opportunity to mate with many females, about equal numbers of them inseminated one, two, or three females. Heterozygous esterase phenotypes confirmed the hybrid nature of the progeny. Department of Genetics, North Carolina State University, Raleigh, NC 27695-7614.

ESBENSHADE, P. R., and A. C. TRIANTAPHYLLOU. Utility of isozymes in the identification of Meloidogyne species.
Enzyme phenotypes, as revealed by electrophoresis of extracts from adult females, are useful taxonomic characters for identification of many species of Meloidogyne. Esterase phenotypes can reliably differentiate several species; e.g., M. arenaria, M. chitwoodi, M. cruciani, M. hapla, M. incognita, M. javanica, M. microtyla, and M. naasi, and can assist in the identification of many others; e.g., M. carolinensis, M. graminicola, M. graminis, M. hispanica, M. microcephala, M. oryzae, M. platani and M. querciana. Esterases are also useful in population-dynamics studies of field populations comprising two or more species, and in sorting the components of such mixed populations into single-species subpopulations. Less species-specific enzymes such as glucose phosphate isomerase, superoxide dismutase and malate dehydrogenase provide valuable supplementary information for species identification. Phenotypes of these enzymes are not influenced by such variables as age of the females or cultivar and species of the host plant. The above conclusions have been drawn from enzymic studies of over 600 populations representing 17 Meloidogyne species from many parts of the world. Department of Genetics, North Carolina State University, Raleigh, NC 27695-7614.

ESSER, R. P. An illustrated diagnostic compendium to females of the genus Hemicriconemoides (Criconematoidea: Hemicycliophorinae).
A diagnostic compendium is presented for 39 species included in Hemicriconemoides. Principal differentiating characters include stylet length, body annule range, RV, and body length. Female head and tail illustrations are included for each species. Florida Department of Agriculture and Consumer Services, P.O. Box 1269, Gainesville, FL 32602.

FERRIS, H., B. A. JAFFEE, M. V. McKENRY, and A. JUURMA. Analysis of nematode stress on peach trees due to Criconemella xenoplax.
Management rules for Criconemella xenoplax (Cx) in Prunus orchards requires analysis of the relationship between 1) management levels and nematode stress dosage, and 2) nematode stress and tree mortality or yield. Numbers of Cx, incidence and prevalence of a disease of Cx caused by Hirsutella rhossiliensis (Hr), and tree productivity were monitored over three years in a peach orchard on Lovell and Nemaguard rootstocks, with and without post-plant nematicides. Nematode stress dosage was described as the cumulative product of nematode density and degree days; nematode counts were adjusted for stage-specific size and extraction efficiency. Nematode stress dosage (y) was related to degree days (x) by $y=ax^b$, with b varying according to host status of the rootstock, nematicide application, and season characteristics. Highest Cx densities and stress dosage values developed on Nemaguard rootstock without post-plant nematicide. Tree mortality and bacterial canker symptoms, associated with predisposition of trees by Cx, were restricted to trees on Nemaguard rootstock. Tree vigor and yield were not clearly related to stress dosage. The incidence of Hr was correlated with nematode numbers, but prevalence of infection of nematodes was less than 10%, even at high densities of Cx. Department of Nematology, University of California, Davis, CA 95616.

FORGE, T. A., and A. E. MacGUIDWIN. Dynamics of Meloidogyne hapla second-stage juvenile cold hardiness.
Acclimation to temperatures of 4 to 24 C for 24 to 96 hours affects the freezing tolerance of Meloidogyne hapla second-stage juveniles; tolerance varies inversely with acclimation temperature. To determine the rate of increased freezing tolerance, samples comprised of juveniles in 5% polyethylene glycol (20,000 m.w.) were placed at 4 C. Freezing tolerance was measured at three-hour intervals by freezing the samples at -4 C for 24 hours and counting the surviving juveniles after thawing. Freezing tolerance at 12 hours was not significantly different from that at 24 hours. To determine the effect of repeated low temperature exposure on freezing tolerance, juveniles were exposed to none, one, or two 24-hour cycles of 12 hours at 4 C followed by 12 hours at 24 C. Freezing tolerance was measured at three-hour intervals during an additional 24-hour cycle. The level of freezing

tolerance attained during the cold phase of the final cycle increased with the number of previous cycles and the rate of freezing tolerance loss during the warm phase decreased with previous cycles. Department of Plant Pathology, University of Wisconsin-Madison, Madison WI 53706.

FORTNUM, B. A., D. T. GOODEN, R. E. CURRIN III, and S. B. MARTIN. Spring or fall fumigation for control of Meloidogyne spp. on tobacco.
Four tests were conducted to evaluate the efficiency of fumigant nematicides for control of Meloidogyne arenaria and M. incognita on tobacco. Chloropicrin, 1,3-D, methyl isothiocyanate and a methyl isothiocyanate plus 1,3-D mixture were applied in the spring or fall as separate in-the-row treatments. Fumigants were applied in the spring preceding the tobacco crop to fields infested with M. arenaria or M. incognita. In two of the test sites containing M. arenaria or M. incognita, fumigants were applied in the fall preceding the tobacco crop to separate plots within the fields. Contact nematicides fenamiphos, fenamiphos plus fensulfothion or ethoprop were applied in the spring as standards. Fumigant nematicides increased yields and reduced galling ($P = 0.01$) at all four tests. Spring and fall application of fumigant nematicides were effective in controlling both M. arenaria and M. incognita and were superior to the contact nematicides tested. Clemson University, Department of Plant Pathology and Physiology, Pee Dee Research and Education Center, Box 531, Florence, SC 29503.

FORTNUM, B. A., D. R. DECOTEAU, and M. J. KASPERBAUER. Root-knot of tomato as affected by plastic mulch color.
Colored plastic mulches alter the light micro-environment affecting plant growth and development. Light quality has been shown to alter the development of Meloidogyne spp. The effects of upwardly reflected light on root-knot was studied in a field setting for 2 years. Changes in plant biomass were recorded after tomato plants were inoculated with Meloidogyne incognita, at an initial population (Pi) of 0, 10, 50, 100, or 200 ($X\ 10^3$) eggs per plant, and grown for 60 days over four colors of polyethylene mulch. Tomatoes grown over white mulch had shoot weights (41%), root weights (14%), and leaf area (30%) greater than similar plants grown over a black mulch. Plants grown over gray and red colored mulches were intermediate in size. Root galling was reduced in plants grown over white mulch when compared to plants grown over black mulch and was the only parameter in which a mulch color x Pi interaction ($P = 0.01$) was observed. Top weights and leaf area declined as Pi increased. Top weight of tomato plants inoculated with 100 ($X\ 10^3$) eggs and grown over white mulch did not differ ($P = 0.01$) from uninoculated plants grown over black mulch (1,039 g vs 1,031 g, respectively). Clemson University, Department of Plant Pathology and Physiology, and USDA-ARS, Box 271, Florence, SC 29503.

FRANCL, L. J., and W. J. KENWORTHY. Heterogeneity in population density of soybean cyst nematodes after evaluation of soybean germplasm.
A wide range of nematode population densities is desirable in studies of population dynamics and yield response. In a study of the soybean cyst nematode, Heterodera glycines, 10x10 contiguous and 10 noncontiguous field plots were established in a conventionally tilled area that had been used the previous season for evaluation of soybean germplasm. Population density of cysts averaged 158/kg soil dry weight (median = 122/kg) and ranged from 2 to 549/kg (Coefficient of Variation = 80); that of eggs averaged 16,060/kg (median = 12,270/kg) and ranged from 120 to 51,150/kg (CV = 82). Population density generally increased in an east-west direction. The 10 noncontiguous plots were located at or near sites where susceptible cultivars were grown but only five plots had population levels above the median. Population densities were significantly ($P < 0.01$) correlated with females on 6-week-old plants, plant vigor at 6 weeks, and seed yield. These relationships were strengthened when parasitized eggs were subtracted from the total number. Nematology Laboratory, USDA, ARS, Beltsville, MD 20705.

FRANDSEN, J. C. Metabolism of xenobiotics by homogenates of the vinegar eelworm, Turbatrix aceti, and the zooparasitic nematode, Trichostrongylus colubriformis.
Research is being conducted to identify basic "type," phase-I, reactions in the 12,000 g supernatant fluid (i.e., free of mitochondria and nuclei) from homogenates prepared from mixed mature and immature T. aceti, grown in culture, and mixed sexes of adult T. colubriformis recovered from the intestines of infected goats. The following reactions occurred in preparations from both species: 1) aliphatic hydroxylation of p-nitrophenol, with formation of p-nitrocatechol, the p-nitrocatechol, in turn, being conjugated by a Phase II reaction that would be expected to occur in this supernatant fluid if the pathways for the intermediary metabolism of this xenobiotic are the same as those in insects and the mammalian liver; 2) aromatic hydroxylation of coumarin, to 7-hydroxycoumarin; 3) N-demethylation of p-chloro-N-methylaniline, with formation of p-chloroaniline; and 4) O-dealkylation of 7-ethoxycoumarin to 7-hydroxycoumarin. These results suggest that both species of nematodes possess well-developed cytochrome P-450/mixed-function oxidase (MFO)

systems. USDA, ARS, Animal Parasite Research Laboratory, Box 952, Auburn, AL 36831-0952.

GERBER, K., and R. M. GIBLIN-DAVIS. Nematode associates of the palm weevils, Rhynchophorus palmarum and R. cruentatus.
Cocoons of Rhynchophorus palmarum were collected from red ring diseased (RRD) coconut palms in Trinidad and allowed to emerge in separate containers. Juveniles of five species of nematodes were recovered from the genital area and body cavity of newly-emerged adults of R. palmarum. Red ring nematodes, Rhadinaphelenchus cocophilus, Teratorhabditis sp., and Diplogasteritus sp. were recovered from > 50% of the R. palmarum examined. In a few cases, Mononchoides sp. and Bursaphelenchus sp. were recovered internally from R. palmarum. Over 90% of R. palmarum females (n = 45) and males (n = 44) were infested internally with red ring nematode juveniles and > 47% contained > 1,000 red ring nematodes each. There was no significant correlation ($P < 0.05$) between body length of R. palmarum and the number of red ring nematodes carried internally by each weevil. Juveniles of Teratorhabditis sp. and Diplogasteritus sp. were extracted and cultured to adults from newly-emerged adults of R. cruentatus from Broward and Collier counties in southern Florida. No red ring nematodes were extracted from R. cruentatus in Florida. 3205 College Ave., University of Florida, IFAS, Ft. Lauderdale, FL 33314.

GIBLIN-DAVIS, R. M., K. GERBER, and R. GRIFFITH. Culture of the red ring nematode, Rhadinaphelenchus cocophilus.
Monoxenic cultures of the fungi, Monilinia fructicola and Botrytis cinerea, and undifferentiated sugarcane leaf spindle callus were inoculated with ca. 100 surface-sterilized juveniles (J3) of the red ring nematode, Rhadinaphelenchus cocophilus. No nematode survival was observed on either fungus after one week, but molting was observed in one culture of sugarcane callus after 4 weeks. Several undefined media were tested for R. cocophilus persistence and development. Red ring nematodes persisted for longer than 70 days in autoclaved red ring stem tissue infusion water (RRW) that was unsupplemented or was supplemented with 5 g D-glucose/500 ml RRW, 3.85 g lactose/500 ml RRW, or 10 g Bacto-lactose broth + 5 g D-glucose/500 ml RRW (R+LB+G). A single adult female, four J4, and 9 J3-J4 intermolts were recovered after 70 days in the R+LB+G media and these nematodes were infective to a healthy coconut petiole. Inoculations of 100 red ring nematodes (J3) into coconut leaves that were kept hydrated for 3-4 weeks produced red ring infestations in 50-60% of the attempts. 3205 College Ave., University of Florida, IFAS, Ft. Lauderdale, FL 33314.

GIBLIN-DAVIS, R. M., K. GERBER, M. MUNDO-OCAMPO, J. G. BALDWIN, R. GRIFFITH, J. ESCOBAR-GOYES, and A. D'ASCOLI-CARTAYA. Morphology and morphometrics of different geographical and host isolates of the red ring nematode, Rhadinaphelenchus cocophilus.
Morphometrics of adult males and females of the red ring nematode, Rhadinaphelenchus cocophilus were compared from red ring diseased (RRD) coconut, Cocos nucifera, stem tissue from a plantation in Manzanilla, Trinidad; from a plantation in Esmareldes, Ecuador; and from oil palms, Elaeis guineensis, with RRD or "Little Leaf" symptomology from San Felipe, Venezuela. Red ring nematodes from RRD coconut from Trinidad and from RRD oil palms from Venezuela were examined with scanning electron microscopy and light microscopy. No morphological differences were observed between adults from either host or location. There were many morphological similarities between R. cocophilus and members of the genus Bursaphelenchus, including the male caudal papillae arrangement. Adults of the red ring nematode from oil palms with "Little Leaf" symptomology were significantly shorter than adults from the other hosts and locations. 3205 College Ave., University of Florida, IFAS, Ft. Lauderdale, FL 33314.

GOLDEN, A. M., and D. W. DICKSON. Morphology and relationship of a Meloidogyne species on strawberry.
A root-knot nematode found infecting strawberry (Fragaria ananassa) in Florida appears to be an undescribed species. Juveniles average only about 355 µm in length and have short tails (about 40 µm) with a short, blunt terminal. Perineal patterns show variable arches, ranging from low to high; are often broad at the level of the anal area; and have coarse, widely spaced, broken striae, generally without wavy striae at outer edges. Excretory pore of the female is located about 33 µm from the anterior end. Males are about 1,400 µm long with stylets 23 µm in length. This species shows some relationship to M. incognita, M. microtyla, and M. arenaria but differs morphologically from each of these. On strawberry, tomato, and pepper (Capsicum annuum), this nematode causes small galls but does not develop on peanut. Since this is the second Meloidogyne species known on strawberry in the U.S. and the galls are similar to those of M. hapla on this plant, identity of the species involved should be made when examining infected strawberry roots. Nematology Laboratory, USDA, ARS, Beltsville, MD 20705.

GOODELL, P. B. Computer use in the Society of Nematologists: Results of a survey.

As part of its committee responsibilities, the Computers in Nematology Committee conducted a survey of the membership of the Society of Nematologists to estimate computer use within the Society. The survey was mailed in December 1988 to the domestic membership from a mailing list provided by the Treasurer. The survey consisted of 12 multiple response questions which considered hardware and software use. A total of 621 forms were sent out and 44% were returned with 93% responding that they were currently using computers. Of these, 85% used IBM or IBM compatibles, 23% used Apple Macintosh, and 23% used a mainframe computer. The data indicated respondents used multiple computers. In ranking the top five applications, wordprocessing was first followed by statistical analysis, graphics, spreadsheets, and finally data base management. With respect to hardware, 61% of the respondents used a laser printer, 50% reported using a phone modem, 41% used a 'mouse' device, and 30% used a pen plotter. Individual software preference was also reported. Cooperative Extension, University of California, P.O. Box 2509, Bakersfield, CA 93303.

GOURD, T. R., and D. P. SCHMITT. Penetration rate of second-stage juveniles of Meloidogyne spp. and Heterodera glycines into soybean roots.
The time requirements for second-stage juveniles (J2) of Meloidogyne arenaria, M. hapla, M. incognita, M. javanica and Heterodera glycines races 1 and 5 to penetrate 'Lee 68' soybean were determined under greenhouse conditions. Freshly hatched J2 were pipetted directly around seedlings with 3-cm long radicals growing in sandy loam soil in 450-cm^3 styrofoam cups. Amount of J2 penetration was determined at 3, 6, 24, 48, and 120 hours after inoculation. Respective J2 invasion rates into roots by H. glycines races 1 and 5 were 3.2 and 7.3% at 3-hours. Less than 1% of the M. incognita and M. javanica J2 penetrated at 3 hours. At 6 hours, the respective percentages of J2 of these nematodes in roots increased to 2.4 and 4.1%. J2 of M. arenaria were first found in soybean roots at 6 hours and of M. hapla at 24 hours. Root penetration by nematodes in this study was rapid through 48 hours. No significant ($P=0.05$) increase of J2 numbers in the roots was achieved at 120 hours compared to 48 hours after inoculation. In some cases, fewer J2 were seen at 120 hours than at 48 hours. Thus, nematode penetration data at 48 hours after inoculation is more precise and easier to obtain than those for later times. Department of Plant Pathology, Box 7631, North Carolina State University, Raleigh, NC 27695-7631.

GOWEN, S. R., A. C. CHANNER, and N. G. M. HAGUE. The control of root-knot nematodes with Pasteuria penetrans.
Pasteuria penetrans spore inoculum was bulked by the addition of spore-encumbered nematodes to tomato plants and the subsequent incorporation of root material into the potting soil after crop senescence. This soil was air-dried and examined for its capacity to suppress nematode reproduction. Tomato plants growing in treated or control soil were inoculated with three populations of Meloidogyne spp. The latter was derived similarly to the former, but in the absence of P. penetrans inoculum. After six weeks, highly significant decreases in nematode fecundity were observed in treated pots ranging from 94% for a M. javanica population from Papua New Guinea to 98% for populations of M. javanica from Sri Lanka and M. incognita/M. arenaria from Tuvalu. Spore concentrations in the treatment soils could not be determined; but an earlier experiment in which 10,000 and 45,000 spores per g were applied, gave 40 and 79% decreases in the egg mass production of a M. javanica population from Pakistan. Department of Agriculture, University of Reading, Earley Gate, Reading, RG6 2AT, UK.

GRIFFIN, G. D. Effect of age of stand and harvest frequency on the pathogenicity of Ditylenchus dipsaci on alfalfa.
Survival of Ditylenchus dipsaci-susceptible semidormant Ranger alfalfa and nondormant Moapa alfalfa, in the presence of D. dipsaci, was dependent on plant stand age, and harvest frequency. The greater the cutting frequency, the greater the stand reduction. In D. dipsaci-infested soil, one-, four-, and five-year-old stands of Ranger were reduced more than two-, and three- year-old stands; survival was greatest on two-year-old stands. Moapa alfalfa stands were reduced by D. dipsaci most in the third and fourth year, while survival was greatest in one-year-old stands. Alfalfa cuttings, made one, two, three, and four times during the growing season resulted in stand reductions of 10, 14, 19, and 29%, and 2, 4, 4, and 7% in two-year-old Ranger alfalfa in D. dipsaci-infested and uninfested soil, respectively. This compared to stand reductions of 13, 16, 18, and 38%, and 0, 2, 4, and 6% reductions in Moapa over the same treatment periods. Alfalfa stands of resistant semidormant Lahontan were affected less by cutting frequency in D. dipsaci-infested soil than were the susceptible cultivars. USDA ARS, Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300.

GRIFFIN, G. D. Pathological relationship of Ditylenchus dipsaci and Fusarium oxysporum f. sp. medicaginis on alfalfa.
Ditylenchus dipsaci and Fusarium oxysporum f. sp. medicaginis synergistically affected the mortality and plant growth of Ranger alfalfa, susceptible to nematode and Fusarium wilt.

Effects of the nematode-fungus relationship on mortality and plant growth were additive for Lahontan (nematode resistant and Fusarium wilt susceptible) and Moapa 69 (nematode susceptible and Fusarium wilt resistant). Mortality rates were 13, 16, and 46% for Ranger, 4, 18, and 26% for Lahontan, and 19, 10, and 32% for Moapa 69, when inoculated with D. dipsaci, F. o. medicaginis, and D. dipsaci plus F. o. medicaginis, respectively. Shoot weights for the same treatments were 52, 84, and 26%; 74, 86, and 64%; and 50, 95, and 44% of uninoculated control plants of Ranger, Lahontan, and Moapa 69, respectively. Plant growth suppression was related to the incidence of vascular bundle infection and discoloration of alfalfa root tissue. Disease severity and plant growth of alfalfa were not affected differentially by simultaneous or sequential inoculations of the two pathogens. Growth of alfalfa and nematode reproduction were directly affected by F. o. medicaginis. USDA ARS, Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300.

HAFEZ, SAAD L., and K. HARA. Sugarbeet cyst nematode Heterodera schachtii control by planting host resistant variety or applying nematicides on nonhost rotation crops.
Host root exudates or a low concentration of carbamate nematicides are known to stimulate egg hatching of the cyst nematode. If eggs hatch and there is no susceptible host on which juveniles can feed, they will die from starvation. In these studies, low rates of Temik (1.7 and 2.2 kg ai/ha) alone, or in combination with Furadan (1.7 kg/ha) were applied to fields of dry beans and sweet corn heavily infested with sugarbeet cyst nematode. Also, nematode resistant radish cultivar RSO1841, which is commonly used in Germany for animal feed, was grown for 10 weeks in sugarbeet fields infested with the sugarbeet nematode. Treating sweet corn with Temik alone, in combination with Furadan, or no treatment reduced egg and juvenile population by 57, 83 and 32%, respectively. Treating dry beans with Temik (1.7 and 2.2 kg/Ha) reduced the nematode population by 75 and 84% of the initial population respectively, while the untreated control reduced the population 20%. Planting the German radish variety RSO1841 reduced the nematode population by 67%. University of Idaho, SW Idaho Research and Extension, Parma, ID 83660.

HARRIS, T. S., L. J. SANDALL, and T. O. POWERS. Enhanced molecular diagnostics using polymerase chain reaction.
The polymerase chain reaction technique (PCR) is a rapid enzymatic method for the amplification of DNA sequences. Through the mapping of restriction fragment length polymorphisms in mitochondrial DNA we have identified a region of the mitochondrial genome that contains restriction site polymorphism that distinguish major groupings of mitochondrial genomes in Meloidogyne. The region, a 1.8 kb fragment produced when M. incognita mtDNA is digested with the enzyme Hind III, contains the gene for NADH dehydrogenase subunit 1. Nucleotide sequence analysis shows approximately 50 to 35 percent sequence identity with the NADH 1 genes of Drosophila yakuba and Locusta migratoria, respectively. We have generated 20 basepair oligonucleotide primers for this fragment in order to conduct PCR on small quantities of DNA extracted from juvenile nematodes. Department of Plant Pathology, University of Nebraska, Lincoln, Nebraska 68583.

HEALD, C. M. An overview of Rotylenchulus reniformis.
The genus Rotylenchulus was established in 1940 by Linford and Oliveira with the description of Rotylenchulus reniformis, the reniform nematode. In their original description Linford and Oliveira noted that the nematode was first discovered in 1931 infecting cowpeas on the island of Oahu. Initially, the nematode was thought to be of minor importance until 1936 when it was found infecting pineapple. The reniform nematode is found primarily in the tropical areas of the world and presently there are reports of its presence in more than 38 countries. The most concentrated area outside the tropics appears to be the United States where it occurs in all gulf coast states, and in Georgia, North and South Carolina, and Arkansas. Rotylenchulus reniformis is known to cause economic damage to many plant species in numerous countries of the world. Eight other Rotylenchulus species have been identified since the genus was established. USDA, ARS, Cotton Pathology Research Unit, Route 5, Box 805, College Station, TX 77840.

HEALD, C. M. Control of Meloidogyne hapla infecting roses.
Soil fumigants were supplemented with aldicarb or fenamiphos for control of Meloidogyne hapla in rose fields in eastern Texas. In the first experiment, the following fumigants were broadcast through shanks 30-cm-deep and 30-cm apart one month before planting: 1,3-dichloropropene and related chlorinated hydrocarbons (1,3-D), dichloropropane-dichloropropene (D-D), ethylene dibromide (EDB), D-D + methyl isothiocyanate, and 1,3-D + chloropicrin. After 16 months, aldicarb was incorporated 3-cm-deep to either side of one half of each plot. In the second experiment, only 1,3-D was broadcast at depths of 30 and 50 cm at two rates. Sixteen months later, fenamiphos was applied with the same method used to apply aldicarb in the first experiment. Each experiment was terminated after 2 years and plants were undercut 15-cm-deep and lifted for examination. In the first experiment,

soil fumigants suppressed the root-knot nematode population for the first year; the second year, however, control was maintained only in plots that were treated with aldicarb. In the second experiment, 1,3-D gave excellent control the first year but this control was maintained through the second year only in plots that were treated with fenamiphos. A late-spring-1987 freeze killed 61% of the nonfumigated plants compared to a mean of 19% kill in fumigated plots. USDA, Cotton Pathology Research Unit, Rt. 5, Box 805, College Station, TX 77840.

HERMAN, M., R. S. HUSSEY, and H. R. BOERMA. Field evaluation of soybean genotypes highly resistant to Meloidogyne incognita.
Two soybean genotypes, PI 96354 and PI 417444, identified as highly resistant to Meloidogyne incognita in a greenhouse screen were compared to a moderately resistant cultivar, Forrest, and a susceptible cultivar, Bossier, for two years in field microplots with increasing initial soil population densities (Pi) (0, 31, 125, and 500 eggs/100 cm^3 soil) of M. incognita. When averaged across years, yield was suppressed 97%, 12%, 18%, and <1% at the highest Pi for Bossier, Forrest, PI 417444, and PI 96354, respectively. At 14 days after planting, penetration of roots by second-stage juveniles was related to Pi. Fewer juveniles (62%) were present in the roots of PI 96354 than in roots of the other resistant genotypes. Additionally, soil population densities of M. incognita after 140 days were lowest on PI 96354. PI 96354 has a higher level of resistance to M. incognita than is available in adapted soybean cultivars. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

HEWLETT, T. E., and D. W. DICKSON. Effect of nematicides combined with bahiagrass and susceptible host crop rotations for control of Meloidogyne arenaria on peanut.
Two identical nematicide tests were placed in adjacent fields where Meloidogyne arenaria race 1 had caused peanut yield losses. One field was in bahiagrass for 2 years (bahia site) and the other field was planted with a succession of soybean, hairy vetch, peanut, and hairy vetch (peanut site). The fumigant 1,3-D was applied 7 days preplant broadcast or in-the-row with or without an at-pegging application of aldicarb. Aldicarb and ethoprop were applied in a 30-cm band at-planting or a 35-cm band at-pegging. At mid-season, population levels of the second-stage juveniles in the bahia site were relatively low compared to those in the peanut site; however, at harvest population levels were high in both sites. None of the nematicide treatments in the bahia or peanut sites increased yields over the untreated controls ($P = 0.05$). Bahiagrass alone and the combination of 1,3-D applied broadcast and bahiagrass resulted in 6.6-fold and 9.7-fold increases in yield, respectively, over the untreated control in the peanut site. All treatments in the bahia site produced increases in vegetative growth at midseason and greater yields than the duplicate treatments in the peanut site. Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611-0611.

HOMINICK, W. M., and B. R. BRISCOE. Insect-killing rhabditid nematodes in the United Kingdom.
Rhabditid nematodes of the families Steinernematidae and Heterorhabditidae have potential as biological control agents, but British regulations stipulate that only native agents can be released. Therefore, soil from a number of sites was assayed with the Galleria-trap method to provide nematodes for control programs. Part of the survey was conducted at 15 sites over a period of 28 months and showed that the nematodes varied in their persistence even in adjacent, but different, habitats. There was no seasonal component to their presence. Random soil samples were taken from 403 sites classified as field (pasture, cultivated, hay or wild), woodland (deciduous, coniferous or mixed), hedgerow, roadside verge or heathland in England, Scotland and Wales. The nematodes were widespread, having been isolated from 197 of the sites (prevalence = 48.6%). They were found most frequently in roadside verges (45/68 = 66%) and least often in heathland (3/11 = 27%). Presence of the nematodes was also associated with soil type. Steinernema bibionis (Bovien) was the only steinernematid isolated. A Heterorhabditis sp. was found at only one of the 403 sites. Many of the isolates have been cultured and some are available commercially. Entomophilic Nematode Research Group, Department of Pure & Applied Biology, Imperial College at Silwood Park, Ascot, Berks, SL5 7PY, England.

HUAN, J., G. S. SANTO, and H. MOJTAHEDI. Influence of soil temperature and moisture on disease caused by Pratylenchus penetrans, Verticillium dahliae, and Erwinia carotovora subsp. carotovora on potato.
Twenty-day-old Russet Burbank potato seedlings were inoculated with $1{,}000_8$ Pratylenchus penetrans (Pp), 4×10^4 microsclerotia Verticillium dahliae (Vd) and 1×10^8 cfu Erwinia carotovora subsp. carotovora (Ecc) per 800 g of fumigated sandy loam soil alone and in all combinations. Pots were maintained at 20 and 25 C in temperature controlled water tanks at three moisture regimes (dry - water every 3 days, moist - every 2 days, and wet - daily). At 20 C in the wet regime, effect on disease symptoms and root growth was most severe ($P =$

0.05) when all three pathogens occurred together compared to single or any two pathogens in combination. At 25 C in all moisture regimes the three pathogens together increased (P = 0.05) plant damage compared to the noninoculated and single inoculations. However, it did not differ from any of the double inoculation treatments. Increased disease severity at 20 C compared to 25 C in the wet regime was probably due to plant stress caused by a lower temperature and higher soil moisture condition. Regardless of treatments, plant roots grew better at 25 than at 20 C. Washington State University, IAREC, Prosser, WA 99350-0030.

HUETTEL, R. N. Aggregate formation of some Pratylenchus spp. -Survival mechanism?
Survivability of plant-parasitic nematodes includes several recognized mechanisms, such as anhydrobiosis, dauer larvae, and aggregation. Observations of migratory endoparasitic nematodes propagated on root-explants have indicated that some Pratylenchus spp. and Radopholus spp. may have different survival mechanisms. Pratylenchus agilis forms aggregates, similar to eel-wool, in old culture plates both around roots and in agar. The aggregates are similar to those described for Tylenchorhynchus spp. and Ditylenchus spp. Other species of Pratylenchus, such as P. scribneri and P. brachyurhus, also form aggregates but not as dense as P. agilis. Radopholus spp., on the other hand, appear to undergo anhydrobiosis, indicated by individuals tightly coiled and quiescient in agar or in old roots. Aggregates have not been observed in vitro with Radopholus spp. At present, bioassays are being developed to determine if P. agilis aggregation is pheromonally induced. USDA, ARS, Nematology Laboratory, Beltsville, MD 20705.

HUETTEL, R. N., and F. A. HAMMERSCHLAG. Response of peach scion cultivars and rootstocks to root-knot nematodes in vitro, in the greenhouse and in microplot.
Five peach Prunus persica (L.) Batsch scion cultivars (Sunhigh, Suncrest, Rio Oso Gem, Jerseyqueen, and Redhaven) and two rootstocks (Nemaguard and Lovell) were micropropagated from virus-indexed stock plants and then compared in vitro, in the greenhouse and in microplots for their resistance or susceptibility to the root-knot nematode, Meloidogyne incognita. In vitro, plantlets were evaluated for gall formation 5 weeks after co-cultivating the roots with root-knot nematode. Greenhouse evaluations were conducted 6 months after tissue-cultured plants were transferred to pots and then exposed to M. incognita. Plantlets, transferred to the greenhouse for 6 weeks, were transplanted into microplots and trees in these microplots have been evaluated for three years. Data collected from microplots included nematode soil counts, tree growth and yield. Comparative results indicated that the number and size of galls observed at 5 weeks is indicative of the response of peaches to nematodes under field conditions after three years. In vitro screening appears to be a rapid and reliable measurement of host response to root-knot nematode. This technique should be of value in evaluating novel peaches developed through either culture or genetic engineering technologies. USDA, ARS, Nematology Laboratory, Beltsville, MD 20705.

HUSSEY, R. S., and C. W. MIMS. Ultrastructure of esophageal gland secretory granules in Meloidogyne incognita.
Transmission electron microscopy was used to examine secretory granules formed in dorsal (DG) and subventral glands (SvG) of preparasitic and parasitic M. incognita second-stage juveniles (J2) and adult females. While both types of granules were spherical, membrane-bound, and Golgi derived, they differed from one another in morphology and size. SvG in preparasitic J2 were packed with granules which varied in diameter from 700-1,100 nm and had a heterogeneous matrix. A small core in the granule was less dense than the surrounding matrix and contained distinct spherical structures. The size and position of the core varied within granules. Few granules were present in DG of preparasitic J2. DG granules in 5-7 day-old parasitic J2 and adult females varied in diameter from 300-600 nm. The matrix of a DG granule was homogeneous and more dense than that of a SvG granule. SvG granules of parasitic J2 appeared to be in various stages of degeneration and were mostly absent in adult females. A crystalline-like secretory component, whose fine structure was similar to that of the feeding tubes formed from nematode secretions in host giant cells, accumulated in the DG valve end apparatus of adult females. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

HUSSEY, R. S., O. R. PAGUIO, and F. SEABURY. Localization and partial characterization of a secretory protein in Meloidogyne incognita using monoclonal antibodies.
Monoclonal antibodies specific for secretory granules formed in the esophageal glands of Meloidogyne incognita were generated by injecting BALB/C mice with immunogens prepared from preparasitic second-stage juveniles. A monoclonal antibody that reacted with secretory granules formed in the dorsal and subventral glands was selected by indirect immunofluorescence microscopy of paraformaldehyde-fixed sections of second-stage juveniles. Postembedding immunogold labeling of ultrathin sections of second-stage juvenile esophageal regions revealed the antigen to be localized in a zone around the less electron-dense cores present in subventral gland granules. In the dorsal gland of adult females, gold labeling was

primarily limited to partially empty granules near the gland valve. The antigen was also detected by immunofluorescence microscopy in stylet secretions of adult female nematodes incubated in a perfusion chamber. This secretory component was immunoaffinity purified and appeared to be a large molecular weight (>150,000) glycoprotein as indicated by its slow electrophoretic migration in 7% SDS-PAGE and positive staining with periodic acid-Schiff reagent. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

HYMAN, B. C. Molecular diagnosis of Meloidogyne species.
Nucleic acid analysis has quickly gained acceptance as a useful complement to traditional methods of identifying and grouping nematode populations. Because of its rapid evolutionary rate and high cellular copy number, we have chosen to evaluate nematode mitochondrial DNA (mtDNA) as a useful reagent for the detection and diagnosis of root-knot nematodes. Precise, sensitive mtDNA-based molecular diagnostic assays for several Meloidogyne species have been developed, exploiting nucleotide sequence divergence among their mitochondrial genomes. Based on these results, we have proceeded to optimize nucleic acid hybridization assays for demanding conditions likely to be encountered in analysis of crude field samples. This includes the unambiguous identification of nematode mtDNA derived from a limited number of eggs contained within a variety of soil samples. Strategies for improved nematode molecular diagnostics using cloned mtDNA segments will be presented and discussed in the context of alternative biotechnologies employing nematode nuclear DNA sequences. Department of Biology, University of California, Riverside, CA 92521.

INGHAM, R. E., M. A. MORRIS, and G. B. NEWCOMB. Effects of methods of incorporating ethoprop into soil on potato tuber infection by Meloidogyne hapla.
Methods of incorporating ethoprop into soil and combined treatments of ethoprop and aldicarb after fumigation were studied for management of root-knot nematode (Meloidogyne hapla) damage to potato in the Columbia Basin of Oregon. Postplant water incorporation of granular ethoprop at 13.2 kg a.i./ha did not adequately reduce the number of culled (6+ nematodes/tuber) tubers. Addition of a surfactant in the water or application of gypsum to the soil surface to increase penetration did not further reduce nematode infection. Preplant injection of liquid ethoprop at 30 cm reduced culled tubers from 32% to 9 and 4% with use of 30-cm and 15-cm shank spacings, respectively. Best control was achieved with physical incorporation of 13.2 kg a.i./ha of granular ethoprop before planting. Culled tubers were reduced from 59% in the fumigated only plots to 0% with incorporation by rototilling and to 2% with incorporation by discing. Postplant application of aldicarb at 3.3 kg a.i./ha reduced culled tubers from 32% to 7% in one study and from 59% to 1% in another. Combination of ethoprop and aldicarb was superior to ethoprop alone in all treatments except where ethoprop alone was sufficient. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902.

ISHIBASHI, N. Nonparasitic/nonpredacious nematode antagonists.
Soil organisms are conceivably occupying their own limited habitat. If aliens massively trespass in the natives' residence, the natives will suffer a great nuisance. If the natives keep a big influence there, the aliens may feel humiliated with their small power. To confirm the above concepts, some observations were made: 1) inundative application of steinernematid nematodes brought a great disturbance in the native nematode population in the soil with a low species diversity (=low biological buffering action) through chemical treatments, where the steinernematids persisted longer; 2) gall formation by the root-knot nematode was reduced by the co-inoculation with massive steinernematids and/or aphelenchids. The latter two were also attracted to the root-tips, preventing the access of M. incognita J2; and 3) an increase in free-living nematodes decreased plant-parasitic nemas. For instance, soil application of cinnamic aldehyde decreased the M. incognita population with an extreme increase in the rhabditid nematode population. Application of this chemical after fumigation induced an earlier establishment of free-living nematodes than plant-parasitic ones. Department of Applied Biological Sciences, Faculty of Agriculture, Saga University, Saga 840, Japan.

JAFFEE, B. A. and A. E. MULDOON. Parasitism of Heterodera schachtii in soil naturally infested with the nematophagous fungus Hirsutella rhossiliensis.
Juveniles (J2) of Heterodera schachtii were added to soil naturally infested with high (about 10^6 spores/100 cm^3 of soil) or low levels of Hirsutella rhossiliensis. Cabbage seedlings in soil infested with high levels of H. rhossiliensis contained 50-77% fewer Heterodera schachtii than seedlings in soil infested with low levels of the fungus. Spores of H. rhossiliensis were observed on the cuticles of 10% of the nematodes removed from roots; about one-half of these were infected. H. rhossiliensis spores adhered to 40-63% of H. schachtii J2 incubated in the suppressive soil without plants for 2 days. Of those J2 with spores at day 2, 82-92% were infected (i.e., were alive but contained infection bulbs ± assimilative hyphae). Infected nematodes died within 2-3 days. Addition of KCl to nematode inoculum did not increase the percentage of nematodes infected. A higher propor-

tion of nematodes was infected when they were naturally inoculated with H. rhossiliensis in soil than when artificially inoculated. Department of Nematology, University of California, Davis, CA 95616.

JOHNSON, A. W., W. W. HANNA, and C. C. DOWLER. Improved pearl millet - a potential grain crop in the United States.
Improved pearl millet is drought tolerant, disease resistant, and requires little nitrogen for grain production. Millet was planted in field plots infested with Meloidogyne incognita and Criconemella ornata. The experimental design was a split plot with irrigation vs no irrigation as whole plots, nematicide vs no nematicide as subplots, and fertility treatments as sub-subplots. Root-gall indices were not affected by treatments. Yield was increased ($P = 0.05$) 133 % in the nonirrigated, nematicide-treated, low fertility plots (3,650 kg/ha) compared with the irrigated, nematicide-treated, high fertility plots (1,568 kg/ha). USDA, ARS Coastal Plain Experiment Station, Tifton, GA 31793.

KALOSHIAN, I., P. A. ROBERTS, J. G. WAINES, and I. J. THOMASON. Chromosomal location of root knot-resistance gene in the D genome of wheat.
Monosomic analysis was used to locate a single dominant Meloidogyne javanica resistance-gene present in the D-genome of synthetic hexaploid 'Prosquare' derived from Aegilops squarrosa L. G 3489. Monosomic lines of Triticum aestivum cv. Chinese Spring for each of the seven D chromosomes (1D-7D) were crossed with the synthetic hexaploid. Fifteen-day-old seedlings of the seven F2 generations, derived from monosomic F1 plants from the above crosses, were inoculated with 5,000 eggs. Plants were harvested after accumulating approximately 630 degree days. Presence or absence of nematode resistance was determined by the level of nematode reproduction on the roots expressed as eggs per gram of roots. Six lines (1D-5D and 7D) segregated into 3:1 resistant to susceptible ratio in reaction to M. javanica. Monosomic 6D deviated from the 3:1 ratio which indicated that the nematode-resistant-gene is located on chromosome 6D. Department of Nematology, University of California, Riverside, CA 92521.

KAPLAN, D. T., and E. L. DAVIS. Lectins influence the rate of infection of excised citrus roots by burrowing nematodes.
An in-vitro bioassay using a 96-well microtiter plate was devel- oped to facilitate studies on nematode penetration of plant roots. In each well a single root segment (5 mm), excised from the zone of elongation of rough lemon roots was buried in 0.50 g of steri-lized, dried Astatula sand. Individual wells received 50 l of nematode suspension containing 300 nematodes in test solution. The technique assured uniform treatment concentration throughout the medium using relatively little test material. Acid fuchsin-stained roots indicated that burrowing nematodes infect citrus root pieces within 16 - 24 hours. The lectins (100 ppm) Concanavalin A (CON A), soybean, wheat germ, and Lotus tetragonolobus agglutinins stimulated an 80% increase in infection rates of citrus root segments by Radopoholus citrophilus as compared with controls under test conditions. Concentrations as low as 25 ppm of CON A stimulated burrowing nematode infection of citrus roots. U.S. Department of Agriculture, ARS, USHRL, 2120 Camden Road, Orlando, FL 32803.

KAPLAN, D. T., D. E. WALTER, and E. L. DAVIS. Lectins stimulate trap formation in Arthrobotrys dactyloides.
The nematode-trapping fungus, Arthrobotrys dactyloides, produce septate conidia on erect conidiophores. Conidia germinate readily in aqueous solution but do not produce traps (constricting rings) spontaneously. Trap formation can be routinely stimulated by the addition of nematodes. Five lectins and their corresponding carbohydrates (Concanalvalin A/mannose or methyl-a-mannopyranoside, Limulus polyphemus agglutinin/sialic acid, soybean agglutinin/N-acetyl galactosamine, Lotus tetragonolobus agglutinin/fucose, and wheat germ agglutinin/N-acetyl glucosamine) were selected to assess the potential role of both lectins and carbohydrates in trap formation. All lectins (100 ppm) tested stimulated 100% of germinating conidia to produce traps within 40 hours in the absence of nematodes. Nematodes and lectins together had a significant synergistic effect, enhancing trap formation within 16 hours. Corresponding carbohydrates (100 mM) did not influence the rate of trap formation in the presence or absence of nematodes. Conidia were labeled positively with TRITC-conjugated lectins. U.S. Department of Agriculture, ARS, USHRL, 2120 Camden Road, Orlando, FL 32803.

KAYA, H. K., K. L. H. LEONG, T. M. BURLANDO, K. SMITH, and M. A. YOSHIMURA. Entomogenous nematodes for biological control of the western spotted cucumber beetle, Diabrotica undecimpunctata.
Field tests were conducted in San Luis Obispo, California, where natural populations of Diabrotica undecimpunctata occurred. Zucchini (cv Dark Green 16815) was planted on 22 June 1988, and treated with Steinernema feltiae A11 and Heterorhabditis sp. HP88. Treatments were: water control, chemical control (25% diazinon EC at 2 ml formulated

insecticide/liter/0.8 m^2), and three concentrations (25, 50, and 100 infective nematodes/cm^2) each of Heterorhabditis HP88 and S. feltiae. Treatments were applied to 5 replicated plots as a drench every 2 weeks, starting 18 July and ending 25 August, 1988. Fruit was weighed weekly, and root rating and plant dry weight were determined on 2 September. Fruit yield, root rating, and plant weight did not differ significantly among treatments. Although Diabrotica adults were abundant throughout the study, larval distribution on zucchini roots was patchy. This patchy distribution probably contributed to the lack of differences among treatments. Department of Nematology, University of California, Davis, CA 95616 and Department of Biology, California Polytechnic State University, San Luis Obispo, CA 93407.

KHAN, M. R., and M. W. KHAN. Interaction of simulated acid rain and Meloidogyne incognita race 1 on tomato.
Interaction of simulated acid rain (SAR) at two pH levels (6.6 & 3.2) and Meloidogyne incognita race 1 (MI) was studied on tomato in sequential inoculation-exposures(pre-,concomitant- and postinoculation exposures). Bifacial white to tan-colored lesions caused by 3.2 pH SAR became more prominent in nematode inoculated-SAR treated plants. MI and SAR at pH 3.2 singly and in combination significantly reduced plant growth, yield, and leaf pigments. Postinoculation exposure to SAR at pH 3.2 was most harmful. Significant reductions occurred only in preinoculation exposure to SAR at pH 6.6. MI and SAR caused synergistically greater reduction in post- and preinoculation exposure at pH 3.2 and 6.6, respectively. The nematode was favored at pH 6.6, but harmed at 3.2. MI decreased count of stomata and trichomes and stomatal size. SAR at pH 6.6 reduced count and size of stomata and enhanced count and length of trichomes. Drastically low counts and sizes of stomata and trichomes and wide stomatal aperture were observed on the leaves of inoculated/uninoculated plants at pH 3.2. Department of Botany, Aligarh Muslim University, Aligarh-202 002, India.

KIM, D. G., and R. D. RIGGS. Distribution and efficacy of Arkansas Fungus 18-A in nematode control.
Arkansas Fungus 18-A (ARF18-A) was first isolated in 1986 on artificial media and found infective to Heterodera glycines, H. graminophila, H. lespedezae, H. leuceilyma, H. schachtii, H. trifolii and Meloidogyne incognita but not Globodera virginiae. The fungus was isolated during 1986-88 from 6 of 45 populations of Heterodera glycines in widely distributed soybean fields in Arkansas. One field where ARF18-A was found contained 70% diseased eggs. Soil from that field was placed in 10-cm-d clay pots, treated with formalin, aldicarb, or PCNB+ethanol to suppress the fungus and then planted with 'Lee' soybean. After 3 months, 17 times more eggs had developed in formalin-treated pots than in aldicarb, PCNB+ethanol, or control pots suggesting a possible suppressive role of ARF18-A in field soil. Gel pellets of ARF18-A applied 10 or 20 g/10-cm-d pot of Captina silt loam naturally infested with H. glycines reduced nematode numbers significantly ($P = 0.05$) by 85% to 89%, but plant growth was not affected after 60 days. ARF18-A treatments also significantly reduced the number of eggs of Meloidogyne incognita ($P = 0.01$) and increased plant height and weight ($P = 0.01$) of 'California Wonder' peppers equivalent to those planted in sterilized soil, even though there was no reduction in M. incognita juveniles. Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

KING, P. S., R. RODRIGUEZ-KABANA, D. G. ROBERTSON, and L. WELLS. Preplant applications of metam-sodium for control of Meloidogyne arenaria in peanut: relative efficacy and rates.
In-row preplant applications of Busan 1020 (32.7% metam sodium) at rates of 28-187 L/ha reduced end-of-season juvenile populations of Meloidogyne arenaria in soil in a field experiment with Florunner peanut (Arachis hypogaea). The relation between Busan 1020 rate (X) in L/ha and numbers of juveniles per 100 cm^3 soil (J) was described (R^2=0.94) by $J=20.5e^z$, where $z = (X-232)^2/17{,}199$. Yield (Y) in kg/ha was related (R^2=0.98) to rate by $Y=1{,}421.66 + 12.51X - 0.03X^2$ while the relation between Y and J was defined (R^2 = 0.95) by $Y=2{,}638.288 - 5.635X + 0.007X^2$. Another field experiment revealed that preplant in-row applications of Busan 1020 at 94 L/ha resulted in equivalent peanut yield increases and control of M. arenaria juveniles as those obtained with preplant in-row applications of 1,3-D (Telone II) at rates of 47-84 L/ha or an at-plant application of aldicarb (Temik 15G) at 2.2 kg a.i./ha in a 20-cm-wide band (10 kg a.i../ha broadcast). Department of Plant Pathology, Auburn University, AL 36849-5409.

KIRKPATRICK, T. L., D. M. OOSTERHUIS, and S. D. WULLSCHLEGER. Effects of Meloidogyne incognita infection on water relations of two cotton cultivars.
The effects of M. incognita infection on cotton plant-water relations were investigated. M. incognita-susceptible (Stoneville 506) and -resistant (Auburn 634) cotton was grown in pots in a growth chamber for 3 weeks then half of each group was inoculated with M. incognita eggs. At 2 and 4 weeks after inoculation, various plant morphological and physiological parameters were measured following a water-stress period. Nematode infection had no

effect on plant height, leaf area, or root length. However, nematodes and water stress significantly decreased the pressure-induced water flow through the roots of both cultivars. No cultivar x nematode interaction occurred, although a trend was apparent for the flux of Stoneville 506 to be decreased more than that of Auburn 634. The decrease in root hydraulic conductivity seen due to nematodes was not reflected in poststress measurements of transpiration, stomatal resistance, leaf temperature, or components of leaf-water potential. University of Arkansas, Southwest Research and Extenstion Center, Route 3, Box 258, Hope, AR 71801.

KO, M. P. Interactions of Pratylenchus penetrans and alfalfa callus cells cultured in Pluronic polyol-based medium.
Plant cells cultured in vitro may provide defined, reproducible, and quantitative systems to be employed in biochemical and physiological studies on nematode-plant cell association. In this study, alfalfa callus cell clones capable of growing and multiplying in Pluronic F127 based media were selected and characterized, and their ability to support P. penetrans reproduction was determined. Sterile 3-day-old alfalfa seedlings were transferred to Pluronic polyol based media (semi-solid) consisting of Modified White's, Murashige and Skoog, Gamborg's B5, or Dunstan and Short (BDS) medium plus 2 mg/L of auxin to initiate calli formation. The cultures were incubated at 25 C in the dark. Cell clones that multiplied rapidly were selected and subcultured monthly or bimonthly in the respective media for 12 months. Only BDS medium supported a persistently viable clone with friable cells that multiplied rapidly. These cells were redispersed in BDS medium (1,000 cells/ml) by liquefying the Pluronic at 15 C, inoculated with sterile P. penetrans (1 nematode/10 cells) and then incubated at 25 C for a month. Number of P. penetrans increased 2-5 fold but multiplication and viability of alfalfa cells were suppressed. Most of the P. penetrans were observed to feed extracellularly and rarely intracellularly. Department of Plant Pathology, Cornell University, Ithaca, NY 14853.

KUNG, S. P., and R. GAUGLER. Abiotic soil factors affecting the persistence of two entomopathogenic nematodes, Steinernema feltiae and Steinernema glaseri (Nematoda: Steinernematidae).
The persistence of Steinernema feltiae (All strain) and Steinernema glaseri was tested at various soil types, pH, moistures and temperatures. Both nematodes showed optimal persistence in sandy soils and their persistence decreased as the proportion of clay increased. The persistence of both species increased as soil pH increased to pH 8 and drastically dropped at pH 10. S. feltiae persistence was greater than that of S. glaseri at low soil moisture (2%). S. feltiae persistence was greater at lower temperatures as compared to S. glaseri which was greater at higher temperatures. S. feltiae was generally more tolerant of environmental extremes than S. glaseri. Department of Entomology, Rutgers University, New Brunswick, NJ 08903

LAIRD, D. W., J.-S. HUANG, and K. R. BARKER. Iron and ferritin relationships in Heterodera glycines-infected soybean.
Heterodera glycines, the soybean cyst nematode (SCN), interferes with nodulation and nitrogen fixation on susceptible soybean cultivars. Previous research suggests an alteration in iron metabolism in SCN-infected plants as a possible cause. Levels of soluble iron, heme and ferritin (an iron storage protein) in nodular tissues of SCN race 1-infected Lee 68 soybean were determined over time. Nodules of plants inoculated simultaneously with SCN race 1 and Bradyrhizobium japonicum contained high ferritin and soluble iron levels 21 days after inoculation (DAI). All plants, including controls, had similar ferritin protein levels at 28, 35 and 42 DAI. Soluble iron levels were slightly higher, whereas heme levels were reduced in nematode-infected plants at all dates. Ferritin iron content was higher in nodules from infected plants at later sampling dates. In nodules of plants where nematode inoculation was delayed 3 days after Bradyrhizobium inoculation, no differences occurred in ferritin, soluble iron or heme levels for 28 DAI. At 35 and 42 DAI nodules of these plants exhibited changes similar to trends noted in plants inoculated simultaneously with SCN race 1 (due to secondary infection). Lower specific nitrogenase activity was negatively correlated with high iron content of ferritin in all treatments. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

LAMONDIA, J. A. The effect of oxamyl on Globodera tabacum population dynamics and shade tobacco yield.
The preplant soil application of 0.0, 2.2 or 6.7 Kg ha^{-1} oxamyl to shade grown tobacco in Globodera tabacum-infested field soil was investigated in 1987 and 1988. Oxamyl application increased marketable leaf yields over untreated plots by 10.7 to 21.0% for 2.2 and 6.7 Kg ha^{-1} rates, respectively. Fresh weight leaf yield was negatively correlated with initial G. tabacum density, which ranged from 33 to 154 second-stage juveniles (J2) per cm^3 of soil. The number of G. tabacum J2 and developing juveniles and adults (J3-adults) per gm root were fewer in plants from oxamyl-treated plots than untreated plots. Four, six and

eight weeks after transplanting, the numbers of J2 in roots were reduced by 80, 89 and 4%, respectively, and numbers of J3-adults were reduced by 96, 89 and 21%, respectively, in high rate oxamyl plots compared to untreated plots. G. tabacum reproduction, as measured by the ratio of final to initial soil densities, was less in plots to which oxamyl had been applied than in untreated plots. The Connecticut Agricultural Experiment Station, Valley Laboratory, P.O. Box 248, Windsor, CT 06095.

LEI, Z., J. M. WEBSTER, and T. A. RUTHERFORD. Behavior of entomopathogenic nematodes in the presence of Delia radicum and its host plant seedlings.
Entomopathogenic nematodes are more likely to control the cabbage maggot, Delia radicum, if the insect is attractive to the nematodes and if the plants on which the insect feeds do not repel the nematodes. Experiments were done using the infective juveniles of three strains (NC162, A13-5, and T327) of Heterorhabditis heliothidis, seedlings of radish and rutabaga, and third instar larvae and puparia of D. radicum, on 1.5% Bacto Agar in Petri dishes (100 x 15 mm). Results are summarized as follows: 1) nematodes of strain NC162 moved randomly on the agar and were neither repelled by nor attracted to seedlings of radish and rutabaga; 2) nematodes of strains NC162 and A13-5 moved randomly on the agar in the presence of different numbers of newly-formed D. radicum puparia. This indicates that chemicals released by the puparia were either insoluble in water, too weak to affect the nematodes, or had no effect on nematode behavior; and 3) nematodes of strain T327 were more attracted than those of strain NC162 towards frozen, dead, third instar larvae of D. radicum on the agar. Although the two strains behaved differently, there was no tendency for greater concentrations of insect larvae to attract more nematodes or to do so over greater distance. Department of Biological Sciences, Simon Fraser University, Burnaby, B.C., Canada, V5A 1S6.

LEIJ DE, F., and B. R. KERRY. The potential of Verticillium chlamydosporium as a bio-control agent against root-knot nematodes (Meloidogyne spp.).
The potential of Verticillium chlamydosporium as a biological control agent against Meloidogyne spp. on tomato plants was investigated in glasshouse conditions. Postcropping nematode populations were reduced by >80% by one fungal isolate (three tested) which was rhizosphere-competent and was able to colonize the rhizoplane of galls and uninfected roots. Applications of selected strains were tested for their effects on nematode multiplication and rates of egg parasitism. The fungus reduced numbers of nematode eggs by up to 90% of which about 50% were parasitized after one generation. Plant damage caused by the second nematode generation was significantly less in fungus inoculated treatments, but final nematode populations were only reduced when precropping populations were small. The fungus did not appear to invade the root cortex and there were no direct effects of the fungus on plant growth. V. chlamydosporium gave similar control to aldicarb (3.75 kg/ha) of the first nematode generation and was significantly better in the second. Therefore, selected isolates of the fungus may have potential as biological control agents for root-knot nematodes. AFRC, IACR, Rothamsted Experimental Station, Harpenden, Herts., AL5 2QJ, England.

LONG, M., and V. M. WILLIAMSON. Studies on alcohol dehydrogenase in Panagrellus redivivus.
Alcohol dehydrogenase (ADH) activity has been observed in a number of nematode species but little work has been done on the properties of this enzyme in nematodes. The free-living nematode Panagrellus redivivus can survive and reproduce in solutions containing 10% ethanol. ADH which is responsible for catalyzing the first step in ethanol degradation is present in nematode extracts. Specific activity of ADH is induced 1.7-fold one and a half hours after incubation of P. redivivus in the presence of 7 or 10% ethanol. Electrophoresis of extracts on cellulose acetate reveals only a single band of ADH activity whether the nematodes have been exposed to ethanol or not. This result suggests that there is only one alcohol dehydrogenase enzyme (and therefore gene) present. The biochemical properties of ADH in P. redivivus and in C. elegans are currently under investigation. In addition, genomic libraries of DNA from P. redivivus and C. elegans will be probed with cloned ADH genes from yeast and Drosophila in an attempt to obtain a clone of the nematode gene. Department of Nematology, University of California, Davis, CA 95616.

MacGUIDWIN, A. E., and D. I. ROUSE. Effect of Meloidogyne hapla on Russet Burbank potato, alone and in combination with Verticillium dahliae.
Fumigated microplots on Plainfield loamy sand soil were inoculated in 1986 with two levels of Meloidogyne hapla and one level of Verticillium dahliae, alone and in combination. The population of V. dahliae recovered after inoculation (3 microsclerotia/g soil) was below that causing yield loss in earlier studies. Disease symptoms and yields of Russet Burbank potato grown in the microplots were evaluated in 1986-1988. Nematode populations increased during the 3 years of the study; Verticillium populations did not. Symptoms associated with potato early dying disease were more severe in plots inoculated with V. dahliae in 1986 and 1988 than in noninoculated plots. Only M. hapla reduced tuber yields. By 1988,

yields of plots inoculated with low (70 eggs per 100 cm^3 soil) and high (144 eggs per 100 cm^3 soil) numbers of nematodes were reduced an average of 48% and 70%, respectively, as compared to noninoculated controls. Synergistic interactions between M. hapla and V. dahliae were not observed for symptom expression or yield reduction. Department of Plant Pathology, University of Wisconsin, Madison, WI 53706.

MANKAU, R. Problems in taxonomic differentiation of nematode-trapping fungi.
The morphology and arrangement of hyalophragmoconidia produced at the tips of simple conidiophores are the main characters separating the genera of predacious hyphomycetes. Drechsler originally delineated the long-held parameters of such major genera as Arthrobtrys, Dactylella and Dactylaria and recent workers have reexamined these and Monacrosporium without a clear resolution of these taxa. A study of one of the largest collections of nematophagous fungi currently available determined that related isolates clearly overlap current concepts of all the above genera. Fungi similar to all these genera may produce conidia either singly, in groups, or acropleurogenously on simple or branched conidiophores. Monacrosporium-like species can be segregated from Dactylella easily by their fusiform, obovoid or broadly turbinate conidia with at least one median cell of much greater width and volume than distal cells. Several genera in the predacious series are not valid and Dactylaria should be reserved for species with partly pigmented fructifications such as the nonpredacious forms in this genus, but most isolates have biological affinities to the form genus Arthrobotrys although some cannot match its designated conidial morphology. Precise and rational identification is important in applied and ecological investigations on this important group of fungi. Department of Nematology, University of California, Riverside, CA 92521.

MANNION, C. M., R. K. JANSSON, and G. C. SMART, JR. Susceptibility of the sweetpotato weevil to entomogenous nematodes.
The sweetpotato weevil (SPW), Cylas formicarius elegantulus, is the most destructive insect pest of sweet potato in the southern United States, the Caribbean and other tropical regions. Much of the life cycle of the SPW is spent within the vines and roots making chemical control difficult. The potential of entomogenous nematodes for control of the SPW was tested in the laboratory. SPW larvae and pupae were exposed to various densities of several strains of Steinernematid and Heterorhabditid nematodes in petri plate bioassays. SPW larvae and pupae were susceptible to all nematode strains tested. SPW mortality increased with an increase in nematode density. An LD_{50} was determined for each nematode strain. Selected strains were tested in a second bioassay in which various densities of nematodes were suspended in water and poured over infested roots of sweet potato buried in soil. Percent SPW mortality was determined at each density. Considerably more nematodes were necessary to obtain equivalent mortality in the soil bioassay compared to the petri plate bioassay. Nematology Laboratory, Bldg. 78, University of Florida, Gainesville, FL 32611-0611.

MASHELA, W., and R. MCSORLEY. Pathogenicity of Belonolaimus longicaudatus on seedlings of Alysicarpus vaginalis.
Under field conditions shoot weight/plant of alyceclover, Alysicarpus vaginalis, was negatively correlated with densities of sting nematode, Belonolaimus longicaudatus. The pathogenicity of B. longicaudatus on seedling establishment of A. vaginalis was demonstrated under greenhouse conditions. Five initial populations (Pi) of 0, 4, 16, 64, or 256 nematodes/pot were established in 7-day transplants of alyceclover in 15-cm-d pots. At harvest (10 weeks), the reproductive factor (Pf/Pi) was greater than one for Pi>0. Both the shoot heights and weights showed significant ($P \leq 0.05$) decreases with increasing nematode densities. Similar results were obtained in the second test. Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.

McELROY, FRED D. Nematode management in brambles.
Species of Pratylenchus, Xiphinema, Longidorus, and Meloidogyne have been associated with decline and mortality of brambles (Rubus species). Some species are capable of causing direct feeding damage and others transmit viruses which result in poor fruit quality and plant decline. A nematode management program has been developed by the author to minimize chemical use and nematode impact while optimizing fruit production. Nematode management is an integral part of a Plant Health Care Program which manages above and below ground pests and diseases, as well as, fertility in berry plantations. Nematode control decisions are based on pre- and postplant soil sampling. Preplant assay results determine chemical and rate, and set the base line for future sampling. Postplant sampling of soil and roots follows a preset pattern in which samples were collected and composited from selected reference plants throughout the plantation. Frequency of sampling on an annual basis and application of control measures are determined by the proximity of populations to economic threshold levels and farm management practices which affect nematode impact on the plantation. Peninsu-Lab, P.O. Box 3000, Kingston, WA 98346.

MCGAWLEY, E. C., K. C. HADDEN, and K. L. WINCHELL. Studies on the biology and host-parasite relationship of Rotylenchulus reniformis.
Severe root pruning, root necrosis, unthrifty growth, and significant yield reduction have been reported as consequences of parasitism by the reniform nematode, Rotylenchulus reniformis. This nematode, now reported from 38 countries, was first described by Oliveira in 1940 from the roots of cowpea, Vigna sinensis, in Hawaii. Plants in the Leguminosae, Curcubitacae, Malvacae, and Solanaceae predominate as hosts. Reniform nematodes have a life history similar to Tylenchulus Cobb, 1913, with the female embedded in the root after the fourth molt. Vermiform juveniles, females, and males of Rotylenchulus possess many characteristics in common with the genus Rotylenchus Filipjev, 1936. Unlike most other plant-parasitic nematodes, the reniform preadult female is the infective stage. The most concentrated occurrence of Rotylenchulus reniformis outside of the tropics appears to be in the southeastern United States. In both Louisiana and Mississippi, the nematode is a major problem on soybean, Glycine max (L.) Merr., and cotton, Gossypium hirsutum L. The possible existence of distinct physiological races of Rotylenchulus reniformis has been suggested. Exudates from hosts and nonhosts have been shown to exert allelopathic influences. Department of Plant Pathology and Crop Physiology, Louisiana Agricultural Station, Louisiana State University, Baton Rouge, LA 70803.

McKENRY, M. V., R. BOSTOCK, and J. KRETSCH. Predisposition to bacterial canker complex.
Nemaguard (Prunus persica X P. davidiana) rootstocks with almond (P. amygdalus) scion were planted into 12 cm^3 fiberglass tanks filled with washed river sand. This provided a closed substrate to evaluate Criconemella xenoplax as a predisposing agent to bacterial canker complex (BCC). Treatments included: 1) addition of 10 K vermiform C. xenoplax from a greenhouse grown sand culture; 2) addition of 1.2 kg soil containing 10 K vermiform C. xenoplax plus other unknown organisms associated with a BCC field site; and 3) noninoculated control. Throughout the 3-year period of the trial populations of C. xenoplax were 5-10 times higher for treatment 1 than treatment 2. Treatment 3 remained free of C. xenoplax for 3 years. Five months after inoculation with Pseudomonas syringae, 5 of the 6 trees that had received treatment 1 exhibited limb or twig death with symptomology similar to BCC. Some limbs not directly inoculated with P. syringae were among those that died. No other trees from treatments 2 or 3 exhibited any dead limbs or twigs. Trees receiving treatments 1 and 2 exhibited significantly reduced top weights, fibrous roots, and trunk diameters. In this test predisposition to BCC occurred with C. xenoplax alone and there are organisms associated with C. xenoplax that are antagonistic to it in treatment 2. Department of Nematology, University of California-Riverside, Riverside, CA 92521.

MCLEAN, K. S., G. W. LAWRENCE, and K. W. ROY. Effects of Fusarium solani, causal agent of sudden death syndrome of soybean, on development of Heterodera glycines.
Effects of Fusarium solani (form FS-A) on cyst development of soybean cyst nematode (SCN), Heterodera glycines race 3, were investigated. Four isolates of FS-A recovered from field collections of SCN cysts, were inoculated in combination with SCN, on Coker 156 soybean. Colonization of females by FS-A ranged from 33 to 44 percent. Significant differences ($P = 0.05$) were measured among the isolates relative to their ability to colonize cysts. In addition, the number of females reaching maturity and the number of juveniles recovered from cysts were significantly less from FS-A-infected plants. Observations using light and scanning electron microscopy revealed chlamydospores within cysts and SCN eggs and atypical female development in roots inoculated with FS-A. Department of Plant Pathology and Weed Science, Mississippi State, MS 39762.

MCSORLEY, R., and D. W. DICKSON. Vertical distribution of nematodes beneath soybeans in Florida.
Vertical distributions of five plant-parasitic nematode species were monitored in two fields planted to 'Davis' soybean during 1987 and 1988. Soil samples were collected from three depths (0-15, 15-30, and 30-45 cm) at each of eight sites per field. Soil texture at all three depths averaged about 96% sand, 1.5% silt, and 2.5% clay. More than 50% of Belonolaimus longicaudatus (BL) occurred in the upper 15 cm at planting, but became more evenly distributed through the other depths later in the season, with only 30-40% present at 0-15 cm. Criconemella sphaerocephala was sparse (<20% of total density) in the upper 15 cm in one field, but more evenly distributed among the three depths in a second field which had heavy BL damage. Maximum soil population densities of Pratylenchus brachyurus occurred at 15-30 cm on most sampling dates; often 50% of the population density occurred at this depth. Meloidogyne incognita (MI) and Paratrichodorus minor (PM) showed few differences ($P \leq 0.05$) with depth during the 1987 season. During 1988, PM occasionally was more abundant at the lower depths than at 0-15 cm, but vertical distribution of MI was erratic. More than 70% of MI occurred at 15-30 cm in May, but 80% were found at 0-15 cm in October. A diagnostic sample taken 0-15 cm deep would catch less than 40% of most nematodes observed here. Seasonal variation in depth distribution was apparent in some instances as well.

Nematology Lab., Bldg. 78, 0611-IFAS, University of Florida, Gainesville, FL 32611-0611.

MELAKEBERHAN, H. Bursaphelenchus xylophilus densities that affect Scots pine longevity.
When pines are inoculated simultaneously with similar levels of Bursaphelenchus xylophilus they die at different times. This has led to the speculation that the nematode population must reach a certain threshold to kill the pines. Thus, the rate of nematode reproduction within the pine tissues would be an important factor. When seven-month-old Scot's pines were inoculated with 0, 10,000 or 20,000 B. xylophilus B.C. strain nematodes and maintained at 20 degree-days (base 10 C) per day, ca. 50% of the nematodes were recovered 48 hours later. Examination of 36 pines each inoculated with 2,500 nematodes at 3, 7, 11, 14, 18, 28, 53, and 68 days after inoculation showed an increase in pine mortality from 11% at day 14 to 47% at day 68. While the mean nematode population at day 14 was 510 per gram fresh plant weight, the mean for the period from day 18 to day 68 was 2,699 ± 1,185. Further data analysis suggests that the number of nematodes may have to reach a threshold before killing the pines. Under specified experimental conditions, time to pine death cannot be predicted from the initial infection levels. Department of Biological Sciences, Simon Fraser University, Burnaby, B.C. Canada V5A 1S6.

MERRIFIELD, K. J., and R. E. INGHAM. Population dynamics of Pratylenchus penetrans, Paratylenchus sp. and Criconemella sp. on western Oregon peppermint.
Population dynamics of Pratylenchus penetrans, Paratylenchus sp., and Criconemella sp. associated with peppermint in the Willamette Valley of Oregon were monitored from 8 April through 9 August 1988. Five pairs of plots (oxamyl treated and nontreated) were sampled biweekly in each of two fields by taking cores 5-cm-d X 15-cm deep. Pratylenchus penetrans numbers in roots and rhizomes peaked in early May while soil populations peaked in late May. Within the volume of the soil column sampled, 30 to 90% of the total P. penetrans population was recovered from soil, 30 to 90% from roots, and 0 to 20% from rhizomes, demonstrating the importance of including root, and possibly rhizome, extractions as well for population estimates of P. penetrans. Paratylenchus and Criconemella populations in soil also peaked in mid- to late May. Oxamyl (1.1 kg a.i./ha) was applied to treated members of paired plots on 26 May. Although P. penetrans numbers had begun to decline, populations in the treated plots declined more sharply after treatment than did numbers in untreated plots. Oxamyl appeared to have little influence on population densities of Paratylenchus and Criconemella in this study. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902.

MILLER, L. I. Morphological comparisons of second-stage juveniles of one isolate each of Heterodera glycines, H. cruciferae and one of their hybrids.
Comparisons were made of second-stage juvenile characters of 21 specimens, each of one isolate of Heterodera glycines (M) cultured on 'Lee' soybean, one isolate of H. cruciferae (C) cultured on 'Market Prize' cabbage, and one of their hybrids (MC) cultured on 'Kobe' lespedeza. Dimensions in μm were as follows - stylet knobs to dorsal gland orifice: M 4.3-5.9 (mean 4.7, standard deviation ± 0.4), C 6.0-7.5 (6.7 ± 0.4), MC 3.9 - 4.8 (4.2 ± 0.3); stylet length: M 22.0 - 27.6 (23.6 ± 1.1), C 22.0 - 26.5 (24.4 ± 1.0), MC 23.0 - 27.1 (25.0 ± 0.9); head tip to base of esophageal glands: M 176 - 219 (197 ± 10.6), C 167 - 248 (211 ± 24.7), MC 156 - 218 (177 ± 13.6). M, C and MC measurements were significantly different (P = 0.05) for all characters compared. The anterior faces of the subventral stylet knobs in lateral view slope posteriorly for M and C but anteriorly for MC. The MC hybrid was able to reproduce on soybean, cabbage and 'US75' sugarbeet. M was able to reproduce on soybean, but not on cabbage and sugarbeet; and C was able to reproduce on cabbage, but not on soybean and sugarbeet. Department of Plant Pathology, Physiology, and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

MILLER, R. W. Novel pathogenicity assessment technique for Steinernema and Heterorhabditis entomopathogenic nematodes.
A novel laboratory bioassay, the "cell technique" is presented for assessment of pathogenicity of Steinernema and Heterorhabditis spp. nematodes in the indicator host Galleria mellonella. This technique utilizes culture cell walls to individually confine single nematodes and one insect host in a small arena less prone to humidity fluctuations and nematode population dynamics than other commonly used techniques. Expected host mortality utilizing G. mellonella to measure Steinernema pathogenicity approaches 50% of a sample of 96 insects 48 hours after inoculation. Similar mortality curves have been developed for some Heterorhabditis spp. The cell technique offers unique opportunities for pathogenicity assessment and strain development in populations of Steinernema and Heterorhabditis. Biosys, Inc., 1057 E. Meadow Circle, Palo Alto, CA 94303.

MINTON, N. A., and R. M. SAYRE. Suppressive influence of Pasteuria penetrans in Georgia soils on reproduction of Meloidogyne arenaria.
For 20 years, field plots of ca. 2 ha located at Tifton, Georgia, have been used for

nematode research. Despite cropping to hosts of Meloidogyne arenaria, populations in the plots in recent years have dropped to levels that only slightly affect peanut yield. Bioassays using the migrating second-stage juveniles (J2) of M. arenaria, revealed that most J2 that emerged from the suppressive soils were heavily encumbered with endospores (>25/nematode) of the bacterium, Pasteuria penetrans. Endospore loads of this magnitude are sufficient to prevent some J2 from penetrating plant roots and to cause the bacterial disease on maturing stages of M. arenaria within the roots. In greenhouse experiments, incidence of M. arenaria galling and reproduction were inversely related to numbers of endospores. In soils where levels of P. penetrans gave bacterial infective classes of 0, 1.8 and 2.7, M. arenaria galling index values of tomato, Lycopersicon esculentum Mill., were 4.0, 3.0 and 2.5 and relative reproduction rates were 1.00X, 0.23X and 0.00X, respectively. We concluded that a naturally occurring population of P. penetrans acted as a biological control agent of M. arenaria. USDA-ARS, Coastal Plain Experimental Station, Tifton, GA and USDA-ARS, Nematology Laboratory, Beltsville, MD 20705.

MOJTAHEDI, H., R. E. INGHAM, G. S. SANTO, G. L. REED, and J. H. WILSON. Role of migrating Meloidogyne chitwoodi in potato production.
Seasonal migration of Meloidogyne chitwoodi and its impact on potato production was studied. Eggs and second-stage juveniles (J2) of M. chitwoodi were placed at different depths (0-180 cm) in columns in field and in field plots. Columns were removed at intervals over a 9-month period and soil was bioassayed on tomato roots. Upward migration began in the spring after water had percolated through the columns. Nematodes were detected in the top 5 cm of columns within 1-2 months depending on the depth of placement. In field plots in Washington and Oregon, potatoes were grown for 4 (site 1) and 5 (site 2) months, respectively, before the tubers were evaluated for infection. Nematodes placed at 60 cm caused severe tuber damage at both test sites. Significant tuber damage also occurred with nematodes placed at 90 cm at site 2, but not at site 1. This was probably due to the longer growing season at site 2, which gave the nematodes additional time to infest the tubers. At site 1, eggs were detected on roots at 90, 120, and 150 cm without serious impact on tuber quality. The importance of deep placed M. chitwoodi below the fumigation zone may depend on the length of the growing season. LAREC, Washington State University, Prosser, WA 99350, and Oregon State University, Corvallis, OR 97331.

MOORE, J. F. Potato cultivars susceptible to Ditylenchus destructor and effects on tubers.
Eighteen cultivars not previously tested were found to be susceptible to D. destructor. The tests were done in 25-cm-d by 23-cm earthenware pots filled with uninfested compost (sand/peat/soil). Peelings and tissue from infested potato tubers were added to the compost as a source of inoculum. The test on each cultivar was replicated five times and after planting (April) the pots were placed in a peat plunge outdoors and allowed to grow for four months. At harvest, the tubers produced were examined for external and internal symptoms of D. destructor. When nematode feeding pockets were uncovered by peeling the skins, the presence of D. destructor was confirmed by microscopic examination. All cultivars tested were found to be susceptible and showed many subcutaneous infestation pockets leading to external symptoms and included cv Cara, which contains resistance to Globodera rostochiensis (Rol). It was not considered necessary to rank the cultivars on the number of infestation pockets or on the severity of external symptoms as all cultivars were equally severely affected. These results taken in conjunction with other workers suggest that all commercial cultivars, especially in the British Isles, are susceptible to D. destructor. Kinsealy Research Centre, Dublin 17, Ireland.

MUELLER, J. D., and B. A. FORTNUM. Yield reduction of corn by Hoplolaimus columbus.
Pioneer 3369A field corn was planted on April 5 at the Pee Dee and April 15 at the Edisto Research and Education Center in South Carolina in fields infested with an average of 28 and 2 Hoplolaimus columbus/100 cm^3 of soil. Both experiments consisted of 18 replications of paired plots each consisting of six rows (12.2 m long on 96-cm centers) untreated and six rows treated at planting with 32 g a.i./100 m row (3.2 kg a.i./ha) of carbofuran. The carbofuran was applied in an 18-cm-wide band in front of the press wheel. At Pee Dee carbofuran treatment significantly reduced ($P < 0.05$) numbers of H. columbus from roots from 55 to 15 per g dry weight of root but did not reduce numbers of H. columbus from soil at anthesis or harvest. Reductions of H. columbus infection levels resulted in an increase in: number of ears harvested per plot from 78 to 98, ear weight from 6,547 g/plot to 9,452 g/plot, and grain weight from 5,348 g/plot to 7,772 g/plot. Pf/Pi was 56 in the untreated plots at Pee Dee. Carbofuran treatment reduced levels of H. columbus at Edisto from 116 to 16 per gram dry weight of root, and from 15 to 2/100 cm^3 soil at anthesis. Ear weight, grain weight, and height were unaffected. Pioneer 3369A appears to support a high level of H. columbus reproduction in the field. Clemson University, P.O. Box 247, Blackville, SC 29817.

MUNDO-OCAMPO, M., J. G. BALDWIN, and W. LIU. Cyst nematodes of Mexico including new

species.
Economically important cyst nematodes of Mexico include Globodera rostochiensis on potato and Punctodera chalcoensis on maize at cool, high elevations. Surveys at low elevations in central Mexico led to recovery of Cactodera and Heterodera which differ in morphology or distribution from known species and previous reports. A Cactodera sp. recovered from soil of maize and sorghum fields at Cienega de Chapala, Michoacan State is similar to C. amaranthi. A second species of Cactodera recovered from soil and roots of Opuntia in Zacatecas and San Luis Potosi States is similar to C. cacti, but SEM observations indicate differences in the cone morphology from other populations. A Heterodera species from soil of corn and sorghum at Cienega de Chapala differs from other species including H. zeae by three lateral lines on second-stage juveniles and absence of bullae. Other unidentified species of Heterodera have been isolated from maize-growing areas from Michoacan, Jalisco, and Mexico States. Morphology of population variants and new species as well as additional surveys to describe the host and geographical distribution are in progress. Department of Nematology, University of California, Riverside, CA 92521.

NEWCOMB, G. B., R. E. INGHAM, R. W. SMILEY, and J. A. PINKERTON. Effects of nematicide treatment on Heterodera avenae and wheat yield in Northeast Oregon.
In a study of the effects of five nematicides on Heterodera avenae reproduction and yield of Stephens wheat in Northeast Oregon, banded soil applications of aldicarb (1.2 kg a.i./ha), ethoprop (0.7 kg a.i./ha) and carbofuran (1.4 kg a.i./ha), and seed treatments of thiodicarb (5 g a.i./kg seed) and aldoxycarb (3.8 g a.i./kg seed) were made and compared to a nontreated control. Yields ranged from 3.5 Mg/ha in the nontreated control to 3.8 Mg/ha in the aldicarb-treated plots but there was no significant difference ($P < 0.05$) between any of the treatments. Numbers of cysts and eggs plus second-stage juveniles (J2) obtained from cysts averaged over all treatments at harvest were 39 and 951/100 g soil, respectively, and were not different between any of the treatments. Soil populations of J2, monitored biweekly from nontreated areas by Baermann extraction, increased from 29/100 g on 3 March 1988 to 262/100 g on 26 April 1988 and then declined to a low of 4/100 g on 1 July. Males were first observed on 1 June, suggesting completion of the first generation by that time. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331 2902.

NGUYEN, K. B., and G. C. SMART, JR. A new steinernematid nematode from Uruguay as a biological control agent of mole crickets.
A new steinernematid nematode collected from Uruguay appears to have a relatively narrow host range, being quite specific to mole crickets and a few other Orthoptera. A host range experiment was conducted using the tawny and southern mole crickets (Scapteriscus vicinus and S. acletus), house cricket (Acheta domestica), field cricket (Gryllus sp.), granulate cut worm (Feltia subterranea), wax moth larva (Galleria mellonella), fall army worm (Spodoptera frugiperda), American cockroach (Periplaneta americana), honey bee adult (Apis mellifera), velvet bean caterpillar (Anticarsia gemmatalis), earth worm (Lumbricus terrestris) and two beetle species (Megacephala virginica and Pacimacus sublaevis) which prey on mole crickets. The mole crickets and house cricket were killed at a rate of 100%, the field cricket at 22% and all others at 10% or less. When released in the field at three different sites 4 years ago in North Florida, the nematode became established. It continues to kill mole crickets, and has become disseminated at least 24 km from the nearest release site. Nematology Laboratory, Bldg. 78, University of Florida, Gainesville, FL 32611-0611.

NIBLACK, T. L., B. L. CONKLING, and R. W. BLANCHAR. Rhizosphere pH and root length measurements of soybean cultivars susceptible to Heterodera glycines.
Roots of H. glycines-tolerant and intolerant soybean cultivars may differ in their early (pre-V3) responses to infection. In four tests in which rhizosphere pH and root length were the responses measured, soybean cultivars Coker 237 and Williams 82 (both intolerant to H. glycines), and Coker 156 (tolerant) were grown for 6-10 days in plexiglas minirhizotrons which allowed for in situ rhizosphere pH measurements. Soil was either uninfested or infested with 1,000 H. glycines eggs/100 cm^3. Rhizosphere pH measurements were made with glass microelectrodes with sensing tips of 0.02 mm diam x 0.05 mm which were manufactured in the laboratory. Measurements were made on each plant at six sites along both main and lateral roots at distances of 0.0-0.5 mm, 0.5-1.5 mm, 1.5-2.5 mm, 2.5-3.5 mm, and >3.5 mm from the root surface. After the pH measurements were completed, root lengths and total H. glycines penetration were recorded. Root lengths were consistently higher in the infected intolerant cultivars compared with controls, while root length was lower in the infected tolerant cultivar compared with controls. Rhizosphere pH changes differed among cultivars but were not affected by H. glycines infection. Department of Plant Pathology, 108 Waters Hall, University of Missouri, Columbia, MO 65211.

NISHIZAWA, T. Comparison of heat resistance and nematicide resistance of endospores of

Pasteuria penetrans from Meloidogyne incognita with a related bacterium parasitizing Heterodera glycines.
In addition to the host ranges and the morphometric differences, the bacterial parasite of the soybean cyst nematode (BSCN) was also distinguished from a closely related species, Pasteuria penetrans parasitizing root-knot nematodes (PR-KN), in their heat resistance and nematicide resistance. Volcanic ash soils heavily contaminated with endospores either of PR-KN or BSCN were treated with high temperatures in water baths or high doses of selected nematicides at room temperatures. After that, activities of the endospores in these treated soils were measured by a bioassay technique. Although endospores of PR-KN tolerated temperatures up to 90 C for one hour, and all nematicides tested (1,3-D, EDB, chloropicrin, prophos, oxamyl and aldicarb), a gradual decrease of the BSCN endospore activities in soils treated at temperatures over 60 C was observed. Endospores of BSCN also showed specific susceptibilities against carbamate nematicides. Laboratory of Nematology and Soil Zoology, National Institute of Agro-Environmental Sciences, Kannondai 3-1-1, Tsukuba, Ibaraki 305, Japan.

NOE, J. P. Yield-loss relationships and population dynamics of Hoplolaimus columbus on cotton, soybean, and peanut in Georgia.
Field plots (4 rows wide x 6 m long) were established in areas naturally infested with Hoplolaimus columbus for long-term monitoring of host-parasite relationships in a cropping system of cotton cv. Deltapine 90, soybean cv. Gordon, and peanut cv. Florunner. Plots were arranged in grids of 36 or 40 plots, with two grids per crop, for a total of 6 grids. Nematode densities were assayed at preplant, midseason, and harvest. Soil fertility was assayed in each plot at planting, and harvest data were recorded at maturity for the respective crops. Nematode density frequency-class means were used as predictors of yield. The best-fit linear model for cotton yield (r^2 = 0.79, P>F = 0.003) indicated a decrease of 1.2 kg/ha lint per unit increase in preplant H. columbus/100 cm^3 soil, whereas population densities increased 80% from preplant to harvest. Soybean yield decreased 2.6 kg/ha seed per unit increase in preplant numbers of H. columbus/100 cm^3 soil (r^2=0.49, P>F = 0.02), with a corresponding population density increase of 490% from preplant at harvest. Densities of H. columbus decreased 70% during one growing season of peanut, which was selected as a nonhost in the cropping system. Multiple regression models indicated that phosphorous, potassium, and calcium significantly impacted the relationships of crop yield to nematode stress. Department of Plant Pathology, University of Georgia, Athens, GA 30602.

NOEL, G. R., and D. I. EDWARDS. Population development of Heterodera glycines and soybean yield following initial nematode infestation.
A long-term experiment was established in 1979 to study population introduction into a study area that was in grass-clover for ca. 20 years. The six treatments were either continuous susceptible or resistant soybean, and 2-year rotations of resistant or susceptible soybean with maize or maize rotated with soybean. Nematode-infested (50 cysts/plot introduced in 1979) and noninfested plots were separated by 3 m of sod and sanitation of equipment was practiced. Susceptible soybeans were cvs. Amsoy 71, Beeson 80, and Williams 82, and resistant cvs. were Franklin, CN290, and Fayette planted in 1979, 1980-83, and 1984-88, respectively. From 1979-1983, a few cysts were recovered from all treatments, but increases were greater in continuous susceptible soybeans grown in plots infested intentionally. In 1984, planting of both Williams 82 and Fayette resulted in population declines. Populations subsequently increased on Williams 82 but remained at very low levels on Fayette with no nematodes being recovered in 1988. In 1983, yield of Beeson 80 in the infested and continuous susceptible treatment was reduced significantly. Reduced yield of Williams 82 in the infested and continuous susceptible treatment first occurred in 1988. Fayette yield whether rotated or not was superior to Williams 82. USDA ARS, Urbana, IL 61801.

NOLING, J. W., and A. J. OVERMAN. Estimation of crop loss caused by nematodes in Florida tomato production.
Tomato losses caused by nematodes were estimated from 25 years of Florida pesticide research and from an exploratory survey of Florida Cooperative Extension personnel. Mean relative yield and standard errors were calculated using the maximum yield in each study as the reference point for yield comparisons with alternative methods of nematode management. With few exceptions, methyl bromide soil fumigants consistently provided highest yields. The biological spectrum of activity for each nematode management activity was then subtractively used to partition crop losses among pest groups. The results from these studies suggests that use of methyl bromide avoids average potential losses of 48.1%, 18.7% of which is attributable to nematodes and 29.4% to weeds and other plant pathogens. Based on survey results, nematode crop losses statewide are thought to be negligible because the entire commercial tomato acreage is treated with broadspectrum fumigant nematicides and nematode populations develop too late in the season to be of consequence. Annual pest control costs of $3.1 million dollars was assumed an economic loss incurred by farmers to

avoid nematode damage. Scenarios describing changes in crop production and pest control costs with loss of specific pesticide registrations were estimated. University of Florida, IFAS, Citrus Research & Education Center, Lake Alfred, FL 33850.

NORDMEYER, D., D. W. DICKSON, L. T. OU, and H. L. CROMROY. Metabolism of carbofuran and fenamiphos by Meloidogyne incognita.
Second-stage juveniles of M. incognita (150,000) were exposed to 2.5 µg/ml radiolabelled carbofuran or fenamiphos for 48 hours. After exposure, residual nematicide clinging to the exterior of the nematodes was removed by alternately washing three times with both acetone and water. The nematodes were then homogenized and the parent compounds and their metabollites extracted and analyzed by thin-layer chromatography and autoradiography. Carbofuran was metabolized readily by the nematode into less active or nonnematicidal metabolites (3-hydroxy-carbofuran, 3-keto-carbofuran, and a high perecentage of water soluble products). In contrast, fenamiphos was rather stable with ca. 70% and 30% of the total radioactivity recovered as parent compound and fenamiphos sulfoxide (a nematicidal metabolite), respectively. In uptake studies fenamiphos reached equilibrium within the nematode after ca. 24 hours, whereas carbofuran did not reach an equilibrium even after 96 hours. Despite a higher uptake and superior intrinsic activity on acetylcholinesterase, carbofuran appears to be less active than fenamiphos in vivo against M. incognita due to its rapid degradation into less active or inactive products in the nematode. Department of Entomology and Nematology, University of Florida, Nematology Lab, Gainesville, FL 32611-0611.

NYCZEPIR, A. P. Management of nematodes of stone fruits.
The major nematode pests of stone fruits in the United States include root-knot nematodes, Meloidogyne spp., ring nematodes, Criconemella spp., dagger nematodes, Xiphinema spp., and root-lesion nematodes, Pratylenchus spp. Nematode management begins with proper site selection and site treatment -- establishing a new orchard on land not having a history of stone fruits or nematode problems, and planting trees free of nematode infestation. If nematode-free sites are not available, research-based management practices should be implemented beginning with a knowledge of nematodes present in the soil. Recommended control measures include pre- and postplant nematicide application, resistant rootstocks (when available), or crop rotation. Proper sanitation measures should be followed to prevent reinfestation of treated sites. Major research efforts in the Southeast and California are focused toward: 1) identity and development of peach rootstocks that are C. xenoplax and P. vulnus resistant, which is the ultimate goal for long-lasting nematode control; 2) development of ground covers and (or) rotational crops that when planted will mitigate general replanting problems, or when planted in association with stone fruits will suppress nematode density; and 3) discovering the nature of nematode suppression or use of biological control agents. USDA, ARS, S.E. Fruit and Tree Nut Research Laboratory, Byron, GA 31008.

O'BANNON, J. H., R. N. INSERRA, and W. M. KEEN. The host status of citrus and citrus relatives to Tylenchulus graminis.
In a field test sour orange (Citrus aurantium) seedlings grown in association with Tylenchulus graminis-infected broomsedge (Andropogon virginicus), were not infected with T. graminis after 18 months. The noncultivated soil had nematode densities ranging from 0.03 to 0.4 second-stage juveniles (J2)/cm^3. In a greenhouse test, two T. graminis populations did not infect sour orange seedlings grown for two years in naturally infested soil with 0.3 and 1.3 J2/cm^3. Exposure of rough lemon (C. limon), trifoliate orange (Poncirus trifoliata) cv. Argentina and Swingle citrumelo (C. paradisi X P. trifoliata) seedlings to initial T. graminis population densities (Pi) of 7 J2/cm^3 soil drastically suppressed nematode population levels to terminal values (Pf) of <0.1 J2/cm^3 soil. Pf values >70.0 J2/cm^3 occurred in soil with broomsedge. These findings provide conclusive evidence that T. graminis is a specific parasite of grasses and does not infect citrus. Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, FL 32602.

OMWEGA, C. O., I. J. THOMASON, and P. A. ROBERTS. Identification of new sources of resistance to Meloidogyne spp. in Phaseolus spp.
Fifty-four common bean and sixty-four tepary bean lines were screened for resistance to the root-knot nematodes Meloidogyne incognita, M. javanica, M. arenaria, and M. hapla. Common bean lines PI 165426 and Alabama No. 1 were found to be resistant to M. incognita races 2, 3 and 4, and to M. hapla. They were susceptible to M. incognita race 1 and M. arenaria. Breeding lines A252, A315, A328, A443, and A445 were resistant to M. javanica and M. incognita race 1. Line A322 was resistant to M. javanica, but susceptible to M. incognita race 1. A selected number of bean lines were screened against M. arenaria and M. hapla. Lines G2618, A445 and A315 were resistant to M. arenaria races 1 and 2. We postulate that resistance to M. incognita races 2, 3, and 4 is under similar genetic control and that this gene(s) is present in PI 165246 and Alabama No. 1. However, resistance to M. incognita

race 2, M. javanica and M. arenaria races 1 and 2 is determined by another genetic system which is derived from lines G1805 and G2618. Common bean line G12727 has a moderate level of resistance to M. javanica and M. incognita. Tepary bean accession PI 310606 had moderate to good resistance to M. incognita and M. arenaria. Variability in parasitism was observed in M. javanica: Isolate PRJC-2 was found to be more aggressive to resistant lines than isolates PRJC-18 and NCSU-Mj. Department of Nematology, University of California, Riverside, CA 92521.

OOSTENDORP, M., D. W. DICKSON, and D. J. MITCHELL. Effect of crop rotations on the dynamics of Pasteuria sp. in microplots.
The effects of spring-fall rotations of peanut with fallow, vetch, and rye on the dynamics of Pasteuria sp. on Meloidogyne arenaria were studied over 2 years. Treatments included second-stage juveniles (J2) of M. arenaria, J2 infected with Pasteuria sp., and an untreated control. Each treatment was replicated 10 times for each rotation. The infection level of Pasteuria sp. on the J2 changed from 0.11 spores/nematode in the fall of 1987 to 0.11, 0.23, and 0.16 spores/nematode in the spring of 1988 under fallow, rye, and vetch, respectively. In the fall of 1988, the respective infection levels of Pasteuria sp. were 0.33, 0.61, and 0.75 spores/nematode. At harvest in 1987, nematode infection of peanut pods was reduced ($P = 0.05$) in plots infested with Pasteuria sp. when compared to plots with healthy nematodes. A reduction ($P = 0.05$) of nematode infection of roots was observed 38 days after planting in 1988 in all three rotations. There were no differences ($P = 0.05$) in yield and nematode population levels at harvest in either year between treatments with healthy nematodes and nematodes infected with Pasteuria sp. Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611-0611.

OPPERMAN, C. H., and S. CHANG. An adrenergic drug receptor isolated from Caenorhabditis elegans.
Alprenolol and propranolol are B-adrenergic receptor blocking drugs in vertebrate systems, specifically competing for the norepinephrine binding site. The effects of propanolol on Caenorhabditis elegans were striking: late L4 and adult nematodes were not affected, nor were egg-laying or hatch. The L1, however, ceased movement near molting time and did not develop further. At slightly higher dosages, hypercontaction and stimulation of egg laying were observed. Neither the B-adrenergic receptor agonists isoproterenol and pindolol nor the alpha-adrenergic receptor agonists clonidine, etc. had any observable effects. [^{3}H]-propranolol was utilized to detect specific binding in fractions from an affinity chromatography column. The results for the receptor elution fraction show binding in the identical range as seen for vertebrate preparations. Oligonucleotide probes prepared to conserved regions of identified receptors were used to isolate several fragments from C. elegans genomic DNA. Characterization is underway. Department of Plant Pathology, North Carolina State University, Raleigh, NC, 27695-7616.

PAYAN, L. A., and D. W. DICKSON. Intraspecific variation in Pratylenchus brachyurus determined by isozyme phenotype comparisons.
Intraspecific variation among five Pratylenchus brachyurus populations selected from different geographical regions and hosts was studied. Analysis of three isozyme systems using isoelectric focusing electrophoresis in conjunction with enzyme-staining systems from 250 females revealed differences in protein banding patterns among populations. Three distinct phenotypic groups were observed in the malate dehydrogenase (MDH) and phosphoglucomutase (PGM) systems. The number of bands among populations varied from two to eight in the MDH system, and from three to five in the PGM system. Only one phenotype composed of one band was observed for all populations in the phosphoglucose isomerase system. Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.

PELOQUIN, J. J., D. McK. BIRD, and E. G. PLATZER. Morphologically homogeneous populations of Meloidogyne hapla have two distinct mitochondrial genome sizes.
Powers et al., (J. Nematol., 18:288-293, 1986) showed that the mitochondrial DNA (mtDNA) from a San Bernardino county isolate of Meloidogyne hapla (BRDO strain) had a genome with three predominant Hind III fragments (ca. 13.5 kb, 6.8 kb and 4.7 kb; total = 25 kb). More recently, Powers and Sandall (J. Nematol., 20:505-511, 1988) have reported the size of the M. hapla BRDO mtDNA Hind III fragments as being ca. 16 kb, 2.6 kb and 1.7 kb (total = 20.3 kb). To resolve this apparent discrepancy, we have examined restriction patterns of mtDNA from the M. hapla BRDO isolate maintained at UCR. Eggs were isolated from tomatoes heavily infected with M. hapla BRDO (species confirmed by Dr. J. Baldwin), and mtDNA extracted and purified on CsCl gradients containing either bis-benzamide or EtBr. Restriction digests of mtDNA were fractionated on agarose, and Southern blots hybridized with a cloned nematode mitochondrial gene probe (generated from the R. culicivorax cox-1 gene). Initial results indicated that the mtDNA was the 25 kb form originally observed, although closer examination of EtBr stained gels and blots revealed the presence of a small amount of the 20.3 kb form. This experiment was repeated a number of times using serially passaged nematode

populations. A transition of mtDNA form from the large to the small was observed, with the 20.3 kb form ultimately predominating. No morphological changes in the nematodes were apparent during this transition. To distinguish between mitochondrial heteroplasmy and a mixed population of homoplasmic M. hapla, DNA was prepared from single egg masses (harvested from beans grown in pouches and isogenically infected), restricted, blotted and probed with cox-1; the female in each case was confirmed as being M. hapla. In no case has heteroplasmy been observed, suggesting that there are two morphologically identical populations of M. hapla BRDO with different mitochondrial genomes. Department of Nematology, University of California, Riverside, CA 92521.

PERRY, R. N. Aspects of the hatching physiology of Globodera rostochiensis and G. pallida.
A comparison of the response of unhatched juveniles of Globodera rostochiensis and G. pallida to hatch stimulation shows variation in the rate of water content changes and in the response of the dorsal oesophageal glands. Compared with G. rostochiensis, G. pallida responds more slowly to hatch stimulation and this is correlated with a slower rate of hatch and a less rapid utilization of lipid reserves. By contrast with Meloidogyne javanica, lipases appear not to be involved in eclosion. Entomology & Nematology Department, AFRC Institute of Arable Crops Research, Rothamsted Experimental Station, Harpenden, Herts., AL5 2JQ, England.

PHILLIPS, R., B. A. JAFFEE, and M. MANGEL. Determination of host threshold density for nematophagous fungi and bacteria: an age-structured model.
An age-structured model was developed to study temporal density-dependent parasitism (TDDP) of soilborne nematodes by their obligate, spore-forming parasites. The universe of the model is small (20 cm^3 of soil) because nematodes and their antagonists are microscopic and move slowly. The parasites become locally extinct unless supplied with a minimum number of host nematodes. This minimum number is called the host threshold density (HTD). HTD and TDDP are functions of P (probability of infection), SPN (numbers of spores produced per infected nematode), and L (spore longevity). All parameters in the model can be estimated with laboratory experiments. HTD is low if P, SPN, and L are large. The proportion of nematodes infected increases rapidly with increased nematode numbers if P, SPN, and L are large. Mathematics, Nematology, and Zoology Departments, University of California, Davis, CA 95616.

PLATZER, E. G. Lectin binding on juveniles of Romanomermis sp.
Fluorescent labeling of the mouth, amphids, and head region of preparasites of a Romanomermis sp. was observed after exposure to concanavalin A (ConA) labeled with FITC. Treatment with the specific carbohydrate inhibitor, a-methyl mannopyranoside (a-MMP), reversed binding on only one half of the pre-parasites showing half of the binding was nonspecific. In the presence of ethylene glycol, the non-specific binding was eliminated and a-MMP reversed the remaining lectin binding. After penetration of mosquito larvae, the amount of ConA binding increased; fluorescence was present on the mouth, amphids, head, and entire body. This binding was reversed by a-MMP in the presence of ethylene glycol. ConA binding on parasitic juveniles was eliminated by pretreatment with proteolytic enzymes thus demonstrating the putative glycoprotein nature of the ConA binding sites. Department of Nematology, University of California, Riverside, CA 92521.

POPIEL, I., I. GLAZER, and E. M. VASQUEZ. Desiccation of Steinernema feltiae infective juveniles.
The purpose of this investigation was to determine the physiological and biochemical responses of S. feltiae-infective juveniles (IJs) to desiccation. IJ pellets maintained in an atmosphere of 97±2% relative humidity at 25° C for 3 days lost 45% of their total water and reduced their oxygen demand by 95%. Trehalose and glycerol levels increased at the expense of glycogen and lipid. IJs maintained in these conditions survived and retained full pathogenicity for 60 days, after which survival declined. When the nematodes were exposed to lower relative humidities, survival declined within days. Further pre-adaptation for long-term survival at lower water contents is required for commercial storage of entomopathogenic nematodes. BIOSYS, 1057 East Meadow Circle, Palo Alto, CA 94303.

POPIEL, I., and E. VASQUEZ. Cryopreservation of Steinernema feltiae and Heterorhabditis sp. infective juveniles.
Third stage infective juveniles (IJs) of Steinernema feltiae and Heterorhabditis sp. strain HP88 can be cryopreserved in liquid nitrogen following evaporative desiccation and incubation in ice cold 70% methanol (James & Popiel, unpublished). In order to avoid the difficulty of maintaining sterility during the evaporative desiccation step, we developed a modified cryopreservation method utilizing osmotic desiccation as a pretreatment. Eighty to ninety-five percent survival of S. feltiae in 1-ml volumes was achieved following incubation in 21.7% glycerol for 24 hours, ice cold 70% methanol for 10 minutes and freezing in liquid nitrogen. IJs of Heterorhabditis were less tolerant of both the incubation and

freezing steps. A maximum of 50% survival of Heterorhabditis sp. frozen in 20 µl volumes was achieved following preincubation in 13.7% glycerol for 24 hours and ice cold 70% methanol for 10 minutes; survival in 1-ml volumes was in the range 10-35%. This method of cryopreservation is being utilized for maintenance of nematode inocula for in vitro production and for stock cultures of different geographical isolates. BIOSYS, 1057 East Meadow Circle, Palo Alto, CA 94303.

POWERS, L. E., R. A. DUNN, and R. MCSORLEY. The mode of resistance in Alysicarpus vaginalis to Meloidogyne incognita.
The tropical legume Alysicarpus vaginalis (alyceclover) has been bred for resistance to Meloidogyne incognita race 3 to enhance its value as a forage crop in Florida. Greenhouse studies were conducted to determine the mode of resistance in alyceclover to M. incognita. Inoculated plants of resistant (FL-4) and susceptible (FL-100) lines were harvested every third day for 36 days, and the nematodes present in the roots were counted and the life cycle stage identified. The length, width, and cross-sectional area of each nematode were measured. Resistance effects were observed at all stages of the nematode life cycle in the resistant line. Nematode penetration decreased 75%, and size and egg production of adult females decreased 45% and 96% respectively ($P < 0.05$), in FL-4 compared to FL-100. Department of Entomology and Nematology, University of Florida, Gainesville FL 32611.

POWERS, T. O., and L. J. SANDALL. Mitochondrial DNA and species boundries in Meloidogyne.
The high rate of mitochondrial DNA evolution and its high copy number have stimulated investigations into its application for species identification. While initial studies indicate that sufficient genotypic diversity exists to characterize specific mitochondrial genomes, the relationship of these genomes to species boundries requires special consideration. Two theoretical concerns, recent speciation from a mitochondrially polymorphic ancestor and hybridization between facultative meiotically parthenogenetic forms, could lead to lack of concordance between species relationships derived from nuclear and mitochondrial data. Hybridization among Meloidogyne isolates has been suggested as a likely evolutionary pathway leading to triploid and hypotriploid forms. We are testing evolutionary hypotheses through a combined examination of mitochondrial, enzymatic and chromosomal data sets. Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583.

QUENEHERVE, P. Components of nematode damage on bananas: distinction between effects on growth and harvest.
The effects of plant-parasitic nematodes, including Radopholus similis, Heliocotylenchus multicinctus, and Pratylenchus coffeae, on components of yield of bananas was measured in nematicide and horticultural trials in the Ivory Coast. Duration of plant phenological phases, including planting to flowering, flowering to harvest, and harvest to next flowering, was expressed as the median number of days in each interval. Measurements at harvest included bunch weight, percent of bunches harvested, and total weight of the harvest. The effects of nematodes over three harvest cycles were: 1) lengthening of vegetative cycles; 2) lengthening of vegetative cycles and reduction of total harvest; and 3) lengthening of vegetative cycles, reduction of total harvest, and irreversible reduction of plantation longevity. The separate effects on vegetative and reproductive phases of banana growth reflect the pathogenicity of nematodes to the plant root system, impairing absorption, conduction of solutes, and anchorage. These effects were expressed in different combinations depending on the environment and the nematode species involved. ORSTOM, BP V51, 01 Abidjan, Ivory Coast.

QUENEHERVE, P., and H. FERRIS. Use of geometric vs arithmetic mean in the prominence value index and diagram frequency vs abundance.
Prominence value index (PV) and diagrams of frequency vs abundance are useful descriptors of nematode communities. Typically, the arithmetic mean is used to calculate the PV and to diagram frequency vs abundance. The use of the arithmetic mean is valid when the distribution is normal; its use may be misleading as the distribution becomes skewed or aggregated. For aggregated distributions, the geometric mean is a more meaningful statistic in the calculation of comparative indices or diagrams because it varies with the value of k (the dispersion index of the negative binomial distribution). Use of the arithmetic mean does not create a problem when populations of the same species are compared; however, it is a more serious problem when comparisons are made between species with different distribution characteristics, especially when the number of samples is small. In that case, the use of the arithmetic mean may lead to an overestimation of the PV for nematode populations with skewed distributions (small values of k). Department of Nematology, University of California, Davis, CA 95616.

RADICE, A. D., N. SHERIF, and S. W. EMMONS. Expression of the transposable element Tc1.
In order to understand the process of Tc1 excision and transposition, we are studying transcription and translation of Tc1 using Northern and Western blot analyses. A series of

mutator and nonmutator strains with various rates of Tc1 germline activity were analyzed. Using a Tc1-derived RNA probe we detected a 1.3 kb transcript present in all strains, including those such as Bristol and DH424 that are inactive in germline transposition and excision. Results from primer extension experiments indicate the 5′ end of the Tc1 message may be within the terminal inverted repeat. There is a possibility that Tc1 regulation may be under the control of a foreign promoter. To study expression of Tc1 at the protein level, antibodies were raised to the putative transposase encoded by the Tc1 open reading frame. Antibodies from both synthetic peptides and to the fusion protein react with a common 35 Kdal protein. The 35 Kdal protein is more prevalent in strains where Tc1 is active in the germline as well as the soma. 35 Kdal is roughly the size expected for the product of the Tc1 open reading frame. When monospecific antisera are obtained, in situ reactions will be carried out to determine whether the amount of this protein parallels Tc1 activity. Albert Einstein College of Medicine, Bronx, NY.

REID, A. P., and W. M. HOMINICK. Characterization of entomophilic nematode species and strains using recombinant DNA technology.
The use of entomophilic rhabditids for the control of crop pests instead of chemical insecticides is of both ecological and economic importance. So far, 196 of 403 (48.6%) sites in Britain have proved positive for Steinernema bibionis. Some of these isolates display different biological characteristics, so that some strains are more effective as control agents than others. Therefore, a quick and reliable method for strain identification was required. Southern blots of DNA extracted from over 20 strains were hybridized with a clone of the ribsomal DNA repeat unit from Caenorhabditis elegans (a gift from Dr. J. E. Sulston). Using this probe, the strains can be divided into several distinct groups due to their various restriction fragment length polymorphisms. By using the same probe, Steinernema feltiae can be identified as well as several strains of Heterorhabditis spp. Entomophilic Nematode Research Group, Department of Pure and Applied Biology, Imperial College of Science and Technology, London, England.

RICKERT, L. E., and R. GAUGLER. The role of the sheath in entomopathogenic nematodes.
The pathogenicity of Steinernema feltiae (All) and Heterorhabditis bacteriophora was tested with and without the sheath. Freshly harvested infective-stage juveniles (J3) were divided into three treatment groups: sheathed, desheathed, and exsheathed. Pathogenicity was tested in multiwell tissue culture plates with one Galleria larva per well. Dose ranges were 1,3,5,and 10 for S. feltiae and 1,10,20, and 40 for H. bacteriophora. Galleria mortality was recorded at 24-hour intervals and both LT50′s and LD50′s were calculated. No significant differences were found between any of the S. feltiae treatment groups; however, differences between the sheathed and desheathed H. bacteriophora were significant. Department of Entomology, Rutgers University, New Brunswick, NJ 08903.

RIGA, E., and J. M. WEBSTER. Viability and behaviour of inter- and intraspecific crosses of pinewood nematode isolates.
Matings between isolates of the pinewood nematode species complex (PWNSC) were performed. Isolates of putative Bursaphelenchus xylophilus (St. William, Ibaraki, $Q_{14/16}$, MSP_4, and St. John) and isolates of putative B. mucronatus (Chiba and French) from Europe, Japan and/or North America were used. Virgin adults were mated to determine if viable progeny were produced. Mated isolates of B. xylophilus produced fertile F_1 and F_n populations. However, mated isolates of B. mucronatus produced F_1 generations, some of which died in subsequent generations. Interspecific hybridization among isolates of B. mucronatus and B. xylophilus usually produced F_1′s but some did not survive. The number and sex ratio of F_1 and F_2 offspring were compared with those of the parent population. Investigation of pheromone attraction between isolates clarified the taxonomic separation of the isolates based on mating success. Department of Biological Sciences, Simon Fraser University, Vancouver, B.C., Canada V5A 1S6.

ROBBINS, R. T., L. R. OLIVER, and A. J. MUELLER. Evaluation of interaction between soybean cyst nematode, an insect, and three weeds in soybean.
A study to detect interaction between soybean cyst nematode (SCN) (Heterodera glycines Ichinohe), (high initial density or nematicide treated, low density); threecornered alfalfa hopper (TCAH) (Spissistilus festinus Say) (0, 30, or 70% girdling); and three weeds, common cocklebur (CC), (Xanthium strumarium L.), pitted morningglory (PMG) (Ipomoea lacunosa L.), and sicklepod (SP) (Cassia obtusifolia L.) (0, or 1 weed/m plot)) in 'Forrest' soybeans was evaluated 1983-86. Lack of irrigation resulted in low soybean yields and reduced the potential treatment differences in the drought years of 1983 and 1984. The average soybean seed yield losses 1983-86 (LSD_{05} = 12%) were: SCN 14%; 70% TCAH girdling, 25%; CC 22%; SP 14%; and PMG 12%. Soybean tolerated SCN damage better during years of adequate moisture than during drought years. Soybean tolerated ca. 35% TCAH girdling before yield was reduced significantly. No interactions between these plant pests were noted. Thus, the reductions in yield due to these pests were additive only. Departments of Plant Pathology,

Agronomy, and Entomology, University of Arkansas, Fayetteville, AR 72701.

ROBERTS, P. A., and W. C. MATTHEWS. Variation within Meloidogyne incognita of parasitic ability on resistant cowpea cultivars.
Several isolates of Meloidogyne incognita, most from California, were tested for ability to reproduce on and to injure susceptible and resistant cultivars and breeding lines of cowpea, Vigna unguiculata, in greenhouse and field experiments. Cultivars previously reported as resistant to M. incognita, including 'Mississippi Silver' and 'California Blackeye No. 5' (CB5), were resistant to some M. incognita isolates but susceptible to others. Furthermore, isolates classified as the same host race of M. incognita, such as race 3, differed in parasitic ability on the nematode-resistant cultivars and lines, demonstrated by induction of resistant or susceptible reactions. Under field conditions, populations of M. incognita parasitic on nematode-resistant cultivars caused plant injury and yield reduction, indicating low tolerance to nematode attack in compatible interactions. The M. incognita isolates parasitic on nematode-resistant cowpea cultivars did not predispose Fusarium wilt-resistant cultivars such as 'CB46' to wilt disease, but they promoted wilt disease symptoms in wilt-susceptible cultivars such as 'CB5.' Department of Nematology, University of California, Riverside, CA 92521.

ROBERTSON, W. M., J. M. S. FORREST, and D. STEWART. Production of antisera to the surface of Longidorus elongatus and L. attenuatus.
Polyclonal antisera to Longidorus elongatus were produced in rabbit and mouse. L. elongatus were sieved from soil, washed 3 times in TRIS buffer and carefully checked for contaminants. Rabbits received 8-12 mg (wet weight) of nematodes injected intramuscularly on three occasions one week apart. The sera produced following the first injection labelled the head and tail only of L. elongatus and L. attenuatus, but did not label L. macrosoma or L. caespiticola. Sera removed following subsequent injections labelled the L. elongatus over the entire body. Sera raised in mouse by intrasplenic injection required only 10-20 specimens injected 14 days apart and labelled head and tail of L. elongatus. Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland.

ROBINSON, A. F. Selected aspects of the biology and behavior of Rotylenchulus reniformis.
Distinguishing characteristics of the biology of Rotylenchulus reniformis can be discerned by comparing observations of R. reniformis and Meloidogyne incognita in the lower Rio Grand Valley (LRGV). R. reniformis usually has a high temperature requirement for motility, infection, development, and reproduction; however, an isolated population on the high plains of Texas has persisted several years at much lower mean soil temperatures than occur in most tropical and subtropical regions. In the LRGV, R. reniformis achieves highest population densities and causes greatest damage in finely textured soils high in silt content; silty soils also favor population buildup in greenhouse boxes and pots. Populations of R. reniformis within fields are more uniformly distributed than are populations of M. incognita, and high densities in cotton fields often occur as deep as 2 m. High densities deep in finely textured soil suggests tolerance for low oxygen tension. Crop damage thresholds and minimum yields for R. reniformis are usually much higher on susceptible hosts than for M. incognita. However, R. reniformis population densities are characteristically several times as high as M. incognita densities, and the nematodes frequently cause crop damage. USDA, ARS, Southern Crops Research Laboratory, College Station, TX 77840.

ROBINSON, A. F., C. M. HEALD, and G. BAKER. Orientation of infective juveniles of Hexamermis sp. and Agamermis sp. perpendicular to light.
Eggs of a Hexamermis sp. and an Agamermis sp. were collected from soil in areas of New South Wales where parasitic stages occur endemically within orthopteran hosts. When infective juveniles that hatched from eggs were placed on water agar, they oriented perpendicularly to unidirectional sun or artificial light and migrated rectilinearly with no geotactic bias. Heat filters did not alter the response. When continuously stimulated, juveniles oriented within 2-15 seconds and retraversed the experimental arena, parallel to each other, for more than 8 hours. Dual light experiments revealed no obvious dorsoventral or lateral bias. Photoreception appeared to occur anteriorly when juveniles were partly shaded, and decaudate juveniles oriented, but no pigmented spots were observed. Response extinctions for narrowband (10 nm) light yielded greatest sensitivity from 404-539 nm with a 1 uW/cm^2 mean stimulus threshold for those wavelengths. This is the first phototaxis observed in infective juveniles of mermithids and the first report of transverse phototaxis in nematodes. USDA, ARS, Southern Crops Research Laboratory, College Station, TX 77840, and Biological and Chemical Research Institute, New South Wales Agriculture and Fisheries, Rydalmere 2116, Australia.

ROBINSON, M. P. Quantification of soil and plant populations of Meloidogyne using immunoassay techniques.
Following the production of specific monoclonal and polyclonal antisera, a number of assays

have been developed to quantify Meloidogyne spp. in soil and plant samples. These are based on the "ELISA" immunoassay format and are designed for use by workers with no previous experience with the technique. Soil samples can now be tested for species presence (including mixed populations) and numbers of nematodes per unit volume. Chemical and resistance screening programs could incorporate the plant-based assay in order to accurately determine levels of infection. This would obviate the need for time-consuming determination of root-knot indices. Both assays have been designed for development into kit form. Entomology and Nematology Department, AFRC Institute of Arable Crops Research, Rothamsted Experimental Station, Harpenden, Herts., AL5 2JQ, England.

RODRIGUEZ-KABANA, R., D. B. WEAVER, D. G. ROBERTSON, and E. L. CARDEN. Bahiagrass for the management of nematodes in soybean.
Soybean cultivars Braxton, Centennial, Gordon, Kirby, LeFlore, Ransom, and Stonewall were planted in a field infested with Meloidogyne arenaria and Heterodera glycines (race 4) in plots that had been planted with Pensacola bahiagrass (Paspalum notatum) the previous 2 years, and in others that had been in monoculture with soybean. Yields of all cultivars were higher following bahiagrass than after soybean. Yield responses to the rotation ranged from 33% for LeFlore to 233% for Braxton. The average percent increases in yield across cultivars was 110%. Nematode populations in soil were determined 3 weeks before harvest. Juvenile populations of M. arenaria were either not affected by the cropping system or were lower in the bahiagrass-soybean plots than in monoculture plots. The highest numbers of M. arenaria juveniles were in monoculture plots with LeFlore. Numbers of H. glycines juveniles were lowest in plots with LeFlore. For all cultivars but Kirby and LeFlore plots with bahiagrass-soybean had slightly higher numbers of H. glycines juveniles than those in monoculture. Department of Plant Pathology, Auburn University, AL 36849-5409.

RODRIGUEZ-KABANA, R., D. B. WEAVER, C. F. WEAVER, D. G. ROBERTSON, and E. L. CARDEN. Evaluation of sorghum for the management of soybean nematodes.
Soybean cultivars Braxton, Centennial, Gordon, Kirby, LeFlore, Ransom, and Stonewall were planted in 1988 in a field infested with Meloidogyne arenaria and Heterodera glycines (race 4) in plots that had been planted with Pioneer 8222 sorghum (Sorghum bicolor) the previous 2 years and in others that had been in soybean monoculture. Yields of all cultivars were higher following sorghum than after soybean; yield increases varied from 31% for Kirby to 231% for Stonewall. The average increase in yield across cultivars was 85%. Soil samples for nematode analyses taken 3 weeks before harvest indicated that H. glycines juveniles were lowest in plots with LeFlore; however, numbers of juveniles of this nematode were too low (<40/100 cm^3 soil) to permit establishment of any pattern of response to cultivars and cropping systems. Numbers of M. arenaria juveniles in the soil were lower with soybean after sorghum than in monoculture plots. The highest populations of M. arenaria were associated with LeFlore in monoculture plots. Department of Plant Pathology, Auburn University, AL 36849-5409.

RUSSELL, C. C., and L. L. SINGLETON. Application of subnematicidal rates of carbofuran to winter wheat.
Nematicide application to winter wheat in the U.S. for the control of Pratylenchus spp. produces significant yield increases which are not considered economical due to high chemical cost and low wheat value. As carbofuran activity is based in part on disruption of nematode orientation responses, we theorized that its application to alternate rows at subnematicidal rates would concentrate the populations in untreated rows. At-plant applications of carbofuran at 0.28, 0.56, and 1.12 kg/ha (rate per 15,932.5 m of row applied, in-furrow on 25.4 cm centers in 46.8 l/ha water) to all rows (=BRD) or to alternate rows only (=ALT). Significant (P = 0.05) yield increases were obtained for forage and/or grain at all locations in the 3-year study. Calculations based on the minimum fixed input production cost estimates and yield increases from five location-years' data indicated that 0.28 kg/ha ALT (0.14 kg/ha on a broadcast basis) was the lowest risk, most economical treatment. Calculation of the dollar value of the yield increases of this treatment in a graze and grain system revealed an increased net profit of $31.93/ha (19.9%), forage and $8.61/ha (9.2%), grain. These findings demonstrate the economic feasibility of this strategy of chemical application to winter wheat. Department of Plant Pathology, NRC 110, Oklahoma State University, Stillwater, OK 74078.

RUTHERFORD, T. A., and J. M. WEBSTER. Movement rates and population growth with temperature in the pinewood nematode species complex (PWNSC).
The pinewood nematode (PWN) has spread throughout most Japanese forests, however, pine wilt disease does not occur in cool areas of Japan or above 700 M elevation. Outside Japan, pine wilt disease is confined to forests warmer than 20 C mean daily temperatures. Disease development appears to be caused by large numbers of nematodes disrupting living cells associated with translocation. PWN is amphimictic and continual mating is necessary for max-

imum production. Since rapid population buildup from a low, natural inoculum appears to be necessary for pathogenicity, nematode movement (sine waves/min) and reproduction were examined over a range of temperatures for the following isolates of the PWNSC from pines reared on Botrytis cinerea: Bursaphelenchus xylophilus Fukushima, Q52A, BXUJA, Ibaraki, B.C., MSP4; B. mucronatus Chiba, French and Norway. Increased mating frequency produced increasing numbers of progeny per female. The B.C., Q52A and Norway isolates, all from cool northern climates, moved more rapidly at low temperatures than did Chiba and MSP4 (from warmer climates). B.C., MSP4 and Norway, produced more nematodes at high temperatures than did the other isolates tested. There is some correlation between increased reproduction and pathogenicity as these three are apparently more pathogenic than the remaining isolates. Thus, increased temperatures contribute to pathogenicity by influencing mating frequency (movement), progeny output per female, and consequent increases in population density to pathogenic levels. Centre for Pest Management, Simon Fraser University, Burnaby, B.C. Canada, V5A 1S6.

SAGITOV, A. O., and K. A. PEREVERTIN. The problems of management of plant-parasitic nematode populations in Kazakhstan.
The need for scientifically sound principles of nematode population control currently being developed and improved originates from the considerable harvest waste caused by these deleterious organisms. The main specificity of the control scheme resembles schemes used in technical cybernetics in that control is based not on the harvest's output value, but on the prediction of this value. This peculiarity of the agrocenosis taken as an object of control presupposes rigid requirements for the adequacy of predictive models. The reliability of forecasting depends on the ability to determine a "critical point" for the density of contamination of a given plot. This is complicated by the difficulty of identifying and counting nematodes and by the clustered distribution of nematodes in the field. Biological testing is proposed as the best method for estimating density of contamination. Some models for basic operating effect optimization (crop rotation, nematicides, sowing time) are widely approved in Kazakhstan. Laboratory of Phytopathology, Kazakh Agricultural Institute, Abaj av8, Alma Ata, Kazakh SSR, USSR.

SANDALL, L. J., and T. O. POWERS. Evidence for rapid and widespread dispersal of the soybean cyst nematode.
Mitochondrial DNA analysis is a powerful tool for the examination of the genetic structure of populations. An assessment of the genetic population structure can provide insight into the evolutionary processes that create and maintain that structure. We have examined the mitochondrial DNA from over 30 populations of the soybean cyst nematode in an effort of assess population structure in this sedentary endoparasite. Our results strongly suggest that at least one SCN isolate has been recently introduced and dispersed throughout the U.S. This indicates that the high rates of gene flow may be actively spreading genes among SCN populations. Other variant mitochondrial genomes are present in some populations. The relationship of these variants to the "introduced" genome will be discussed. Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583.

SANO, Z. Reduced motility and survival of Meloidogyne incognita juveniles in field plots cropped with tomato.
Tomato (Fukuju-nigo) seedlings were grown from May 17 to July 14 in two experimental plots, where either tomato plants or eggplants were cropped in the previous summer. Soil samples collected 8 cm or 40 cm distant from bases of the tomato roots at a depth of 12-17 cm, and second-stage juveniles (J2) of M. incognita were extracted by a sieving-centrifugal flotation technique and their rates of motility and amounts of food reserves were examined. At least up to the middle of June, thousands of living overwintered J2/100 ml soil were extracted which retained a large amount of food reserves. Irrespective of sampling distance from base of the plant roots, their rates of motility were very low showing MT-50 values, the time periods required for migration of 50% of J2, of 24 hours or more. On 13 July, on the other hand, when a large part of the population was occupied by newly hatched J2, the MT-50 values were about 2 hours, which increased up to more than 24 hours in September. These results suggest physiological alterations of M. incognita J2 would probably be closely associated with a mechanism in survival of J2 in fields. Division of Plant Pathology and Entomology, Kyushu Natl. Agri. Expt. St. Suya, Nishigoshi, Kumamoto, 861-11, Japan.

SAYRE, R. M., L. J. FRANCL, and M. P. STARR. Visual criteria to distinguish cysts of Heterodera glycines parasitized by a Pasteuria sp.
The lack of detection of Pasteuria spp. parasitizing cyst nematodes in the U.S. may stem in part from insufficient criteria needed to recognize its presence within samples of cysts. A 45-d-old population of cysts of Heterodera glycines that as juveniles had been exposed to infectious endospores of a Pasteuria sp. from Japan was examined for the bacterium using the following search strategy. The focus of the binocular microscope was maintained at the

bottom of the sample dish as diseased cysts were usually free of entrapped air and rarely floated. Most parasitized cysts had yellow patches restricted to the posterior of a white cyst and invariably had no eggs. Entirely white cysts occasionally contained immature bacterial sporangia. Uniformly yellow and light tan to dark brown cysts customarily contained healthy eggs. To verify infection, cysts were transferred to a dish on the stage of an inverted microscope (250X). A narrow stream of cup-shaped sporangia, indicative of the mature stage of the bacteria, erupted from cysts when gentle pressure was applied and confirmed the presence of a Pasteuria sp. These visual characteristics should be useful in the search for Pasteuria spp. indigenous to the U.S. that might serve as biocontrol agents of cyst nematodes. USDA, ARS, Nematology Laboratory, Beltsville, MD 20705.

SAYRE, R. M., and R. L. GHERNA. A method for the cryopreservation of Pasteuria penetrans.
Root galls of tomato (cv. Marglobe) containing Meloidogyne arenaria infected with Pasteuria penetrans were cut into 1-cm segments and placed in a 50% solution of pectinol. After 48 hours on a rotary shaker (100 rpm), the partially macerated root galls were removed and filtered through a 38-μm-pore (400 mesh) sieve. The filtrate containing the mature sporangia of P. penetrans was centrifuged (15 minutes at 2,125 X G) and resuspended in a 7% dimethyl sulfoxide (DMSO) solution. Small quantities (1 ml) were quickly frozen in liquid nitrogen and stored for 72 hours. After storage they were thawed at room temperature and juveniles of M. arenaria were added. A day later ca. 1,000 juveniles encumbered by infectious endospores were added about the roots of tomato seedlings to determine if the attached endospores had remained viable. Six weeks later the tomato root galls were examined and mature root-knot nematode females infected with sporangia of P. penetrans were found. P. penetrans kept in liquid nitrogen assures that a genetically unaltered bacterial isolate will be available for future investigators. USDA, ARS, Nematology Laboratory, Beltsville, MD 20705.

SAYRE, R. M., and W. P. WERGIN. Fine structure and morphology of the trophozoites of Theratromyxa weberi (Protozoa:Vampyrellidae) predacious on soil nematodes.
Trophozoites of Theratromyxa weberi, a vampyrellid amoeba, were reared on prey nematodes, Aphelenchoides rutgersi. The early stages of contact and encystment were observed with light, scanning and transmission microscopy. Light microscopy revealed that the amoeba appeared to envelop their prey with a continuous multinucleate protoplast in less than 3 hours. However, when this process was observed with scanning electron microscopy, the trophozoites appeared as numerous interwoven protoplasmic strands that systematically contacted, covered, and enfolded the nematode juveniles. Only after total engulfment did the strands of the amoeba coalesce to form a continuous membrane around the nematode. Transmission electron microscopy revealed the presence of numerous organelles typical of eukaryotes. Nuclei, mitochondria and particulate helices were the predominant organelles present during the contact stage; whereas lipid bodies, lysosomes and osmiophilic bodies predominated during the formation of the digestive cyst. Nematology Laboratory Plant Sciences Institute, U.S. Department of Agriculture, Beltsville, MD 20705.

SCHMITT, D. P., and B. S. SIPES. Fluctuations of Heterodera glycines populations under seven cropping systems.
A 6-year study involving seven cropping sequences was established in a field infested with race 2 of Heterodera glycines. The cropping sequences were: continuous soybean 'Centennial' (races 1 and 3 resistant), continuous soybean 'Coker 156' (susceptible), corn-Coker 156, corn-Centennial, corn-wheat-Coker 156, corn-Coker 156 treated with EDB or aldicarb, and corn-Coker 156-corn-Centennial. Numbers of nematodes in each plot were assayed annually. Centennial supported greater numbers of H. glycines than Coker 156 in monoculture. The population levels were higher in years with rainfall adequate for good plant growth than in dry years. The fluctuation patterns of this nematode's eggs were similar whether cultivars were grown in monoculture, or in rotation with corn. The nematicides had little influence on this pattern. A corn-wheat-Coker 156 rotation maintained very low numbers of eggs throughout the six years of this study. Delayed planting in the spring is a potential management tactic for maintaining relatively low numbers of H. glycines. Department of Plant Pathology, Box 7631, North Carolina University, Raleigh, NC 27695-7631.

SCHNEIDER, R. C., C. C. LEE, and R. E. GREEN. Persistence of ^{14}C fenamiphos in pineapple soils in Hawaii.
Fenamiphos (Nemacur) is widely used as a postplant nematicide in pineapple cultivation over a wide range of soil types and climatic conditions on three islands in the State of Hawaii. In this study we assessed the persistence of fenamiphos and its major metabolite fenamiphos sulfoxide on nine field soils from the islands of Oahu and Maui. A pilot study by Lee (1987) calibrated pesticide degradation in the field with incubations done under controlled laboratory conditions. Half-lives were determined from first-order rate coefficients. In this study, fenamiphos half-lives ranged from 3 to 8 days. The metabolite, fenamiphos sulfoxide, showed greater persistence with half-lives on the order of 30 to 70 days.

Fenamiphos sulfoxide degradation was measured directly by addition of the metabolite to soil at the start of the incubation. Also, with fenamiphos used as the starting material, fenamiphos sulfoxide persistence was estimated from production and decay curves by a least-squares curve-fitting technique. These data should be useful in determining the optimal application frequencies of this nematicide on different soil types. Department of Agronomy and Soil Science, University of Hawaii, HI 96822.

SCHNEIDER, S. M., D. P. SCHMITT, and K. R. BARKER. A distributed development model of soybean cyst nematode.
A computer model of the soybean cyst nematode (SCN) driven by degree days (basal threshold of 5C, vertical upper threshold of 32C) was developed. The life cycle was divided into four functional stages: egg, infective juvenile, parasitic juvenile, and adult. Each stage was divided into substages to allow movement to the next stage to be distributed over a range of ages. The development processes for eggs, parasitic juveniles, and adults were described with positively skewed probability functions defined over the range of 70 to 130% of the average age at stage transition. The penetration process was described by a negative exponential function. Mortality was applied equally to each substage resulting in lower mortality among the faster maturing individuals and higher mortality in the slower maturing individuals. The mean duration of the egg, parasitic juvenile, and adult stages was 190, 150, and 520 $DD_{5/32}$, respectively. Penetration was 50% for the first 20 $DD_{5/32}$ and declined exponentially over the next 210 $DD_{5/32}$. Survival was 90%, 4%, 30%, and 100% for the egg, infective juvenile, parasitic juvenile, and adult stages, respectively. The rate of egg production was 0.25 eggs/female/$DD_{5/32}$. The model was structured to facilitate future linkage to SOYGRO, a soybean plant model. Crops Research Laboratory, P.O. Box 1555, Oxford, NC 27565, and Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695.

SCHOTS, A., F. J. GOMMERS, E. EGBERTS, and J. BAKKER. Serodiagnosis of nematode species.
Antibodies have been used to identify animal species. For the identification of nematode species (e.g. Meloidogyne, Heterordera, and Globodera spp.) conventional polyclonal antisera have been developed, however, with little success due to extensive cross-reactions. Hybridoma technology offers the possibilities to develop specific monoclonal antibodies (McAbs) that can be used for qualitative and quantitative assessment of nematode populations. In our laboratory, McAbs have been developed for the identification and quantification of the potato cyst nematode species G. pallida and G. rostochiensis. Mice were immunized with partially purified thermostable species specific proteins. One hybridoma was obtained which produced antibodies specific for the genus Globodera and two other hybridomas produced antibodies specific for G. pallida. Several more antibodies cross-reacted with species from the genera Heterodera and Meloidogyne. Similarly, there are reports on McAbs specific for M. incognita which do not cross-react with other genera. Laboratory for Monoclonal Antibodies, P.O. Box 9060, 6700 GW Wageningen, The Netherlands.

SHAHINA, F., and M. A. MAQBOOL. Morphology and relationship of three new species and a new genus of the subfamily Criconematinae (Nematoda: Tylenchida) from Pakistan.
A new genus is proposed under the subfamily Criconematinae Taylor, 1936. It differs from all the known genera of Criconematinae by the presence of greater body annuli, well developed submedian lobes, and scales very wide in proportion to length. This new genus comes close to Pateracephalenchus Metha and Raski, 1971, and Discocriconemella De Grisse and Loof, 1965 on the basis of discoidal head annule, but it differs from Pateracephalenchus by the presence of submedian lobes; greater body annuli with smooth scale, wide as compared to length; and without any projection of fringe of spine. It can be distinguished from Discocriconemella by having scales on entire body and submedian lobes well developed. Type and the only species of this new genus was collected from soil around the roots of Vinca rosea L. from Karachi. Two new species of Ogma were collected from the soil around the roots of Cynodon dactylon L. from Karachi can be distinguished from all the known species of the genus Ogma by having greater body annuli and well developed submedian lobes. Diagnosis of the genus Ogma has been emended. National Nematological Research Centre, University of Karachi, Karachi-32, Pakistan.

SHARMA, N. K., L. D. DWINELL, J. P. NOE, and T. S. PRICE. Nematode survey of Conservation Reserve Program pine plantings in Georgia.
Under the Conservation Reserve Program 449,309 acres of marginal agricultural land in Georgia are being planted to loblolly and slash pines. Seedling survival has been poor on certain sites. In 1988, soil was sampled around dead and living pine seedlings at 42 farms for nematode assay. Nematodes were extracted by elutriation and centrifugal-flotation. Ring (Criconemella spp.) and dagger (Xiphinema spp.) nematodes, the most common parasitic species, were present in 72% and 56% of the 324 samples, respectively. Ring and dagger nematode densities averaged 20 and 9/100 g soil, respectively. The species of ring nematode were determined in 50 samples. Criconemella cylindricus and C. sphaerocephala

were identified in 64% and 20%, respectively, of the samples. Criconemella xenoplax, C. ravidus, and C. ornata occurred at low frequencies (less than 4%). Xiphinema tarjanense and X. radicicola were identified in 89% and 11%, respectively, of 19 samples. Species of Helicotylenchus, Pratylenchus, Hoplolaimus, Trichodorus, Tylenchorhynchus, and Hemicycliophora were also noted in some samples. The causes of planting failures are complex and factors besides nematodes must be considered. Department of Entomology and Agriculture, University of Horticulture and Forestry, Solan (HP), India.

SIKORA, E. J., and G. R. NOEL. Effect of root leachates from resistant and susceptible soybean cultivars on hatch and emergence of Heterordera glycines races 3 and 4.
Egg hatch and emergence of second-stage juveniles (J2) of Heterodera glycines races 3 and 4 exposed to soybean root leachate of cv. Fayette (resistant to H. glycines) and H. glycines-susceptible cvs. Asgrow 2575, Asgrow 3127, and Williams 82 were determined. Leachate was obtained from 8-week-old plants using double-distilled water. Pots containing the sand potting medium served as controls. Leachate effects were evaluated by incubating 20 cysts from field-grown soybeans in 1.0 ml of leachate at 24 C. After 2 weeks, hatch and emergence of J2 was 29 and 20% for race 3 and race 4, respectively. Leachate obtained from Williams 82 stimulated more hatch and emergence of both race 3 and race 4 J2 (42 and 21%, respectively) than did leachate from the other cultivars. Differences between egg hatch and emergence of race 4 J2 in leachate from Williams 82 and leachate from the other cultivars were not as pronounced as for race 3. U.S. Department of Agriculture-Agricultural Research Service, Department of Plant Pathology, University of Illinois, Urbana, IL 61801.

SIKORA, R. A., J. RACKE, and F. BODENSTEIN. Influence of plant-health-promoting rhizobacteria antagonistic to Globodera pallida and Heterodera schachtii on soil-borne fungal and bacterial pathogens of potato and sugarbeet.
Isolates of rhizobacteria applied to potato in tests for antagonistic activity of G. pallida, caused increases in bacterial soft rot of potato caused by Erwinia carotovora var. carotovora. The rhizobacteria Agrobacterium radiobacter and Bacillus sphaericus which reduce G. pallida infection 40% when sprayed onto seed pieces were, therefore, tested for activity to soft rot. Seed pieces were inoculated with E. carotovora 24 hours before rhizobacteria application. B. sphaericus did not affect soft rot or plant growth, whereas, A. radiobacter increased plant growth. Sugarbeet seed treated with isolates of Pseudomonas fluorescens with or without known antagonistic activity toward H. schachtii, significantly increased plant emergence and growth in soil heavily infested with Pythium spp. An increase in Pythium sp. infection due to the presence of rhizobacteria was not detected. The results demonstrated that bacterial colonization of the rhizosphere can simultaneously reduce nematode and fungal infection on sugarbeet. Institut fuer Pflanzenkrankheiten der Universitaet Bonn, Nussallee 9, 5300 Bonn 1, Federal Republic of Germany.

SIKORA, R. A., and R-P. SCHUSTER. Formulation of fungal egg parasites in alginate and their influence on biological control of Globodera pallida.
Acremonium sordidulum and a species of Fusarium isolated from G. pallida were incorporated into Na-alginate in a mixture containing: 1 l culture broth with approximately 1.5 g fungus (dry weight), 20 g alginate and 20 g milled bran. Dry pellets 1% w/w were mixed into field soil containing cysts and planted with potato or fallowed. Parasitism was determined after 8 weeks by microscopic examination of egg suspensions on agar plates. A. sordidulum and Fusarium caused reductions of 64 and 70% in cyst number and increased egg parasitism from 3% in the control to 15 and 21%, respectively ($P = 0.05$). Egg parasitism in fallowed soil increased from 7% in the control to 26 and 28% ($P = 0.05$). A. sordidulum applied 2 or 4 weeks after planting caused 67 and 40% reductions in cyst number over the treatment at planting ($P = 0.05$). Cyst counts were not significantly affected at pellet concentrations below 0.5% w/w. The results obtained with this model system demonstrate that egg parasites, produced in liquid culture, can be formulated as granules and can effectively and quickly parasitize nematode eggs. Institut fuer Pflanzenkrankheiten, Universitaet Bonn, Nussallee, 9, 5300 Bonn 1, Fed. Rep. Germany.

SIPES, B. S., and D. P. SCHMITT. Changes in parasitic phenotypes of Heterodera glycines in response to six crop rotations.
A 6-year cropping systems study was initiated in a field infested with Heterodera glycines race 2. Environmental variance of cyst production on Glycine max PI 88788 was 2.5, 2.1 and 2.2 times greater than the genetic variance in 1983, 1984, and 1985, respectively. Environmental variance of cyst production on G. max Peking ranged from 3.2 (1984) to 0.35 (1985) times the genetic variance. Frequency (0 to 1) of genes for parasitism on PI 88788 changed little during the six years. In contrast, frequency of genes for parasitism on Peking differed ($P = 0.05$) among years in corn-susceptible soybean and in corn-wheat-susceptible soybean cropping systems. Frequency of Peking parasitism ranged from 0 to 0.5 in the corn-susceptible soybean system. In the corn-wheat-susceptible soybean system, frequency of Peking parasitism was 0.08 in 1982 increasing to 0.47 in 1984. A lack of pre-

dictable changes in gene frequency for either resistant soybean may be due in part to survival of eggs produced in previous years. The erratic response from year to year can be attributed to the high environmental variance encountered in the experiment. Rotations conducted longer than 6 years may be needed to effect a change in gene frequency of parasitism in this population of H. glycines. Department of Plant Pathology, Box 7616, North Carolina State University, Raleigh, NC 27695-7616.

SIPES, B. S., and D. P. SCHMITT. Comparative fecundity of three isolates of Heterodera glycines from North Carolina.
Three isolates of Heterodera glycines were compared for the number of eggs produced per cyst. One nematode isolate parasitized the resistant soybeans, Glycine max Peking and G. max PI 88788 (P2), another parasitized only G. max PI 88788 (P1), and a third was unable to parasitize either resistant soybean (P3). Naive males were mated with virgin females in all possible combinations; P1XP1, P1XP2, P1XP3, P2XP2, P2XP3, and P3XP3. Females were collected 2 weeks after mating, crushed, and numbers of eggs/cyst determined. P2 females produced more eggs ($P = 0.01$) than P1 or P3 females (346 vs. 270 vs. 241 eggs/cyst, respectively). P2 and P3 males were associated with more eggs/cyst than P1 males ($P = 0.01$). Crosses of P2 females with P2 males produced the greatest number of eggs (418)/cyst. P1XP1 produced the least number of eggs (167)/cyst. The greater fecundity of P2 may account, at least in part, for the high frequency of this biotype of H. glycines in surveys of North Carolina soybean fields. Department of Plant Pathology, Box 7616, North Carolina State University, Raleigh, NC 27695-7616.

SLATER, T. M., and B. C. HYMAN. Real-time sequence deletion in the Romanomermis culicivorax mitochondrial genome.
The mitochondrial genome of the parasitic nematode Romanomermis culicivorax is large and complex, due to the presence of amplified DNA segments. A 1.1-kilobase pair (kb) deletion was detected within one copy of the repeated DNA. The deletion-containing region was isolated by molecular cloning, and endpoints of the deletion localized by restriction mapping and DNA sequencing. The position of the endpoints indicates that the deletion was sponsored by pairing between two 58-base pair regions of sequence similarity separated by 1.1 kb. The absence of this rearrangement in an independently-reared laboratory culture reproductively isolated from our population for only 160 generations indicates the deletion was a recent, "real-time" event. This represents the first evidence for possible recombination in animal mitochondrial DNA. Department of Biology, University of California, Riverside, CA 92521.

STAPLETON, J. J., J. E. DEVAY, and B. LEAR. In vitro effects of ammonium phosphate fertilization and soil heating on soil nitrogen, galling of tomato roots by Meloidogyne incognita, and numbers of Pythium ultimum.
Moistened, fine sandy loam soil heated in polyethylene bags for 1-4 weeks in an incubator (diurnal heating regime: high 45 C; low 28 C) had more soluble NH_4-N + NO_3-N than non-heated soil. Adding commercial, 16-20-0 ammonium phosphate fertilizer (100, 200, 300, or 400 mg NH_4-N/liter) to similar soil which was naturally infested with Meloidogyne incognita and Pythium ultimum in pint-jar experiments reduced root galling by M. incognita of 'Early-Pak 7' tomato seedlings, and numbers of P. ultimum as compared to nonfertilized soil. Greater decreases in root galling index or numbers of P. ultimum sometimes were found when soil was subsequently heated. Results from in vitro techniques generally resembled those found in field experiments. Statewide IPM Project, University of California Cooperative Extension, 733 County Center III, Modesto, CA 95355.

STAPLETON, J. J., B. A. JAFFEE, and H. FERRIS. Influence of composted chicken manure on soil nitrogen, parasitism of Criconemella xenoplax by Hirsutella rhossiliensis, and numbers of Pythium spp. in a peach orchard.
Sandy peach orchard soil near Livingston, CA amended to 25-cm depth with ca. 73,000 kg/ha composted chicken manure containing 3,280 mg/kg NH_4-N had greater concentrations of NH_4-N and NO_3-N, compared to nonamended soil, up to 30 weeks later. Nitrogen concentrations were generally higher at 0-30 cm than at 30-60 cm soil depth throughout the sampling period. Numbers of Criconemella xenoplax and parasitism of C. xenoplax by Hirsutella rhossiliensis were high and were not affected by manure. Numbers of C. xenoplax and percentage parasitism by H. rhossiliensis were greater at 30-60 cm than at 0-30 cm. Numbers of bacterial-feeding nematodes were higher at 0-30 cm than at 30-60 cm, and were not affected by manure. Numbers of Pythium spp. at 0-30 cm were 79-97% lower after addition of manure, throughout the 30-week sampling period. Statewide IPM Project, University of California Cooperative Extension, 733 County Center III, Modesto, CA 95355.

STARR, J. L., and J. P. STACK. Egg mass-associated microflora of Meloidogyne incognita.
Soil microflora may have a role in density-dependent winter survival of Meloidogyne species. Egg masses (EM) of M. incognita were collected from field-grown cotton in Novem-

ber and December of 1988 and numbers and species of bacteria and fungi associated with the EM were determined. The mean bacterial population, colony-forming units (CFU), for intact EM was 3 X 10^5 CFU/EM. Eight common egg mass-associated (EMA) bacterial species, including four Pseudomonas spp., two Agrobacterium spp., Flavobacterium indologenes, and Cytophaga johnsonae were identified. Fungi included species of Penicillium, Paecilomyces, Alternaria, Fusarium, and several unidentified nonsporulating isolates. Three actinomycete spp. were also isolated. Four composite mixtures of frequently isolated EMA-bacteria were assayed for effects on egg survival and hatch. No inhibitory effects were observed but three composite mixtures stimulated egg hatch by two to three-fold. The EMA microbes will be further tested to determine possible mechanisms of action. Department of Plant Pathology & Microbiology, Texas Agricultural Experiment Station, College Station, TX 77843.

STEINBERGER, Y. Abundance and distribution of nematodes in the root rhizosphere of a desert shrub Zygophyllum dumosum.
Nematodes, numerically, are one of the most abundant fractions of the soil fauna in deserts. A year's study on abundance and distribution of nematodes in the rhizosphere area of a desert shrub showed: 1) correlation in vertical changes of population with change in soil moisture; 2) microbial feeders were the most common of all trophic groups; 3) pattern and behavior of Negev populations are found to be similar to those in other deserts. Department of Life Sciences, Bar-Ilan University, Ramat-Gan 52100, Israel.

STURHAN, D. Morphological and host range diversity of Pasteuria parasitic on plant and soil nematodes.
Pasteuria infections were studied in a wide range of plant-parasitic, mycophagous, bacteriophagous and predacious nematodes of different origin. Difference in size, shape and structure of sporangia and endospores as well as other developmental stages indicate that a multiplicity of Pasteuria taxa exists. Most of these species or "forms" are obviously highly specific to a few nematode hosts. Related host taxa are mostly parasitized by similar Pasteuria taxa. Up to seven morphologically differing "forms" could be identified in nematodes from a single sampling site, on a total of ten host nematodes. Differences in infectivity, development, and pathogenicity were also observed. Biologische Bundesanstalt, Institut fuer Nematologie und Wirbeltierkunde, Toppheideweg 88, D-4400 Munster, Federal Republic of Germany.

SWARTZ, M. S., G. W. BIRD, and J. T. RITCHIE. A modeling-monitoring approach to the risk/benefit assessment of aldicarb in potato production.
An integrated modeling system was developed for estimating potential environmental risk and nematicide benefit associated with aldicarb in potato (Solanum tuberosum) production. In 1986-88, potato production information was collected from Sec. 8, 9, 16 and 17 of Douglass Township, Montcalm County, Michigan, and used for evaluation of the model. Potential risk was measured as estimated aldicarb residual leached below the root zone, and benefit measured as on-farm profitability. An analytical potato model (SUBSTOR) describing plant growth, pest interactions, nitrogen movement, and aldicarb movement was used to estimate profitability and potential risk under several management systems. The ERDAS GIS (geographic information system) was used to spatially correlate weather, soils, and land use information for parameterization of the model. Total potato production profit loss for removing aldicarb from Sec. 8, 9, 16 & 17 of Douglass Township in 1986-88 was simulated to be $146,021, with 0.0219 lbs/A of aldicarb residuals leached below the root zone. Almost no aldicarb residuals (<0.000026 lbs/A), however, were collected in lysimeter leachates validations. Department of Entomology, Michigan State University, East Lansing, MI 48824.

SYDENHAM, G. M., and R. B. MALEK. Comparative host suitability of selected crop species for Pratylenchus hexincisus and P. scribneri.
A greenhouse study was conducted to determine the comparative host suitability of ten graminaceous, leguminous, and solanaceous crop species for Illinois isolates of Pratylenchus hexincisus and P. scribneri. Plants were inoculated with 1,000 nematodes of either species cultured on carrot discs, and total populations per pot were estimated 90 days later. Populations of P. hexincisus increased on corn, potato, rye, sorghum and winter wheat and decreased on alfalfa, red clover, tomato, soybean and white clover. Populations of P. scribneri increased on corn, potato, rye, sorghum, soybean, tomato, white clover and winter wheat and decreased on alfalfa and red clover. Populations of the two nematode species did not differ significantly on corn. Population increase of P. hexincisus was significantly greater than that of P. scribneri on rye and winter wheat, whereas increase of P. scribneri was greater than that of P. hexincisus on potato and sorghum. Results indicate that populations of both species can be managed through crop rotation in the midwestern USA. Department of Plant Pathology, University of Illinois, Urbana, IL 61801.

THIES, J. A., A. D. PETERSON, and D. K. BARNES. Host suitability of cool-season grasses and legumes for Pratylenchus penetrans.

Fourteen grasses and 2 alfalfas were planted in a binary choice test (BCT). Each grass was planted in a polyethylene tube with Baker alfalfa (susceptible to Pratylenchus penetrans) or MN GRN-16 (field resistant). Fourteen legumes and 18 grasses were planted in individual tubes in a no-choice test (NCT). In both tests, four tubes were inoculated with 92 P. penetrans in each of 2 locations (glasshouse and growth chamber at 25 ± 2 C) and an equal number were left uninoculated. Six weeks after inoculation, numbers of nematodes in the roots were determined by acid fuchsin staining. BCT: each alfalfa supported 76% of total numbers of nematodes in the binary grass-alfalfa combinations. Of the grasses, oats and quackgrass had the largest number of nematodes/g root; timothy and pearl millet had the least. NCT: kura clover, sainfoin, cicer milkvetch, and oats had the greatest numbers of nematodes/g root and pearl millet, sweet clover, tall fescue, perennial ryegrass, sudangrass, sudex, and forage sorghum had the least. Alfalfa was intermediate as a host. It should be possible to design cropping systems that affect nematode populations. USDA-ARS and University of Minnesota, Department of Plant Pathology, 495 Borlaug Hall, 1991 Buford Circle, St. Paul, MN 55108.

THOMAS, S. H., and K. ARNOLD. Influence of Meloidogyne incognita-resistant cotton cultivars on yield parameters and nematode population dynamics.
Twelve cotton cultivars and advanced breeding lines were evaluated under heavy preplant nematode pressure (1,600 eggs and juveniles (J2)/500 cm^3 soil) in sandy loam soil for resistance to Meloidogyne incognita host race 3 in microplots. J2 populations 60, 90, and 120 days postplant and final egg densities/g root were used as criteria for assessing levels of resistance among cultivars and compared with results from 40-days seedling-screening trials in the greenhouse. Various yield and growth parameters were also examined for relationship to nematode population dynamics. Blended breeding lines 83-315 and 83-240 supported the least ($P = 0.05$) nematodes and yield loss, and resulted in a net reduction of M. incognita numbers over the growing season. Acala 1517-75, Acala C-32, and Deltapine 90 were judged moderately resistant. Yield losses were attributable to reductions in numbers and weight of bolls. Department of Entomology, Plant Pathology and Weed Science, Box 3BE, New Mexico State University, Las Cruces, NM 88003.

THURSTON, G. S., and W. N. YULE. Persistence of entomogenous nematodes in agricultural soils.
The use of entomogenous nematodes as biological control agents for soil insect pests has been hampered by a poor understanding of the effects of the environment on the nematodes. Among other factors, the ability of a nematode to persist and remain active in the soil may be desirable in some biocontrol situations. This study was initiated to determine whether certain entomogenous nematodes are capable of long-term survival in agricultural soils and if soil type has any effect on persistence. Heterorhabditis bacteriophora, H. heliothidis, and several strains of Steinernema feltiae, and five diverse soil types were used. The Breton and DD136 strains of S. feltiae persisted poorly while the All, Mexican and Kapow strains and the heterorhabditids persisted well, depending on the soil type. Persistence was poor and no active nematodes were ever found in the sand and clay soils. Persistence was better in loamy or muck soils and active nematodes were detected, but only at high soil moisture contents. Laboratory studies have shown that some of these nematodes are capable of entering anhydrobiosis at low soil moisture contents; this may partially explain the field results. The implications of these findings for insect pest control are discussed. Department of Entomology, MacDonald College of McGill University, Ste Anne de Bellevue, QC. Canada H9X-1C0.

TIMPER, P., and H. K. KAYA. Persistence of entomogenous nematodes in soil naturally infested with the nematophagous fungus Hirsutella rhossiliensis.
The objective of this study was to determine if Hirsutella rhossiliensis (Hr) could reduce the persistence of entomogenous nematodes in natural soil. Three nematode species, Heterorhabditis heliothidis (Hh), Steinernema feltiae (Sf) and S. glaseri (Sg) were added separately to 76 cm^3 of soil containing no Hr, ~2,000 conidia/cm^3 (low Hr) or 4,000 conidia/cm^3 (high Hr). Hh and Sg exhibit high motility, and Hh retains its second-stage (J2) cuticle in soil. Nematodes were extracted periodically from soil, counted, and 20-30 living and dead nematodes examined for fungal infection. Days required for 50% reduction of the populations were approximately 34 (no Hr), 25 (low Hr) and 19 (high Hr) for Hh; 77 (no Hr), 38 (low Hr) and 25 (high Hr) for Sf; and 143 (no Hr), 38 (low Hr) and 3 (high Hr) for Hh. After 21 days in high Hr soil, Sg, Sf and Hh were reduced to 14, 45, and 46% of their controls (no Hr), respectively. In a separate experiment, Hh with J2 cuticles removed decreased to 25% of controls (Hh with J2 cuticles) after 4 days in high Hr soil. Lack of a retained J2 cuticle and high motility probably contribute to the rapid decline of Sg in high Hr soil. Department of Nematology, University of California, Davis, CA 95616.

TOMIMATSU, G. S., and J. D. EISENBACK. Plant-parasitic nematode populations of two Blue Ridge Mountain forest ecosystems.

Soil samples from two depth intervals (25-100 cm and 100-200 cm) and three different soil substrates (oak, conifer, and pasture) of two forests in the Blue Ridge Mountains (southwestern Virginia) were collected monthly in 1988 and assayed for plant-parasitic nematodes. Generally, higher populations of nematodes were extracted from Salt Pond Mountain (~1,260 m above sea level) than from Brush Mountain (~750 m above sea level), regardless of soil substrate. Extraction of nematodes by semi-automatic elutriation and centrifugal flotation was greater from the top 100 cm than from the lower 100 cm of soil in most of the samples. Plant-parasitic nematodes (up to 700/500 cm^3) were also recovered from the leaf litter of oak and conifer substrates. Criconemella spp. were the predominant nematodes in all substrates from both regimes. Helicotylenchus, Hoplolaimus, and Tylenchorhynchus were other common genera recovered from all soil samples. Less frequent, although occasionally numerous, were species of Hemicycliophora, Paratylenchus, Pratylenchus, Rotylenchus and Meloidogyne. Malenchus spp. and Gracilacus spp. were found primarily in oak and conifer substrates of both forests. At present, there is no consistent relationship between numbers of nematodes and soil pH or percent organic matter. Department of Plant Pathology, Physiology, & Weed Science, VA Polytechnic Institute & State University, Blacksburg, VA 24061-0331.

TSAI, B. Y., and S. D. VAN GUNDY. In vitro feeding by obligate plant-parasitic nematodes.
The development of axenic culture of obligate plant-parasitic nematodes has been hindered by the complication of mechanical and biochemical factors associated with in vitro feeding. A technique using non-toxic dyes as feeding indicators was developed to facilitate the development of feeding in/on axenic cultural media. Among the dyes tested, amaranth was the most suitable feeding indicator. With this indicator, Pratylenchus scribneri was demonstrated to feed in vitro in the absence of plant tissue. A filtrate of excised corn root culture in Gamborg's B5 medium provided the strongest feeding stimulus among the feeding stimuli tested. This feeding system has the potential to screen nutrients and develop an axenic culture medium. Department of Nematology, University of California, Riverside, CA 92521.

TUDOR, M. T., G. C. WALLACE, and T. R. FUKUTO. The development of new nematicides which show downward phloem mobility.
N-methyl derivatives of the O-methylcarbamoyloxime, oxamyl, were synthesized in an attempt to increase foliar penetration as well as phloem mobility. Several thiocarbamate derivatives of oxamyl were synthesized and examined as downward systemic nematicides. Ring-opened analogs of the organophosphate 2(methoxy (methylthio) phosphinylimino) 3-ethyl-5-methyl-1,3-oxazolidine were also synthesized. This organophosphate has been recognized as having excellent systemic behavior but also showed very high mammalian toxicity. Attempts were made to maintain its systemic behavior and lower mammalian toxicity. Several compounds in both groups showed good phloem movement, when compared to oxamyl. A series of bioassays, along with quantitative analysis, were performed to verify phloem movement and protection of the plant against infection by root-knot nematode species. Department of Nematology and Entomology, University of California, Riverside, CA 92521.

TUDOR, M. E., and M. V. MCKENRY. Unraveling the various nematicidal activities within aqueous extracts of plant refuse.
Of twenty plant species from which aqueous extracts were collected, all had the ability to deplete oxygen levels when added to tap water. Extracts from three of the plant materials were also nematicidal at 18 g/liter. Extracts from California Poppy, Eschscholzia papaver, were highly effective at causing nematode immotility and some nematode mortality at 3 g/liter fresh weight. The effect of poppy was a result of antioxidants present in the extract. Extracts from Signet Marigold, Tagetes tunuifolia, were equal in effect on nematode motility but provided greater nematode mortality. Marigold exhibited the antioxidant effect but also possessed additional toxic constituents which when separated from the antioxidants were still nematicidal. Department of Nematology, University of California, Riverside, CA 92521.

UMESH, K. C., K. KRISHNAPPA, and D. J. BAGYARAJ. Interaction of Radopholus similis with Glomus fasciculatum in banana.
Banana was grown for 120 days in soil infested with Radopholus similis (Rs), the vesicular arbuscular mycorrhizal fungus Glomus fasciculatum (Gf), or both Rs and Gf. Gf additions were simultaneous with, 7 days before, or 7 days after Rs additions. Root length and weight were decreased by Rs and increased by Gf. Plant height, pseudostem girth, and leaf number and area were not significantly affected by the treatments. Concentrations of N, P, K, reducing sugars, and total sugars were higher in mycorrhizal plants. Ca, Mg, phenols, and total amino acids were not affected by mycorrhiza or nematodes. Mycorrhizal plants contained fewer Rs, supported lower numbers of Rs in soil, and had fewer Rs-induced root lesions than nonmycorrhizal plants if Gf was added simultaneously with, or 7 days before Rs. Addition of Gf 7 days after Rs failed to reduce nematode numbers and damage. Mycor-

rhizal colonization of roots were reduced but spore production was unaffected by Rs. Department of Plant Pathology, University of Agricultural Sciences, G.K.V.K., Bangalore 560 065, India.

VAN DE VELDE, M. C., and A. COOMANS. Stoma structures in monhysterids.
Electron microscopic observations on Geomonhystera disjuncta and Diplolaimella dievengatensis suggest that apart from the cuticular differentiations, the identity of the supporting tissues is of importance for distinguishing the stomatal regions. 1) The cheilostom is lined with the continuation of the body cuticle that surrounds the lip tissue; 2) the prostom has a thin cuticle surrounded by arcade tissue; 3) the mesostom cuticle is thick and has characteristic electron dense radial bands and is surrounded by epithelial pharynageal tissue; 4) the metastom has a similar though thinner cuticle but is surrounded by the anteriormost ring of pharyngeal muscle cells (m_1); 5) the telostom has an amorphous cuticle and is surrounded by the second ring of pharyngeal muscle cells (m_2). Similar configurations have been found in Caenorhabditis elegans and we suggest that they are homologuous. Preliminary results indicate that the same principles apply to Tobrilus. Instituut voor Dierkunde, Rijksuniversiteit Gent, Gent, Belgium.

VEECH, J. A. The response of kenaf (Hibiscus cannabinus) to the root-knot nematode (Meloidogyne incognita).
Each race of Meloidogyne incognita tested reproduced on each of six genotypes of kenaf, Hibiscus cannabinus. The best reproduction was observed on 'Cubano,' 15-2, 'Everglades 71' and 'Guatamala 4' for races 1, 2, 3, and 4, respectively. Races 1, 3, and 4 had the poorest reproduction on genotype 19 117-2; race 2 reproduced poorest on PI 318723. Kenaf, unlike its close relative cotton, which resists reproduction by M. incognita races 1 and 2 but does not resist reproduction by races 3 and 4, showed no tendency to retard reproduction of any race of the nematode. At the incubation time tested (9 weeks), M. incognita reduced plant height by as much as 40% and foliar biomass by as much as 45%. I conclude that 1) all races M. incognita can reproduce aggressively on kenaf; 2) race 2 (if the race designation is confirmed) is the most destructive race of the nematode to kenaf, and 3) various degrees of resistance to root-knot nematodes exist within the genome. USDA, Cotton Pathology Research Unit, Route 5, Box 805, College Station, TX 77840.

VERDEJO, S. Factors affecting adhesion of Pasteuria penetrans spores to Meloidogyne javanica juveniles.
Surface disinfected and nondisinfected M. javanica juveniles were added to water-agar plates containing 5 x 10^4 spores. Spores were obtained from non- or surface disinfected parasitized females. After 24 hours, the number of spores/juvenile was counted in 45 nematodes/treatment. The nematode source did not affect adhesion unless other factors interacted, fewer spores adhered to nonsurface disinfected juveniles from whole plant than those from monoxenic cultures. Surface disinfection of parasitized females decreased spore adhesion in juveniles from whole plant. Fewer spores on juveniles from monoxenic cultures only occurred on nonsurface disinfected juveniles. Surface disinfection of juveniles decreased attachment in juveniles from monoxenic cultures or whole plant when nonsurface disinfected or surface disinfected parasitized females were used, respectively. The surface disinfection of parasitized females had greater effect on the rate of spores attached than that of the juveniles or the nematode source. IRTA, CIAC, Crta. de Cabrils s/n. 08348 Cabrils (Barcelona) Spain.

VRAIN, T. C., and H. S. PEPIN. Effect of Pratylenchus penetrans on root rot of red raspberry caused by Phytophthora erythroseptica.
Selfed seedlings of red raspberry cv. Skeena were inoculated in the greenhouse with 0, 4000, and 8000 Pratylenchus penetrans of all stages per plant, with or without a mycelial suspension of the fungus. P. erythroseptica reduced raspberry growth in 65 days. After 115 days, 43% of plants inoculated with fungus alone and 46% of plants inoculated with fungus and nematodes had died. The fungus but not the nematodes lowered the weight of canes and foliage. Fungus and nematode separately or together impaired root development. Raspberry cv. Willamette plants were grown in field microplots for 3 years in P. penetrans-infested field soil. Soil nematode densities at planting ranged from 0 to 1,470/50 cm^3. The high densities of nematodes in soil depressed shoot growth every year. P. erythroseptica depressed shoot growth in plots with low initial nematode densities. The weak interaction between the two pathogens was probably masked by the aggressiveness of the fungus. Agriculture Canada Research Station, 6660 N.W. Marine Drive, Vancouver, B.C. Canada V6T 1X2

VRAIN, T. C., and D. WAKARCHUK. Construction of a set of cloned rDNA probes for the specific differentiation of the Xiphinema americanum group.
Restriction fragment length polymorphism analysis can be used to identify the populations and species constituting the Xiphinema americanum group. Nematodes from a population of X. bricolensis were extracted in Baermann pans and further cleaned of traces of soil organic

matter by active extraction in solidified low temperature agarose. Total DNA and RNA were extracted and purified on cesium chloride gradient. The DNA was digested with EcoR1, and ligated into EcoR1-treated pUC13 plasmids. The ligated plasmids were transformed into competent *Esrichia coli* NM522 cells. Six hundred clones were selected, and are being screened using ^{32}P labelled cDNA probes made from *X. bricolensis* RNA. Isolated genes will be used as probes to differentiate populations and species of the *X. americanum* group. Agriculture Canada Research Station, 6660 N.W. Marine Drive, Vancouver, B.C. Canada V6T 1X2.

WALTER, D. E., and D. T. KAPLAN. Antagonists of nematodes in Florida citrus groves: They're out there, but what are they doing?

A survey of citrus rhizosphere soil for antagonists of phytonematodes in Florida citrus groves using burrowing nematode (*Radopholus* spp,.) from laboratory cultures as the bait/prey organism has disclosed a diverse assemblage of antagonists including nematode-trapping fungi, endoparasites (phycomycetes and a sporozoan), and predators (nematodes and arthropods). The citrus nematode antagonist fauna is a subset of the antagonists present in other habitats in Florida, and is dominated by species with broad, eurytopic distributions. Older groves (>20 years) with a history of citrus nematode (*Tylenchulus semipenetrans*) infestation typically have locally diverse and abundant assemblages of nematode antagonists. Nematophagous fungi have been found associated with declining greenhouse cultures of citrus nematode. Some fungi (*Verticillium*, *Paecilomyces*) and actinomycetes (*Streptomyces*) associated with citrus nematode eggs-matrices and weak or dying nematodes have also been detected and may be useful antagonists. U.S. Department of Agriculture, ARS, 2120 Camden Road, Orlando, FL 32803.

WARNER, F. W., G. W. BIRD, J. F. DAVENPORT, and M. HANNA. Distribution and regulation of Meloidogyne nataliei in Michigan.

The Michigan grape root-knot nematode (*Meloidogyne nataliei*, Golden, Rose & Bird, 1981) was discovered in 1977 in a declining grape vineyard (*Vitis labrusca* cv. Concord) in Sec. 13 of Antwerp Twp. of Van Buren County, Michigan. The type site was sampled intensively in 1981, 1982, and 1983, along with other vineyards in SW Michigan. *M. nataliei* was found only in the type site vineyard in Sec. 13 and 14 of Antwerp Twp. This vineyard was removed and the soil fumigated in 1984 as part of an eradication-risk reduction program implemented by the Michigan Department of Agriculture. *V. labrusca* cv. Concord seedlings were planted throughout the former type vineyard as bioassay indicators. *M. nataliei* was recovered from 1 or 2 bioassay vines in 1985, 1986, and 1987, and the infested areas spot-fumigated. In the spring of 1988, two additional *M. nataliei* infested vineyards (Sec. 27 & 34 of Antwerp Twp.) were detected from soil samples submitted to the MI State University Nematology Lab. Additional sampling in the fall of 1988 and infrared remote photography showed that *M. nataliei* was present in a significant portion of these vineyards. The known distribution of *M. nataliei*, however, is still limited to a single township in Michigan. Department of Entomology, Michigan State University, East Lansing, MI 48824.

WEAVER, C. F., R. RODRIGUEZ-KABANA, D. G. ROBERTSON, L. WELLS, and P. S. KING. Crops uncommon to Alabama for the management of Meloidogyne arenaria in peanut.

In a 1987 field study, numbers of juveniles (J2) of *Meloidogyne arenaria* determined near peanut harvest were almost undetectable in plots with American jointvetch (*Aeschynomene americana*), castor bean (*Ricinus communis*), partridge pea (*Cassia fasiculata*), sesame (*Sesamum indicum*) and cotton (*Gossypium hirsutum*) while plots with peanut averaged 120 J2/100 cm^3 soil. Application of aldicarb (12 kg a.i./ha broadcast) in peanut resulted in an average of 27 J2/100 cm^3 soil. In 1988 all plots were planted to peanut and the aldicarb treatment was repeated in plots that had the nematicide in 1987. In 1988 peanut yields from plots that had no peanut in 1987 were 51-69% higher than the yield from those with continuous peanut with no nematicide; the aldicarb treatment resulted in 57% increase in yield. In 1988 harvest-time *M. arenaria* J2 populations in soil were the lowest in plots that had castor bean in 1987; however, the partridge pea-peanut and the sesame-peanut rotations also reduced numbers of J2 when compared with continuous peanut with no nematicide. The aldicarb treatment resulted in J2 populations equivalent to those found with either the partridge pea or the sesame rotations. Department of Plant Pathology, Auburn University, AL 36849.

WESTERDAHL, B. B. Nematode management in California vineyards.

Grapes account for 1.3 billion of California's 17 billion dollar agricultural industry. Nematode management varies in the three major growing areas because of variety of grapes, climate, soil type, irrigation and other cultural practices, major nematode pests, and the background and interests of the researchers called upon to develop the management programs. The north and central coastal areas (area 1) have small vineyards specializing in high quality wine grapes with little or no irrigation on heavy soil. The San Joaquin Valley (area 2) grows large quantities for bulk wine and raisin production using mostly flood and furrow irrigation on light and medium textured soils. Southern California (area 3) spe-

cializes in growing table grapes on sandy soils with low volume irrigation. The major nematodes found in California vineyards are: dagger, Xiphinema index with the potential to transmit grapevine fanleaf virus, and X. americanum (areas 1 and 2); root knot, Meloidogyne spp. (areas 2 and 3); citrus, Tylenchulus semipenetrans (areas 2 and 3); ring, Criconemella xenoplax (areas 1 and 2); lesion, Pratylenchus vulnus (areas 1 and 2); stubby root, Paratrichodorus spp. (all areas); and needle, Longidorus africanus (area 3). Current management programs consist of a combination of resistant rootstocks, pre- and postplant chemicals, and cultural practices designed to minimize stress. Recent developments include the application of nematicides via low volume irrigation systems with timing determined by nematode population dynamics; the release of resistant rootstocks for management of X. index; and trials with biological control agents and cover crops. Department of Nematology, University of California, Davis, CA 95616.

WHEELER, T. W., K. R. BARKER, and S. M. SCHNEIDER. Effect of soil moisture on development of Meloidogyne incognita and related tobacco growth.
A factorial design with four moisture levels and six initial population densities (Pi) of Meloidogyne incognita was set up in microplots with tobacco. Plants were sampled destructively 10 times during the growing season. Data collected included root length, leaf weight, and nematode numbers/stage (J2 and eggs in soil, J2 in roots, 3rd-4th juvenile stages, and adults). Soil moisture had no effect on rate of development of the first generation of the nematode. Both soil moisture and Pi levels influenced leaf and root growth throughout the season. Tobacco yielded significantly better in the moderate soil moisture treatment (average moisture levels = -0.2 bars) than in all other moisture treatments. There was an interaction among Pi and soil moisture levels on final yield. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

WILLIAMSON, V. M., G. COLWELL, H. MEI, and L. M. LI. Toward cloning the Mi gene of tomato.
Mi is a dominant locus that confers resistance to three species of root-knot nematode when present in tomato. A clone of Mi would be of value for increasing understanding of the mechanism of resistance. Also, using recombinant DNA techniques, it may be possible to transfer resistance to susceptible tomato cultivars and to other plant species. Mi is closely linked to a gene, Aps-1, encoding acid phosphatase-1, in tomato. A clone of Aps-1 has been obtained by using "reverse genetic" techniques. This clone will be used as a starting point to isolate Mi by "chromosome walking." In addition, DNA clones that flank the region of the genome containing Mi have been used to probe Southern blots of DNA from tomato cultivars which differ in their resistance. These blots indicate that the size of the region of the genome derived from the wild tomato species L. peruvianum (the source of Mi) varies among cultivars. This region of foreign DNA is quite extensive in some cultivars such as VFNT cherry, where it includes a DNA marker which is 7 map units from Aps-1. Department of Nematology, University of California, Davis, CA 95616.

WINDHAM, G. L., G. A. PEDERSON, M. M. ELLSBURY, R. G. PRATT, M. R. McLAUGHLIN, and G. E. BRINK. Influence of Meloidogyne incognita, cypermethrin, benomyl, and peanut stunt virus on white clover yield.
The effects of Meloidogyne incognita, cypermethrin, benomyl, and peanut stunt virus (PSV) on growth of 'Regal' white clover, Trifolium repens, was determined in a 2-year field study. The experimental design was a split plot with each treatment combination replicated six times. Plots were infested with 2,500 M. incognita eggs/500 cm^3 soil at planting in September 1986, and plants were inoculated with PSV in April and November 1987. Cypermethrin and benomyl were applied monthly at a rate of 0.045 and 0.46 kg a.i./ha, respectively. None of the treatments had a significant ($P = 0.05$) effect on clover yield in 1987. However, in 1988, M. incognita reduced forage yields by 17%. Insecticide and fungicide treatments increased forage yields by 84 and 12%, respectively. An interaction between the cypermethrin and the M. incognita treatments for clover yields was observed in 1988. Nematode effects on yield were greater in plots treated with cypermethrin. USDA-ARS, Forage Research Unit, P. O. Box 5367, Mississippi State, MS 39762.

XUE, B. G., D. L. BAILLIE, K. BECKENBACH, and J. M. WEBSTER. DNA hybridization probes for the genotypic differentiation of Meloidogyne spp.
A direct analysis of the genotype of Meloidogyne spp. was done using DNA restriction fragment length differences (RLFD). This was done by using a cloned rDNA fragment isolated from Caenorhabditis elegans as a probe to Meloidogyne incognita races 1, 3, and 4, M. arenaria race 1 and M. javanica. This probe showed differences between the species and not between the races. In order to obtain an intraspecific probe a portion of the non-transcribed spacer region of the ribosomal repeat was cloned from M. arenaria. When this clone was hybridized against the races, RFLD's were detected. One 3.1 kb fragment in M. incognita race 3 is unique in comparison with races 1 and 4. Random probes were made and tested against these species. Using these probes it was possible to distinguish between the species and some are useful as intraspecific probes. It is these probes that will be

particularly useful in species and race diagnosis. Department of Biological Sciences, Simon Fraser University, Burnaby, B.C. Canada V5A 1S6.

YOUNG, L. D. Responses of soybean and Heterodera glycines to selected cropping sequences.
Frequent planting of soybean, Glycine max (L.) Merr., cultivars resistant to the soybean cyst nematode (SCN), Heterodera glycines Ichinohe, may lead to development of SCN populations that suppress yields of these cultivars. Yield, cyst density, and SCN reproduction on resistant cultivar 'Bedford' were measured for five treatments [1) continuous susceptible cultivar 'Forrest,' 2) resistant cultivar 'Bedford,' 3) 30:70 blend of Forrest and Bedford, and rotations of Bedford with 4) corn and 5) susceptible cultivars Forrest and 'Essex'] in a field of Routon silt loam soil from 1979 to 1988. Continuous Bedford had higher (P = 0.05) yield than continuous Forrest in 8 of 10 years. Bedford grown in the rotations and the blend of cultivars exceeded (P = 0.05) the yield of continuous Bedford only in the ninth year of the study. Cyst density in continuous Bedford plots averaged one-half of the density in continuous Forrest plots. SCN reproduction on Bedford exceeded 50% of reproduction on susceptible cultivar Essex when planted in soil from continuous Bedford plots from 1981 to 1988. Reproduction on Bedford was also high in soil from plots of Bedford in rotation with corn but was low for the other treatments. USDA-ARS, Nematology Research, 605 Airways Boulevard, Jackson, TN 38301.

YOUNG, R. W., R. RODRIGUEZ-KABANA, D. B. WEAVER, D. G. ROBERTSON, and E. L. CARDEN. Hairy indigo for the management of soybean nematodes.
Soybean cultivars Braxton, Centennial, Gordon, Kirby, LeFlore, Ransom, and Stonewall were planted in 1988 in a field infested with Meloidogyne arenaria and Heterodera glycines (race 4) in plots that were planted with hairy indigo (Indigofera hirsuta) the year before and in others that had been in monoculture with soybean. Yields of all cultivars were higher following hairy indigo than after soybean. Yield responses to the rotation ranged from 17% for LeFlore to 210% for Braxton. The average percent yield improvement obtained with the indigo-soybean rotation regardless of cultivar was 55%. Soil samples for nematode analyses taken 1 week before harvest evidenced for all cultivars higher M. arenaria juvenile populations in plots with indigo-soybean than in those with monoculture. Plots with LeFlore had the highest M. arenaria juvenile populations. Numbers of H. glycines juveniles were low (<40/100 cm^3 soil) and no pattern of population response to cropping systems or cultivars could be established for this nematode. Department of Plant Pathology, Auburn University, AL 36849-5409.

ZERVOS. S. In vitro productivity of entomopathogenic nematodes (Rhabditidae) in relation to temperature and inoculum size.
Steinernema glaseri (Sg) and Heterorhabditis heliothidis (Hh) infective juveniles (IJ) live in soil, carry entomopathogenic bacteria, enter the haemocoel of insects, cause insect death by the release of the bacteria, mature, and produce a new generation of IJs. When these nematodes are cultured in final larval instars of Galleria mellonella, nematode production/IJ is inversely proportional to size of IJH inoculum (IJI), but production/Galleria is highest at 10 Hh and 100 Sg IJI. Nematode yield varies with IJI and temperature: there is no production at 500 IJI, at 5-10 C with Sg or at 5-10 C and 30 C with Hh; highest production is at 20-25 C with Sg and 20 C with Hh, and development time decreases with increasing temperature up to 25 C then decreases with Sg. The period over which nematodes emerge from the insect is shortest at 15-20 C and small IJI with Sg or at 25 C and large IJI with Hh. Greatest nematode yield occurs in the first 5 days with Sg or second 5 days with Hh from onset of emergence. Biological Sciences, Simon Fraser University, B.C. V5A 1S6 Canada.

ZUNKE, U. Behavior of the root lesion nematode Pratylenchus penetrans.
A research and teaching firm was produced in co-operation with the Institut fur den wissenschaftlichen Film, Gottingen, West Germany (C1676, 16 mm, color, 14 min., English commentary) in attempt to explain plant damage caused by the endoparasitic root lesion nematode, Pratylenchus penetrans. The behavior of the nematode at root hairs and inside roots of host plants are recorded in addition to IC-microscopy and TEM with a modified professional 1" video system with high resolution and contrast enhancement (Rev. Nematol. 9, 91-94, 1986). Although Pratylenchus penetrans is one of the smallest species of plant-parasitic nematodes, with the help of the video system in vivo observations within the roots by high magnification up to 3000 times were possible, which otherwise remain obscure even with optimal IC-microscopy. The film shows symptoms of root attack by Pratylenchus penetrans on roots of barley as examined in the field, the feeding behavior at root hairs and inside roots in aseptic cultures of different host plants as potato, tobacco, and rape seeds, migration through cortex cells, some aspects of defaecation, egg-laying, moulting, the damage of roots caused by migration and feeding of the nematode and its consequences for the root system and the whole plant. The film ends with pictures of field damage in barley and maize, and gives some aspects of plant protection. Institut fur Angewandte Botanik, Universitat Hamburg, Marseillerstr. 7, D-2000 Hamburg 36, West Germany.