ABSTRACTS OF PAPERS PRESENTED AT THE TWENTIETH ANNUAL MEETING OF THE SOCIETY OF NEMATOLOGISTS

SEATTLE, WASHINGTON 16-19 AUGUST 1981

ABDEL-RAHMAN, F. H. and A. R. MAGGENTI. *The embryology and post-infection development of a new species of Meloidogyne.*

A new species of *Meloidogyne* (root-knot nematode) was found on the roots of the sedge (*Scripus robustus*) at Pompino Beach, California. Laboratory tests revealed that from the first cleavage to eclosion takes approximately 20 d at 20 C ± 2 C. At eclosion it is the second-stage larva that emerges; one molt occurs within the egg shell. The second-stage larva is the infective stage; it was used in subsequent experiments to study the postinfection development at 20 C. Ten days following inoculation, second-stage larvae were developing but remained sexually undifferentiated. After 12 d, male and female larvae are distinguishable; males have one gonad and females have two. The second and third molts occur within the cuticle of the second-stage larva. The third stage appears 14 d after inoculation and the fourth stage after 16 days. Both larval stages lack a stylet and therefore do not feed. In addition, the esophagus and metacorpus are poorly developed. Young adult females are evident 18 d after inoculation. At this time the female is the same size as the fourth-stage larva; however, the stylet is now well developed, as is the valve in the metacorpus. The metacorpus is now considerably larger than in any previous stage. The adult female is globose with the reproductive tract occupying most of the body volume. The gelatinous matrix, into which eggs are deposited, is first seen 27 d after inoculation. The first eggs are deposited into the matrix after 28 d. The number of eggs per mass is approximately 400.—*Division of Nematology, University of California, Davis, CA 95616.*

ABDEL-RAHMAN, F. H., and A. R. MAGGENTI. *Morphological and biological studies on two new species of nematodes found associated with sedge roots in California.*

Two new species of plant-parasitic nematodes have been found associated with sedge (*Scirpus robustus*) roots in California. Extremely large galls were found to contain large numbers of *Hirschmaniella* sp. as well as second-stage larvae of *Meloidogyne* sp. Light miscroscopy studies revealed that the two species are morphologically different from other known species in both genera. Scanning electron microscope (SEM) studies of the *Meloidogyne* sp. show the shape of perineal pattern and the heads of males, females, and larvae. SEM was also employed with the *Hirschmaniella* sp. to determine the shape of female and male heads, the structure of the lateral field, and the shape of the tail. Host tests were done using tomato 'VF 145,' rice 'S-G,' barley 'Hunnchen' and 'C. V. Wasco,' wheat 'Anza' and 'DG 301,' Sudan grass 'piper,' sugar beet, African alfalfa, broad beans, and red clover. *Meloidogyne* did not infect or reproduce on any of the tested hosts. *Hirschmaniella* infected all the hosts, except tomato. However, it did not reproduce well on any of the tested plants. Culturing on carrot discs was attempted with the *Hirschmaniella* sp.

Nematodes were surface sterilized with 6,000 ppm dehydrostreptomycin sulfate and 133 ppm Aretan (the formulation containing 3% organic mercury) and then transferred to carrot discs in jars. Examination 4–6 months later revealed that the nematodes survived and reproduced on the carrot discs.—*Division of Nematology, University of California, Davis, CA 95616.*

APT, W. J. *The application of phenamiphos and oxamyl by drip irrigation for the control of the reniform nematode on pineapple in Hawaii.*

Phenamiphos and oxamyl were applied monthly by drip irrigation for the first 16 months of growth at 1.7 and 3.4 kg a.i., respectively, in 664 hl of water/ha. The nematicide applications reduced the populations of the reniform nematode, *Rotylenchulus reniformis,* 91–94% at 12 months. Phenamiphos applications at 1.7 and 3.4 kg/ha produced a total yield (plant crop thru ratoon) of 220.2 and 216.4 metric tons/ha (fresh fruit density), respectively, compared to 170.2 metric tons from the irrigated control. Oxamyl applied at the same rates produced 209.2 and 206.5 tons compared to the control. The data indicated that phenamiphos and oxamyl applied at 3.4 kg/ha had some inhibiting effect on yield when compared to the 1.7 kg/ha rate. In plant crop, the percentage of the larger fruit sizes (2½, 2T) and sucker size (from which the ratoon crop is produced) was significantly greater in the phenamiphos and oxamyl treatments than in the control. In ratoon, the increase in larger fruit sizes was of greater magnitude than in the plant crop. Phenamiphos treatment at 1.7 and 3.4 kg/ha resulted in 45.7 and 49.1 tons/ha, respectively, of 2½ and 2T fruit compared to 17.9 tons from the control. Oxamyl treatment resulted in 48.4 and 44.6 tons, respectively, compared to the control.—*Department of Plant Pathology, University of Hawaii, Honolulu, HA 96822.*

ARENS, M. L., J. R. RICH, and N. C. SCHENCK. *Interaction between two root-knot nematode species and three mycorrhizal fungi on tobacco in field microplots.*

Sixty-day-old tobacco seedlings (*Nicotiana tabacum* L.) cv. McNair 944 colonized by *Gigaspora margarita, Glomus mosseae,* or *G. clarus* were transplanted into 75-cm-d microplots. One day prior to transplanting, *Meloidogyne incognita* or *M. javanica* were added to each microplot at 8, 15, and 23 cm deep and at concentrations of 2, 8, or 24 nematode eggs and/or second-stage larvae per 100 cm^3 of soil. Treatments were replicated eight times in a randomized complete block design. Root and soil samples were taken 40, 70, and 104 d after transplanting. The number of mycorrhizal spores and nematodes present in 250 cm^3 of soil was determined. Roots were stained with cold acid fuchsin-lactophenol. The percentage of mycorrhizal colonization in 0.5 g of root tissue was determined by the gridline technique at 30 ×. The remaining roots were cut into pieces 2 cm long, placed between two microscope slides, and examined at 100 × to determine the number of nematodes inside. Yield data were also taken. Compared to the other two mycorrhizal fungi, the percentage of roots colonized by *G. margarita* increased in plants infected with *M. javanica* and higher numbers of *G. margarita* spores were recovered at midseason and harvest. At the low and high initial nematode inoculum levels (P_i's), lower numbers of *M. incognita* were found in tobacco plants colonized with *G. margarita,* as compared to other treatments. Numbers of *M. javanica* larvae were similar in treatments with or without *G. margarita.* Presence of *G. mosseae* and *G. clarus* did not have an effect on the population of either root-knot nematode species. *Glomus mosseae* alone or in combination with the low P_i's of both nematode species significantly increased tobacco yield, whereas *G. clarus* significantly reduced tobacco yield at the high P_i of *M. incognita* or *M. javanica.*—*Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611; Agricultural Research Center, Live Oak,*

FL 32060; and Department of Plant Pathology, Gainesville, FL 32611.

BACHIREDDY, V. R., and R. PAYNE, JR. *Distribution of nematodes parasitic on soybeans in Louisiana.*

Louisiana soybean acreage has increased to 4 million acres. Production is threatened by soybean parasitic nematodes, especially soybean cyst, *Heterodera glycines;* root-knot, *Meloidogyne incognita* group; and reniform nematode, *Rotylenchulus reniformis.* Soybean yield losses in heavily infested fields were estimated from 5% to 90% of the crop. Farm surveys were made for nematode infestations and populations in Louisiana. Soil samples were collected from soybean fields that have had soybeans growing on them for two or more years and analyzed for soybean parasitic nematodes. All soybean-growing parishes in Louisiana were indexed for soybean parasitic nematodes. Thirty-six soybean growing parishes were surveyed for plant parasitic nematodes. Eleven plant parasitic nematode species were found closely associated with soybean roots. Root-knot nematode was found in 12 parishes, soybean cyst nematode in 22 parishes, and reniform nematode in 15 parishes. Other genera recovered were *Tylenchorhynchus, Helicotylenchus, Pratylenchus, Xiphinema, Trichodorus, Aphelenchoides, Criconemoides,* and *Hopolaimus* spp. Many non-parasitic nematodes were associated with soybean roots. Most soybean cyst nematode infestations were found in parishes bordering the Mississippi river and in the south central and south west parishes of Louisiana.—*USDA SEA CR, Department of Plant and Soil Sciences, Southern University, Baton Rouge, LA 70813.*

BAJAJ, H. K., and D. S. BHATTI. *Life cycle of Heterodera mothi Khan & Husain 1965 on Cyperus rotundus L.*

Life cycle studies of *Heterodera mothi* were carried out on *Cyperus rotundus* L. under Hissar conditions. Hatching occurred in distilled water in March and April. Larvae obtained from egg masses penetrated roots in 48 h without showing preference for any tissue. Second moult occurred in 96 h and third moult 6 d after inoculation. Males developed faster than females and adult males could be seen on day 8, whereas female larvae took 14 d to reach adult stage. Males coiled around virgin females and a maximum of seven males were seen around a single female. There was no greater increase in the width of females who remained fully inside the root until a very late stage. Egg laying started on day 17, and eggs were deposited within the roots. Females erupted out of the roots leaving eggs attached thereto. In only a few instances (2%), was a female found with egg masses in gelatinous matrix which was larger than adult stage. An egg mass contained about 100 eggs and a cyst about 188. Brown phase of cysts was reached on day 30. In October-March, both egg laying and hatching did not occur. Considering the time taken for completion of one life cycle and the seasons of the year favorable for development, *H. mothi* could complete 7–8 generations in a year.—*Department of Nematology, Haryana Agricultural University, Hissar-125004, India.*

BALDWIN, J. G. *Fine structure of the esophagus of males of Sarisodera hydrophila compared with other Heteroderoidea.*

The esophagus, including procorpus, metacorpus, isthmus, glandular lobe, and esophago-intestinal junction, was examined in males of *Sarisodera hydrophila* with the transmission electron microscope and compared with *Heterodera glycines* and *Meloidogyne incognita.* The procorpus, metacorpus, and isthmus are similar to *H. glycines.* The gland lobe of *S. hydrophila* is about 70 μm long and the posterior half consists primarily of two subventral gland cells. Anteriorly, the subventral glands are partially ensheathed by a combination of tissues. These tissues include nonglandular cells associated with the esophagus lumen as well as a sheet-like portion of the dorsal gland in which cell bodies of several neurons are embedded. Most of the dorsal gland cell occurs anterior to the widest part of the lobe and the esophago-intestinal junction, although a narrow process may extend further posteriorly. The three gland cells of *S. hydrophila* are separated by distinct plasmalemmas; however, parallel mem-

branes between adjacent portions of subventral glands are interrupted by regions of deep invaginations which result in formation of vesicles within each of the gland cells. Nuclei and other contents of the three glands resemble those of *H. glycines*, and each anterior gland process enters the esophagus lumen through a single cuticle-lined duct. In contrast, ducts of *M. incognita* are trifurcate and the dorsal gland is absent. The three distinct esophageal gland cells of *S. hydrophila* differ from *H. glycines*, in which the gland lobe is reportedly syncytial.—*Department of Nematology, University of California, Riverside, CA 92521.*

BARKER, K. R., and W. W. WEEKS. *Influence of soil type and Meloidogyne incognita on yield and quality of tobacco.*

A factorial microplot experiment with six soil types and four inoculum densities (P_i) of *Meloidogyne incognita* (MI) was designed to determine the effects of these parameters on yield and quality of 'McNair 944' tobacco. Five plots per soil type were infested with NaOCl-extracted eggs for each MI level (P_i): 0, 1250, 5,000, and 20,000 eggs/500 cm^3 of soil. Soils included at a common Fuquay-sand site with their respective percentages of sand, clay, and silt were Fuquay sand (91, 3, 6), loamy sand (84, 4, 12), loamy sand (72, 10, 18), muck (58, 9, 33), sandy clay loam (53, 29, 18), and a sandy clay (48, 39, 13). Reducing sugar and nicotine contents in tobacco infected by MI were measured. The effects of MI populations on yield and quality were less in the clay soils than in the other soils. Both sugar and nicotine levels were suppressed by MI populations. Regression analysis of the independent variables P_i, clay, and sand vs. yield gave an R^2 of 0.40. Examples of other coefficients of determination for yield vs. selected factors were root-necrosis index 0.40; root-gall index 0.18; root-gall index, cation-exchange capacity (CEC) 0.34; root-necrosis index, CEC 0.56; and root-necrosis index, sand, soil-acidity, calcium 0.62. Soil type had only slight to moderate effects on nematode reproduction. —*Departments of Plant Pathology and Crop Science, North Carolina State University, Raleigh, NC 27650.*

BERNARD, E. C., and T. L. ARROYO. *Distribution, development, and host range of Entomophthora vermicola (Zygomycetes: Entomophthorales).*

The ability of the sticky secondary spores of an entomophthoraceous fungus (*Entomophthora vermicola* McCulloch) to adhere to and destroy nematodes was investigated. The fungus, originally described from Queensland, Australia, has been found in snapbean, tomato, and soybean fields in Tennessee, but not in noncultivated areas. *Entomophthora vermicola* was the most frequently encountered nematode-destroying fungus found in six west Tennessee soybean fields (51% of 146 isolations) when Mankau's semiquantitative method was used. There were no correlations between the presence of *E. vermicola* and soil texture (clay or silt loam), or addition of *Cruznema lambdiense* to half the plates. The fungus was maintained at room temperature in cultures of *C. lambdiense*. When *C. lambdiense* was inoculated with 5–10 secondary spores, penetration occurred within 15–30 min. Invasive hyphae were about 100 μm long after 4 hr, and the fungus began sporulating less than 24 hr after inoculation. Species of Rhabditidae were the only hosts in which the fungus grew and reproduced. Spores adhered to species of Bunonematidae but did not infect the nematodes. Spores remained attached to the cuticles of several Cephalobidae, *Helicotylenchus pseudorobustus*, and *Macroposthonia xenoplax* for 5–10 min, then fell away. Spores did not adhere to *Meloidogyne incognita* larvae or *Tripyla* sp. When *M. incognita* eggs and infected or healthy *C. lambdiense* were mixed with soil and extracted 7 d later, no differences in root-knot larval numbers were found between treatments with infected *C. lambdiense* and those with healthy *C. lambdiense*. Despite the apparent presence of *E. vermicola* only in cultivated soils, the fungus does not appear to have promise as a biological control against phytoparasitic nematodes.—*Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37916.*

BHATTI, D. S., M. R. DALAL, R. S. DAHIYA, and INDRA MALHAN. *Chemical control of Heterodera avenae in wheat.*

Field experiments were conducted during 1973–76 to evaluate chemicals for the control of *Heterodera avenae* in the areas of Mohindergarh district (Haryana State, India) where initial nematode infestation ranged from 6 to 12 eggs and larvae/g soil. The chemicals included D-D soil fumigant at 400 L/ha; DBCP (Nemagon 60-EC) at 15, 30, 45, and 60 L/ha; aldicarb (Temik 10-G), carbofuran (Furadan 3-G), and phorate (Thimet 10-G) each at 1, 1.5, and 2 kg a.i./ha; and fensulfothion (Dasanit 5-G) at 5 and 10 kg a.i./ha. DBCP, aldicarb and carbofuran were used in split doses as well. All treatments including control, were replicated four times in plots measuring 5 × 5 m. Fumigants were applied 4 wk before planting wheat cv. Kalyan Sona. Granular chemicals were mixed with basal doses of fertilizers and drilled at the time of sowing. Observations were recorded on grain yields and final nematode populations. Considering the cost of nematicides alone and value of the increased yields from the treated plots as compared to untreated control, the cost-benefit ratios were determined. The ranges of cost-benefit ratios with aldicarb at different doses were 1:4 to 11; with phorate, 1:3 to 8; with carbofuran, 1:1.6 to 6; with DBCP, 1:0.7 to 2; with fensulfothion, 1:0.6 to 1; and with D-D, 1:0.15 to 0.5. In general, *H. avenae* population reduction obtained with D-D, DBCP, and fensulfothion treatments was higher than that with aldicarb, carbofuran, and phorate; grain yields with the latter three chemicals, however, were comparable. Aldicarb at 1.5 to 2 kg a.i./ha is recommended for the control of *H. avenae* in Haryana State.—*Department of Nematology, Haryana Agricultural University, Hissar, India.*

BIRD, A. F., and B. A. STYNES. *Post-embryonic development of Anguina agrostis.*

Post embryonic growth of the second-stage larva of *Anguina agrostis* and its subsequent development to adulthood in seed galls of annual ryegrass (*Lolium rigidum*) is described. Growth and development of the freshly hatched second-stage larva (FHL_2) into the infective second-stage "dauer" larva (DL_2) is followed under field conditions and in callus tissue culture. Growth did not take place beyond the DL_2 stage in tissue culture. The transition from FHL_2 to DL_2 involved thickening of the cuticle and the synthesis of numerous lipid storage granules. The growth of DL_2s to adults was followed under field conditions. Three moults were observed to occur during parasitic development. The transition from the DL_2 to the second-stage parasitic larva (PL_2) is marked by the disappearance of the lipid storage granules and the development of a pronounced intestine. During moulting the innermost basal zone of the shed cuticle was resorbed and changes were observed in the ultrastructure of the epicuticle.—*Division of Horticultural Research, CSIRO, Box 350, G.P.O. Adelaide, 5001, Australia; and Plant Pathology Branch, Western Australian Department of Agriculture, Jarrah Road, South Perth, 6151, Australia.*

CARTER, W. W. *Onion as a host of Rotylenchulus reniformis.*

Onion, *Allium cepa*, was previously reported to be immune to the reniform nematode, *Rotylenchulus reniformis*. In a greenhouse experiment, however, three isolates of the reniform nematode reproduced on six commercial cultivars of onions. Significantly more larvae of a Rio Grande Valley Texas isolate penetrated and developed on four of six onion cultivars tested than did larvae of isolates from Louisiana or Lubbock, Texas. The larvae penetrated onion roots within 24 h. Significant differences in numbers of attached, immature reniform females, egg masses, and total nematodes were found among the onion cultivars. No significant differences in eggs per egg mass were counted. As in dicotyledenous plants, the reniform nematode fed in either an endodermal or pericyclic cell and had no specificity for root tissue of a particular age. Pericycle cells hypertrophied, extending to either side of the initial feeding cell. In field experiments, numbers of larvae increased from 0 four weeks after fumigation

with 34 liters D-D (1-3, dichloropropene 1,2-dichloropropane)/ha to 108 larvae/100 g of soil at harvest 27 weeks after planting the onions. This compares to 322 and 205 larvae/100 g of soil at planting and harvest, respectively, for nonfumigated controls. No differences in numbers of surviving seedlings, seedstems, or pink root, caused by *Pyrenochaeta terrestris*, were found between fumigated and nonfumigated treatments. Although yields were not affected by *R. reniformis*, onions could be an important host in planning crop rotation sequences.—*USDA SEA AR, Plant Health and Production Research Laboratory, P. O. Box 267, Weslaco, TX 78596.*

CASWELL, E. P., A. E. MacGUIDWIN, K. T. MILNE, C. E. NELSEN, and I. J. THOMASON. *A simulation model of Heterodera schachtii infecting Beta vulgaris.*

A simulation model of the sugarbeet cyst nematode (*Heterodera schachtii*) infecting sugarbeet (*Beta vulgaris*) was developed. The emphasis of the model is on *H. schachtii* population dynamics, with consideration given to the effect of parasitism on beet growth and yield. The simulation is an interactive program developed from the existing literature. The user initializes the model with various parameters and data values which function as controls and state variables. Time varying distributed delays are used to model egg development, root penetration by second-stage larvae, and the maturation of males and females within the root. Developmental rates of *H. schachtii* and the growth rate of the beet are modulated through soil temperature fluctuations. The model was validated, and sensitivity analyses were conducted. The interactions depicted by the model go beyond a simple regression model and effectively combine appropriate data on *H. schachtii-B. vulgaris* interaction into a dynamic whole. Future research priorities are identified, and the value of predictive simulation models as an aid in applied integrated pest management is discussed.—*Departments of Entomology, Computer Science, and Plant Pathology, Michigan State University, East Lansing, MI 48824; and Department of Nematology, University of California, Riverside, CA 92521.*

CURRAN, J. *Morphological variation in aquatic mermithids.*

Morphological variation was examined in two aquatic mermithids: *Romanomermis culicivorax* Ross and Smith 1976 and a *Gastromermis* sp. Because different methods of preparing permanent mounts affected their morphology, a standard procedure was established and used throughout subsequent investigations. The morphology of field-collected *Gastromermis* sp. varied, and this led to an assessment of diagnostic characters of species in *Gastromermis*. Such intraspecific variability in mermithids was confirmed experimentally by rearing the progeny of a single mating pair of *R. culicivorax* under different environmental conditions. Thus, the nature and extent of intraspecific morphological variation and the effects of host species, extent in infection, and temperature on morphology were determined. Because many quantitative characters were affected by environment, and the measurements were related allometrically, many ratios commonly used in mermithid taxonomy were rejected. Qualitative characters were also variable, but were not associated with environment. This led to the conclusion that descriptions based on a single or a few specimens do not provide a sound foundation for mermithid taxonomy. Use of larger samples, all developmental stages, and both qualitative and quantitative characters may overcome this problem. Since many single diagnostic characters appeared unreliable, while a combination of characters increased reliability, multivariate methods of analysis could provide a more efficient means of analysing such data. —*Imperial College at Silwood Park, Ascot, Berkshire, England SL5 7PY. Present address: Department of Biological Sciences, Simon Fraser University, Burnaby, B. C. Canada V5A 1S6.*

DABAJ, K. H., and E. A. EDONGALI. *Preliminary survey of nematodes associated with vegetable crops in Libya.*

The coastal cultivation area in Tropoli region (Tripolitania, from Khomas to

Zawia) was surveyed for nematodes. Samples of soil from different fields were collected and processed using sieving and gravity techniques. Collected nematodes were killed in hot water and fixed in FAA. The most common plant-parasitic nematodes, besides root-knot nematode (*Meloidogyne incognita* and *M. javainca*) were: *Tylenchorhynchus* spp., *Pratylenchus* spp., *Zygotylenchus* spp., *Merilinus* spp., and *Tetylenchus* spp. Additionally, *Dorylaimus* spp., *Endorylaimus* spp., *Xiphinemella* spp., were recovered but their impact on these vegetable crops is not known. Many free-living nematodes were found associated such as *Acroboloides* spp., *Acrobeles* spp., *Diplogaster* spp., and *Rhabditis* spp.— *Department of Plant Protection, University of Alfateh, S.P.L.A.J.*

DAVIS, B. O., JR., and D. B. DUSENBERY. *Laser microbeam studies of the location of receptors mediating chemotaxis in the nematode, Caenorhabditis elegans.*

The location of receptors mediating chemotaxis in the nematode is being studied using a laser microbeam. The microbeam focuses on the order of 0.1 megawatt of 450 nm photons through an area about 3 μm in diameter for about 0.1 microsec. This extreme intensity leads to nonlinear, multi-photon processes, and no absorbing pigment is required. Nematodes are anesthesized with tricaine and tetramisole or with carbon dioxide. The response of individual nematodes to various chemical stimuli is assayed by the tethered-worm technique. Initial results suggest that destruction of the lateral lips and, thus, the amphids produces little if any change in response to ions. However, damage to all six lips causes a reversal of the response. In response to Na^+, for instance, negative responses are made instead of the usual positive response. These observations suggest that the amphids are not the principal receptors for detecting ions. The most likely alternative type of receptors are the inner labial sensilla, which appear in electron micrographs to open to the outside. The reason for the reversal of the response is not clear. However, it could be explained by a neural mechanism in which stimulation of inner labial sensilla in the head is compared to stimulation (presumably of phasmids) in the tail.—*Kennesaw College, Marietta, GA 30061; and School of Biology, Georgia Institute of Technology, Atlanta, GA 30332.*

DUNCAN, L. W. and H. FERRIS. *Preliminary considerations of a model of multiple nematode species—plant growth relationships.*

Models of effects of multispecies nematode parasitism on plant growth can be developed from Seinhorst's equation, $y = m + (1-m)z^{Pi-T}$. The equation $y = m' + (1-m')c'z_1^{Pi_1}z_2^{Pi_2}$ in which $m' = m_1 + (m_2-m_1)[(1-y_1)/(1-y_2) + (1-y_1)]$ and $c' = (z_1^{-T_1} + z_2^{-T_2})/2$, was derived as a predictive model for a system in which *Vigna sinensis* cv. Blackeye #5 is parasitized by *Meloidogyne incognita* and *M. javanica* (represented by subscripts 1 and 2). The cultivar used is moderately resistant to *M. incognita*. The term m′ represents effects of interspecies competition on minimum yield, while c′ is the tolerance capacity of Blackeye #5 to the two species. To establish model parameter values, dry seed weights were recorded from individual plants grown in tubes of sand containing eggs of each species in a geometric progression from 10 to 20,480 eggs/tube. Ten treatments of various levels of multiple species inoculations were included to test the multiple species model. Average deviations of predicted from actual yields in multiple species treatments was 3.6%. Equilibrium densities of both species coincided with Pi at which m first occurred and may influence that value. In a second study of the same basic design, plant roots were stabbed with steel needles of different diameters to simulate damage by different organisms. Measurements of plant top growth at 7, 14, and 21 d following treatment supported the model assumption of a multiplicative relationship between root damage caused by different agents. Average deviation of predicted from actual measurements in 12 multiple agent treatments was 1.8%.—*Department of Nematology, University of California, Riverside, CA 92521.*

EISENBACK, J. D. *Morphological comparison of head shape and stylet morphology of males of several populations of Meloidogyne hapla.*

Males of 10 populations of *Meloidogyne hapla* were compared by light microscopy (LM) and scanning electron microscopy (SEM). Four of the populations belonged to race A; they had haploid chromosome numbers of 14, 15, 16, or 17 and reproduced by facultative meiotic parthenogenesis. The other six populations were from race B; they had somatic chromosome numbers of 30, 31, 43, 45, or 48 and reproduced by obligatory mitotic parthenogenesis. The external morphology of the heads and excised stylets was observed by SEM. Light microscopic examination included the gross morphology of heads and stylets as well as certain morphometrical characters. Distinct differences were found between the two cytological races and among populations of race A, whereas populations of race B were morphologically similar. Differences in head morphology included shape of the head cap, expression of lateral lips, and size of the head region in relation to the first body annule. Stylet morphology differed in overall size, shape of the shaft, and width and height of the knobs. This detailed study of several populations of *M. hapla* was an attempt to better define and describe the variability of males of populations within this species complex.—*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27650.*

EISENBACK, J. D., and H. HIRSCHMANN. *Morphological comparison of males of the four common species of root-knot nematodes (Meloidogyne spp.).*

A technique was developed for the removal of stylets of males of root-knot nematodes. The stylets of one population each of *Meloidogyne incognita, M. javanica, M. arenaria,* and *M. hapla* were compared by scanning electron microscopy (SEM). Stylets differed among the species in size and shape of the cone, shaft, and knobs. The stylet morphology and the head shape of an additional 155 populations from geographical areas around the world were examined by light microscopy (LM). Differences in stylet morphology and head shape, as revealed by SEM, were evident by LM. The head morphology of the species differed in shape of the head cap and head region. The identifications made on the basis of head and stylet morphology of males conformed with identifications based on perineal pattern morphology, differential host response tests, or cytology. It can, therefore, be concluded that head shape and stylet morphology of males are reliable characters for rapid identification of the four most common *Meloidogyne* species.—*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27650.*

ENDO, B. Y. *Stomatal ultrastructure of second-stage larvae of the soybean cyst nematode, Heterodera glycines.*

Studies of ultrastructural morphology of the infective second-stage larvae of the soybean cyst nematode *Heterodera glycines,* reveal an extensive stomatal system available for host penetration and feeding. The cephalic framework and portions of the stomal wall have a fibrillar matrix which merges with and supports the surface cuticle. The flat broad base of the dorsal and ventral cephalic framework blades causes a bilateral orientation to the framework to which protractor and cephalic muscles are attached. Protractor muscles consist of 10 muscle elements attached by desmosomes to the cephalic framework. They extend posteriorly and centripetally to join the outer stomal wall and later attach to the stylet knobs as three distinct muscles formed from the merging of specific muscle elements. Observations were made on the ultrastructure and morphology of the stylet with its component cone, shaft, and knobs. It is apparent that the stylet knobs have a close relationship to the surrounding sarcoplasm. The intimate contact between the stylet knobs and sarcoplasm is provided by the extensive inter-hemidesmosomal membrane evaginations that extend from the stylet knob surfaces into the protractor muscle cells.—*USDA SEA AR, Beltsville Agricultural Research Center, Beltsville, MD 20705.*

ESSER, R. P. *Reproductive development of Verutus volvingentis (Tylenchida: Heteroderidae).*

Verutus volvingentis Esser 1981 deposits eggs in the rhizosphere without a gelatinous matrix. Ecdysis was never observed in the egg. Spincular primordia in the rectal area of a second-stage larvae are well defined. Male development took from 6 to 15 d. Female development took 17 d. One larva increased in width from 28.2 m to a maximum of 51.7 m after 176½ hours of feeding and just prior to the second ecdysis, after which it decreased steadily in width to 33.3 m as a fully developed male. Males leave the third-stage larval integument embedded in the root following final ecdysis. The unique feature of female development was the occurrence of large vaginal primordia cells.—*Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, FL 32602.*

ESSER, R. P. *Host-parasite relationships of Verutus volvingentis (Tylenchida: Heteroderidae).*

Larvae of *Verutus volvingentis* Esser, 1981, entered roots by penetrating the middle lamella between two epidermal cells. Tissue discoloration became evident 3–4 h after entry of the nematode into the root. A number of larvae abandoned the site after actively feeding. Nuclei in invaded cells were distinctly larger than nuclei in cells not entered by the nematode. Host exudates were noticeably extruded at attack sites and these exudates adhered to the cervical area of females feeding at the site. In longevity tests, eggs and larvae survived 3 years in the absence of a host. Results indicate that ova are the survival stage of this nematode. —*Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, FL 32602.*

EVANS, K. *Water use and tolerance of cyst-nematode attack in potatoes.*

Potato varieties differ in their ability to tolerate attack by cyst-nematodes, and in a dry season this ability seemed to be related to concentration of calcium in leaves: ranking varieties for calcium concentration gave the same order as when they were ranked for tolerance. Trials in following years did not give the same rankings, but rainfall was above average and plants probably did not use water efficiently. Because calcium enters plants by mass flow, efficient use of water is accompanied by low concentrations of calcium in leaves, and the relationship between calcium concentration and nematode tolerance may have been due to efficient water use in the tolerant varieties in a dry year. Maturity date, water supply, and level of nematode infestation have all been shown to influence water use and calcium uptake, and a very strong correlation between total water and total calcium uptake has been found. The effects of nematodes on water use efficiency resemble the effects that abscisic acid (ABA) has on plants. Assaying leaves of field-grown potatoes for ABA has shown that the levels of this stress hormone were increased when nematodes were present.—*Rothamsted Experimental Station, Harpenden, Herts., England, AL5 2JQ.*

FATTAH, F. A., and J. M. WEBSTER. *Effect of culture filtrate of Fusarium oxysporum f. lycopersici on the ultrastructure of giant cells induced by Meloidogyne javanica in tomato.*

Tomato (*Lycopersicon esculentum*) seedlings cv. Pearson A-1 IMP, susceptible to race 1 *Fusarium oxysporum* f. *lycopersici,* and cv. Pearson IMP, resistant to this wilt fungus, were inoculated with *Meloidogyne javanica* larvae. *F. oxysporum* was grown in liquid medium for 30 d; the medium was then filtered to produce the fungus-free filtrate that was used in subsequent experiments. Two weeks after nematode inoculation 1-cm lengths of root containing galls were excised and incubated for 12 h at 27 C in small watch glasses containing *Fusarium* culture filtrate, liquid culture medium, or tap water. The last two treatments served as controls. Transmission electron microscope observations of sections of the root pieces showed major ultrastructural differences in the giant cells of roots treated with filtrate compared with those in both control treatments. In roots treated with culture filtrate, giant cell nuclei lost their characteristic irregular

shape and became spherical, the nuclear membrane showed occasional swellings and ruptures, the mitochondria were elongated and irregularly shaped, and there was no endoplasmic reticulum. Within the nuclei of filtrate treated roots there were small spherical electron dense structures throughout the nucleoplasm. Giant cells of roots treated with liquid medium appeared very similar to those treated with tap water. These results confirm earlier observations on *Fusarium* infected potted plants that the giant cells abort at sites remote from the location of the fungus.—*Department of Biological Sciences, Simon Fraser University, Burnaby, Vancouver, Canada.*

FERRIS, H., S. M. SCHNEIDER, and M. C. STUTH. *Meloidogyne arenaria penetration and infection probability in grape cultivars.*

Meloidogyne arenaria phenology is influenced by cultivar-specific penetration and infection processes which reflect host status. Single-bud dormant cuttings of 14 grape cultivars were rooted in moist, heated sand and transplanted into 4.2- × 15.5-cm tubes of sand standing on bricks. The bricks were sub-irrigated to generate uniform moisture conditions in the tubes by capillarity. Each tube was inoculated with 200 *M. arenaria* larvae. Number of nematodes in stained cortical and vascular tissues and number of root tips were determined at daily intervals in four plants of each cultivar until there was no further penetration. The relationship between number of nematodes penetrating, or establishing infection sites, and physiological time (degree days, base 10 C [DD_{10}]) was adequately described by logistic functions for all cultivars except resistant rootstocks. In the latter, a few larvae penetrated during the first 50 DD_{10} and then apparently left the root. The relationship between number of root tips and DD_{10} was linear during the period of the experiment. To compare levels of resistance to penetration and infection among cultivars, nematode counts were expressed per root tip by dividing the appropriate logistic function by the corresponding linear root tip function. Cultivars could be grouped according to their susceptibility to penetration and infection. The groups were similar to those in studies on development rates after infection. In general, cultivars with specific environmental requirements were more susceptible than those which flourish under a wider range of conditions.—*Department of Nematology, University of California, Riverside, CA 92521.*

FORTUNER, R. *Identification of Helicotylenchus spp.*

Forty characters have been used in the diagnosis of new *Helicotylenchus* spp. Among these characters, some have no value whatsoever (e.g., absence of hemizonid), some are artifacts (e.g., punctuation in lateral field), some are very variable (e.g., number of annules from phasmid to anus), and some are very difficult to observe (e.g., position of spermatheca). Only 10 characters were acceptable for identification purposes (body length, stylet length, V-value, broad shape of tail, habitus, position of phasmids, shape of lips, relative length of tail, presence of males, and presence of intestinal canals). Using these 10 characters, it was not possible to arrange the known species of *Helicotylenchus* into well-defined groups that would fit in a dichotomous or tabular key. However, any of the species is characterized by specific values for each of the 10 characters. Gower's coefficient of similarity gives an estimate of the relationships existing between two species or populations on the basis of the 10 diagnostic characters. By comparing coefficients, the species of *Helicotylenchus* which are morphologically most similar to an unknown population can be inferred.—*California Department of Food and Agriculture, Laboratory Services, Nematology, 1220 N Street, Sacramento, CA 95814.*

FRANCO, J., P. JATALA, and M. BOCANGEL. *Efficiency of Paecilomyces lilacinus as a biocontrol agent of Globodera pallida.*

Since the preliminary studies on the biological control of *Globodera pallida* indicated infection of the eggs by *Paecilomyces lilacinus*, the efficiency of this fungus as a

biocontrol agent was further investigated under laboratory condition. One-year-old cysts of *G. pallida* were surface sterilized with 10% Clorox and sprinkled in petri plates containing PDA, V8, or water agar medium recently inoculated with *P. lilacinus* spores. The plates were maintained at 20 C for 5, 10, 15, 20, 25, and 30 d. At the end of each period, cysts were recovered from plates, washed, and divided in two groups. Infected eggs were counted in one group while the second group of cysts were exposed to potato root exudates to determine the extent of hatching. The percentage of infected eggs increased as the time of exposure to fungus increased, but there were no differences in egg infection in different media. Results of the hatching tests indicated a stimulatory effect of media up to 25 d. Thereafter, hatching decreased significantly. The decreased hatching was correlated with the increased infection of eggs by *P. lilacinus*. Studies on the effect of this fungus on *G. pallida* under greenhouse and field condition are in progress.—*Department of Nematology and Entomology, International Potato Center, Apartado 5969, Lima, Peru.*

GARABEDIAN, S., and N. G. M. HAGUE. *The effect of oxamyl on the control of Heterodera sacchari on sugar cane.*

The effectiveness of foliar sprays of oxamyl-L-(S-methyl N'N'-dimethyl N-[methylcarbamoylosy]-1-thio-oximidate) for control of *Heterodera sacchari* was affected by plant size, timing of application, and application frequency. Oxamyl at 500, 1,000, and 2,000 μg/ml applied to seedlings more than 2 wk old only slightly reduced invasion of roots of sugar cane seedlings by *H. sacchari* juveniles. When sugar cane seedlings were inoculated 5 d after foliar applications of oxamyl, there was a significant reduction in the total number of females per root system. At 1,000 and 2,000 μg/ml, the reduction was 44% and 57%, respectively. When oxamyl was applied immediately after inoculation or 5 d after inoculation, no significant reduction in female numbers was observed. When oxamyl was applied only once, none of three concentrations resulted in a significant reduction in the number of females in the roots. However, by using two successive sprays of oxamyl (a 5-d interval was allowed between successive treatments) at either 1,000 or 2,000 μg/ml, there was a significant reduction in the number of females (40% and 54%, respectively) compared to untreated. With three sprays of oxamyl (500, 1,000, or 2,000 μg/ml), the reduction in the number of females was only slightly improved over two applications (33%, 44%, and 51%, respectively).—*Department of Nematology, University of California, Riverside, CA 92521.*

GIBLIN, R. M., and H. K. KAYA. *Association of the nematodes Huntaphelenchoides sp. (Aphelenchoididae) and Acrostichus sp. (Diplogasteridae) with the semisocial soil dwelling bee, Halictus farinosus (Malictidae: Hymenoptera).*

Halictus farinosus adults and immatures from Davis, California, were collected and examined over a 2-yr period. Dauer juveniles (J_{III}) of *Huntaphelenchoides* sp. were found in the penis of 32% (n = 22) and bursa copulatrix of 44% (n = 122) of adult male and female *H. farinosus*, respectively. Dauer juveniles (J_{III}) of *Acrostichus* sp. were found in the Dufour's gland of 21% (n = 122) of the above mentioned adult female bees. *Acrostichus* sp. dauers have not been recovered from male *H. farinosus*. *Huntaphelenchoides* sp. and *Acrostichus* sp. dauers were found in the bursa copulatrix and Dufour's gland, respectively, in 7.4% of the adult female bees (n = 122). An early season nest of a *Huntaphelenchoides* sp. infested queen bee was excavated and examined. *Huntaphelenchoides* sp. propagated on an unidentified fungus on the cell walls of all of the immature bee stages (egg, larva, and pupa) and could also be propagated on *Monilinia fructicola*. *Acrostichus* sp. propagated on *Escherichia coli*. The association between both nematode species and *H. farinosus* appears to be phoretic. Vertical transmission (transmission of nemas between bee generations) for *Huntaphelenchoides* sp. could occur during oviposition by overwintered nematode infested queen bees and for *Acrostichus* sp. could occur when infested overwintered queen bees and workers deposit the contents of the Dufour's

gland and nemas during brood cell construction.—*Division of Nematology, University of California, Davis, CA 95616.*

GOLDEN, A. M., and D. W. DICKSON. Morphological observations on a *Meloidogyne* species from strawberry in Florida.

In 1966 a root-knot nematode found infecting strawberry (*Fragaria ananassa*) in Florida was thought initially to be *Meloidogyne incognita.* Peanut (*Arachis hypogaea*) and pepper (*Capsicum annuum*) were inoculated with this nematode and only pepper became infected. The nematode has been maintained on pepper and strawberry for further morphological studies. This nematode has characteristics different from *M. incognita.* The perineal patterns of females from both pepper and strawberry have widely spaced, discontinuous striae which are unusually coarse, especially at the level of the vulva and above. Wavy striae at the outer edges of the pattern, common in *M. incognita,* are generally reduced or absent. Overall, the patterns appear to have some characteristics of both *M. incognita* and *M. thamesi.* Second-stage larvae, averaging only about 360 μm in length, have a distinctively short tail (about 40 μm) with a short blunt terminal. Males average approximately 1,500 μm in length and have stylets averaging 22 μm long. Further morphological examination and host differential tests are being conducted to determine more accurately the taxonomic status of this nematode. Other than *M. hapla,* this is the first root-knot nematode to be found on strawberry in the United States.—*USDA SEA AR, Nematology Laboratory, Beltsville, MD 20705; and Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.*

GOLDEN, A. M., J. FRANCO, P. JATALA, and E. ASTOCAZA. *Morphology and relationship of an undescribed cystoid nematode from the Andes mountains of Peru.*

This nematode was found on *Oxalis tuberosa, Ullucus tuberosus, Chenopodium quinoa, Medicago hispida,* and *Solanum tuberosum* subsp. *andigena* in the highlands of the Andes in the vicinity of Lake Titicaca in the Department of Puno, southern Peru. In greenhouse tests it attacked several additional plants, including eggplant. Females are white, spherical, without a posterior protuberance, and appear similar to *Globodera pallida,* but do not form cysts. Females, about 600 μm in length, become filled with eggs from which second-stage larvae hatch readily. Body surface of females shows a lace-like pattern except on the far anterior portion and on the neck where annules are present. The vulva is terminal and the vulval-anal distance, which is highly variable, averages about 65 μm. Larvae measure approximately 400 μm, and males 1,000 μm, in length. On roots, females of this cystoid nematode can easily be mistaken for young females of the potato-cyst nematodes, *G. rostochiensis* and *G. pallida.* This nematode belongs in the subfamily Ataloderinae and is closely related to the genus *Thecavermiculatus* in which it can be placed with rather minor generic emendations.—*USDA SEA AR, Nematology Laboratory, Beltsville, MD 20705; and Department of Nematology and Entomology, International Potato Center, Apartado 5969, Lima, Peru.*

GORDON, R., and I. R. BURFORD. *Uptake of palmitic acid by the entomophilic nematode, Romanomermis culicivorax.*

Newly hatched first-instar larvae of the mosquito *Aedes aegypti* were infected with controlled doses of the mermithid nematode, *Romanomermis culicivorax.* Juveniles at an advanced stage of parasitic development were dissected from hosts and incubated under controlled conditions in physiological saline with U-^{14}C-palmitic acid. The capacity of the nematode to absorb the nutrient across its outer cuticle was investigated in relation to time, isotope concentration, and presence of metabolic-sodium pump inhibitors. Up to 1 h incubation, absorption of the isotope by the nematode was curvilinear with respect to time. Short-term (5 min) incubation experiments showed that membrane transport system used by the nematode for uptake of palmitic acid is mediated by a carrier

system(s), because it displayed saturation kinetics. Uptake of palmitic acid (9.54×10^{-4} μmoles/ml) was significantly diminished in short-term and long-term (1 h) incubation experiments by the metabolic inhibitors potassium cyanide (1 m*M*) and 2-4-dinitrophenol (1 m*M*), indicating that the carrier system is energy dependent. Ouabian (1 m*M*) significantly decreased the nematode's capacity to absorb palmitic acid (5 min; 1 h incubations), suggesting that the carrier system for palmitate absorption is linked to a Na^+ or K^+ dependent ATPase pump. Mechanisms involved in the absorption of monoacylglycerols and triacylglycerols by the mermithid are being investigated.—*Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland, Canada A1B 3X9.*

GRIFFIN, G. D. *The interaction of Heterodera schachtii and Ditylenchus dipsaci on sugarbeet.*

Germinated sugarbeet seed (AH 14) were inoculated with 50 *Ditylenchus dipsaci* (alfalfa race) juveniles and adults and 500 second-stage *Heterodera schachtii* larvae singly and in combination or left uninoculated. After 42 d *H. schachtii* significantly ($P = 0.05$) reduced sugarbeet root growth below that of uninoculated controls at 20, 24, and 28 C, while *D. dipsaci* significantly ($P = 0.05$) reduced root growth below that of uninoculated controls at 16, 20, 24, and 28 C. A combination of *H. schachtii* and *D. dipsaci* significantly ($P = 0.05$) reduced root growth below that of single inoculations of *H. schachtii* at all temperatures and *D. dipsaci* at 20, 24, and 28 C. Single inoculations of *H. schachtii* and *D. dipsaci* significantly ($P = 0.05$) reduced top growth of sugarbeet over that of uninoculated controls at 20, 24, and 28 C, and 16, 20 24, and 28 C, respectively. A combination of the two nematodes significantly ($P = 0.05$) reduce top growth below that of single inoculations of *H. schachtii* at all temperatures. However, a combination of the two nematodes failed to significantly ($P = 0.05$) reduce top growth below that of single inoculations of *D. dipsaci* at any temperature. Inoculations of either *H. schachtii* or *D. dipsaci* did not affect infections of the other nematode, and *D. dipsaci* did not affect maturation and reproduction of *H. schachtii*. *D. dipsaci* did not reproduce on sugarbeet.—*USDA SEA AR, Crops Research Laboratory, Utah State University, Logan, UT 84322.*

HADISOEGANDA, W. W., and J. N. SASSER. *Evaluation of relative resistance of tomato to the root-knot nematode (Meloidogyne spp.), based on host suitability.*

Fifty cultivars of tomato (*Lycopersicon esculentum*) were evaluated for resistance or suitability to species and host races of root-knot nematodes (*Meloidogyne spp.*). Many were highly or very resistant to certain species and races, but none were immune. All cultivars were susceptible to *M. hapla*. Resistance of cvs. Anahu, Atkinson, Healani, Nemared, Patriot, Rossol, and VFN-8 to *M. incognita* and *M. javanica* was confirmed; cvs. Beef Master, Manalucie, Marmande, Money Maker, Ponderosa, and Roma, previously reported to be resistant, were susceptible in our tests. Index of reproduction (IR) and egg mass index (EI) values were significantly correlated ($r = .81$) for the various species and races. Regression analysis of IR values on egg mass indices justified the use of five relative host response designations (highly resistant, very resistant, moderately resistant, slightly resistant, and susceptible) for the tomato cultivars tested. If additional tests on other crops substantiate these relationships, then more reliance can be placed on the use of EI values in rating crops for resistance. Since much more time is needed to establish IR values, compared to EI ratings, it would appear worthwhile to study these relationships further.—*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27650.*

HAFEZ, S. L., and B. LEAR. *Action and longevity of some systemic nematicides in soil and roots of tomato for controlling Meloidogyne incognita.*

Six-week-old tomato (*Lycopersicon esculentum*) seedlings, cv. Early Pack, grown in 15-cm plastic pots filled with autoclaved sand and soil (3:1) and infested with

Meloidogyne incognita, were used to determine the persistence of aldicarb 10G, phenamiphos 15G, and fensulfothion 10G at rates of 4.5, 6.75, and 16.9 kg ai/ha, respectively. To study persistence of these nematicides in the soil, tomato seedlings were transplanted to nematicide-treated soil after 0, 14, 21, 28, 35, and 42 d. Nematode larvae (500/pot) were added at time of transplanting. Results showed phenamiphos, aldicarb, and fensulfothion gave 100% control 42, 35, and 21 d after treatment, respectively. To study persistence in plant tissues, plants grown in nematicide-treated soil for 14 d were transplanted to untreated autoclaved soil and inoculated with *M. incognita* second-stage larvae at 0, 7, 14, 21, and 28 d after transplanting. Aldicarb persisted in plant tissues in amounts sufficient for more than 95% control after 14 d, and 91, 96, and 99% control after 28, 35, and 42 d, respectively. Phenamiphos and fensulfothion gave 95% control up to 28 d, 77% after 35 d, and 89% after 42 d. To study persistence in both soil and plant tissues, nematicides were applied to established plants and nematode larvae were added after 0, 14, 21, 28, 35, and 42 d. Phenamiphos and fensulfothion resulted in 100% control up to 42 d from application. Aldicarb gave 100% control up to 14 d, and 50, 76, 93, and 96% after 21, 28, 35, and 42 d, respectively. In conclusion, phenamiphos has a longer residual nematicidal activity than either aldicarb or fensulfothion in soil and plants. Aldicarb persisted in nematicidal amounts for a longer period in plants than in soil.—*Department of Plant Pathology, University of California, Davis, CA 95616.*

HAFEZ, S. L., D. J. RASKI, and A. M. KHEIR. *Effect of inoculum levels of Meloidogyne incognita on Thompson Seedless grapevine.*

Meloidogyne incognita (Kofoid & White 1919) appears to be one of the most widely distributed root-knot nematodes throughout California vineyards. *Vitis vinifera* cv. Thompson Seedless rooted grape cuttings, 8 wk old and growing in 20-cm-d clay pots filled with sand and soil (3:1), were inoculated with 100, 1,000, and 10,000 *M. incognita* per pot. This inoculum was given a surface sterilization treatment using Aretan and Dihydrostreptomycin to eliminate bacteria or fungi associated with the nematode. Root and shoot weights and plant heights after 390 d of inoculation were significantly less than uninfected control. The root-gall scores were varied and inversely proportional to the initial inoculum concentration (averaging 4.8, 8.4, and 9.4 for the 100, 1,000, and 10,000 inoculum levels, respectively). Histopathological changes and abnormalities in root tissues were mainly noted as hyperplastic and hypertrophied cells in stele and cortex. The pressure exerted by hypertrophied giant cells and the growing nematodes resulted in malformation of the surrounding cells. In conclusion, *M. incognita* is a strong pathogen to *Vitis vinifera* cv. Thompson Seedless and can cause significant growth reduction and histological damage at all levels of inoculation.—*Department of Plant Pathology, Kansas State University, Manhattan, KS 66506; and Nematology Division, University of California, Davis, CA 95616.*

HEALD, C. M., and E. R. STEIN. *Effect of the Reniform nematode on Sunflowers.*

The effect of the reniform nematode, *Rotylenchulus reniformis,* on growth, yield, and oil quality of sunflowers was compared in fumigated and nonfumigated plots in the Lower Rio Grande Valley of Texas. In 1975, 1976, and 1979 plots were established in a sandy loam field naturally infected with the reniform nematode. Treatments included Telone II (1,3-dichloropropane) at 56 and 75 liter/ha chiseled 25 cm deep, and an untreated chiseled control. The soil fumigant significantly reduced the populations of the reniform nematode in all years when compared to untreated plots. Plant heights taken in 1975, 42 d after planting, were significantly higher in fumigated plots when compared to untreated plots. Differences were not, however, significant at harvest. In 1975 and 1976 yields were significantly increased in fumigated plots by 18 and 27%, respectively, over unfumigated plots. There was no significant difference in yield during 1979. In 1975 seeds from fumigated and unfumigated plots were

analyzed for palmitic, stearic, oleic, and linoleic acid. Oleic acid was significantly higher in seeds from fumigated plots.—*USDA SEA AR, Weslaco, TX 78596.*

HEWLETT, T. E., and A. C. TARJAN. *Analysis of diagnostic characters of the genus Meloidogyne Goeldi 1887.*

The criteria used for erecting nominal species of *Meloidogyne* was evaluated. Accordingly, the value of the perineal pattern as a major diagnostic character is deemphasized because of variability within populations and lack of sufficient objectivity in the descriptions. Morphometrics of each nominal species were compared. Primary diagnostic characters used were the basic shape of the perineal pattern, juvenile body length and gamma measurement, and stylet lengths of females, males, and juveniles. Secondary diagnostic characters were position of excretory pore and existence of vulval protuberance in females, number of male lateral incisures, position of the hemizonid in juveniles, and spicule length. A key to 34 species has been completed. Six nominal species and one subspecies are considered synonyms of older species. Three nominal species are regarded as *species inquirendae.—Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.*

HIRSCHMANN, H. *Morphological comparison of second-stage juveniles and males of members of the Meloidogyne incognita species complex using the scanning electron microscope.*

The external morphology of second-stage juveniles and males of 14 populations of *Meloidogyne incognita* belonging to two cytological races (A and B) was compared by scanning electron microscopy (SEM) in order to elucidate possible variation in this species. Cytological race A has 2n = 40–46, and race B 2n = 32–36 chromosomes. Both races reproduce exclusively by mitotic parthenogenesis. All four recognized host races were represented among the 14 populations. Observations were made on head morphology of second-stage juveniles and males including structure of labial disc and lips, expression of labial and cephalic sensilla, and annulations in the head region. In second-stage juveniles, variation occurred mainly with respect to shape of medial and lateral lips and number of head annulations. Males varied with regard to expression of lateral lips and number of head annulations. Populations of cytological race B were slightly different from those of race A, but differences were not great enough to justify taxonomic recognition of the cytological races. No correlation was found between morphology and host races. Some populations in each cytological race appeared to be distinct but still shared the general features characteristic of the species.—*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27650.*

HUETTEL, R. N., and D. W. DICKSON. *Pheromone-mediated behavior in the banana and citrus races of Radopholus similis from Florida.*

Pheromone-mediated behavior was successfully demonstrated within the banana and citrus races of *Radopholus similis* from Florida. Males of the banana race were attracted to agar discs in which females of the banana race presumably had secreted an attractant. Males of the citrus race also were attracted to agar discs in which females of the citrus race presumably had secreted an attractant. The male-to-male combinations in both races resulted in random movement in the citrus race and negative movement in the banana race. In the female-to-female combinations there was no significant response in either the banana or citrus races. The female nematodes did exhibit movement, but this was random and limited to the area of original placement in the bio-assay. The male-to-male and female-to-female combinations of both races failed to demonstrate attraction. A reaction between sexes would indicate the presence of an aggregation pheromone. However, as the response in the nematode was only between opposite sexes, the response was most likely caused by a sex pheromone.—*Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.*

HUTZELL, P. K., and L. R. KRUSBERG. *Fatty acid composition of Caenorhabditis elegans and C. briggsae.*

The closely related species of free-living nematodes, *Caenorhabditis elegans* and *C. briggsae,* contained approximately 19.6% and 22.1% lipid on a dry weight basis, respectively. Qualitatively, the fatty acid compositions of the two species were identical although there were quantitative differences. Approximately 78% of the total fatty acids of *C. elegans* were unsaturated, as were 56% of those of *C. briggsae.* The same 26 fatty acids were detected in both species. The saturated fatty acids identified were 14:0, 15:0, 16:0, 17:0, 18:0, 19:0, and 20:0. Several branched chain fatty acids were detected, including *iso*-15:0, *iso*-16:0, *iso*-17:0, and *iso*-18:0. The 18:1 fraction accounted for approximately 30–33% of the total amount of fatty acids of both nematodes and consisted mostly of oleic and vaccenic acids with a smaller amount of the Δ13 isomer. Additional monounsaturated fatty acids identified were two isomers of 16:1 and two isomers of 20:1. The two isomers of 16:1 present were 16:1Δ9 and 16:1Δ11 and those in the 20:1 fraction were 20:1Δ11 and 20:1Δ13. The polyunsaturated fatty acids detected were 18:2Δ9, 18:3Δ6, 18:3Δ9, 20:2Δ11, 20:3Δ8, 20:4Δ5, 20:4Δ8, and 20:5Δ5. Trace amounts of several other fatty acids were also detected.—*Department of Botany, University of Maryland, College Park, MD 20742.*

IBRAHIM, I. K. A., M. A. REZK, and H. A. A. KHALIL. *Resistance of 15 malvaceous plant cultivars to root-knot nematodes in Egypt.*

The reactions of 15 malvaceous (nine cotton, two kenaf, two okra, one mallow, one roselle) cultivars to five populations of *Meloidogyne* spp. were determined in the greenhouse. The nematode populations were identified as *M. arenaria* (Race 1), *M. incognita* (Race 2, Race 3, Race 4), and *M. javanica* with Sasser's differentials. Seeds of the tested cultivars were sown in 25-cm clay pots containing autoclaved sandy loam soil. One week after emergence, seedlings were thinned to two/pot and the soil was infested with 5,000 nematode eggs/pot. Each of the applied treatments was replicated four times. Plants were harvested 75 d after sowing. Gall and egg mass ratings were made on a 0–5 scale. Plants with average ratings of 2 or under were considered resistant while those with ratings of 3–5 were considered susceptible. Results show that the cotton (*Gossypium barbadense*) cv. Giza 69 was resistant to *M. arenaria* and *M. incognita* Race 2. Cotton (*G. barbadense*) cvs. Giza 67 and Bahtim 110 and (*G. hirsutum*) cv. Deltapine 16 showed resistant reactions to *M. arenaria, M. incognita* Race 2, and *M. javanica.* Cotton (*G. barbadense*) cvs. Giza 68, Giza 70 and Giza 75 and (*G. hirsutum*) cvs. Acala 4-42 and Acala 67A, as well as the roselle (*Hibiscus sabdariffa*) cv. Baladi, appeared resistant to the tested nematodes. In contrast, the Egyptian mallow (*Malva parviflora*), kenaf (*H. cannabinus*) cvs. Giza 1 and Giza 2, and okra (*H. esculentus*) cvs. Clemson Spineless and Baladi were susceptible to the tested nematode populations.—*Department of Plant Pathology, College of Agriculture, Alexandria University, Alexandria, Egypt.*

INSERRA, R. N., and N. VOVLAS. *Parasitism of walnut, Juglans regia, by Cacopaurus pestis.*

The parasitic habits of an Italian population of *Cacopaurus pestis* were studied on walnut roots. On walnut, *C. pestis* primarily parasitized the secondary roots. Nematode colonies were formed between the epidermis and the phellem where swollen females, males, juveniles, and eggs were observed embedded in a felt-like mass of curled hairs beneath the epidermis. The females inserted their stylets into the phellem where feeding caused necrosis of this tissue. Feeding also caused necrosis of the phellogen, phelloderm, and outer cortical parenchyma. These cells formed a necrotic pit surrounded by healthy root tissues. No evidence of damage to the stele was detected. The biological behavior of *C. pestis* was similar to that reported for *Gracilacus peratica. Cacopaurus pestis* was first reported in California and later in France, Iran, and Spain as well as Italy. Other hosts are lilac (*Syringa vulgaris*), poplar (*Populus nigra*), rose (*Rosa indica* cv. Major), and sour orange (*Citrus*

aurantium).—Istituto Nematologia Agraria, Consiglio Nazionale delle Ricerche, 70126 Bari, Italy.

JATALA, P., R. SALAS, R. KALTENBACK, and M. BOCANGEL. *Multiple application and long-term effect of Paecilomyces lilacinus in controlling Meloidogyne incognita under field conditions.*

Preliminary results of a successful attempt in controlling *Meloidogyne incognita* under field conditions by *Paecilomyces lilacinus* was reported in 1980. To determine the effect of multiple application of the fungus on nematodes in three consecutive crops of potatoes and beans and potaties, a randomized field plot experiment was carried out in a field heavily infested with *M. incognita*. The experiment consisted of four treatments and was replicated five times. Treatments consisted of fungal application one, two, and three times and the noninfested control plots. The contents of 14-d-old PDA plates of *P. lilacinus* were macerated and the suspension was applied to the soil at planting. Each treatment plot received the contents of 100 plates. Upon harvest, roots or tubers were examined for nematode infection. Data indicated a significantly lower root and tuber galling index in the first two crops from the fungus infested plots than from the noninfested plots. However, there were no differences in the root galling index of the third crop grown in infested and noninfested plots. A careful examination revealed that the noninfested plots were contaminated by *P. lilacinus*, and there were no differences in colony counts from the samples obtained from all plots. This contamination is attributed to dissemination of the fungus by tools, water, and improper handling of the field throughout the growing season. Regardless of this contamination, there was a significant reduction of nematode damage in all treatments. After three crops the galling index of the original severe infection was reduced to that of trace or moderate infection. Apparently one application of *P. lilacinus* is sufficient to establish the fungus.—*Department of Nematology and Entomology, International Potato Center, Apartado 5969, Lima, Peru.*

JOHNSON, A. W., C. C. DOWLER, J. E. EPPERSON, D. R. SUMNER, N. C. GLAZE, R. B. CHALFANT, and S. C. PHATAK. *Effects of management practices on nematodes and yield in an intensive cropping system.*

Nematode populations were studied in an irrigated turnip-corn-southern pea cropping sequence with four nematicide treatments for 6 years. An annual application of methyl bromide (358 kg/ha) or DD-MENCS (327 liters/ha) suppressed populations of *Meloidogyne incognita* to very low levels on turnip (*Brassica campestris* ssp. *rapifera*) and corn (*Zea mays*), but nematodes increased on southern pea (*Vigna sinensis*). Ethoprop (8.96 kg ai/ha) applied before planting each crop did not reduce the population of nematodes or increase yields when compared with untreated controls. Yields were highest when nematodes, soilborne fungi, and weeds were controlled in plots treated with methyl bromide or DD-MENCS, but maximum pest control was not economically feasible. The greatest annual net return (mean $/ha) resulted from treatments utilizing pesticides as needed, based on monitoring of pests ($358) and minimal use of pesticides ($666).—*USDA SEA AR, and the University of Georgia College of Agriculture Experiment Stations, Coastal Plain Experiment Station, Tifton, GA 31793.*

KAPLAN, D. T. and L. W. TIMMER. *Interrelationship between Pratylenchus coffeae and Tylenchulus semipenetrans in citrus.*

The natural distribution of *Pratylenchus coffeae* (PC) and *Tylenchulus semipenetrans* (TS) in a central Florida citrus grove was mutually exclusive ($r = -0.69$). Tree decline was associated with the presence of PC but not with the presence of TS. A field study was conducted to determine if a nematode-nematode antagonism was functioning to protect TS-infected trees from infection by PC. Aqueous suspensions of PC or TS were added to sites (2.5×30 cm) within TS- or PC-infested areas, re-

spectively, as well as to noninfested areas. Five months after inoculation, soil and root samples were taken at each inoculation site as well as from adjacent naturally occurring TS or PC populations. Samples were taken from 0–23 cm and from 23–46 cm with a soil auger (7.6-cm d). Addition of TS to existing PC populations resulted in populations of TS which were 50% smaller than those TS populations in areas where no nematodes had existed previously. However, the size of PC populations developing in TS-infested areas did not differ from that of PC populations in areas which were not previously TS infested. TS and PC, both independently and together, reduced root weight by 50% in the 0–23 cm zone, but had no effect on root weight from 23–46 cm. PC appears to be antagonistic to TS, but TS was not antagonistic to PC under our experimental conditions.—*USDA SEA AR, Horticultural Research Laboratory, Orlando, FL 32803; and University of Florida, IFAS, AREC, Lake Alfred, FL 33850.*

KINLOCH, R. A. *Incidence of Meloidogyne incognita and the yield of soybean grown in rotations with maize.*

Soil infestation levels of root-knot nematode, root galling indices, and crop yield were monitored annually from 1972 to 1980 in a replicated cropping study established on soil harboring low levels of *Meloidogyne incognita* (< 1 juvenile/10 cm^3 soil per plot). Root-knot susceptible soybeans were grown in multiple series in alternate years, each third year, and each fourth year in rotations with maize. Monocultured soybeans were maintained as controls. Average number of juveniles/10 cm^3 soil at harvest in 1980 were 371, 285, 134, and 67 in the monoculture, 2-yr, 3-yr, and 4-yr rotations, respectively. Root galling indices (evaluated on a scale of 0–5) increased at annual rates of 0.42, 0.31, 0.19, and 0.19 in the same sequence of rotations. Soybean yields from the 4-yr rotation remained stable over the period (1972 = 2,177 kg/ha, 1980 = 2,182 kg/ha). Relative yields for the entire 9-yr period were as follows: 4-yr rotation = 100a, 3-yr = 90ab, 2-yr = 85b, monoculture = 68c (letters indicate Duncan's multiple-range groups, $P < 0.01$). For the last 3 yr, relative yields were as follows: 4-yr = 100a, 3-yr = 91ab, 2-yr = 80b, monoculture = 50c.—*University of Florida, Agricultural Research Center, Jay, FL 32565.*

KLEINEKE-BORCHERS, A., and U. WYSS. *Physiological investigations of changes in Fusarium susceptibility of tomatoes after infection by Meloidogyne incognita.*

The occurrence of changes in *Fusarium* susceptibility of Fusarium-susceptible and resistant tomato plants after infection by *Meloidogyne incognita* was quantitated by determining the fresh weight and the degree of mycelial growth within this plant (with the help of the Glocosamine determination). The promotion of mycelial growth was always more pronounced in the susceptible than in the resistant plant and stronger in roots than in shoots. Possible reasons for this induced susceptibility were investigated. After infection by *M. incognita*, there was an enrichment of carbohydrates, especially of the reducing sugars glucose and fructose as well as of free amino acids in the roots but less in the shoots. Secondary infection by *Fusarium* resulted in a reduction of these compounds. The components had a positive effect on the fungus growth in vitro and in vivo. The auxin content was increased by both *Meloidogyne* and *Fusarium* in roots and stems. The auxin content was even higher when plants were infected by both pathogens. This could explain the earlier typical *Fusarium* symptom expression (e.g., epinastie and adventitious root growth). Cytokin content was also increased by *Meloidogyne* but decreased by *Fusarium*. —*Institut für Pflanzenkrankheiten and Pflanzenschutzder Universität Hannover.*

KRUPINSKY, J. M., P. A. DONALD, and R. E. BARKER. *Helicotylenchus spp. and Tylenchorhynchus spp. associated with grasses in the western Dakotas.*

Vegetative collections of blue grama (*Bouteloua gracilis*), and western wheatgrass (*Agropyron smithii*), were made in the short- and mixed-grass prairies of western North Dakota and South Dakota in 1977. Plant parasitic nematodes were found in 59% of

3,099 soil samples associated with the collected plants. *Helicotylenchus* spp. and *Tylenchorhynchus* spp. were found in 47% and 21%, respectively, of the collections containing plant parasitic nematodes. *Helicotylenchus* spp. and *Tylenchorhynchus* spp. were found in all 24 counties sampled in North Dakota. Of 28 counties in South Dakota, *Helicotylenchulus* spp. and *Tylenchorhynchus* spp. were found in 27 and 26 counties, respectively. In the combined 52 counties, *H. leiocephalus, H. glissus, H. exallus, H. pseudorobustus,* and *H. digonicus* were found in 46, 30, 13, 8, and 5 counties, respectively. *H. hydrophilus, H. platyurus,* and *H. rotundicauda* were each found in one county. In the combined 52 counties, *T. nudus, T. acutoides, T. robustus, T. maximus, T. stegus,* and *T. canalis* were found in 26, 25, 10, 9, 7, and 4 counties, respectively. *T. pachys* was found in one county.—*USDA SEA AR, Northern Great Plains Research Center, P. O. Box 459, Mandan, ND 58554; and 2935 Edgmont, Fargo, ND 58102.*

LAURITIS, J. A., R. V. REBOIS, and B. Y. ENDO. *Monoxenic culture of Heterodera glycines propagated on root cultures of susceptible soybean.*

Monoxenic cultures of *Heterodera glycines* Ichinohe were established on root cultures of *Glycine max* (L) Merr. cv. Kent. Larvae of the soybean cyst nematode (SCN) were extracted from cyst and egg masses of infected soybean plants grown in Tennessee. Larvae were surface sterilized with an aqueous mixture of streptomycin sulfate (50 ppm) and 8-quinolinol sulfate (20 ppm), washed three times with sterile distilled water, concentrated by centrifugation at 1,500 rpm for 5 min, suspended for 1 h in aqueous streptomycin sulfate (1,000 ppm) and harvested on filters (Millipore, 10 μm). Excised soybean roots, grown aseptically on agar culture medium in plastic petri dishes (100 $\times$ 15 mm), were inoculated with aqueous suspensions of larvae and incubated at 26 C. Developmental stages were observed by microscopic examination of root cultures. Root penetration by infective second-stage (L-2) larvae occurred within 24 h after inoculation. Sites of nematode penetration were indicated by the formation of a necrotic lesion in the root cortex. Swollen larvae were observed 6 d after inoculation (DAI). Adult males appeared 13 DAI with mating occurring 14 DAI. The life cycle of *H. glycines* was completed with egg hatchings and emergence of L-2 larvae at 21 DAI. Stock cultures were established by subsequent transfer of either egg masses or L-2 larvae to axenic soybean root cultures.—*USDA SEA AR, Nematology Laboratory, Beltsville, MD 20705.*

MacGUIDWIN, A. E., E. P. CASWELL, R. L. TUMMALA, and G. W. BIRD. *A model simulating the population dynamics of Meloidogyne hapla infecting onion (Allium cepa).*

A computer model was developed to simulate the population dynamics of *Meloidogyne hapla,* the nematode component of an onion agro-ecosystem. The daily development of a cohort of *M. hapla* infecting a single onion plant is predicted by the model. All nematodes within the model are assigned to one of six life stages. To increase the accuracy of the estimated population levels, each life stage is further divided into age classes. The abiotic and biotic variables used to predict rates of nematode development and survival include soil temperature, onion plant growth, mycorrhizal infection of the host plant, and *M. hapla* density. Output from the model includes data on the density of *M. hapla* within each life stage and onion plant growth. The model is a useful tool for summarizing published data and for identifying research needs. Further experimentation and validation will be necessary to refine the predictive capacity of the model with regard to the interaction between environmental variables, nematode density, and onion growth. The population dynamics of *M. hapla* and several insect pests associated with onions were studied independently using systems science methodology. Future plans include coupling the various pest models with an onion crop model. This discrete component approach allows the eventual characterization of the structure and behavior of the onion agro-ecosystem.—*Department of Entomology,*

Michigan State University, East Lansing, MI 48824.

MALEK, R. B., and R. D. McCLARY. *Symptom development in Scotch pine afflicted with pine wilt.*

The development of symptoms of *Bursaphelenchus lignicolus*-caused pine wilt in 15–80-yr-old Scotch pines was studied visually and photographically in a local epidemic of the disease in Illinois. There were two periods of tree mortality, late winter to late spring and mid summer to late fall. The most dramatic symptom was a change in tree coloration, which progressed through four relatively distinct stages. Foliage suddenly turned a grayish green color in stage 1, then proceeded through a yellowish green stage 2 and a yellowish brown stage 3. The process terminated in a totally light brown stage 4. The color change from the first indication of stage 1 to stage 4 was most rapid and uniform over the tree in August and September, when it was completed in as little as 4 wk. The change slowed and became nonuniform in the fall. Mortalities ceased in November, but flagging of individual branches continued into December. The foliar color change of flags was the same as that of total tree mortality. Flagged trees survived the winter but died during the less intense period of spring mortality. There was little or none of the needle wilt characteristic of the disease in longer and finer needled species. Needles were retained on trees up to a year after death, depending on tree age, time of death, and exposure. Resin disappeared from branches and bluestain fungi began staining wood as early as stage 2. *B. lignicolus* in population densities up to 20,000/g of dried tissue became almost totally systemic in wood of summer-fall mortalities, but was detectable only in the trunk and a few branches in spring mortalities. The nematode always was scarce in twigs and absent from needles and cones.—*Department of Plant Pathology, University of Illinois, Urbana, IL 61801.*

MAQBOOL, M. A. *Morphological relationships of three undescribed neotylenchid nematodes (Neotylenchoidea) from Pakistan.*

Three undescribed species in the superfamily Neotylenchoidea have been collected during comprehensive surveys conducted in Pakistan during 1979–80. One of these, in the genus *Paurodontella* (Paurodontidae), is closely related to *P. densus* (Thorne 1941) Hussain & Khan 1967 and *P. minuta* Hussain & Khan 1967 but differs from them by having a larger body, seven incisures in the lateral field, and a different shaped tail. A second undescribed species, belonging to the genus *Nothotylenchus* (Nothotylenchidae), is related to *N. affinis* Thorne 1941 but can be recognized by having a longer, more robust body with fine cuticular annules, a more posterior vulva, indistinct basal knobs of the stylet, and poorly developed metacorpal area. *N. geraerti* and *N. tuberosus* are also close to this undescribed species, but they have a more developed metacorpal area and a larger post uterine sac. The third undescribed species, in the genus *Boleodorus* (Nothotylenchidae), can easily be recognized from all other species of this genus by its excretory pore open at a level with the base of the basal esophageal bulb and by its six distinct lines in the lateral field.—*Nematological Research Centre, University of Karachi, Karachi-32, Pakistan.*

MAQBOOL, M. A. *Occurrence of root-knot and cyst nematodes in Pakistan.*

During 1978–79 a comprehensive survey of plant parasitic nematodes was carried out in Pakistan. Many species of cyst and root-knot nematodes have been found widely attacking many economically important crops of the country. *Meloidogyne incognita, M. javanica, M. hapla,* and *M. arenaria* have been observed on *Glycine soja, Solanum melongena, Capsicum frutescens, Gossypium hirsutum, Chrysanthemum* sp. *Zingiber officinale, Zea mays, Carica papaya, Beta vulgaris, Nicotiana tabacum,* and *Solanum nigrum* for the first time from Pakistan. *Globodera rostochiensis, Heterodera avenae, H. zeae, H. mani, H. vigni, H. mothi,* and *H. sacchari* were also observed in Pakistan. *H. sachachtii* is recorded on a new host. *G.*

rostochiensis was found in potato field soil at Abbottabad, and *H. avenae* was collected from wheat and maize at Peshawar and Mardan, respectively. *H. zeae* occurs widely in Peshawar and Mardan on maize, gram, citrus, pear, and garlic; all but maize are new host records. *H. schachtii, H. sacchari, H. mani, H. vigni,* and *H. mothi* were found in soils where cauliflower, sugarcane, wheat, and cowpea, respectively, were grown.—*Nematological Research Centre, University of Karachi, Karachi 32, Pakistan.*

MARTIN, M. J., R. M. RIEDEL, and R. C. ROWE. *Pratylenchus penetrans and Verticillium dahliae: causal agents of Early Dying in Solanum tuberosum cv. Superior, in Ohio.*

In 1980, field microplots in muck, sandy loam, and silt loam with three levels of *Pratylenchus penetrans,* two levels of *Verticillium dahliae,* all combinations, and an uninfested check were used to determine if *P. penetrans* and *V. dahliae* interacted to cause Early Dying in potato, *Solanum tuberosum* cv. Superior. The high, medium, and low initial nematode numbers per 100 cm^3 of soil were, respectively, on muck—146, 51, and 16; on sandy loam—140, 39, and 14; and on silty loam—106, 30, and 9. The high and low numbers of microsclerotia per 10 g soil were, respectively, on muck—17.1 and 6.6; on sandy loam—468 and 95; and on silty loam—362 and 128. Results indicated that nematodes accelerated symptom expression and increased severity of Verticillium wilt resulting in Early Dying. The degree of interaction ranged from less than completely additive to synergistic. In muck, top and root weight were not reduced by low levels of either pathogen alone but were reduced 40 and 36%, respectively, by medium and high levels. Tuber weight was not reduced by pathogens alone except by the high nematode treatment. All nematode-fungus combinations reduced top, root, and tuber weight 75, 60, and 36%, respectively. In sandy loam, nematodes alone decreased top and root weight by 35 and 30%, respectively, but had no effect on tuber yield. *Verticillium* alone reduced top, root, and tuber weight 75, 50, and 45%, respectively. Nematode-fungus combinations reduced them 90, 80, and 70%, respectively. Seasonal rainfall was 106 and 77 mm above average for muck and sandy loam, respectively. In silt loam, high fungus alone reduced top weight 60% while other pathogens alone had no effect. Combinations reduced top weight 85%. Root and tuber data were unreliable due to rot resulting from 236 mm of rainfall in August.—*Department of Plant Pathology, Ohio State University, Columbus, OH 43210.*

McKENRY, M. V. *Estimating nematode damage levels in vineyards.*

Nematicidal treatments in vineyards with relatively high nematode populations have not provided consistent positive vine responses. It is apparent that nematode numbers exclusive of pertinent field information provide little value for estimating nematode damage in California vineyards. Field experience indicates that at least six factors must be considered in the estimation of nematode damage: 1) Nematode species and their numbers based on standard extraction efficiencies. 2) Identification of field tolerance of the grape variety. 3) Identification of soil conditions within the major rooting zone. 4) Description of irrigation methods. 5) Cropping and cover-cropping records. 6) Identification of other soil-borne problems. Other factors should also be considered, but these six, being most important, were given priority and developed into a general scheme applicable to California vineyards. The scheme has evolved over the past 4 yr and will continue to evolve as it is used. This specific scheme has been implemented via a recent UC Grape-IPM manual which promotes a holistic approach to vineyard production.—*Department of Nematology, University of California, Riverside, CA 92521.*

McSORLEY, R. *The computer as a research tool for the analysis of nematode survey data.*

Nematological surveys and data accumulated by diagnostic laboratories can provide valuable research resources where quantitative analyses are feasible. The values of such data bases are increased if non-nematological data are included. The computer pro-

vides the capability to perform progressively more complex analyses of such data beyond simple tabulation of numbers and frequencies. As an example of a prototype system for analysis of survey data, data from 123 samples collected from mango (*Mangifera indica* L.) groves in southeastern Florida were formed into statistical analysis system (SAS) data sets for analysis by an Amdahl 470 V/6 II computer. Data included for each sample were counts of nematode genera in soil, grower, tree age, tree condition rated on a 1–6 scale, soil moisture, and weed density rated on a 1–5 scale for each of the six most widely distributed weeds as well as for a composite of all weeds together. *Rotylenchulus reniformis* and *Hemicriconemoides mangiferae* were the nematodes found most frequently in the survey, each occurring in 87.8% of the samples collected, at average numbers of 149.5/100 cm^3 and 90.4/100 cm^3 of soil, respectively. *Helicotylenchus* spp. and *R. reniformis* densities showed significant ($P = 0.05$) positive correlations with soil moisture, while densities of several nematodes were positively correlated with weed density. Tree condition was significantly ($P = 0.01$) correlated with density of *H. mangiferae*. This correlation increased when only samples from trees more than 10 yr old were considered, and was strongest when considering samples from trees more than 10 yr old having more than 100 *H. mangiferae*/100 cm^3 of soil.—*University of Florida, Agricultural Research and Education Center, Homestead, FL 33031.*

MELAKEBERHAN, H., and A. A. F. EVANS. *Interaction of root-knot nematode and vascular wilt-fungi in selected Tanzanian cotton varieties.*

Two Tanzanian cotton varieties, UK71 and UK77, resistant to Fusarium wilt were observed for 110 d to determine the nature of their response to *Meloidogyne incognita* in combination with either *Fusarium oxysporum* f. sp. *vasinfectum* or *Verticillium albo-atrum* under glass house conditions. Three-week-old seedlings were inoculated with 5,000 newly hatched *M. incognita* larvae and 5×10^6 fungus spores per plant either separately, simultaneously, or sequentially. In the sequential treatment the fungi were applied 2 or 4 wk after nematode inoculation. The plants were assessed for presence of the fungus in the tissues. Roots and shoot weights, plant height, and number of leaves were recorded for all treatments at termination of the experiments. *V. albo-atrum* had no visible effect on the plants, and the fungus could not subsequently be isolated from plants of any of the treatments. Both cotton varieties wilted more and weighed significantly less when treated with the nematode and *F. oxysporum* simultaneously or 2 wk apart than did the untreated control plants. The nematode appeared to be a prerequisite for wiltings but not for fungal infection. *M. incognita* is an important factor in breaking Fusarium wilt resistance in cotton.—*Imperical College Field Station, Ashurst Lodge, Ascot, Berks, England.*

MINTON, N. A., D. K. BELL, and A. S. CSINOS. *Effects of nematicides applied at planting and postplant on peanut yields, root-knot nematodes, and white mold.*

Ethylene dibromide (EDB) and phenamiphos (PH) were evaluated in the production of peanuts in 1979 and 1980 in soil infested with *Meloidogyne arenaria* and *Sclerotium rolfsii* in split-plot experiments with at-plant and postplant treatments comprising the whole plots and subplots, respectively. Whole plot and subplot treatments were untreated check, EDB at 17.9 and 35.8 kg ai/ha, and PH at 1.1 and 2.8 kg ai/ha. Two-year average peanut yields ranged from 4,156 kg/ha in untreated check plots to 5,088 kg/ha in plots that received EDB at 17.9 kg ai/ha at planting + PH at 2.8 kg ai/ha postplant. PH applied at 2.8 kg ai/ha at planting and all postplant treatments significantly ($P = 0.05$) increased yields. PH at 1.1 and 2.8 kg ai/ha applied postplant significantly ($P = 0.05$) increased yields when applied to plots treated at planting with PH at 1.1 kg ai/ha. Also, PH at 2.8 kg ai/ha applied postplant significantly ($P = 0.05$) increased yields in plots treated at planting with EDB at 17.9 kg ai/ha. Yields of plots treated preplant with PH at 2.8 kg ai/ha and EDB at 35.8

kg ai/ha were not enhanced by addition of any postplant treatment. Root-knot indices were reduced ($P = 0.05$) by all at-plant or postplant treatments. Root-knot indices indicated that the high rates of EDB and PH applied at planting were adequate for good nematode control and a postplant application was not needed. *S. rolfsii* was present at a relatively high level and was unaffected by treatments.—*USDA SEA AR, and the University of Georgia College of Agriculture Experiment Stations, Coastal Plains Experiment Station, Tifton, GA 31793.*

MUNDO, O. M., and J. G. BALDWIN. *Comparative histopathology of Sarisodera hydrophila and Atalodera ucri with other Heteroderidae.*

The histopathology of *Sarisodera hydrophila* and *Atalodera ucri* was examined on their respective type-hosts, *Salix lasiolepis* (willow) and *Haplopappus palmari*. Tissue containing giant cells associated with nematodes at varying developmental stages were processed for histological examination including bright field, interference, and scanning electron microscopy. *Sarisodera hydrophila* induces formation of a single uninucleate giant cell about 0.3 × 0.1 mm. The area of the giant cell where the stylet penetrates is characterized by increased density of the cytoplasm, presence of the enlarged nucleus, and thickening of the cell wall. On roots with primary growth the giant cell is situated between vascular bundles, whereas in tissue with secondary growth the cell extends adjacent to xylem, vascular cambium, and phloem. *Atalodera ucri* induces a variably sized syncytium apparently formed by dissolution of cell walls. The cytoplasm initially becomes highly vacuolated and granulated, and the nuclei and nucleoli increase in size. As syncytia mature, nuclei aggregate and the increasingly dense cytoplasm surrounds fragments of cell walls. *Sarisodera hydrophila* is thought to be closely related to *Heterodera* spp., although the response of its type-host most nearly resembles that reported for *Hylonema ivorense*. On the other hand, the response of the type-host to *Atalodera ucri* resembles that reported for *Heterodera* spp. on many hosts.—*Department of Nematology, University of California, Riverside, CA 92521.*

NIGH, E. L., JR. *Evaluation of sampling and extraction techniques to determine citrus nematode, Tylenchulus semipenetrans, populations.*

Variation in the number of *Tylenchulus semipenetrans* recovered from soil around citrus trees using a 2.5-cm soil probe, a 10-cm soil augar, and a shovel was compared. Samples were taken from the dripline to within 2 ft of the tree trunk and composited. Two, four, six, or eight subsamples were collected from 15–45-cm depths; 100 cm^3 soil and 10-gm root samples were selected from the composite samples for Baermann funnel and mist chamber extraction. Greater variation was found in samples taken with the soil probe or augar, regardless of the number of samples/tree, than with those taken by shovel from the north and south sides of the tree. Baermann funnel, gravity-flotation screening, a combination of the two systems, fenwick flotation apparatus, and mist chamber were compared for maximum efficiency in extracting citrus nematode larvae. The funnel, screening, and combination techniques produced no significant differences in numbers extracted if processed for 48 h, but significant variations occurred in recovery from the mist chamber or the fenwick extractor. Variability between samples and subsamples in the number of larvae recovered from roots by use of mist chamber was probably due to biased error in selecting 10 gm of roots from each sample. Samples processed immediately after harvest yielded larger numbers of larvae than samples stored 7 or 14 d at 6–8 C or at ambient temperatures fluctuating between 15 and 35 C.—*Department of Plant Pathology, University of Arizona, Yuma, AZ 85364.*

NIGH, E. L., JR. *Relation of citrus nematode to root distribution in flood irrigated citrus.*

In flood irrigated citrus, 66% of the feeder roots occur between 15 and 60 cm deep. Less than half of the total root system

extends beyond the dripline of the tree. Citrus nematodes are correlated with this distribution; 98% of the population may be recovered in the 15–60-cm depth. Less than 6% of the nematodes were found beyond the dripline. This is probably attributed to greater fluctuations in the ecosystem due to higher temperatures, cultural practices, and greater water evaporation with subsequent oxygen variations beyond the dripline. From these observations, it is obvious that effective control of this nematode can be obtained only by the delivery of nematicides to those infested soil areas in which the nematode is located. The application of materials beneath the trees by soil injection is highly impractical. The use of flood irrigation water as a delivery system is ideal since the pesticide can be carried to the infested roots.—*Department of Plant Pathology, Agricultural Experiment Station, University of Arizona, Yuma, AZ 85364.*

NOE, J. P., K. R. BARKER, and D. P. SCHMITT. *Comparison of four soil sampling methods for estimating field populations of plant parasitic nematodes.*

Nematode populations were estimated in each of 100 quadrats (10 × 10 m) in each of two fields. Repeated samples were taken from these quadrats by a single core (2.5-cm d), a composite of five cores, and a bucket auger (8-cm d). In addition, 10 randomly selected large quadrats were subdivided into twenty-five 2- × 2-m quadrats and sampled more intensively with a bucket auger (one sample/small area). A randomly selected location was sampled within each quadrat. One field had been planted in soybeans the previous year and the other in corn. Plant-parasitic nematode species present were *Tylenchorhynchus claytoni, Paratrichodorus minor, Pratylenchus zeae, Xiphinema americanum, Hoplolaimus galeatus,* and *Meloidogyne* spp. *Heterodera glycines* occurred in only one field. Significant differences in the mean population estimates were obtained for each nematode species within both fields, but there was no stable trend in the estimates among methods. There were no significant differences among sampling methods in the coefficients of variation (CV's), although the composite samples tended to have lower CV's. Data from selected small quadrats tended to have higher CV's, indicating that this method may increase the variation within samples in population estimates. None of the sample data could be fitted by the Poisson frequency distribution. Ninety percent of the sample counts from the large quadrats could be fitted by either the negative binomial or Neyman type-A distributions. Because of increased variability among small areas of the fields, only 44% of the samples from the small quadrats could be fitted to either distribution. Thus, the greater variability among clusters in the small areas requires a sampling pattern which includes the entire field.—*Department of Plant Pathology, North Carolina State University, Raleigh, NC 27650.*

NOEL, G. R., and H. J. WILSON. *Association of a rickettsia-like organism with reduced Heterodera glycines populations.*

A rickettsia-like organism (RLO) has been reported in *Heterodera glycines* but was not implicated in pathogenesis of the host. We report an RLO associated with second-stage larvae in a population which showed reduced numbers of *H. glycines* females on soybean (*Glycine max*) cvs. Williams and Essex by as much as 87 and 90%, respectively, when compared to controls which did not contain the RLO. Larvae from populations which failed to develop normally were examined by transmission electron microscopy and found to contain an intracellular RLO. The RLO was rod-shaped, walled, and measured .2 × .6 μm. Further research designed to confirm these preliminary findings of the RLO and its effect(s) on nematode population dynamics are in progress.—*USDA SEA AR, and Department of Plant Pathology, University of Illinois, Urbana, IL 61801.*

NORDMEYER, D., and D. W. DICKSON. *Effect of oximecarbamates, organophosphates, and one avermectin on the oxygen uptake of three Meloidogyne species.*

The rate of oxygen uptake of freshly hatched larvae of *Meloidogyne javanica, M.*

arenaria, and *M. incognita* after exposure to 5 ppm carbofuran, ethoprop, aldicarb, oxamyl, or phenamiphos and 0.05 ppm avermectin B_{2a} (Merk, Sharp and Dohme L-6-76, 897-00G18) was compared to untreated controls. The nematodes were exposed to the chemicals for 24 h at 28 C. Each treatment was replicated six times. The oxygen uptake was measured by an oxygraph (Gilson K-1C) equipped with a Clark electrode. Each sample consisted of 50,000 nematodes concentrated in a 1 ml chamber. The chamber was located inside a waterpacketed cell, through which 28 C water was pumped. The O_2 consumption was recorded for 5 min and the obtained value converted to micromole O_2 per mg of nematode dry weight. Each of the compounds decreased the oxygen consumption. However, only aldicarb showed significant differences between the three species. The average oxygen uptake was reduced 3.3% by carbofuran, 18.7% by ethoprop, 20.7% by aldicarb, 26.0% by oxamyl, 28.2% by phenamiphos, and 61.1% by avermectin B_{2a} for the three root-knot nematode species.—*Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.*

NYCZEPIR, A. P., J. H. O'BANNON, and G. S. SANTO. *Distribution of Meloidogyne chitwoodi on potato in the Pacific Northwest.*

The Columbia root-knot nematode, *Meloidogyne chitwoodi* (Mc), is a pest of potato in the Pacific Northwest. A survey of the major potato growing regions of the Pacific Northwest was conducted in the fall-spring of 1980–81 to determine the distribution of Mc and other root-knot nematodes. Potato and/or soil samples infested with *Meloidogyne* spp. were obtained from northern California, Idaho, northern Nevada, Oregon, and Washington. Species identification was characterized by examining perineal patterns, female stylet lengths, second-stage juvenile lengths and tail shape, and the reproductive potential of each population on a series of differential hosts. Mc and *M. hapla* (Mh) were the only root-knot nematode species found parasitizing potato in the Pacific Northwest. Mc was found in a greater number of samples than Mh and appears to be the dominant root-knot nematode species, particularly in Idaho. The greater incidence of Mc as compared to Mh is due in part to the increased acreage of small grains planted in rotation with the potato, a good host for Mc but a poor to nonhost for Mh. Another factor may be the cool growing season encountered in 1980, which favors Mc but not Mh. The wide distribution of Mc is probably due to dissemination by reused irrigation water, primarily the Columbia River drainage system which includes the Snake River, and infected seed potato. It is important that potato growers determine which root-knot nematode species are infesting their fields so that proper control practices can be implemented.—*USDA SEA AR, and Dept. of Plant Pathology, Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.*

O'GRADY, R. T., and N. A. CROLL. *Cuticular changes in developing fourth-stage larvae of Ascaris suum.*

Fourth-stage larvae and young adults of *Ascaris suum* were collected from piglets at 11–22 days after infection (DAI) with 15,000 eggs. Specimens were examined at mid-body by light and scanning electron microscopy for changes in the total cuticular thickness, its ratio to body diameter, and orientation of the spiral fibers in the basal layer. Results were compared to morphometric parameters of the fourth-stage larvae and data collected from mature female worms. Cuticle thickness and ratios for the larvae were 1.0 μm, 1:50 at 14 DAI; 2.9 μm, 1:34 at 18 DAI; and 3.3 μm, 1:135 at 22 DAI. Ensheathed young adults at 22 DAI were 3.0 μm, 1:150. Mature females were 63.44 μm, 1:69. Formalin fixed whole mounts of the larvae first showed a spiral fiber network at 14 DAI. Worm length and θ, the spiral angle, were 3.21 mm, 71.21 $\pm$ 0.95° at 14 DAI; 7.84 mm, 69.89 $\pm$ 1.7° at 18 DAI; and 24.25 mm, 62.34 $\pm$ 1.5° at 22 DAI. Young adults at 22 DAI were 24.16 mm, 71.30 $\pm$ 1.5°. Mature females were 204.5 mm, 72.73 $\pm$ 0.8°. The value of de Man's "a" ratio increased from 31 at

11 DAI to 45 at 22 DAI in the larvae. The allometric constant for body diameter vs. length was 0.84. Results indicate a relative thinning of the cuticle with respect to body diameter in the fourth stage. The angle θ approached the critical value of 54.73° for a system of locomotion relying on turgor pressure and an anisometric skeleton of spiral fibers. Models constructed according to the allometric growth shown can predict the decrease in θ.—*Institute of Parasitology, Macdonald Campus of McGill University, Quebec, Canada. H9X 1CO.*

OKABE, F. K., and W. J. APT. *Effect of population density of Rotylenchulus reniformis on pineapple.*

Pineapple crowns were grown in a fumigated Wahiawa Oxisol soil and inoculated with 0, 50, 500, 5,000, or 50,000 reniform nematodes, *Rotylenchulus reniformis,* per plant. The plants were grown for 6 months at two soil moisture levels, a lower moisture of 30% and a higher moisture level of 35-40%. On completion of the test no differences were observed in numbers of nematodes between the four levels of inoculum on the root systems. Crowns inoculated with 50,000 nematodes had the largest number of nematodes in the soil. Smallest measurements of "D" leaf length, width, and dry weight were recorded at the highest inoculum level. Dry root weights were unaffected by inoculum level. Fibrous root ratings were highest for control plants and lowest at the highest inoculum. No differences in the final nematode counts in soil between the two soil moisture treatments were observed, but the lowest populations in root systems were found on plants grown at low soil moisture. "D" leaf length, width, and dry weight and plant top and root dry weights were greatest at high soil moisture. Fibrous root ratings were not affected by soil moisture.—*Department of Plant Pathology, University of Hawaii, Honolulu, HA 96822.*

OLSEN, H. C., G. W. BIRD, and M. L. VITOSH. *Joint action of potassium fertilizer and selected pesticides on Pratylenchus penetrans and tuber yield of Solanum tuberosum.*

The joint role of two levels of potassium fertilizer (0, 56, and 168 kg K_2O/ha) and two at-planting pesticides (nontreated control; aldicarb, 3.3 kg a.i./ha; and dinitrochlorobenzene, 9.0 kg/ha) were evaluated under Michigan *Solanum tuberosum* cv. Superior production conditions in 1980. A completely randomized block factorial design with five replications was used. Soil and leaf tissue nutrient levels, *Pratylenchus penetrans, Verticillium* spp., and insect populations were monitored. *P. penetrans* populations were monitored at eight intervals throughout the growing season. Tubers were harvested 1,547 degree days at a base of 10 C (DD_{10}) after planting. The initial population density of *P. penetrans* was 10.7 per 100 cm^3 of soil. Aldicarb significantly ($P = 0.05$) retarded population growth of *P. penetrans* throughout the growing season. This was first observed 735 DD_{10} after planting. Insect population dynamics under a commercial production spray schedule was monitored, and no significant foliar damage occured. *Verticillium* spp. were monitored three times during the growing season; there were no treatment effects on the amount of infection. Dinitrochlorobenzene had no significant ($P = 0.05$) effects on nematode, insect, or fungi population densities monitored. Aldicarb significantly ($P = 0.05$) increased the yield of marketable tubers. Potassium fertilizer had no significant influence on tuber yield; however, treatment with potassium fertilizer and aldicarb significantly ($P = 0.05$) increased oversized tuber yields. The pesticides had no effect on potassium concentrations in the plant tissue.—*Departments of Entomology and Crop and Soil Science, Michigan State University, East Lansing, MI 48824.*

ORBIN, D. P. *Recovery of nematodes and other microfauna from sewage sludge using molasses flotation.*

Analysis of the biotic community of an activated sludge sewage treatment plant

could provide a rapid means of assessing the biological activity of the system. Saprophytic nematodes and other bacterial-feeding organisms play a significant role in such biotic communities. Isolation of the organisms from the activated sludge must be accomplished rapidly to avoid oxygen depletion due to the high biological oxygen demand. An investigation was conducted using a centrifuge flotation technique utilizing molasses as the flotation solution. The technique used centrifugation to reduce the volume of water, which composed 70–80% of the activated sludge. This was followed by addition of a molasses solution and a second centrifugation. The solution was poured onto a 44 micron (325 mesh) screen, and the micro-organisms were washed into a counting dish. The technique effectively isolated nematodes, rotifers, and large protozoa (especially colonial ciliates). Total processing time was less than 5 min.—*Department of Biology, Pennsylvania State University, Hazleton Campus, Hazleton, PA 18201.*

ORR, C. C. *Cotton losses to nematodes on the Texas High Plains.*

Estimates of crop losses to nematodes and other pests are frequently requested by research institutions, industry, regulatory agencies, administrators, and others. Most estimates are based on the estimators' knowledge and experience, but often with little supporting data. Presented here is an estimate based on yield for losses to root-knot nematodes, *Meloidogyne incognita* (Kofoid and White) Chitwood, for 17 counties in the Southern High Plains of Texas. This area produces 1.7 million bales or 15% of the U.S. cotton crop. Mean data from 153 field tests collected over 16 yr in five counties, showed 20.2% increased cotton lint yield from the use of the nematicide DBCP (1,2-dibromo-3-chloropropane). A survey for root-knot nematodes in the 17-county area showed that 42.6% of 2,909 soil samples, representing 10% of the farms, contained populations of root-knot nematodes. Mathematical calculations from these data show a possible crop loss in the 17-county area of ca. 163,000 bales, or 9.2% of the crop. At 1980 cotton prices, the dollar loss would approach $50 million.—*USDA SEA AR, Lubbock, TX 79401.*

OVERMAN, A. J. *Off-season land management and soil fumigation for tomato on sandy soil.*

Four off-season management procedures were established to determine their effects on yield of tomato on Myakka fine sand heavily infested with *Meloidogyne incognita* and *Verticillium albo-atrum*. The management procedures were herbicide (Paraquat), fallow, establishment of native weed cover or sorghum sudangrass, and solarization of the soil under 150-μm clear polyethylene film. Thirty days after the treatments were initiated, a nontreated control and three soil fumigants were applied to randomized single bed plots within the four replicates of each of the cultural management systems. Vorlex (DD-MENCS) (327 liters/ha), Telone C-17 (76.3% 1,3-D + 17.1% chloropicrin) (275 kg/ha), or Telone II (98% 1,3-D) (170 kg/ha) was injected in three streams 15 cm apart and 20 cm below the surface of the compacted raised bed. All plots were sealed with a full-bed mulch of 32-μm black polyethylene film. Two weeks later containerized transplants of tomato cv. Tempo were set through the mulch. Compared to herbicide fallow, tomato yields following native cover, sorghum, and solarization were increased 5, 22, and 48%, respectively, without fumigation. Yield improvement via soil fumigation was greatest following native cover, 83% with Telone C-17 to 91% with Telone II, and least following solarization, 22% with Vorlex to 38% with Telone C-17. Root-knot galling was equally severe on mature plants regardless of management procedure or soil treatment. Ten weeks after planting, 8% of the plants from solarized beds were wilted, compared to 80% from the herbicide fallow. Vorlex was most effective in reducing wilt of tomato, regardless of off-season management.—*Agricultural Research & Education Center, Bradenton, FL 33508.*

PAPADOPOULOU, J., and A. C. TRIANTAPHYLLOU. *Sex differentiation of female, male, and sex reversed juveniles of Meloidogyne incognita.*

Sex differentiation was studied by examining the cellular structure of gonad primordia extracted from second-stage juveniles developing under different environmental conditions. In female juveniles, divisions of the two somatic cells of the primordium occurred in mid second stage and resulted in 12 cells, two of which were differentiated as cap cells, two occupied the anterior central, and eight the posterior central part of the V-shaped primordium. The two germinal cells divided at the 6–8 somatic cell stage of the primordium; i.e., earlier than in any other plant-parasitic nematode. In male juveniles of similar developmental stage, divisions of somatic cells resulted in 10 cells: one cap cell at the posterior tip and nine cells at the anterior part of the rod-shaped primordium. Germinal cells divided at the 6–8 somatic cell stage. On the basis of gonad anatomy, it was concluded that sex reversed juveniles are female individuals that have undergone sex reversal and proceed with further development as males. The degree of expression of intersexual features during gonad development depends on the period at which sex reversal occurs. Failure of one of the early somatic cells to differentiate as a cap cell or subsequent degeneration of the nucleus of one of the cap cells resulted in sex reversed juveniles of four recognizable types. Types A and B give rise to males with one testis. Types C and D result in males with two testes of unequal length in C and of equal length in D.—*Departments of Plant Pathology and Genetics, North Carolina State University, Raleigh, NC 27650.*

PLATZER, E. G. *Octomyomermis muspratti: factors affecting egg hatching.*

The mass rearing of *Octomyomermis muspratti*, a mermithid parasite of mosquito larvae in tree holes, has not been accomplished largely because *O. muspratti* eggs appear to be in diapause and, consequently, large numbers cannot be hatched. If sand cultures of *O. muspratti* are flooded with water, eggs hatch sporadically at a very low, slow rate (< 0.1%/wk). When attempts were made to induce hatching, it was found that third-instar *Aedes taeniorhynchus* ingested the eggs readily; subsequent dissection of mosquito larvae showed the eggs did not hatch within the mosquito gut; however, all eggs hatched within 1 wk after removal from the mosquito gut when stored in water. These observations suggested a unique interaction between host and parasite. When the tree-hole habitat is populated by mosquito larvae, the older larvae browse the bottom detritus and the nematode eggs are thereby passed through the host gut. Passage through the mosquito gut activates the hatching mechanism and the preparasitic larvae emerge and enter the host by penetration of the cuticle. In the absence of mosquito larvae, the eggs hatch at a very low rate. Egg hatching can also be induced by chemical treatments. Exposure of eggs to 5.25% sodium hypochlorite for 2 min resulted in 10% egg hatch/wk. Subsequent exposure of bleach-treated eggs to 43 μm sodium dodecyl sulfate for 30 min resulted in 100% hatching within 1 wk. Presumably the chemical treatments simulated the physiological triggering mechanisms of the host gut.—*Department of Nematology, University of California, Riverside, CA 92521.*

POZDOL, R. F., G. R. NOEL, and D. I. EDWARDS. *Comparative analysis of Heterodera glycines races by a refined polyacrylamide gel slab electrophoresis technique.*

Races of *Heterodera glycines* were studied electrophoretically and their banding patterns compared. 'Essex' soybeans (*Glycine max*) were inoculated with larvae of races 1, 2, 3, and 4. Soluble proteins were extracted by crushing 200 young white females of each race in 0.05M Tris-chloride buffer, pH 6.9. The homogenate was sonicated, centrifuged, and subjected to discontinuous polyacrylamide gel slab electrophoresis. Proteins migrated as anionic entities which were stacked in 3% acrylamide (pH 6.9, 0.06M Tris) and resolved in 9% acrylamide (pH 8.9, 0.35M Tris). Tris-glycine (pH 8.3, 0.005M) was utilized as the electrode vessel buffer. Proteins were fixed

in methanolic-TCA and stained with Comassie Blue R250. Prior to this study, electrophoretic analysis of *H. glycines* had resolved only 12 bands. The electrophoresis system developed for the current study yields 26 discernible bands, thus illustrating its sensitivity and high resolving capabilities. The greater sensitivity of this system is attributed to refinements in the preparation and clarification of the nematode protein homogenate, improved buffer relations, and optimized staining conditions. Comparative analysis of the four races of *H. glycines* indicated identical banding patterns. However, among the races the intensity of six bands varied.—*Department of Plant Pathology and USDA SEA AR, University of Illinois, Urbana, IL 61801.*

PREISER, F. A., J. R. BABU, R. A. DYBAS, A. A. HAIDRI, and I. PUTTER. *Avermectins, a new class of nematicides.*

The avermectins, a group of novel compounds derived from *Streptomyces avermitilis,* are highly potent antiparasitic agents. Under greenhouse conditions, two of these avermectins, B_{1a} and B_{2a}, and a derivative of the latter, known as B_{2a}-23-one, have been found to be effective against *Meloidogyne incognita* at 3.0, 1.0, and 0.3 lb/acre, respectively. Similarly, the estimated relative potencies follow the same order; i.e., B_{2a}-23-one is more potent than B_{2a} (relative potency = 0.633) and B_{2a} is more potent than B_{1a} (relative potency = 0.247). In greenhouse experiments, the nematicidal activity of B_{2a} lasted for up to 28 d in soil and a partial activity was evident 56 d later. Increasing the organic matter fraction of the soil decreased the nematicidal activity of B_{2a}.—*Merck & Company, Inc., Rahway, NJ 07065.*

PROCTOR, J. E., and H. D. HIGGINS. *Use of phenamiphos for the control of Meloidogyne incognita, Pratylenchus penetrans, Criconemoides, and Xiphinema sp. on peaches, apples, and cherries.*

Problems relating to nematode damage on fruit trees, specifically peaches, apples, and cherries, have been of concern for some time in eastern fruit growing areas. The nematode problem is especially severe when new orchards are replanted on old sites. The use of a contact nematicide such as phenamiphos (nemacur) offers the grower the best opportunity for rapid orchard re-establishment. The use of phenamiphos eliminates the need for total root removal and cultivation of an existing orchard site, thereby saving 2–3 yr in orchard re-establishment. Phenamiphos also offers the grower an opportunity to control nematodes in an established orchard. Studies conducted from 1975 to 1979 showed that phenamiphos used as a contact nematicide is beneficial to orchard re-establishment. Growth responses exceeding 50% of the check and yields in excess of the check were observed. Phenamiphos has eliminated early tree mortality and decline caused by nematodes in orchards.—*Mobay Chemical Corporation, Agricultural Chemicals Division, Kansas City, MO 64120.*

REBOIS, R. V., and LAURITIS, J. A. *Propogation of Rotylenchulus reniformis, Linford and Oliveira, reniform nematode, on monoxenic excised root tissue culture.*

Reniform nematode cultures were established on excised roots of tomato, *Lycopersicon esculentum* (L) Mill cv. Marglobe, under gnotobiotic conditions. Larvae, males, and preadult females of the *Rotylenchulus reniformis,* cultured in the greenhouse on cotton, were extracted from infested soil by seiving. The nematodes were placed on several layers of sterile tissue paper in petri dishes (modified Baermann technique) containing 50 ppm streptomycin sulfate (SS) and 20 ppm 8-quinolinol sulfate. After 48 h, the nematodes that moved through the tissues were concentrated by low speed centrifugation and resuspended three times in 1,000 ppm SS over 1-h period and subsequently washed several times in distilled water before transferring to root tissue cultures. The monoxenic tomato roots were established in petri dishes containing 1.5 or 2% agar and a defined synthetic nutrient base and incubated at 26 C. *R. reniformis* penetrated the roots and began to swell within 4 d after inoculation (AI). Males

were attracted to swollen females having a gelatinous matrix and mating occurred 7 d AI. Egg laying, egg hatch, and third-stage larvae were observed at 10, 16, and 19 AI, respectively. Under these conditions, the life cycle was completed within 30 d AI. Larvae from the tomato root tissue cultures were able to infect and complete their life cycles on similar cultures of soybeans, *Glycine max* L. Merr. cvs. Essex and Kent.—*USDA SEA AR, Nematology Laboratory, Beltsville, MD 20705.*

RINKER, D. L., and J. R. BLOOM. *Spread of free-living nematodes by sciarid flies in mushroom houses.*

Infestations of free-living nematodes in mushroom beds are frequently the cause of drastic reductions in the yield of mushrooms. Studies were conducted to determine if mushroom flies could disseminate these nematodes. Two free-living nematodes, *Caenorhabditis elegans* and *Cruzenema lambdiensis*, and a sciarid fly, *Lycoriella mali*, were selected for the phoretic study. Eight and six-tenths grams of pasteurized compost was placed in 30-ml plastic pill cups and 4.6 g of peat moss was added to the top of the compost in each cup. The cups were placed in plastic boxes (30 cm × 15 cm × 8.5 cm) and arranged with one cup in the center of the box and five cups in a circle around the center cup. The center cup in each box received 15,000 nemas plus 20 fly pupa, or 20 pupa and no nemas, or were uninfested checks. Treatments were replicated five times. Boxes were covered with fitted lids and incubated 18 d at 21 ± 1 C. Spread of nematodes to adjacent cups was determined by microscopic examination of the peat moss or by Baermann funnel technique. *C. lambdiensis* were transported to only 8% of the cups; however, *C. elegans* were carried to 52%. Dispersal was favored by swarming.—*Department of Entomology and Department of Plant Pathology, Pennsylvania State University, University Park, PA 16802.*

ROBERTSON, W. M. *A histological study using the periodic acid-Schiff reaction of the esophageal bulb of Xiphinema index.*

Biochemical analyses of macerated esophageal bulbs have suggested that the secretory-like granules found in the dorsal gland cell are acid glycoproteins which stain with the periodic acid-Schiff (PAS) reagent. Light microscopy of sections of formaldehyde fixed specimens embedded in the water miscible resin, 2 hydroxyethyl methacrylate, and stained with the PAS reagent has indicated intense staining of the basement membrane which encloses the esophageal bulb. Only light general staining was observed within the dorsal and subventral gland cells and the radial muscles which together make up most of the esophageal bulb volume. Substitution of the Schiff part of the PAS reagent with thiosemicarbazide-silver proteinate (TSC-SP) makes the reaction products visible in the electron microscope when applied to thin sections of formaldehyde-fixed specimens embedded in epoxy resin. This PA-TSC-SP reagent gives faint staining of the secretory-like granules but intense staining of the membrane which forms the ducts. It also stains other components of the three main cell types of the esophageal bulb.—*Scottish Crop Research Institute, Invergowrie, Dundee, Scotland DD2 5DA.*

ROBINSON, A. F., and C. C. ORR. *Effects of oxygen and temperature on the activity and survival of Nothanguina phyllobia.*

Nothanguina phyllobia is a promising biological control agent for the perennial weed, *Solanum elaeagnifolium*. An important aspect of the biology of *N. phyllobia* is the influence of abiotic variables on the activity and survival of infective fourth-stage juveniles. To evaluate the effects of temperature and oxygen, fourth-stage juveniles were exposed in vitro for several time periods to a variety of temperature and oxygen regimes. Nematode activity was quantified in terms of waves/unit time. Activity was not affected over a wide range of O_2 concentrations (0.8–9.0 ppm); however, below 0.8 ppm O_2 activity decreased

and nematodes were motionless at 0.15 ppm O_2. Survival was prolonged during the first 4 d of anoxia, after which time the absence of oxygen began to have detrimental effects. After 6 d exposure, most juveniles died. Activity increased as a linear function of temperature up to a thermal optimum of 24 C; above 24 C activity decreased. Continued exposure to 40 C was lethal, but the effects of 6 h exposure to nine temperatures less that 40 C were completely reversible. Survival was prolonged by low temperature. At 4 C, 70% survived after 98 d, while at 23 C, 50% mortality occurred within 7 d. These results suggest that *N. phyllobia* infective juveniles may overwinter in the continuously hydrated condition. However, juveniles are not likely to survive if exposed to more than 1 wk of anoxia.—*USDA SEA AR, Lubbock, TX 79409.*

RODRIGUEZ-KABANA, R., P. S. KING, and M. H. POPE. *Combinations of anhydrous ammonia and ethylene dibromide for control of nematodes parasitic on soybeans.*

In a greenhouse test NH_3 was applied to a sandy loam soil infested with *Tylenchorhynchus claytoni* Steiner 1937, *Helicotylenchus dihystera* (Cobb 1893) 1961, *Pratylenchus brachyurus* (Godfrey 1929) Goodey 1951, and *Hoplolaimus galeatus* (Cobb 1913) Sher 1961 at rates of 0, 7.8, 15.6, 31.2, 62.5, and 125.0 mg N/500 gm soil. The applications reduced soil populations of *T. claytoni* and *H. dihystera* at the three highest rates. Numbers of *P. brachyurus* in 'Ransom' soybean (*glycines max*) roots were not reduced by any NH_3 treatment. Root populations of *H. dihystera* and *H. galeatus* were reduced only with the 125-mg rate. Two field experiments demonstrated that at-planting applications of anhydrous ammonia, at rates ranging up to 224 kg N/ha, were relatively ineffective in reducing late season larval numbers of *Meloidogyne arenaria* (Neal 1889) Chitwood 1949, although significant yield increases were obtained in response to the treatments in one experiment. Results from a third field experiment demonstrated that at-planting applications of anhydrous ammonia at rates of 56 and 112 kg/ha reduced numbers of larvae of *Heterodera glycines* (race 3) Ichinohe 1952 in soil samples collected 14 d after planting. At-planting applications of ethylene dibromide (4.7-18.6 l/ha) combined with anhydrous ammonia (56 and 112 kg N/ha) resulted in yield increases and a degree of control of *M. arenaria* and *H. glycines* superior to results obtained when each chemical was applied singly.—*Department of Botany, Plant Pathology, and Microbiology, Auburn University, Agricultural Experiment Station, Auburn, AL 36849.*

SANTO, G. S., and J. H. O'BANNON. *Ecology of root-knot nematodes on Russet Burbank potato in Washington.*

The Columbia root-knot nematode (*Meloidogyne chitwoodi*) and the Northern root-knot nematode (*M. hapla*) are economic pests of potato in Washington. A series of ecological studies to compare these two nematode species on Russet Burbank potato were conducted. Soil and tuber samples were taken every 2 wk from five random locations in adjacent fields infested with *M. chitwoodi* or *M. hapla* to determine and compare the incidence and severity of *M. chitwoodi* and *M. hapla* infection of potato tubers. Tubers were more severely infected by *M. chitwoodi* than *M. hapla* in 1980. Monthly soil samples were taken in 1980 at 30, 61, 91, and 122 cm deep with a 10-cm-d auger from five random locations in fields infested with *M. chitwoodi* or *M. hapla* to determine the vertical distribution. The vertical distribution of both species were similar, with most of the nematodes extracted from the upper 61 cm of soil. Highest populations occurred August-October. Soil temperature studies showed that *M. chitwoodi* infected potatoes at cooler temperatures than did *M. hapla.* The reproductive potential of *M. chitwoodi* was greater than *M. hapla* at 15, 20, and 25 C. *Meloidogyne hapla* reproduction rate was higher at 30 C. When both species co-inhabited the same roots, more *M. chitwoodi* females were found in roots at 15, 20, and 25 C but not at 30 C, where no differences occurred.—*Department of Plant Pathology, Washington State University,*

and USDA SEA AR, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.

SANTO, G. S., and R. P. PONTI. *Control of root-knot nematodes on Russet Burbank potato in Washington with fumigant and nonfumigant nematicides.*

Approximately $9 million are spent annually on chemicals to control the Columbia root-knot nematode (*Meloidogyne chitwoodi*) and the Northern root-knot nematode (*M. hapla*) on potato in Washington. Nematicide treatments were evaluated for the control of *M. chitwoodi* and *M. hapla*. Nematicides, rates (a.i./ha), and method of applications were DD mixture, 140 and 187 liter, preplant chisel; 1,3-D, 103 and 129 liter, preplant chisel; EDB, 47 liter, preplant chisel; metham, 153 liter, preplant water; ethoprop, 6.5, 9.7, and 12.9 kg, preplant broadcast spray on soil surface and rototill; aldicarb, 3.2 and 6.5 kg, at-plant or post-plant sidedress next to seed-piece; and oxamyl, 0.5, 1.1, and 2.2 kg, at-plant spray on seed-piece in furrow. Plots were three rows 10.6 m long and spaced 86 cm apart arranged in a randomized complete block with five replicates. Pretreatment nematode soil samples showed that the *M. chitwoodi* plots were infested with an average of 37 second-stage juveniles per 250 cc soil and the *M. hapla* plots with 200. Potatoes were planted 6 May and harvested 20–24 October 1980. No yield differences were observed in the *M. hapla* plots. In the *M. chitwoodi* plots, 12 treatments yielded significantly ($P = 0.05$) more than the nontreated plots. In general, the soil fumigants were more effective that the nonfumigants, in reducing nematode soil populations, especially *M. chitwoodi*. Tuber examination for nematode infection from the *M. chitwoodi* plots showed that only 1,3-D at 129 liter and 1,3-D at 129 liter plus oxamyl at 2.2 kg effectively prevented nematodes from infecting tubers. Most of the nematicide treatments effectively prevented *M. hapla* from infecting the tubers. These results indicate that *M. chitwoodi* is more difficult to control than *M. hapla*.—*Department of Plant Pathology, Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.*

SCHMITT, D. P., and F. T. CORBIN. *Population dynamics of Heterodera glycines as affected by aldicarb and herbicides.*

Three randomized complete block design experiments were conducted in 1978 and 1979 to determine the effect of aldicarb and/or alachlor, fluchloralin, linuron, metalachlor, and metribuzin on population dynamics of *Heterodera glycines*. 'Ransom' soybeans were planted in 1978 and 'Davis' soybeans in 1979. Plots were four rows wide (91-cm row spacing) and 9.1 m long in 1978 and 12.2 m long in 1979. Soil samples were collected from the middle two rows in each plot prior to treatment at selected intervals during the growing season. The nematodes were extracted from the soil by a combination of elutriation and centrifugation. Although there was much variation among the three experiments, alachlor, fluchloralin, and metolachlor generally enhanced nematode population increase (e.g., 264 juveniles/500 cm^3 soil for alachlor vs. 100 for the check in 47 d). Similar results occurred with metribuzin but later than that for alachlor. Late season resurgence occurred with fluchloralin, linuron, and metolachlor (e.g., 8,820, 4,420, and 2,860 *H. glycines* eggs/500 cm^3 soil for fluchloralin, linuron, and the check, respectively). Aldicarb alone induced considerable nematode resurgence by harvest. The resurgence was greater with the in-furrow treatments than with the band treatment (e.g., 3,500, 10,900, and 2,860 eggs/500 cm^3 for the band, furrow, and check, respectively). With the combination treatments, midseason population densities in two experiments were greater with alachlor plus aldicarb than with aldicarb alone. At harvest, however, nematode numbers were less with the combinations than with aldicarb alone. These pesticide-altered nematode densities must be understood to plan good nematode control programs.—*Departments of Plant Pathology and Crop Science, North Carolina State University, Raleigh, NC 27650.*

SLANA, L. J. *A survey of nematodes associated with canker diseases in orchards.*

A total of 221 bark samples from 34 orchards, including peaches, apples, cherries, and nectarines from Indiana, Maryland, New York, Pennsylvania, Virginia, and West Virginia, were examined for the presence of an undescribed *Aphelenchoides* sp. associated with *Cytospora* canker of peach. Bark samples (2 cm^2) with cankers or pycnidia of *Cytospora leucostoma* from cherries, nectarines, and peaches and similar samples of *Batryosphaeria ribes* cankers from apples were submerged in filtered water in Syracuse watchglasses. After 24 h, nematodes were recovered and identified by A. M. Golden (Nematology Laboratory, Beltsville, MD). The previously reported undescribed *Aphelenchoides* sp. was present and in close association with *Batryosphaeria ribes* on apples in New York and Pennsylvania, and with *Cytospora* sp. on cherries in New York, nectarines in Maryland and West Virginia, and on peaches in Indiana, West Virginia, Maryland, Pennsylvania, and New York. Other nematodes found included two *Aphelenchoides* spp., a *Paraphelenchus* sp., and occasionally members of the rhabditid and diplogasterid groups.—*Appalachian Fruit Research Station, USDA SEA AR, Kearneysville, WV 25430.*

SLANA, L. J., and R. M. SAYRE. *A method for measuring incidence of Bacillus penetrans spore attachment to the second-stage larvae of Meloidogyne spp.*

A bioassay method was devised for measuring incidence of the attachment of the infectious spore of *Bacillus penetrans* to the cuticle of the second-larval stages of *Meloidogyne incognita acrita, M. grahami, M. hapla, M. javanica, M. incognita incognita,* and *M. arenaria.* Aliquots (20 g) of greenhouse soil used in propagation of tomatoes infested with *M. incognita* and heavily contaminated with bacterial spore were air dried to kill larvae and then prepared as a slurry. Sixty ml water containing approximately 1,000 larvae of each of the nematode species was added to each aliquot. After 30 min on a wrist action shaker, the excess water in the soil slurry was drawn off using a filter and Bushner funnel. Nematodes were extracted from the moist soil 40 h later using the screen-flotation and modified Baermann funnel techniques. Larvae were microscopically examined for spores adhering to their cuticle. Significant differences were found in the incidence of the bacterial spores on the nematode species. *Meloidogyne incognita acrita* had the highest incidence of larvae with one or more spores, 88.9%; followed by *M. grahami,* 70.5%; *M. hapla,* 59.8%; *M. javanica,* 50.1%; *M. incognita incognita,* 39.7%; and *M. arenaria,* 28.4%. Spores attached more readily to *M. incognita acrita,* the species on which the bacterium was originally found. The soil bioassay provides a method for the evaluation and selection of isolates of *B. penetrans* as specific biocontrol agent against the different species of root-knot nematodes.—*Appalachian Fruit Research Station, USDA SEA AR, Kearneysville, WV 25430; and Nematology Laboratory, USDA SEA AR, Beltsville, MD 20705.*

TAYLOR, C. E. and D. J. F. BROWN. *Variability in the taxonomy and biology of the virus vector nematode, Xiphinema diversicaudatum.*

Populations of *Xiphinema diversicaudatum* obtained from several European countries, New Zealand, and the USA were maintained as breeding cultures, and several aspects of the taxonomy and biology of these populations were studied to determine if variability existed within the species. Significant differences were recorded when the morphobiometrics of different populations were compared. However, all populations, except those from Sicily and Spain, reproduced when allowed access to a combination of strawberry, raspberry, and rose host plants. Also, fertile F_1 hybrids were produced in cross-breeding experiments using females from different populations crossed with males from a Scottish population. Parthenogenetic reproduction was not observed in any of the populations used in the cross-breeding experiments. Specificity of virus transmission was shown to exist between nematode populations and virus strains. Also, crossing specimens from a population which readily transmitted

virus with one which did not transmit virus produced F_1 hybrids having a rate intermediate between that of the parent populations. F_2 hybrids transmitted virus more frequently than did the F_1 hybrids.—*Scottish Crop Research Institute, Invergowrie, Dundee, Scotland, DD2 5DA.*

THOMSON, K. M., and R. S. HUSSEY. *Influence of vesicular-arbuscular mycorrhizae and phosphorus on root-knot on tomato.*

The influence of vesicular-arbuscular mycorrhizal fungi and phosphorus (P) nutrition on infection of tomato cv. Walter by *Meloidogyne incognita* was studied in the greenhouse. Inoculation of plants with either *Gigaspora margarita* or *Glomus mosseae* 2 wk prior to nematode inoculation did not alter infection by *M. incognita* compared with nonmycorrhizal plants regardless of soil P level. However, plants grown in soil containing 35 μg available P/g soil (high P) had significantly fewer eggs/root system and second-stage larvae (L2)/g root than plants in soil with 3μg P/g soil (low P). The number of eggs/female nematode on mycorrhizal or nonmycorrhizal plants was not influenced by the P treatment. Tomato plants with split root systems were used to determine whether the P effect was translocatable. Plants with split root systems were transplanted into double-compartment containers which had either low P soil in both sides or high P in one side and low P in the other. One-half of the split root system of each plant was inoculated with 5,000 eggs/plant 2 wk after transplanting. The total numbers of L2/root system and L2/g of root were reduced by 40% for plants receiving the high P treatment even when the high P soil was opposite the half of the root system inoculated with nematodes. *G. margarita* had no effect on nematode infection of tomato plants with split root systems. These data indicate that supplemental P (35 μg/g) alters root-knot nematode infection of tomato more than does endomycorrhizal fungi.—*Department of Plant Pathology, University of Georgia, Athens, GA 30602.*

TOWSON, A. J., and BERT LEAR. *Injury to bare-rooted roses hot-water treated for elimination of endoparasitic nematodes.*

Heat-induced injury to greenhouse rose, *Rosa* sp., cv. Festive grafted to *R. noisettiana* 'Manetti' followed a linear relationship when reduction in subsequent shoot growth was plotted as the effect of various combinations of the log of the time and the reciprocal of temperature. A 50% reduction in shoot growth resulted when roots were immersed in water at 48.3 C for 14.3 min. The ability to tolerate heat was increased by a hardening pretreatment at 38 C for 24 h. Plants fully immersed at 48.3 C for 20 min produced 214 mm growth in 6 wk; hardened plants produced 1,208 mm growth; check plants produced 1,750 mm growth. Differences were significant according to a rank-sum test. Hardened plants produced more growth ($P < 0.10$) if only roots were immersed than if plants were immersed entirely, according to a rank- sum test. In the fall of 1980, field grown greenhouse *Rosa* sp. cv. Royalty grafted to Manetti were lifted early from the field at Orland, California, to test the hypothesis that plants are more dormant early in the fall and therefore would be more tolerant of hot-water treatments. Dormancy was measured by the number of days until initiation of new growth when planted in the greenhouse; plants required 36, 19, and 9.6 days when lifted in October, November, and December, respectively. Unhardened plants were most sensitive when lifted in October; none survived if fully immersed at 48.3 C for 18 or 25 min, and 10–90% survived if lifted in November or December. Hardened plants survived at rates of 90–100% if lifted in October and November, and 60–90% if lifted in December.—*Department of Plant Pathology, University of California, Davis, CA 95616.*

WALKER, J. T., and J. B. MELIN. *Lesion nematode populations from Pennlawn fescue as influenced by water at different pH values.*

Equal numbers of Pennlawn fescue (*Festuca rubra*) seedlings growing in 7.6-cm pots containing sand were watered routinely

and infested 2 wk after planting with 2,000 larvae and adults of *Pratylenchus penetrans*. Starting one month after planting, seedlings were watered three times a week with equal volumes of water adjusted with sulfuric acid to pH 1.8 and 2.6, distilled water at pH 5.6, or tap water at 8.7. Plants were harvested, nematodes recovered from roots, and roots and grass dry weights measured 3, 5, and 8 wk after initial pH treatments. Greatest nematode populations, based on per gram of tissue dry weight, occurred in grass treated with water adjusted to pH 2.6. Lowest populations occurred where plants were treated with water at pH 1.8. Nematode populations were intermediate in grass watered at pH 5.6 and 8.7. Detrimental effects on grass occurred mainly at pH of 1.8; 35% of the leaf area was necrotic and dry matter was considerably less at this value than at others. Dry matter produced was comparable at pH 2.6, 5.6, and 8.7. Data indicate that acidic rainfall, or natural watering at extreme low pH, may influence populations of lesion nematodes on fescue.—*Department of Plant Pathology, University of Georgia, Georgia Station, Experiment, GA 30212.*

WESTERDAHL, B. B., and R. K. WASHINO. *Influence of soil type on reproduction of Romanomermis culicivorax Ross and Smith.*

The effectiveness of the mosquito parasitic mermithid *Romanomermis culicivorax* in IPM programs will be enhanced if the nematode is able to persist in an aquatic habitat following initial application. The ability of the nematode to reproduce in various substrates is one of many interacting environmental parameters that affect the survival of *R. culicivorax*. Postparasites placed in outdoor ponds with three different substrates (clay loam, loamy sand, and fine sandy loam) were able to penetrate the soil, molt to adults, and produce viable preparasites in all three soil types. A laboratory study was conducted with the following soil types: silty clay, clay loam, loam, fine sandy loam, sandy loam, loamy sand, fine sand, and medium coarse sand. Postparasites burrowed into all of the substrates tested. However, the number of preparasites produced varied, and in some soils postparsites remained on the surface for several days prior to penetration. Although *R. culicivorax* is able to reproduce in a wide variety of substrates, the tendency of postparasites to remain on the surface of some soils for several days prior to penetration could be detrimental to survival in aquatic habitats that contain significant numbers of predators.—*Department of Entomology, University of California, Davis, CA 95616.*

WILLUT, J. M., and R. B. MALEK. *Population response to temperature by Hoplolaimus galeatus, Helicotylenchus pseudorobustus, and H. dihystera.*

The effect of temperature on population development of *Hoplolaimus galeatus, Helicotylenchus pseudorobustus,* and *H. dihystera* were compared on dent corn and red clover in two experiments in constant temperature tanks. Using 5 C increments, the first test ranged from 10 to 35 C and the second from 22 to 32 C. The optimum temperature for population increase of all three species on both hosts was approximately 27 C. The upper limit for reproduction was close to 32 C. There was little or no nematode survival at 35 C. The range for population increase for *H. galeatus* was 22–30 C on corn and 20–32 C on clover; for *H. pseudorobustus,* 20–30 C on corn and 22–30 C on clover; and for *H. dihystera,* 15–32 C on both hosts. Clover was a better host than corn for all three species. Population increase was greatest in *H. dihystera* on both corn and clover and least in *H. galeatus* on corn.—*Department of Plant Pathology, University of Illinois, Urbana, IL 61801.*

WOMERSLEY, C. *A comparison of carbohydrate and lipid reserves in undesiccated and desiccated/rehydrated nematodes.*

The trehalose glycogen and lipid contents of six species of nematodes were studied. Highest glycogen contents occurred in undesiccated *Panagrellus redivivus* and *Turbatrix aceti larvae* (25.23% and 22.73% dry wt., respectively). The glycogen content of desiccated *Anguina tritici* larvae was low

(1.113% dry wt.). Desiccated samples of *A. tritici* and *Ditylenchus dipsaci* contained comparatively high levels of trehalose (9.1% and 4.63% dry wt., respectively); high lipid contents were also recorded (40.6% and 38.3% dry wt., respectively). Undesiccated *Aphelenchus avenae* larvae contained 36.65% dry wt. lipid; this level was reduced by more than 60% in desiccated samples. Total lipid from desiccated *A. tritici* and *A. avenae* samples consisted of approximately 75% triglyceride and 15% phospholipid, with traces of free fatty acids and hydrocarbons. Oleic and linoleic acid were the major free fatty acid components. The phospholipid fraction of both *A. tritici* and *A. avenae* was composed mainly of phosphatidyl ethanolanine and phosphatidyl choline with lesser amounts of phosphatidyl inositol and phosphatidyl serine. The results suggest that the role played by carbohydrate reserves in nematodes capable of desiccation survival may differ from that in nematodes incapable of surviving desiccation. No specific adaptations in lipid composition were apparent in desiccated nematode samples, the results conforming with current research and indicating that high lipid contents appear to function only as food reserves.—*Department of Nematology, University of California, Riverside, CA 92521.*

WOMERSLEY, C., and E. G. PLATZER. *The effect of mermithid parasitism on hemolymph pyruvate levels in mosquito larvae.*

The effect of parasitism by *Romanomermis culicivorax* on the pyruvic acid content of the hemolymph of three species of mosquitos was studied. The hemolymph of healthy *Culex pipiens* late fourth-stage larvae contained the highest pyruvate levels (2.60 mg/ml); the pyruvate content of healthy early fourth-stage larvae was approximately 50% of the former. The hemolymph of healthy *Anopheles freeborni* and *Aedes taeniorhynchus* late fourth-stage larvae had pyruvate contents of 1.25 and 1.35 mg/ml, respectively. In both *C. pipiens* and *A. freeborni* infected late fourth-stage larvae, hemolymph pyruvate levels were reduced by more than 50%. Such a reduction was not apparent in infected *A. taeniorhynchus* late fourth-stage larvae; the pyruvate content of the hemolymph was marginally higher than that found in healthy larvae. The differences observed in pyruvate content between healthy early fourth and late fourth *C. pipiens* larvae emphasize the need for age synchronization of larval mosquitos when conducting comparative studies. Greater variance in pyruvate content was found in the infected hemolymph of *A. freeborni* and *A. taeniorhynchus* larvae, and it is thought that this reflects the lack of compatibility with the parasite. The reduction in pyruvate levels in infected *A. freeborni* and *C. pipiens* larvae suggests a possible disruption of normal carbohydrate and nitrogen metabolism and may be indicative of physiological stress. The significance of the unaltered pyruvate content of *A. taeniorhynchus* hemolymph is at present unknown.—*Department of Nematology, University of California, Riverside, CA 92521.*

WRIGHT, D. J., and A. ROWLAND. *Effects of oxamyl on postinfection development of Meloidogyne incognita.*

Oxamyl (2.5 $\mu g \times g^{-1}$ soil) was applied to cucumber seedlings containing *Meloidogyne incognita* at different stages of development. It was found that the pesticide was very effective in reducing the number of second-stage juveniles which developed to young pyriform adult females, but when applied to third- or fourth-stage juveniles its action was much less marked. These observations support the hypothesis that development of the actively feeding second-stage juveniles of *Meloidogyne* species should be more susceptible to systemic nematicides than that of non-feeding juvenile stages. The application of oxamyl to second-stage juveniles was also found to significantly reduce ($P < 0.001$) the number of females with egg masses, whereas later application of pesticide had no effect. The number of eggs per egg mass and the cross-sectional area of the young adult females was significantly reduced ($P < 0.001$) by all oxamyl treatments; however, the earlier the application of oxamyl the greater the effect. When oxamyl was applied fairly late

in nematode development (when a majority of individuals were young adult females) egg production was reduced compared to control nematodes but the growth of the adult female was affected to a much greater degree. This suggests that under conditions of limited food supply female *M. incognita* are able to direct most of their available resources into egg production.—*Department of Pure and Applied Biology, Imperial College Silwood Park, Ascot, Berkshire, England.*

YIK, CHOI-PHENG, and W. BIRCHFIELD. *Gossypium germplasm resistant to the reniform nematode.*

All commercial cotton varieties are susceptible to the reniform nematode (RN), *Rotylenchulus reniformis*. Wild and cultivated *Gossypium* spp. were tested in the greenhouse for RN resistance. Plants (six replicates) were inoculated with 2,000 RN/plant. These were rated for RN egg production/gram root after 35 d to determine host resistance. Known susceptible, *G. hirsutum* 'Deltapine 16,' was used as a check. A broad range of host reactions was observed. Resistant germplasm was less commonly observed than susceptible. Immunity to RN was observed in wild *G. longicalyx*, and very high resistance in *G. stocksii, G. somalense*, and in the race stock, *G. barbadense* 'Texas 110.' Other cotton lines with potential value in breeding for RN resistance are *G. hirsutum* race marie galante (Texas 893); *G. arboreum* P.I. 417895, P.I. 417891, and CB 3839; and *G. herbaceum* P.I. 408775. All these supported less than 20% egg production compared to the check. Female development and egg production reflected host resistance. Females penetrating the immune *G. longicalyx* did not develop to kidney shapes. Root sections of RN susceptible plants showed typical pericycle hypertrophy, enlarged nuclei and nucleoli, cell wall dissolutions, and granular cytoplasm. In resistant plants endodermal and pericycle cells at feeding sites were collapsed or killed. Heavily stained deposits accumulated in and around these cells. *Gossypium* germplasm immune and highly resistant to the reniform nematode was identified.—*Department of Plant Pathology & Crop Physiology and USDA SEA AR, Louisiana State University, Baton Rouge, LA 70803.*

KRAUS, R. *Effects of the herbicide diallate on hatch, population levels, and control of Heterodera schachtii.*

Heterodera schachtii larval emergence was stimulated 2- to 3-fold in the presence of 2.5–80 ppm diallate. Compared to untreated tests, 2.5 and 5 ppm diallate in soil increased infection of sugarbeet by *H. schachtii;* similarly, treated larvae more readily infected sugarbeet. In field studies, diallate altered population development of *H. schachtii* on different hosts and under different nematode control schemes. At 3.5 l/ha cyst numbers from first generation nematodes increased 1.5 fold in sugarbeets and 2.5-fold in rape, compared to untreated crops; at harvest cyst numbers increased 2-fold in sugarbeet and 3.5-fold in rape. Compared to initial soil populations, the number of eggs and larvae at harvest decreased 31% in untreated and were unchanged in treated sugarbeet soils; in full season rape, untreated soil populations decreased 46% and treated soil populations increased 161%; in wheat and trap crop rape, untreated soil populations decreased 48 and 61%, respectively, and in treated soils populations decreased 86 and 87% in wheat and trap crop rape, respectively. Aldicarb at 10 kg/ha reduced cyst production in sugarbeet by 24%; in combination with diallate cyst populations were reduced 62%. Adicarb in combination with diallate gave the greatest reduction (52%) in egg and larval numbers.—*Institut f. Pflanzenkrankheiten Universitat Bonn, Nussallee 9, Germany.*

McGUIRE, J. M., and S. L. WICKIZER. *Association of Xiphinema americanum with spread of necrotic ringspot of blueberry.*

Necrotic ringspot disease of blueberry is caused by the nepovirus, tobacco ringspot virus (TRSV). In Arkansas, it was first identified in blueberry in 1978. In 1980, four

fields were surveyed for occurrence of necrotic ringspot diseased plants associated with the nematode vector of TRSV, *Xiphinema americanum*. Eight to 75% of plants in affected areas of these fields were infected by, or had died from TRSV. Patterns of occurrence suggested slow spread along or across rows. Viruliferous *X. americanum* were extracted from soil to depths of 60 cm. Highest populations occurred in the upper 15 cm of soil. In 1981, 16 additional plants in one field showed necrotic ringspot symptoms, and all were near previously diseased plants. In another field 42 newly infected plants were found, mostly near previously diseased plants. *X. americanum* transmitted TRSV to blueberry.—*Department of Plant Pathology, University of Arkansas, Fayettevelle, AR 72701.*