ROTHAMSTED RESEARCH

Report for 1961

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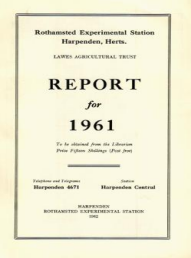

Entomology Department

C. G. Johnson

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the central nervous system, resistant strains of fly required larger doses of diazinon applied externally than did susceptible strains. Experiments were done to see whether the isolated ganglia of the central nervous system of the resistant strain differed from those of the susceptible strain with respect to inhibition of their cholinesterase. "Diazoxon", the active analogue of diazinon, was used. The thoracic ganglia from susceptible and resistant houseflies were dissected out and incubated with various concentrations of "diazoxon" in 0·13*M*-NaCl for 30 minutes, when cholinesterase inhibition was assessed. Histochemical examination by a modification of the Koelle technique (Gomori, 1952) showed no difference between the strains, and this was confirmed when the ganglia were macerated after treatment, and cholinesterase inhibition assessed in the Warburg. Hence, with no differences detected between the properties of the ganglia of the strains, the cause of resistance probably lies elsewhere.

Housefly heads from susceptible and resistant strains were compared for cholinesterase inhibition by "diazoxon" and no difference found. Inhibition in both strains was partially reversible by diluting the solution of inhibited enzyme, and experiments in the Warburg suggested that the body extract partially protected the head cholinesterase from inhibition. The protection was greater when the body extract and "diazoxon" were incubated together in strong than in weak solution. (Lord and Molloy.)

Pyrethrins and related compounds

Calythrone. Earlier work showed that the lower boiling of the two "enols" obtained from pyrethrolone by the action of methanolic sodium methoxide was a substituted cyclopentenedione, and a general route to cyclopentenediones by oxidation of the corresponding ketols was developed (*Rep. Rothamst. exp. Sta.* for 1960, p. 144). Interest was thus stimulated in calythrone, an alkali-soluble compound isolated from *Calythrix tetragona* Lab., for which the structure 4, 5-dimethyl-2-isovalerylcyclopentene-1, 3-dione (I) was proposed, but attempts to confirm it by synthesis failed. Calythrone was interesting, because the suggested structure is related to that of valone, 2-iso-valerylindane-1, 3-dione, which has had some commercial use as an insecticide. The synthesis was therefore attempted. It was found impossible to acylate a preformed dimethylcyclopentenedione in the 2-position, either using a sodium derivative of the cyclopentenedione or with a condensing agent such as boron trifluoride or aluminium chloride and an acid chloride or anhydride.

By using the highly active condensing agent sodium hydride, dimethyl dimethylmaleate was condensed with isobutyl methyl ketone to give calythrone and an acyclic ester (II), so formulated from its properties and because it could not be cyclised to calythrone by further treatment with sodium hydride.

This synthesis confirmed the proposed structure for calythrone, because all the chemical and physical data agreed with those reported for the natural product. When applied to adult mustard beetles by topical application in a 1-μ l. drop of acetone the LD50 lay between 0·05 and 5% w/v. An earlier test with valone indicated that the LD50 for this material was approximately 0·2% w/v, so

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acetic acid decreased the free proline, an effect known to be produced by DDT and organophosphorus compounds. The increase in alanine caused by respiratory poisons would follow the accumulation of pyruvic acid resulting from disturbance to the respiratory cycle. Conversely, a decrease in alanine might reflect either increased activity of the respiratory cycle or a decrease in the amount of pyruvic acid because of blocking of either fat or carbohydrate metabolism. (Lord and Solly.)

Inhibition of cholinesterases in the central nervous system of Musca domestica *L. by diazinon.* After poisoning with diazinon, inhibition of cholinesterase in the central nervous system is localised in certain areas, which include the peripheral regions of the supra-oesophageal and thoracic ganglia, and, more generally, the sub-oesophageal ganglion and the lamina ganglionaris. In contrast to these areas where inhibition is almost complete, the neuropile or synaptic regions of these ganglia retained much enzyme activity 24 hours after a lethal dose had been applied. Lethal doses rarely inhibited cholinesterase throughout the nervous system. Hence, if death is caused by the inhibition of cholinesterase in the nervous system it is because of local inhibition and not generalised inhibition, as has often been supposed. (Molloy.)

Cholinesterase in the peripheral nervous system of Musca domestica *and* Periplaneta americana. The existence of a cholinergic system of neuromuscular transmission in insects is in doubt, partly because the essential components of the system, acetyl choline, choline acetylase and cholinesterase, have not been demonstrated in insect muscle, either biochemically or histochemically. A search was started for cholinesterase in frozen sections of cold-acetone-fixed insect nerve-muscle preparations, using a modification of the thiocholine method of Koelle and Friedenwald. An enzyme that hydrolyses acetyl thiocholine iodide and is inhibited by treatment with eserine, and so is probably specific cholinesterase, occurs in the nerves and finer nerve branches in the leg muscle of the cockroach (*P. americana*), but the amount is very small compared with that in the central nervous system.

Prolonged incubation in the substrate (18 hours at 25° and pH 5·8) shows that this enzyme may also occur in the cockroach leg-muscle fibres themselves, as distinct from the nervous elements in the muscle, particularly in the fibres of the "white" or fast-contracting muscle. However, the technique is not yet good enough to show which parts of the fibre contain the enzyme.

The fine nerve branches in the indirect flight muscle of houseflies are only faintly stained for cholinesterase after 24-hour incubation with the substrate and, unlike *P. americana*, enzyme was not found in the muscle tissue itself.

Preliminary experiments with diazinon-poisoned houseflies showed almost no stain in nerve-muscle preparations, indicating almost complete inhibition of cholinesterase. However, there is so little enzyme present in the unpoisoned fly that it is difficult to assess the degree of inhibition. (Molloy.)

Inhibition of cholinesterase of susceptible and resistant strains of housefly, Musca domestica, *by "diazoxon".* Earlier work showed that to produce a given amount of inhibition of cholinesterase in

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INSECTICIDES AND FUNGICIDES DEPARTMENT

C. POTTER

F. T. Last left to become head of the Mycology and Bacteriology Section of the Glasshouse Crops Research Institute. Mrs. Evelyn Piall also left and was replaced by D. W. Eveling. J. H. Stevenson was appointed to work on pyrethrum.

A. J. Arnold returned after three years at the West African Cocoa Research Institute, and Mr. A. A. Buadu came from the Institute for technical training.

INSECTICIDES

The action of organophosphorus insecticides

Effect of organophosphorus poisoning on the free amino acids in houseflies. Preliminary tests showed that the free amino-acid content of houseflies (*Musca domestica*) was changed by treatment with diazinon and some other organophosphorus poisons. The largest effect was a decrease in alanine, but two other ninhydrin reacting substances, tentatively identified as glutamic and aspartic acids, were also affected. A technique was developed to estimate more quantitatively the free amino acids in houseflies and used to study the effect of diazinon on the content of amino acids of strains of houseflies susceptible and resistant to this poison.

Although some evidence was obtained that the free amino-acid content differs with the strain, this is difficult to establish, because the content in male houseflies depends on age and nutrition. There was no evidence that free amino-acid contents were related with resistance. With all the strains tested, doses well in excess of the LD95 of diazinon decrease some free amino acids; 24 hours after treatment, α-alanine and proline fall by about half, aspartic and glutamic acid by less. The amount of β-alanine also sometimes falls. The amino-acid content is affected 2 hours after treatment, at about the same time as the insects first show symptoms of poisoning. Insects were also treated with a smaller dose (approx. LD50) and examined 16–18 hours later; the amino-acid status of surviving insects was unchanged, whereas in those that die it changed in much the same way as in those treated with larger doses of the poison. The fall in amino-acid content is not related to the amount of poison applied, but to its toxicity; an amount that affects a susceptible strain may have to be increased by 40 times to affect a resistant strain.

Because all but one of the amino acids affected by organophosphorus poisoning are closely linked to the tricarboxylic acid cycle through related keto-acids, the effect of inhibitors of the tricarboxylic acid cycle (fluor-acetic acid) and respiration (cyanide) were examined. Both inhibitors increased the free alanine. Fluor-

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reflect the beneficial effects of the fumigants on yield. The residual larvae on the treated plots multiplied to give populations equal to, or greater than, those in the untreated plots, where the poor root system of the heavily infested plants prevented an increase proportional to that where the plants grew vigorously. The benefit then is only for the immediately succeeding potato crop, and the cost is too great to apply to field crops, where adequate crop rotation can control potato-root eelworm. However, these results have their practical use where tomatoes are grown under glass in infested soil.

A preliminary trial in co-operation with Mr. C. A. Collingwood of the National Agricultural Advisory Service showed that tomato plants growing on " Trapex "-injected plots compared well with those on adjacent steamed areas and were much better than on untreated plots. Root invasion was decreased by 93% in treated plots: estimates of kill from root invasion agreed with those from hatching tests. Applying the fumigant to the soil surface was unpleasant and ineffective. Although treated only 34 days before planting at a soil temperature of 9° C., the tomato plants were unharmed. (Peachey.)

The differences in kill estimated from root invasion and hatching tests, the relative merits of both methods and their relationship to initial and final cyst densities are being studied. (Rao.)

Soil fumigants were applied at recommended doses to strawberry-growing land in Pembrokeshire infested with *Xiphinema diversicaudatum*. " D.D " increased the yield by 50% in 1960 and decreased the incidence of arabis mosaic virus. " Vapam " and " Mylone " failed, probably because they did not penetrate. In 1961, after treatment with " D.D " at 800 lb./acre or methyl bromide at 1 lb./50 sq. ft., no living *Xiphinema* was found. " D.D " at 400 lb./acre killed 97%, and " Trapex " 54%. The methyl bromide penetrated to 12 inches, reaching a CTP of 100 mg./l./hr. Ammonia-nitrogen, determined by Gasser, Chemistry Department, increased after all treatments, reaching 63 p.p.m. for methyl bromide, a tenfold rise over controls. The direct effect of this nitrogen on yields will be considered in 1962. (Peachey and Harrison, Plant Pathology Department.)

Winter fumigation of Woburn ley–arable plots with " Vapam " killed 90% of the plant-parasitic nematodes. (Peachey.)

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in 5% sodium hypochlorate for about 30 minutes, a treatment that partly dissolved the cyst walls. Soaking cysts in trypsin for 24 hours was ineffective. Keeping cysts in darkness during their removal from soil and throughout the hatching test did not give an increased hatch. The possibility that larvae, in the process of hatching, produce a substance which affects the egg membrane was considered. Cysts of *H. rostochiensis* were placed in potato-root diffusate for 2 days and then transferred to water in which many larvae hatched and were removed by sieving. Unstimulated cysts of *H. rostochiensis* and *H. göttingiana* were then placed in this fluid, but there was no hatch from either species.

Hatching in *H. schachtii* has been observed for the first time. As with *Meloidogyne* spp., *H. rostochiensis* and *H. cruciferae*, the larva can move inside the egg just before hatching. Observations began 15 minutes before the larva was liberated, when the stylet was already moving. The larva moved its head slowly back and forth in an arc around the end of the egg, making rhythmical stylet probes at a rate of 40/minute for some time, but about 5 minutes before hatching the rate increased to 90/minute. Eventually the head emerged through a hole about the same as the width of the larva, and the rest of the body squeezed out through the aperture, which did not enlarge.

Various artificial hatching agents have been found for *H. schachtii*, several of them having an activity equivalent to or greater than average beet-root diffusate. Some of these substances are oxazine, mono-azo, diphenyl-methane and anthraquinone dyes, and others, including one found by Dr. C. Winner in Germany, are acridines. Such substances may be useful in unravelling the chemical properties associated with hatching activity. (Shepherd.)

Nematicides

Recommended doses of soil fumigants were applied in autumn 1960 or spring 1961 to small plots of land on Long Mead, Woburn, heavily infested with potato-root eelworm. Their effects on yield were determined by taking a crop of Majestic potatoes, and their effects on the survival of the eelworm by growing Majestic potato plants in pots containing samples of soil from the variously treated plots and counting the number of larvae that invaded a given weight of root. The untreated plots yielded 0·2 tons of ware tubers/acre and had 5,834 larvae/g. of root. Plots treated with methyl bromide in autumn yielded over 11 tons of ware/acre and had only 144 larvae/g. of root. Autumn treatments of " Vapam " or " Mylone " gave yields of 8 tons/acre and root infestations of about 500 larvae/g. of root. Spring treatments with " Trapex " (methyl isothiocyanate) and " Vapam " gave yields varying from 8 to 6 tons/acre, but had lower root infestations of about 100 larvae/g. of root. Plots treated with " D.D " or " Tridipam " yielded only 3 tons/acre, though they decreased the root invasion by 85%. A reasonable yield of potatoes, however, apparently demands bringing the invasion well below the 900 larvae/g. of root achieved by these treatments.

Counts of cysts after the potatoes had been harvested did not

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the eelworm populations of the plots increased, but there was no relationship between yield of tops and peas and the eelworm population, suggesting that yield was influenced more by other factors. At Rothamsted in plots filled with heavy soil, height of plants, weight of tops and weight of peas decreased significantly as the eelworm population increased. The same was true for plots filled with light soil, but the level of significance was less. On neither type of soil were initial and final populations correlated. The eelworm multiplied more in slightly than in highly infested plots, and the population declined in some of the most heavily infested plots. In consequence, the population level was less variable after growing one variety of peas, and tended towards a ceiling of about 100 eggs/g. soil. In 1961 at Rothamsted the plots were divided into two groups, those with 50–100 and those with 100–150 eggs/g. soil and peas, variety Onward, were again sown. Sulphate of ammonia at 0, 10·5 and 21 lb. N/acre was applied to plots on the light soil and 0 and 21 lb. N/acre on the heavy soil. On the light soil nitrogen was without effect, and all plots failed completely from eelworm attack. On the heavy soil nitrogen increased yield significance by 5% on the less heavily infested plots but not on the highly infested plots. (Jones and Shepherd.)

Hatching and hatching factors

As part of the work on hatching factors, large quantities of potato-root diffusate were produced from potted potato plants and small quantities from tomatoes and rape kale. Progress was made in the final stages of characterising the hatching factor for potato-root eelworm (see Clarke, Biochemistry Dept.). Characterisation of the factors for beet eelworm, of which there appear to be several, are still in an early stage.

The method of bioassay in use, devised by Dr. D. W. Fenwick, is to put replicate batches of cysts in water and in dilutions ($\frac{1}{1}$, $\frac{1}{4}$, $\frac{1}{16}$, $\frac{1}{64}$, $\frac{1}{256}$, $\frac{1}{1024}$) of a stock of diffusate and to count the larvae that hatch after 3 weeks at 24°. The hatch is then plotted against dilution to give a standard dilution curve, with which the unknown solutions prepared in the Biochemistry Department are compared after making a suitable series of dilutions. Because cysts and diffusate vary, a standard curve must be included in each weekly set of assays. The method is laborious and time-consuming, and efforts are being made to find ways of making it less so. A simple pipette was devised to produce batches of cysts, and attempts are being made to estimate hatch by absorptiometry, the object being to avoid counting cysts and larvae except as checks on technique. Preliminary results are promising, but assay of purified factors by the dilution technique is beset with many difficulties, the chief of which, apart from variability, is the absence of a sharp end-point to hatching-factor activity. When hatch is plotted against dilution the curve is asymptotic to the water hatch, and the arbitrary end-point found by drawing a straight line through the points to cut the water hatch is not always satisfactory, though no better method of fixing an end-point has been devised. (Gander and Jones.)

Continued attempts to make *H. göttingiana* hatch in the laboratory failed, but active larvae were successfully released by soaking

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diver technique showed that oxygen consumption by *T. macrurus* is independent of size and sex, but is proportional to the surface area of the nematode rather than to its length or volume. (Wallace and Greet.)

Movement of Nematodes

An analysis of the movement of different nematodes from different habitats includes studies of their wave formation in thick and thin water films and between solid particles. Ciné films showed that the active plant nematodes *Ditylenchus*, *Aphelenchoides* and *Anguina* differ greatly from the soil forms such as *Heterodera* and *Tylenchorhynchus*. The results are being used to test mathematical interpretations of undulatory movement. The active plant nematodes, because of their high wave frequency (wave/minute), can swim in deep water, and therefore move into thick water films on the surface of plants and soil. In thin films and between solid particles the wave frequency is *decreased*, and symmetrical waves of long wavelength and short amplitude are produced. The soil nematodes, by contrast, form incomplete and unco-ordinated waves in deep water, and this, combined with a low wave frequency, precludes any swimming in water films and prevents them from escaping from the soil. In thin films and between particles the wave frequency is *increased* and symmetrical, and co-ordinated waves are produced, which permits efficient movement. Free-living nematodes, e.g., *Rhabditis*, *Diplogaster*, have a locomotion similar to the active parasites, suggesting that there are ecological relationships between the two groups. That both of the genera *Aphelenchoides* and *Ditylenchus* contain free-living species supports this hypothesis. (Doncaster and Wallace.)

Cyst-forming Nematodes *Heterodera* spp.

Population studies

Experiments on pea-root eelworm in microplots are in progress at Rothamsted and at Yaxley in collaboration with the Pea Growing Research Organisation. At Yaxley in 1960 the effect of growing seven varieties of pea was compared with broad bean, field bean and fallow in soil previously mixed and containing on average 25 cysts/100 g. and 10 eggs/g. The pea varieties were harvested at the time appropriate for canning, freezing or packeting, and increases in population were roughly proportional to the length of vegetative-life, the least increase being under the quick-maturing variety Meteor (58 cysts/100 g. and 52 eggs/g.) and the greatest under Perfected Freezer (187 cysts/100 g. and 200 eggs/g.). Field bean, harvested dry, raised the population greatly (131 cysts/100 g., 150 eggs/g.), but broad bean harvested in the green-pod stage was comparable with Meteor pea (66 cysts/100 g., 71 eggs/g.). At Yaxley in 1961 and at Rothamsted in 1960 one variety of pea was grown on all microplots (Big Ben at Yaxley and Onward at Rothamsted). At Yaxley there were significant differences in weight of tops, weight of peas, straw length and leaf-stipule areas after the 1960 treatments. The height of the plants and their leaf area declined significantly as

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growing aseptically on an agar film by a water-soluble and dialysable substance that exudes from the seedling. Most larvae were attracted to the root–stem junction of the plant, though some were attracted to the roots, especially the root tips. Larvae moving across an agar surface increased their rate of turning (klinokinesis) near to the plant, and accumulation at the plant appeared to involve a dynamic equilibrium. The attractant was non-specific; it was produced by non-host plants and resistant varieties, and also attracted larvae of the lucerne race. Larvae were also attracted to oat seedlings growing in sand, when the moisture content of the sand allowed nematodes to move.

The number of pre-adult larvae that invaded plants of the susceptible oat variety Sun II and the resistant Manod was not significantly different. Invasion of the susceptible variety, however, led to dissolution of the middle lamellae, hypertrophy and cell digestion, and the larvae matured and multiplied rapidly, whereas there was little cell separation and hypertrophy in the resistant variety, where sexual maturity was delayed and multiplication was greatly slowed. Adult males and females from the resistant variety had shorter bodies and gonads. The length of the female gonad increased rapidly and heterogonically compared with the body during the late fourth stage, especially immediately after the moult, in individuals from both susceptible and resistant varieties. Throughout their growth the length of the body (x) and the length of the gonad (y) were related by the equation $y = bx^k$, where b and k are constants with different values before and after the final moult. (Blake.)

Larvae in dried infected leaves containing the narcissus strain of *D. dipsaci* survived storage at 5° better than at 10° or 20°. Pre-adult larvae revived after 18 months' storage were less infective than pre-adults revived after only 2 months. The population peak in bulbs was slightly earlier than the peak in leaves, and fell almost to zero as bulbs died. In the leaf the population level decreased and then remained constant as the leaf dried and larvae became inactive as eelworm wool. Eelworms migrated into the soil continuously in numbers proportional to the numbers in the bulb. All stages moved into the soil, mostly through the bulb base, and, because the population of the bulb declined as the disease progressed, there was no mass migration when it died. (Webster.)

Biology of *Tylenchorhynchus macrurus*

Tylenchorhynchus macrurus is being used as a test organism in an attempt to get as complete a picture as possible of the ecology of one species of nematode. It occurs in two size forms, of which only the larger has been described. The taxonomy and size distribution of both are being studied in populations from Rothamsted and in Holland. The body length of the two does not overlap, and they may prove to be distinct species. *T. macrurus* orientates in a moisture gradient, and its movement is related to soil moisture and temperature much as in *Heterodera*, *Ditylenchus* and *Aphelenchoides*, which suggests that the basic responses of nematode species of widely different habits follow a similar pattern. The Cartesian

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Stem and Bulb Eelworm, *Ditylenchus dipsaci*

Next to the cyst-forming nematodes, the various biological races of stem and bulb eelworm are the most important nematode pests in Great Britain. Because they attack leaves and stems rather than roots, infection occurs in the soil surface and the nematodes tend to be carried above ground, partly by their own movements and partly by elongation of stems. However, the vertical distribution of *D. dipsaci* in soil of an infested oat plot was similar to that of other nematodes, except that, after rain, the numbers of *D. dipsaci* increase at the surface of the soil and can survive drying in an atmosphere of 50% relative humidity for 34 days, equivalent to a soil moisture tension of pF6 in a dry soil. When infested plants were wetted many *D. dipsaci* emerged. This nematode moved farther in a sandy loam than in a clay soil, but oat seedlings were invaded at similar rates in a clay loam and a sandy loam. Because *D. dipsaci* moves little in clay soils, any tendency it has to move downwards from the infection site at the soil surface is inhibited. Thus, higher concentrations persist on the surface of clay than of sandy soils, and the infestation rate, as well as lateral spread in the surface run-off, is enhanced. Also in similar weather clay soils retain surface moisture longer than sandy soils, so clay soils probably provide more opportunity for the nematodes to move and invade the host plant.

Studies of the directional movements of *D. dipsaci* in gradients of physical stimuli showed that: (*a*) in a temperature gradient of 2°–30° over 15 cm., *D. dipsaci* aggregates at about 10°; (*b*) in a moisture gradient the nematodes aggregate at the end with a high moisture content; (*c*) in a particle-size gradient they collect in the fine particles at one end of the gradient, and that (*d*) the orientation of *D. dipsaci* is unaffected by light, gravity or water percolation, but passive directional movement may occur under the last two stimuli. Orientation in temperature and moisture gradients cannot be explained in terms of a simple orthokinetic response, but aggregation in a particle-size gradient can. (Wallace and Greet.)

The speed with which *D. dipsaci* from oats moves in sand is related to the moisture characteristic where the pore diameter permits movement. In sands of particle size 150–250 μ, 250–500 μ and 500–1,000 μ maximum invasion of oats occurred at the flex point of the moisture characteristic and was greatest in the 250–500 μ sand. For three sands examined, the movement and invasion curves were closely correlated. Movement in sand depended on the forces holding water between the soil particles, and was independent of the osmotic pressure of solutes dissolved in the soil water until their concentration caused incipient plasmolysis of the nematodes. The concentration required to kill *D. dipsaci* approximated to that causing permanent wilting of plants, and so it is unlikely that soil additives such as sugars that act only osmotically would be effective nematicides, although they have been claimed to be. So much would be needed to raise the osmotic pressure of soil water, of which there are some 200 tons/acre, that plants would fail to grow and the soil microfauna would be greatly affected.

Fourth-stage larvae of *D. dipsaci* were attracted to oat seedlings

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subtenuis, *Aphelenchus avenae*, *Ditylenchus myceliophagus* and *Paraphelenchus myceliophthorus*. Six species of fungus-eating nematodes were tested on cultures of the dry-rot fungus, *Merulius lacrymans*, and another wood-rotting fungus, but none reproduced or affected the mycelia adversely. (Goodey and Hooper.)

To study variation in the posterior cuticular pattern of females, on which identification is based, the root-knot nematodes *Meloidogyne arenaria*, *M. javanica* and *M. incognita* were cultured on tomato roots in nutrient foam-agar in plastic bags. The method is time consuming and sometimes fails, but is better than pot culture, because it eliminates cross infection. Inoculations were made with eggs and larvae from selected females and mounts prepared from parents and female offspring of the first and second generations. Infested roots were treated with different fixatives at different temperatures, but there was little difference between mounts, except in the ease with which phasmids could be seen or unwanted tissues cleared away from the cuticle. Better mounts were obtained with lactophenol than with formalin. When adequate collections of patterns have been accumulated they will be used to show the variability between individuals of the same clone. Males were not extracted from the agar-foam cultures, although a few were seen in stained roots. As in *M. arenaria* and *M. incognita*, reproduction in *M. javanica* appears mainly parthenogenetic. (Franklin.)

Visitors from India, Ireland, Japan, Persia, Poland, Switzerland and Yugoslavia were taught to identify nematodes and to extract them from soil by various techniques. Many samples were received for diagnosis and many specimens for identification. *Citrus* spp. from Tripoli were infested with *Tylenchulus semipenetrans*. *Meloidogyne javanica* was received from Tripoli and Egypt and *M. hapla* from Tripoli. (Franklin, Goodey, Hooper.)

Short lengths of film were made of fungi that trap nematodes, of the amoeba *Theratromyxa* that engulfs larvae and of the small zoospore of an Archimycete which attacks *Heterodera* larvae. Zoospores gather in clusters on some part of the nematode body and the cuticle swells. The attacked nematode gradually ceases to move, is penetrated and flask-shaped zoosporangia are formed in it from which zoospores are liberated. (Doncaster.)

Samples taken in February and May from Broadbalk had similar nematode populations after 3, 4 and 9 years continuous wheat. In the wheat crops grown in 1961 the May counts, as expected, were smaller than the February ones, but in the 1961 fallow plots numbers were well maintained in May, and many genera of Tylenchida were more plentiful than in February.

In the Woburn irrigation experiment the effects of irrigation were more pronounced on the grass plots than in the wet season of 1960. In August *Paratylenchus* spp. and *Pratylenchus* spp. were more numerous on watered plots, whereas *Aphelenchus* sp. was more numerous on the unwatered plots. To measure the depth distribution of nematodes in Rothamsted flinty loam and Woburn sand, pits were dug and a post-hole borer was used. Although nematodes were most numerous in the top foot of soil, they were not confined to this layer. Spear-bearing and plant-parasitic nematodes penetrated more deeply than other forms. (Winslow.)

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NEMATOLOGY DEPARTMENT

F. G. W. JONES

Mary T. Franklin and J. B. Goodey were awarded the degree D.Sc. (Lond.) and H. R. Wallace D.Sc. (Liverpool). Seven members of the department and four visiting workers attended the Sixth International Nematology Symposium in Ghent, at which C. C. Doncaster showed films on predators of soil nematodes and on feeding mechanisms. J. B. Goodey visited the Laboratory for Phytopathological Research, Wageningen, and the Bulb Research Station, Lisse. Mr. G. N. Rao (India) joined the department to work for two years on the assessment of nematicides in field trials, and J. M. Webster was appointed in place of J. J. Hesling, who left in December 1960. Mr. W. C. Clark returned to New Zealand in July and became his country's first plant nematologist. R. D. Winslow left in August to join the staff of the Department of Agriculture, Queen's University, Belfast, where he is first holder of the post of nematologist in Northern Ireland.

SYSTEMATICS AND BIONOMICS

The revised text of *Soil and Freshwater Nematodes* went to the publisher in October. It contains some 500 pages, about 300 figures, half of which are new, and 87 tabular keys for the identification of nematodes down to genera.

Work on *Radopholus* shows that it falls into two groups of species. A joint paper with Dr. M. Luc (Côte d'Ivoire) proposes a new genus, *Hirschmannia*, to include *R. lavabri*, *R. gracilis*, *R. oryzae* and *R. mucronatus*. The new genus is distinguished by its high, hemispherical head not offset from the body, by the ventral overlap of oesophagus and intestine, and by the mucronate tail. The five new species of *Longidorus* mentioned last year were described as *L. leptocephalus*, *L. attenuatus*, *L. goodeyi*, *L. caespiticola* and *L. macrosoma*, and the neotype of *L. elongatus* (de Man, 1876) Thorne & Swanger 1936 from the type locality in Holland was redescribed. Careful examination of populations of *Trichodorus* in connection with work on transmission of soil-borne viruses (with Harrison, Plant Pathology Department) showed the presence of an undescribed species together with *T. primitivus*, the vector of tobacco rattle virus. An undescribed species of *Paratylenchus* was also found and will be described. *Aphelenchoides limberi* Steiner 1936 from mushroom compost readily fed and reproduced on mushroom hyphae on malt agar. It also reproduced on *Botrytis cinerea*. Males were not seen; the shape of the female tail terminus varied greatly. Another species of *Aphelenchoides*, close to *A. hunti* Steiner 1935, also reproduced on cultures of *B. cinerea*. Both nematode and fungus were isolated from rotting gardenia buds. Other species which also reproduced readily on *Botrytis cinerea* were *Aphelenchoides composticola*, *A. dactylocercus*, *A. saprophilus*, *A.*

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sampler at the site, and from the dried grass by the standard method used for mouldy hay. This is believed to be the first collection of the fungus in Europe. It is not yet known whether the British strains of the fungus produce sporidesmin. (Gregory and M. E. Lacey.)

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