ADDENDUM

NEMATODES

A Radioisotope Studies

1566 Dropkin, V. H., King, R. C. PLANT PARASITIC NEMATODES HOMOGENEOUSLY LABELED WITH RADIOPHOSPHORUS. Expt. Parasitol. 5, 5 (1956) 469-80.

A quantitative study has been made of the volume and P content of root-knot and golden nematodes (Meloidogyne incognito acrita and Heterodera rostochiensis) during different stages of their life cycles. Galled tissues of plants infested with root-knot nematodes have accumulated P^{32} from labelled nutrient at a lower rate than uninfected roots of the same plant. Infection in one part of a root system, therefore, does not impair the ability of uninfected roots of the same plant to take up P. The P content of the nematode population of an infected tomato plant makes up no more than 10% of the total P of the plant. It follows that the unhealthy condition of the plant is not caused by the parasite "robbing" the host of this vital element. Less P is translocated out of gall roots than out of ungalled roots.

1567 Hunter, A. H. NUTRIENT ABSORPTION AND TRANSLOCATION OF PHOSPHORUS AS INFLUENCED BY THE ROOT KNOT NEMATODE (MELOIDOGYNE INCOGNITO ACRITA). Soil Sci. 86 (1958) 245-50.

Greenhouse experiments with tomato plants grown in nutrient solution indicated that the observed detrimental effects of the root-knot nematode on growth cannot be attributed to an interference with the absorption or translocation of N, K, Ca, Mg, Fe, Cu or P. Although the rate of P absorption as indicated by use of P^{32} was reduced in the infected plants, the total percentage of P content of infected plants was higher than in normal plants. (CA 53: 17405a, 1959)

1568 Oteifa, B. A., Barrada, Y., El Gindi, D. M. AN APPROACH FOR USING LABELLED RADIOACTIVE PHOSPHORUS IN PHYSIO-PATHOLOGICAL STUDIES OF PLANT NEMATODE DISEASES. 2nd UN International Conference on the Peaceful Uses of Atomic Energy, A/CONF. 15/P/1494. 27 (1958) 48-50.

P^{32}-labelled ($KH_2P^{32}O_4$) nutrient solution was used to study the effects of the root-knot nematode, Meloidogyne javanica (Chitwood) on the physio-pathological status of tomato plants, Lycopersicum esculentum Mill. The phosphorus content and the physiological route of the element through host tissue were affected. The root parasitic nematodes incite gall formation. An infection in the early stages of plant growth makes the host utilize its energy in the production of new lateral rootlets, i. e. meristematic tissue capable of absorbing more nutrient. The new rootlets then become infected with the newly hatched larvae. Extensive gall formation subsequently causes a reduction in the root absorptive surface. The presence and activity of the parasite in the root interfere with the translocation of nutrient. Phosphorus uptake by the nematode is, however, only 10%. Reasons for the interference are discussed.

B Ionizing Radiation Studies

1569 Anonymous. RADIATION OUT AS NEMATOCIDE. J. agric. Food Chem. 6, 8 (1958) 567.

USDA scientists are disappointed to find that nematodes can withstand large doses of radiation. It takes 120 000 r to kill the golden nematode, up to 20 000 r to sterilize the female. Some other nematodes require 350 000 to 640 000 r before giving up the ghost. (Humans will invariably die from a 650-r dose.) Plants cannot withstand the dosage necessary to kill nematodes, so there is no prospect that radiation can be used for killing nematodes on living plants. (from Research Newsletter)

1570 Fassuliotis, G. EFFECTS OF IONIZING RADIATIONS ON THE GOLDEN NEMATODE, HETERODERA ROSTOCHIENSIS. Radiation Res. 9 (1958) 112-3.

The golden nematode, H. rostochiensis, is a parasite of potatoes and tomatoes. The resistant stage of the nematode, the cyst, containing several hundred embryonated eggs, was irradiated with x-rays from a G. E.

Maxitron 250 delivering a dose rate of 1000 r/min and with γ-rays from a Co^{60} source emitting 670 000 r/h at the Brookhaven National Laboratory, Upton, New York. The doses were 5, 10, 20, 40, 80, 160, 320, 640 and 1280 kr. Hatching tests from cysts exposed to both types of radiations revealed a disturbance in the response of the larvae, after a dose of 160 kr and above. A delay in the onset of hatching and a reduction in the total number of larvae emerging from the cysts resulted. No larvae hatched after 640 kr; they were found to be in a moribund condition one week after irradiation. Injury resulting in abnormal body movements became apparent after 80 kr. Eighty-four per cent of the females developing from larvae irradiated with 20 kr were sterilized, 98% after 40 kr, and 100% after 80 kr. However, no larvae hatched from the 20 and 40 kr-females. Viability was not altered in developing females following postirradiation storage of irradiated cysts for 6 months at 40°F. Chromosome aberrations in the form of fragments and bridges at anaphase were found in maturing eggs recovered from females which developed from irradiated larvae.

(Abstract of paper presented at the Intern. Congr. of Radiation Res., Burlington, Vermont, 10-16 Aug. 1958)

1571 Fassuliotis, G. OBSERVATIONS ON THE BIOLOGICAL EFFECTS OF IONIZING RADIATIONS ON THE LIFE CYCLE OF HETERODERA ROSTOCHIENSIS WOLLENWEBER, 1923. Ph. D. Thesis, New York Univ. 1958.

1572 Fassuliotis, G., Sparrow, A. H. PRELIMINARY REPORT OF X-RAY STUDIES ON THE GOLDEN NEMATODE. Plant Dis. Reptr. 39, 7 (1955) 572.

Data were obtained which indicate that the life cycle of Heterodera rostochiensis is interrupted by x-rays at dosages of 20 000 r and above. The lowest dose found to inhibit the development of embryonated eggs is the same as the dose found to inhibit completely the sprouting of potatoes. Although the nematode data were obtained from free cysts, the results indicate that irradiation of tubers infected with the golden nematode will not only inhibit sprouting, but will probably also interrupt the life cycle of the parasite, thus eliminating one of the possible routes of spread of the golden nematode.

1573 Myers, R. F., Dropkin, V. H. EFFECTS OF X-RAYS AND γ-IRRADIATION ON SOIL AND PLANT-PARASITIC NEMATODES. Radiation Res. 9 (1958) 158.

Ten genera of plant parasitic and three genera of free-living nematodes were exposed to graded doses of radiation. Pot experiments showed that some genera required up to 160 000 rep for complete sterilization, whereas other genera were sterilized at doses between 20 000 and 40 000 rep. Dosages necessary to kill 50% of Panagrellus silusiae adults in culture within 24 h were between 400 000 and 500 000 rep. Similar dosages killed Tylenchorhynchus claytoni in pot experiments. A marked reduction in population size of cultures and pot experiments was noted at dosages well below the sterilizing dose. A high percentage of embryos of Panagrellus were killed at 5000 r. The ability of nematodes to survive large doses of irradiation is probably correlated with the cell constancy in these forms. The dosage necessary to sterilize plant parasitic nematodes is too high to make radiation a feasible tool for soil sterilization or for treatment of living plants.

(Abstract of paper presented at the Intern. Congr. of Radiation Res., Burlington, Vermont, 10-16 Aug. 1958)

1574 Myers, R. F., Dropkin, V. H. IMPRACTICABILITY OF CONTROL OF PLANT PARASITIC NEMATODES WITH IONIZING RADIATIONS. Plant Dis. Reptr. 43, 3 (1959) 311-3.

Irradiation of 11 species of plant parasitic nematodes indicates that the dose required for complete sterilization is variable; reproduction being completely stopped with doses of 40 000 r in only one species. For six other species, doses above 160 000 r were required to stop reproduction. However, a large reduction in the reproduction of most species can be achieved with a dose of 80 000 r. The irradiation of nematodes in field soil with a Co^{60} source is not practical because of the length of time required to irradiate even small areas. Since damage to plant roots occurs at levels of irradiation below those required to disrupt the nematode's life cycle, control of plant parasitic nematodes in and on plant roots by ionizing radiations is not feasible. (auth.)

1575 Myers, R. F. THE SENSITIVITY OF SOME PLANT-PARASITIC AND FREE-LIVING NEMATODES TO GAMMA AND X-IRRADIATION. Nematologica 5 (1960) 56-63.

The sterilizing effect of ionizing rays was examined on 14 free-living and plant-parasitic nematodes. Reductions in population could be obtained with considerably lower doses than those required for complete sterilization. The embryonic stage is the most sensitive stage in the developmental cycle of Panagrellus silusiae. Larvae and adults support much higher doses. Cell division took place up to 320 000 r provided

the gonads were already formed. In Tylenchorhynchus claytoni cells matured up to 500 000 r as judged from an increase in length, and the formation of vulva and spicula. Body changes due to radiation could take the form of an increase or decrease in body length. These opposite effects were due to damage which prevented uptake of nourishment, or to sterilization without accompanying effect on food intake. Morphological changes occurred in both cases, and include cuticular and internal damage.

1576 Weischer, B. DIE WIRKUNG IONISIERENDER STRAHLEN AUF DIE ENTWICKLUNG VON HETERODERA ROSTOCHIENSIS UND H. SCHACHTII (The effects of ionizing rays on the development of Heterodera rostochiensis and H. schachtii). Nematologica 2 (1957) 300-5. (In German)

Cysts of the golden and the turnip nematode were subjected to radiation from a radium source. The dose was of the order of 400 r/h. Only after 72 h irradiation could any effect be observed. The duration of treatment was extended to 196 h for the experiments. Hatching of larvae was speeded up in the case of the golden nematode, and slowed down for the turnip nematode. The former is, however, interpreted as a pathological stimulus which significantly reduced vitality. This may be seen in experiments on infectivity extended over two generations.

1577 Wood, F. C., Goodey, J. B. EFFECTS OF GAMMA RAY IRRADIATION ON NEMATODES INFESTING CULTIVATED MUSHROOM BEDS. Nature 180 (1957) 760-1)

Nematodes in a compost from infested mushroom beds were identified as Ditylenchus destructor and Saprobes, mostly Rhabditis spp. Duplicated 200 g samples were subjected to doses of 6000, 12 000, 24 000, 48 000 and 96 000 rep of γ-radiation from a Co^{60}-source. The inactivation dose for these nematodes appears to lie between 48 000 and 96 000 rep, more than twice as great as the 10 000 - 20 000 r found to inactivate cysts of potato-root nematode (Heterodera rostochiensis) (see Fassuliotis and Sparrow, Plant Disease Reporter 38 (1956) 572).

APPENDIX

TABLE Ia

DISPERSAL OF RADIOISOTOPE-MARKED FOREST INSECTS

Insect	Isotope	No. released	Recovery and longevity	Maximum dispersal (km)	Authority
White Pine Weevil *Pissodes strobi*	Co^{60}	64	33% in 60 d	--	[101]
" "	Sc^{46}	1600	60 - 70% up to 8.5 months	0.22	[99]
Douglas Fir Beetle *Dendroctonus pseudotsugae*	P^{32}	--	--	--	[260]
Southern Pine Beetle *Dendroctonus frontalis*	Ir^{192}	20 000	--	--	[371]
Engelmann Spruce Beetle *Dendroctonus engelmanni*	P^{32}	19 000	5% up to 14 d	--	[354]
" "	I^{131}	--	--	4.8	[98]
European Pine Shoot Moth *Rhyacionia buliana*	Co^{60}	104	42.9	0.046	[123]
White grubs	Ta^{182}	Movement in soil		--	[371]

Jenkins, D.W. Table II in "Radioisotopes in ecological and biological studies of agricultural insects." p. 3 - 21 in "Radioisotopes and Radiation in Entomology. Proceedings of a Symposium, Bombay 5 - 9 December 1960". Vienna, IAEA. 1962, 307.

TABLE 1b

DISPERSAL OF RADIOACTIVE-MARKED ORCHARD INSECTS

Insect	Isotope	No. released	Longevity	Maximum dispersal (km)	Authority
Plum curculio Conotrachelus nenuphar	P^{32}	82	up to 120 d	0.11	[369] [370]
" "	Co^{60}	705	up to 8.5 months	0.27	" "
" "	Zn^{65}	23	up to 120 d	0.041	" "
" "	Sr^{89}	175	3 d	0.123	" "
" "	I^{132}	86	--	0	" "
Oriental Fruit Fly Dacus dorsalis	P^{32}	--	up to 40 d	--	[95]
Fruit Fly Drosophila melanogaster	P^{32}	20 000	--	3.84	[97]
Mediterranean Fruit Fly Ceratitis capitata	P^{32}	944	--	32.0	[92]
Cherry Fruit Fly Rhagoletis cingulata	P^{32}	2010	up to 42 d	0.287	[93]
Walnut Husk Fly Rhagoletis completa	P^{32}	15% of natural population	--	14.4	[91]

Jenkins, D.W. Table III in "Radioisotopes in ecological and biological studies of agricultural insects." p. 3-21 in "Radioisotopes and Radiation in Entomology. Proceedings of a Symposium, Bombay 5-9 December 1960". Vienna, IAEA. 1962, 307.

TABLE Ic

DISPERSAL AND FLIGHT RANGE OF RADIOACTIVE-MARKED MOSQUITOES

Species	Locality	No. mosquitoes released × 1000	% Recovery	Maximum flight range (km)	Reference	
Aedes communis	Churchill	3000	0.005	1.6	JENKINS and HASSETT	[110]
Aedes flavescens	Saskatchewan	—	—	0.16	SHEMANCHUK et al.	[348]
" "	Saskatchewan	415	0.02	10.5	Ibid.	[115]
Aedes nigromaculis	California	400	0.12	3.0	THURMAN and HUSBANDS	[118]
Aedes spencerii	Saskatchewan	—	—	0.023	SHEMANCHUK et al.	[348]
Aedes taeniorhynchus	Florida	1000	0.03	32.0	PROVOST	[111]
" "	Florida	1580	0.12	40.0	Ibid.	[112]
" "	Georgia	2000	0.023	32.6	BIDLINGMAYER and SCHOOF	[108]
Anopheles bellator	Brazil	3	—	0.8	ARAGÃO et al.	[343] [107] [344]
Anopheles gambiae	Tanganyika	60	0.5	3.8	GILLIES	[771]
Culex tarsalis	California	10	—	1.6	THURMAN and HUSBANDS	[118]
Psorophora confinnis and P. discolor	Arkansas	50 —	0.09 —	9.6 2.4	QUARTERMAN et al.	[114]

Jenkins, D.W. Table VI in "Radioisotopes in entomological studies of endemic and tropical diseases." p. 233-66 in "Radioisotopes in Tropical Medicine. Proceedings of a Symposium, Bangkok, 12 - 16 December 1960". STI/PUB/31, Vinna, IAEA. 1962, 379 p.

TABLE Id

DISPERSAL AND FLIGHT RANGE OF RADIOACTIVE-MARKED FLIES

Locality	Habitat	No. flies released × 1000	% Recovery	Maximum flight range (km)	Reference	
Housefly Musca domestica						
Oregon	Rural	36	4.6	19.2	LINDQUIST et al.	[74]
Oregon	Rural	54	2.78	32.0	YATES et al.	[90]
Arizona	City	31	0.73	4.8	SCHOOF et al.	[80]
Arizona	City	56	0.51	8.0	SCHOOF et al.	[80]
Arizona	City	342	1.8	14.4	SCHOOF and SIVERLY	[82]
Georgia	Rural	13.5	8.0	13.1	QUARTERMAN et al.	[78]
Georgia	City	40	0.24	12.2	QUARTERMAN et al.	[79]
Blowfly Phormia regina						
Oregon	Rural	1.2	14.0	12.8	LINDQUIST et al.	[74]
Oregon	Rural	60	2.64	44.8	YATES et al.	[90]
West Virginia	City	16	0.06	16.5	SCHOOF and MAIL	[81]
Georgia	City	--	--	6.4	QUARTERMAN et al.	[79]

Jenkins, D.W. Table VII in "Radioisotopes in entomological studies of endemic and tropical diseases." p. 233-66 in "Radioisotopes in Tropical Medicine. Proceedings of a Symposium, Bangkok, 12 - 16 December 1960". STI/PUB/31, Vienna, IAEA. 1962, 379 p.

TABLE II

RADIATION STERILIZATION OF MEDICALLY-IMPORTANT INSECTS

Dosage (r)	Stage irrad.	% Sterility and egg laying	Insect	Reference
2500	male pupae	100%; few sterile eggs laid	Callitroga hominivorax	BUSHLAND and HOPKINS [1111]
5000	female pupae	100%; few sterile eggs laid	Ibid.	BUSHLAND and HOPKINS [1111]
8050	adults	few fertile eggs	Drosophila	HASSETT and JENKINS [1252]
16100	adults	100%; no eggs	Ibid.	HASSETT and JENKINS [1252]
3200	pupae	few eggs	Anopheles quadrimaculatus	DAVIS et al. [1116]
6400	pupae	50% reduction of sterile eggs	Ibid.	DAVIS et al. [1116]
12900	pupae	no decrease in fertile eggs	Ibid.	DAVIS et al. [1116]
8865	pupae	2% eggs hatched	Ibid.	DAVIS et al. [1116]
5000	adults	66% decrease in eggs. 89% hatch	Ibid.	DAVIS et al. [1116]
8865	adults	100% sterile, few eggs, no hatch	Ibid.	DAVIS et al. [1116]
10000	nymph	9 - 82% eggs hatched	Pediculus humanus	COLE et al. [888]
10000	adult	100%, no hatch	Ibid.	COLE et al. [888]

Jenkins, D.W. Table III in "Radioisotopes in entomological studies of endemic and tropical diseases." p. 233 - 66 in "Radioisotopes in Tropical Medicine. Proceedings of a Symposium, Bangkok, 12 - 16 December 1960". STI/PUB/31, Vienna, IAEA. 1962. 379 p.

TABLE III

MORTALITY OF IRRADIATED INSECTS OF MEDICAL INTEREST

Insect	Radiation	Dosage (r)	Mortality (%)	Time (days)	Reference
Aedes aegypti (adult)	x	20 000	50	18	TERZIAN [1333]
Ibid.	x	30 000	50	12	Ibid.
Ibid.	x	40 000	50	9	Ibid.
Ibid.	x	20 000	100	30	Ibid.
Ibid.	x	30 000	100	21	Ibid.
Ibid.	x	40 000	100	12	Ibid.
Drosophila adult (fasted)	B	60 000	100	1	KING and WILSON [1319]
Ibid. (fed)	B	60 000	60	14	Ibid.
Ibid.	γ	64 000	100	21	HASSETT and JENKINS [1252]
Ibid.	γ	193 000	100	2	Ibid.
Blattella germanica (60 days)	γ	72 000	14	--	Ibid.
Musca domestica egg	γ	130	50	1	COLE et al. [888]
Ibid. larva	γ	1 300	50	1	Ibid.
Ibid. pupae	γ	15 000	50	1	Ibid.
Ibid. male	γ	72 000	50	1	Ibid.
Ibid. female	γ	110 000	50	1	Ibid.
Pediculus h. humanus egg	γ	24 000	50	1±	Ibid.
Ibid. nymph ♂/♀	γ	170 000	50	1±	Ibid.
Blattella germanica nymph ♂/♀	γ	76 000	50	2	Ibid.
Periplaneta americana nymph	γ	28 000	50	1	Ibid.
Ibid. adult	γ	50 000	50	1	Ibid.

Jenkins, D.W. from Table IV in "Radioisotopes in entomological studies of endemic and tropical diseases." p. 233 - 66 in "Radioisotopes in Tropical Medicine. Proceedings of a Symposium, Bangkok, 12 - 16 December 1960". STI/PUB/31, Vienna, IAEA. 1962, 379 p.

TABLE IV

REFERENCES FOR THE SYNTHESIS OF SOME RADIO-LABELLED ORGANIC INSECTICIDES AND RELATED COMPOUNDS

Common name	Chemical name and isotope	Reference
Chlorinated Hydrocarbon		
Endrin	1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo, endo-5, 8-dimethanonaphthalene-6, 7-C^{14}	[497]
DDT	2, 2-bis-(p-chlorophenyl)-1, 1, 1-trichloro-2-C^{14}-ethane 2, 2-bis-(p-chlorophenyl-4, 4′-C^{14})-1, 1, 1-trichloroethane	[463] [480] [483] [465]
Thiodan	6, 7, 8, 9, 10, 10-hexachloro-1, 5, 5a, 6, 9, 9a-hexahydro-6, 9-methano-2, 4, 3-benzodioxathiepin-3-oxide-5a, 9a-C^{14}_2	[501]
Organophosphorus		
Co-Ral	O, O-diethyl O-3-chloro-4-methylumbelliferone-P^{32}-phosphorothioate	[514]
Demeton	O, O-diethyl S(and O)-2-(ethylthio)ethyl-P^{32}-phosphorothioate	[634]
DDVP	O, O-dimethyl 2, 2-dichlorovinyl-P^{32}-phosphate	[554] [555]
Diazinon	O, O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl)-P^{32}-phosphorothioate	[542]
Dimethoate	O, O-dimethyl S-(N-methylcarbamoylmethyl)-P^{32}-phosphorodithioate	[552]
Dipterex	O, O-dimethyl 1-hydroxy-2, 2, 2-trichloroethyl-P^{32}-phosphonate	[554] [555]
Malathion	O, O-dimethyl S-(1, 2-dicarbethoxyethyl)-P^{32}-phosphorodithioate	[567] [566]
Parathion	O, O-diethyl O-(p-nitrophenyl)-P^{32}-phosphoro-S^{35}-thioate O, O-diethyl O-(p-nitrophenyl) phosphoro-S^{35}-thioate	[575] [578]
Ronnel	O, O-dimethyl O-(2, 4, 5-trichlorophenyl)-P^{32}-phosphorothioate	[601]
Carbamate		
Sevin	1-naphthyl-1-C^{14}-N-methyl carbamate	[706]
Pyrethroid		
Allethrin	d, l-allelrethonyl-d, l-cis, trans-2-C^{14}-chrysanthemate d, l-3-allyl-2-C^{14}-methyl-4-oxo-2-cyclopenten-1-C^{14}-yl chrysanthemate	[667] [679]
Synergist		
Piperonyl Butoxide	α-[2-(2-butoxyethoxy)ethoxy]-4, 5-methylenedioxy-2-propyltoluene-1-C^{14}-methylene	[676]
Repellent		
Deet	N, N-diethyl-m-toluamide (C^{14}-carboxy)	[714]

Hopkins, T.L. Table I of "Radioisotope Techniques and Recent Research on Metabolism of Insecticides in Insects." p. 101-111 in "Radioisotopes and Radiation in Entomology. Proceedings of a Symposium, Bombay 5-9 December 1960". Vienna, IAEA. 1962, 307.

TABLE V

RADIOTRACER STUDIES ON THE METABOLISM OF ORGANOPHOSPHATE INSECTICIDES BY PLANTS

(Abbreviations: Me = methyl, Et = ethyl, Ph = phenyl, antiChE = anticholinesterase agent or cholinesterase inhibitor)

No.	Structure and name	Absorption and translocation	Hydrolysis products	Non-hydrolysed metabolites
1	$(MeO)_2P(O)OCH=CCl_2$ DDVP	pea [555]	pea [555]	
2	$(MeO)_2P(O)OC(Me)=CHC(O)OMe$ Phosdrin or OS 2046 alpha and beta isomers studied separately	Bryophyllum, cucumber, pea [660]	pea [1441] [660]; bean, Bryophyllum, corn, cucumber [660]; plants; $(MeO)_2P(O)OH$? and $(MeO)_2P(O)OC(Me)=CHC(O)OH$? [660]; pea; $(MeO)_2P(O)OH$ and $(MeO)_2P(O)OC(Me)=CHC(O)OH$ [598]	None in plants [1441] [660]
3	$(MeO)_2P(O)OC(Me)=CHC(O)OH$ Carboxylic acid hydr. prod. of alpha Phosdrin		pea; $(MeO)_2P(O)OH$ and $(MeO)(HO)P(O)OC(Me)=CHC(O)OH$ [598]	
4	$(MeO)_2P(O)OCHBr\cdot CCl_2Br$ Dibrom		plants?; $(MeO)_2P(O)OH$, $BrCl_2C\cdot CHO$, $Cl_2HC\cdot CHO$, and complex amino acid conjugates	plants?; $(MeO)_2P(O)OCH=CCl_2$
5	$(MeO)_2P(O)CHOH\cdot CCl_3$ Dipterex, Dylox, Bayer L 13/59	pea [555]	pea [555]	
6	$(MeO)_2P(O)CHOC(O)Me$ CCl_3 acetylated Dipterex	pea [555]	pea [555]	
7	$(MeO)_2P(O)SC_2H_4SEt$ methyl isosystox, thiol isomer of meta-Systox		many plants; $(MeO)_2P(O)OH$, H_3PO_4 and lecithins [645]	many plants; $(MeO)_2P(O)SC_2H_4S(O)Et$ and $(MeO)_2P(O)SC_2H_4S(O_2)Et$ [645]
8	$(MeO)_2P(O)SC_2H_4S(O)Et$ sulphoxide of methyl isosystox		cabbage, potato; $(MeO)_2P(O)OH$, H_3PO_4 and lecithins [645]	cabbage, potato; $(MeO)_2P(O)SC_2H_4S(O_2)Et$ [645]

TABLE V (cont'd)

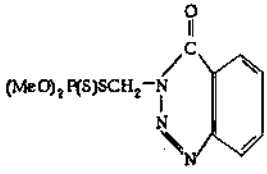
No.	Structure and name	Absorption and translocation	Hydrolysis products	Non-hydrolysed metabolites
9	$(MeO)_2P(O)SC_2H_4S(O_2)Et$ sulphone of methyl isosystox		cabbage, potato; $(MeO)_2P(O)OH$, H_3PO_4 and lecithins [645]	
10	$(MeO)_2P(S)OPh{-}NO_2{-}4$ methyl Parathion	many plants [574]	many plants [574]; hydrangea; H_3PO_4 and unident. metabolites [574]	
11	$(MeO)_2P(S)OPh{-}S(O)Me{-}4$ Bayer 25198	cotton [657]	cotton [657]	
12	 Guthion, Gusathion, Bayer 17147	cotton [562]	cotton; hydr. prod's including phosphatides [562]	cotton; two strongly lipophilic unident. metabolites, of unknown toxicity, but no apparent P = O Guthion [562]
13	$(MeO)_2P(S)SCH_2C(O)NHMe$ Dimethoate, Rogor	corn, cotton, pea, potato [551]	corn, cotton, potato; $(MeO)_2P(O)OH$, $(MeO)_2P(S)OH$, $(MeO)(HO)P(S)CH_2C(O)NHMe$, and $(MeO)_2P(O)SCH_2C(O)OH$ [551]; pea; as above plus H_3PO_4 [551]	corn, cotton, pea, potato $(MeO)_2P(O)SCH_2C(O)NHMe$ [551] bean, lettuce; $(MeO)_2P(O)SCH_2C(O)NHMe$? and a less polar antiChE-agent [763]
14	$(CH_3O)_2P(S)SCH_2C(O)NHEt$ CL 18,706	cotton [551]	cotton [551]	
15	$(MeO)_2P(S)SCH(CH_2C(O)OEt)\cdot C(O)OEt$ Malathion	bean [50]	bean; $(MeO)_2P(S)OH$, H_3PO_4, $(MeO)_2P(S)SH$?, $(MeO)_2P(S)SCH(CH_2C(O)OH)\cdot(CO)OH$ and $(MeO)_2P(S)SCH(CH_2C(O)OEt?)\cdot C(O)OH$	bean; $(MeO)_2P(O)SCH(CH_2C(O)OEt?)\cdot C(O)OEt$
16	$(EtO)_2P(O)SC_2H_4N(Et)_2$ Amiton	cotton, lemon [664]	cotton, lemon [664]	none in plants [664]

TABLE V (cont'd)

No.	Structure and name	Absorption and translocation	Hydrolysis products	Non-hydrolysed metabolites
17	$(EtO)_2P(O)SC_2H_4N(Et)_2 \cdot HX$ salts of Amiton (Tetram or Chipman R-6199 is hydrogen oxalate salt)	cotton; citrate, dimethyl sulphate, oxalate, picrate, phthalate, p-toluene sulphonate, trichloroacetate salts [644]; lemon; dimethyl sulphate, hydrochloride, oxalate, p-toluene sulphonate salts [644]; orange; oxalate salt [644]; cacao; p-toluene sulphonate salt [658]	cotton, lemon; oxalate salt [644]; cacao; p-toluene sulphonate salt [658]	none in plants [644] [658]
18	$(EtO)_2P(O)SC_2H_4S(Me)Et \cdot MeSO_4$ dimethyl sulphonium salt of isosystox	cotton, lemon [642]		cotton; unidentified metabolite [642]
19	$(EtO)_2P(O)SC_2H_4SEt$ and $(EtO)_2P(S)OC_2H_4SEt$ Systox Demeton (mixed isomers)	cotton [630] [732]; lemon [756]	many plants; field residue data [643]; plants; $(EtO)_2P(O)OH$?, alcohols? [643]	apple, orange, walnut; $(EtO)_2P(O)SC_2H_4S(O)Et$, $(EtO)_2P(O)SC_2H_4S(O_2)Et$?, $(EtO)_2P(S)OC_2H_4S(O)Et$ plus $(EtO)_2P(S)OC_2H_4S(O_2)Et$ and/or $(EtO)_2P(O)OC_2H_4S(O)Et$ [643]
20	$(EtO)_2P(O)SC_2H_4SEt$ isosystox, thiol isomer of Systox or Demeton	cotton, lemon [644] [642]; bean, lemon [641]; potato, tobacco [646]; bean, borage, mustard [648]; apple, bean, coleus [649]; lettuce, nettles [620]; alfalfa, cotton, sugar beet [595]; cotton [755]	cotton [644]; bean, cotton [646] [647]; orange [643]; potato, tobacco [646] [647]; bean, borage, mustard [648]; apple, bean, coleus [649]; lettuce, nettles [620]; alfalfa, cotton, sugar beet [595]; cotton [755]	orange; $(EtO)_2P(O)SC_2H_4S(O)Et$, $(EtO)_2P(O)SC_2H_4S(O_2)Et$ [643]; cotton; $(EtO)_2P(O)SC_2H_4S(O)Et$, $(EtO)_2P(O)SC_2H_4S(O_2)Et$ [642] [635] [636]; Brassica, nettles, sugar beet, turnip; 3 unidentified metabolites [638]; bean, lettuce; unidentified metabolite(s) [641]; potato, tobacco; unidentified "more toxic" compounds [646]; bean, borage, mustard; 2 unidentified metabolites [648]; lettuce, nettles; $(EtO)_2P(O)SC_2H_4S(O)Et$ plus 1 unidentified oxidative metabolite plus 2nd unidentified metabolite [620]

TABLE V (cont'd)

No.	Structure and name	Absorption and translocation	Hydrolysis products	Non-hydrolysed metabolites
21	$(EtO)_2P(O)SC_2H_4S(O)Et$ sulphoxide of isosystoc	cotton, lemon [642]	cotton [642]	cotton; $(EtO)_2P(O)SC_2H_4S(O_2)Et$ [642]
22	$(EtO)_2P(S)OC_2H_4SEt$ Systox or Demeton	cotton, orange [643]: bean, lemon [641]: turnip [620]: many plants [651]	bean, cotton, orange [643]	orange; $(EtO)_2P(S)OC_2H_4S(O_2)Et$, $(EtO)_2P(O)OC_2H_4S(O)Et$ [643]: plants; unidentified metabolite(s) [638]: bean, lemon; unidentified metabolite(s) [641]: cotton; $(EtO)_2P(S)OC_2H_4S(O)Et$ plus $(EtO)_2P(S)OC_2H_4S(O_2)Et$ and/or $(EtO)_2P(O)OC_2H_4S(O)Et$ [635]: turnip; 3 unidentified metabolites [620]
23	$(EtO)_2P(S)OC_2H_4N(Et)_2$ thiono isomer of Amiton	cotton, lemon [644]	cotton, lemon [644]	
24	$(EtO)_2P(S)SCH_2SEt$ Thimet or Phorate	many plants [589]: alfalfa, cotton, sugar beet [595]: alfalfa, cotton, lemon [755]: bean [590]: pea [592]	many plants [589]: alfalfa, cotton, sugar beet [595]: cotton [755]: bean; $(EtO)_2P(S)SH$, $(EtO)_2P(S)OH$, $(EtO)_2P(O)OH$, H_3PO_4, unknown (maybe de-ethylated deriv.) [590]: pea [592]	cotton; $(EtO)_2P(S)SCH_2S(O)Et$, $(EtO)_2P(S)SCH_2S(O)_2Et$, $(EtO)_2P(O)SCH_2S(O)Et$, $(EtO)_2P(O)SCH_2S(O_2)Et$ [589]: pea; $(EtO)_2SP(S)SCH_2S(O)Et$, $(EtO)_2P(S)SCH_2S(O_2)Et$ [589]: alfalfa, cotton, lemon; as above on cotton [755]: bean; as above on cotton [590]
25	$(EtO)_2P(S)SC_2H_4SEt$ Disyston, Dithiodemeton, Ekatine	cotton [657]: alfalfa, cotton, sugar beet [595]: alfalfa, bean, cotton, lemon [755]: pineapple [558]	cotton [657]: alfalfa, cotton, sugar beet [595]: alfalfa, cotton [755]: cotton; diethyl phosphoric acids?, H_3PO_4?, phospholipids [755]: cotton, tomato and 10 other plants [559]	alfalfa, bean, cotton, lemon; $(EtO)_2P(S)SC_2H_4S(O)Et$, $(EtO)_2P(S)SC_2H_4S(O_2)Et$, $(EtO)_2P(O)SC_2H_4S(O)Et$, $(EtO)_2P(O)SC_2H_4S(O_2)Et$ [755]: cotton, tomato and 10 other plants; as above [559]: cotton; $(EtO)_2P(S)SC_2H_4S(O)Et$, $(EtO)_2P(S)SC_2H_4S(O_2)Et$ [754]

TABLE V (cont'd)

No.	Structure and name	Absorption and translocation	Hydrolysis products	Non-hydrolysed metabolites
26	$(EtO)_2P(S)SSP(S)(OEt)_2$? impurity in Delnav	bean, cotton, tomato [749]	bean, cabbage, cotton, tomato [749]	bean, cabbage; more polar derivatives, possibly phosphorothiolates [749]
27	$(EtO)_2P(S)OPh-NO_2-4$ Parathion	many plants [574]; apple [581]	many plants [574]; grape and lemon leaf juice [574]	
28	$EtOP(S)(OPh-NO_2-4)_2$ impurity in Parathion	plants [574]	plants [574]	
29	$(EtO)_2P(S)OPh-S(O)Me-4$ Bayer 25141	cotton [657]	cotton [657]	cotton; $(EtO)_2P(S)OPh-S(O_2)Me-4$, $(EtO)_2P(S)OPh-SMe-4$ (trace), $(EtO)(EtS)P(O)OPh-S(O)Me-4$ (major), $(EtO)(EtS)P(O)OPh-S(O_2)Me-4$ [657]
30	$(EtO)_2P(S)O-N$  Bayer 22408	cotton [726]	cotton: $(EtO)(HO)P(O)O$-naphthalimido?, H_3PO_4 incorporated into plant products? [726]	cotton: $(EtO)_2P(O)O$-naphthalimido [726]
31	$(EtO)_2P(S)S$  impurity in Delnav	bean, cotton, tomato [749]	bean, cabbage, cotton, tomato [749]	bean, cabbage; more polar derivative, probably $(EtO)_2P(O)S$-p-dioxene-2 [749]
32	$(EtO)_2P(S)S-$  $(EtO)_2P(S)S-$ Delnav-studies on separate and combined cis and trans isomers	bean, cotton, tomato [749]	bean, cabbage, cotton, tomato [749]	bean, cabbage; more polar derivatives, more active antiChE agents, possibly phosphorothiolates [749]
33	$EtOP(O)(NMe_2)_2$	turnip [620]	turnip [620]	turnip; $EtOP(O)(NMe_2)(NHMe)$? $EtOP(O)(NHMe)_2$? [620]
34	$MeHNP(O)(NMe_2)_2$	turnip [620]	turnip [620]	turnip; $(MeHN)_2P(O)NMe_2$? [620]
35	i-PrHNP(O)$(NMe_2)_2$	turnip [620]	turnip [620]	turnip; i-PrHNP(O)(NHMe)(NMe_2)? [620]

TABLE V (cont'd)

No.	Structure and name	Absorption and translocation	Hydrolysis products	Non-hydrolysed metabolites
36	n-BuHNP(O)$(NMe_2)_2$	turnip [620]	turnip [620]	turnip; n-BuHNP(O)(NHMe)(NMe_2)?, n-BuHNP(O)$(NHMe)_2$? [620]
37	$(Me_2N)_3P(O)$ impurity in Schradan	bean [604]; turnip [620]; sugar beet, strawberry [618]	bean [604]; turnip [620]; sugar beet, strawberry [618]; plants [616]	bean; more and less polar derivative(s), some containing organically bound formaldehyde [604]; turnip; $(Me_2N)_2P(O)NHMe$? [620]; sugar beet; $(Me_2N)_2P(O)NMe\cdot CH_2OH$? [618]; plants; unidentified intermediate [616]
38	$(Me_2N)_2P(O)F$ Dimefox, Hanane	pea [604]; bean [751]	pea [604]	pea: less and probably also more polar derivative(s), some containing organically bound formaldehyde and antiChE activity [604]
39	(MeHN)$(Me_2N)P(O)OP(O)(NMe_2)_2$ demethylated Schradan		turnip [620]	
40	$(Me_2N)_2P(O)OP(O)(NMe_2)_2$ and $(Me_2N)_2P(O)OP(O)NMe_2$ $(Me_2N)_2P(O)O$ Schradan or OMPA, technical	brussel sprout, hop, sugar beet, strawberry [617]	brussel sprout, hop, sugar beet, strawberry [617]	
41	$(Me_2N)_2P(O)OP(O)(NMe_2)_2$ Schradan or OMPA	sugar beet, strawberry [618]; bean, cabbage, hop, pea, strawberry [609] [750]; groundnut [627]; bean [756] [629] [626]; lemon, orange [624]; borage, mustard [614]; apple, bean, chrysanthemum, coleus [608] [752]; cotton [625]	clover, turnip [620]; sugar beet, strawberry [618]; plants [616]; bean [751] [629] [626]; groundnut [627]; lemon, orange [624]; borage, mustard [614]; apple, bean, chrysanthemum, coleus [608] [752]; plants; $(Me_2N)_2P(O)OH$, $(Me_2N)(Me_2NO)P(O)OH$? plus non-chloroform extractibles [620]; cotton, $(Me_2N)_2P(O)OH$?, H_3PO_4? [625]; many plants; $(Me_2N)_2P(O)OH$? [621]	plants; general reviews [414, 622]; bean; unidentified plant metabolite(s) [604]; bean, brussel sprout, clover, turnip; $(MeHN)(Me_2N)P(O)OP(O)(NMe_2)_2$ [620]; clover; $(MeHN)(Me_2N)P(O)OP(O)(NMe_2)$ plus antiChE agents [620]; plants; $(Me_2NO)(Me_2N)P(O)OP(O)(NMe_2)_2$, $(HOCH_2\cdot MeN)(Me_2N)P(O)OP(O)-N(Me_2)_2$, $(MeHN)(Me_2N)P(O)OP(O)-(NMe_2)_2$ [620]; plants; no non-hydrolysed intermediates [616]; bean; antiChE agent(s) [629]

J. E. Casida. Table I in "Metabolism of organophosphate insecticides by plants: A review." p. 49-64 in "Radioisotopes and Radiation in Entomology. Proceedings of a Symposium, Bombay 5-9 December 1960".

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*) Some comparison with other ionizing radiation(s)

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