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Effects of nematicides on nematode population densities and crop yield in a turnip-corn-pea cropping system

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Four management systems were evaluated in a six-year study to control nematodes in a turnip-corn-pea annual cropping system on plots of Tifton loamy sand naturally infested with *Meloidogyne* spp. (about 90 % *M. incognita* and 10 % *M. hapla*), *Pratylenchus* spp. (about 65 % *P. scribneri*, 25 % *P. brachyurus*, and 10 % *P. zeae*), *Paratrichodorus minor* and *Criconemella ornata*. Turnip (*Brassica campestris* subsp. *rapifera*) supported low numbers of all nematodes. 'Pioneer 3369A' corn (*Zea mays*) supported greater numbers of all nematodes than 'Funks G-4507'. Population densities of *Meloidogyne* spp. juveniles (J_2) were suppressed below 80 per 150 cm^3 of soil by 98 % methyl bromide + 2 % chloropicrin and 20 % methyl isothiocyanate + 80 % chlorinated C_3 hydrocarbons on turnip and corn, and increased rapidly on 'Pinkeye purplehull', but not on a resistant cultivar, 'Worthmore' pea (*Vigna unguiculata*). Population densities of other nematodes were not affected by cultivar of pea or the nematicide, ethoprop. Fenamiphos was more effective than ethoprop in suppressing nematode population densities. Increases in crop yield in the intensive management system ranged from 4 % to 52 % over untreated controls.

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Nous avons évalué quatre systèmes de conduite de cultures lors d'une étude de 6 ans afin de lutter contre les nématodes dans un système annuel de production de navet-maïs-pois sur des parcelles de sable loameux Tifton naturellement infestées par les *Meloidogyne* spp. (environ 90 % de *M. incognita* et 10 % de *M. hapla*), les *Pratylenchus* spp. (environ 65 % de *P. scribneri*, 25 % de *P. brachyurus* et 10 % de *P. zeae*), ainsi que par les *Paratrichodorus minor* et *Criconemella ornata*. Le navet (*Brassica campestris* subsp. *rapifera*) a toléré de faibles quantités de tous les nématodes. Le maïs (*Zea mays*) 'Pioneer 3369A' a toléré de plus importantes quantités de tous les nématodes que le maïs 'Funks G-4507'. Les densités de populations de juvéniles (J_2) de *Meloidogyne* spp. ont été abaissées en-deçà de 80 par 150 cm^3 de sol par un mélange composé de 98 % de bromure de méthyle et 2 % de chloropicrine et par 20 % de méthyl isothiocyanate combiné à 80 % d'hydrocarbones C_3 chlorinés sur le navet et le maïs. Ces populations de nématodes ont augmenté rapidement chez le pois (*Vigna unguiculata*) 'Pinkeye purplehull' mais ce ne fut pas le cas chez le cultivar Worthmore. Les densités de populations des autres nématodes n'ont pas été affectées par le cultivar de pois ou par le nématicide, en l'occurence l'éthoprop. Le fenamiphos a été plus efficace que l'éthoprop en abaissant les densités de nématodes. Les augmentations de rendement du système intensif de conduite des cultures se sont échelonnées de 4 % à 52 % par rapport aux témoins non-traités.

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Introduction

In the southeastern United States, turnip (*Brassica campestris* subsp. *rapifera* [Metzg.] Sinsk.) may be planted in the spring or fall and grown from seed to maturity in about 60 days. The mature leaves may be picked by hand and sold on the fresh market. Much of the commercial production is harvested mechanically and processed as canned or frozen greens.

Corn (*Zea mays* L.) is grown in numerous crop rotations for grain or silage and with the long growing season it can be used in double or triple cropping with vegetables (Johnson *et al.* 1983).

Pea (*Vigna unguiculata* [L.] Walp.) is an important food crop from which a significant part of the world population obtains much of its dietary protein. Peas are grown commercially and in many home gardens in all except northern states of the United States, and are eaten as tender immature pods, green mature pods, mature green seeds, and dry seeds. Frequently, pea is grown in monocrop or double-crop systems in the spring or fall. Presently, all commercial production of pea in Georgia is under overhead sprinkler irrigation with a planned pest management program (Sumner *et al.* 1978).

Nematodes are important pests on corn and pea in monocrop and intensive cropping systems (Johnson and Fassuliotis 1984). Limited information is available on the effects of nematicides on nematode population densities and yield of turnip, corn, and pea in intensive cropping systems (Johnson *et al.* 1983). The objective of this study was to determine the effects of nematicides on nematode population densities and crop yield in a turnip-corn-pea cropping system.

Material and methods

Plots (three beds each 1.8 m wide and 7.7 m long) were established in September 1974 and maintained until December 1980 on Tifton loamy sand (85 % sand, 10 % silt, 5 % clay, 0.5 % organic matter and pH 6.0-6.7) naturally infested initially with *Meloidogyne* spp. (about 90 % *Meloidogyne incognita* [Kofoid & White] Chitwood, race 1, and 10 % *Meloidogyne hapla* Chitwood), *Pratylenchus* spp. (about 65 % *Pratylenchus scribneri* Steiner, 25 % *Pratylenchus brachyurus* [Godfrey] Filip. & Sch.-Stek., and 10 % *Pratylenchus zeae* Graham), *Paratrichodorus minor* (Colbran) Siddiqi, and *Crinconemella ornata* (Raski) Luc and Raski.

Nematicide treatments. The four treatments were replicated six times in a randomized complete block design. For the first treatment (MBR-CP), the soil was treated between 14 November and 8 February each year with 358.7 kg/ha MBR-CP (98 % methyl bromide + 2 % chloropicrin, DOWFUME MC-2) injected throughout a 25-cm layer with chisels 20 cm apart. The soil surface was shaped and sealed with a bed-shaper, and plots were covered with black polyethylene (152 µm thick). The polyethylene was removed from the plots 48 h after soil treatment. For the second treatment (DD-MENCS), the soil was treated between 14 November and 17 December each year with 376.6 kg/ha DD-MENCS (20 % methyl isothiocyanate + 80 % chlorinated C_3 hydrocarbons, VORLEX) as described for MBR-CP, except the plots were not covered with polyethylene. In the third treatment (E-F), ethoprop (*0*-ethyl *S*,*S*-dipropyl phosphorodithioate, MOCAP 10G) was applied at 8.96 kg a.i./ha overall to the soil surface and incorporated into the top 15 cm with a tractor-driven rototiller before planting each crop from 1975 to 1978. However, poor nematode control was obtained. Therefore, fenamiphos (Ethyl 3-methyl-4-(methylthio) phenyl(1-methylethyl) phosphoramidate-NEMACUR 15G) was applied at 8.96 kg a.i./ha in 1979 and 1980 as described for ethoprop. No nematicides were used in the untreated plots. Additional pesticides to control other pests were applied to crops grown under the four nematicide treatments and are listed in Table 1.

Plot establishment. The soil was disc-harrowed, plowed 15-20 cm deep, and shaped into beds 1.8 m wide and 10 to 15 cm high with a rototiller before planting each crop. The annual cropping sequence was turnip, corn, and pea. Turnip cv. Shogoin was planted in February and harvested in March or April. Immediately after turnip was harvested, plots were subsoiled 45 to 60 cm deep with chisels 91 cm apart, and a nonvolatile nematicide and other pesticides were applied (Table 1). Corn cv. Pioneer 3369A (1975-1978) or Funks G-4507 (1979-1980) was planted 1 to 8 days later and harvested in August. Pea was planted 2 to 7 days after corn harvest and was harvested in October. Cultivar Pinkeye purplehull used between 1975 and 1978 was susceptible to *M. incognita* and *M. arenaria* Chitwood, but resistant to *M. hapla* and cv. Worthmore used in 1979 and 1980 was susceptible to *M. arenaria*, but resistant to *M. incognita* and *M. hapla* (J. D. Gay and R. E. Motsinger, personal communication). Plots were disc-harrowed after pea harvest and clean-fallowed until turnip was planted.

The nematicide treatments were maintained on the same land unit for the duration of the experiment. Supplemental irrigation was supplied as needed to enhance seedling emergence and plant growth when natural rainfall was insufficient. Liquid formulations of nitrogen (N), phosphorus (P), and potassium (K) (10-34-0, a 32% solution of NH_4NO_3-urea, and 0-0-60 KCl) were applied broadcast via irrigation system in multiple applications after planting each crop. The total kg per ha N-P-K applied to each crop each year was 123, 45, 90 for turnip; 308, 39, 100 for corn; and 22, 22, 84 for pea. Yield was taken on 7.7 m of the center bed.

Twenty soil samples (2.5 cm in diameter and 15 cm deep) were collected monthly from 1975 to 1980 from within the rows adjacent to the center bed, composited, and thoroughly mixed. A 150-cm^3 subsample was assayed for plant-parasitic nematodes by the centrifugal flotation method (Jenkins 1964).

Table 1. Pesticides applied to crops grown under four nematicide treatments in a turnip-corn-pea intensive cropping system (1975-1980)

Nematicide treatment	Pesticide applied (year)	Rate (kg a.i./ha)	Crop
MBR-CP§	Carbofuran (1978-1980)	2.24	Corn
	Methomyl (1976)	0.50	Corn
DD-MENCS†	DCPA (1975-1980)	4.48	Turnip
	Butylate (1975-1977)	4.48	Corn
	Cyanazine (1977-1980)	1.40	Corn
	2,4-D (1976-1980)	0.28	Corn
	Paraquat (1977)	0.28	Corn
	Pendimethalin (1978-1980)	0.84	Corn
	Methomyl (1976)	0.50	Corn
	Carbofuran (1977-1980)	2.24	Corn
	Trifluralin (1977-1980)	0.56	Pea
	Dinoseb (1975-1980)	1.68	Pea
E-F‡	DCPA (1975-1980)	4.48	Turnip
	Butylate (1975-1977)	8.96	Corn
	Cyanazine (1977-1980)	1.34	Corn
	Paraquat (1977)	0.28	Corn
	Pendimethalin (1978-1980)	0.84	Corn
	Methomyl (1976)	0.50	Corn
	Carbofuran (1978-1980)	2.24	Corn
	Trifluralin (1975-1980)	0.56	Pea
	Dinoseb (1975-1980)	1.68	Pea
Untreated¶	DCPA (1975-1980)	4.48	Turnip
	Butylate (1975-1977)	8.96	Corn
	2,4-D (1976-1978)	0.28	Corn
	Pendimethalin (1978-1980)	0.84	Corn
	Trifluralin (1975-1980)	0.56	Pea

§ Plots maintained weedfree by handweeding.

† Plots maintained weedfree by additional handweeding and cultivation.

‡ E-F: Ethoprop (1975-1978) and fenamiphos (1979-1980) used on each crop. Herbicides, cultivation, and insecticides used only as needed to control weeds and insects.

¶ No nematicide; one herbicide and cultivation were used to control weeds.

Statistical analyses. The data for the nematode populations presented in the tables were obtained from the treatment means for each month in 1975-1978 for turnip, 'Pioneer 3369A' corn and 'Pinkeye purplehull' pea and in 1979-1980 for turnip, 'Funks G-4507' corn and 'Worthmore' pea. Data were analyzed as a randomized complete block design with least-squares analysis of variance (Steel and Torrie 1960) and Waller-Duncan K-ratio *t*-test (Waller and Duncan 1969). Correlation coefficients (*r*) were determined for yield of crops and nematode population densities in the soil each month during 1975-1980.

Results

Meloidogyne incognita was the most prevalent plant-parasitic nematode in the soil. The mean number of *M. incognita* juveniles (J_2) in untreated plots decreased to 22 per 150 cm^3 of soil on turnip and increased to 878 and 1103 per 150 cm^3 of soil in 'Pioneer 3369A' corn and 'Pinkeye purplehull' pea, respectively, in 1975-1978 (Table 2). MBR-CP and DD-MENCS prevented rapid increase of *M. incognita* in corn, but not in 'Pinkeye purplehull' pea. The mean number of J_2 in plots of corn and 'Pinkeye purplehull' pea treated with ethoprop (1975-1978) did not differ from those in untreated plots. However, in 1979-1980 the density of J_2 was reduced in 'Funks G-4507' corn treated with fenamiphos and in 'Worthmore' pea (Table 2). The root-knot nematode species identified from roots of 'Pinkeye purplehull' pea in 1977 was *M. incognita*.

Table 2. Effect of nematicide treatments on population densities of *Meloidogyne incognita* juveniles in a turnip-corn-pea fallow cropping system

			Density§ (number per 150 cm^3)				
Year	Month of sampling	Cropping sequence	MBR-CP	DD-MENCS	Ethoprop	Untreated	LSD¶ (0.05)
1975-1978	January	Fallow	36	77	248	192	565
	February	Fallow	9	4	134	85	
	March	Turnip	41	4	42	49	
	April	Turnip	0	0	9	22	
	May	Corn†	0	0	9	10	
	June	Corn	0	0	13	23	
	July	Corn	1	0	342	389	
	August	Corn	32	6	871	878	
	September	Pea‡	4	6	151	187	
	October	Pea	610	416	931	1103	
	November	Fallow	942	812	1001	859	
	December	Fallow	249	264	535	545	
Year	Month of sampling	Cropping sequence	MBR-CP	DD-MENCS	Fenamiphos	Untreated	LSD¶ (0.05)
1979-1980	January	Fallow	30	8	58	85	752
	February	Fallow	7	0	71	85	
	March	Turnip	0	1	13	31	
	April	Turnip	1	0	17	10	
	May	Corn†	1	0	17	4	
	June	Corn	0	0	0	18	
	July	Corn	1	0	1	151	
	August	Corn	42	56	1	1746	
	September	Pea‡	4	4	1	222	
	October	Pea	17	2	0	71	
	November	Fallow	3	2	0	79	
	December	Fallow	5	6	1	28	

§ Means of six replicates.

† Cultivar Pioneer 3369A in 1975-1978, Funks G-4507 in 1979-1980.

‡ Cultivar Pinkeye purplehull in 1975-1978, Worthmore in 1979-1980.

¶ LSD for different treatments in the same month.

The mean number of *Paratrichodorus minor* did not increase above 21 per 150 cm^3 of soil in turnip or pea, but increased rapidly in corn following treatment with MBR-CP and DD-MENCS (Table 3). The numbers of *P. minor* were greater in corn in July than at any other sampling date during each year. *Paratrichodorus minor* densities in plots of 'Pioneer 3369A' treated with ethoprop (1975-1978) were not different from those in untreated plots, but the density was lower in plots of 'Funks G-4507' treated with fenamiphos (1979-1980) than in untreated plots in June (Table 3).

The mean number of *Criconemella ornata* was greater in 'Pioneer 3369A' corn in August than in other crops and was not affected by ethoprop (1975-1978) (Table 4). Population densities of *C. ornata* in all crops were less than 16 per 150 cm^3 of soil in plots treated with MBR-CP, DD-MENCS and fenamiphos (1979-1980) on all sampling dates.

The mean number of *Pratylenchus* spp. in untreated plots was greatest in 'Pioneer 3369A' corn in August (1975-1978) (Table 5). Ethoprop suppressed population densities of *Pratylenchus* spp. on 'Pioneer 3369A' corn in August 1975-1978 compared with untreated control. Population densities of *Pratylenchus* spp. were less than 8 per 150 cm^3 of soil in all crops for plots treated with MBR-CP, DD-MENCS and fenamiphos on all sampling dates (Table 5). *Pratylenchus* species identified from roots of corn were as follows: 1975 - *P. brachyurus* (92 %), *P. scribneri* (5 %),

Table 3. Effect of nematicide treatments on population densities of *Paratrichodorus minor* in a turnip-corn-pea fallow cropping system

Year	Month of sampling	Cropping sequence	Density§ (number per 150 cm^3)				LSD¶ (0.05)
			MBR-CP	DD-MENCS	Ethoprop	Untreated	
1975-1978	January	Fallow	1	3	5	2	32
	February	Fallow	1	1	3	3	
	March	Turnip	0	0	2	3	
	April	Turnip	0	0	3	7	
	May	Corn†	0	1	8	15	
	June	Corn	17	32	17	44	
	July	Corn	72	45	24	27	
	August	Corn	26	22	10	4	
	September	Pea‡	14	9	6	6	
	October	Pea	4	5	1	3	
	November	Fallow	5	3	1	6	
	December	Fallow	8	2	4	4	
Year	Month of sampling	Cropping sequence	MBR-CP	DD-MENCS	Fenamiphos	Untreated	LSD¶ (0.05)
1979-1980	January	Fallow	0	0	1	1	50
	February	Fallow	0	0	4	1	
	March	Turnip	1	0	3	7	
	April	Turnip	1	1	3	6	
	May	Corn†	6	5	2	7	
	June	Corn	74	102	1	91	
	July	Corn	179	182	26	55	
	August	Corn	15	11	3	8	
	September	Pea‡	3	5	0	3	
	October	Pea	21	16	1	1	
	November	Fallow	5	3	0	3	
	December	Fallow	4	1	1	2	

§ Means of six replicates.

† Cultivar Pioneer 3369A in 1975-1978, Funks G-4507 in 1979-1980.

‡ Cultivar Pinkeye purplehull in 1975-1978, Worthmore in 1979-1980.

¶ LSD for different treatments in the same month.

Table 4. Effect of nematicide treatments on population densities of *Criconemella ornata* in a turnip-corn-pea fallow cropping system

Year	Month of sampling	Cropping sequence	Density[§] (number per 150 cm³)				LSD[¶] (0.05)
			MBR-CP	DD-MENCS	Ethoprop	Untreated	
1975-1978	January	Fallow	60	31	38	30	75
	February	Fallow	2	1	49	27	
	March	Turnip	1	2	28	23	
	April	Turnip	0	1	43	27	
	May	Corn[†]	1	2	52	31	
	June	Corn	1	3	53	48	
	July	Corn	1	8	131	111	
	August	Corn	6	7	175	227	
	September	Pea[‡]	6	4	80	59	
	October	Pea	7	8	27	36	
	November	Fallow	2	4	34	18	
	December	Fallow	5	1	22	16	
Year	Month of sampling	Cropping sequence	MBR-CP	DD-MENCS	Fenamiphos	Untreated	LSD[¶] (0.05)
1979-1980	January	Fallow	1	0	10	7	19
	February	Fallow	0	0	5	4	
	March	Turnip	0	0	1	5	
	April	Turnip	0	0	5	8	
	May	Corn[†]	0	0	15	13	
	June	Corn	0	0	6	19	
	July	Corn	1	1	3	35	
	August	Corn	0	0	1	128	
	September	Pea[‡]	0	1	0	49	
	October	Pea	0	1	1	19	
	November	Fallow	1	0	0	20	
	December	Fallow	0	1	1	18	

§ Means of six replicates.

† Cultivar Pioneer 3369A in 1975-1978, Funks G-4507 in 1979-1980.

‡ Cultivar Pinkeye purplehull in 1975-1978, Worthmore in 1979-1980.

¶ LSD for different treatments in the same month.

P. zeae (3 %); 1977 - *P. scribneri* (32 %), *P. zeae* (68 %); and 1979 - *P. brachyurus* (7 %), *P. scribneri* (69 %), and *P. zeae* (24 %). Those identified from roots of 'Pinkeye purplehull' pea in 1977 were *P. brachyurus* in four blocks and *P. scribneri* in two blocks.

Generally the yield of turnip was greater from MBR-CP than other treatments (Table 6). Yield was greater from plots treated with DD-MENCS compared with untreated plots in 1977 and 1979. The mean yield data across all years indicate a 41 % increase from MBR-CP treatment and a 4 % and 15 % decrease from DD-MENCS and E-F treatments, respectively, as compared to yields from untreated plots.

Yield of 'Pioneer 3369A' corn was consistently greater from plots treated with MBR-CP, except in 1975, and from DD-MENCS than from untreated plots (Table 6). The application of ethoprop prior to planting 'Pioneer 3369A' corn did not result in yield increase. Yield of 'Funks G-4507' was not affected by the treatments. The mean yield of 'Pioneer 3369A' across years and treatments was 8 % greater than yield of 'Funks G-4507'.

Yield from 'Pinkeye purplehull' pea was consistently greater from plots treated with MBR-CP and DD-MENCS than from untreated plots (Table 6). The application of ethoprop prior to planting 'Pinkeye purplehull' did not increase yields ($P \leq 0.05$) over untreated plots. The mean yield data across years indicate a 52 %, 51 % and 9 % increase, respectively, from MBR-CP, DD-MENCS and ethoprop treatments over

Table 5. Effect of nematicide treatments on population densities of *Pratylenchus spp.* in a turnip-corn-pea fallow cropping system

Year	Month of sampling	Cropping sequence	Density§ (number per 150 cm³)				LSD¶ (0.05)
			MBR-CP	DD-MENCS	Ethoprop	Untreated	
1975-1978	January	Fallow	10	9	17	18	23
	February	Fallow	1	1	12	17	
	March	Turnip	0	0	12	13	
	April	Turnip	0	0	5	11	
	May	Corn†	1	1	3	5	
	June	Corn	0	0	1	3	
	July	Corn	0	0	4	10	
	August	Corn	1	0	22	47	
	September	Pea‡	1	1	14	51	
	October	Pea	1	0	5	7	
	November	Fallow	0	0	6	20	
	December	Fallow	1	1	6	8	
Year	Month of sampling	Cropping sequence	MBR-CP	DD-MENCS	Fenamiphos	Untreated	LSD¶ (0.05)
1979-1980	January	Fallow	1	0	0	3	11
	February	Fallow	0	0	1	5	
	March	Turnip	0	0	1	2	
	April	Turnip	1	0	1	3	
	May	Corn†	0	0	0	2	
	June	Corn	0	0	0	0	
	July	Corn	1	0	0	2	
	August	Corn	1	0	0	12	
	September	Pea‡	7	0	0	27	
	October	Pea	3	2	0	6	
	November	Fallow	0	0	0	12	
	December	Fallow	2	2	0	14	

§ Means of six replicates.

† Cultivar Pioneer 3369A in 1975-1978, Funks G-4507 in 1979-1980.

‡ Cultivar Pinkeye purplehull in 1975-1978, Worthmore in 1979-1980.

¶ LSD for different treatments in the same month.

untreated plots. Yield of 'Worthmore' pea was greater from plots treated with MBR-CP and fenamiphos in 1979 and DD-MENCS in 1980 than yields from untreated plots. The mean yield data across years for 'Worthmore' pea showed a 13%, 9% and 9% increase, respectively, from MBR-CP, DD-MENCS and fenamiphos treatments over untreated plots. Mean data across treatments and years indicate that yields of 'Worthmore' were 85% greater than 'Pinkeye purplehull' pea.

All correlation coefficients presented were significant ($P \leq 0.05$) unless stated otherwise. There were no relationships ($P \leq 0.05$) between yield of turnip and total numbers of nematodes ($r = -0.05$ to 0.15) in the soil from time of planting the crop until harvest. However, there were inverse relationships between yield of turnip and numbers of *Meloidogyne incognita* J_2 ($r = -0.18$ to -0.28) in the soil during clean fallow in November, December, and January before seeding turnip.

Inverse relationships between numbers of nematodes in the soil at or near planting in April and May and yield of 'Pioneer 3369A' corn ranged from $r = -0.22$ to -0.35, but the inverse relationships decreased with time until harvest. Negative correlations were determined between numbers of *Meloidogyne incognita* J_2 ($r = -0.46$) in the soil in May and yield of 'Funks G-4507' corn. Correlation coefficients indicated a negative relationship between all nematodes ($r = -0.20$ to -0.25) except *C. ornata*, and *P. minor*, in the soil in September and October and yield of 'Pinkeye purplehull' pea. There were negative correlations among numbers of *C. ornata*, ($r = -0.30$)

Table 6. Yield (t/ha) of turnip, corn, and pea as affected by the nematicide treatments in an intensive cropping system

Treatment[§]	Turnip 1975	1976	1977	1978	1979	1980
MBR-CP	20.19 a[†]	23.10 a	18.24 a	24.81 a	25.05 a	9.00 a
DD-MENCS	10.45 b	4.13 c	10.94 b	20.92 ab	25.78 a	9.97 a
E-F	12.40 b	11.19 b	5.11 c	13.13 c	21.89 b	9.48 a
Untreated	12.40 b	21.64 a	4.86 c	15.81 bc	21.89 b	9.00 a
	Corn					
	cv. Pioneer 3369A				cv. Funks G-4507	
	1975	1976	1977	1978	1979	1980
MBR-CP	12.12 b	16.00 a	13.62 a	14.71 a	12.67 a	12.67 a
DD-MENCS	13.96 a	15.73 a	13.62 a	13.48 b	12.53 a	12.60 a
E-F	12.87 b	12.87 c	12.73 ab	13.21 bc	11.30 a	13.21 a
Untreated	11.98 b	14.14 b	11.85 b	12.46 c	11.64 a	12.39 a
	Pea					
	cv. Pinkeye purplehull				cv. Worthmore	
	1975	1976	1977	1978	1979	1980
MBR-CP	1.79 a	0.89 a	1.79 a	2.06 a	2.47 ab	2.85 ab
DD-MENCS	1.50 ab	0.85 a	1.86 a	2.28 a	2.21 bc	2.93 a
E-F	1.47 ab	0.59 ab	1.29 b	1.32 b	2.58 a	2.51 b
Untreated	1.22 b	0.42 b	1.11 b	1.54 b	2.08 c	2.63 b

§ MBR-CP = 98 % methyl bromide + 2 % chloropicrin; DD-MENCS = 20 % methyl isothiocyanate + 80 % chlorinated C_3 hydrocarbons; E-F = ethoprop (1975-1978) and fenamiphos (1979-1980); and untreated = no nematicide.

† Means followed by different letters in columns are significantly ($P \leq 0.05$) different according to Waller-Duncan K-ratio *t*-test.

and *Meloidogyne incognita* J_2 ($r = -0.35$) in the soil in September and October respectively, and yield of 'Worthmore' pea.

Discussion

Soil fumigation with MBR-CP and DD-MENCS reduced densities of nematodes and increased yields of crops, but treatments were not economically feasible (Epperson *et al.* 1982). The rapid increase in numbers of *M. incognita* J_2 in 'Pinkeye purplehull' pea in fumigated soil following corn supports results reported for intensive cropping systems under film mulch and trickle irrigation (Johnson *et al.* 1979). Also, the increase in numbers of *P. minor* following soil fumigation supports other results (Perry 1953).

Fenamiphos was more effective than ethoprop in suppressing nematode populations in corn. Similar results with ethoprop used to control nematodes and increase yields in other intensive cropping systems have been reported (Johnson *et al.* 1983).

Turnip, grown from seed to maturity in about 60 days when soil temperatures 4 cm deep ranged from 11°C to 24°C in March and 16°C to 30°C in April, supported low numbers of nematodes. Similar results were reported on turnip in other intensive cropping systems (Johnson *et al.* 1983). Yield of turnip increased four of the six years in MBR-CP treated plots, but not in fenamiphos treated plots, although similar nematode control resulted. The differences in yield of turnip were caused by soil-borne fungal pathogens controlled by MBR-CP (Sumner *et al.* 1985).

Corn supported moderate to large numbers of all nematodes. While numbers of nematodes were high in corn in June, July, and August, they were lower on 'Funks G-4507' than 'Pioneer 3369A'. Our data indicate that in a turnip-corn-pea production system in fields infested with *Meloidogyne incognita* and *M. hapla*, 'Funks G-4507' would support fewer *M. incognita* than 'Pioneer 3369A', but neither cultivar would support *M. hapla*. Resistance to *M. incognita*, *M. arenaria*, *M. javanica* (Treub) Chitwood, and *M. hapla* has been identified in hybrids and inbred lines of corn (Baldwin and Barker 1970; Ibrahim and Rezk 1978; Norse 1972; Windham and Williams 1987, 1988).

Density of *Meloidogyne incognita* J_2 in plots of 'Pinkeye purplehull' pea following 'Pioneer 3369A' corn was similar to those reported when 'Pinkeye purplehull' pea followed cucumber (*Cucumis sativus* L.) in an intensive cropping system (Johnson *et al.* 1983). The resistance of 'Worthmore' pea to *M. incognita* resulted in adequate yields and nematode control without the use of nematicides.

A single application of ethoprop before planting each crop in a turnip-corn-pea cropping system was not beneficial for controlling nematodes. A single application of fenamiphos before planting 'Funks G-4507' corn prevented a rapid increase in nematode population densities near harvest in July and August. However, based on the value of increased yields of all crops compared with the costs of nematicides and application would not justify the use of MBR-CP, DD-MENCS, ethoprop, or fenamiphos for nematode control in a turnip-corn-pea cropping system under irrigation.

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